ATLAS OF OTOLARYNGOLOGY, HEAD AND NECK OPERATIVE SURGERY

Open Access Atlas of Otolaryngology, Head & Neck Operative Surgery

University of Cape Town

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1.1: Management Principles/Guidelines for Head and Neck Cancer in Developing Countries

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Clare Stannard, Sameera Dalvie

Developing countries constitute the majority of the world's landmass (*Figure 1*) and are home to more than 50% of its people.

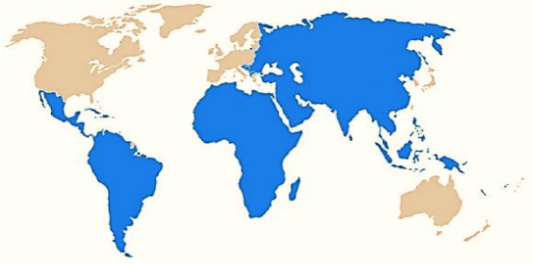


Figure 1: Developing (blue) vs. developed world (tan)

Cancer poses a major public health crisis in the developing world. Developing countries accounted for >50% of newly diagnosed cancers in 2010; it is projected that this figure will increase to 70% by 2030 (*Figure 2*)[1]. This increasing percentage is attributed to population growth, reduced mortality from infectious diseases and an aging society[1].

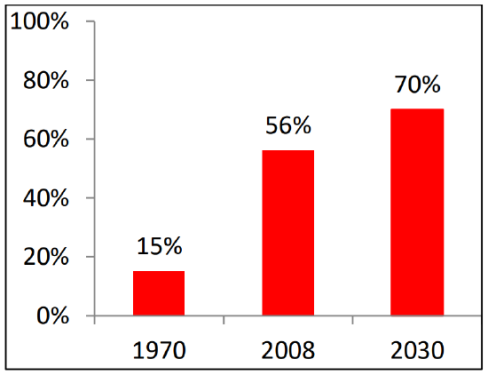


Figure 2: Increasing percentage of global burden of cancer in the developing countries[1]

There is a wide disparity in a cancer-related fatality which is aligned with income levels, ranging from 75% in low-income countries to 46% in high-income countries (*Figure 3*)[1]. Even though developing countries account for 67% of cancer-related deaths, they account for only 5% of cancer-related spending[1].

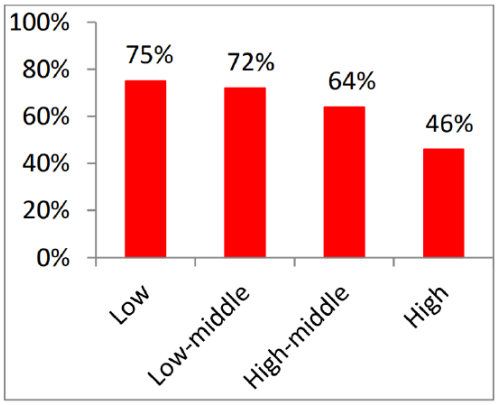


Figure 3: Case fatality from cancer according to income levels of countries[1]

Therefore, it is apparent that it is essential that innovation, expertise, resources, teaching and research be directed to addressing cancer in the developing world if we are to improve cancer outcomes globally. Given the financial and infrastructural challenges, the cancer management also must be adapted to local constraints. (https://developingworldheadandneckcance rguidelines.com/)

HEAD & NECK CANCER IN DEVELOPING COUNTRIES

Rapid economic growth in developing countries has been accompanied by lifestyle changes associated with squamous cell cancer such as smoking, alcohol, and longevity. Two-thirds of oral and pharyngeal cancers (excluding nasopharynx) occur in developing countries[2]. *Figure 4* illustrates the significant geographical variation for oral cancer; it is the most common cancer in males in high-risk areas such as Sri Lanka, India, Pakistan and Bangladesh where it accounts for up to 25% of all new cancers[2]. The principal causes of oral cancer are tobacco (smoked or chewed) and betel quid[2]. Cancer of the nasopharynx is also principally a developing world problem where it is related to Epstein Barr virus infection (*Figure 5*)[3,4,5].

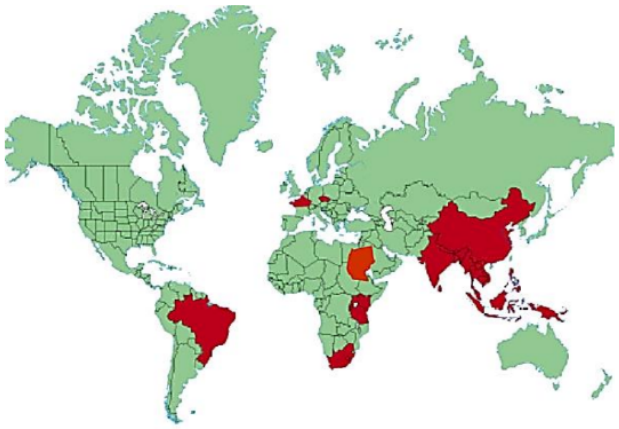


Figure 4: Countries (brown) with high incidence and mortality from oral cancer[2].

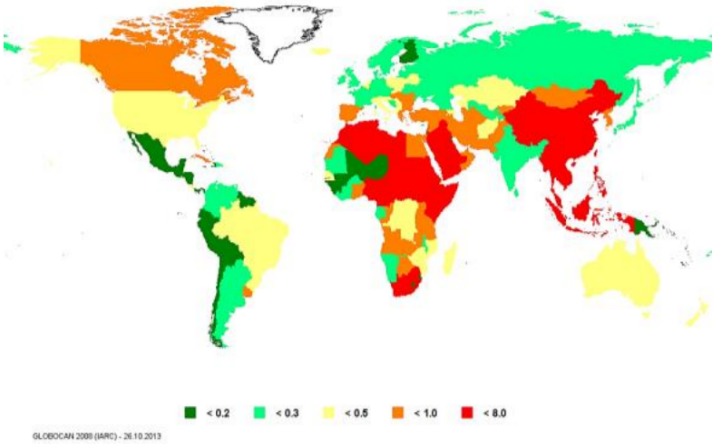


Figure 5: Nasopharyngeal carcinoma: Estimated age-standardized incidence rate/100,000; GLOBOCAN 2008 (IARC)[3].

HIV is also associated with malignancies of the head and neck. The prevalence of HIV is highest in developing countries; sub-Saharan Africa accounts for two-thirds of HIV positive people[6]. HIV is associated with Kaposi's sarcoma and non-Hodgkin's (and Hodgkin's) lymphoma; with Kaposi's sarcoma and lymphoma, surgery is restricted to obtaining a tissue biopsy. Squamous cell carcinoma of the conjunctiva is also associated with HIV[7]. Patients with advanced squamous cell carcinoma of the conjunctiva and metastases to parotid and cervical lymph nodes may require orbital exenteration, parotidectomy, neck dissection, and orbital reconstructive procedures. The association between HIV and mucosal squamous cell carcinoma of the upper aerodigestive tract is less clear-cut[8].

FACTORS TO CONSIDER WHEN TREATING HEAD & NECK CANCER IN DEVELOPING COUNTRIES

One should guard against simply extrapolating management protocols from developed world centers to head and neck patients in developing countries.

1. Advanced cancers

Patients in developing countries are more likely to present with advanced cancer[9,10]; consequently, treatment is mostly palliative[11]. Even in a middle-income country like South Africa, 52% of patients undergoing total laryngectomy initially required an emergency tracheostomy[12]. Late presentation may be due to ignorance, poverty, poor access to health services, and patients consulting traditional healers and using traditional medicines.

The adverse consequences of delayed presentation are compounded by long waiting lists for surgery and irradiation. Frequently patients become inoperable while awaiting surgery or radiation; this complicates initial patient selection and treatment planning. Jensen et al (2007) reported that one month's delay was associated with a 62% increase in tumour size, 20% new nodal metastases, and that cancers were upstaged (TNM) in 16% of patients studied; mean tumor volume doubling time was 3 months[13]. Some institutions administer "holding chemotherapy" (methotrexate or platinum-based drugs) in an attempt to slow tumor progression while patients await definitive treatment; yet there is no evidence that this improves outcomes.

2. Does HIV status matter?

Do HIV^+ patients need to be managed differently? One may need to consider the following questions when managing HIV^+ patients, especially when resources are limited:

Is radiotherapy accompanied by increased mucosal and cutaneous toxicity in HIV^+ patients? Although there are many reports of radiotherapy-induced skin and mucosal toxicity with Kaposi sarcoma, the few reports of toxicity with other head and neck malignancies indicate good tolerance to radiation +/- chemotherapy[14,15,16].

Should antiretroviral therapy be commenced to boost CD4 counts in immunocompromised patients prior to (chemo)radiation? Radiation can suppress CD4 counts. Yet even though it may seem reasonable to institute antiretroviral therapy to boost depressed CD4 counts prior to radiation, there are no controlled studies that address this question. Although interactions between antiretroviral therapy and radiation have not been well documented in the literature, there is a theoretical concern about the combination of the myelosuppressive effects of certain antiretroviral agents and myelosuppressive chemotherapeutic agents used with head and neck cancers such as platinum alkylators e.g. cisplatin and carboplatin[16].

What is the anticipated life expectancy of an HIV$^+$ patient? Adults that commence antiretroviral therapy before CD4 counts drop to < 200 cells/mm^3 have about 80% of normal life expectancy; even severely ill HIV patients treated with antiretrovirals have at least an 80% chance of surviving 2 years[17].

Do CD4 count and HIV status affect surgical outcomes? Even major surgery does not depress CD4 counts[18], and HIV status per se does not increase the likelihood of early surgical complications[19]. A depressed CD4 count (<100 cells/mm^3) has however been reported to be a predictor of postoperative sepsis[20,21]. Instituting antiretroviral therapy prior to surgery has the benefits of reducing the viral load of the patient (viral exposure to surgical team) and increases patients' CD4 counts.

It may be concluded that there is insufficient evidence to modify treatment of "apparently healthy" HIV +ve patients with head and neck cancer with CD4 counts of >350 cells/mm^3 [16]. There is also little reason to routinely determine the HIV status of healthy-looking head and neck cancer patients from an oncologic perspective alone; only when HIV infection causes ill health and immunosuppresssion may HIV status preclude patients from undergoing major surgery or chemoradiation.

3. How does one prioritize head and neck cancer patients?

Deciding who or who not to treat when the burden of cancer exceeds available treatment resources is perhaps the most difficult task that oncologists and surgeons in developing countries must deal with. Arriving at a decision involves ethical and practical considerations such as tumor stage, prognosis, palliation vs. cure, comorbidities, nutritional status, age, socioeconomic status, social support structure, distance from the closest treatment center, likelihood of regular follow-up, parental status, employment status, and the difficult ethical issue of possibly denying access to publicly funded treatment to patients originating from a foreign country without adequate treatment facilities.

However, when access to surgery and radiotherapy are the principal treatment constraints, it is reasonable **to prioritize patients with the most curable (early stage) malignancies**, especially when adjuvant radiation is not available or will be significantly delayed following resection of advanced malignancies.

4. Radiotherapy

Though central to treatment of head and neck cancer, **radiotherapy is unavailable in much of the developing world**. *AbdelWahab et al* (2013) reported that only 23/52 African countries had radiotherapy facilities, and that facilities were concentrated in the southern and northern parts of the continent (*Figure 6*); that brachytherapy resources were available in only 20 countries; and that, because only 2% of African countries had modern imaging equipment and treatment planning systems, simple, curative treatment is generally based on two-dimensional imaging and treatment planning[11].



Figure 6: Radiation therapy services in Africa[11]

Tatsuzaki & Levin (2001) similarly reported significant unavailability of radiation facilities in Asia and the Pacific regions[22]; and *Zubizarreta et al* (2004) reported a major restriction to access to radiotherapy in 16/18 South American countries due to insufficient numbers of specialists[23].

Consequently, most radiation services in the developing world are fairly basic and deliver mainly palliative care[9]. Radiation therapists also need to be cautious about extrapolating favorable treatment results emanating from modern radiation therapy centers of excellence to situations where reliance is placed on dated technology.

Patients that undergo radiation to the head and neck require **long term follow-up to detect and manage delayed radiotherapy-related complications** e.g. hypothyroidism increases over time and is present in 25% of patients at 5 years[24]. Therefore reliability for follow-up and the ability to monitor thyroid function and treat hypothyroidism must be considered when selecting patients for radiation.

5. Chemoradiation

In developed countries, chemoradiation (mostly chemotherapy used concurrently with radiotherapy / CCRT) is widely used as an organ-sparing treatment strategy with squamous cell carcinoma of the oral cavity, larynx, and oro-, hypo-, and nasopharynx. Compared to radiotherapy alone it has an 8% advantage in terms of locoregional control and survival rates[25].

However, to achieve such favorable outcomes, the "package of care" must include modern, sophisticated imaging (CT, MRI, PET) both for treatment planning and follow-up, medical and intensive care support for chemotoxicity, PEG feeding, and complex salvage surgery for persistent cancer or for recurrence as well as dental, speech, swallowing and audiological rehabilitation. Salvage surgery requires high levels of surgical expertise including proficiency with free tissue transfer flaps.

Because chemoradiation is expensive, toxic[25] and complex treatment and requires a "package of care" not available in many developing world centres, it has to be employed with great circumspection in a developing world setting.

Kumar et al reported a 14% mortality rate during and within 30 days of treatment in patients with advanced head and neck cancer treated with concomitant boost radiotherapy with concurrent weekly cisplatin at a tertiary hospital in India; the authors attributed the high mortality to poor support to deal with acute morbidity, poverty, malnutrition, illiteracy, and poor hygiene and concluded that "on present evidence in the setting of a developing country, CCRT with concurrent cisplatin cannot be recommended as primary therapy in advanced head and neck cancers without formal comparison with other treatment modalities" (*Figure 7*)[26].

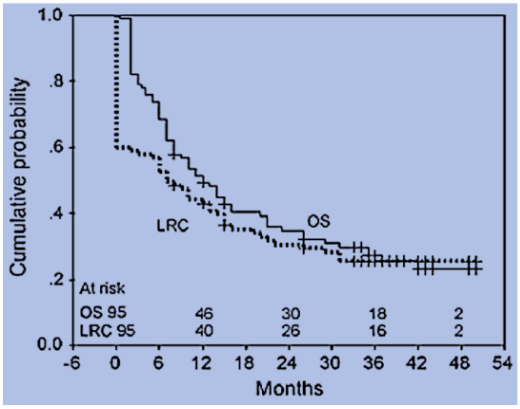


Figure 7: Locoregional Control (LRC) and Overall Survival (OS)[26]

Therefore, if chemoradiation is to be considered, patients must be carefully selected to predict favourable outcomes by considering factors such as age, general health, social support, immune (HIV) status, tuberculosis, and the "package of care" mentioned above should be available.

6. Altered fractionation

Altered fractionation schedules also improve locoregional control. **Accelerated radiotherapy** is perhaps better suited to a developing world setting than chemoradiation as it is cheaper and better tolerated. Overgaard et al reported that a 6-fractions per-week radiation schedule significantly improved locoregional control for squamous cell carcinoma of the larynx, pharynx and oral cavity when compared to conventional schedules of 5-treatments per-week. Despite increased acute morbidity, accelerated radiotherapy did not cause increased late morbidity and had the benefit of reducing overall treatment by 1 week[27]. **Concomitant boost radiotherapy** with a 2nd daily fraction to the gross tumor volume in the final 10 days of treatment also reduces overall treatment time, thus reducing the chance of repopulation and improves local control[28].

However, unless a radiation therapy department already treats patients 6 days/week, both the above schedules require reorganization to accommodate the 2nd daily fraction.

7. Surgery

Surgery is often the only treatment available because of inadequate radiotherapy and chemoradiation facilities. Yet, surgeons in developing countries frequently lack head and neck surgical training, and modern surgical technology (bipolar cautery, laser, transoral robotic surgery, endoscopic surgery), frozen section, blood products, adequate operating time, good anesthesia and intensive care support are often lacking[29]. Surgeons in developing countries need to keep abreast of and adapt modern surgical principles and techniques to a lower technology type practice e.g. substitute transoral microsurgery for early laryngeal cancer with laryngofissure and other open partial laryngectomy procedures; ensure wide tumor resection margins in the absence of frozen section control and postoperative radiation therapy; liberally employ elective neck dissection in the absence of sophisticated imaging, and rely on a range of pedicled rather than microvascular free tissue transfer flaps to reconstruct surgical defects.

MANAGEMENT PROTOCOLS

Selecting appropriate treatment for head and neck cancer patients in developing countries is particularly challenging and involves complex, individualized decisions often without the benefit of special investigations such as FNAC, CT, MRI, PETCT and HPV status.

Unlike the situation in well-resourced health systems, it ***may not always be possible for treatment to be protocol-driven*** as most patients are dependent on state run services with poor health infrastructure and resources. For the same reasons, ***protocols designed for developed world settings are not always relevant;*** e.g. tuberculosis mimics metastases on PET scan, therefore limiting its utility as a staging tool in societies where tuberculosis is endemic (*Figure 8*).

Reliance therefore frequently is placed on clinical acumen, experience, intuition and institutional bias, often in the absence of scientific evidence to support clinical decisions. Investigations and treatment must be tailored to the individual patient taking into account resource constraints relating to e.g. CT, MRI, operating rooms, ICU, radiation facilities, and blood transfusions; treatment delays (often many months); likelihood of regular follow-up; access to drugs e.g. thyroid and calcium replacement; nutritional status; social support; poverty; comorbidities (often poorly treated or neglected) including HIV; cultural bias; and the availability of surgical expertise, radiation therapy and chemotherapy.

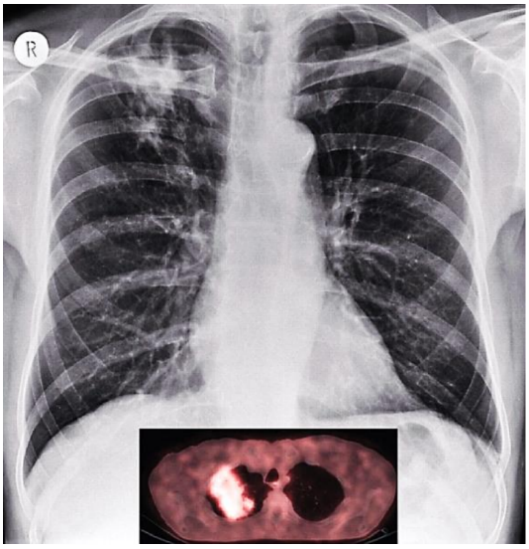


Figure 8: PET CT image of pulmonary TB:

Roy M, Ellis S. Radiological diagnosis and follow-up of pulmonary tuberculosis. Postgrad Med J 2010;86:663-74

Certain principles will now be highlighted that may be considered when designing management protocols in resource constrained settings.

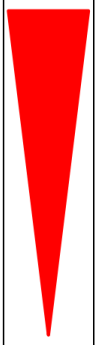
History: Consider cultural and religious values of patients as these may affect management. Inquire about risk factors including betel nut, areca nut, reverse smoking, chewing tobacco and comorbidities *e.g.* tuberculosis.

Metastatic workup: When access to operating time and adjuvant radiotherapy is limited, one could argue in favor of employing CT (even if it is a limited and expensive resource) to rule out pulmonary metastases that are not evident on CXR before (inappropriately) committing scarce surgical resources to advanced T and N stage cancers that have metastases.

N_0 neck: It is reasonable to have a low threshold to electively treat the N0 neck by means of a selective neck dissection in cases of unreliable follow-up, lack of specialized imaging (initially and for follow-up), and delayed adjuvant radiation. Surgeons should have a low threshold to convert a selective to a modified neck dissection when suspicious lymph nodes are encountered, especially in the absence of postoperative radiation capability.

N^+ neck: Even though lymphadenopathy in patients from poorer communities may result from untreated dental, oral and pharyngeal infections, HIV, or TB, palpable nodes within the expected lymphatic drainage area of a cancer should be treated with modified or radical neck dissection to avoid undertreating a neck that harbors metastases.

Adjuvant irradiation: When the burden of disease outstrips a centre's capacity to provide postoperative radiation to all deserving patients, an oncologist may have to ***make a call as to who are most likely to benefit***. Even though studies do not rank accepted indications for postoperative radiation, Table 1 is an attempted ranking ("thumb-suck") of indications for adjuvant radiation (not to be cited). *E.g.* having >2 cervical metastases is generally considered to be an indication for adjuvant radiation, even though the evidence to support this threshold is tenuous; hence centers that lack capacity to provide radiation to all deserving patients could argue that this threshold be adjusted upwards so that patients most likely to benefit *e.g.* with positive margins, extracapsular spread (ECS), and large tumor volumes are not deprived of adjuvant radiation[30]. A final (major) caveat relating to using histological criteria for adjuvant radiation is the inaccuracy of histopathological (under)reporting, especially of the presence of cervical micrometastases and perineural invasion (PNI).

Indications	Ranking
Primary tumour • Incomplete resection / +ve margin / tumour peeled off major structure *e.g.* carotid artery • Tumour spillage • PNI along major nerves *e.g.* VII, XII (macroscopic) • Invasion of bone marrow • Advanced T stage • PNI along minor nerves (microscopic) • Close margins • Vascular and/or lymphatic invasion • Invasive vs. pushing margin/tumour islands	

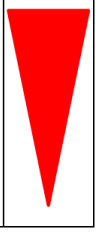
Cervical metastases
• Extracapsular spread (ECS)
  ○ Histological
  ○ Invading muscle/other extranodal tissues
  ○ Attached to major structures *e.g.* carotid artery
  ○ N3 node
• Tumour spillage
• ≥3 nodes
• <3 nodes
	

Table 1: Relative ranking of indications for postoperative irradiation (A thumb-suck, not to be cited)

Reconstruction: Although excellent functional results can be achieved with microvascular free tissue transfer flaps[31], the surgery is time-consuming and requires specialized training. In the absence of microvascular free tissues transfer flaps, surgeons should become proficient at using a range of pedicled flaps e.g. pectoralis major, buccinator, temporalis, nasolabial, buccal fat pad, deltopectoral, Latissimus dorsi, paramedian forehead, trapezius, cervicofacial, supraclavicular and submental artery island flaps.

Oral cavity: When postoperative radiation is unavailable, surgery for T1 and T2 cancers should be prioritized, including cancers that are T4 due to only limited bony invasion that can be resected by marginal or segmental mandibulectomy or by partial maxillectomy. Cancers of the tongue and floor of mouth that are palpable (likely to be >4 mm thick) or are staged >T2 should undergo elective neck dissection due to the likelihood of there being occult cervical metastases. Preserving oral function is crucial; other than microvascular free transfer flaps, surgeons can employ pedicled flaps *e.g.* pectoralis major, buccinator, buccal fat pad, temporalis, nasolabial, and submental artery island and supraclavicular flaps. With inferior or total maxillectomy, one must separate the oral cavity from the nose; if prosthetic appliances are not available, this can be achieved with temporalis muscle flaps. Without

the facility to reconstruct bone (*e.g.* free fibula flap), mandibular resection should not be extended beyond the midline to avoid the crippling and unsightly *Andy Gump* deformity (Fig 9).

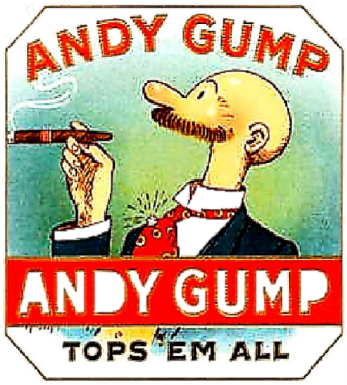


Figure 9: Andy Gump deformity

Oropharynx: Management of cancers of the oropharynx has undergone a paradigm shift with the realization that HPV infection is both an etiologic and prognostic factor for a subset of oropharyngeal squamous cell carcinomas; the introduction of transoral robotic surgery (TORS) to resect oropharyngeal tumors as well as attempts to reduce the morbidity of chemoradiation by accepting smaller resection margins when combined with postoperative radiation. However, HPV testing, transoral robotic surgery, and chemoradiation are generally not available in developing world centers; neither is the ability to deal with adverse consequences of chemoradiation. Surgical resection and/or radiation are therefore the mainstay of treatment in developing countries. Pedicled flaps used to reconstruct soft palate, lateral pharyngeal wall or base of tongue include pectoralis major, buccinator, buccal fat pad, supraclavicular, submental artery island and temporalis flaps.

Larynx and Hypopharynx: In developed world centers early cancers are commonly excised with CO_2 laser. Advanced cancers (dysfunctional larynx, cartilage invasion, tracheostomy for stridor) are treated with total laryngectomy. The remainder are offered chemoradiation with surgery reserved for salvage for persistent or recurrent cancer. CO_2 laser is generally not available in developing world centers; chemoradiation is expensive and the package of care required to manage both acute and late consequences and complications of chemoradiation (dysphagia, PEG feeds, cancer surveillance with MRI and PET scans, complex salvage surgery, hypothyroidism, hypocalcaemia) is lacking. Therefore such centres have to rely on open approaches such as laryngofissure, vertical partial, supraglottic, supracricoid and neartotal laryngectomy for smaller cancers, and total laryngectomy for advanced cancers. When performing total laryngectomy, the surgeon should attempt to preserve both thyroid lobes and the parathyroids to minimize the risks of hypothyroidism and hypoparathyroidism, particularly when thyroid and calcium monitoring and replacement are difficult or impossible. With a dedicated speech therapy service, fistula (*Figure 10*) speech results can be achieved that match those of developed world centers even with poor, illiterate patients living long distances from treatment centers[32]. Voice prostheses are however expensive; hence the adoption of strategies such as using removable prostheses as indwelling prostheses to reduce expense[32]. Heat moisture exchange (HME) devices are used in developed world centers to humidify and warm inspired air; however, a homemade cloth stoma cover/bib (*Figure 11*) is equally effective at a fraction of the cost[33].

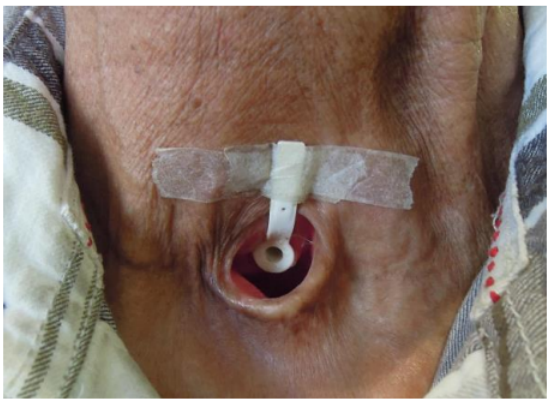


Figure 10: Speaking valve



Figure 11: Cheap homemade Bib

Although esophageal speech does not cost anything, only 27% of patients in a Brazilian study mastered esophageal speech[34]. Another option is to use mucosal shunts; however, the surgery is technically difficult and can be used only in highly selected patients with good pulmonary function who can cope with aspiration[34]. Because there is a severe shortage of speech therapists in many developing countries[28,34] an electrolarynx is a reasonable alternative to achieve post-laryngectomy speech.

Nasopharynx: Cancers of the nasopharynx occur mainly in the developing world (*Figure 5*). Chemoradiation is the mainstay of treatment[35]. However, the supportive care required for the extreme chemotoxicity is not always available in developing countries. Patients generally present with advanced disease; in an unpublished study conducted in Cape Town, South Africa, 50% of patients presented with Stage 4B disease of which 28% did not complete treatment for socioeconomic reasons (Dalvie et al: unpublished data). Hence it may be prudent to accept lower survival using radiation alone, than to try to improve survival with concurrent CTRT with its attendant morbidity. Intensity modulated radiotherapy (complex 3D conformal radiotherapy) has a documented survival benefit and can improve quality of life due to reduced xerostomia; however, this generally is not available in developing countries[35].

Thyroid: Most thyroidectomies in developing countries are done by surgeons not specializing in endocrine surgery. Bilateral recurrent laryngeal nerve injury causing airway compromise, or hypoparathyroidism causing hypocalcaemia in situations where monitoring serum calcium and treating hypocalcaemia with calcium and Vitamin D are not possible may have fatal consequences. Regardless of surgical expertise, complication rates rise with the extent of resection. Subtotal thyroidectomy preserves the blood supply to the parathyroid glands and reduces the risk of hypocalcaemia. Thyroid lobectomy causes hypothyroidism in 25% of cases, but almost never causes significant hypoparathyroidism. Total thyroidectomy is however associated with both increased short- and long-term morbidity relating to recurrent laryngeal nerve paralysis and hypocalcaemia, particularly in an occasional thyroid surgeon's hands. In the absence of convincing evidence that total thyroidectomy confers survival benefit in favourable, differentiated thyroid cancer[36, 37] (especially when I131 therapy is not available), coupled with the morbidity and mortality of total thyroidectomy where calcium monitoring and replacement are suboptimal, the occasional thyroid surgeon practicing in a developing world center may be wise to perform thyroid lobectomy or subtotal thyroidectomy for such cases.

PREVENTION AND SCREENING

Given the cancer tsunami that the developing world is facing, and the late presentations of patients with advanced disease, prevention (education and anti-smoking campaigns) and screening would appear to be reasonable strategies to adopt. Yet a Cochrane review reported that visual screening for oral cancer did not have survival benefit, although there was some evidence that it might be effective in high-risk patients[38, 39]. Techniques using toluidine blue staining, brush biopsy or cytology, or fluorescence imaging as primary screening tool or as adjunct for screening have also not been shown to have any benefit[38]. Consequently, it appears that based on current evidence, there are more important interventions than investing scarce human and financial resources in screening that will improve head and neck cancer outcomes in a resource constrained setting. Our efforts should rather be directed towards educating patients to seek advice early when symptoms appear, educating doctors and health care workers to recognize potential malignancies and to refer patients early for appropriate management.

CONCLUDING REMARKS

There needs to be a global effort to educate and train oncologists and surgeons to manage head and neck cancer in developing countries through residency programs, clinical fellowships and outreach projects. These should focus on developing sustainable

head and neck cancer programs, integrating them with existing local services and focusing on teaching and training. Open access to journals and textbooks should be encouraged. In addition, a multifaceted approach is required including lobbying international organizations, governments and aid organizations to support infrastructure development and research, and for industry to provide appropriate and affordable technology. In this way the developed world can make a substantial difference to the outcome of the enormous head and neck cancer burden in the developing world.

REFERENCES

1. Farmer P, Frenk J, Knaul FM, et al. Expansion of cancer care and control in countries of low and middle income: a call to action. Lancet. 2010 Oct 2;376 (9747):1186-93
2. Warnakulasuriya S. Global epidemiology of oral and oropharyngeal cancer. Oral Oncology. 2009;45:309-16
3. GLOBOCAN 2008: International Agency for Research on Cancer (IARC), 2013 http://gco.iarc.fr/
4. Yoshizaki T, Ito M, Murono S, et al. Current understanding and management of nasopharyngeal carcinoma. Auris Nasus Larynx 2012;39:137-44
5. Maxwell JH, Kumar B, Feng F, et al. HPV positive, P16 positive, EBV negative nasopharyngeal cancer in White Americans. Head Neck 2010; 32(5): 562-7
6. UNAIDS 2012 http://www.unaids.org/en/regionscountries/countries/southafrica/ (Accessed on 19 October 2013)
7. R Newton, J Ziegler, C Ateenyi-Agaba, et al. The epidemiology of conjunctival squamous cell carcinoma in Uganda. Br J Cancer. 2002 July 29; 87(3): 301– 8
8. Engsing FN, Gerstoft J, Kronborg G, et al. Head and neck cancer in HIV patients and their parents: a Danish cohort study. Clin Epidemiol. 2011; 3: 217–27
9. Onyango JF, Macharia IM. Delays in diagnosis, referral and management of head and neck cancer presenting at Kenyatta National Hospital, Nairobi. East Afr Med J. 2006 Apr;83(4):85-91
10. Da Lilly-Tariah OB, Somefun AO, Adeyemo WL. Current evidence on the burden of head and neck cancers in Nigeria. Head Neck Oncol. 2009 May 28;1:14 http://www.headandneckoncology.org/content/1/1/14 (Accessed on 19 October 2013)
11. Abdel-Wahab M, Bourque J-M, Pynda Y, et al. Status of radiotherapy resources in Africa: an International Atomic Energy Agency analysis. The Lancet Oncology. April 2013;14(4): e168 - e175) http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045%2812%2970532-6/fulltext#article_upsel
12. Stephenson KA, Fagan JJ. Do Proton Pump Inhibitors Reduce the Incidence of Pharyngocutaneous Fistulae following Total Laryngectomy? Head Neck [Epub ahead of print]
13. Jensen AR, Nellemann HM, Overgaard J. Tumor progression in waiting time for radiotherapy in head and neck cancer. Radiother Oncol. 2007 Jul;84(1):5- 10
14. Sanfilippo NJ, Mitchell J, Grew D, DeLacure M. Toxicity of head-and-neck radiation therapy in human immunodeficiency virus-positive patients Int J Radiat Oncol Biol Phys. 2010 Aug 1;77(5):1375-9.
15. Klein EA, Guiou M, Farwell DG, et al. Primary radiation therapy for head and neck cancer in the setting of human immunodeficiency virus. Int J Radiat Oncol Biol Phys. 2011 Jan 1;79(1):60- 4
16. Housri N, Yarchoan R, Kaushal A. Radiotherapy for HIV patients: Are special precautions necessary? Cancer. 2010;116(2):273–83
17. Global update on HIV treatment 2013: Results, impact and opportunities. WHO report in partnership with UNICEF and UNAIDS. June 2013 http://apps.who.int/iris/bitstream/10665/85326/1/9789241505734_eng.pdf (Accessed 19 October 2013)
18. Okumu G, Makobore P, Kaggwa S, et al. Effect of emergency major abdominal surgery on CD4 cell count among HIV positive patients in a subSaharan Africa tertiary hospital - a prospective study. BMC Surg. 2013 Feb 26;13:4. doi: 10.1186/1471-2482-13-4
19. Cacala SR, Mafana E, Thomson SR, Smith A. Prevalence of HIV status and CD4 counts in a surgical cohort: their relationship to clinical outcome. Ann R Coll Surg Engl. 2006 Jan;88(1):46-51
20. Su J, Tsun A, Zhang L, et al. Preoperative risk factors influencing the incidence of postoperative sepsis in human immunodeficiency virus-infected patients: a retrospective cohort study. World J Surg. 2013 Apr;37(4): 774-9
21. Guild GN, Moore TJ, Barnes W, Hermann C. CD4 count is associated with postoperative infection in patients with orthopaedic trauma who are HIV positive. Clin Orthop Relat Res. 2012 May; 470(5):1507-12
22. Tatsuzaki H, Levin CV. Quantitative status of resources for radiation therapy in Asia and Pacific region. Radiother Oncol. 2001 Jul;60(1):81-9
23. Zubizarreta EH, Poitevin A, Levin CV. Overview of radiotherapy resources in Latin America: a survey by the International Atomic Energy Agency (IAEA). Radiother Oncol. 2004 Oct;- 73(1):97-100

24. Rønjom MF, Brink C, Bentzen SM, et al. Hypothyroidism after primary radiotherapy for head and neck squamous cell carcinoma: Normal tissue complication probability modelling with latent time correction. Radiother Oncol. 2013 Nov;109(2):317-22
25. Machtay M, Moughan J, Trotti A, et al. Factors associated with severe late toxicity after concurrent chemoradiation for locally advanced head and neck cancer: an RTOG analysis. J Clin Oncol 2008;26:3582-9
26. Kumar S, Pandey M, Lal P, et al. Concomitant boost radiotherapy with concurrent weekly cisplatin in advanced head and neck cancers: a phase II trial. Radiother Oncol. 2005 May;75 (2):186-92
27. Overgaard J, Mohanti BK, Begum N, et al. Five versus six fractions of radiotherapy per week for squamous cell carcinoma of the head and neck (IAEA-ACC study): a randomised, multicentre trial. The Lancet Oncology 2012;11(6):553 - 60
28. Fagan JJ, Jacobs M. Survey of ENT services in Africa: need for a comprehensive intervention. Global Health Action, Vol 2 (2009) http://journals.sfu.ca/coaction/index.ph p/gha/article/view/1932
29. Fu KK, Pajak TF, Trotti A, et al. A Radiation Therapy Oncology Group (RTOG) phase III randomised study to compare hyperfractionation and two variants of accelerated fractionation to standard fractionation radiotherapy for head and neck squamous cell carcinomas: first report of RTOG 9003. Int J Radiat Oncol Biol Phys 2000;48(1):7- 16
30. Brown JS, Shaw RJ, Bekiroglu F, Rogers SN. Systematic review of the current evidence in the use of postoperative radiotherapy for oral squamous cell carcinoma. Br J Oral Maxillofac Surg. 2012 Sep;50(6):481-9
31. Van Zyl JH, Fagan JJ. Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery in The Open Access Atlas of Otolaryngology, Head and Neck Surgery https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be586fbaeba29d/Principles%20and%20technique%20of%20microvascular%20anastomosis%20for%20free%20tissue%20transfer%20flaps%20in%20head%20and%20neck%20reconstructive%20surgery.pdf (Accessed on 20 October 2013)
32. Fagan JJ, Lentin R, Quail G. International practice of laryngectomy rehabilitation interventions: a perspective from South Africa. Curr Opin Otolaryngol Head Neck Surg. 2013 Jun;21(3): 199-204
33. Quail G, Fagan JJ, Raynham O, Krynauw MH, John LR, Carrara MH. The effect of cloth stoma covers on tracheal climate of laryngectomy patients. Head Neck. 2016 Apr;38 Suppl 1:E480-7
34. Vartanian JG, Carrera-de-Angelis E, Kowalski LP. Practice of laryngectomy rehabilitation interventions: a perspective from South America Curr Opin Otolaryngol Head Neck Surg 2013, 21:212-7
35. Bourhis J, Le Maitre A, Baujat B, et al. Individual patients' data meta-analyses in head and neck cancer. Curr Opin Oncol 2007;19:188-94
36. Lee J, Park JH, Lee CR, Chung WY, Park CS. Long-term outcomes of total thyroidectomy versus thyroid lobectomy for papillary thyroid microcarcinoma: comparative analysis after propensity score matching. Thyroid. 2013; 23(11):1408-15
37. Nixon IJ, Ganly I, Patel SG, et al. Thyroid lobectomy for treatment of well differentiated intrathyroid malignancy. Surgery. 2012;151(4):571-9
38. Brocklehurst P, Kujan O, Glenny AM, et al. Screening programmes for the early detection and prevention of oral cancer. Cochrane Database Syst Rev. 2010 Nov 10;(11):CD004150
39. National Cancer Institute: PDQ® Oral Cancer Screening. Bethesda, MD: National Cancer Institute. Date last modified 09/26/2013. Available at: http://cancer.gov/cancertopics/pdq/scre ening/oral/HealthProfessional (Accessed 19 October 2013)

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Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Authors

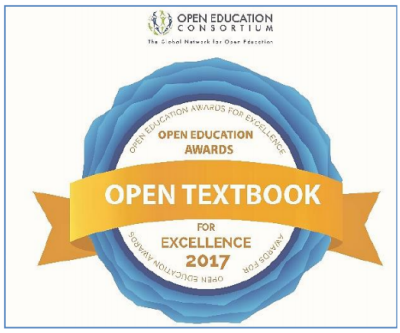
Clare Stannard MB.BS, FFRadOnc (SA)
Associate Professor Division of Radiation Oncology,
Groote Schuur Hospital,
University of Cape Town

Cape Town, South Africa
clare.stannard@uct.ac.za

Sameera Dalvie MBChB, FFRadOnc (SA)
Specialist Division of Radiation Oncology,
Groote Schuur Hospital,
University of Cape Town
Cape Town, South Africa
s.dalvie@uct.ac.za

THE OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY
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1.2: Head and Neck Lymph Node and Tumor Biopsy Techniques

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Johan Fagan, Kathy Taylor, Ellen Bolding

Almost any mass or tumor requires cytological or histological diagnosis before a management plan can be formulated. Performing tissue biopsy of masses and lymph nodes of the head and neck fills many junior doctors with fear due to the complex anatomy and the vascular structures and nerves that traverse the head and neck. Yet diagnostic material can be safely obtained from most masses in the head and neck in an ambulatory care setting.

Techniques and pitfalls to obtain diagnostic material are presented in this chapter. Techniques include brush cytology, fine needle aspiration biopsy/cytology (FNAB/FNAC), core biopsy, punch biopsy, and open surgical biopsy

Tumors of the upper aerodigestive tract are ideally biopsied directly either transorally or transnasally. Subcutaneous tumors are first sampled by the least invasive technique; only if the diagnosis remains in doubt does one employ progressively more invasive biopsy techniques until a diagnosis is made. A typical diagnostic sequence is: FNAC - core biopsy - open surgical biopsy.

What do pathologists require to make a diagnosis?

Clinical detail: A pathologist's differential diagnosis and types of pathological tests are informed by the clinical information; this is particularly important with FNAC.

FNAC

- Cellular aspirate
- Smear material directly onto slide
- Spray with cytofixative & leave to dry
- Can also rinse needle in 50% alcohol solution or in liquid-based cytology fluid to retrieve cells "stuck" in needle

Tissue biopsy

- Adequate size
- Biopsy technique (not crushed)
- From periphery of specimen (avoids necrotic tumor)
- Place biopsy in 10% formalin for fixation
- If suspect TB or other infective cause, also place a biopsy in sterile saline or culture media for microbiology

Pitfalls and caveats

- ***Insufficient clinical detail on pathology request form:*** A pathologist's differential diagnosis and types of pathological tests can be steered in the right direction by having adequate clinical information; this is particularly important with cytology
- ***Not excluding a primary tumor prior to proceeding to lymph node biopsy:*** Especially in non-otolaryngologists' hands, patients commonly (inappropriately) undergo excision biopsy of a cervical lymph node before having undergone a thorough search for a primary malignancy in the upper aerodigestive tract or skin. Not only may the lymph node biopsy prove to have been unnecessary, but it may also complicate subsequent surgical treatment of the neck
- ***Not considering infective causes:*** Diseases such as tuberculosis (TB) and actinomycosis (*Figure 1*) may masquerade as malignant tumors and lymph node metastases; it is therefore advisable to send a segment of an excised lymph node for TB culture
- ***Proceeding to open surgical biopsy of a neck mass or lymph node before FNAC:*** FNAC is cheap, safe and minimally invasive and often yields a diagnosis making open biopsy unnecessary

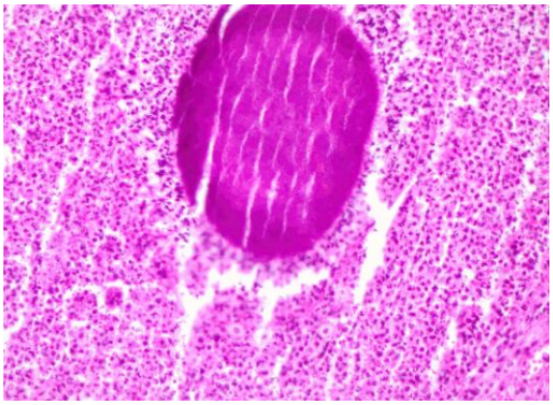


Figure 1: Actinomyces surrounded by neutrophils

- ***Bloody FNAC aspirate:*** A bloody smear is often unhelpful; repeat the procedure using a non-aspiration technique
- ***Inadequate sample size of open tissue biopsy:*** Having opened the neck, the surgeon should ensure that an adequate volume of tissue is sampled to avoid having to repeat the biopsy
- ***Taking a biopsy from the necrotic center of a tumor:*** This applies especially to the oral cavity; biopsy viable cells at the periphery of a tumor
- ***Non-representative tissue:*** When a biopsy is being repeated following previous "non-representative" or "inadequate" biopsy, have frozen section done, not to make a diagnosis, but to ensure that pathological tissue has indeed been sampled
- ***Assuming that a cystic aspirate is infective or benign, and not malignant:*** Certain malignancies of the head and neck e.g. squamous cell carcinoma (SCC) of the oropharynx and skin, and metastatic melanoma may have cystic lymph node metastases (Figure 2); the appearance of the aspirate may vary from crystal-clear to purulent. Cystic aspirates should therefore always be sent for cytologic examination even when malignancy is not suspected. Smear the aspirate as uniformly as possible (Figure 6). Cystic, well differentiated SCC can also be mistaken for a benign epidermoid or branchial cyst
- ***Incorrect transport medium:*** Ensure that tissue sent for histological analysis is placed in formaldehyde in a sealed container; tissue sent for TB culture is transported in normal saline
- ***Anticoagulation:*** FNAC can be safely done in patients taking aspirin and nonsteroidal anti-inflammatories. Patients on anticoagulants or with bleeding disorders may present a problem if anticoagulation cannot be safely stopped; ultrasound guided FNAC (USGFNAC) may be appropriate in such cases to avoid puncturing large blood vessels

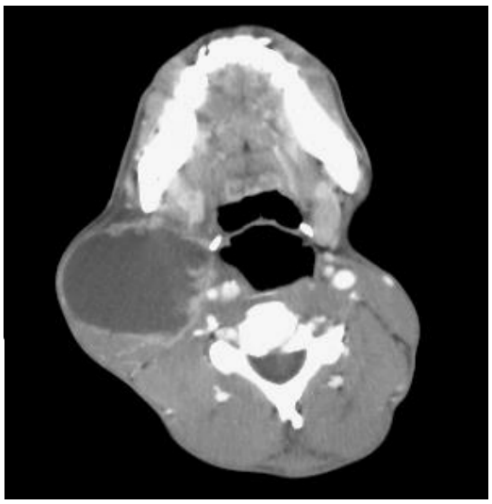


Figure 2: Cystic cervical nodal metastasis originating from squamous cell carcinoma of the tonsil

Fine needle aspiration cytology/biopsy (FNAC/FNAB)

This is a technique whereby a cytologic diagnosis is made on an aspirate of cellular material that has been collected through a small-caliber needle and smeared and fixed on a glass microscope slide. In the absence of an obvious primary tumor, FNAC is generally the 1st line investigation of a neck mass. Because the relationship of tumor cells to the basement membrane cannot be

determined on cytology, ***the cytologist is unable to distinguish between high grade dysplasia (carcinoma in situ) and invasive carcinoma;*** this distinction can only be made on histological examination of a tissue biopsy that includes the basement membrane.

FNAC is particularly useful in the head and neck for the following reasons:

- Simple, quick, safe and inexpensive
- Requires minimal practice and training
- No anesthesia required (not even local anesthesia)
- Rapid diagnosis
- Insignificant risk of injury to nerves *e.g.* facial nerve in the parotid gland
- Does not cause seeding of tumor cells
- Insignificant risk of bleeding; if a major vessel *e.g.* carotid artery or internal jugular vein is punctured with a small gauge needle, bleeding settles with finger pressure applied to the puncture site
- Good yield for metastatic SCC, and for differentiating inflammatory masses from neoplasia

Equipment for FNAC (Figure 3)

- 23-gauge needle: a thin needle causes less bleeding, is less painful, and has a similar diagnostic yield as larger needles
- Syringe (5 or 10 mL)
- Alcohol / iodine gauze swab to sterilize skin
- Gauze swab to compress needle puncture site
- Two glass microscope slides
- Cytology fixative (unless air-dried)

Local anesthesia

The authors do not use local anesthesia as the additional needle stick for the anesthetic also causes discomfort and the anesthetic solution may obscure a small mass.



Figure 3: FNAC equipment: syringe, gauze swab, 2 glass microscope slides, 23-gauge needle, alcohol swab, fixative

Accessing the mass

FNAC is done either with the patient sitting in a chair or lying down. With FNAC of the thyroid the neck may be hyperextended over a bolster placed under the shoulders. Access to lymph nodes along the jugular chain may be improved by turning the head. If possible, the mass is fixed between the fingers of the nondominant hand.

Masses in Level 1b of the neck may be more accessible and better stabilized by displacing them inferolaterally with a finger placed in the lateral floor of mouth. Great care should however be taken not to pierce the operator's finger in the mouth with the tip of the needle.

Ultrasound-guided (USGFNAC) or CT-guided FNAC may be done for masses that are difficult to access with confidence e.g. deep-seated masses in the deep lobe of parotid or parapharyngeal space, or smaller masses.

Harvesting the cellular material

Non-aspiration technique

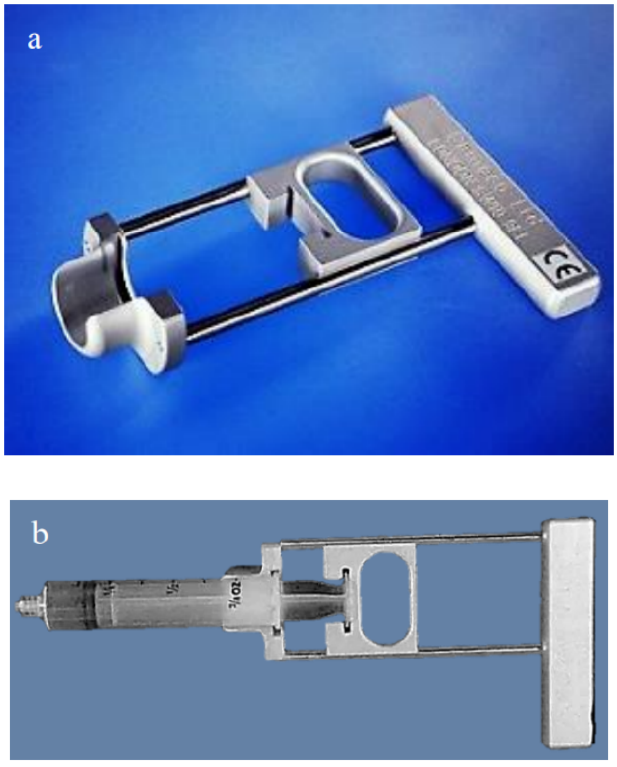
Also known as the *fine-needle capillary method*, this is the authors' preferred method. It relies on capillary action to draw sheared cells up a small-caliber needle. The non-aspiration technique is easier to perform than aspiration technique, improves the operator's ability to direct the needle tip into a smaller mass, and is less likely to cause a bloody aspirate which is particularly advantageous with vascular structures such as thyroid gland.

- Hold the hub of a 23-gauge needle between index/middle finger and thumb of the non-dominant hand without syringe attached
- Advance the needle through the skin into the mass
- Move the needle back-and-forth with short, rapid strokes while rotating the needle
- Withdraw the needle
- Attach a syringe with plunger retracted, to the hub of the needle
- Carefully eject the material onto a glass microscope slide

Aspiration Technique

The aspiration technique employs negative pressure generated by a syringe as well as the shearing effect of the needle, to aspirate cellular material from a mass. A pistol grip syringe holder can be used as it allows more uniform suction and makes it easier to direct the needle (*Figure 4*).

- Attach the needle to the syringe
- Insert the needle into the mass without applying suction
- Pull back the plunger of the syringe
- Maintain suction while moving the needle back-and-forth
- Release the plunger of the syringe to relieve the negative pressure
- Withdraw the needle
- Disconnect the needle from the syringe
- Retract the plunger of the syringe to fill it with air and reattach it to the needle
- Eject the aspirated material onto a glass microscope slide



Figures 4a, b: Example of pistol grip syringe holder

Smearing the aspirate

As soon as the aspirate has been ejected onto the glass microscope slide, a 2nd microscope slide is used to smear the cellular material into a ***monolayer*** of cells for microscopic examination (Figure 5).

Figure 6 illustrates two techniques that may be used to create a thin film. The "pull-push" smear technique is only applicable to liquid aspirates. The authors favor the so-called "crush" technique for FNAC of solid tumors which involves gently smearing the tissue between two opposing glass slides.

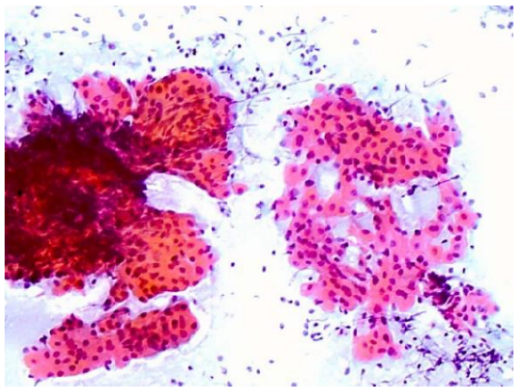


Figure 5: Example of a smear showing oncocytic cells and lymphocytes that is too thick on the left, and a desired thickness (monolayer) on the right

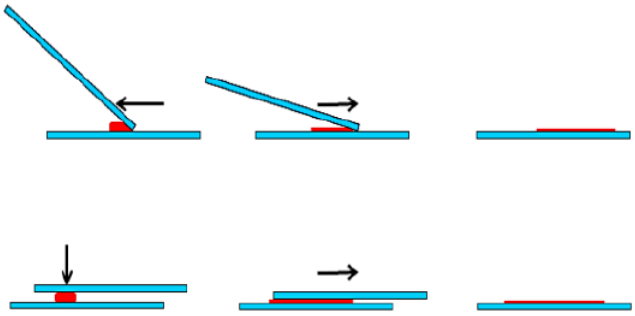


Figure 6: "Pull-push" (above) & "crush" (below) smear techniques

Fixing the smear

Smears are immediately fixed to avoid shrinkage artifact. This is achieved by either wet fixation or air-drying. Consult your cytopathologists about their preferred fixation method. As different stains are used for each technique, some prefer using both techniques for the same specimen, as the two methods can produce complementary results.

Wet-fixation technique

This is achieved by dipping the slide into 95% ethanol solution, or by applying a spray fixative (Figure 3). Spray fixatives typically consist of an admixture of polyethylene glycol and ethyl alcohol or isopropyl alcohol. The alcohol evaporates and leaves the glycol covering the smear. Material fixed by wet-fixation technique can be stained both with Papanicolaou (PAP) and hematoxylin-eosin (H&E) stains (*Figure 7*).

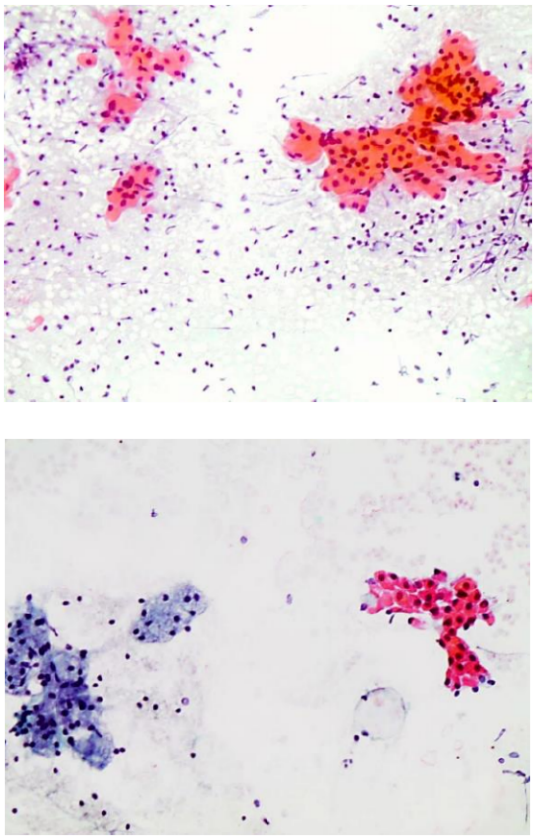


Figure 7: Examples of an H&E smears showing oncocytic cells and lymphocytes

Air-drying fixation technique

The smeared material is allowed to air-dry; drying should be quick and may be aided with a hairdryer or a fan. The WrightGiemsa stain is used for air-dried smears.

Labeling

Label the slides with the patient's details and the origin of the aspirate. The slides in *Figure 8* have been sandblasted at one end so that details can be written on the slide with pencil.

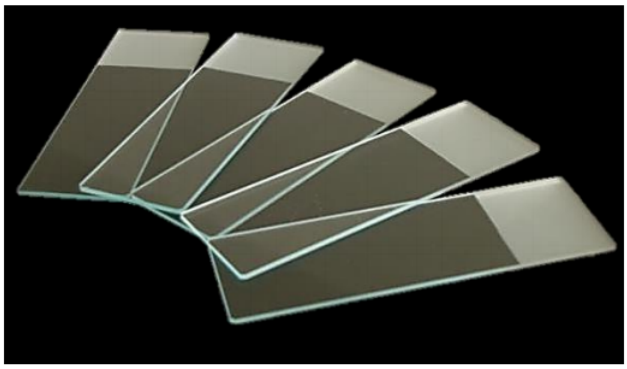


Figure 8: Sandblasted end of slides for labeling with pencil

Liquid based cytology

This technique is useful for hypocellular aspirates. Instead of being spread onto a glass slide, the material obtained by aspiration or by cytobrushing is transferred to a vial of fixative. The vial is then centrifuged, and the sediment is used for the smear.

Exfoliative or brush cytology

Brush cytology is cheap, non-invasive, and virtually painless and requires minimal training. Although it is highly specific, it is less sensitive *i.e.* negative brush cytology does not rule out malignancy. It is therefore useful for screening suspicious oral lesions; if dysplastic cells or molecular alterations are identified, patients should be referred for tissue biopsy.

Figure 9 shows a close-up view of the tip of a cytobrush. A toothbrush is a reliable and cheap alternative (*Figure 10*).



Figure 9: Tip of cytobrush



Figure 10: Toothbrush is a reliable and cheap alternative for a cytobrush[1]

Method of brush cytology

Apply the cytobrush to the oral lesion with enough pressure to slightly bow the handle

- Rotate the cytobrush through 360° while applying pressure to the lesion
- Punctate bleeding indicates that the basement membrane has been breached and an adequate tissue depth has been sampled
- Deposit the brushings onto a microscope glass slide by rolling the brush on the surface of the slide through 360°
- Immediately fix the smear in accordance with the technique previously described with FNAC
- Label the slides with the patient's details and the origin of the aspirate

Trucut biopsy

Percutaneous core biopsy allows one to harvest a solid core of tumor for histological examination in an ambulatory setting. It is generally done with a *Trucut* biopsy system. Unlike FNAC, ***Trucut biopsy can seed tumor cells***; therefore, avoid using it for salivary gland tumors, melanomas *etc.* unless the tumor is considered to be inoperable.

An outer cannula unsheathes a sharp-pointed needle that can be retracted and advanced into and out of the cannula. The needle has a notch which traps a core of tissue which has been sliced off the tumor by the sharp end of the outer cannula (*Figures 11a-d*). It requires a two-handed technique, although automated and semiautomated systems are also available.

Method

- Clean and infiltrate the skin with local anesthetic at the intended biopsy site
- Steady the mass with the non-dominant hand
- Make a small (3 mm) stab incision in the skin with a scalpel

- With the central needle retracted into the cannula (*Figures 11 a, b*), advance the Trucut needle and cannula into the mass taking care to avoid large vessels

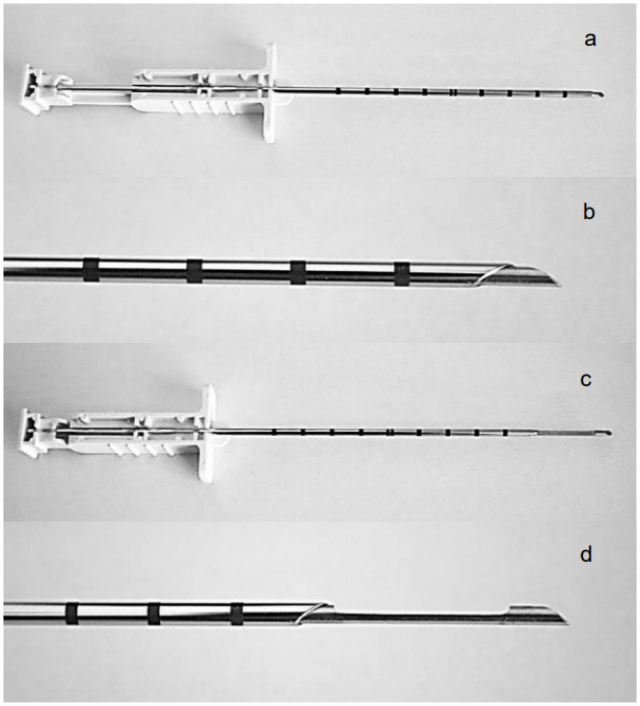


Figure 11: Trucut biopsy needle with plunger retracted (a, b) and plunger advanced (c, d)

- Steady the position of the handle of the outer cannula with the non-dominant hand
- Advance the plunger (which is attached to the needle) so that the needle extrudes from the tip of the cannula into the mass (*Figures 11 c, d*); this allows tumor tissue to fill the notch in the needle
- Steady the position of the handle of the needle with the dominant hand while rapidly advancing the handle of the outer cannula with the non-dominant hand so that the cannula is advanced over the notch of the needle, slicing off and trapping tumor tissue that has prolapsed into the notch
- Withdraw the Trucut apparatus from the patient
- Advance the handle of the needle to expose the core of tissue (*Figure 12*)
- Place the core of tissue in a specimen jar with formaldehyde
- Apply light pressure to the incision for hemostasis



Figure 12: Core of tissue in the notch of the Trucut needle

Biopsy of oral and oropharyngeal mucosal tumors

Mucosal tumors of the upper aerodigestive tract are typically biopsied under local anesthesia in the office or outpatient clinic. Topical anesthesia is applied to the mucosa following which local anesthesia (1% or 2% lidocaine with 1:100,000 epinephrine) is injected into the surrounding submucosa or a nerve block is done *e.g.* of the lingual nerve (http://emedicine.medscape.com/article/82850-overview).

Once well anesthetized, a punch biopsy is taken with Blakesley forceps, taking care not to crush the tissue. A through-cutting Blakesley forceps is preferred as it does not tear tissue and causes less crush artifact (*Figure 13*). Bleeding is generally minor and stops spontaneously or can be arrested with chemical cautery using a silver nitrate stick (*Figure 14*).



Figure 13: Blakesley nasal forceps (above); through-cutting Blakesley forceps (below)



Figure 14: Silver nitrate sticks used for hemostasis

Punch Biopsy of Skin

Punch biopsy is used for pigmented skin lesions, neoplasms, inflammatory and chronic disorders of skin. It is done under local anesthesia with a circular blade attached to a handle that is rotated as it is advanced to produce a 3-4 mm cylindrical full thickness core of skin (*Figure 15*).



Figure 15: 3mm/4mm punch

Method

- Determine the direction of Langer's lines (lines of skin tension); stretching the skin perpendicular to the lines while doing the biopsy results in an elliptical-shaped wound with the long axis along Langer's lines and allows for easier closure with a single suture and a better cosmetic result (*Figure 16*).

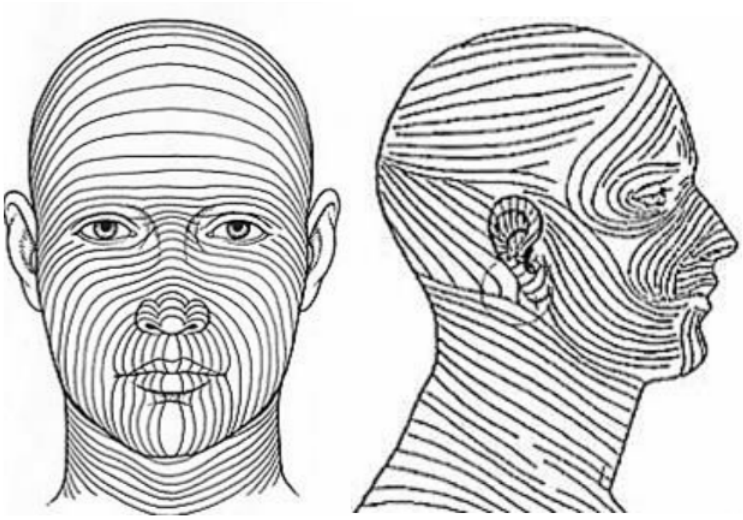


Figure 16: Langer's lines / Tension lines

- Select an appropriate punch biopsy instrument (3 or 4 mm)
- Clean and infiltrate the skin with 2% lidocaine with epinephrine
- Stretch the skin at 90^{o} to Langer's lines between thumb and index finger of the non-dominant hand
- Apply the punch vertically to the skin and rotate the punch between thumb and index finger of the dominant hand, cutting through epidermis, dermis and into subcutaneous fat (*Figures 17, 18*)
- Remove the punch
- Gently elevate the 3-4 mm cylindrical core of skin with a needle to avoid crush artifact, and cut it free at its base with iris scissors
- Only larger punch biopsy sites require closure with a single nylon suture



Figure 17: Appropriate diameter punch applied to skin

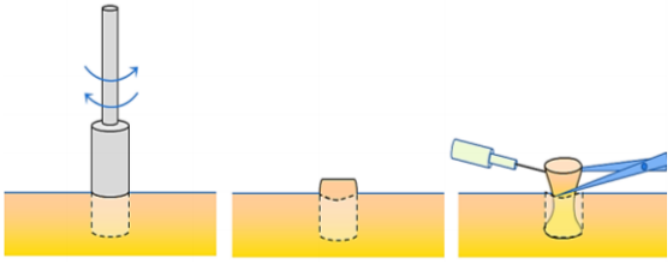


Figure 18: Rotate punch through skin, and divide the specimen with fine scissors below the dermis while holding it with a needle

Open Surgical Biopsy

Open surgical biopsy is indicated when FNAC and Trucut biopsy are inconclusive or are suggestive of lymphoma.

Anesthesia: Biopsy is done under local or general anesthesia. Because taking a biopsy of a deep-seated lymph node is often more difficult than expected, especially for a surgeon not well versed in the detailed surgical anatomy of the neck, one should have a low threshold for doing such biopsies under general anesthesia.

Hemostasis: At the conclusion of the surgery, ask the anesthetist to do a Valsalva procedure to identify venous bleeders. Have a low threshold for leaving a drain in place to prevent a hematoma.

Skin incisions: Incisions are made along Langer's lines (*Figure 16*); when a neck dissection may subsequently be required, incisions should be made along neck dissection incision lines.

Lymph node biopsy: Lymph nodes should ideally be completely ***excised rather than incised*** to avoid contaminating the neck with cancer cells of an unsuspected cervical metastasis.

Submandibular triangle (Level 1) biopsy: Masses of the submandibular gland are removed by resecting the whole gland. Removing lymph nodes in the vicinity of the mandibular ramus puts the marginal mandibular nerve at risk of injury; it is safest and cosmetically best to place the incision in the vicinity of the hyoid bone; to raise a superiorly based flap over Level 1 as for a neck dissection or as for excision of the submandibular salivary gland (See Submandibular gland excision); and to identify the marginal mandibular nerve where it crosses the facial vessels deep to platysma before excising the node (*Figure 19*).

Posterior triangle (Level V) lymph node biopsy: The spinal accessory nerve is very superficial in the posterior triangle, often just deep to skin in a thin patient. Injury to the nerve is a common cause of litigation. It exits the sternocleidomastoid muscle to enter the posterior triangle about 1 cm behind Erb's point which is at the junction of the upper and middle thirds of the muscle where the cervical plexus branches exit (*Figure 20*). Avoid muscle relaxants so that mechanical or electrical stimulation can be used to help identify the nerve

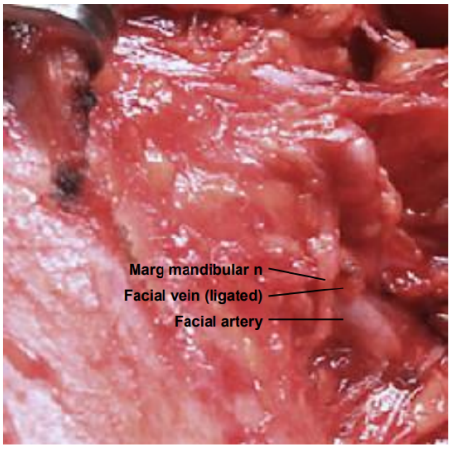


Figure 19: The marginal mandibular nerve is seen crossing the facial artery and vein (right neck)

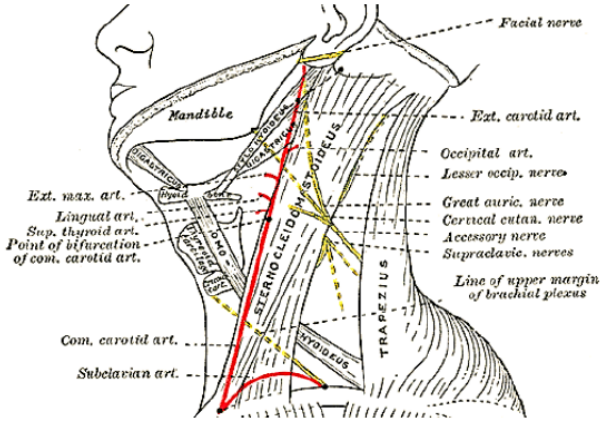


Figure 20: Course of spinal accessory nerve (Wikipedia)

Parotid biopsy: The principal concern is injury to the facial nerve. Other than in the hands of an experienced parotid surgeon, a mass should not simply be excised, but removed by formal partial parotidectomy with identification of the facial nerve (See Parotidectomy).

Nasal & Nasopharyngeal tumors

Tumors in the nasal cavity and nasopharynx can generally be biopsied in the office/outpatients department under local anesthesia ***with the exception of vascular tumors*** such as angiofibromas. Angiofibromas should be suspected in younger males and should not be biopsied.

Ambulatory endoscopic biopsy technique of the nasopharynx

- Patient inhales topical local anesthetic (4% lidocaine) and decongestant (1% phenylephrine) through the nose to ease the passage of instruments through the nose and because biopsy of normal nasopharyngeal mucosa causes discomfort
- Inspect both nasal cavities and the nasopharynx with a flexible or rigid endoscope (*Figure 21*)

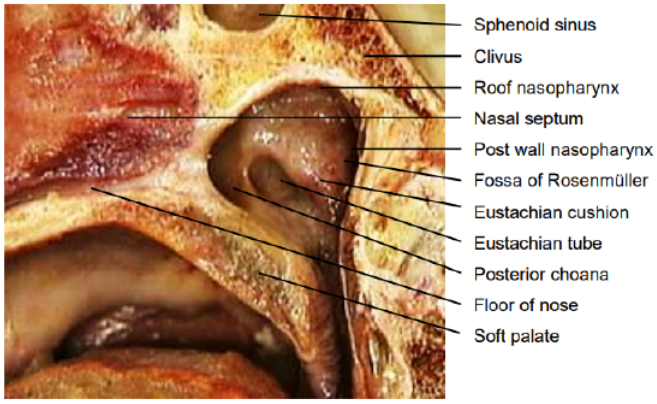


Figure 21: Sagittal view of nasopharynx

- Examine the mass and note the easiest transnasal approach for the biopsy forceps
- *Gently* pass a Blakesley nasal forceps blindly *along the floor of the nose* until it stops against the nasopharynx
- Tilt the patient's head back by about 30^{o} so that the Blakesley forceps does not drop out of the nose when released
- Pass a flexible or rigid endoscope up the contralateral (or ipsilateral) nasal cavity
- Visualize the tip of the biopsy forceps in the nasopharynx
- Biopsy the tumor under direct vision and withdrew the forceps and specimen
- Significant bleeding is unusual

Transoral biopsy technique of the nasopharynx under general anesthesia

- Intubate the patient orally
- Place the patient in a tonsillectomy position
- Insert a tonsillectomy (Boyle Davis) gag
- Pass a suction catheter through each nasal cavity, around the soft palate, and out the mouth and retract the palate anteriorly

- The nasopharynx can then be viewed using a warmed laryngoscopy mirror placed in the oropharynx either directly with a headlight or through an operating microscope (*Figure 22*)
- Biopsies can then be taken either transorally or transnasally under vision

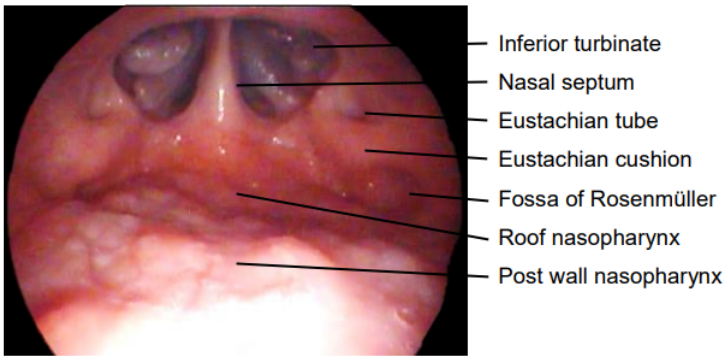


Figure 22: Transoral view of nasopharynx with laryngoscopy mirror

- Alternatively, one can displace the soft palate anteriorly with a Yankauer postnasal speculum (*Figure 23*) and take the biopsy through the speculum under direct vision

Pitfalls of nasopharyngeal biopsy

- Avoid transnasal biopsy without direct endoscopic visualization of the mass
- Bleeding diathesis
- Vascular masses
- Lesions near the carotid artery *i.e.* of the lateral wall behind fossa of Rosenmuller (*Figures 21, 22*)
- Ectatic internal carotid arteryInadequate local anesthesia
- Cystic lesion causing CSF leak



Figure 23: Yankauer postnasal speculum

References

1. Babshet M *et al*. Efficacy of oral brush cytology in the evaluation of the oral premalignant and malignant lesions. *J Cytol* 2011;28(4):165-72

Authors

Kathy Taylor MBChB, DCH (SA), MMed
(Anat Path)
Anatomical pathologist
Pathcare
Cape Town, South Africa
kathy.taylor@pathcare.co.za

Ellen Bolding MBChB, DCH (SA), MMed
(Anat Path)
Anatomical pathologist

Pathcare
Cape Town, South Africa
boldred@pathcare.co.za

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.3: Sentinel Lymph Node Biopsy (SLNB) Techniques for Cutaneous and Mucosal Malignancy of the Head and Neck

Cecelia E. Schmalbach, Carol R. Bradford

Sentinel lymph node biopsy (SLNB) is a minimally invasive procedure used to localize and sample the first echelon individual draining nodes of a malignant tumor and to identify occult (micro-metastatic) disease. In doing so, the technique provides accurate regional staging and identifies patients who may benefit from additional surgery and/or adjuvant therapy. Even though sentinel nodes are by definition, confined to the first echelon draining nodes, technological advances now permit multiple echelons to be detected.

The advantage of SLNB is that patients are saved the morbidity associated with traditional selective neck dissection (SND). In addition, the pathologist is provided a limited number of lymph nodes for comprehensive evaluation that includes microsectioning and cancer-specific immunohistochemical staining. This comprehensive evaluation is not feasible from time and cost standpoints for all nodes harvested in a traditional SND which can exceed twenty nodes.

The combination of auditory cues from the radioactive nucleotide identified with the handheld gamma probe and visual cues from the blue dye injection provides the highest success rate for SLN identification. For this reason, the combined modalities are considered standard of care in many countries. However, when nuclear medicine resources are unavailable, one can attempt to perform the SLNB technique as outlined below using intradermal blue dye alone and employing a wider surgical approach.

Indications

Indications for SLNB are cancer-type specific. The technique should be considered in the workup of patients with cutaneous melanoma[1], Merkel cell carcinoma[2], early oral cavity squamous cell carcinoma[3] and aggressive, recalcitrant cutaneous squamous cell carcinoma[4].

Cutaneous Melanoma

All patients presenting with clinically and radiographically localized Stage I and II disease and a tumor depth of invasion >1 mm should be offered SLNB. In addition, select patients with thinner melanomas measuring a depth of 0.75 - 1.0mm in the setting of poor prognostic features to include young age, tumor regression, ulceration, mitotic rate >1 feature/mm^2, angiolympathic invasion, and a positive deep margin can also be offered the procedure.

Merkel Cell Carcinoma (MCC)

MCC is a rare neuroendocrine cutaneous cancer common in the head and neck region of elderly patients. Due to the high rate of regional metastasis, patients with localized MCC can be offered SLNB.

Cutaneous Squamous Cell Carcinomas (cSCC)

It is also recognized that a subset of aggressive, recalcitrant cSCCs such as those seen in the immunosuppressed patient population, may benefit from regional restaging with SLNB.

Mucosal SCC

Oral cavity SLNB studies demonstrate a 90-100% detection rate for occult nodal metastasis when conducted in the setting of experienced institutions[5]. SLNB has been adopted for early stage mucosal SCC of the oral cavity. Patients with early stage T1 and T2 tumors can be considered for this staging modality if they are clinically and radiographically node negative. Other mucosal subsites within the head and neck region have not been included due to the challenge of anatomic access for preoperative injections described below.

Regardless of cancer type, all patients require a punch biopsy or narrow margin (1-3 mm) excisional biopsy of the primary tumor for diagnosis (*Figure 1*). Wide local excision (WLE) with larger 0.5-2 cm margins is discouraged because the surrounding tissue which contains the true draining lymphatics of the cancer is removed in the process and thereby can compromise sentinel lymph node (SLN) mapping and SLNB accuracy.



Figure 1: Melanoma of left temple following diagnostic punch biopsy with 1 cm margin marked for definitive wide local excision following SLNB. Note the surrounding solar changes

Preoperative work-up

SLNB is traditionally considered a staging modality. Therefore, thorough clinical physical examination of all draining nodal basins is required. If available, radiographic evaluation with contrasted CT scanning or ultrasound should be considered. Any patients with suspicious nodal disease clinically or radiographically should undergo fine needle aspiration. If negative, SLNB can be considered.

Collaborative Effort

SLNB is a collaborative team effort. The multidisciplinary oncology team should ideally include dermatopathology, radiology, dermatology, otolaryngology, surgical oncology, radiation oncology and medical oncology to review the final pathology and appropriate use of adjuvant therapy.

There is a significant surgical learning curve. The surgeon should ideally meet with the nuclear medicine team during the preoperative stage. At some institutions the surgeon is responsible for injection of the radioactive colloid. Data from the first melanoma *Multicenter Selective Lymphadenectomy Trial (MSLT-1)* demonstrated a 50-case learning curve to reduce the rate of false omission.[6]

The nuclear medicine team must be well versed in injection of the radioactive nucleotide, because if the material is spilled or splattered during the initial injection, the gamma probe will be rendered useless and the case will need to be rescheduled. For cutaneous injections, clear communication with the nuclear medicine team is paramount to ensure that the correct lesion is injected because most skin cancer patients have significant solar changes (*Figure 1*).

Equipment for SLNB

- Radioactive colloid
- Lymphoscintigraphy or Single-photon emission computed tomography/computed tomography (SPECT/CT)
- Gamma probe/monitor: a hand-held device containing a scintillation counter and is used intraoperatively following injection of the radioactive colloid to locate the sentinel lymph nodes by their radioactivity (*Figure 2*)
- Blue dye (methylene blue preferred)
- Local anesthesia
- Scalpel
- Small retractors
- Forceps
- Scissors
- Electric cautery/bipolar
- Facial nerve monitor for tumors draining to parotid nodal basin
- Nerve stimulator
- Needle driver and closing suture
- Pathology cups with formalin



Figure 2: Example of gamma probe (front) and monitor. The number on the screen depicts the radioactivity detected by the probe

SLNB Technique

- 2 to 4 hours prior to surgery patients undergo an intradermal or mucosal 4-quadrant injection of radioactive colloid tracer into the tissue immediately surrounding the malignant lesion.
- Delayed imaging provides the surgeon with a ‘road map’ of the anticipated number and location of sentinel nodes.
- Traditionally, 2-dimenstional planar imaging (lymphoscintigraphy) was used (*Figure 3*)

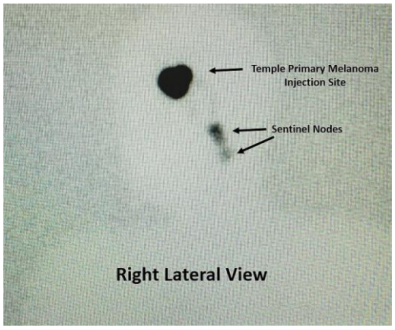
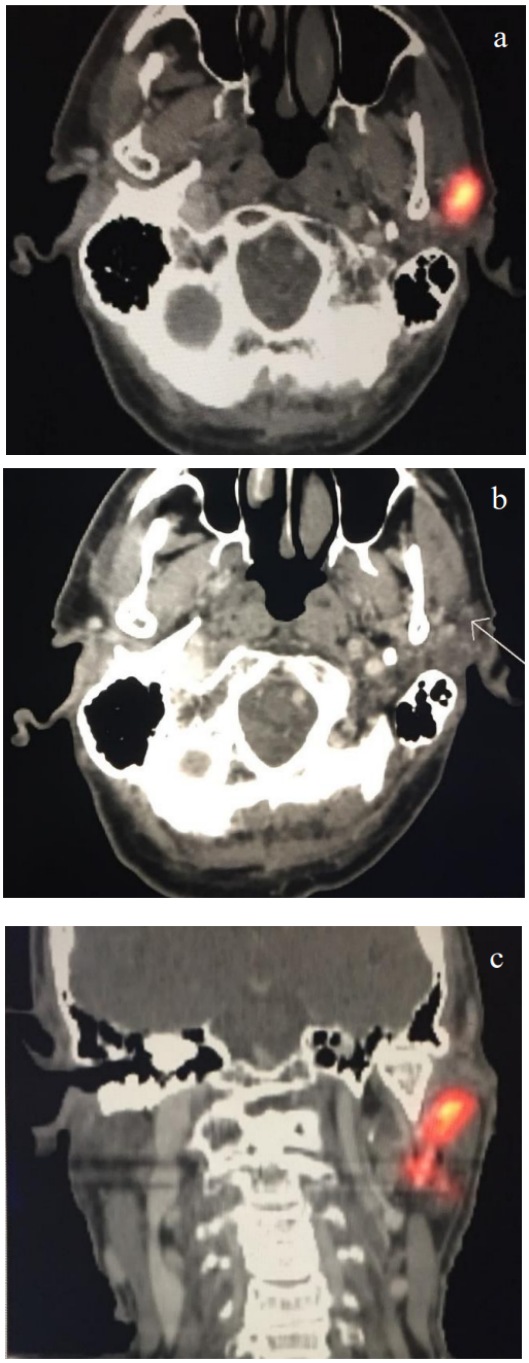


Figure 3: Traditional lymphoscintigraphy with 2-dimensional planar imaging. This left temple melanoma drained to the parotid basin and level IIA

- Recently, fused single-photon emission computed tomography/computed tomography (SPECT-CT) has emerged as a superior modality allowing for increased nodal harvest and improved melanoma disease free survival. The added anatomic information of SPECT-CT is especially helpful in the parotid region and Level IB (*Figures 4a-c*)
- The superior detail provided by SPECTCT allows for smaller incisions and often alters the surgical approach compared to traditional planar imaging. Regardless of imaging technique, the radioactive injection is especially helpful for midline lesions which have a propensity to drain bilaterally



Figures 4ab (axial) and 4c (coronal): Same temple melanoma imaged with SPECT/CT following radioactive colloid injection. Note the increased anatomic information with a clear sentinel node in the left parotid basin and the anatomic CT correlate (white arrow)

- Following radioactive injection, patients are brought to the operating room and placed under general anesthesia
- A second intradermal injection of blue dye (methylene blue is preferred) into the surrounding cutaneous or mucosal tissue is completed (*Figure 5*). Typically 1-2ml is adequate. Several minutes must pass prior to injection of local anesthesia with vasoconstrictors in order to allow for adequate dissemination throughout the immediate lymphatic system
- The patient is prepped and draped in the standard surgical fashion



Figure 5: Methylene blue dye injection into the subdermal region immediately surrounding the left temple melanoma lesion. Note the facial nerve monitor given drainage to the parotid nodal basin

- Due to the close proximity of head and neck primary tumours and surrounding draining nodal basins, WLE of the primary cancer with the standard recommended margins is typically performed first to avoid masking the surrounding nodal basins; this is known as radioactive “shine through” and renders the handheld gamma probe useless (*Figure 6*)



Figure 6: Resection of the primary temple melanoma to avoid radioactive shine-through. Note the circular demarcations identified with transcutaneous use of the gamma probe. These increased areas of radioactive correspond to the preoperative imaging depicted in Figures 3 and 4

- With cSCC, oral cavity SCC, and MCC, the primary site can be closed at the time of SLNB, ideally following pathologic evaluation of margins using frozen section. However, because frozen section carries a 10% false negative rate for melanoma, most surgeons will elect to delay definitive repair and closure of melanomas until negative permanent margins have been achieved
- With cSCC, oral cavity SCC, and MCC, the primary site can be closed at the time of SLNB, ideally following pathologic evaluation of margins using frozen section. However, because frozen section carries a 10% false negative rate for melanoma, most surgeons will elect to delay definitive repair and closure of melanomas until negative permanent margins have been achieved

- Following WLE, the handheld gamma probe is used to identify areas of increased radioactivity representing the location of the SLN
- Once identified, a small 1-3 cm incision is made directly over the area of activity
- Make the incision wide enough to allow for introduction of the entire circumference of the head of the gamma probe into the subcutaneous tissues (*Figure 7*)
- Using careful blunt dissection and minimal cautery, identify the SLN through the combined auditory cues of the radioactive nucleotide/gamma probe and visual clues from the blue dye (*Figures 8, 9*)
- Send each harvested SLN individually to the pathologist for permanent histologic evaluation and immunohistochemical staining if required



Figure 7: A 1-2 cm incision is made over the area of increased radioactivity. The incision should be large enough to introduce the entire head of the gamma probe



Figure 8: Sentinel node dyed by methylene blue

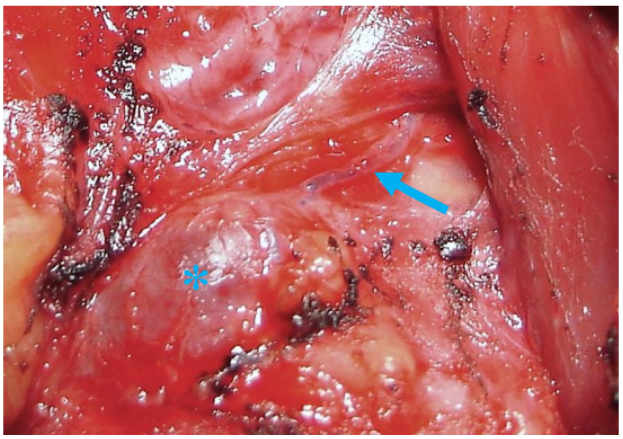


Figure 9: Methylene blue dye in lymphatic vessel (arrow) leading to sentinel node (*)

- Many sentinel lymph nodes are in ***close proximity to cranial nerves*** *e.g.* level IB lymph nodes are in close proximity to the marginal mandibular branch of the facial nerve; and nodes in level V are in close proximity to the accessory nerve. Detailed anatomical knowledge, use of careful blunt dissection, bipolar cautery and a nerve stimulator +/ monitor help to minimize the risk nerve injury
- In the parotid region, SLNB in experienced hands has proven to be safe and effective. Use of a facial nerve monitor is recommended (*Figure 5*)
- SLNB in the parotid region is done by placing the incision somewhere along the cosmetically favorable modified Blair incision as opposed to dissecting directly over the sentinel node as this provides for a more acceptable cosmetic result of a camouflaged scar which can easily be incorporated into the surgical approach in the event that a formal parotidectomy is required following a positive SLNB (*Figure 10*)



Figure 10: Preauricular approach to a parotid sentinel node. This small incision can easily be incorporated into a modified Blair incision should a formal parotidectomy be required following positive sentinel node biopsy

- The SLNB procedure is considered complete when the surgical background radioactivity drops to 10% of the hottest ex vivo SLN
- The SLNB harvested sites are irrigated
- Hemostasis is achieved and wounds sutured

Post-SLNB management

Positive SLNB

- Patients with a positive SLNB should ideally be returned to the operating room within 1-2 weeks for completion lymphadenectomy (CLND) of all atrisk nodal basins
- The surgeon should now have a clear understanding of the drainage pattern identified on radiographic imaging. However ultimately the nodal echelons to be dissected are based on the anatomic location of the primary tumor
  - Cutaneous cancers of the lower face and neck should include Levels 1-4
  - Because cancers higher on the cheek, scalp, temple, or forehead drain via parotid nodes *en route* to the cervical nodes, a parotidectomy with facial nerve preservation should be done
  - Cutaneous lesions posterior to an imaginary coronal plane through external auditory canal, *e.g.* the posterior neck or scalp, require a posterolateral neck dissection up to the posterior midline of the neck, as well as the suboccipital and retroauricular nodes
  - Patients with a positive oral cavity SLNB should have Levels 1-4 included

MCC warrants special consideration given that these elderly patients often have significant medical comorbidities. For MCC patients with a positive SLNB, adjuvant radiation to the at-risk draining nodal basins is a reasonable alternative[2].

Negative SLNB

Patients with a negative SLNB are traditionally followed closely with routine examinations of the primary tumor site and draining lymph nodes.

MCC is an exception due to the high rate of regional metastasis that exceeds that of melanoma. MCC patients with a negative SLNB can be considered for prophylactic irradiation to the nodal basins[2]. The SLN mapping serves as a helpful guide to radiation planning for midline lesions which may drain in multiple directions.

SLNB in cutaneous melanoma

The role of SLNB in cutaneous melanoma has recently shifted from a staging and diagnostic modality to a potentially therapeutic intervention[7]. Results of the long-awaited MSLT-II have now been published[8]. This international, multi-institutional prospective trial randomized patients with a positive SLNB to CLND (n=824) versus observation with ultrasound (n=931); 14% of enrolled patients had primary head & neck melanoma. At 3-years' follow-up the primary outcome measure of melanoma specific survival was identical between the immediate CLND and observation arms (86 +/- 1.3% versus 86 +/- 1.2%; p=0.42). For this reason, melanoma patients with a positive SLN are now being offered observation with serial ultrasound instead of CLND at some institutions. It should be noted that immediate CLND did demonstrate an improved overall disease-free survival (68 +/- 1.7% vs. 63 +/- 1.7%; p=0.05). Specifically, the disease control rate in the regional nodes was 92 +/- 1.0% for the CLND arm versus 77 +/1 1.5% in the observation arm (p<0.001). Ultimately, a candid conversation is required to allow patients to understand the risks and benefits associated with CLND versus observation so that they can make an informed decision.

SLNB Complications

- Normal risks of surgery that include that of general anesthesia, bleeding, scarring, loss of skin sensation, and infection
- Damage to cranial nerves
- Hematoma/seroma/sialocele
- Failure to identify the sentinel node
- Anaphylaxis related to methylene blue (rare)

SLNB in resource constrained settings

Lymphoscintigraphy and nuclear medicine facilities are unavailable in most of the developing world. Hence reliance must be placed on methylene blue dye for SLNB. Methylene blue is cheap, relatively safe, and promising results have been reported in SLN studies in breast cancer when used alone[9]. Methylene blue dye alone was also used for SLN identification in early oral cancers with good accuracy and sensitivity in a small study by Ramamurthy *et al*[9]. However, without lymphoscintigraphy one loses the benefit of doing targeted biopsies through small incisions, as all the nodes in the drainage area must be exposed to inspect them for blue discoloration. Another drawback is the inability to stage the contralateral N0 neck without contralateral wide surgical exposure. Consequently, the value of SLNB using only blue dye, as compared to an elective SND, is questionable.

References

1. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Melanoma (Cutaneous). V2.2018. www.nccn.org. March 8, 2018
2. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Merkel Cell Carcinoma. V1.2018. www.nccn.org. March 7, 2018
3. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Head and Neck Cancers. V1.2018. www.nccn.org. March 18, 2018
4. National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology: Squamous Cell Carcinoma. V2.2018. www.nccn.org. March 8, 2018
5. Civantos FJ, Stoeckli SJ, Takes RP, Woolgar JA, et al. What is the role of sentinel lymph node biopsy in the management of oral cancer in 2010? Eur Archive Otolaryngol. 2010;367: 839-44
6. Morton DL, Thompson JF, Essner Ret al. Validation of the accuracy of intraoperative lymphatic mapping and sentinel lymphadenectomy for earlystage melanoma: a multicenter trial. Multicenter Selective Lymphadenectomy Trial Group. Annals Surg 1999; 230:453-463; discussion 463-55
7. Schmalbach CE, Bradford CR. Completion lymph node dissection for sentinel node positive cutaneous head and neck melanoma. Laryngoscope Investig Otolaryngol. 2018 Feb 5;3(1): 43-Faris MB, Thomspon JF, Cochran AJ, et al. Completion dissection or observation for sentinel-node metastasis in melanoma. N Engl J Med 2017;376: 2211-22
8. Ramamurthy R, Kottayasamy Seenivasagam R, Shanmugam S, Palanivelu K. A Prospective Study on Sentinel Lymph Node Biopsy in Early Oral Cancers Using Methylene Blue Dye Alone. Indian Journal of Surgical Oncology. 2014;5(3):178-83

Authors

Cecelia E. Schmalbach MD, MS, FACS
Professor of Otolaryngology
Department of Otolaryngology-HNS
Indiana University School of Medicine
Roudebush VA Medical Center
Indianapolis, IN, USA
cschmalb@iu.edu

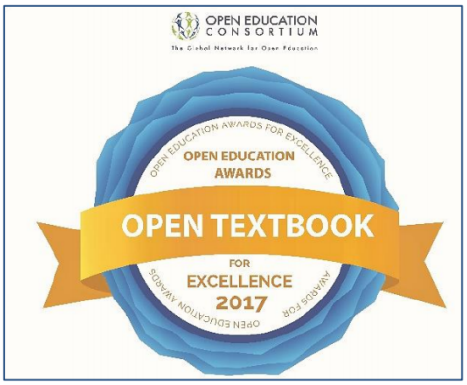
Carol R. Bradford MD, MS
Executive Vice Dean for Academic Affairs
University of Michigan Medical School
Ann Arbor, Michigan, USA
Cbradfor@med.umich.edu

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Mark De Groot

Adult bronchoscopy, rigid esophagoscopy and laryngoscopy for both diagnostic and therapeutic reasons are generally done under general anesthesia. Panendoscopy (all 3 procedures) is commonly performed to rule out synchronous primaries with squamous cell cancer of the upper aerodigestive tract. This chapter covers the techniques, pitfalls and safety measures of these 3 procedures.

Morbidity of rigid endoscopy

Sharing the airway with an anesthetist requires close communication and a good understanding between surgeon and anesthetist.

It is surprising how often rigid endoscopy causes minor extralaryngeal and extraesophageal trauma. It is ***extremely easy to tear or perforate*** the delicate tissues that line the upper aerodigestive tract; this can lead to deep cervical sepsis, mediastinitis and death. Consequently it is important that a surgeon exercises extreme caution and knows when to abandon e.g. a difficult esophagoscopy procedure.

Mucosal injury occurs in up to 75% of cases and commonly involves the lips or angles of the mouth[1]. To protect especially the lower lip one should advance the scope over the fingers of the non-dominant hand (*Figure 1*).

Dental trauma *e.g.* chipping or loosening of teeth occurs in up to 6.5% of laryngoscopies[1]. A patient with prominent upper incisors, caries, periodontal disease, dental fillings, implants, crowns, and gaps between the front teeth (*Figure 2*) is particularly at risk. Refer patients with dental disease for preoperative dental assessment. Always use a dental guard to protect the teeth (*Figure 3*). Ask a dentist to make a customized guard for patients with abnormal teeth (*Figure 4*) or fashion one in the operating room from thermoplastic sheeting (*Figures 5a, b*).

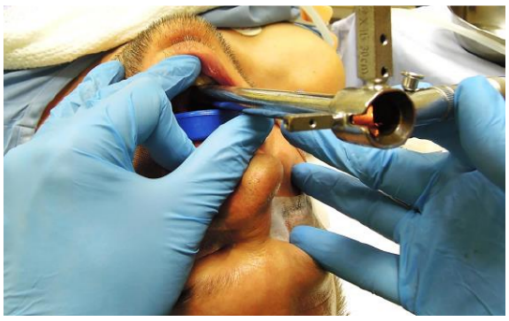


Figure 1: Protecting the lips with the fingers of the non-dominant hand



Figure 2: Endoscopes exert excessive lateral pressure on the teeth to either side of a gap between the front teeth



Figure 3: Dental guard can be purchased at sports shops (Note: Guards melt in the autoclave!)



Figure 4: Customized dental guard





Figures 5a, b: A dental guard can be made in the operating room with thermoplastic sheeting (used for radiotherapy molds or nasal splints) softened for 30 secs in hot water and molded around the upper teeth

Gum trauma: Avoid trauma in edentulous patients by covering the upper gum with a cotton swab.

Unstable cervical spine, rheumatoid or osteoarthritis or prior neck surgery or injury: Avoid spinal and neurological injury by requesting flexion-extension cervical X-rays, and obtain an expert opinion if there are any concerns.

Mucosal tears of the pharyngeal arches and tonsillolingual sulci: These occur not uncommonly in cases with difficult access due to forceful upward suspension of the laryngoscope.

Lingual, glossopharyngeal and hypoglossal nerve injury: It has been reported that minor alterations relating to taste occur in 18%, subjective swallowing complaints in 16% and partial tongue numbness in 13% of patients following suspension laryngoscopy due to traction injury of the lingual and glossopharyngeal nerves; average duration of neurological fallout is 11 (6- 34) days[2].

Klussmann reported 4 cases of hypoglossal injury in a series of 339 cases of suspension laryngoscopy[1]. It is more likely to occur with prolonged procedures *e.g.* transoral laser microsurgery for tumor resection.

Ischaemic injury of the tongue: With prolonged transoral microsurgery one should intermittently release the laryngeal suspension.

Operating room setup

A typical setup has the anesthetic machine placed either at the patient's feet or to the patient's side to allow unrestricted access to the head; this may require extensions for anesthetic tubing and intravenous lines (*Figure 6*).

Anesthesia

The principal anesthetic challenges are to intubate a difficult airway (tumor, trismus, stridor, bleeding *etc.*), to allow the surgeon to work in the confined space of the larynx and pharynx, and to permit access to the trachea and bronchial tree.



Figure 6: Typical operating room setup with anesthetist at the foot of the bed

It is crucial that the surgeon examines the patient's upper airway preoperatively to forewarn the anesthetist about anatomical distortions, and that there is agreement between surgeon and anesthetist about how to maintain the patient's airway.

The airway may be maintained in a number of ways

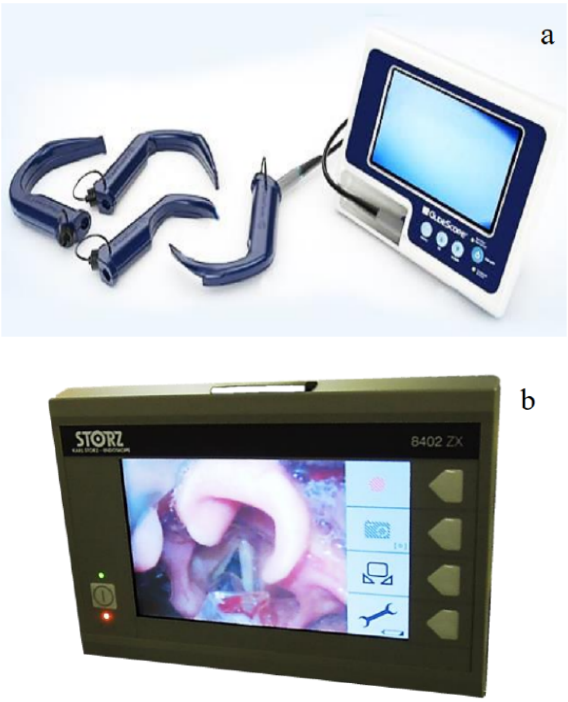
- Nasal or oral endotracheal intubation with a small (6 mm ID) tube (authors' preference)
- Intermittent jet ventilation
- Intermittent extubation with endoscopy during apnoeic intervals
- Open airway
  - Spontaneous breathing of anesthetic gases administered through the suction port of the laryngoscope (*Figure 9*)
  - Intravenous anesthesia
- Tracheostomy

The surgeon must remain at the patient's side from the time of induction until the patient has been extubated and is breathing freely. The laryngoscopy instruments, light source, light cable and suction must be close at hand in case the anesthetist is unable to intubate the larynx due to poor access or bleeding. Occasionally the surgeon may use the anesthetist's Macintosh laryngoscope to obtain a panoramic view to visualize a lesion, to remove foreign bodies from the pharynx or larynx, or to direct the bronchoscope into the larynx (*Figure 7*).



Figure 7: On the left is a Macintosh laryngoscope with a range of laryngoscope blades. On the right is a laryngoscope with a flexible tip adjustable through 70° to elevate the epiglottis and improve the view of the vocal cords; the lever alongside the handle controls the angulation of the tip

Fibreoptic laryngoscopes project the image of the larynx onto a small screen and may improve access with difficult intubations (*Figures 8a, b*).



Figures 8a, b: Fibreoptic laryngoscopes

Another option is to intubate a patient over a fiberoptic bronchoscope. This is done either with the patient awake and the upper airway anesthetised with topical agents, or in a patient whose airway can be maintained with mask ventilation. A flexible bronchoscope is advanced through the endotracheal tube; the tip of the bronchoscope is advanced into the larynx and trachea and the endotracheal tube is railroaded over the bronchoscope (*Figure 9*).



Figure 9: Bronchoscope protruding from the end of the endotracheal tube

When it is anticipated that an emergency tracheostomy may be required for a difficult intubation, then the surgeon should anesthetize skin, subcutaneous tissues and trachea with local anesthesia and vasoconstrictor, have the tracheostomy set ready, and ***scrub and gown before general anesthesia is commenced.***

Direct Laryngoscopy

Instrumentation

To view the entire larynx and pharynx requires a range of laryngoscopes (*Figure 10*). Employ the largest laryngoscope to maximise exposure. Larger laryngoscopes are used to access endolaryngeal, upper tracheal and hypopharyngeal lesions; smaller diameter laryngoscopes provide access for difficult exposures *e.g.* the anterior commissure of the larynx, subglottis and upper trachea (*Figure 10*). Light is delivered by a light source and is transmitted via a fibreoptic light cable to a light carrier that it attached to the scope (*Figures 11*, *12a*, *b*). The light carrier is inserted into a slot on the inside of the laryngoscope (*Figure 12a*) or clipped onto the laryngoscope (author's choice as it is more robust) (*Figure 12b*). To perform microsurgery the laryngoscope is suspended in a fixed position with a laryngoscope holder (*Figures 12*, *13*).

The chest piece of the holder is rested on a plastic/wooden board on the chest to distribute the pressure over the chest wall; alternatively a laryngoscope holder with an adjustable supporting plate which is attached to the side of the operating table can be used to avoid pressure being applied to the chest (*Figure 14*).

When employing CO_2 laser, laryngoscopes with matt finishes are used to avoid the laser beam being deflected off the metal (*Figure 15*).

Distending laryngoscopes are used to resect tumors in the hypopharynx, supraglottic larynx and base of tongue with CO_2 laser (*Figures 16*, *17*).

A *Weerda diverticuloscope* is used for endoscopic divertilostomy of Zenker's diverticula and to resect carcinoma of the hypopharynx with CO_2 laser that extends to the upper esophagus (*Figure 18*).



Figure 10: Range of laryngoscopes; note tube on side of 2nd scope to connect anesthetic gases to for spontaneous ventilation



Figure 11: Light source and cable





Figures 12 a, b: Fiberoptic light guide carriers



Figures 13: Laryngoscope holder

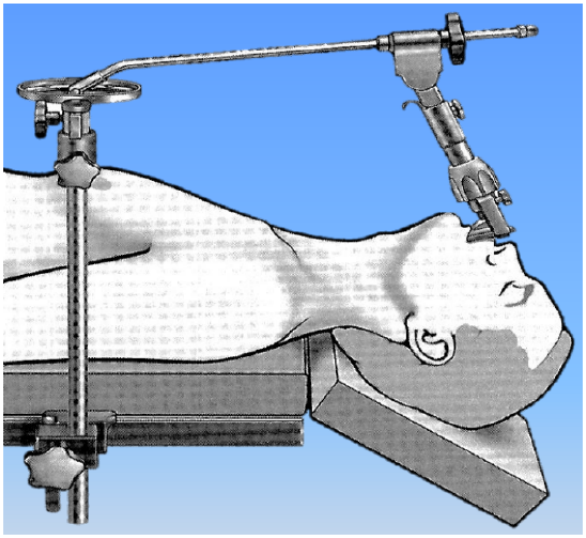


Figure 14: Laryngoscope suspended on a laryngoscope holder with adjustable supporting plate which is fixed to the side of the operating table (Karl Storz)



Figure 15: Matt-black laryngoscopes used for CO_2 laser surgery



Figure 16: Distending laryngopharyngoscope to resect lesions in the hypopharynx and supraglottic larynx

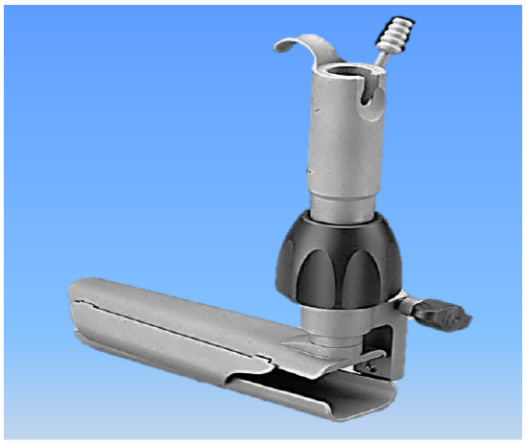


Figure 17: Distending oropharyngoscope used to resect tumors of the base of tongue, vallecula and lingual epiglottis with CO2 laser; note the side-flaps that keep the endotracheal tube and soft tissues out of the surgical field

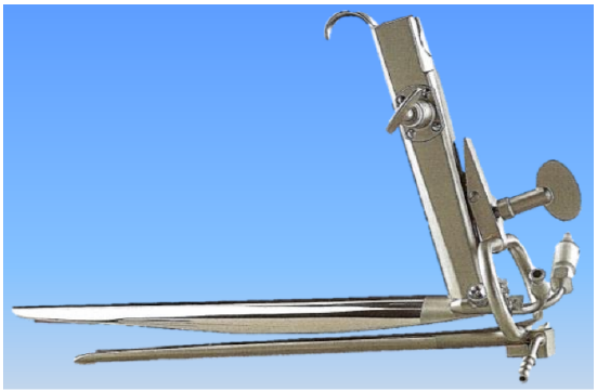


Figure 18: Weerda diverticuloscope

Laryngoscopy technique

- Place the patient in a supine position
- Ensure that the back of the head is well supported on the operating table (especially in old patients with limited neck extension)
- Elevate the head and flex the neck to allow better exposure for laryngoscopy and to reduce pressure of the laryngoscope on the oropharyngeal walls
- Sit down at the head of the table and adjust the table to a comfortable height
- Select the appropriate laryngoscope (largest that is likely to be suitable)
- Apply aqueous gel to the laryngoscope
- Cover the upper teeth with a dental guard (cotton swab if edentulous)
- Insert the laryngoscope, protecting the lips from injury with the fingers of the non-dominant hand (*Figure 19*)



Figure 19: Protecting the lips and teeth with fingers of non-dominant hand

- Keep in the midline while advancing the laryngoscope and sequentially identify base of tongue, vallecula, epiglottis, posterior pharyngeal wall and arytenoids
- Identify the endotracheal tube; keeping the tube in view posteriorly, advance the tip of the scope until the vocal cords come into view
- ***Initially inspect the upper aerodigestive tract not involved by tumor to avoid traumatizing tumor and obscuring the field with blood***
- Fully inspect the larynx by moving the tip of the scope and moving the larynx with the non-dominant hand placed externally on the neck (*Figure 20*)

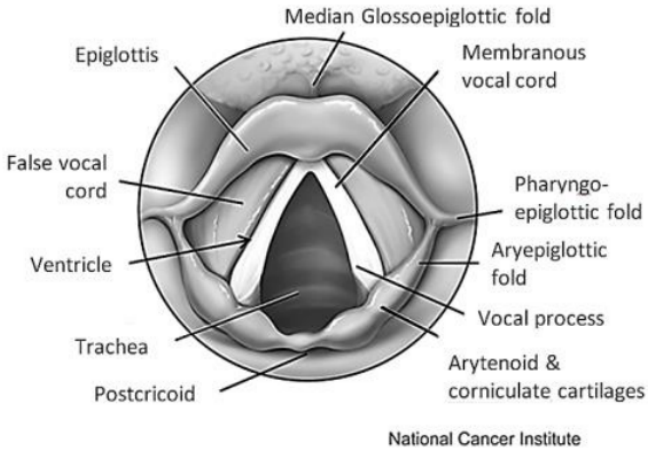


Figure 20: View of larynx

- Inspect the posterior part of the larynx by directing the tip of the scope behind the endotracheal tube
- The subglottis can be inspected by passing a Hopkin's rod through the laryngoscope
- Take special care not to overlook pathology on the laryngeal surface of the epiglottis (can be difficult to see) by pressing down on the larynx with the non-dominant hand while slowly retracting the laryngoscope

- Inspect the pyriform fossae and postcricoid regions of the hypopharynx
- Inspect the valleculae and base of tongue
- ***Proceed to esophagoscopy and bronchoscopy before taking tissue biopsies of laryngeal or hypopharyngeal pathology to avoid the field becoming obscured with blood***
- Biopy a suspected tumor with long Blakesley-like forceps (*Figure 21*); using microinstruments may yield specimens that are too small and cause a pathologist to understage an invasive cancer
- Bleeding from mucosal trauma or biopsies settles spontaneously; only very rarely is hemostasis with adrenaline-soaked gauze or with cautery required



Figure 21: Blakesley forceps

Rigid esophagoscopy

The esophagus may be examined by flexible (transoral or transnasal) or rigid esophagoscopy. In worldwide practice, most diagnostic examinations are generally performed by flexible endoscopy (usually a flexible gastroscope) where equipment is available. It offers the advantage of performance under topical anesthetic with intravenous sedation thereby avoiding general anesthesia. It gives superior inspection and allows complete endoscopy of the full length of the esophagus including the esophagogastric junction. In addition, it avoids many of the inherent hazards involved in rigid esophagoscopy. Many therapeutic procedures such as esophageal dilation and stent placement involve the addition of radiological imaging. Conversely, certain therapeutic procedures such as foreign body removal may be better achieved with a rigid esophagoscope. Optimally, the operator should be familiar and proficient with both modalities.

In otolaryngology, most pathology is located in the cervical esophagus, where the use of short rigid scopes is adequate and expedient when combined with other procedures. For the mid- and distal esophagus, flexible endoscopy holds a distinct advantage.

Endoscopic anatomy

The esophagus is a 25 cm long muscular tube lined by a delicate, non-keratinized stratified squamous epithelium that traverses the neck, superior and posterior mediastinum. In the neck it is located immediately behind the trachea and anterior to the prevertebral fascia, and the 6^{th} - 8^{th} cervical vertebrae; laterally are the contents of the carotid sheaths and the thyroid lobes. In the superior mediastinum it veers slightly to the left before returning to the midline (*Figure 22*). It passes behind the aortic arch and to the right of the descending aorta until it reaches the inferior mediastinum where it passes anterior and slightly to the left of the aorta before traversing the diaphragm (*Figure 22*). Anteriorly it abuts trachea, right pulmonary artery, left main bronchus, pericardium, left atrium, and diaphragm. Posteriorly it is related to the vertebrae, the thoracic part of the aorta, and diaphragm.

Three points of external compression are visible at esophagoscopy *i.e.* aortic arch, left main bronchus and diaphragm (*Figure 22*). The left main bronchus crosses the esophagus anteriorly and indents it below the aortic arch (*Figure 23*).

Pathology seen at rigid esophagoscopy is recorded as its distance from the upper incisors (*Figure 22*, *Table 1*). The distance markings are etched onto the outside of the scopes (*Figures 22*, *24*).

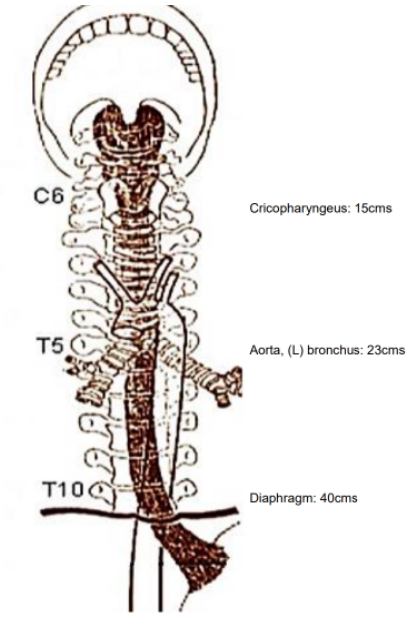


Figure 22: Anatomical relations of esophagus and distances from upper incisors

(adapted from http://training.seer.cancer.gov /ugi/anatomy/esophagus.html)

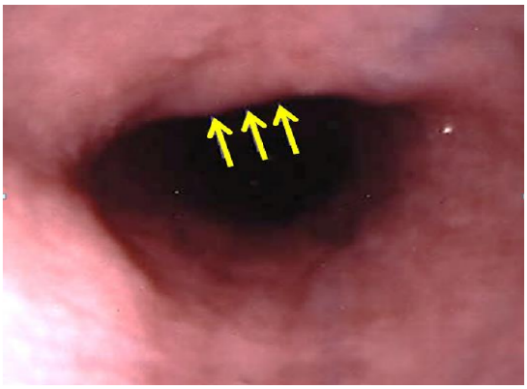


Figure 23: Indentation by left main bronchus in anterior wall of esophagus

	Distance from incisors	Extends distally from
Cervical	Cricopharyngeus 15-18cms	6th cervical vertebra / Lower edge of cricoid
Upper thoracic	18-23cms	Thoracic inlet
Mid-thoracic	23-32cms	Tracheal bifurcation
Lower thoracic	32-40cms	Gastroesophageal junction

Table 1: Measurements of the esophagus

Instrumentation

Basic rigid esophagoscope design dates back over a century. In its crudest form it is a hollow tube with a light on the end. Many variants are in common use attesting to their almost indestructible nature. Evolution incorporates fiberoptic wave guides and prismatic lenses (*Figure 24*).



Figure 24: Selection of various types of esophagoscopes in use

More modern designs have smooth beveled edges and prismatic wave guides to maximize the size of the working channels (*Figures 25*, *26*). Because otolaryngologists generally deal with pathology in the cervical and upper/mid-thoracic esophagus, a 25 cm rigid scope is usually adequate (*Figures 25*, *26*).



Figure 25: Rigid esophagoscope (25 cm)

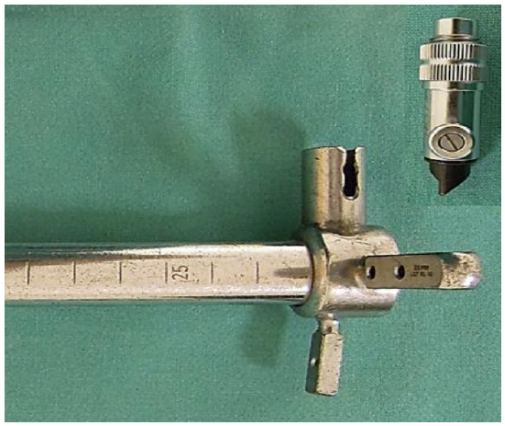


Figure 26: Light carrier is inserted into a slot on the side of the esophagoscope

Only use a longer scope for pathology located in the distal esophagus. Use a scope with a beveled, smooth, rounded end. Both adult and pediatric sized scopes are available; select a larger size if possible as it transmits more light, one can see better, and it is less likely to perforate the esophageal wall.

Indications

Some of the indications listed below may be addressed by flexible esophagoscopy. The limitations of flexible endoscopy are examining the postcricoid region and upper esophageal sphincter, as these areas cannot be insufflated with air. Indications include to:

- Exclude 2nd primaries in patients with squamous cell carcinomas of the upper aerodigestive tract
- Remove foreign bodies
- Biopsy, dilate or stent tumors
- Determine the distal extent of hypopharyngeal and esophageal carcinoma
- Dilate strictures
- Exclude traumatic perforations with penetrating injury of the neck
- Inject esophageal varices

Preoperative evaluation

A good history may alert a surgeon to the possibility of a pharyngeal pouch which is easily perforated as the esophagoscope naturally enters a pouch. Chest X-ray is done to exclude a deviated esophagus and an aortic aneurysm. In patients with dysphagia, a contrast esophagogram serves as a roadmap for the endoscopist.

Esophagoscopy technique

Perforating the esophageal wall with a rigid esophagoscope is a life-threatening event. Hence rigid esophagoscopy should be done with extreme caution and with a delicate touch; it also requires clinical judgement as to when to abandon the procedure or call for expert assistance.

- Place the patient in a supine position
- Ensure that the back of the head is well supported on the operation table (especially in old patients with limited spinal extension)
- The proximal esophagus follows the lordosis of the cervical and thoracic spine; bring the cervical spine into a straight line with the thoracic spine by elevating the head (*Figures 27a, b*)
- Prominent osteophytes may impair advancement of the scope and make traumatizing the mucosa more likely (*Figure 28*)
- Sit down at the head of the table and adjust the table to a comfortable height
- Cover the upper teeth with dental guard (cotton swab if edentulous)
- Select the appropriate esophagoscope (largest that is likely to be suitable)
- Apply aqueous gel to the esophagoscope
- Insert the esophagoscope, protecting the lips from injury with the fingers of the non-dominant hand (*Figure 29*)

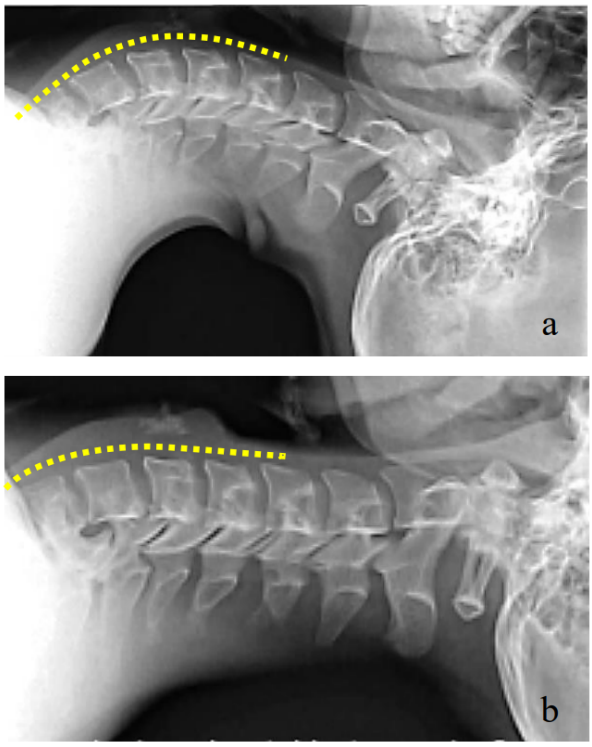


Figure 27: (a) Extension increases lordosis and curvature of esophagus; (b) flexion reduces lordosis and curvature of the esophagus making esophagoscopy easier

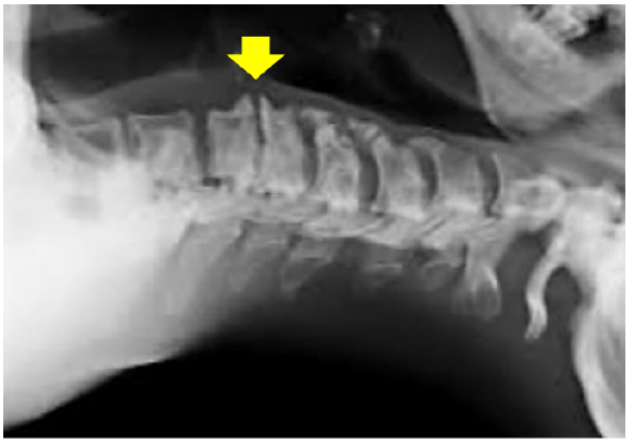


Figure 28: C6/C7 osteophytes

- Use the thumb of the non-dominant hand as a fulcrum for the esophagoscope to protect the teeth (*Figure 29*)
- Keeping in the midline, advance the esophagoscope and identify the posterior pharyngeal wall; advance the scope along the posterior pharyngeal wall while remaining in the midline
- Alternatively, with the neck extended, pass the scope via the right corner of the mouth and floor of mouth, and follow the lateral wall of the right pyriform fossa to its full depth. Readjusting the scope to the midline engages the larynx and elevating it anteriorly usually exposes the cricopharyngeus



Figure 29: Use the thumb of the nondominant hand as a fulcrum for the scope

- ***The most difficult step for an inexperienced endoscopist is to advance the scope through the upper esophageal sphincter (cricopharyngeus)***
- The hypopharynx tapers down to the esophagus like a funnel with the larynx suspended anteriorly
- The scope comes to a dead-stop and the pharyngeal lumen disappears as one reaches the cricopharyngeal sphincter
- Ensure that the bevel of the scope is pointing upwards
- Elevate the tip of the scope against the posterior surface of the cricoid with the non-dominant thumb
- Look for the esophageal lumen to appear while applying steady, firm pressure against the contracted cricopharyngeus
- Slowly advance the tip of the scope while always keeping the lumen in view
- ***Always consider the possibility of a pharyngeal pouch (Zenker's diverticulum) which is easily perforated*** (*Figures 30, 31*)
  - A pharyngeal pouch is located immediately behind the upper esophageal sphincter
  - Finding the esophageal lumen may be very challenging
  - ***A scope will always automatically enter a pouch***
- Advance the scope down the cervical esophagus, ***always keeping the lumen in view while advancing the scope*** (*Figure 32*)
- Use a long metal sucker to clear esophageal contents

- A tightly inflated endotracheal tube cuff may compress the esophagus; deflating it may make passage of the esophagoscope easier
- Once the esophagoscope has been passed all the way, carefully inspect the esophagus for pathology and for mucosal trauma while slowly retracting the scope
- Biopsy lesions with long biopsy forceps

Complications of esophagoscopy

Mucosal tears/lacerations

Minor tears and lacerations can be ignored; if in doubt about the clinical significance, institute antibiotics and nasogastric tube feeding and monitor the patient carefully.

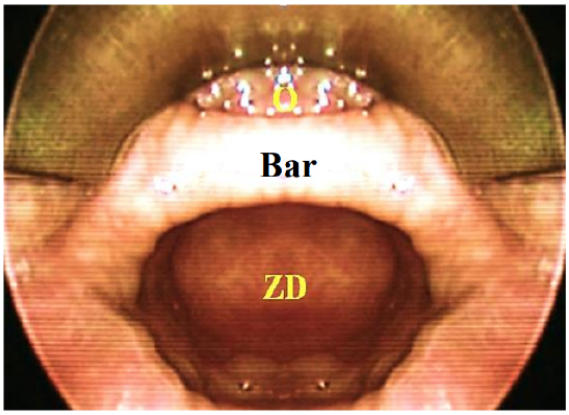


Figure 30: Cricopharyngeal bar contains cricopharyngeus muscle and separates esophagus (O) from Zenker's diverticulum (ZD)

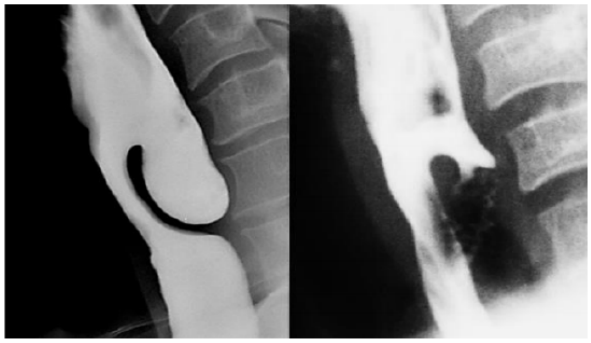


Figure 31: Pharyngeal pouch and perforated pouch

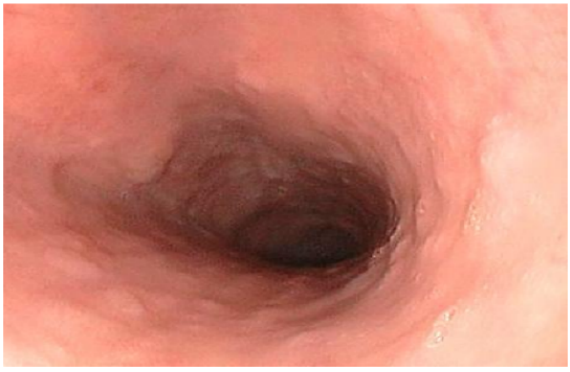


Figure 32: Normal mid-esophagus

Esophageal perforation

This is a ***surgical emergency*** and has significant morbidity and mortality, especially if not promptly recognized and managed. Leakage of esophageal and gastric content into the mediastinum rapidly leads to mediastinitis, sepsis and multiorgan failure.

Clinical pointers include pain in the chest, back and neck, odynophagia, dysphagia, tachycardia, tachypnoea, pyrexia, crepitus and signs of sepsis.

Management includes:

- Nil per mouth
- Broad spectrum antibiotics
- Hemodynamic stabilization and intensive monitoring
- Confirm the diagnosis
  - Chest X-ray
  - Gastrograffin swallow
- Decision-making about the need for surgical intervention
- Nasogastric tube or parenteral feeding
- Conservative/non-operative management may be considered with highly selected perforations that have been promptly diagnosed, mainly of the cervical esophagus, in stable patients with no evidence of systemic sepsis and where there is minimal extraesophageal contamination
- Surgical options include
  - Simple external drainage to create a controlled fistula, allowing it to heal spontaneously (only if there is no distal obstruction)
  - Primary repair and external drainage of extra-esophageal contamination
  - Primary repair with bolstering of the repair with a pedicled soft tissue flap *e.g.* pectoralis major or infrahyoid strap muscle
  - Esophageal diversion and drainage
  - Esophageal stenting
  - Esophagectomy

Drainage +/- repair of a cervical esophageal perforation

- Palpate the cricoid as it marks the proximal end of the cervical esophagus
- Make a transverse skin crease incision at the level of the cricoid, usually on the left side; or an incision along the anterior border of sternocleidomastoid in the lower neck
- Elevate subplatysmal flaps
- Incise the fascia along the anterior margin of the sternocleidomastoid
- Reflect the sternocleidomastoid laterally to expose the carotid sheath
- Identify and divide the omohyoid muscle
- Retract the thyroid gland and larynx to the contralateral side
- Identify and divide the middle thyroid vein
- Palpate the trachea; the esophagus is immediately behind the trachea
- Carefully dissect bluntly behind the esophagus along the retropharyngeal space
- Take care not to injure the recurrent laryngeal nerve which is located in the tracheoesophageal groove
- Drain the sepsis by dissecting bluntly with a finger behind the esophagus along the prevertebral fascia into the superior mediastinum
- Debride devitalized tissue
- Identify and repair the perforation usually in two layers as a complete mucosal repair is essential. A second muscularis layer is approximated over this. Use absorbable suture material for the repair.
- Use a sternocleidomastoid or infrahyoid strap muscle flap to bolster the repair and drain the area
- If the perforation is not visible or suitable for repair, then drain the perforation externally +/- a muscle flap over the defect

Removing esophageal foreign bodies

Foreign bodies often impact at sites of anatomical (upper esophageal sphincter, aortic arch, diaphragmatic hiatus) or pathologic narrowing (diverticulae, webs, strictures, achalasia, and tumors) of the esophagus. A foreign body may be apparent on plain x-ray or CT scan, although not all are radio opaque. Endoscopy is often required on clinical grounds even in the setting of negative radiographs. Contrast studies *e.g.* barium swallow, are avoided as they may impair endoscopic visualization. Esophagoscopy should be done as soon as possible and not be delayed beyond 24 hours as delay can cause strictures or perforations. Before passing the scope, the operator should ensure that a suitable range of grasping forceps is available (*Figure 33*).

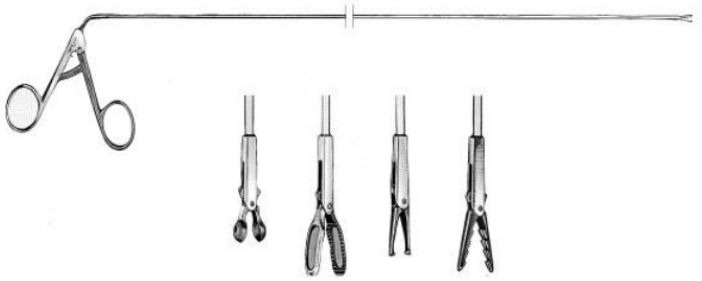


Figure 33: Foreign body grasping forceps

Large pieces should be grasped and impacted into the end of the scope, removing the scope and impacted material simultaneously. Alternately soft material can be removed piecemeal through the lumen of the scope. Avoid the temptation to try and push the obstructing material down the lumen as this may complicate removal or cause perforation. Always repass the scope beyond the site of the obstruction once the foreign body has been removed to rule out traumatic injury and predisposing causes such as tumors, strictures *etc.*

Foreign bodies can also be removed with flexible endoscopy through the use of snares and other purpose built grasping forceps. Pushing a foreign body down the lumen may be appropriate in some instances if the scope can be passed beyond the obstruction first to establish the feasibility of such a maneuver. Flexible endoscopy may be very useful if anatomical restrictions preclude passage of a rigid scope.

Dilating esophageal strictures

Esophageal dilatation has a higher risk of esophageal perforation than routine esophagoscopy and should be performed by an experienced endoscopist. It is indicated for symptomatic benign (anastomotic, sclerotherapy, radiation, corrosive) and malignant strictures. The etiology should first be determined by contrast esophagography and endoscopy. Barium swallow provides a roadmap of the stricture for the endoscopist and is especially valuable with long, tight, and complex strictures. Bougienage may cause bleeding; therefore, anticoagulants should be stopped prior to the procedure.

Two dilatation methods are used: push dilators/bougies and balloon dilators (*Figure 34*). Push dilators may be polyvinyl bougies, weighted (mercury/tungsten filled rubber bougies), or wire guided. Polyvinyl dilators comprise a range of polyvinyl rods (5-20 mm diameter) with rounded and tapered tips. Some have a radiopaque band at the widest point of the dilator to aid radiological localization. These are typically passed over a guide wire that has been passed beyond the obstruction (preferably into the stomach) under x-ray imaging.

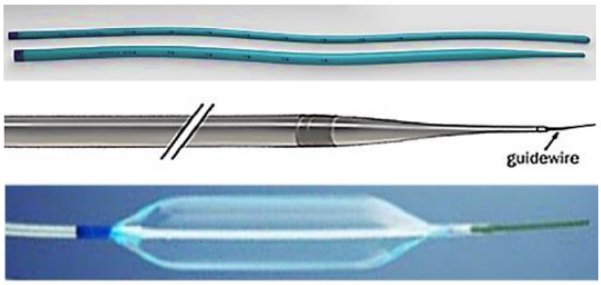


Figure 34: Polyvinyl bougie, wire guided bougie and balloon dilator

The amount of dilation required is determined by the nature of the stricture and the amount of resistance encountered. Rather serially dilate a stricture at multiple sittings than aggressively dilate it with the associated risk of causing a perforation.

Balloon dilators are passed through a scope or are wire guided. Balloon sizes range between 6-40 mm. They are however single use (unless reused for the same patient) and expensive.

Rigid Bronchoscopy

Anatomy of tracheobronchial tree

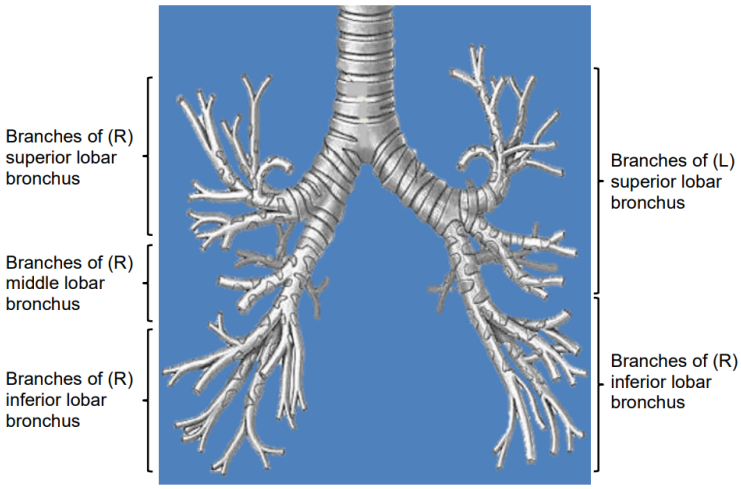


Figure 35: Anatomy of bronchial tree

YouTube video of tracheobronchial anatomy

Flexible bronchoscopy is the preferred way to visualize the bronchial tree as it is less invasive, provides better access to the peripheral airways and to the upper lobes, and can be done under local anesthesia. Flexible bronchoscopes differ from flexible gastroscopes such that they are smaller in size, only flex and extend in one plane requiring they be rotated to provide complete visualization. The working channel is often smaller leading to easy occlusion if used where there is bleeding or pus. Biopsy forceps are also small and may lead to superficial sampling unless numerous biopsies are taken. Newer models have built in CCD camera chips and can be even more slim with larger working channels and permit on-screen visualization as well as image capturing. Slim-line portable scopes (*Figure 36*) allow transnasal upper airway examination either at the bedside or in the examination room. They are optimal for quick examination but are of limited therapeutic use.



Figure 36: Slim-line portable scope

Flexible endoscopy equipment is expensive to purchase and repair. The scopes are delicate and one either needs a large budget or very careful restricted use to make it a cost-effective approach.

Flexible bronchoscopy is preferred for:

Full examination to the distal tracheabronchial tree

- Assistance in difficult intubation
- Assistance in percutaneous tracheostomy
- Assessment of dynamic airway obstruction with spontaneous ventilation

Rigid bronchoscopy is particularly benefitcial for:

- Acute airway obstruction due to intraluminal pathology; it is a quick procedure while maintaining airway patency and ventilation
- Pathology requiring debulking, dilation or stenting

- Removing foreign bodies
- Screening for 2nd primaries as part of a panendoscopy procedure
- Massive hemoptysis
- Large endobronchial biopsies
- Ablative surgery *i.e.* mechanical, laser, electrocautery, cryotherapy
- Stenting the airway for obstruction, tracheomalacia, tracheoesophageal fistulae
- Balloon tracheobronchoplasty

Rigid bronchoscopy equipment

There are numerous manufactures of high-grade rigid bronchoscopes. Most are variations of a simple tubular line with a fiberoptic or transmitted prismatic light source. The selection of the type of scope may be purpose driven whether it be for diagnostic or therapeutic intent. The basic equipment includes >2 sizes of bronchoscopes, suctioning cannulae, and a variety of biopsy forceps and telescopes.

A rigid bronchoscope is a stainless-steel tube through which a rigid telescope can be passed (*Figure 37*). The distal end is beveled to lift the epiglottis and to pass between the vocal cords; it can also be used to core out tumor or to twist the scope through a tight stenosis (*Figure 38*). Slits in the distal wall of the bronchoscope allow ventilation of the contralateral lung while one of the main bronchi is intubated (*Figures 37, 38*). The proximal end of the bronchoscope has a central opening and ports to accommodate a range of accessories, a side-port for ventilation, and a port that permits passage of instruments, catheters and guidewires down the scope (*Figure 39*). Bronchoscopes come in different lengths and diameters; the most commonly used sizes in adult practice have a 6-9 mm external diameter and are 40 cm in length.

A light source is connected by a fiberoptic cable to the light carrier (*Figure 39 A*) or the light is transmitted down a fiberoptic bundle in the sidewall of the scope. A Hopkins rod rigid telescope is passed through the central opening of the bronchoscope (*Figure 40*).



Figure 37: Rigid bronchoscope

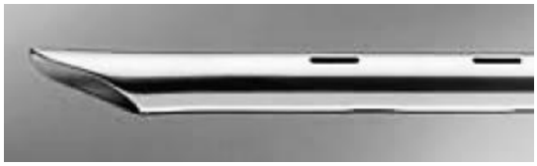


Figure 38: Beveled tip of bronchoscope; note vents in the side of the bronchoscope

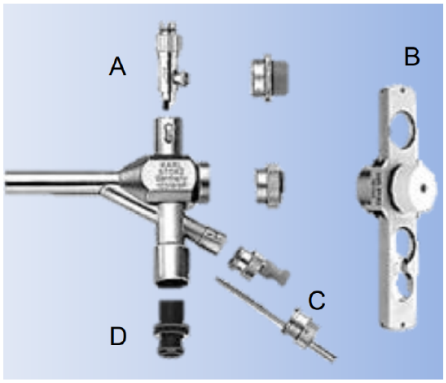


Figure 39: (A) Light carrier connects to light cable; (B) bridge adaptor for endoscope or glass eyepiece or rubber telescope adaptor (for transfer between endoscope and optical forceps); (C) instrument guide for flexible suction catheter or jet ventilation cannula; (D) adaptor for ventilator



Figure 40: Hopkins rod

Use a larger (>6.5 mm) bronchoscope if possible as the optics are better with a larger (5.5 mm) telescope; when using a <6.0 mm bronchoscope one must use a 2.8 mm telescope. To view all the bronchial subdivisions, angled telescopes or a flexible bronchoscope is passed down the rigid bronchoscope. Either the endoscopist looks directly through the lens, or a camera is attached, and the image is projected onto a monitor. Accessories include a variety of forceps, scissors, suction catheters, cautery, injection needles and stents (*Figure 41*).

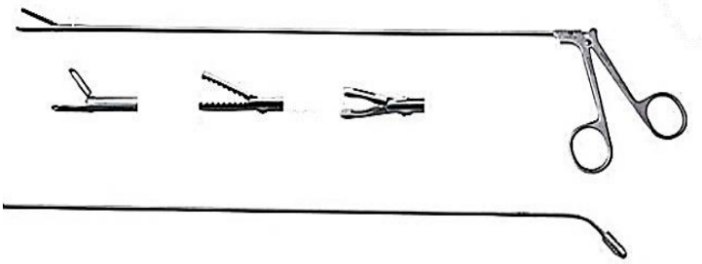


Figure 41: Grasping forceps and long metal sucker/cannula

Anesthesia

- The airway is shared by the anesthetist and the endoscopist; therefore, close communication and cooperation are essential
- Supine position
- General anesthesia
- Induction is via inhaled sevoflurane (usually in critical airway stenosis) or by intravenous agents
- Muscle relaxants are commonly used during insertion of the bronchoscope
- Ventilation
  - Spontaneous-assisted ventilation
  - Jet ventilation overcomes increased airway resistance associated with using a telescope, but carries an increased risk of barotrauma if expiration is obstructed

Finding the larynx and vocal cords

- Select the largest suitable bronchoscope
- Place the patient's head on a pillow and extend the neck (sniffing or intubating position) (*Figure 29*)
- Introduce the bronchoscope in the midline in a vertical plane to the floor with the long end of the bevel facing anteriorly
- Avoid trauma to the upper teeth and lower lip by sliding the scope over the thumb or use a dental guard; avoid using the upper teeth as a fulcrum to lever the bronchoscope (*Figure 29*)
- Advance the scope in the midline and identify the epiglottis
- Lift the epiglottis anteriorly with the tip of the bronchoscope
- Identify the posterior laryngeal inlet *i.e.* the arytenoids and posterior vocal cords; this can be difficult due to the restricted view through the narrow lumen of the bronchoscope.
- Tips to simply finding the laryngeal inlet include:
  - Insert a Hopkins rod into the scope *ab initio*
  - Elevate the epiglottis with the anesthetist's laryngoscope (*Figure 7*)
  - First insert and suspend an operating laryngoscope (*Figure 14*) and pass the bronchoscope through it
  - Follow the endotracheal tube into the larynx

Passing between the vocal cords

- Remove the pillow and extend the patient's head
- Sit down on a mobile stool and adjust the operating table to a comfortable height
- Rotate the bronchoscope clockwise through 90^{o} keeping the longer edge of bevel to the right side

- Advance the scope with the tip of the bevel directed between the vocal cords and slide the shorter edge of bevel against the left vocal cord
- Avoid traumatizing the right cord with the tip of the bevel

Passing along the trachea and entering the main bronchi

- Rotate the scope back through 90°
- Advanced it into the lower trachea
- Identify the carina (Figure 42)



Figure 42: Carina and main bronchi

To enter either bronchial system, rotate the patient's head towards the contralateral shoulder and advance the scope. Segmental airways are difficult to examine unless an angled telescope or flexible bronchoscope is passed through the rigid bronchoscope.

Left bronchial tree

- Move the bronchoscope into the right corner of the mouth
- Turn the patient's head to the right side
- Advance the scope down the left main bronchus
- The lingular and lower lobe bronchi are readily seen
- Pass a telescope or flexible scope through the bronchoscope to visualize segmental and subsegmental bronchi
- An aortic arch aneurysm is a contraindication to passing a rigid bronchoscope down the left main bronchus

Right bronchial tree

- Transfer the bronchoscope to the left corner of the mouth
- Turn the patient's head to the left
- Advance the scope down the right main bronchus
- The right main bronchus, the bronchus intermedius and lower lobe are relatively easily seen
- To examine the anteriorly placed orifice to the middle lobe, the patient's head may need to be further extended
- Pass a telescope or flexible scope via the bronchoscope to visualize the segmental and subsegmental bronchi

Exiting the airway

Carefully re-examine the airway while gently removing the bronchoscope

References

1. Klussmann JP, Knoedgen R, Wittekindt C, Damm M, Eckel HE. Complications of suspension laryngoscopy. Ann Otol Rhinol Laryngol. 2002 Nov;111(11):972-6
2. Rosen CA, Andrade Filho PA, Scheffel L, Buckmire R. Oropharyngeal complications of suspension laryngoscopy: a prospective study. Laryngoscope. 2005 115(9):1681-4
3. Daniel P Raymond DP, Jones C, MD Surgical management of esophageal perforation: http://www.uptodate.com/contents/surgical -management-of-esophageal-perforation

Editor & Author

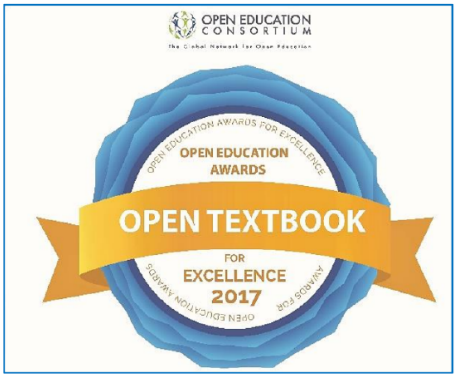
Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Mark de Groot MD, FRCSC
Thoracic Surgeon
Vincent Palotti Hospital
Pinelands, Cape Town South Africa
kmdegroot@icloud.com

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1.5: Parotidectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

The facial nerve is central to parotid surgery for both surgeon and patient. Knowledge of the surgical anatomy and the landmarks to find the facial nerve are the key to preserving facial nerve function.

Surgical Anatomy

Parotid Gland

The parotid glands are situated anteriorly and inferiorly to the ear. They overlie the vertical mandibular rami and masseter muscles, behind which they extend into the retromandibular sulci. The glands extend superiorly from the zygomatic arches and inferiorly to below the angles of the mandible where they overlie the posterior bellies of the digastric and the sternocleidomastoid muscles. The parotid duct exits the gland anteriorly, crosses the masseter muscle, curves medially around its anterior margin, pierces the buccinator muscle, and enters the mouth opposite the 2nd upper molar tooth.

Superficial Muscular Aponeurotic System and Parotid Fascia

The ***Superficial Muscular Aponeurotic System (SMAS)*** is a fibrous network that invests the facial muscles and connects them with the dermis. It is continuous with the platysma inferiorly; superiorly it attaches to the zygomatic arch. In the lower face, the facial nerve courses deep to the SMAS and the platysma. The parotid glands are contained within two layers of ***parotid fascia***, which extend from the zygoma above and continue as cervical fascia below.

Structures that traverse, or are found within the parotid gland

- ***Facial nerve and branches*** (*Figure 1*)
- ***External carotid artery***: It gives off the ***transverse facial artery*** inside the gland before dividing into the internal maxillary and the superficial temporal arteries (*Figure 2*).

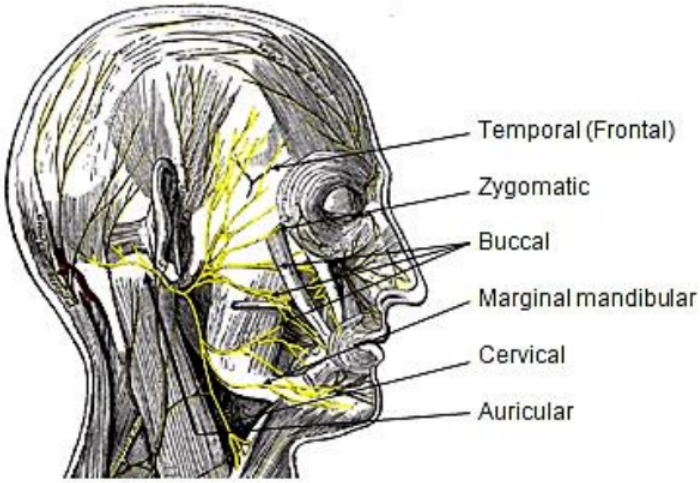


Figure 1: Main branches of facial nerve

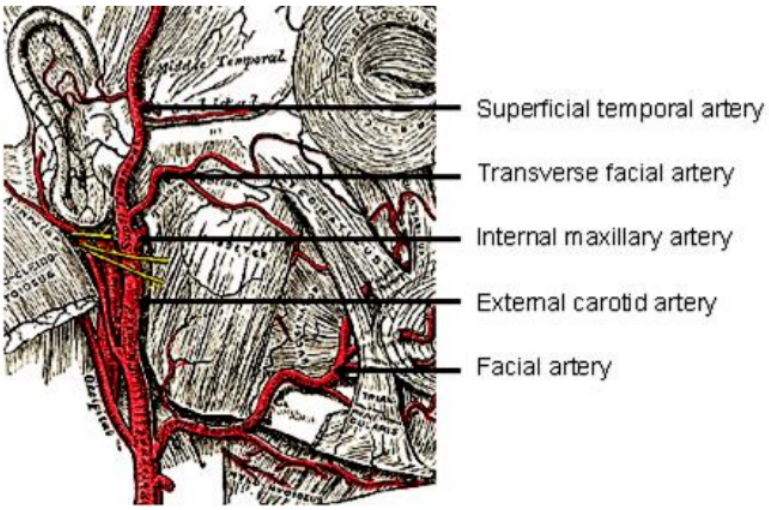


Figure 2: Branches of the external carotid artery

- ***Veins:*** The ***maxillary*** and ***superficial temporal veins*** merge into the retromandibular vein within the parotid gland but are not responsible for draining the gland. Venous drainage of the parotid itself is to tributaries of external and internal jugular veins.
- ***Lymphatics:*** A number of lymph nodes are present within the gland, principally in the superficial lobe, and drain to Level 2 of the neck.

Relevant surgical relations

Posterior: Cartilage of external auditory meatus; tympanic bone, mastoid process, sternocleidomastoid muscle

Deep: Styloid process, stylomandibular tunnel, parapharyngeal space, posterior belly of digastric, sternocleidomastoid muscle

Superior: Zygomatic arch, temporomandibular joint

Facial nerve

The facial nerve exits the stylomastoid foramen and enters the parotid gland. Although the branching pattern does vary from patient to patient, the trunk generally divides at the *pes anserinus* into upper and lower divisions that subsequently branch into temporal (frontal), zygomatic, buccal, marginal mandibular and cervical branches that innervate the muscles of facial expression. Small branches to the posterior belly of digastric, stylohyoid, and auricular muscles also arise from the trunk (*Figure 3*).

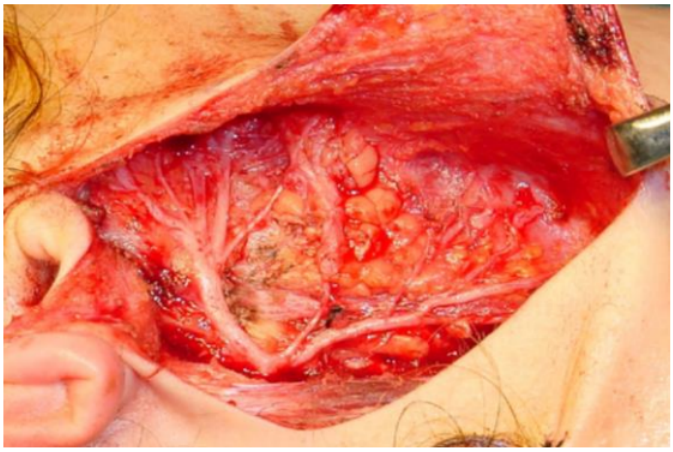


Figure 3: The facial nerve trunk dividing into superior and inferior divisions at the pes anserinus

The nerve traverses the parotid gland, with about 2/3 of the gland substance being superficial to the nerve. As parotid dissection generally is directed along the facial nerve, the nerve in effect divides the parotid from a surgical perspective into superficial and deep lobes, although there is no natural soft tissue dissection plane that separates the two lobes.

The midfacial nerve branches have multiple cross-innervations; however, the frontal and marginal mandibular branches do not have cross-innervations and injury to these branches is followed by paralysis of the forehead and depressors of the lower lip (*Figure 4*).

Therefore, unlike the temporal and marginal mandibular nerves, selected midfacial branches may be sacrificed without loss of facial function.

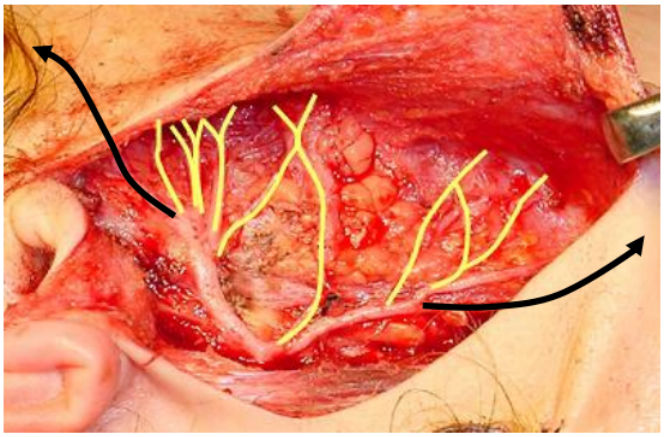


Figure 4: Midfacial branches (yellow) interconnect whereas temporal and marginal mandibular (black) do not

Locating the Facial Nerve

It is useful to know preoperatively whether a parotid tumor is situated deep or superficial to the facial nerve. This facilitates surgical planning and facilitates preoperative consent relating to the likelihood of a temporary postoperative facial nerve weakness

Surface markings

Facial nerve trunk: The trunk exits the skull at the stylomastoid foramen. This is situated at the deep end of the tympanomastoid suture line, which can be located at the junction between the mastoid process and the tympanic ring of the external ear canal

Temporal (frontal) branch of facial nerve: The nerve crosses the zygomatic arch; it runs within the SMAS and lies superficial to the deep temporalis fascia. It courses more or less along a line drawn between the attachment of the lobule of the ear to a point 1.5 cm above the lateral aspect of the eyebrow. To avoid injury to the temporal branch, dissect either in a subcutaneous plane or deep to the SMAS (*Figure 1*).

Radiology

Radiological investigation is not routinely required with parotid tumors. It is recommended for surgical planning with tumors that are large, fixed, and are associated with facial nerve involvement, trismus, and parapharyngeal space involvement. MRI is a valuable investigation with recurrence of pleomorphic adenoma as it is often multifocal.

The extratemporal facial nerve is not visible with ultrasound, CT or MRI. The retromandibular vein is however intimately associated with the facial nerve. The vein courses through the parotid gland immediately deep to the facial nerve, but rarely runs immediately superficial to the nerve (*Figures 5 & 6*). Reliance is therefore placed on the juxtaposition of the retromandibular vein and the nerve to predict whether a tumor is likely to be deep or superficial to the nerve.

The retromandibular vein can be clearly visualized on a CT with contrast, or an MRI (*Figures 7, 8*).

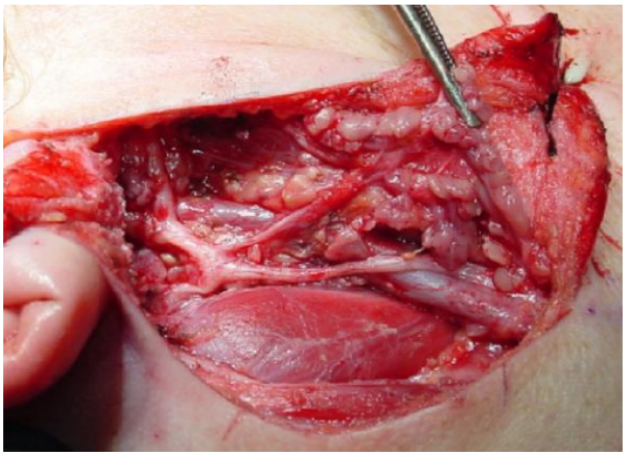


Figure 5: Facial nerve running superficial to retromandibular vein

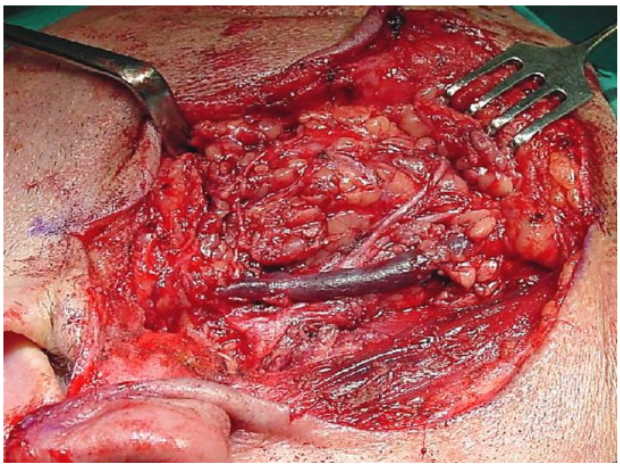


Figure 6: Facial nerve running deep, but close, to retromandibular vein

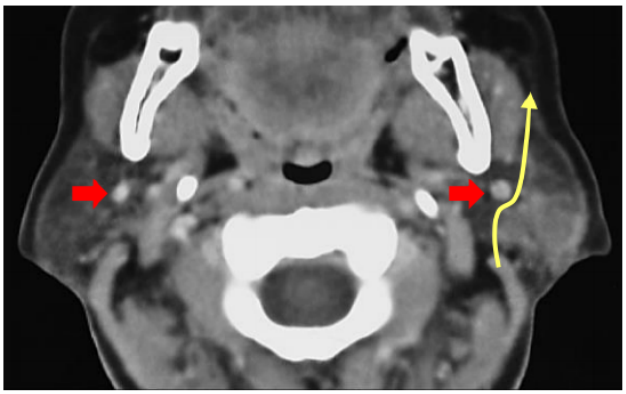


Figure 7: Red arrows indicate retromandibular veins, and yellow arrow the course of the facial nerve in a superficial lobe pleomorphic adenoma

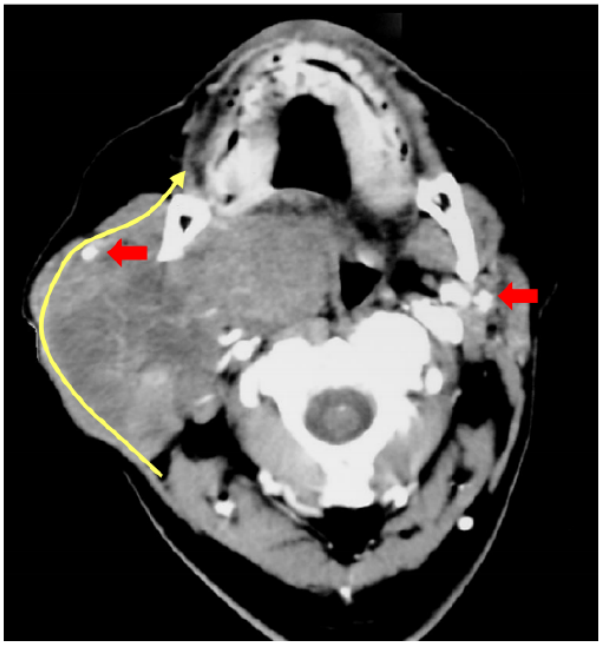


Figure 8: Red arrows indicate retromandibular veins, and yellow arrow the course of the facial nerve in a deep lobe pleomorphic adenoma

Radiology may also alert the surgeon to extension of a deep lobe parotid tumor through the stylomandibular tunnel into the parapharyngeal space (Figure 9).

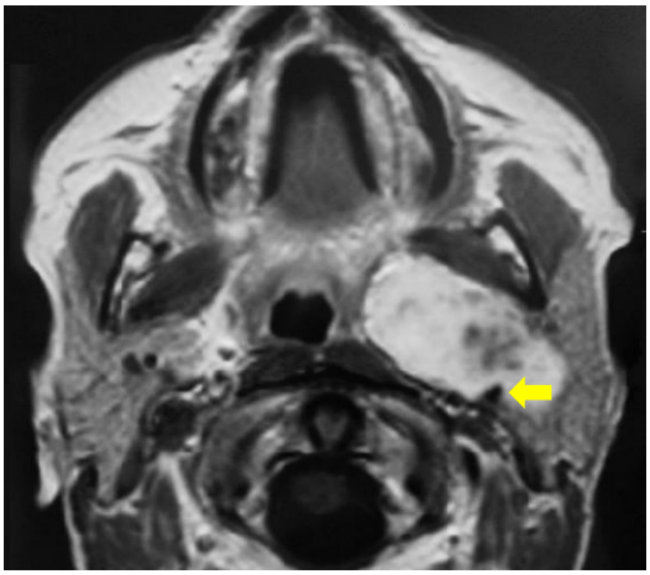


Figure 9: Tumor passing through stylomandibular tunnel to parapharyngeal space (Arrow indicates styloid process)

Intraoperative location of facial nerve

The facial nerve is usually explored by prograde dissection *i.e.* by locating the nerve trunk where it exits from the stylomastoid foramen, and then dissecting anteriorly along the trunk, the *pes anserinus* and the divisions and nerve branches. Occasionally this is not possible *e.g.* with a large fixed mass centered at the stylomastoid foramen. In such cases a retrograde dissection may be required after locating the temporal branch where it crosses the zygoma, the buccal branches which lie parallel to the parotid duct (*Figure 10*), or the marginal mandibular branch where is crosses the facial artery and vein just below or at the inferior margin of the mandible, where it is just deep to platysma (*Figure 11*).

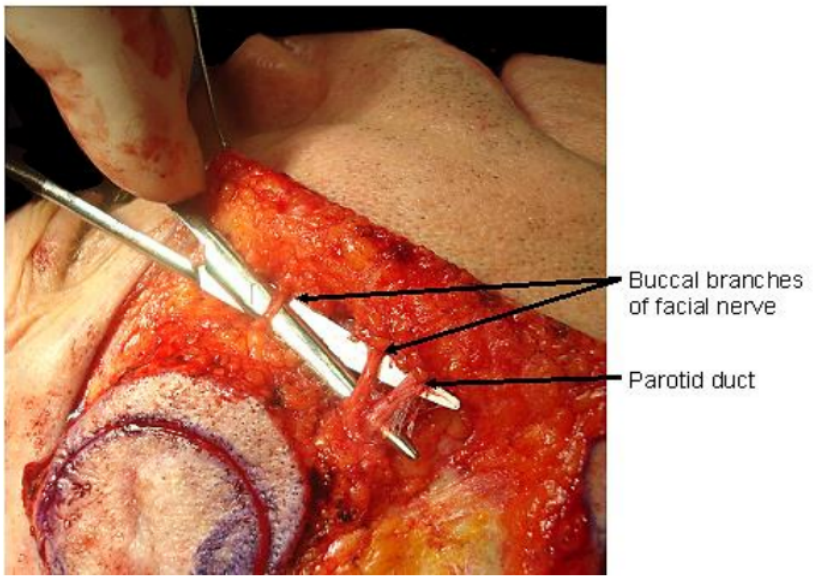


Figure 10: Buccal branches adjacent to the parotid duct

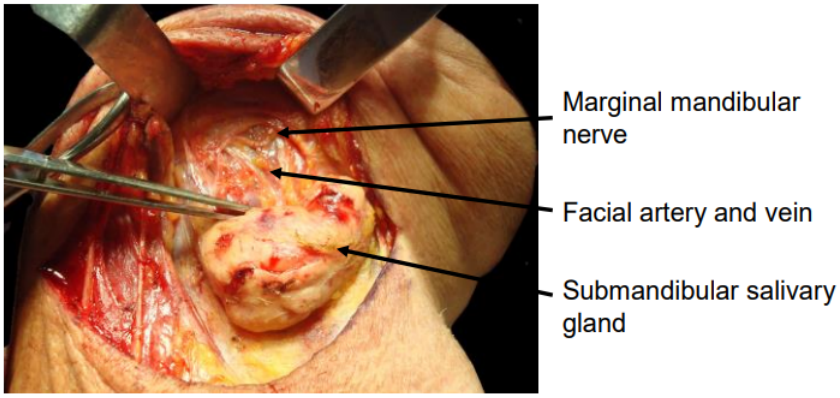


Figure 11: Marginal mandibular nerve crossing facial artery and vein

The surgical landmarks for finding the facial nerve trunk at the stylomastoid foramen are remarkably constant, and all the landmarks should be identified at every operation to facilitate finding the nerve (*Figures 12, 13*)

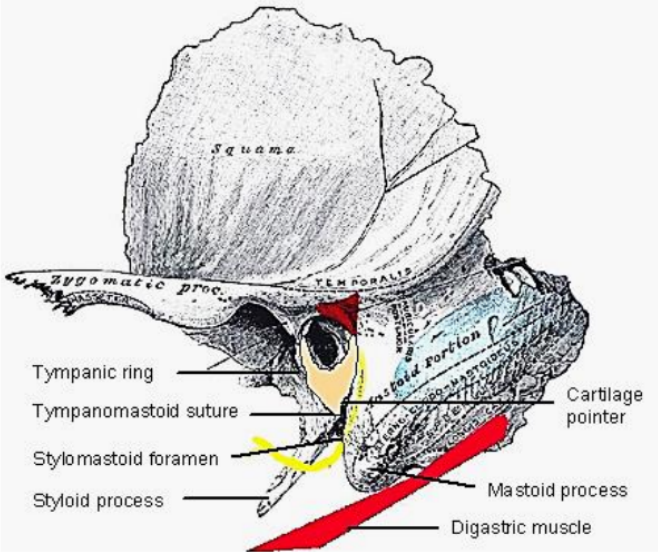


Figure 12: Schematic surgical landmarks for the facial nerve trunk

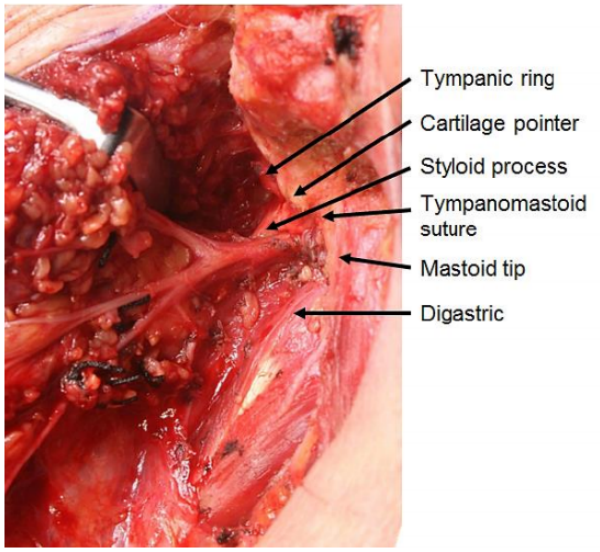


Figure 13: Intraoperative surgical landmarks for the facial nerve trunk

Posterior belly of digastric muscle: The nerve runs at the same depth below the skin surface, and bisects the angle between the muscle and the styloid process

Cartilage pointer: This refers to the medial-most, pointed end of the cartilage of the external auditory meatus. The nerve exits the foramen approximately 1 cm deep and 1 cm inferior to this point

Tympanic ring, mastoid process and tympanomastoid suture line: The tympanomastoid suture line is the most precise landmark for the facial nerve as it leads medially, directly to the stylomastoid foramen

Styloid process: The facial nerve crosses the styloid process. Palpating the styloid process is therefore a useful means to determine the depth and position of the facial nerve

Branch of occipital artery: A small branch of the occipital artery is commonly encountered just lateral to the facial nerve close to the stylomastoid foramen. Brisk arterial bleeding should therefore alert the surgeon to the proximity of the facial nerve; it is easily controlled with bipolar cautery.

Electrical stimulation and monitoring

These need not be routinely employed but may be useful adjuncts to a sound knowledge of facial nerve anatomy in selected cases such as revision surgery and with large tumors. It may however not record facial stimulation with faulty equipment, and nerve fatigue following excessive mechanical or electrical stimulation, and use of a muscle relaxant.

- ***Electrophysiological monitoring:*** An EMG monitor may be used to detect contraction of the facial muscles when the facial nerve is mechanically or electrically stimulated.
- ***Facial nerve electrical stimulation:*** Battery operated, or more sophisticated nerve stimulators may be employed intraoperatively to assist with finding the nerve, or to differentiate between nerve and blood vessels. Stimulating the nerve produces visible contraction of the facial musculature or an EMG signal.

Types of Parotidectomy

- ***Partial parotidectomy:*** Resection of parotid pathology with a margin of normal parotid tissue. This is the standard operation for benign pathology and favourable malignancies
- ***Superficial parotidectomy:*** Resection of the entire superficial lobe of parotid (*Figure 3*) and is generally used for metastases to parotid lymph nodes e.g. from skin cancers, and for high grade malignant parotid tumors.
- ***Total parotidectomy:*** This involves resection of the entire parotid gland, usually with preservation of the facial nerve
- ***Extracapsular parotidectomy:*** The tumor is carefully dissected along its capsule without identifying the facial nerve, and relying on facial nerve monitoring to avoid injury to branches of the nerve

Preoperative consent

- **Scar:** Usually very good healing except over the mastoid where some scarring may occur

- **Anesthesia in the greater auricular distribution:** Skin of inferior part of auricle, and overlying the angle of the mandible
- **Facial nerve weakness:** Temporary weakness common (<50%); permanent weakness rare
- **Facial contour:** loss of parotid tissue leads to a more defined angle of mandible, and deepening of retromandibular sulcus
- **Prominence of auricle:** This is probably due to loss of innervation of the postauricular muscles and preauricular scarring
- **Frey's syndrome (gustatory sweating):** Although common, it only very rarely is bad enough to require treatment with Botox injection

Anesthesia

- General anesthesia
- Short-acting muscle relaxation for intubation only, so that facial nerve may be stimulated and/or monitored
- No perioperative antibiotics unless specifically indicated
- Hyperextend the head, and turn to opposite side
- Infiltrate with vasoconstrictor along planned skin incision, to reduce thermal injury to skin from electrocautery to skin vessels
- Keep corner of eye and mouth exposed to be able to see facial movement when facial nerve mechanically or electrically stimulated (Figure 14)

Partial/Superficial Parotidectomy

- Lazy-S incision: This is placed in preauricular and cervical skin creases (*Figure 14*)



Figure 14: "Lazy-S" incision; Corners of eye and mouth exposed

- Raise superficial cervicofacial flap to the anterior border of parotid mass or of the parotid gland in the plane between the SMAS and the parotid fascia with a scalpel or diathermy. The assistant must monitor the face for muscle contraction to avoid facial nerve injury. Insert a traction suture in the subcutaneous tissue of the ear lobule as well as securing the anterior based skin flap to the drapes (*Figure 15*)

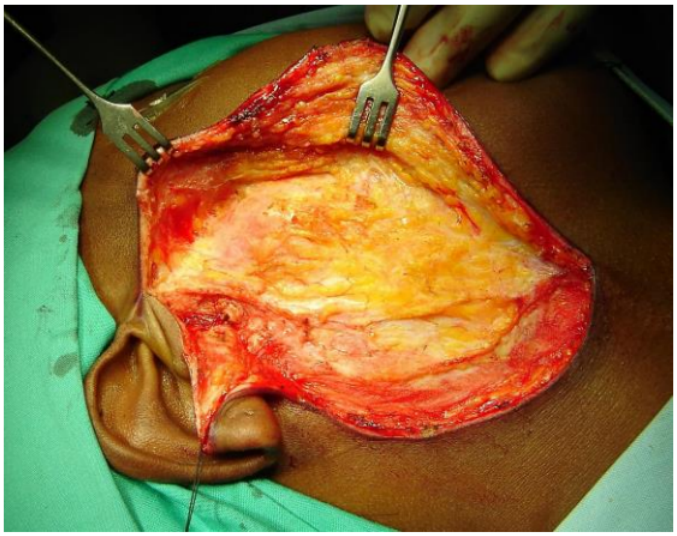


Figure 15: Exposure of parotid mass or gland

- Skeletonize the anterior border of sternocleidomastoid muscle (*Figure 16*)
- Divide the external jugular vein
- Divide the greater auricular nerve as it crosses sternocleidomastoid muscle, posterior to the external jugular vein. An attempt can be made to preserve the posterior branch of the nerve to retain sensation of the skin of the auricle (*Figure 17*)

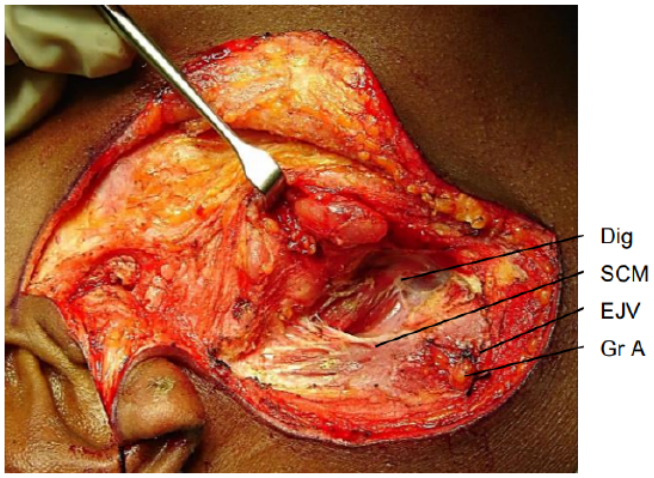


Figure 16: Expose the sternomastoid and posterior belly of digastric muscle

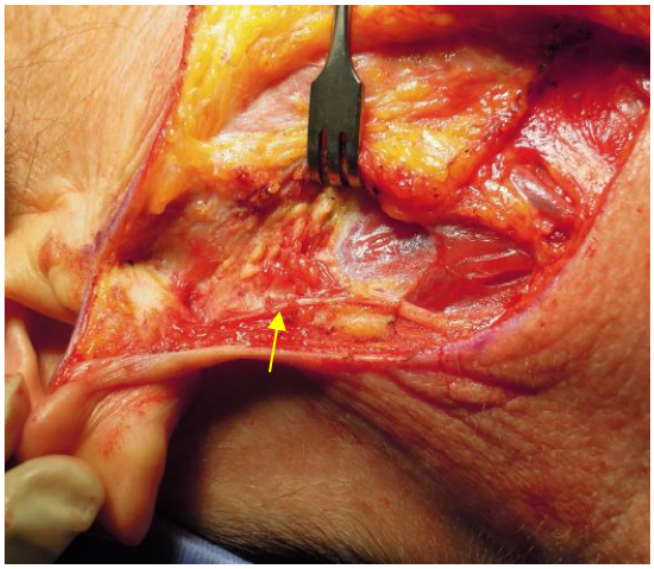


Figure 17: Posterior branch of greater auricular nerve (arrow)

- Identify and skeletonize the posterior belly of the digastric muscle. Do not dissect cephalad of the muscle as one may injure the facial nerve (*Figure 16*)
- Skeletonize the cartilage of the external auditory canal up to the tragal pointer. This can be done quite quickly with electrocautery dissection as the facial nerve exits the stylomastoid foramen 1 cm deep to the tragal pointer
- Skeletonize the mastoid tip to the depth of the tragal pointer
- Identify all the following landmarks for the facial nerve (*Figures 12, 13 & 18*)
  - Tragal pointer (nerve 1 cm deep and inferior)
  - Tympanic ring
  - Anterior aspect of mastoid bone
  - Tympanomastoid suture line (leads directly to stylomastoid foramen)
  - Posterior belly of digastric muscle (Facial nerve at same depth, just above muscle)
  - Palpate the styloid process (facial nerve in angle between styloid and digastric, and crosses styloid more anteriorly)
- Locate the facial nerve trunk by blunt dissection with a fine hemostat (*Figures 18, 19*)

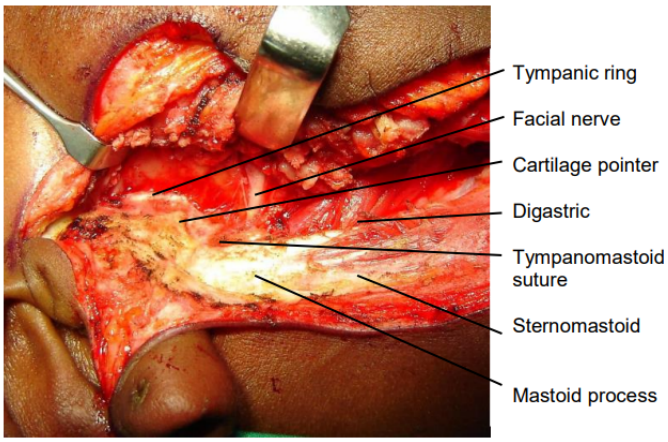


Figure 18: Identify facial nerve landmarks

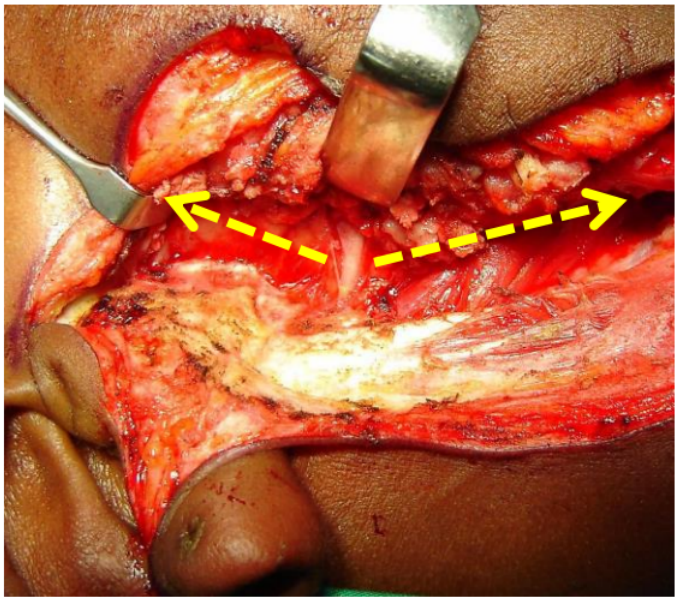


Figure 19: Location of facial nerve trunk, and superior and inferior release of capsule and parotid tissues (yellow arrows)

- Use fine curved blunt tipped scissors for the remainder of the nerve dissection. Tunnel and spread the tissues overlying the facial nerve and its branches, and divide the parotid tissue overlying the nerve. It is important to dissect directly on the nerve so as not to lose sight of it. ***Never*** divide parotid tissue beyond exposed facial nerve. Wearing loupes *e.g.* with 2.5x magnification assists with the dissection and enables one to better distinguish between blood vessels and nerves. Employ bipolar diathermy and fine silk ties for hemostasis.
- Dissect along the trunk to the *pes anserinus*
- Dissect back towards the stylomastoid foramen to exclude early branching from the trunk
- Divide the parotid fascia and parotid tissue superiorly and inferiorly to release the parotid posteriorly and to permit anterior mobilization of the gland/tumor (*Figure 19*)
- Dissect along and strip the superficial lobe off the branches of facial nerve. Unless a complete superficial parotidectomy is done, only the branches close to the mass are dissected and exposed (*Figure 20*)

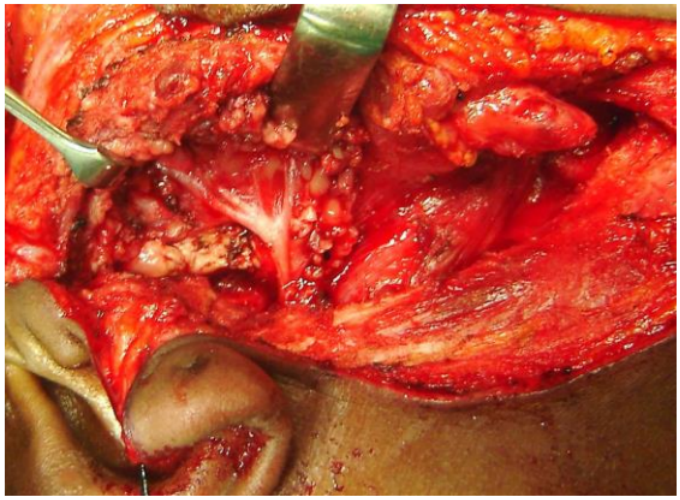


Figure 20: Strip the superficial lobe off the branches of facial nerve

- Identify the retromandibular vein as it crosses the medial to the facial nerve ((*Figure 21*))

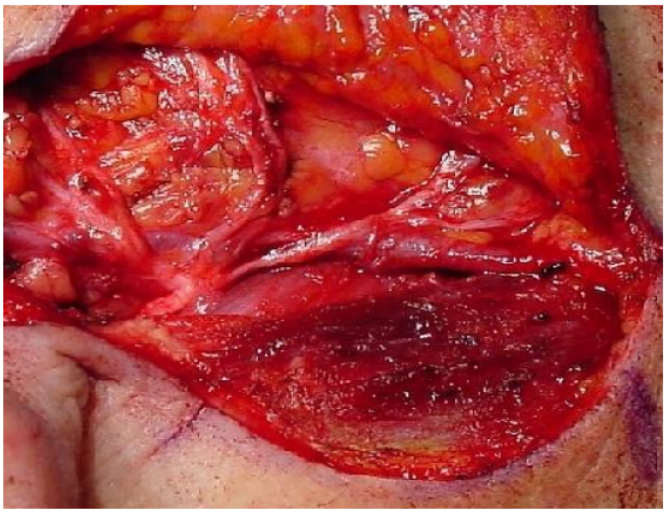


Figure 21: Completed superficial parotidectomy; note nerve crossing retromandibular vein

- If removing the superior part of the gland, identify/ligate the superficial temporal artery superiorly, just anterior to auricle
- If dissecting to the anterior border of the gland, identify and transect the parotid duct
- Remove the tumor with a cuff of the superficial parotid lobe

Parotid dissection for deep lobe tumors

The principles of resecting deep lobe tumors are to:

- Identify, dissect and free up the facial nerve from the underlying deep lobe or tumor, to provide access to the deep lobe. This may involve either a superficial parotidectomy (*Figure 22*), or simply reflecting the superficial lobe anteriorly, keeping the parotid duct intact, and replacing it at the conclusion of surgery (*Figure 23*)
- Deliver the tumor either between, or inferior to the facial nerve or its branches, identifying the branches of the facial nerve around the tumor, and removing tumor between the splayed facial nerve branches (*Figure 24*)

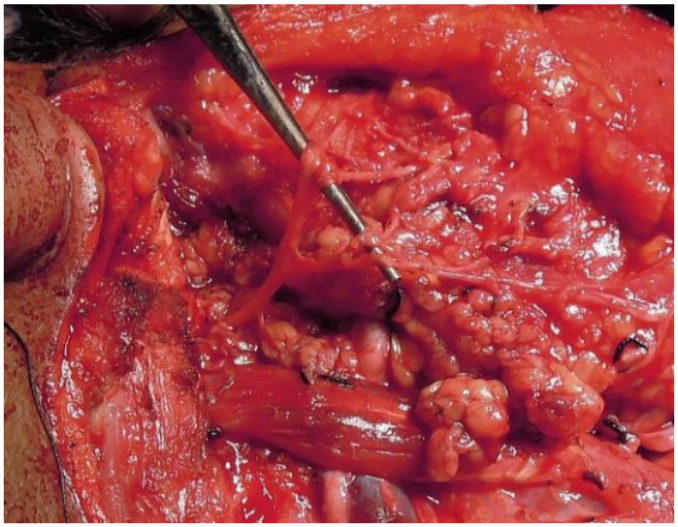


Figure 22: Facial nerve has been freed from deep lobe

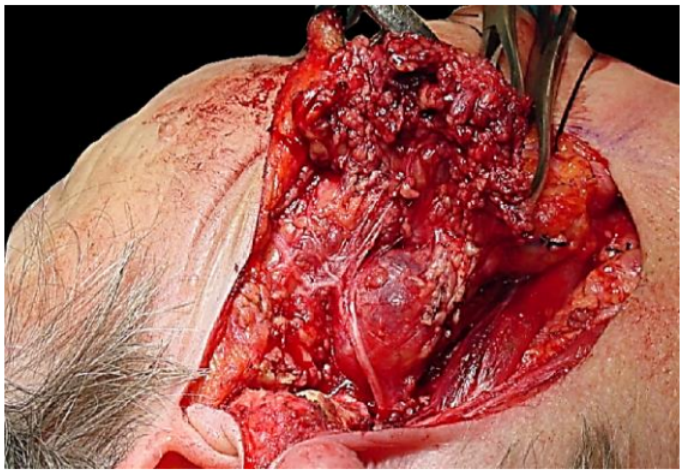


Figure 23: Reflecting superficial lobe for access to facial nerve and to deep lobe tumour

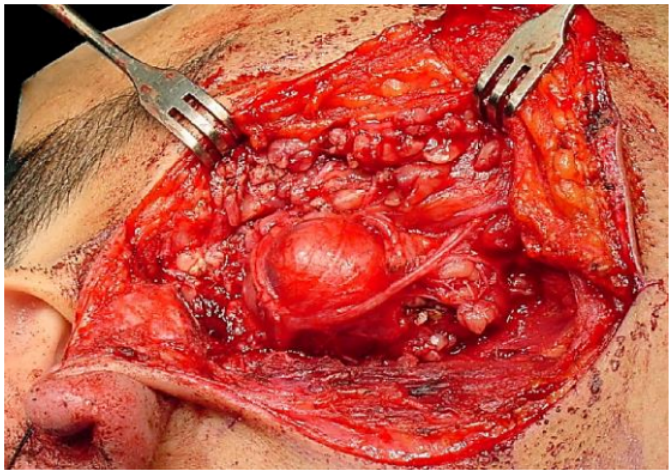


Figure 24: Tumor resected by removing tumor between splayed facial nerve branches

- The deep lobe of the parotid/tumor is bordered medially by the fat of the parapharyngeal space, and can be delivered from the parapharyngeal space by blunt dissection
- Be prepared to divide the external carotid, deep transverse facial and superficial temporal arteries and the retromandibular and superficial temporal veins if and when they are encountered during dissection
- Additional access may be provided to the deep aspect of a tumor by dividing the styloid process and/or via a transcervical approach (*Figure 25*)

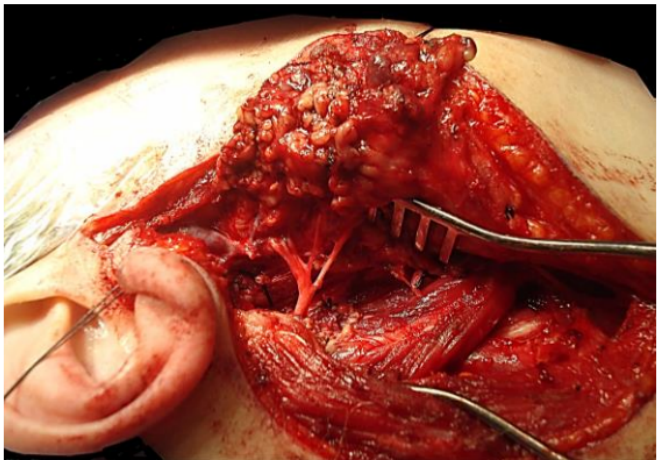


Figure 25: Access to parapharyngeal space tumor extension by reflecting the superficial lobe and division of styloid process

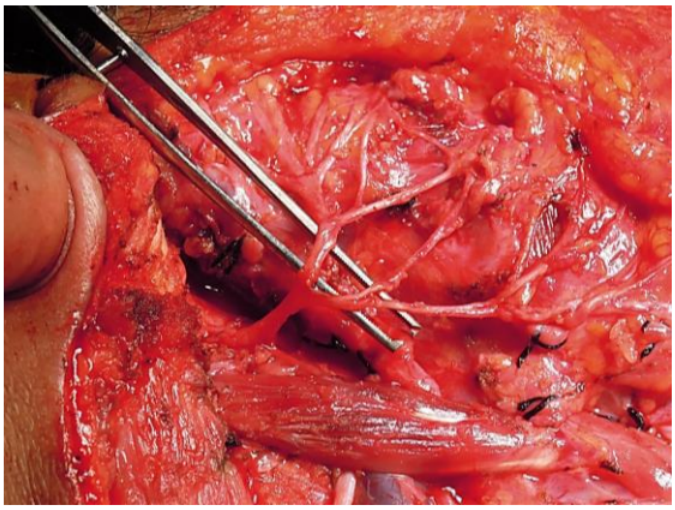


Figure 26: Completed total parotidectomy in patient shown in Figure 22; silk ties are on branches of the external carotid artery

Tumor spillage

Great care should be taken to avoid rupture and spillage of pleomorphic adenoma tissue into the operative site as it may lead to multifocal tumor recurrence, often more than 20 years following surgery (*Figure 27*). A minor controlled capsular rupture may be simply managed by copiously irrigating the wound. With more extensive ruptures, especially of a pleomorphic adenoma in the parapharyngeal space, some would advocate postoperative radiation therapy. Due to the multifocal nature of the recurrence, MRI is an important preoperative investigation for recurrence. Having to operate in a previously dissected field, the facial nerve is at greater risk of injury and should be monitored during surgery.

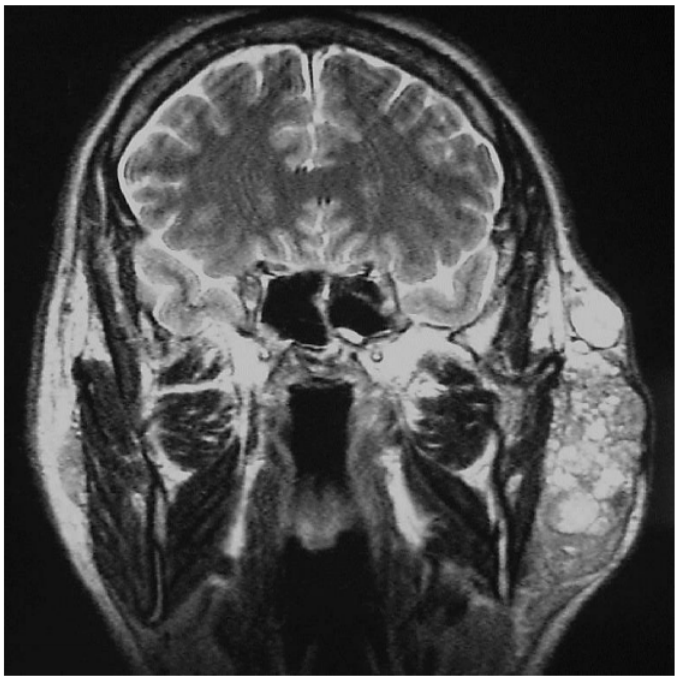


Figure 27: Multifocal recurrence of pleomorphic adenoma

Wound closure

- ***Confirm nerve continuity:*** Carefully inspect the nerve. One may stimulate the nerve with a nerve stimulator. Neuropraxia due to mechanical trauma may however cause failure of muscle contraction
- ***Obtain meticulous hemostasis:*** Use ties and bipolar diathermy. Employ a Valsalva manoeuvre to identify venous bleeding
- ***Sealed suction drain:*** Until drainage <50 mL/24 hrs
- ***Skin closure:*** Subcutaneous and subcuticular absorbable sutures

Facial nerve repair

Unlike with malignant tumors, the facial nerve and its branches can virtually always be dissected free from benign neoplasms. Isolated midfacial branches may be sacrificed without causing visible facial dysfunction. Transection of the temporal (frontal) and marginal mandibular nerves however results in disfiguring facial asymmetry; these nerves should be repaired with 8/0 nylon/prolene epineural sutures. When primary nerve repair is not possible due to undue tension or nerve resection, then the nerve can be grafted with greater auricular nerve, or sural nerve.

The ***greater auricular nerve*** is approximately the same diameter as the facial nerve trunk and has a few branches that can be used to graft more than one facial nerve branch (*Figure 28*).

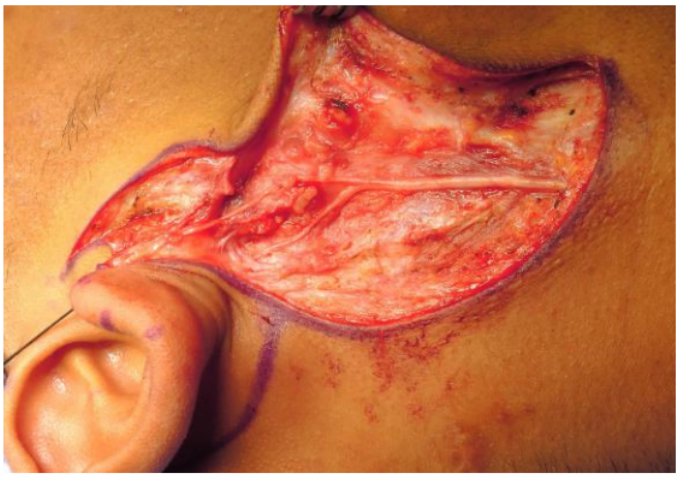


Figure 28: Greater auricular nerve

The ***sural nerve*** provides greater length and more branches and is better suited to bridging longer defects and for grafting to more peripheral branches (*Figures 29, 30*).



Figure 29: Sural nerve

When the proximal end of the facial nerve is not available, *e.g.* with extensive proximal perineural tumor extension, then a ***hypoglossal-facial nerve interposition graft*** can be used to restore facial tone and movement. The nerve graft is sutured end to-end to the distal facial nerve(s), and end-to-side to the hypoglossal nerve after cutting about 25% into the side of the hypoglossal nerve to expose the nerve axons (*Figure 31*).

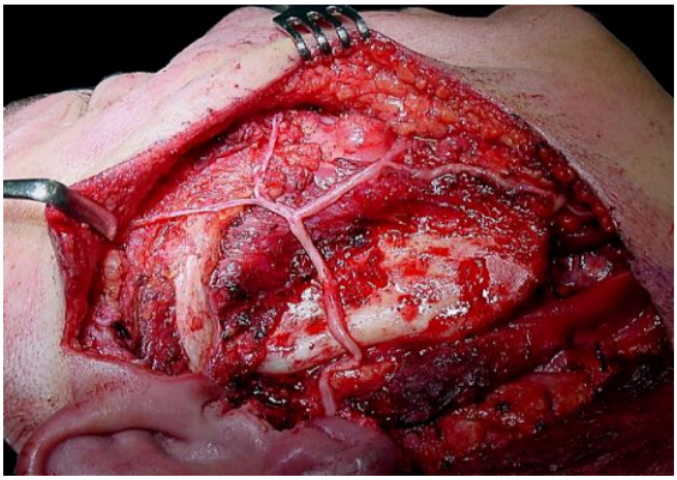


Figure 30: Sural nerve graft

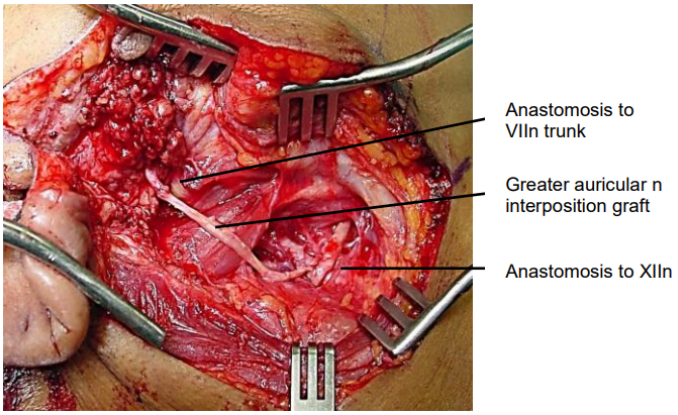


Figure 31: Hypoglossal/facial nerve graft

Also see the Open Access Atlas chapter: Surgical reanimation techniques for facial palsy/paralysis

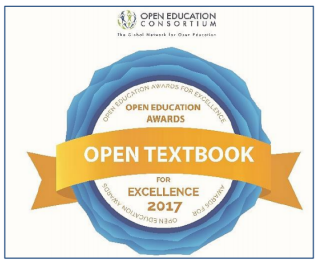
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Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.6: Submandibular Gland Resection

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

The submandibular salivary gland (SMG) may be excised for chronic sialadenitis, sialectasis, sialolithiasis, benign and malignant tumors, and as part of a neck dissecttion. The use of sialendoscopy is likely to reduce the frequency of SMG excision for sialolithiasis.

The key concerns for the patient are the surgical scar, and injury to the marginal mandibular, lingual and hypoglossal nerves.

Surgical anatomy

The ***SMG*** has both an oral and cervical component. It passes around the posterior free margin of the mylohyoid muscle, which forms the “diaphragm” of the mouth and separates the cervical and oral components of the gland. The SMG is situated mainly in the submandibular triangle (Level 1b) of the neck. The oral component extends some distance along the submandibular duct immediately deep to the mucosa of the floor of the mouth (*Figure 1*). The duct opens close to the midline in the anterior floor of mouth.

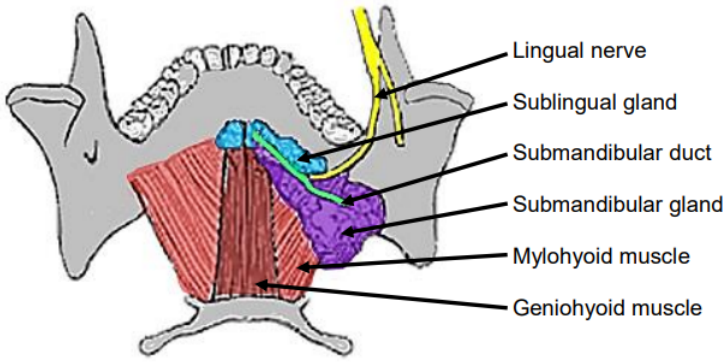


Figure 1: Superior, intraoral view of SMG, duct, lingual nerve and mylohyoid and geniohyoid muscles

The cervical part of the gland is immediately deep to the platysma and is encapsulated by the investing layer of the deep cervical fascia.

The ***digastric muscle*** forms the anteroinferior and posteroinferior boundaries of the submandibular triangle (*Figure 2*). It is an important surgical landmark as there are no important structures lateral to the muscle. The facial artery emerges from immediately medial to the posterior belly, and the XIIn runs immediately deep to the digastric tendon.

The ***mylohyoid muscle*** is a flat muscle attached to the mylohyoid line on the inner aspect of the mandible, the body of the hyoid bone, and by a midline raphe to the opposite muscle (*Figures 1, 2, 4, 8*). It is a key structure when excising the SMG, as it forms the floor of the mouth, and separates the cervical from the oral part of the SMG. Of importance to the surgeon is that there are no important vascular or neurological structures superficial to the mylohyoid; the lingual and XIIn are both deep to the muscle.

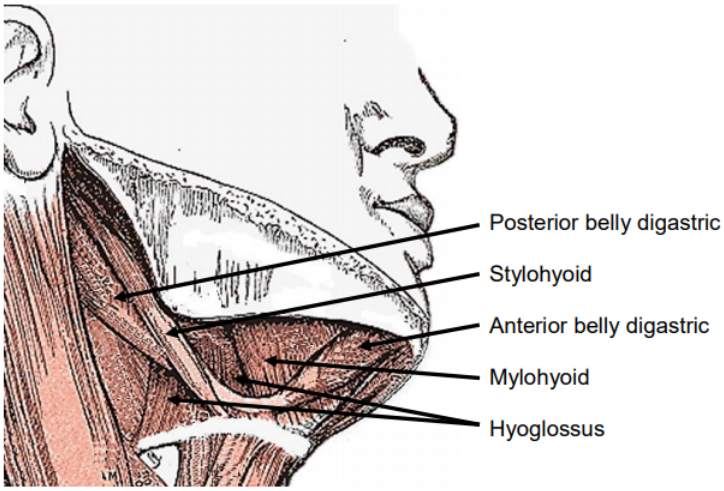


Figure 2: Muscles encountered with SMG excision

The ***marginal mandibular nerve*** is at risk of injury as it runs within the investing layers of deep cervical fascia overlying the gland, and may loop up to 3 cm below the ramus of the mandible. It comprises up to 4 parallel running branches. It crosses over the facial artery and vein before ascending to innervate the *depressor anguli oris* muscle of the lower lip (*Figure 3*). In order to minimize the risk of injury to the nerve, one should incise skin and platysma at least 3 cm below the mandible, and incise the fascial covering of the SMG just above the hyoid and do a subcapsular resection of the SMG.

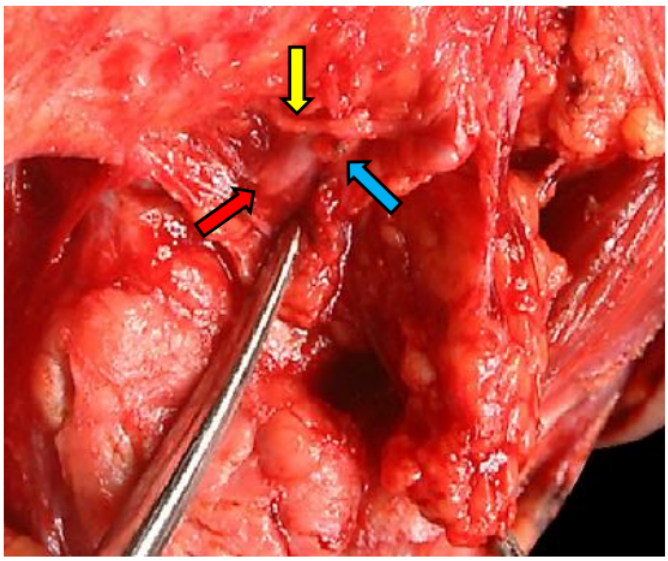


Figure 3: The marginal mandibular nerve (yellow arrow) is seen crossing the facial artery (red arrow) and the ligated vein (blue arrow)

The ***lingual nerve*** is a large, flat nerve, and runs in the lateral floor of mouth above the SMG, and sends secretomotor nerve fibres to the submandibular ganglion which innervate the SMG (*Figures 1 & 4*). It comes into view during SMG excision when the SMG is retracted inferiorly, and the mylohyoid is retracted anteriorly.

The ***hypoglossal nerve (XIIn)*** enters the submandibular triangle posteroinferiorly and medial to the hyoid bone, crosses the submandibular triangle in an anterosuperior direction, and exits into the mouth behind the mylohyoid muscle. It traverses the medial wall of the submandibular traingle, where it is applied to the hyoglossus muscle (*Figure 5*).

The XIIn is covered by a thin layer of fascia, distinct from the SMG capsule, and is accompanied by thin walled **ranine veins** that are easily torn at surgery (*Figure 5*).

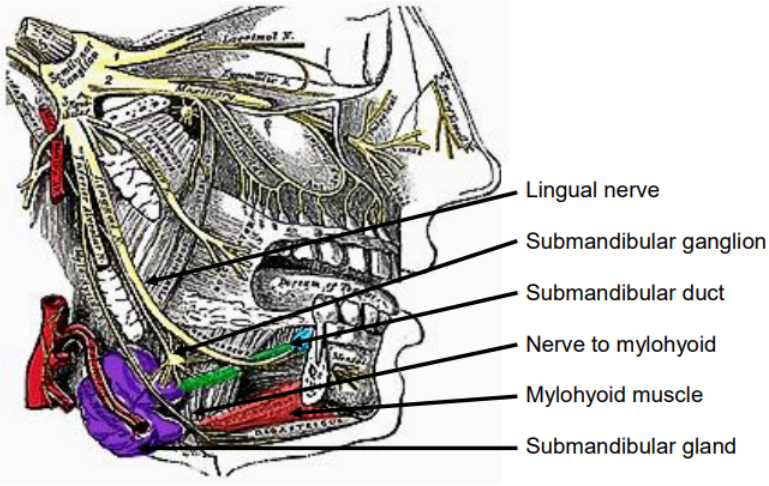


Figure 4: Note the submandibular ganglion, nerve to mylohyoid and how the lingual nerve swerves around the duct

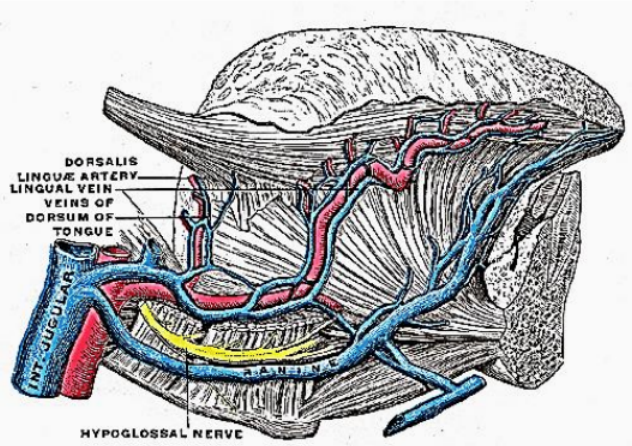


Figure 5: XIIn crossing the hyoglossus muscle, accompanied by ranine veins

The ***nerve to mylohyoid*** is a branch of V3 (*Figures 4 & 6*) and innervates the mylohyoid and anterior belly of digastric. It is generally not looked for or preserved at surgery. However when diathermy is used to mobilise the SMG off the mylohyoid muscle, contraction of the mylohyoid and anterior belly of digastric is usually noted due to stimulation of this nerve.

The ***common facial, (anterior) facial and ranine veins*** are encountered during SMG excision (*Figures 5 & 7*).

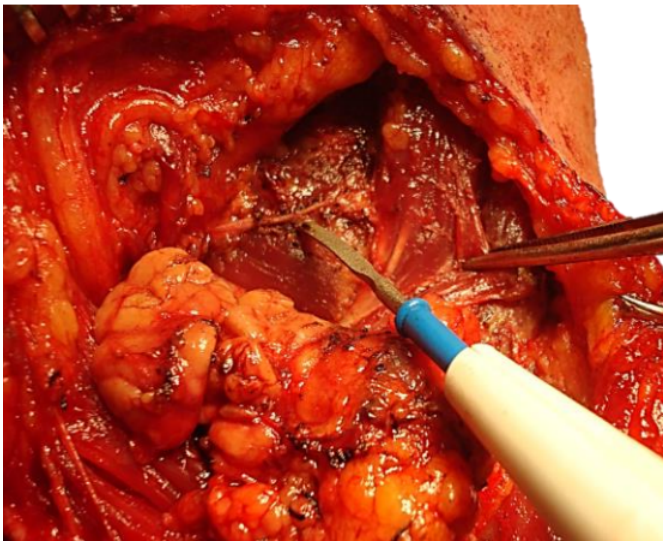


Figure 6: Diathermy tip points to the nerve to mylohyoid crossing the mylohyoid muscle

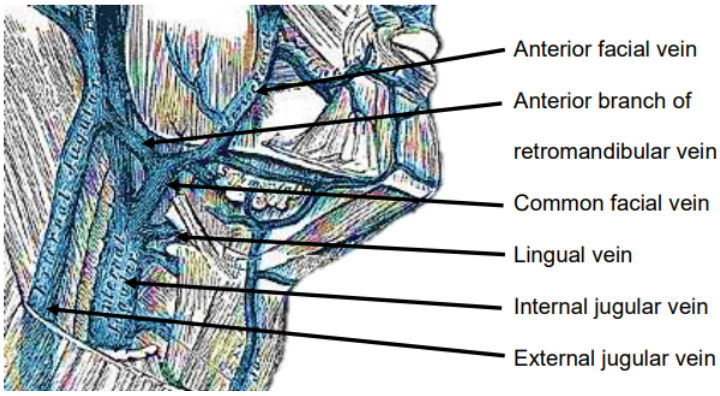


Figure 7: Veins of head and neck

The ***facial artery*** is identified during excision of the SMG. It enters the submandibular triangle posteroinferiorly from behind the posterior belly of digastric and hyoid, courses across the posteromedial surface of the SMG, and reappears at the superior aspect of the SMG where it joins the facial vein to cross the mandible (*Figures 3 & 8*). A few anterior branches enter the SMG and have to be divided if the surgeon elects to preserve the artery during resection of the SMG *e.g.* when a buccinator, nasolabial or submental artery flap is planned (*Figures 8 & 9*).

The submental artery island flap is based on the ***submental branch*** of the facial artery which courses along the inferior, inner margin of the mandible (*Figures 8*).

The ***mylohyoid artery*** and vein are encountered when the surgeon elevates the SMG from the lateral surface of the mylohyoid (*Figures 8 & 9*). It branches from the inferior alveolar artery just before it enters the mandibular foramen, crosses the mylohyoid, and disappears anteriorly behind the digastric. It has connections with the submental artery and via a defect in the mylohyoid, with the sublingual artery in the floor of the mouth.

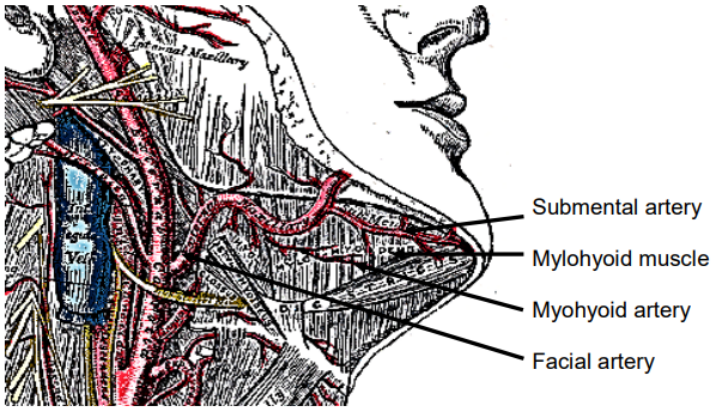


Figure 8: The facial artery emerges from behind the posterior belly of digastric (removed), and gives rise to a few branches including the submental artery

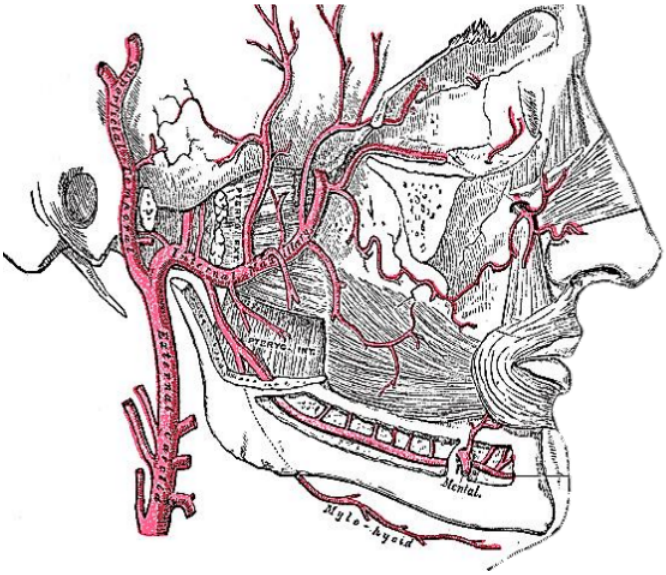


Figure 9: Mylohyoid artery

Operative steps

Anesthesia

The anesthetist should avoid muscle paralysis as it is useful to monitor movement of the lower lip should the marginal mandibular nerve be surgically irritated.

Positioning and draping

The patient is placed in a supine position with neck extended and the head rotated to the opposite side. The skin of the anterior neck and lower face is sterilized. Draping is done in such a way that the lower lip, lower margin of the mandible, and upper neck are exposed.

Incision of skin and platysma

A horizontal incision is placed in a skin crease at least 3 cm below the mandible or at the level of the hyoid bone, extending anteriorly from the anterior border of the sternocleidomastoid muscle (*Figure 8*).



Figure 8: Placement of incision

The incision is carried through skin, subcutaneous tissue and platysma to expose the capsule of the SMG, the facial vein and posteriorly, the external jugular vein (*Figure 9*).

The facial vein is ligated and divided where it crosses the SMG (*Figure 10*).

The fascial capsule of the SMG is incised with cautery or a knife parallel to and just above the hyoid bone to expose the SMG. By applying inferiorly directed traction to the SMG, a subcapsular dissection with exposure of the SMG is done with cautery (*Figure 11*). Contraction of the angle of the mouth alerts the surgeon to the proximity of the marginal mandibular nerve.

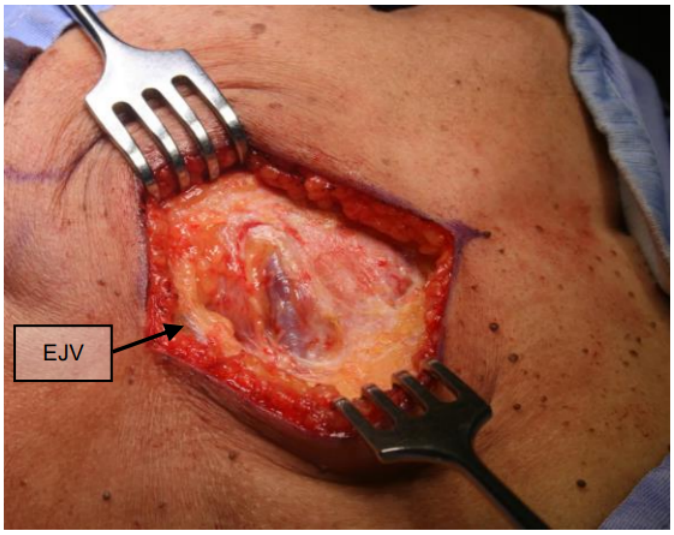


Figure 9: Incision through skin, fat and platysma to expose facial vein crossing over SMG and external jugular vein (EJV)

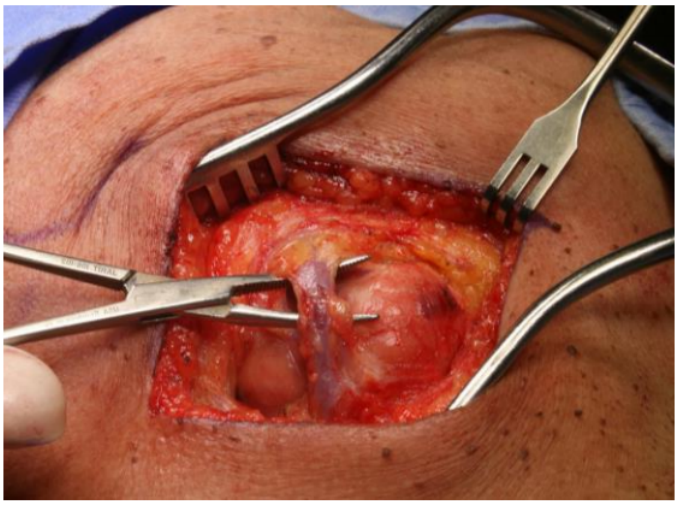


Figure 10: Division and ligation of facial vein inferiorly

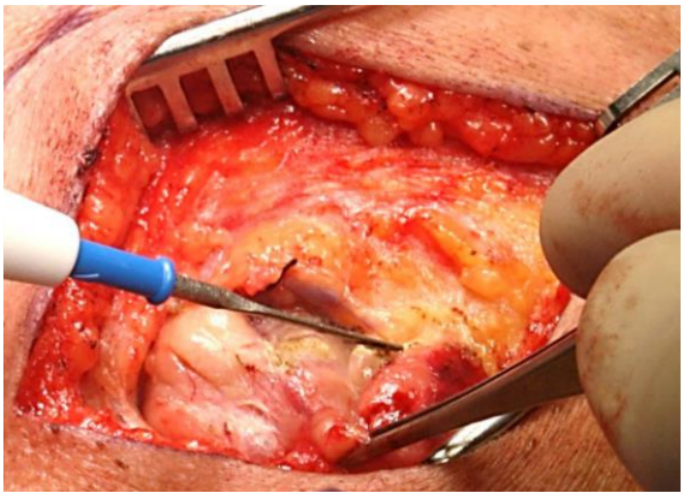


Figure 11: Subcapsular dissection of SMG to avoid injury to marginal mandibular nerve

Once the superior margin of the SMG has been reached, then the surgeon dissects bluntly with a hemostat in the fatty tissue above the gland to identify the facial artery and vein keeping immediately above the SMG to avoid injury to the marginal mandibular nerve (*Figure 12*). Although not essential to do so, the marginal mandibular nerve may be exposed where it crosses the facial artery and vein by careful blunt dissection (*Figures 3 & 12*). Avoid using monopolar cautery in the proximity of the nerve.

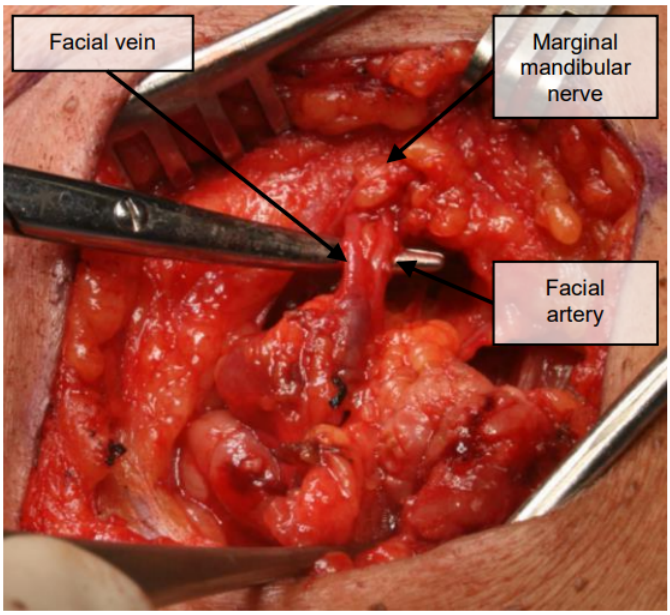


Figure 12: Facial artery and facial vein and marginal mandibular nerve

The surgeon then divides and ligates the facial artery and vein close to SMG to avoid injury to marginal mandibular nerve.

The surgeon next frees the anterior margin of the SMG from the anterior belly of digastric with electrocautery dissection, and proceeds in a posterior direction, elevating the SMG from the lateral surface of the mylohyoid muscle. The only structures of note that one encounters during this part of the dissection are the mylohyoid nerve and vessels (*Figures 6, 13*). By dividing these vessels with electrocautery, one gains free access to the posterior part of the mylohyoid muscle (*Figures 13 & 14*).

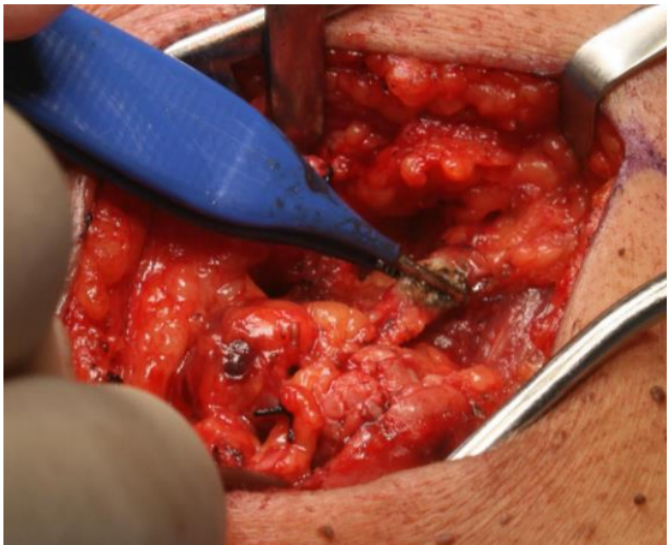


Figure 13: Front-to-back mobilization of SMG off mylohyoid muscle, and division of mylohyoid nerve and vessels

Next skeletonize the posterior free margin of the mylohyoid with diathermy or scissors with the knowledge that the XIIn, ranine veins and lingual nerve are all immediately deep to the muscle and are exposed and vulnerable to injury immediately posterior to the muscle (*Figure 14*).

By retracting the mylohyoid anteriorly and by using careful finger dissection, the lingual nerve, submandibular ganglion, and submandibular duct come into view (Figure 15).

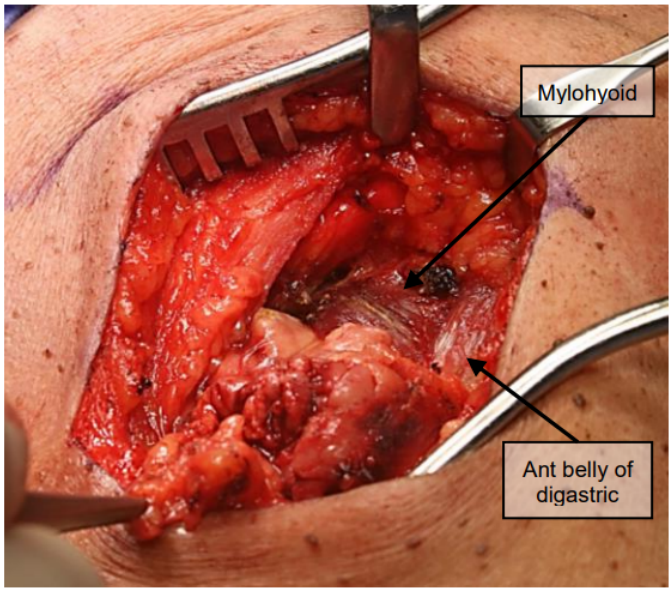


Figure 14: Exposing posterior part of mylohyoid

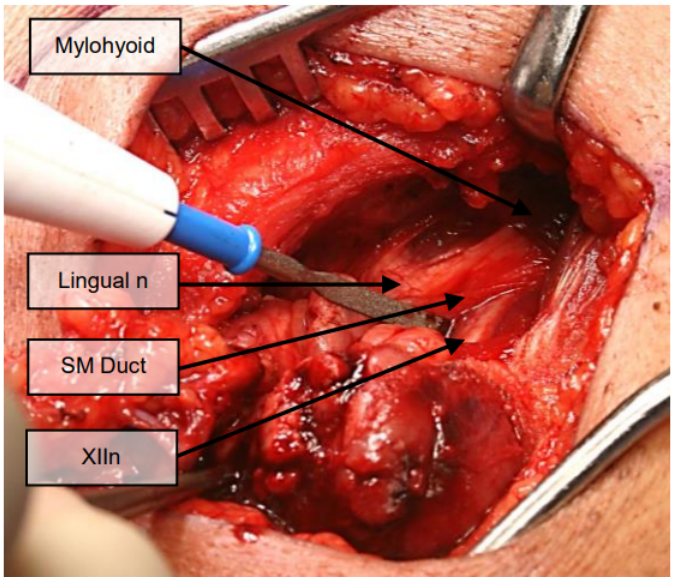


Figure 15: Retracting mylohyoid brings lingual nerve, XIIn and submandibular duct into view

An index finger is passed in the welldefined interfascial plane that exists between the SMG and submandibular ganglion laterally, and the fascia covering the XIIn and ranine veins medially (*Figure 16*). The finger exits posteriorly cephalad to the facial artery where it emerges from behind the posterior belly of the digastric muscle.

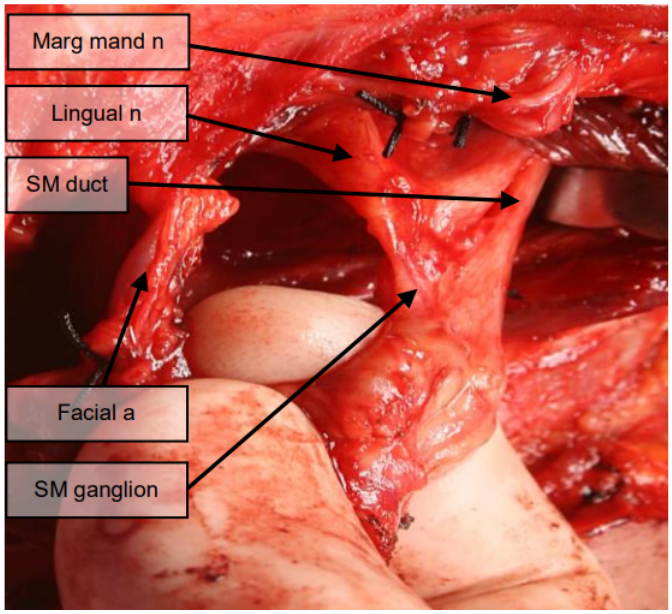


Figure 16: Finger dissection in plane between SMG and fascia covering XIIn and ranine veins

Once the XIIn nerve has been identified, one may safely clamp, divide and ligate the submandibular duct and the branch of the lingual nerve to the submandibular ganglion, taking care not to place the tie across the lingual nerve (*Figure 17*). With surgery for sialolithiasis one should follow and divide the duct more anteriorly in the floor of the mouth to avoid leave behind a calculus.

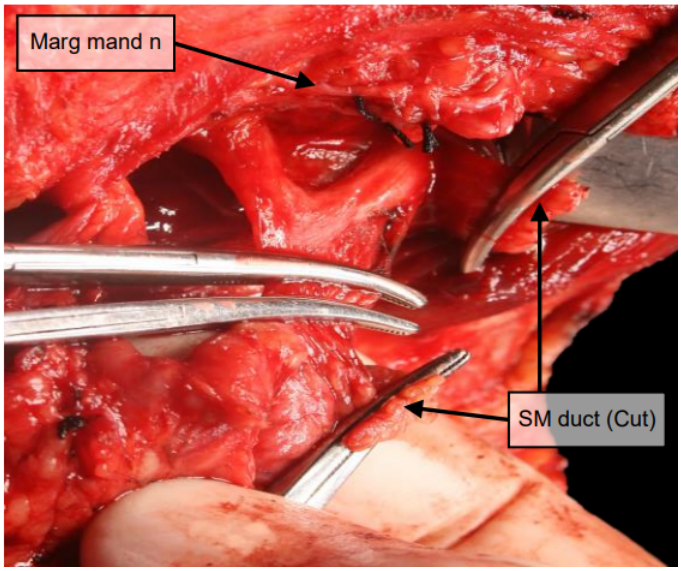
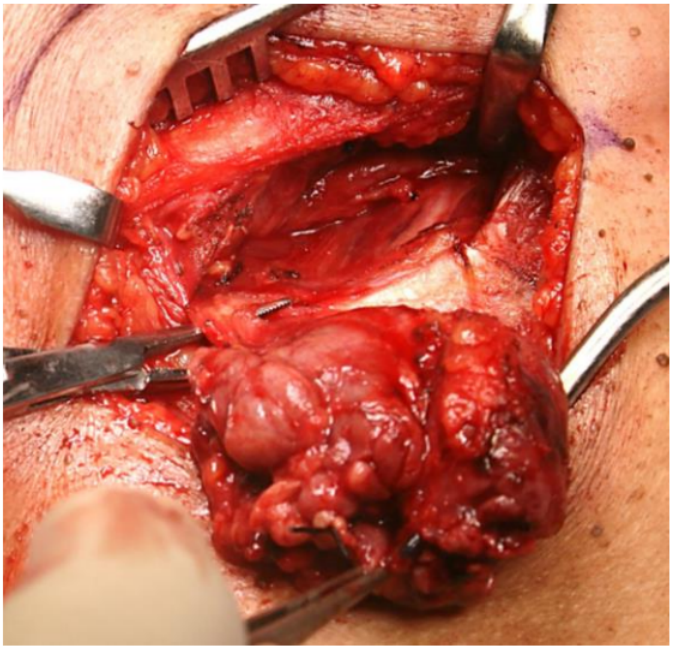


Figure 17: Division and ligation of submandibular duct and submandibular ganglion

The SMG can then be reflected inferiorly, and the facial artery is identified, ligated and divided where if exits from behind the posterior belly of digastric (*Figure 18*).


Figure 18: Ligation and division of facial artery

The SMG is then finally freed from the tendon and posterior belly of the digastric and removed. The final view of the resection demonstrates the XIIn, ranine veins, lingual nerve, and transected duct all on the lateral aspect of the hyoglossus muscle, and the facial artery (*Figure 19*).

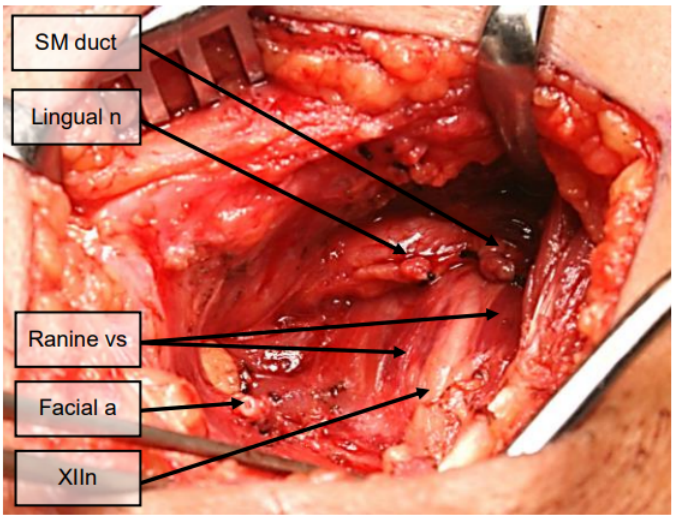


Figure 19: Final view of XIIn, ranine veins and lingual nerve

The wound is irrigated and closed in layers with vicryl to platysma and subcuticular suture to skin. A suction drain is left in situ.

Alternative technique: Preservation of facial artery

The facial artery has to be preserved for pedicled flaps based on the artery *i.e.* the buccinator, nasolabial and submental flaps, the latter which is based on the submental branch of the facial artery (*Figure 8*). Preserving the artery is quite simple and involves dividing the 1-4 anterior branches of the artery as they enter the SMG (*Figure 20*).

Clinical Guidelines for Submandibular Gland Tumors and Cancers

https://developingworldheadandneckcancerguidelines.com/submandibular-salivary-tumours-and-cancers/

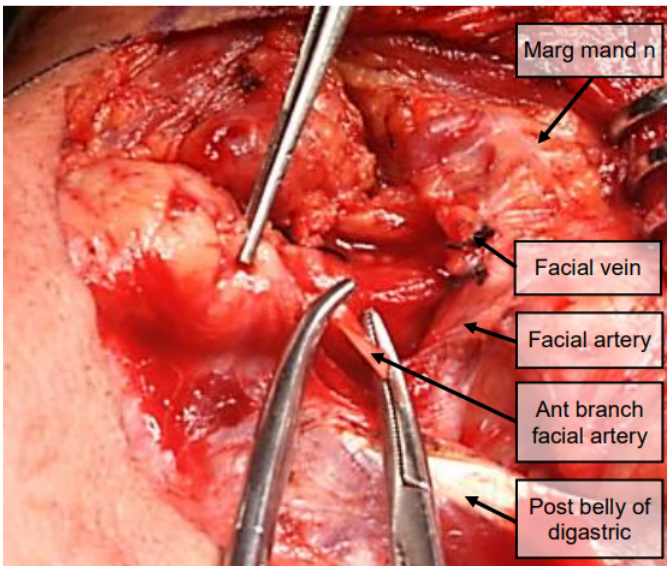
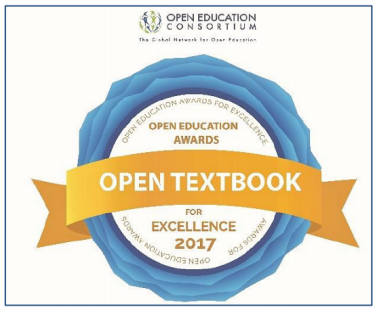


Figure 20: Preserving the facial artery by dividing anterior branches

Author & Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.7: Ranula and Sublingual Salivary Gland Excision

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Johan Fagan

Ranula refers to a collection of extraglandular and extraductal saliva in the floor of the mouth originating from the sublingual salivary gland. It may rarely originate from injury to the submandibular gland (SMG) duct. It is a pseudocyst, as it does not have an epithelial lining.

It classically presents as a soft submucosal swelling in the floor of the mouth (*Figure 1*). The term *ranula* originates from the Latin word for frog (*rana*) as the cyst is said to look like the underbelly of a frog.

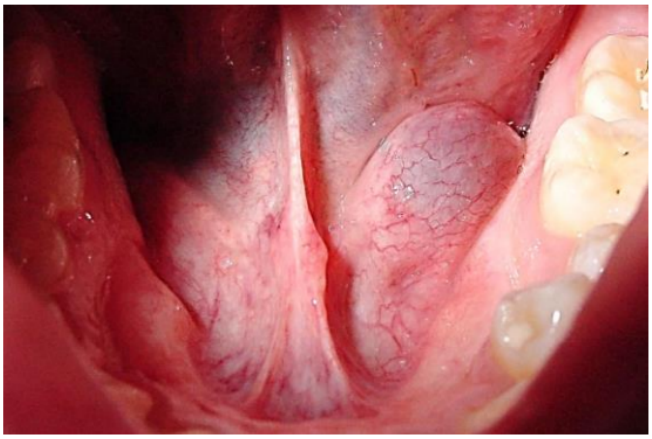


Figure 1: Ranula in floor of mouth

A ***plunging ranula*** extends into the submandibular triangle of the neck through a defect in the mylohyoid muscle, or less commonly, by passing behind the posterior edge of the muscle (*Figure 2*).

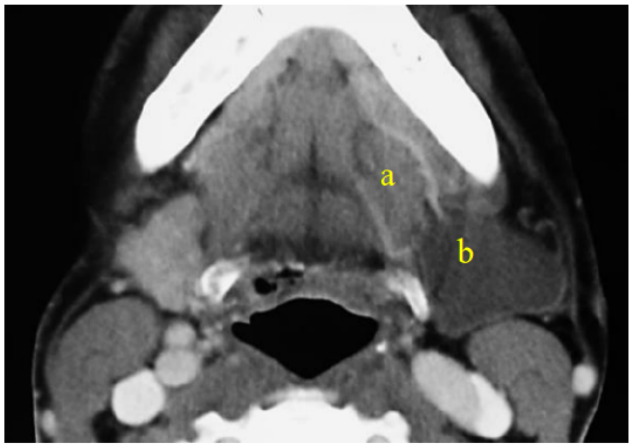


Figure 2: Plunging ranula: oral (a) and cervical (b) components

A ranula may also track posteriorly along tissue planes into the parapharyngeal space (*Figure 3*).

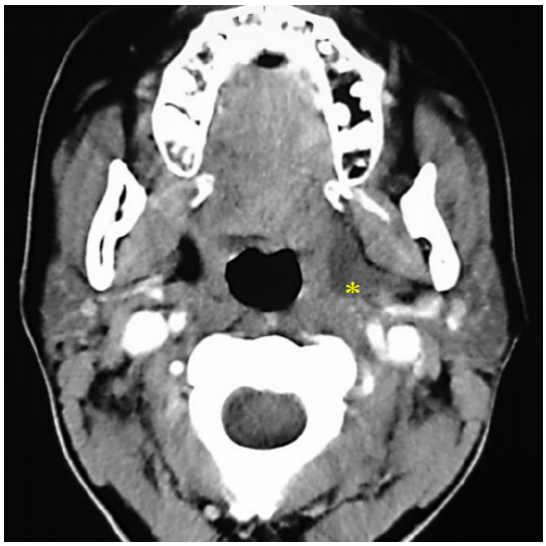


Figure 3: Ranula extension to para-pharyngeal space *, situated adjacent to the medial pterygoid muscle

The simplest way to clinch the diagnosis is by examining a needle aspirate of the typically thick, straw colored saliva (*Figure 4*).



Figure 4: Needle aspirate of thick, straw colored saliva

Treatment of a ranula is controversial, and includes marsupialization, excision of the sublingual salivary gland, excision of the ranula +/- excision of the sublingual salivary gland, and sclerotherapy. ***Excising the sublingual salivary gland is the key to minimizing recurrence. The author's preference is only to excise the gland.***

Surgical anatomy

The paired ***sublingual salivary glands*** are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles (*Figures 5, 6, 7*). The glands drain via 8-20 excretory ducts of Rivinus into the SMG duct and also directly into the mouth on an elevated crest of mucous membrane called the *plica fimbriata* which is formed by the gland and is located to either side of the frenulum of the tongue (*Figures 6 & 7*).

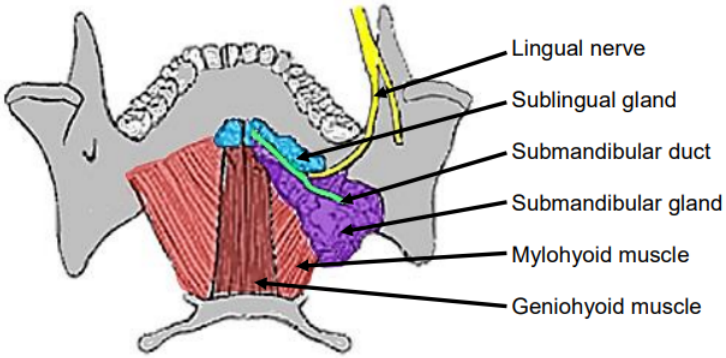


Figure 5: Superior, intraoral view of SMG, duct, lingual nerve and mylohyoid and geniohyoid muscles

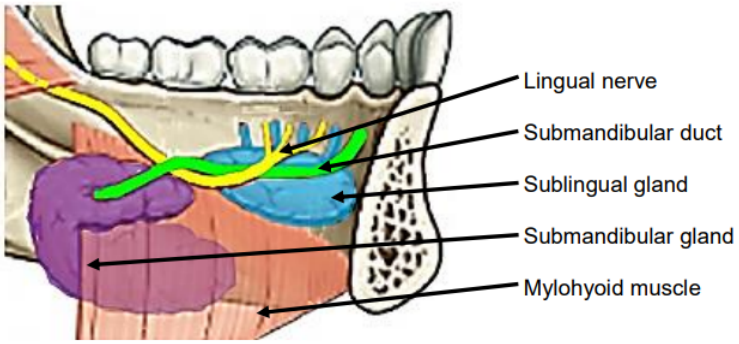


Figure 6: Intraoral view of left sublingual gland with ducts of Rivinus, SMG and duct, lingual nerve and mylohyoid muscles

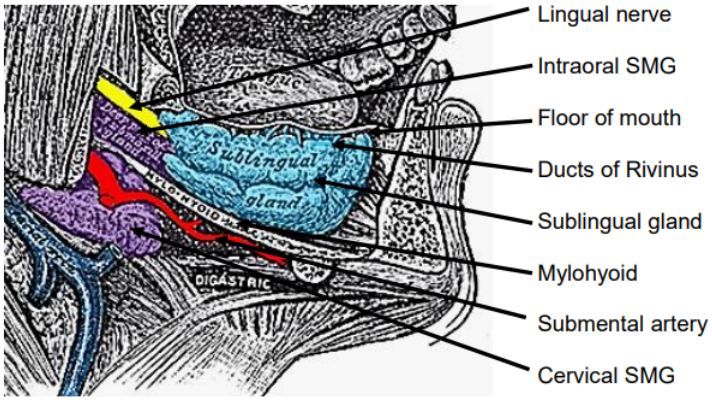


Figure 7: View of right sublingual gland

The ***lingual nerve*** crosses deep to the submandibular duct in the lateral floor of mouth. In the anterior floor of mouth it is located posterior to the duct (*Figures 5 & 6*).

The ***submandibular duct*** is located immediately deep to the mucosa of the anterior and lateral floor of mouth and opens into the oral cavity to either side of the frenulum (*Figures 5 & 6*).

Ranine veins are visible on the ventral surface of the tongue and accompany the hypoglossal nerve (*Figure 8*).

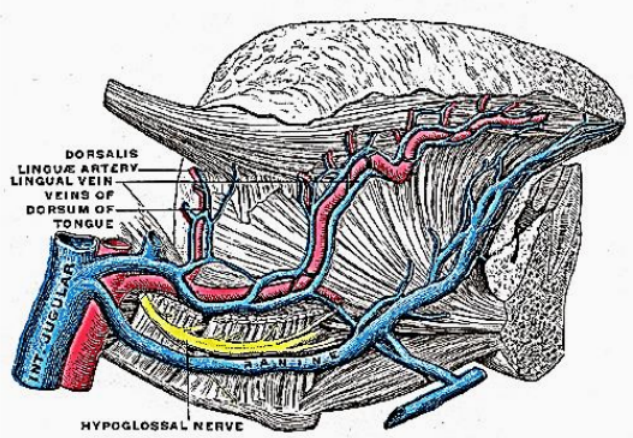


Figure 8: XIIn accompanied by ranine veins

The ***detailed surgical anatomy of the SMG and submandibular triangle*** are dealt with in detail in the chapter on submandibular gland excision.

Operative steps

The following description applies to excision of a simple ranula, the sublingual salivary gland, and a plunging ranula.

Anesthesia

A broad-spectrum antibiotic is administered for 24 hours. With excision of a plunging ranula the anesthetist should avoid muscle paralysis as it is useful to monitor the movement of the lower lip should the marginal mandibular nerve be surgically irritated

Positioning and draping

The patient is placed in a supine position with neck extended. The skin of the anterior neck and lower face is sterilized. Draping is done in such a way that the mouth and upper neck are exposed. A selfretaining retractor is used to open the mouth. A silk traction suture is passed through the tip of the tongue to better expose the anterior floor of the mouth.

Excision of a simple ranula (Figure 1)

The mucosa is incised over the ranula taking care not to enter the sac. A submucosal dissection plane is established over the wall of the ranula. Using sharp and blunt dissection, the cyst is excised, taking care not to injure the submandibular duct or the lingual nerve. Should the submandibular duct be injured, then it is simply translocated to the lateral floor of mouth by mobilizing the duct, and passing it through a stab incision in the mucosa of the lateral floor of mouth. It is secured to the oral mucosa with a suture passed through the side of the duct (*Figure 9*).

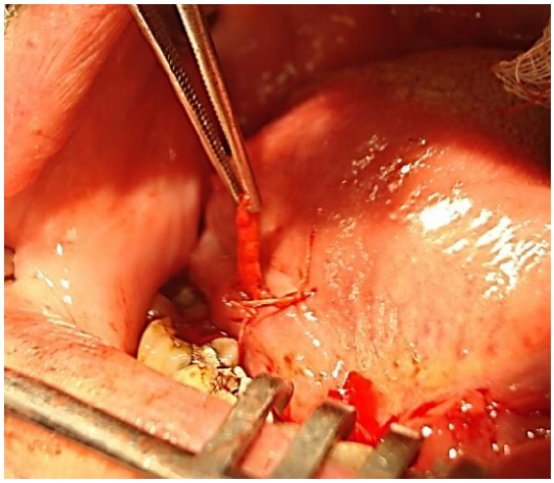


Figure 9: Submandibular duct transposed to right lateral floor of mouth, and sutured to mucosa with a vicryl suture

Excision of sublingual salivary gland

The sublingual gland is surprisingly large and is located immediately deep to the mucosa just anterior to the submandibular duct in the anterior floor of mouth. It may be excised by using electrocautery and blunt dissection (*Figure 10*). Structures at risk of injury are the submandibular duct and lingual nerve (*Figure 11*).

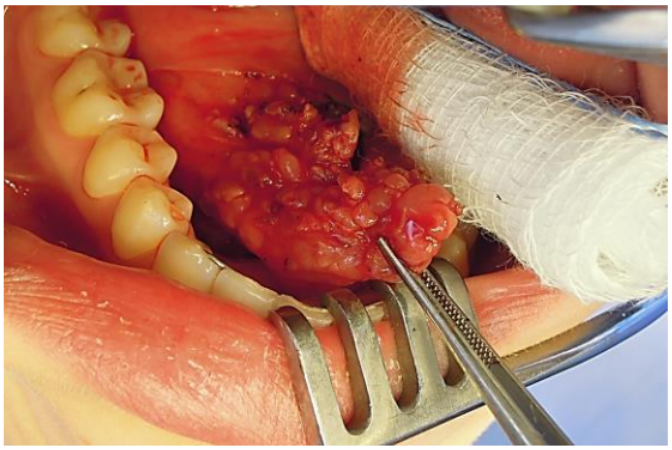


Figure 10: Right sublingual salivary gland

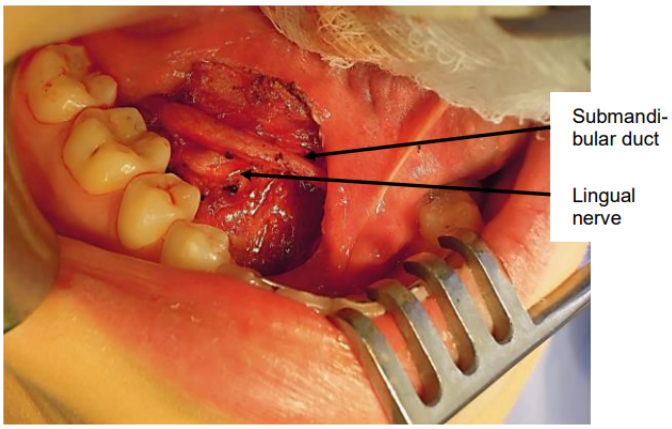


Figure 11: Lingual nerve and submandibular duct

Excision of plunging ranula

A plunging ranula resolve by simply excising the sublingual salivary gland. Yet some surgeons prefer also to excise the ranula.

Readers are referred to the chapter on ***submandibular gland excision*** for the surgical anatomy, as much of the dissection is similar. A horizontal incision, placed in a skin crease and at least 3 cm below the mandible or at the level of the hyoid bone and extending anteriorly from the anterior border of the sternocleidomastoid muscle, is made through skin, subcutaneous tissue and platysma. The common facial and anterior facial veins are identified posteriorly and divided and ligated if required for access. The ranula is identified in the anterior part of the submandibular triangle (*Figure 12*).

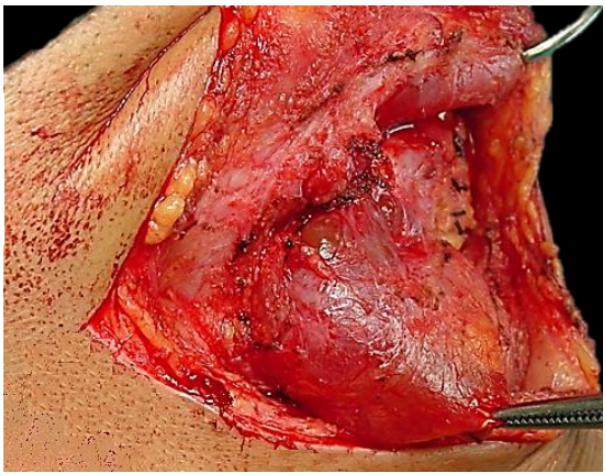


Figure 12: Plunging ranula in right neck

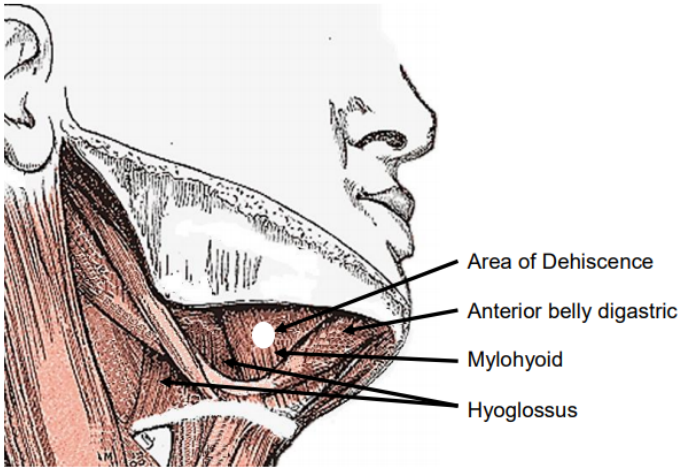


Figure 13: Muscles encountered with SMG excision, and area of dehiscence in mylohyoid through which plunging ranula typically passes into the neck

The anterior belly of digastric is identified and retracted anteriorly. The mylohyoid muscle is identified deep to and behind the anterior belly of digastric (*Figure 13*).

The surgeon may have to mobilize and resect the SMG for better access (*Figure 14*). The ranula is mobilized with sharp and blunt dissection from the surrounding muscles and the SMG posteriorly. It is traced to where it generally passes through a dehiscence in the mylohyoid muscle, or less commonly behind the mylohyoid, into the floor of the mouth. The surgeon then completes the resection transorally, including resection of the sublingual salivary gland. Should the SMG have been preserved, then the status of the submandibular duct is checked to determine whether it needs to be translocated. The mucosal defect in the floor of mouth is then closed with absorbable sutures, and the neck is closed in layers over a suction drain.

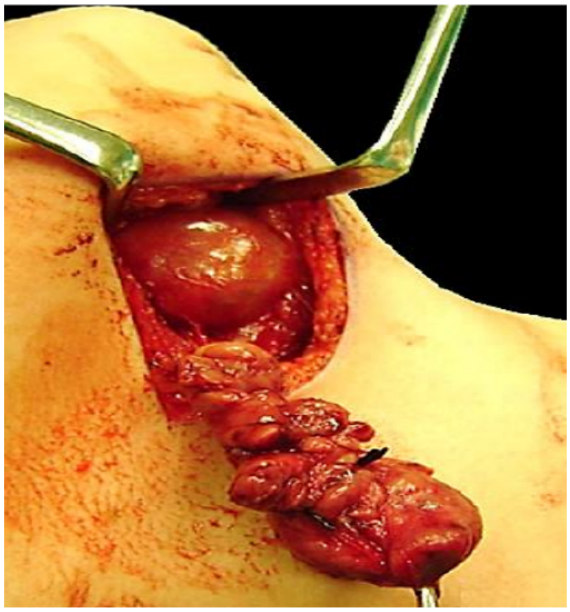


Figure 14: SMG mobilized to better expose plunging ranula

Comment

The author does not marsupialise or excise ranulae, but simply excises the sublingual salivary gland. With plunging ranula he also aspirates the sac at surgery to hasten its resolution and to avoid it becoming infected (Patel MR, Deal AM, Shockley WW. Oral and plunging ranulas: What is the most effective treatment? Laryngoscope. 2009;119(8):1501–9)

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

THE OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY
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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Robert Witt, Oskar Edkins

Sialoliths vary in size, shape, texture, and consistency; they may be solitary or multiple. Obstructive sialadenitis with or without sialolithiasis represents the main inflammatory disorder of the major salivary glands. Approximately 80% of sialolithiasis involves the submandibular glands, 20% occurs in the parotid gland, and less than 1% is found in the sublingual gland. Patients typically present with painful swelling of the gland at mealtimes when obstruction caused by the calculus becomes most acute. When conservative management with sialogogues, massage, heat, fluids and antibiotics fails, then sialolithiasis needs to be surgically treated by transoral, sialendoscopic and sialendoscopy assisted techniques; or as a last resort, excision of the affected gland (sialadenectomy).

Surgical anatomy

The paired ***submandibular ducts (Wharton's ducts)*** are immediately deep to the mucosa of the anterior and lateral floor of mouth (FOM) and open into the oral cavity to either side of the frenulum (*Figure 1*). The ***frenulum*** is a mucosal fold that extends along the midline between the openings of the submandibular ducts.

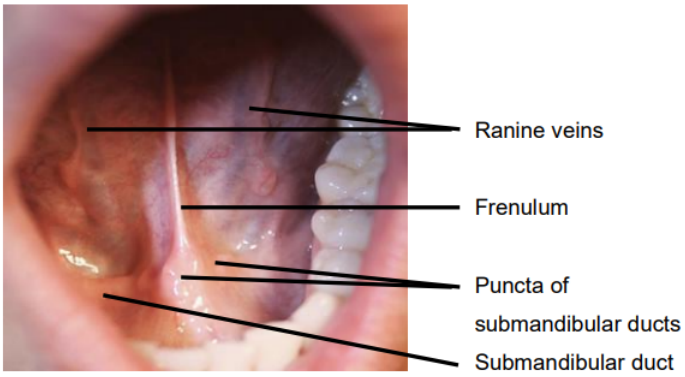


Figure 1: Anterior FOM

The anterior FOM has a covering of delicate oral mucosa through which the thin-walled ***sublingual/ranine veins*** are visible (*Figures 1 & 2*). The veins are visible on the ventral surface of the tongue, and accompany the hypoglossal nerve (*Figure 2*).

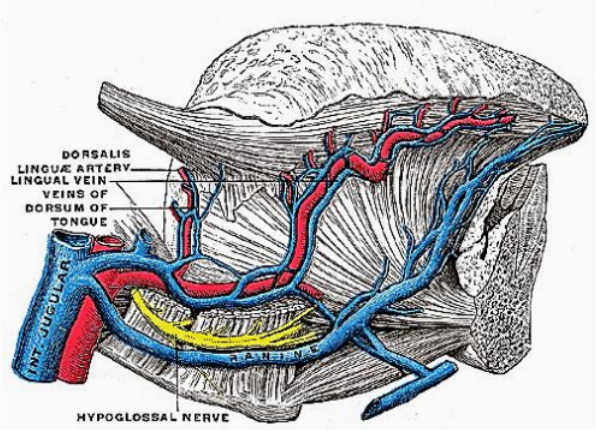


Figure 2: Ranine veins

The paired ***sublingual salivary glands*** are located beneath the mucosa of the anterior FOM, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles (*Figures 3 & 4*). The glands drain via 8-20 excretory ducts of Rivinus into the

submandibular duct and also directly into the mouth on an elevated crest of mucous membrane called the *plica fimbriata* which is formed by the gland and is located to either side of the frenulum of the tongue).

In the anterior floor of mouth the ***lingual nerve*** is located posterior to the duct; it crosses deep to the submandibular duct in the lateral floor of mouth (*Figures 3, 4, 5*).

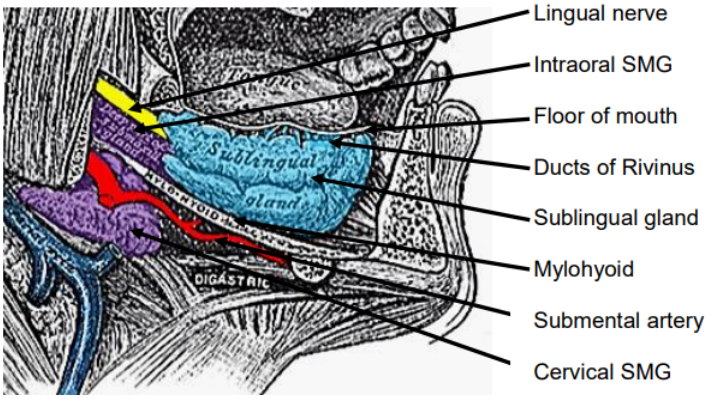


Figure 3: Sagittal view floor of mouth

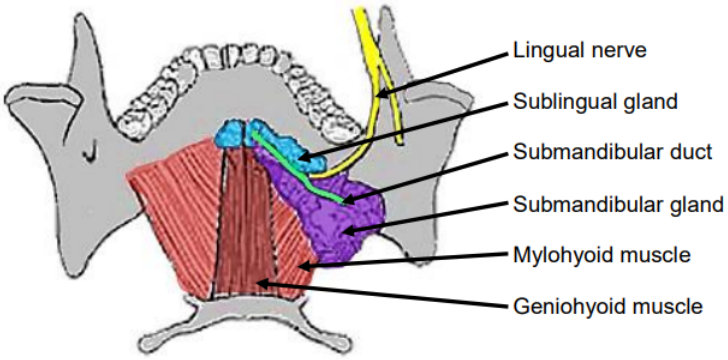


Figure 4: Superior, intraoral view of submandibular gland, duct, lingual nerve and mylohyoid and geniohyoid muscles

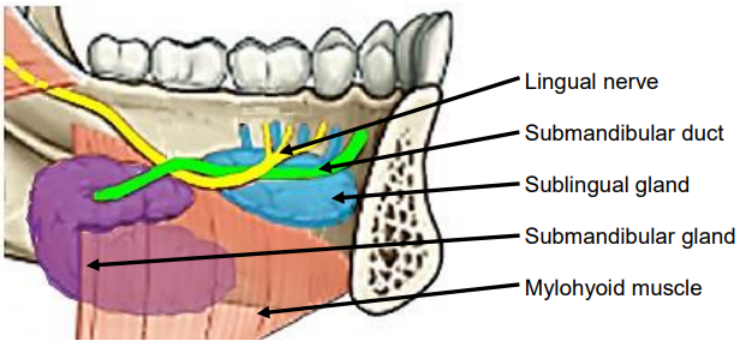


Figure 5: Intraoral view of left sublingual gland with ducts of Rivinus, submandibular gland and duct, lingual nerve and mylohyoid muscles

The ***parotid (Stensen's) duct*** exits the anterior edge of the parotid gland and crosses the surface and hooks around the anterior aspect of the masseter, traverses the buccal fat pad, and pierces the buccinator muscle to enter the mouth opposite the 2nd upper molar (*Figure 6*).

Clinical Evaluation

Visual scanning of submandibular, preauricular, and postauricular regions is the first step to assess for the presence of swelling and erythema; this is followed by intraoral examination. The salivary ductal orifice may be red and edematous. One should massage the gland to milk and inspect the saliva; frank infection may be represented by plaques or whitish secretions emanating from the duct. Manual palpation of the parotid gland allows a surgeon to determine the consistency of the gland.

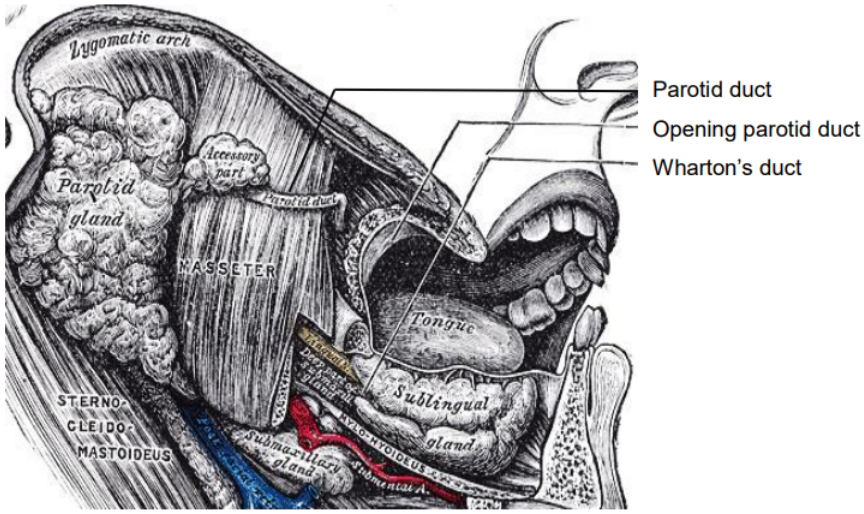


Figure 6: Stensen's duct crosses and hooks around the anterior aspect of the masseter, and pierces the buccinator muscle to enter the mouth (Gray's anatomy)

Bimanual palpation (finger inside and outside the mouth) is particularly important when examining the submandibular gland and its duct.

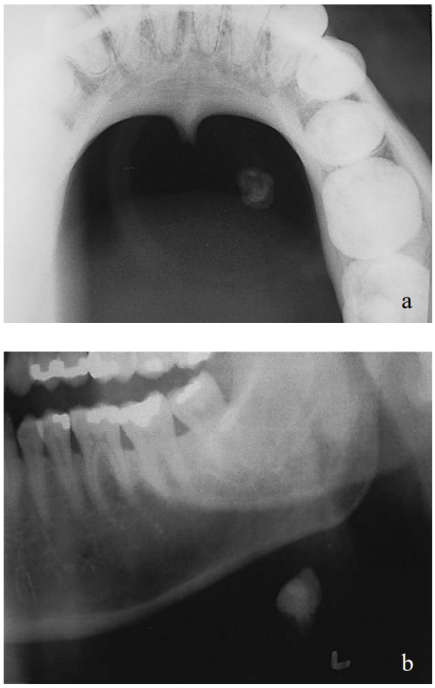
Salivary imaging

Imaging modalities for inflammatory conditions of glands are plain X-rays (*Figures 7a, b*), sialography (*Figure 8*), ultrasound (*Figure 9*), and computed tomography (*Figure 10*).

Plain X-rays have less value with parotid stones because of the higher percentage (60- 70%) of radiolucent stones; approximately 20% of submandibular stones are not visible with plain X-rays.

Sialography provides images of the morphology of the ductal system and allows diagnosis of strictures, dilatations, and filling defects (*Figure 8*).

MR sialography is good means to measure ductal stenosis. Although avoiding ionizing radiation, it has less resolution than conventional sialography, thereby limiting visualization of the peripheral ducts.



Figures 7a, b: Calculi within the duct (occlusal view) (a) and within submandibular gland (b)

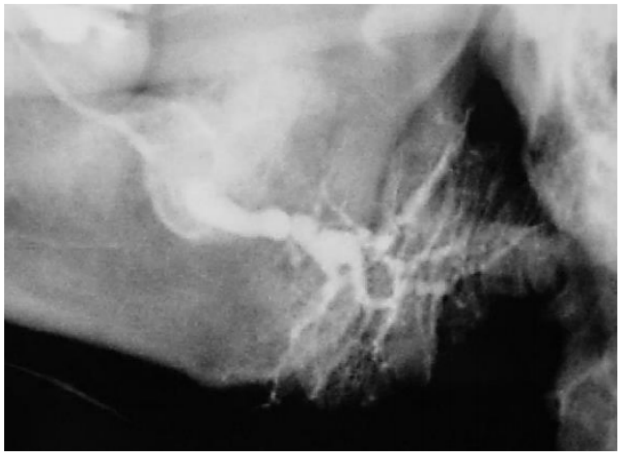


Figure 8: Sialogram demonstrating stricture of submandibular duct

Ultrasound (*Figure 9*) is noninvasive and has no associated discomfort. Failure to detect a stone with ultrasound is not uncommon as the distal portion of the submandibular and parotid ducts can be difficult to visualise using extraoral ultrasound; and ultrasound may be of limited value for the deep portion of the submandibular gland. An obstructed duct that may otherwise not be evident may be better visualized after giving the patient something sour like lemon juice or sour sweets as this may cause ductal dilatation with obstructive pathology (*Figure 10*).

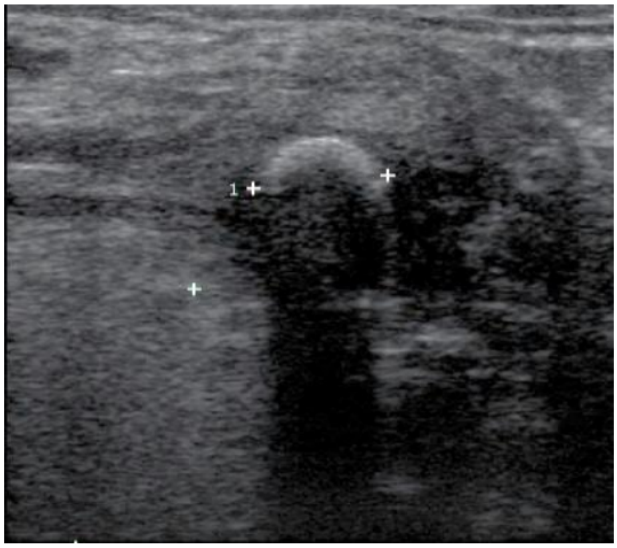


Figure 9: Ultrasound: acoustic shadow cast by calculus

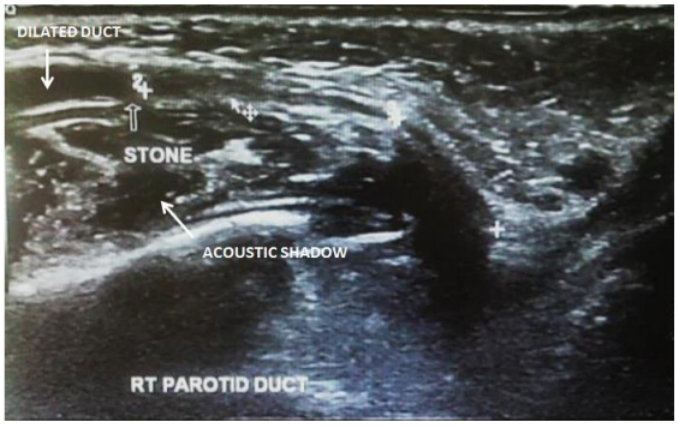


Figure 10: Calculus in right mid Stensen's duct with dilatation of duct proximal to left-sided of stone

Computed tomography (CT) imaging is a good imaging modality to see sialoliths (*Figures 11, 12*). Another advantage is its ability to diagnose and locate intraparenchymal stones and calcification.

Limitations of ultrasound and CT include distinguishing non-echogenic stones from strictures, determining the length of a stenosis and the diameter of the duct distal to an obstruction. Ultrasound is a dynamic and operator-dependent investigation and pathology may be therefore be overlooked.

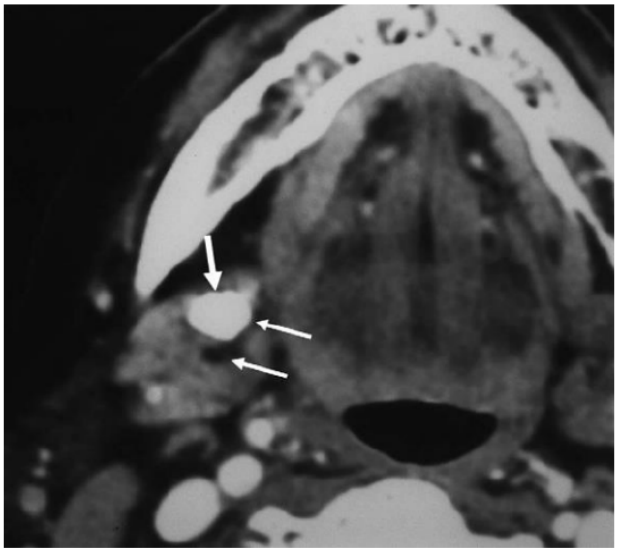


Figure 11: CT scan of calculus within hilum of submandibular gland

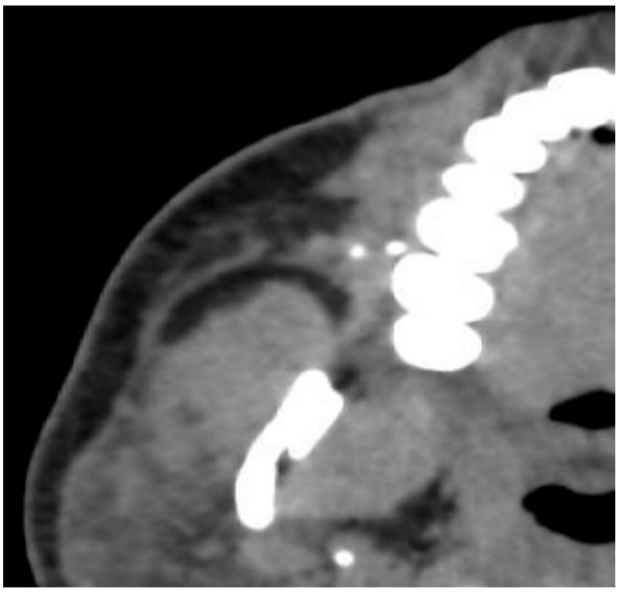


Figure 12: CT scan shows 2 small calculi within distal segment of Stensen's duct

Traditional surgical approaches to submandibular gland sialolithiasis

Prior to sialendoscopy, sialoliths in the submandibular duct and gland were divided into two groups:

1. ***Can be removed via intraoral sialolithotomy approaches,*** including palpable stones up to the 1st molar tooth
2. ***Cannot be removed through intraoral approach and require sialadenectomy;*** this includes stones posterior to the 1st molar region, or stones in the middle part of Wharton's duct that cannot be palpated intraorally

Traditional Intraoral Submandibular Sialolithotomy (*Figure 13*)

- Local or general anesthesia
- Administer local anesthesia with a vasoconstrictor in the floor of mouth at the site of the planned incision

- Place two 3/0 silk sutures around the duct, posterior to the stone, to isolate the stone and to prevent displacing the stone to the proximal part of the duct or hilum of the gland (*Figure 13*)

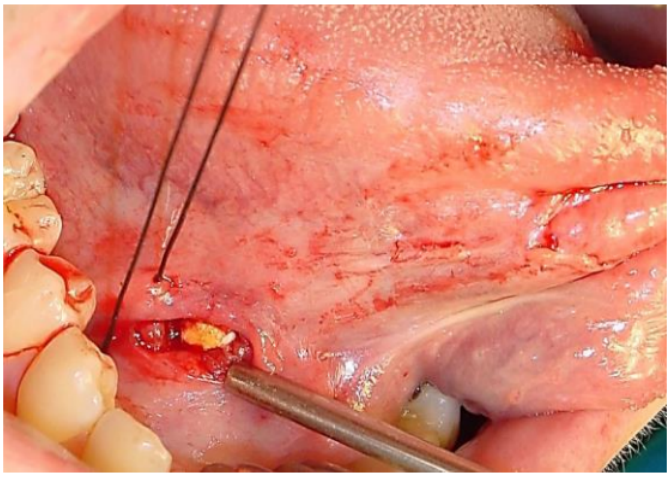


Figure 13: Suture placed posteriorly around submandibular duct which has been incised to expose the calculus

- Cut through mucosa directly onto the stone with a cold blade, electrosurgery, or CO_2 laser
- Remove the calculus
- Marsupialize the opening in the duct by suturing the cut edges of the duct to the oral mucosa with interrupted 4/0 Vicryl sutures (Optional)

Note: Although feasible in selected cases, the same sialolithotomy procedure for the more posterior ductal region carries a significant risk of injury to the lingual nerve and the possibility of severe bleeding from the lingual vessels (*Figure 2*).

Traditional surgical approaches to parotid sialolithiasis

Prior to the advent of sialendoscopy, sialoliths in the parotid duct and gland were divided into two groups:

1. ***Can be removed via intraoral sialolithotomy;*** this technique is useful only for stones located in the distal part of Stensen's duct which is anatomically demarcated by the curvature of the duct around the masseter muscle to where the duct penetrates the buccinator muscle (*Figures 6, 12*)
2. ***Cannot be removed via intraoral approach,*** requiring extirpation of the parotid gland

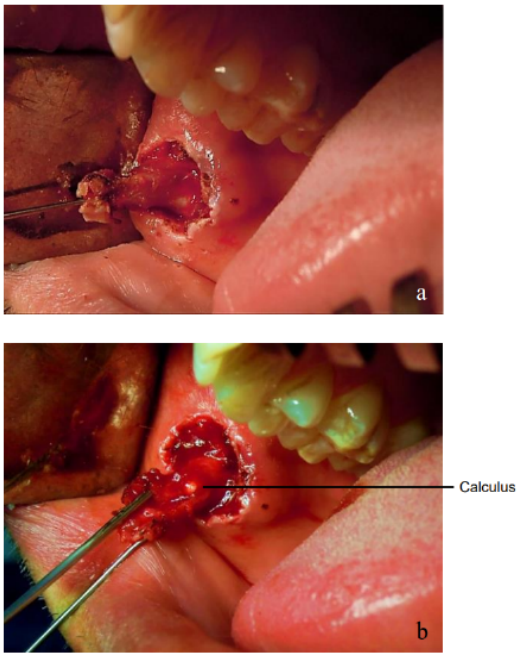
The 1st step therefore is to precisely locate the stone to select a surgical approach.

Traditional Intraoral Parotid Sialolithotomy

- Local or general anesthesia
- Administer local anesthesia with vasoconstrictor around the papilla of Stensen's duct
- Advance a lacrimal probe along the duct until one feels the stone
- Hold the papilla and probe with a hemostat to ensure a safe tract to the stone
- Make a circumferential elliptical incision around the papilla and the probe
- Dissect bluntly and sharply around the duct up to the stone's location (*Figure 14a*)
- Incise the wall of the duct over the stone (*Figure 14b*) remove the stone with curettes
- Following sialolithotomy, massage the gland to release saliva and plaque
- Suture the ductal layer to the oral mucosa with several 4/0 Vicryl sutures to maintain ductal patency
- Insert a stent (silastic tube) to prevent the higher incidence of ductal stenosis encountered with Stensen's as compared to Wharton's duct

Parotidectomy for Sialolithiasis

The difference between parotidectomy for sialolithiasis and a benign tumour is the condition of the gland; inflammation, scarring and fibrosis both inside the gland and around Stensen's duct make the operation difficult and heighten the risk of facial nerve injury



Figures 14a & b: Exposure of parotid duct and opening of duct to remove calculus

Modern sialendoscopic approaches to sialolithiasis

Salivary gland endoscopy has been a major advance, not only in terms of providing an accurate means of diagnosing and locating intraductal obstruction, but for permitting minimally invasive surgery that can successfully relieve blockages not amenable to intraoral approaches. Sialendoscopy also permits both diagnostic assessment and definitive treatment in the same operative session[1].

Indications for sialendoscopy

1. Diagnostic *e.g.* recurrent episodes of swelling of major salivary gland without an obvious cause
2. Treatment (interventional sialendoscopy) of submandibular and parotid sialadenitis, including sialolithiasis
3. Exploration of the ductal system following removal of calculi from the anterior or middle parts of the submandibular and parotid ducts
4. Strictures or kinks of the salivary ductal system
5. Pediatric inflammatory and obstructive pathology

Contraindications to sialendoscopy

Acute sialadenitis is a contraindication as the risks of ductal injury and perforation are increased due to the inflammation and inability to visualize during the procedure from purulent material within the duct.

Sialendoscopy equipment

Rigid and semi-rigid endoscopes have a larger diameter, greater stability, and can be autoclaved (*Figures 15, 16*).

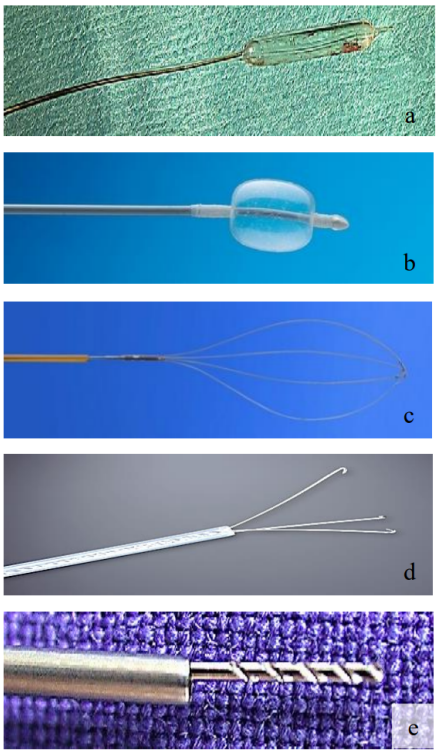


Figure 15: Example of rigid endoscope with working and irrigation ports

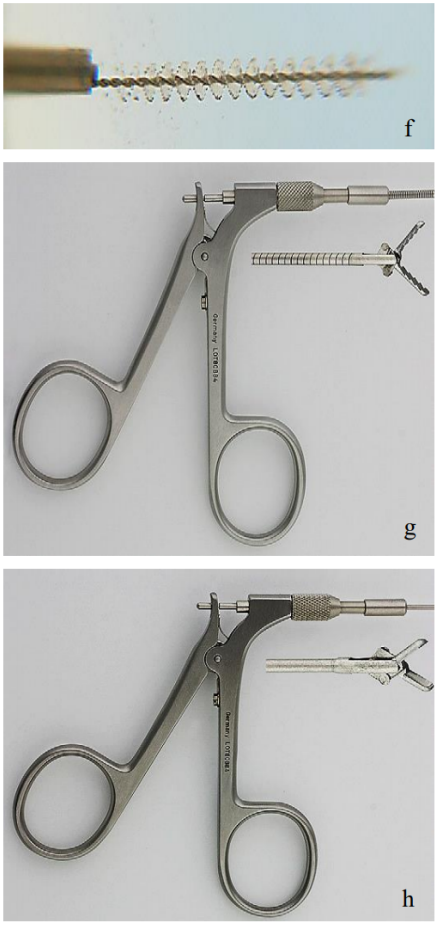


Figure 16: Rigid endoscope, camera and irrigation system

Instrumentation includes an array of grasping forceps, balloons, baskets, graspers, burrs, lasers fibers, and stents (*Figure 17*).



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Figures 17 a-h: Balloons, basket, grasper, hand drill, cytology brush, grasping & biopsy forceps

Sialendoscopy technique

Introducing the endoscope into the ductal papilla, the narrowest portion of the duct, can be challenging. The following methods progressively lead to accomplishing this:

- Use magnification with surgical loupes to visualize and dilate the ductal opening
- Use conical dilators and probes (Figure 18) of increasing diameter to dilate the duct prior to introducing the scope. Alternating the conical dilator between two serial sizes of probes can facilitate this access



Figure 18: Conical dilator, probes of different diameters and papillotomy scissors

- With Wharton's duct:
  - Expose the oral cavity with a mouth prop to permit an unobstructed view of the floor of mouth

- Stabilize the floor of mouth with toothed forceps placed posteriorly and superiorly relative to the punctum. An alternative method is for the surgeon to retract the tongue posteriorly and to the opposite side with a finger, thereby straightening out the punctum, duct and angle-of-approach
- After dilating the duct, pass the tip of the scope into the duct (Figure 19)

- With Stenson's duct:
  - Expose the oral cavity with a mouth prop to permit an unobstructed view of the cheek and punctum
  - Stabilize the bucal mucosa by gently retracting the cheek anterolaterally at the corner of the mouth
  - Negotiating the natural bend in the duct around the masseter muscle is also facilitated by the maneuver
- Passing a guidewire through the working channel of the scope facilitates inserting the scope into a tight papilla (Figure 20)

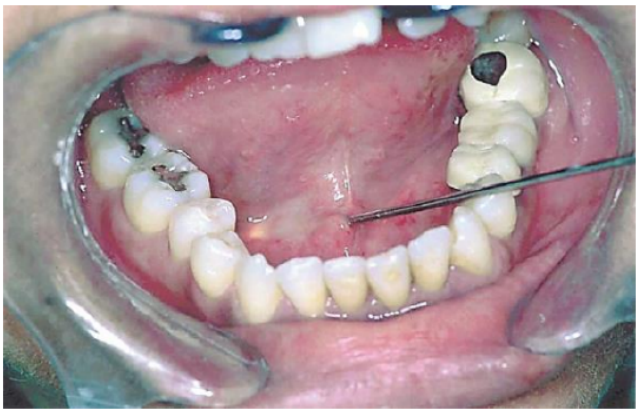


Figure 19: Note light at tip of sialendoscope within the duct

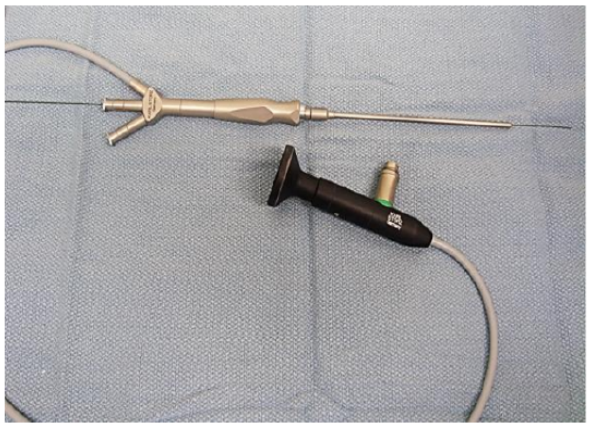


Figure 20: Guidewire inserted through the working channel assists with insertion of endoscope through a tight papilla

Submandibular Stones

Stenosis of the papilla of Wharton's duct may require a cut-down procedure onto the duct; dissecting the sublingual gland laterally and exposing the duct and lingual nerve deep to the duct; and then inserting the sialendoscope. Healing is by secondary intention, or ductoplasty (suturing edges of the duct to the floor of mouth at the end of the procedure) can be performed. With this approach, the duct is best opened along its length superiorly, with the size of the cut limited to the size of the scope used, firstly to avoid transecting the duct and secondly to facilitate not diminishing the hydrostatic pressure required to dilate the duct during the procedure due to escape of wash around the scope.

Saline irrigation is used to expand the otherwise collapsing duct distally. The saline is delivered from a 50-100 mL syringe via intravenous tubing which is attached to the irrigation port of the endoscope (*Figure 16*).

Stones located distally (<1 cm) from the punctum of Wharton's duct can be removed by slitting the duct along its length with insulated needle-tip electrocautery, removal of the lith/stone, followed by sialendoscopy and lavage of the ductal system. The duct heals by secondary intention, and stents are not required to prevent stenosis.

Figure 21 illustrates the unusual situation of a duct that is completely fibrosed at the punctum following removal of a distally located calculus; the distended duct has been exposed (note lingual nerve immediately behind the duct).

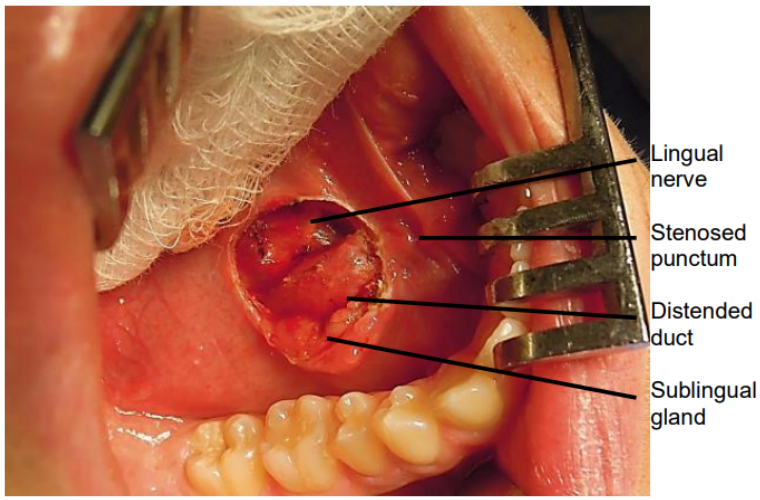


Figure 21: Duct completely fibrosed at the punctum

In *Figure 22* the duct has been transected and translocated to the lateral floor of mouth; absorbable sutures anchor the walls of the duct to the oral mucosa.

Alternatively, treatment for ***distal stones <5 mm is by interventional sialendoscopy. Papillotomy*** frequently must be performed to deliver the calculus because the ostium is the narrowest part of the duct.

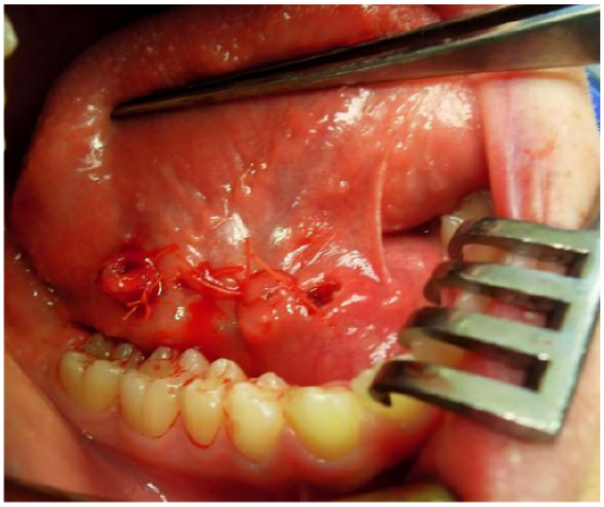


Figure 22: Duct translocated to lateral floor of mouth

Mobile stones located proximally within Wharton's duct and measuring <5 mm, are best removed by ***interventional sialendoscopy using baskets*** passed through the working channel of the sialendoscope (*Figures 17c, 23*).



Figure 23: Calculus clutched by basket

Once a stone is engaged in the basket it often cannot be released. Therefore, the basket is passed beyond the stone and only then opened to avoid the risk of entrapping an immobile, large stone. Another technique is to hold and extract the stone with ***grasping forceps***, without bypassing the stone (*Figures 17g, 24*).

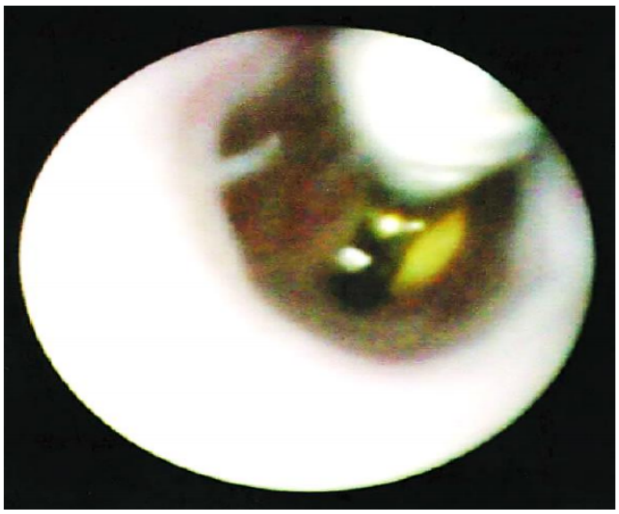


Figure 24: Calculus extracted with grasping forceps

Larger stones may be fragmented with a hand drill (*Figure 17e*) and with forceps (*Figures 17g, h*)); this can be time consuming. Calculi measuring >5 mm and located in the proximal part of Wharton's duct can be removed by *Nahlieli et al.'s* ductal stretching procedure[2] (*Figure 25*) and by limited duct incision.

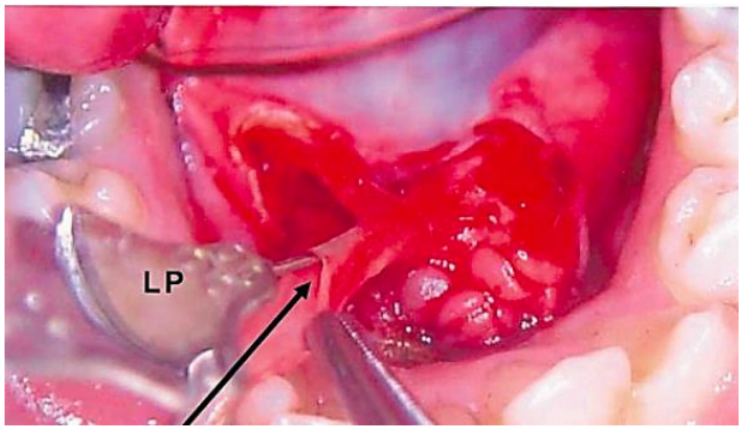


Figure 25: Larger calculi in proximal Wharton's duct removed by ductal stretching procedure with limited duct incision

A safe surgical approach requires a detailed knowledge of the ductal and lingual nerve ***anatomy,*** good ***exposure*** with a mouth prop, and lateral retraction of the sublingual gland with stay sutures passed between the teeth[3].

Repairing the duct proximally can be technically challenging; ***leaving it open*** usually has a good outcome. ***Incising the duct from punctum to hilum*** and then suturing the duct to the floor of the mouth usually avoids ductal stenosis[4]. Alternatively, Marchall[5] ***stents the duct***. A guidewire is passed through the working channel of the sialendoscope and through a ductotomy; the sialendoscope is withdrawn; a stent is advanced over the guidewire; the stent is sutured to the papilla with a nonabsorbable suture and is *left in situ* for about 3 weeks.

Proximal submandibular stones >5 mm in diameter and not able to be removed by transoral techniques can be treated with ***Extracorporeal Shock Wave Lithotripsy (ESWL)*** followed by sialendoscopy. Because of the high calcium content of submandibular calculi, this technique is less successful compared to parotid calculi that have lower calcium content. ESWL is not available or approved for calculi in many countries including the USA.

Parotid Stones

Dissecting along the parotid duct from its oral end may cause stenosis. Interventional sialendoscopy and basket retrieval is the treatment of choice of both proximal and distal parotid stones measuring 5 mm can be treated with ESWL (if available) followed by sialendoscopy. If ESWL is not available, sialendoscopy with any of the various intracorporial fragmentation techniques described above may be performed. Alternatively, a ***gland-sparing approach*** using an external parotid approach combined with sialendoscopy is advocated for calculi of >5 mm within Stensen's duct. Stones are located endoscopically or by intraoperative ultrasound if there is a stenosis distal to the stone. Colored silastic tubing passed up the duct helps to stabilize the duct. An external parotid approach is then used to locate the stone. Nerve monitoring is used, because the duct crosses several branches of the facial nerve. Stensen's duct is then slit lengthwise and the stone is removed. The duct is repaired using 7-0 Prolene. Stenoses can be repaired with a vein graft ductoplasty patch. Check that the closure is watertight by means of transoral back-pressure saline irrigation of Stensen's duct administered via the irrigation channel of the sialendoscope. Fibrin glue may help to secure a salivary seal. Sialostenting introduced either externally or via a sialendoscope and advanced over a guide wire is recommended for 2-4 weeks.

Impalpable intraparenchymal or impacted stones measuring >5 mm

With both submandibular and parotid stones, ESWL followed by sialendoscopy can be performed. A better outcome can be expected for parotid stones (lower calcium content). Multiple intraparenchymal symptomatic stones not amenable to conservative therapy are treated with sialoadenectomy. Where ESWL is not available, sialoadenectomy is advocated for fixed intraparenchymal stones and stones not amenable to the gland-sparing techniques. An expertly performed sialoadenectomy carries a low risk of complication to cranial nerves (V, VII, and XII) and it is a once-off event for the patient without a concern for xerostomia. A balanced informed consent should include sialoadenectomy as an alternative initial approach.

A variety of ***lasers*** have been used for intracorporeal lithotripsy, among them the XeCl-excimer, flash-lamp pulsed dye, the Ho:YAG, and the erbium:YAG laser. An important advantage of most lasers is that the fibers are of small diameter, sometimes only 200µm, yet allow one to deliver highwatt intensities to fragment stones even in the peripheral the ductal system or behind stenotic segments. Visibility is often compromised by floating fragments which are removed by irrigation, baskets, or forceps before

proceeding. Lasers used for intracorporeal lithotripsy are expensive, time consuming, carry a risk of perforating the duct, may require multiple procedures, and can result in the development of abscesses requiring gland removal.

Complications of sialendoscopy

The severity of complications is generally quite modest and includes ductal perforation, basket entrapment, ductal avulsion, postoperative infection and ductal strictures, swelling in the floor of mouth with potential airway compromise and recurrence of symptoms [6]. Risks associated with transoral submandibular approaches include lingual nerve injury and bleeding. Transfacial sialendoscopic approaches can result in trauma to the buccal branches of the facial nerve and formation of a sialocoele; this is managed with Botox (Allergan, Inc. Irvine, CA) and anticholinergics, but is best avoided by a creating a watertight seal and using tissue glue.

Practical tips for the new sialendoscopist

- Attend a hands-on course or get a senior colleague trained in the procedure to assist you
- There is a significant learning curve so choose your initial cases carefully, be patient and allow enough operating time
- Accessing the ducts can be challenging (especially Wharton's duct) so use the appropriate techniques to stabilize the ducts when dilating them
- If you perforate a duct, abort the procedure or call a senior colleague to assist, as the duct may require stenting

Tips about setup and equipment

- Take great care when handling the scopes as they are easily damaged. Nursing and medical staff need to be adequately trained to avoid breakages.
- A 1.3 mm sialendoscope is the most versatile as it has a suitable working channel for most basic instrumentation
- When setting up the camera head to scope the duct, it is important that the orientation of the scope be the same as that on the monitor as disorientation will make it impossible to locate the lumen of the duct
- Guidewires are very useful to access narrowed ducts as well to dilate ductal stenoses

Concluding remarks

Success is measured by treatment that is efficient, clinically effective, cost effective, and gland sparing. Diagnostic and interventional sialendoscopy, and sialendoscopyassisted and transoral techniques have been a major advance, not only by providing an accurate means of diagnosing and locating obstruction, but also permitting minimally invasive surgical management that can successfully address sialolithiasis, and preclude sialoadenectomy in most cases. Multiple or combined measures may prove effective. A flexible methodology is still required [7] .

References

1. Geisthoff UW. Techniques for multimodal salivary gland stone therapy. Oper Tech Otolaryngol 2007;18:332– 40
2. Nahlieli O, Shacham R, Zagury A, et al. The ductal stretching technique: an endoscopic-assisted technique for removal of submandibular stones. Laryngoscope 2007;117:1031–5
3. McGurk M. Treatment for non-neoplastic disease of the submandibular gland. In: McGurk M, Renehan A eds. Controversies in the Management of Salivary Gland Disease. Oxford, UK: Oxford Univ Press; 2001:297–309
4. Zenk J, Constantinidis J, Al-Kadah B, Iro H. Transoral removal of submandibular stones. Arch Otolaryngol Head Neck Surg 2001;127: 432–6
5. Marchall F. Removal of calculi or strictures in salivary ducts that cannot be removed by sialendoscopy. In: Myers EN, Ferris RL, eds. Salivary Gland Disorders. Heidelburg, Germany: Springer; 2007:149–58
6. Walvekar RR, Razfar A, Carrau RL, Schaitkin B. Sialendoscopy and associated complications: a preliminary experience. Laryngoscope 2008;118: 776–9
7. Witt R. Iro H, Koch M, McGurk M, Nahlieil O, Zenk J. Contemporary Review: Minimally Invasive Options for Salivary Calculi. Laryngoscope 2012;122:1306-11

Authors

Robert L Witt MD, FACS
Professor of Otolaryngology-Head & Neck Surgery
Thomas, Jefferson University
Philadelphia, PA, USA
RobertLWitt@gmail.com

Oskar Edkins MBChB, MMed, FCORL
Otorhinolaryngologist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
o.edkins@uct.ac.za

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.9: Parapharyngeal Space

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

The parapharyngeal space (PPS) extends from the skull base above, to the hyoid bone below, and contains fat, the carotid artery, internal jugular vein, and the lower cranial nerves and sympathetic nerve. Surgical resection of tumors of the PPS requires a good understanding of the anatomy, likely pathology (if not known), and surgical approaches.

Relevant Anatomy

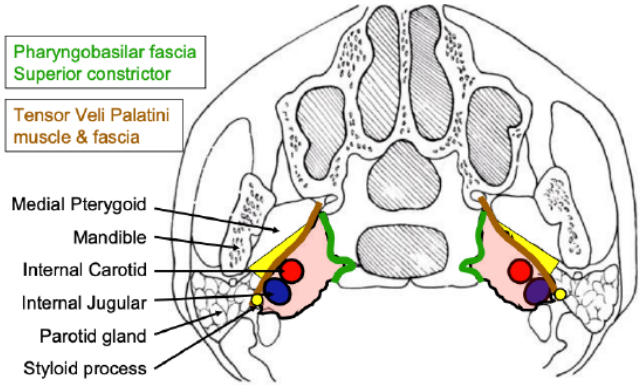


Figure 1: Schematic axial view of prestyloid (yellow) and poststyloid (pink) parapharyngeal spaces

The PPS extends as an inverted pyramid from the base of the skull superiorly, to the hyoid bone inferiorly. *Figure 1* illustrates an axial view of the prestyloid (yellow) and poststyloid components of the PPS, separated by the styloid process, *tensor veli palatini* muscle and fascia stretching between (brown). The poststyloid space contains the internal carotid artery and the internal jugular vein, as well as the lower cranial nerves IX -XII, and the sympathetic trunk. It is confined medially by the pharyngobasilar fascia above, and the superior constrictor muscle of the pharynx.

Prestyloid PPS

Patients typically present with a mass in the lateral oropharynx, displacing the tonsil medially *(Figure 2)*. The prestyloid PPS is bordered anterolaterally by the medial pterygoid muscle, and posterolaterally by the deep lobe of the parotid gland *(Figures 1, 3)*. It extends from the hyoid bone inferiorly, to the skull base superiorly and contains mainly fat



Figure 2: Typical presentation of a prestyloid PPS mass

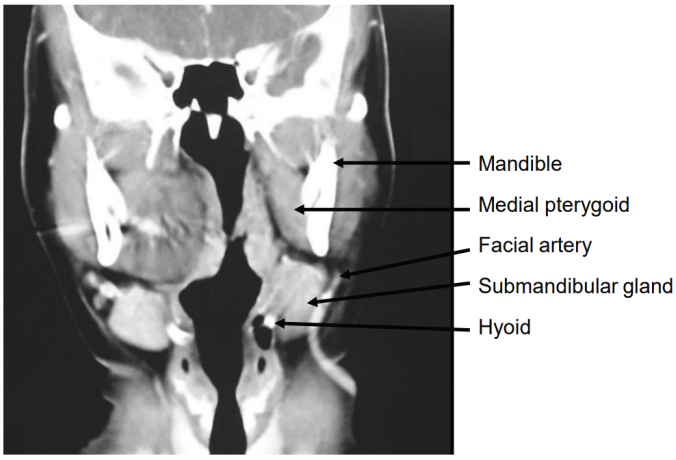


Figure 3: Anatomical relations of prestyloid PPS and contralateral pleomorphic adenoma, to medial pterygoid, submandibular salivary gland, and hyoid bone

Prestyloid tumors displace the PPS fat anteromedially *(Figures 4, 5)*.

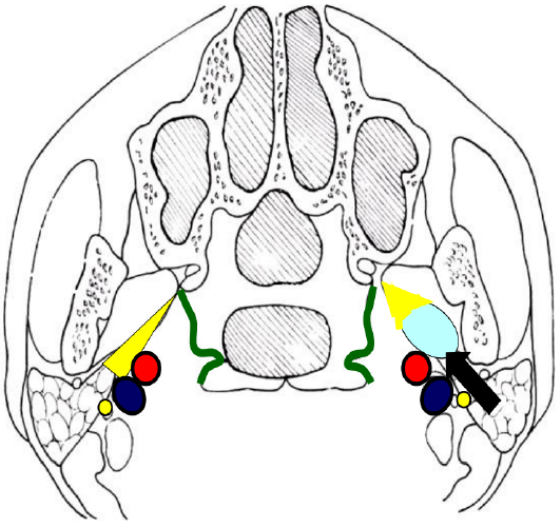


Figure 4: Direction of displacement of fat as seen on CT or MRI with prestyloid PPS mass (light blue)

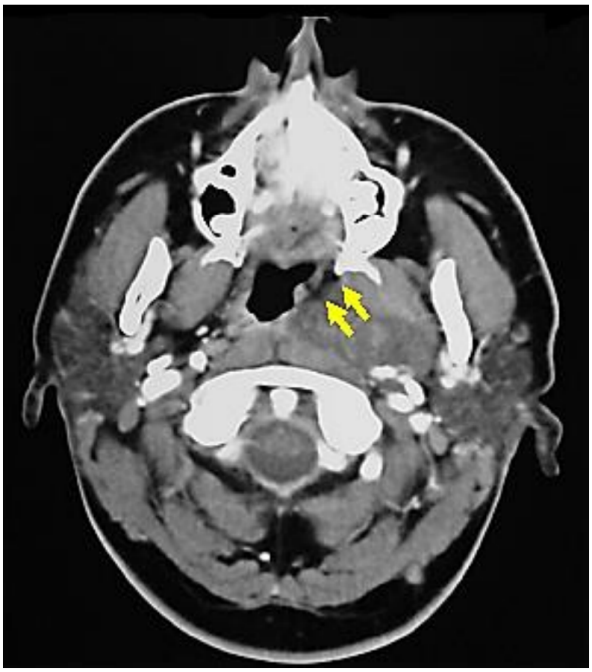


Figure 5: Pleomorphic adenoma of prestyloid PPS displacing fat anteromedially

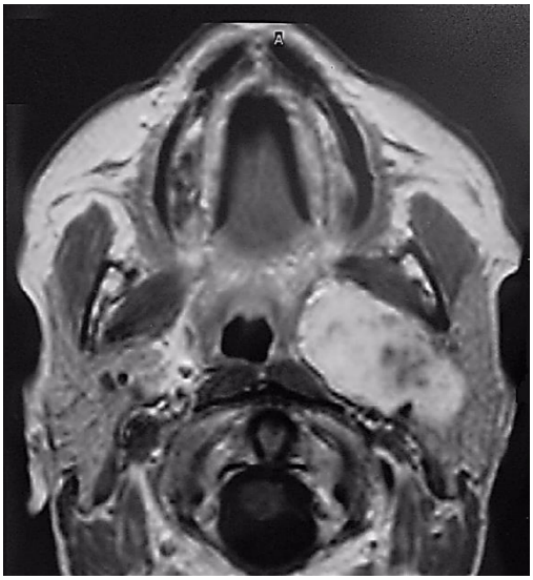


Figure 6: Dumbbell-type deep lobe parotid pleomorphic adenoma extension through stylomandibular tunnel into prestyloid PPS

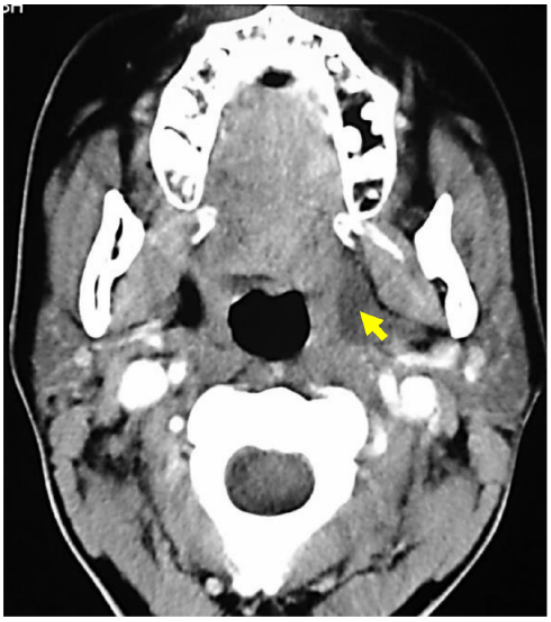


Figure 7: Ranula tracking along prestyloid PPS

Examples of masses commonly encountered in the prestyloid PPS include pleomorphic adenoma *(Figures 3, 5)*, medial extension of a deep lobe parotid tumor *(Figure 6)* and a ranula that has tracked into the PPS *(Figure 7)*.

Poststyloid PPS

Patients typically present with a mass extending into the upper lateral neck in the lateral oro- or nasopharynx, or with dysfunction of cranial nerves IX-XII, or Horner's syndrome. The poststyloid PPS is confined medially by the pharyngobasilar fascia above, and the superior constrictor muscle of the pharynx. It contains the internal carotid artery and the internal jugular vein, as well as the lower cranial nerves IX -XII, and the sympathetic trunk. Unlike prestyloid masses, poststyloid tumors typically displace the PPS fat anterolaterally *(Figures 8, 9)*.

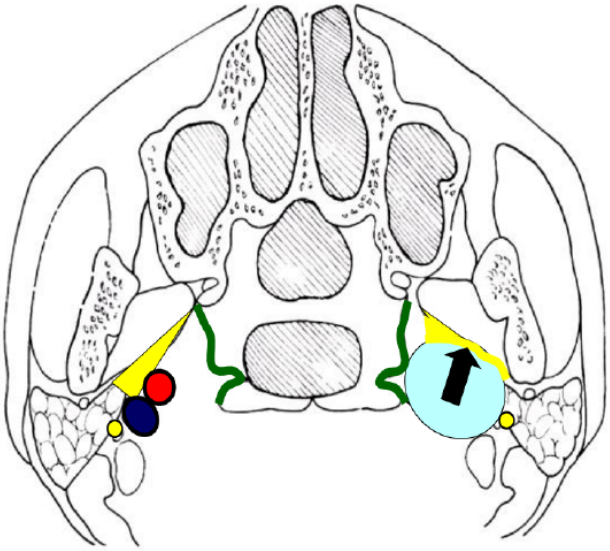


Figure 8: Direction of displacement of fat as seen on CT or MRI with poststyloid mass (light blue)

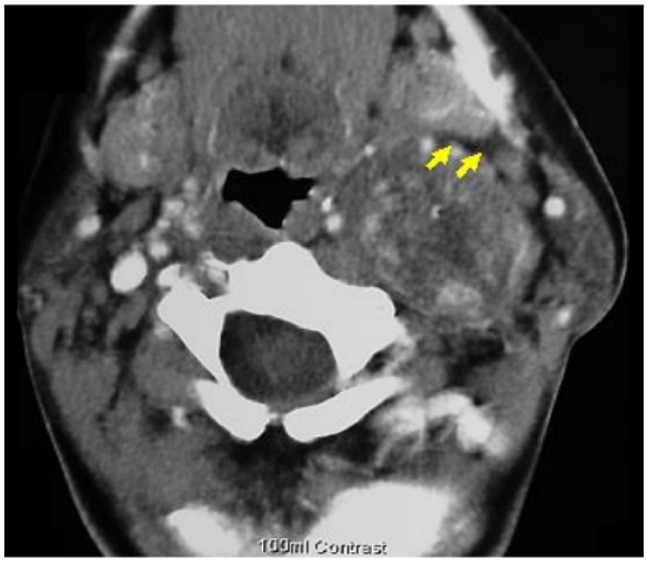


Figure 9: CT scan of poststyloid vagal schwannoma demonstrating direction of displacement of fat and medial displacement of carotid vessels

The most commonly encountered masses include carotid body tumors, or other paragangliomas *e.g.* of the vagus nerve and sympathetic trunk, and schwannomas *(Figures 9, 10)*.

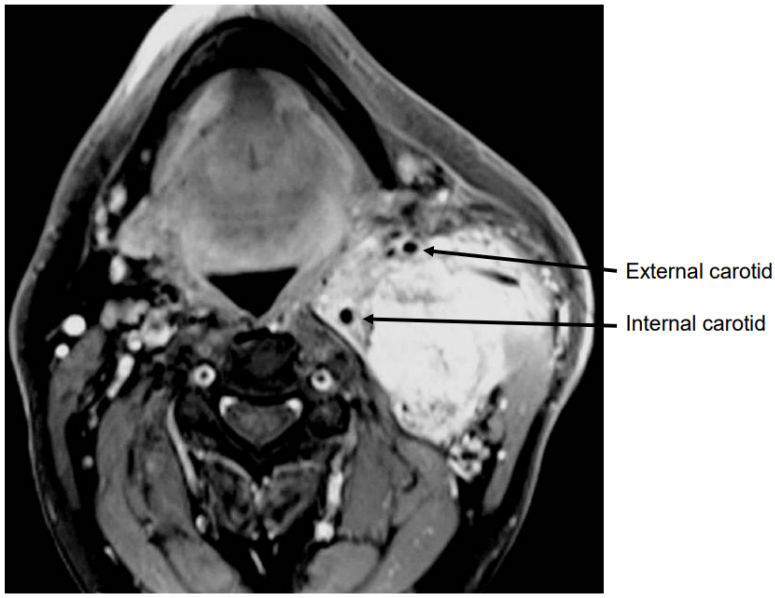


Figure 10: Carotid body tumor in poststyloid PPS, splaying the internal and external carotid arteries

Key Diagnostic Information

One should determine the following before embarking on surgery:

- *Benign / malignant:* This is generally determined by FNAC. The needle biopsy may be done transcervically or transorally. One should not be concerned about puncturing the internal carotid artery with a small needle
- *Vascularity:* A paraganglioma may be suspected on CT or MRI and confirmed angiographically. Vascular tumors may require preoperative embolisation and proximal vascular control, or one may elect to treat it with radiation
- *Prestyloid / poststyloid:* This is determined clinically and radiologically with CT / MRI as indicated previously. This information permits one to narrow down the differential diagnosis, to plan the best surgical approach, and to counsel preoperatively about possible sequelae
- *Is a prestyloid mass originating from the parotid gland?* This information might determine the surgical approach *e.g.* transcervical +/- total parotidectomy. It may be difficult to determine even radiologically whether a prestyloid pleomorphic adenoma simply represents ectopic salivary tissue, or is extending from the deep lobe of the parotid gland

- *Internal & external carotid arteries:* Particularly with poststyloid masses, knowledge of the position of the arteries is important in order to direct the surgery *(Figure 10)*

Surgical Approaches

Figure 11 presents a schematic summary of the surgical approaches to the PPS.

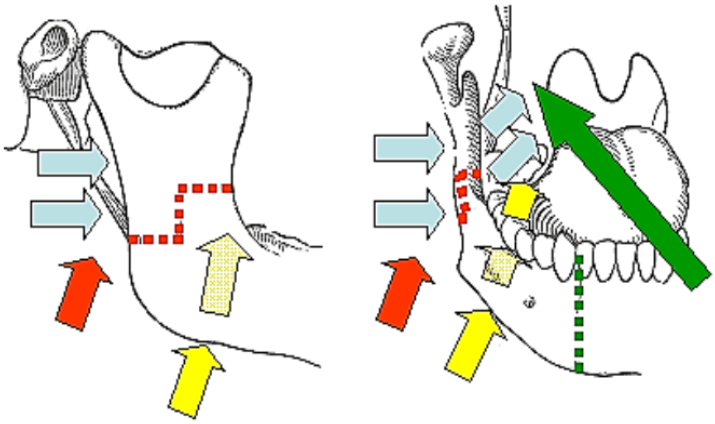


Figure 11: Approaches to PPS: transoral + mandibulotomy (green); transcervical submandibular (yellow), transparotid (blue), and transcervical + mandibulotomy (red)

Prestyloid surgical approaches

Masses in the prestyloid space are mostly benign, well defined, surrounded by fat, and unlike tumors of the poststyloid space, are generally not tethered to structures such as major nerves and vessels. They can therefore generally be removed by careful blunt dissection along the tumor capsule, avoiding tumor rupture (especially with pleomorphic adenomas that may seed). The tumors are situated anywhere between the hyoid bone and the skull base, but generally do not extend above the level of the hard palate or pterygoid plates and are situated on the medial aspect of the medial pterygoid muscle. They are readily accessed via a transcervical submandibular approach. Only rarely a transoral approach + mandibulotomy required. A large tumor arising from the deep lobe of the parotid may require a combined transcervical and transparotid approach.

Transcervical submandibular approach to prestyloid tumors

A horizontal skin crease incision is made at the level of the hyoid bone. The submandibular salivary gland (SSG) and digastric muscle are identified. The anterior facial vein is ligated and divided. The capsule of the SSG is incised. The SSG is mobilized in a subcapsular plane to protect the marginal mandibular nerve. The facial artery is identified posteroinferior to the gland where it emerges from behind the posterior belly of the digastric muscle *(Figure 12)*.

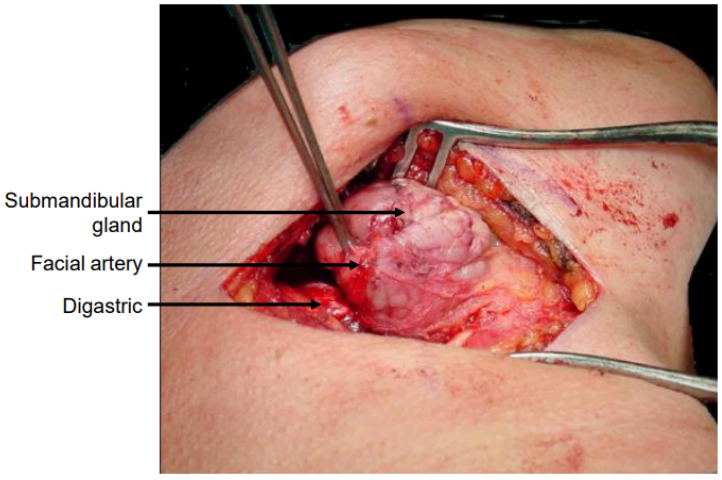


Figure 12: Exposure of left submandibular gland, digastric muscle and facial artery

The facial artery is then ligated and divided above the posterior belly of digastric. The submandibular gland is mobilized with gentle finger dissection in a posterior to anterior direction leaving the thin fascial layer over the ranine veins and the hypoglossal nerve intact *(Figure 12)*. Additional mobility of the SSG may be achieved (if required) by dividing the facial artery and anterior facial vein above the SSG.

By retracting the posterior belly of digastric posteriorly, the mandible superiorly, and the submandibular gland anteriorly the surgeon can pass a finger /instrument directly into the prestyloid PPS *(Figures 13, 14, 15)*.

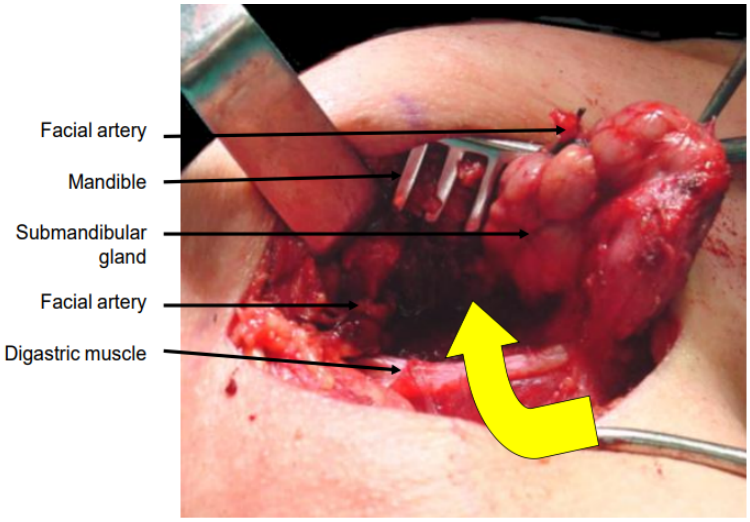


Figure 13: Displacement of submandibular gland for transcervical submandibular access to prestyloid PPS

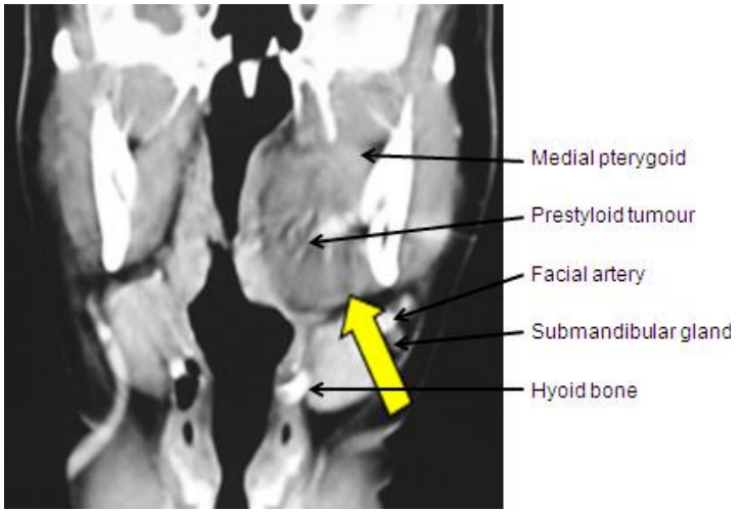


Figure 14: Access to prestyloid PPS mass via transcervical submandibular approach

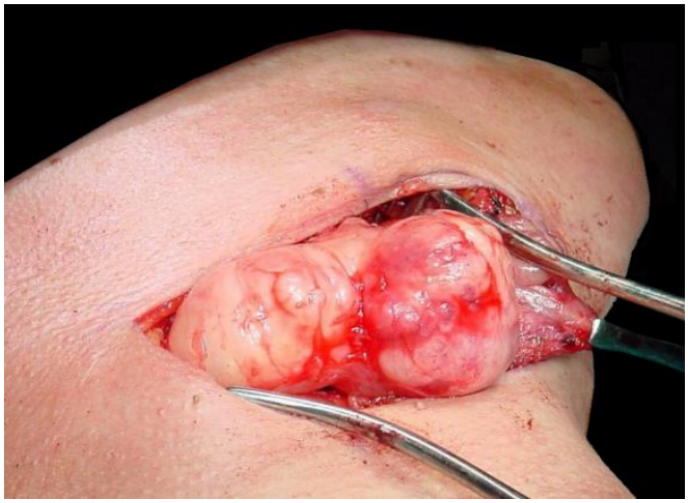


Figure 15: Delivery of prestyloid PPS pleomorphic adenoma via transcervical submandibular approach

Transoral approach to prestyloid tumors

This approach is essentially the same as an extended tonsillectomy and may include a midline or paramedian mandibulotomy for additional access *(Figures 11, 16)*. A disadvantage is that the neck is not opened, and the vessels not exposed in the event of injury to the major vessels requiring proximal vascular control.



Figure 16: Transoral approach to access a prestyloid PPS mass

Combined transcervical submandibular and transparotid approaches to prestyloid tumors

Even large prestyloid tumors *e.g.* arising from the deep lobe of the parotid gland *(Figure 17)* may be resected via a combination of transparotid (see description below) and transcervical approaches.

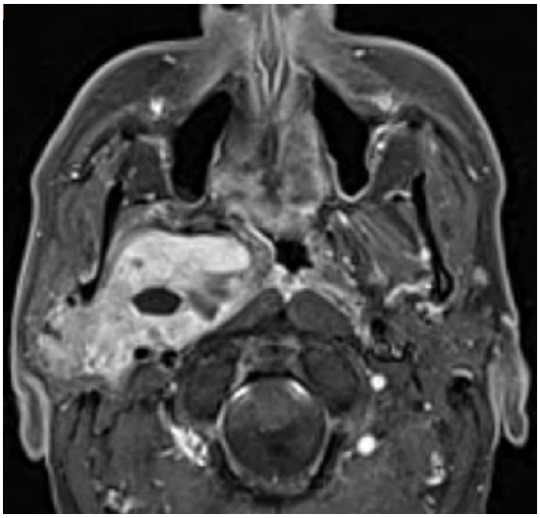


Figure 17: Pleomorphic adenoma arising from deep lobe of parotid extending into PPS resected by combined transcervical submandibular and transparotid approach

Poststyloid PPS surgical approaches

The principal challenges relating to resecting poststyloid masses are avoiding injury to the internal carotid artery, internal jugular vein and the lower cranial and sympathetic nerves. Access is restricted by the vertical ramus of the mandible, the parotid gland, the facial nerve and the styloid process with its muscular and ligamentous attachments.

Masses in the poststyloid space are mostly benign but unlike tumors of the prestyloid space, are generally tethered to/arise from major nerves and vessels. Resection requires good exposure of the mass and the major vessels and nerves via transcervical and/or transparotid approaches. Rarely a mandibulotomy of the vertical ramus of the mandible is required for additional exposure. Patients should be cautioned about the sequelae of vascular and lower cranial nerve injury, as well sympathetic trunk injury causing Horner's and "1st Bite" syndromes. Preoperative embolisation of paragangliomas reduces intraoperative bleeding.

Transcervical approach to the poststyloid PPS (Figures 11, 18)

The transcervical approach is suitable for tumors extending up to about the level of the styloid process, such as smaller carotid body and glomus vagale tumors, as well as lower lying schwannomas. The upper neck is exposed via a transverse skin crease incision, the X, XI, and XII nerves are identified, as are the carotid bifurcation and the internal jugular vein. The mass is then removed using sharp dissection. The posterior belly of digastric is either retracted superiorly or divided to provide access deep to the parotid gland *(Figure 18)*.

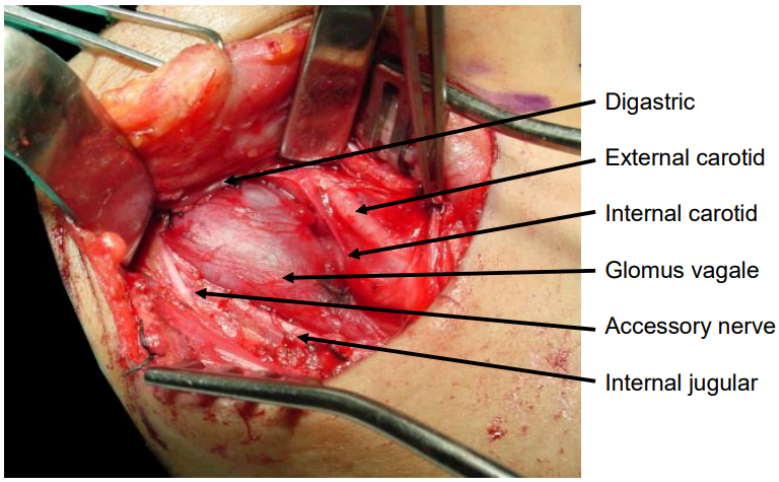


Figure 18: Transcervical resection of glomus vagale

Transparotid approach to the poststyloid PPS (Figures 11, 19, 20, 21, 22)

The transparotid approach is required for masses situated closer to the skull base. The superficial lobe of the parotid gland is elevated off the facial nerve, the nerve is freed from the deep lobe, and the deep parotid lobe is resected. This exposes the styloid process. Immediately medial to the styloid are the contents of the poststyloid PPS. Access can be further improved by excising the styloid process with a bone nibbler and retracting the mandible anteriorly (taking care to avoid excessive tension on the facial nerve), and inferiorly by dividing the posterior belly of the digastric.

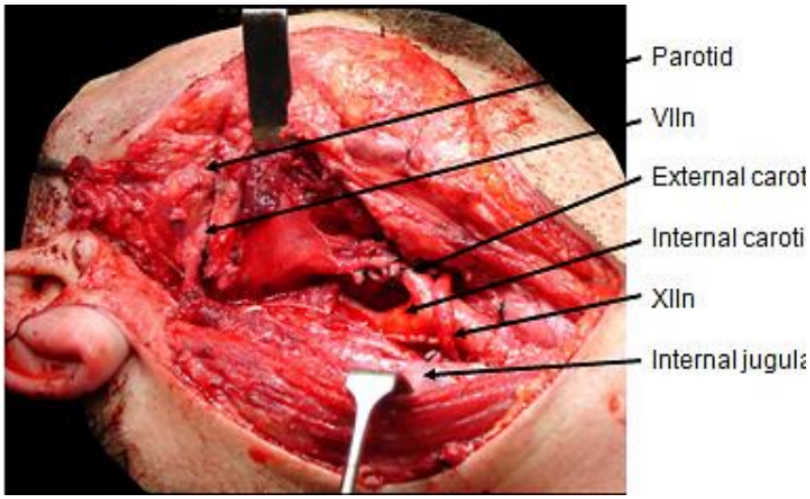


Figure 19: Operative field following resection of carotid body tumor shown in Figure 10

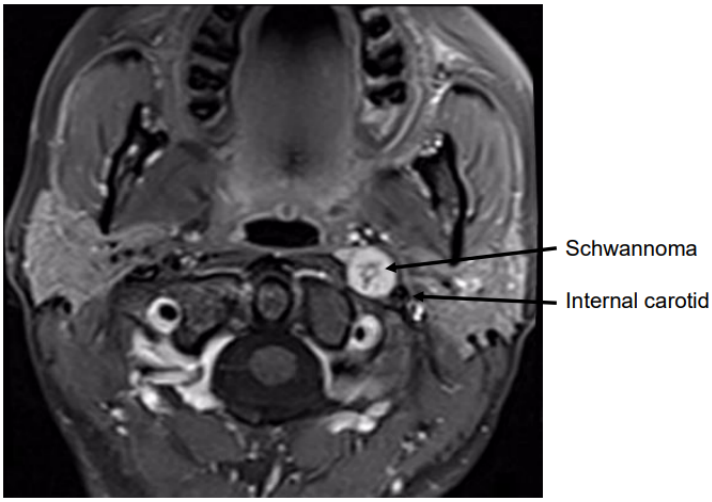


Figure 20: Schwannoma of poststyloid PPS located medial to internal carotid artery

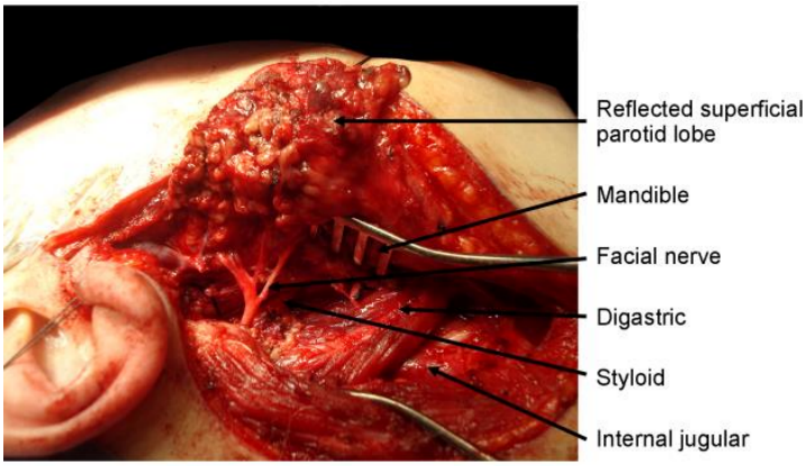


Figure 21: Transparotid access to poststyloid PPS in Figure 20

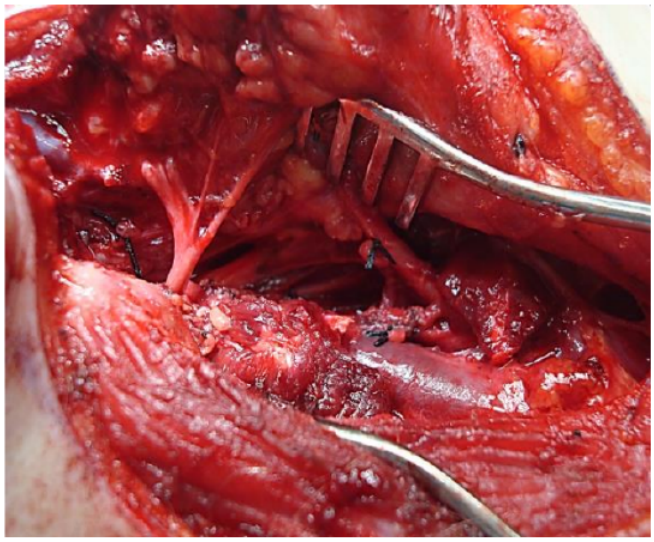


Figure 22: Additional access to poststyloid PPS in Figures 15 & 16 by transection of digastric muscle

Suggested reading

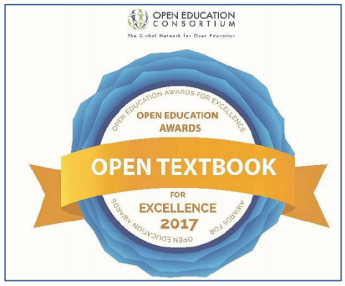
Kundiona I, Fagan JJ. Consequences and complications of surgery for tumors of the pre- versus poststyloid parapharyngeal spaces in 41 patients (our experience). Clin Otolaryngol. 2017 Aug;42(4):886-8

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.10: Resection of Extratemporal Paragangliomas including Carotid Body and Glomus Vagale Tumors

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan & Vincent Vander Poorten

Paragangliomas, also known as glomus tumors or chemodectomas, are neuroendocrine tumors that originate from glomus cells in paraganglia. They are derived from the embryonal neural crest. The cells are part of the sympathetic nervous system and serve as chemoreceptors. They are located in the vascular adventitia of blood vessels which include the carotid bodies in the carotid artery bifurcation *(Figure 1)*.

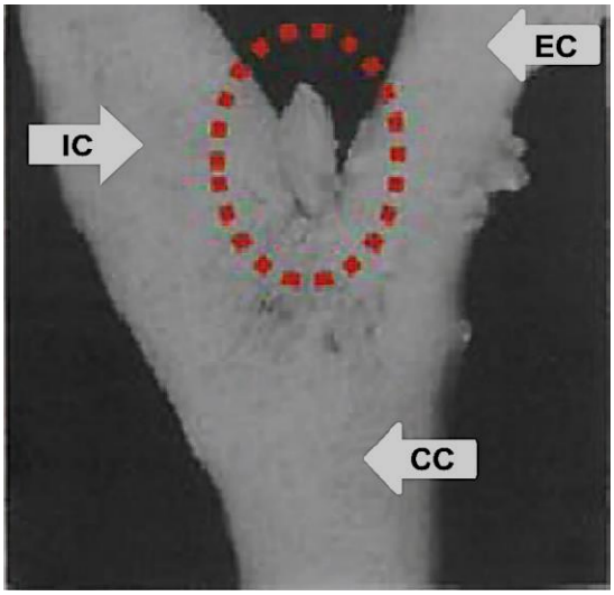


Figure 1: Carotid body within carotid bifurcation; it is equivalent to the size of a grain of rice (Khan Q, Heath D, Smith P. Anatomical variations in human carotid bodies. J Clin Pathol. 1988;41:1196–99)

Paragangliomas occur within the skull base (glomus jugulare, glomus tympanicum), the parapharyngeal space (carotid body tumors, vagal paragangliomas), the larynx and the neck, as well as in the chest and the abdomen. In the head and neck, the carotid body location is most frequent, followed with decreasing frequency in jugular, tympanic and vagal locations. The incidence and prevalence in populations of these rare head and neck tumors remains unclear, as most are benign tumors not captured by cancer registries. The reported proportion of malignant paragangliomas is 6-19%. The malignant nature is demonstrated only by imaging studies showing local invasion, regional or distant metastasis, since the histological appearance of malignant paragangliomas is identical to that of benign tumors[1].

Regarding the genetic basis of these tumors, about 90% of paragangliomas are sporadic, but in 1 in 10 patients a mutation in the gene coding for succinate dehydrogenase (SDH) subunits (SDHD, SDHB, SDHC) is observed. These patients typically develop multifocal paragangliomas already under 40 years of age, and also present with ***phaeochromocytomas***. The latter are neuroendocrine tumors of the adrenal medulla and are closely related to paragangliomas. Unlike paragangliomas they are chromaffin positive and hence secrete catecholamines.

This chapter focuses on the surgical management of extratemporal paragangliomas of the head and neck. Even though surgery remains the mainstay of therapy for easily resectable paragangliomas, many of these tumors are very slowly growing, or do not even grow at all; hence a watchful waiting approach with serial imaging (“Wait and See approach”) may be preferable. Another treatment modality to be considered is irradiation.

Surgically relevant issues

Not all paragangliomas need surgery

On the one hand, an initial ***wait-and-scan policy*** can be justified for many patients based on the slow growth rate, with half of tumors not increasing in volume during long-term follow-up[2]. In a recent study of cervical paragangliomas followed up for a mean of 5yrs (1-17ys), 42% tumors remained stable, 38% grew, and 20% reduced in size. In those that grew, the mean growth was only 2 mm p.a.[3]

On the other hand, in documented volume increasing lesions, both ***radiotherapy*** and ***surgery*** are valid options.

Radiotherapy can consist of Intensity Modulated Radiotherapy (IMRT) using a moderate-dose of 44-50 Gy in 22-25 fractions[1], or stereotactic radiosurgery[4] in selected very small skull base lesions.

Although radiotherapy is not curative, 10-year local control rates using RT of 94% and higher have been reported[5, 6]. Radiotherapy, however, is associated with a (<1%) risk of radiation-induced malignancy, and the natural course of tumor growth mentioned above does question whether the purported benefits of radiation have in fact been overstated. Anyhow, this modality should - like surgery - only be considered in paragangliomas with a documented growth on serial scanning.

Given the potential complications, ***surgery*** is best reserved for limited paragangliomas where minimal morbidity is expected. Typically, these are the carotid body tumors that are classified as *Shamblin* Group I (small, easily dissected from the vessels) and Group II (glomus tumor partially surrounding the vessels). The former constitutes 70% of paragangliomas. For all other tumors (Group III carotid body tumors and vagal – jugular – tympanic paragangliomas), iatrogenic postoperative cranial nerve deficits are hard to avoid. A recent review estimated the prevalence of complications in surgically treated carotid paragangliomas as 22% postoperative cranial nerve deficits, 3% strokes, and 1% perioperative deaths[7]. Reviewing the literature on vagal and jugular paragangliomas, the same authors concluded that on average 1 extra postoperative cranial nerve deficit occurs per patient operated, which is much more than the 8 post-treatment cranial nerve deficits per 100 patients treated with radiotherapy, at a comparable local control rate of 80-90% for both modalities. The authors conclude that, compared to surgery, radiotherapy results in comparable tumor control, but significantly less morbidity. Choosing between the two modalities, one should consider the patient's age, tumor size and Shamblin type, observed tumor growth and cranial nerve function at presentation, and eventually catecholamine production, in order to maximally safeguard quality of life.

Therefore, patients with paragangliomas without features of malignancy, and in the absence of catecholamine induced chronic hypertension and its negative long-term cardiovascular effects, should be given the option of observation. This applies especially to patients with high surgical or anesthetic risk, or with asymptomatic vagal paragangliomas where resection is certain to cause vagus nerve (and probably also hypoglossal) paralysis.

Vascularity

The extreme vascularity of paragangliomas may make surgery challenging. With intratemporal paragangliomas this manifests as pulsatile tinnitus, and a red vascular mass may be visible behind an intact tympanic membrane. In the neck it may manifest as a pulsatile mass in the region of the carotid bifurcation. CT typically shows contrast enhancement *(Figure 2)* and signal flow voids may be evident on MRI *(Figure 3)*. Angiography shows a rich vascular network *(Figure 4)*. Given the high diagnostic accuracy of modern imaging, attempts at taking biopsies from these lesions is considered to be contraindicated.

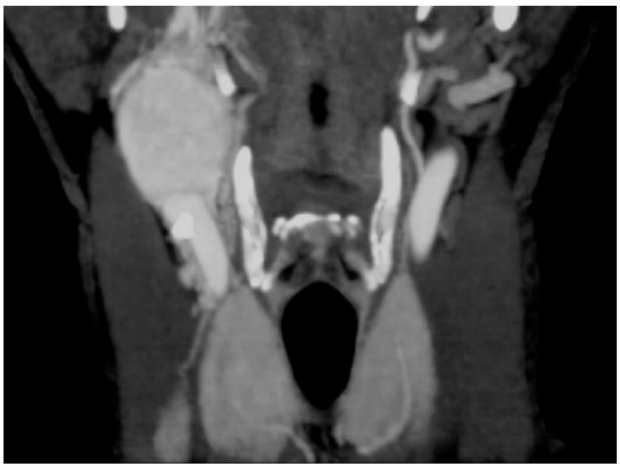


Figure 2: Coronal CT scan shows contrast enhancement of a carotid body tumor

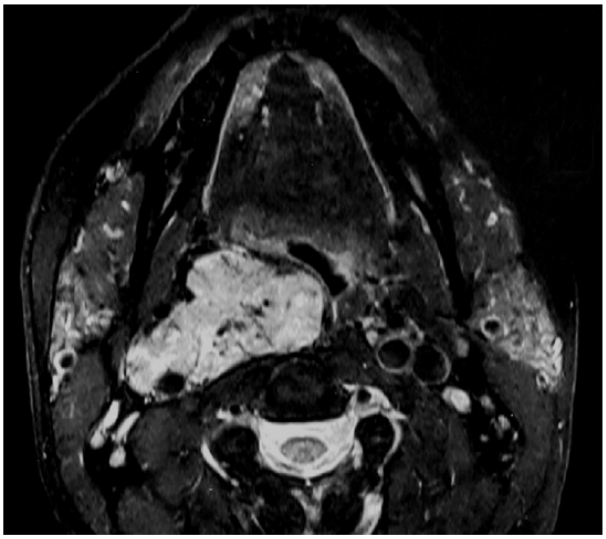


Figure 3: MRI shows (black) signal flow voids of carotid vessels and smaller arteries within a carotid body tumor

Lack of encapsulation

Especially with carotid body tumors, thin-walled vessels cover the surface of the tumor and blend with the adventitia covering the carotid vessels. Because of their thin walls, monopolar cautery is ineffective; hence the need to dissect the tumor from the carotid arteries in a subadventitial plane and to control bleeding from the multitude of thin-walled vessels with bipolar cautery or with multiple ties *(Figure 5)*.

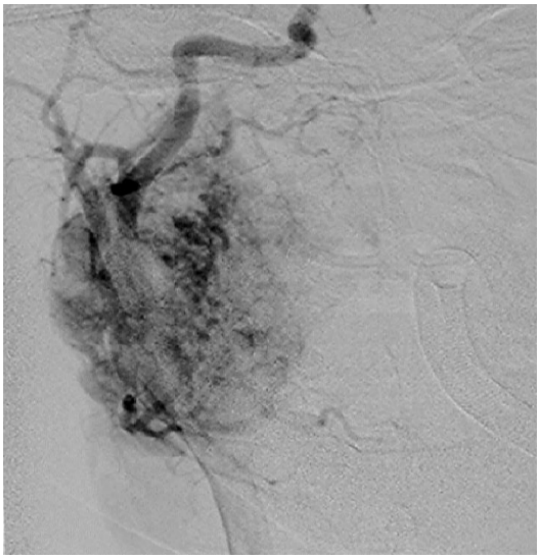


Figure 4: Angiogram illustrating vascularity of a carotid body tumor

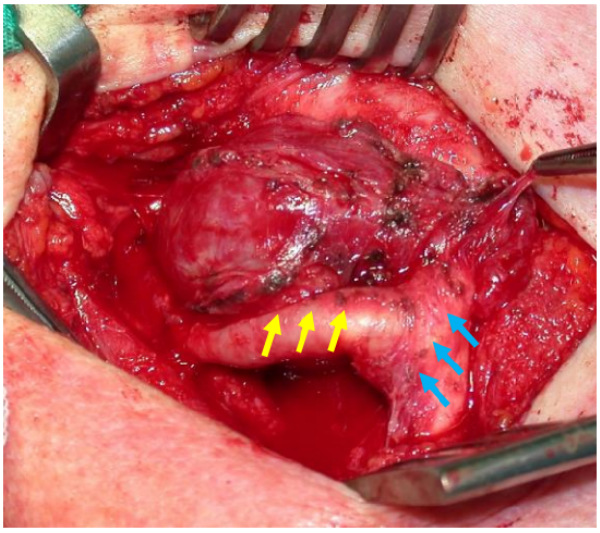


Figure 5: Bipolar cautery has been used to achieve hemostasis, and dissection is maintained in a subadventitial plane (yellow arrows) on the internal carotid artery; retained adventitia indicated by blue arrows (right neck)

Nerves at risk of injury

It is not uncommon for the hypoglossal *(Figure 6a)*, descendens hypoglossi *(Figure 6b)*, superior laryngeal, vagus, and accessory nerves and the sympathetic trunk to be involved by a carotid body tumor. With glomus vagale tumors the vagus nerve is at significant risk of permanent surgical injury, but also the hypoglossal nerve and the sympathetic chain may be embedded within a vagal paraganglioma. These nerves need to be carefully identified beyond the confines of the tumor before commencing the tumor resection so that they can be dissected free and preserved if at all possible.

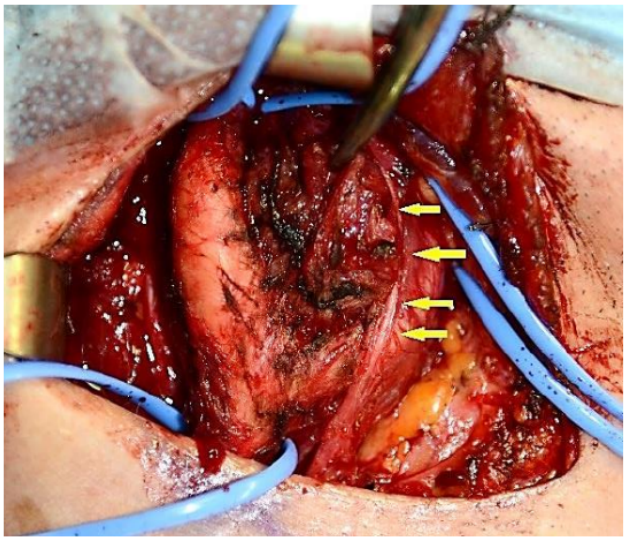


Figure 6a: After vessel-loop control of the common, internal and external carotid arteries, subadventitial dissection of this right sided Shamblin type I carotid body tumor proceeds using bipolar cautery; arrows indicate descends hypoglossi branch to ansa cervicalis

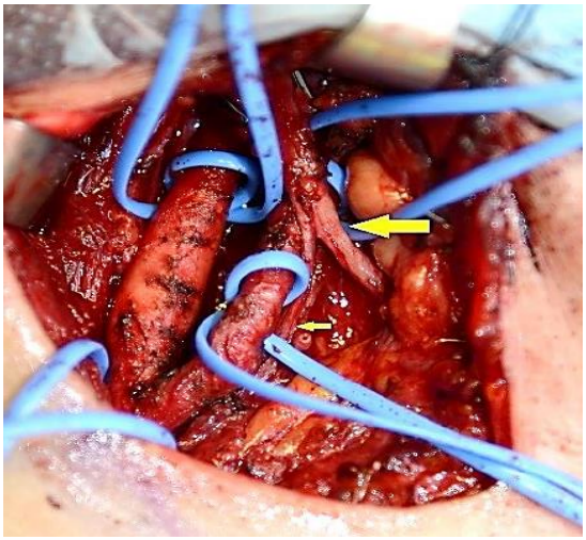


Figure 6b: Situation after removal of the tumor shows the preserved hypoglossal nerve (big arrow) and descendens hypoglossi (small arrow)

Catecholamine secretion

Phaeochromocytoma-like symptoms due to catecholamine secreting tumors occur in 1–3% of patients with paragangliomas in the head and neck, and manifest with palpitations, hypertension, headaches, and sweating. If left unattended, heart failure and arrhythmia will ensue in the long run. Failure to detect catecholamine secretors can lead to life-threatening hemodynamic instability during embolization or surgery. Perioperative optimisation includes adrenergic receptor blocking agents. Hence the need to test for free catecholamines so that secretors can be optimized preoperatively. Alternately one can test for urinary metanephrine levels or urinary vanillylmandelic acid (VMA) levels (least expensive, but least specific). Because secreting paragangliomas in the head and neck are so uncommon, raised catecholamines should prompt one to exclude the presence of a phaeochromocytoma. Proton pump inhibitors may cause false positive elevation of serum chromogranin A; if elevated, PPIs should be discontinued for a week and the test repeated.

Genetic screening

A family history is associated with increased likelihood of multiple paragangliomas and of patients presenting at an earlier age. There are various genetic mutations of which 10% are hereditary[8].

Patients with a positive family history and those with multiple paragangliomas must be offered genetic testing, although nowadays it could be argued that all patients deserve genetic testing as often an SDH mutation is found despite a negative family history. Paragangliomas also occur in MEN syndromes types 2A and 2B.

Multiple paragangliomas

About 10% of carotid body tumors are bilateral. Multiple paragangliomas should be suspected in patients with a positive family history and with head and neck paragangliomas that have raised catecholamines *(Figure 7)*.



Figure 7: Bilateral carotid body tumors (*) and left vagal paraganglioma (arrow) in a patient with a SDH-D mutation. Following this diagnosis the patient's brother was also diagnosed with an SDH-D mutation and multiple paragangliomas

Radiological investigations

Radiological investigations may determine the following:

Confirm that it is a paraganglioma

CT, MR and MR angiography of the head and neck have such typical findings, that they obviate the need for a (hazardous) biopsy. Imaging studies reveal the location, extent, relation to the great vessels, and unsuspected coexistent paragangliomas at other sites.

CT with contrast typically shows a hyperaemic mass *(Figures 2, 8)*. A small paraganglioma may however not enhance if peak-tumor opacification is mistimed; the mass may then be mistaken for a schwannoma or a lymph node. Metastatic papillary carcinoma of the thyroid may also enhance with contrast.

MRI reveals a hyperaemic mass with signal flow voids on T2 *(Figures 3, 9b)* sometimes giving a classic *salt-and-pepper sign*.

Carotid body tumor vs. vagal paraganglioma

Carotid body tumors classically splay the internal and external carotid arteries (Lyre sign) *(Figures 8a, b)*; vagal paragangliomas displace the internal and external carotid artery anteriorly *(Figures 9a, b)*.

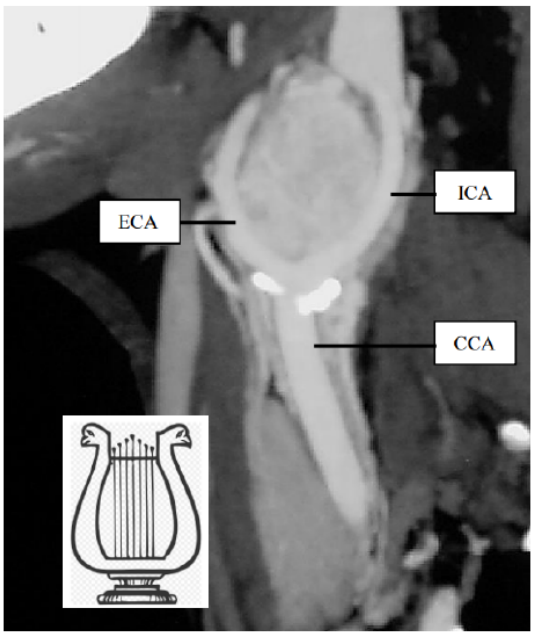


Figure 8a: Splayed carotid bifurcation (Lyre sign)

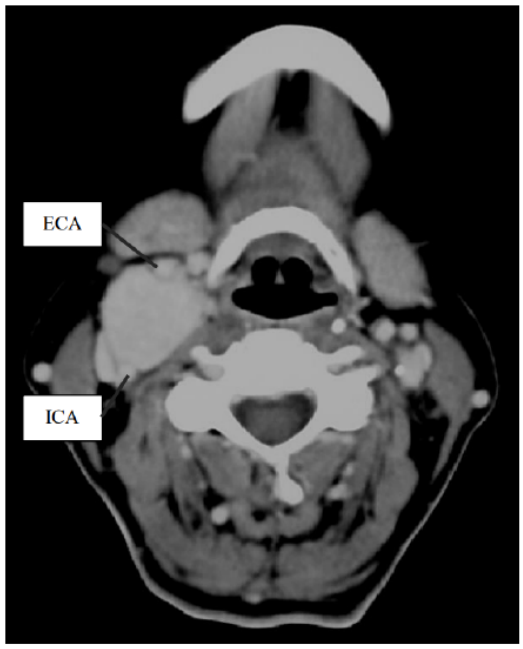


Figure 8b: Carotid body tumors splay the internal and external carotid arteries

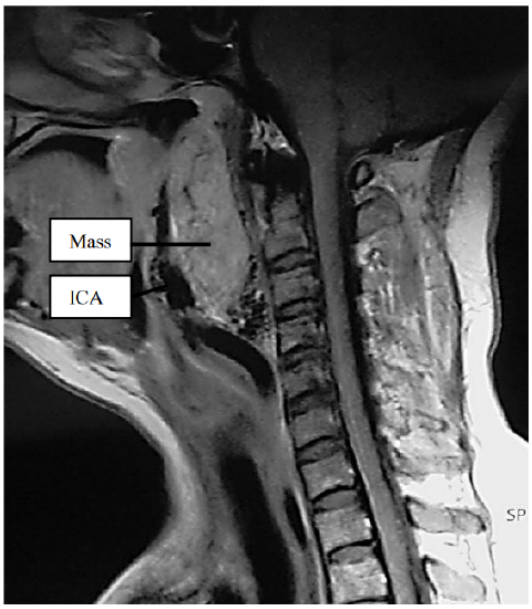


Figure 9a: Vagal paraganglioma displacing the internal carotid artery anteriorly



Figures 9b: Vagal paraganglioma typically displaces the internal carotid artery anteriorly

Resectability

Resectability is largely determined by the degree of involvement and encasement of the common and internal carotid arteries. Preoperative classifications however have limitations as tumor adherence to the carotid can ultimately only be determined at surgery during subadventitial dissection.

The ***Shamblin classification*** *(Figure 10)* groups carotid body tumors according to the degree of encasement of the carotid vessels. *Group I* tumors are minimally attached to the carotids and are easily resected. *Group II* tumors partially surround the carotids, are generally more adherent to the adventitia and more difficult to resect, though still amenable to subadventitial resection. *Group III* tumors encase the entire circumference at the carotid bifurcation; surgical dissection may be impossible and is more likely to require sacrifice and grafting of the internal carotid. As stated above, nonsurgical treatment e.g. radiation therapy should be considered for Group III tumors; if surgery is elected, it may be prudent to do an angiogram to check cerebral crossflow, and the surgeon should be experienced, and a vascular surgeon should be on standby.

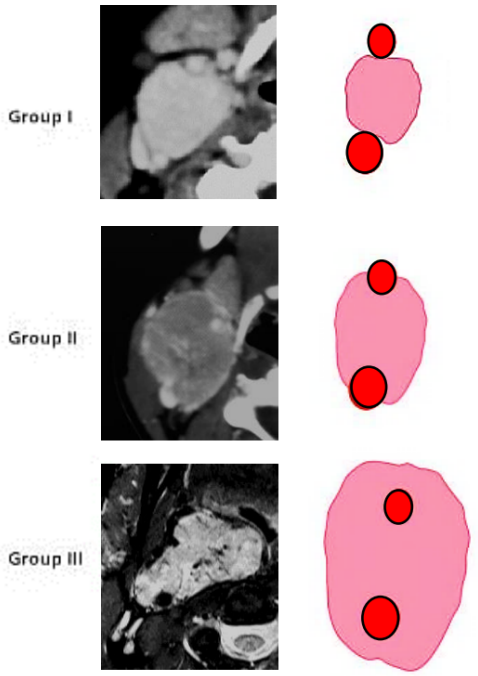


Figure 10: Shamblin classification of carotid body tumors; all 3 tumors on the left were resected without vascular complications

Surgical relationship to carotid vessels

CT or MRI is employed to determine the position of the internal and external carotid arteries relative to the mass to provide a roadmap for the surgeon to plan a surgical approach.

Multiple paragangliomas

Additional paragangliomas may influence management and should be suspected in patients with a family history, and with head and neck paragangliomas that have raised catecholamines. They may be detected by imaging studies *e.g.* ultrasound, CT, MRI or angiography. A somatostatin receptor scan (octreotide scan) can also be very useful to assess the entire body to detect multiple paragangliomas.

Principal feeding vessel(s)

The ascending pharyngeal artery is generally the principal feeding vessel for carotid body tumors. Some surgeons prefer to have the artery embolised preoperatively to facilitate the resection.

Stroke risk with occlusion of common or internal carotid artery

When concerns exist that cerebral blood flow may be interrupted when resection necessitates division of the common or internal carotid arteries, then preoperative angiography (with balloon occlusion test to check for patency of the Circle of Willis) may be employed to check the degree of cerebral crossflow. When available, it is recommended to use perioperative brain oxygen saturation monitoring *(Figure 11)*.



Figure 11a: Electrodes placed on patient's forehead to monitoring brain oxygenation using the ForeSight system ®



Figure 11b: Symmetry of oxygenation can be followed throughout the procedure using the ForeSight system ®

Clinical presentation

- Cervical mass
  - Generally, a non-tender asymptomatic mass; vagal paragangliomas may be more cephalad
  - Mobile in transverse, but not vertical planes
  - May be pulsatile and have a bruit
  - May extend cephalad within the poststyloid parapharyngeal space to the cranial base and medially displace the lateral pharyngeal wall
  - May produce vague pain, hearing loss, pulsatile tinnitus
- Bilateral (10% carotid body tumors)
- Nerve palsies in about 10% o Cranial nerves IX (velopharyngeal insufficiency), X (hoarseness, aspiration), XI (shoulder weakness), XII) o Horner's syndrome
- Phaeochromocytoma-like symptoms: up to 3% secrete catecholamines

Preoperative assessment

- Is it a paraganglioma?
  - Family history o MEN type 2A and 2B
  - Imaging (do not required all three)
    - CT with contrast
    - MRI
    - Angiography
- Is it secreting or non-secreting?
  - 24-hour urinary catecholamines and metanephrines
  - Plasma metanephrine if at high risk *e.g.* predisposing genetic syndromes, family history of phaeochromocytoma)
- If secreting
  - Exclude phaeochromocytoma
  - Refer to physician or anesthetist for pre- and perioperative optimization including adrenergic receptor blocking agents
- Has a “Wait and scan” strategy demonstrated growth?
- Is it resectable – what is the Shamblin group?
- Is it malignant?
- Is the patient a good surgical candidate?
- What alternative management is available?
- Are there other paragangliomas?
  - Ultrasound neck and abdomen
  - CT / MRI of skull base to abdomen
  - MIBG scan
- If for surgery
  - Possible consequences and complications?
  - What side to operate on 1st with bilateral carotid body tumors?
    - Generally, operate on easier side as less likely to cause cranial nerve complications
    - If have cranial nerve complication, then still have the option to observe or irradiate the 2nd side
  - What is the position of the carotid vessels relative to the tumor?
    - Important for planning the surgical approach and performing the surgery
    - Contrasted CT / MRI / angiogram o Should the tumor be embolized preoperatively?
    - Conflicting views among surgeons about benefits of embolization
    - Potential for neurological complications
    - Greatest theoretical value with large tumors
    - Most commonly embolize the ascending pharyngeal artery
  - What is the cerebral crossover blood flow like should the common or internal carotid artery have to be sacrificed? Should this be a concern it can be determined by angiography +/- balloon occlusion tests

Surgical approaches

The principal challenges relating to poststyloid masses are avoiding injury to the internal carotid artery, internal jugular vein and the lower cranial (especial XII) and sympathetic nerves. Access is limited by the vertical ramus of the mandible, the parotid gland, the facial nerve and the styloid process with its muscular and ligamentous attachments.

Carotid and vagal paragangliomas are located in the poststyloid parapharyngeal space and are initially approached via the transcervical approach; additional anterior exposure is achieved by a transcervicalsubmandibular approach; and additional superior access is achieved by including the transparotid approach *(Figures 12, 22)*. (See chapter Access to Parapharyngeal Space). Patients should therefore always be consented for transcervical and transparotid approaches. The authors have never had to resort to a mandibulotomy.

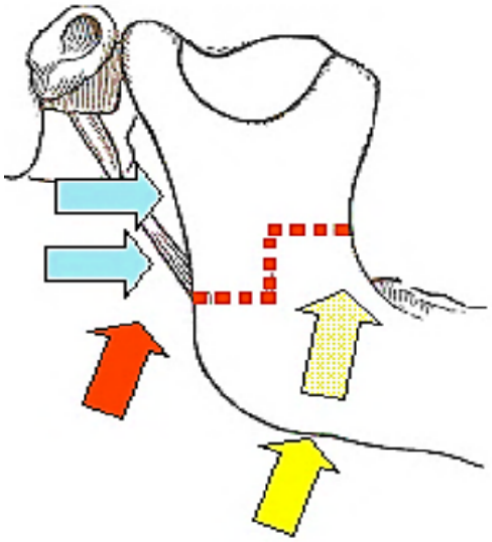


Figure 12: Surgical approaches: transcervical submandibular (yellow), transparotid (blue), and transcervical + mandibulotomy (red)

Consent

Patients should be cautioned about the sequelae of vascular and lower cranial nerve injury, as well injury to the sympathetic trunk causing Horner's and "1st Bite" syndromes.

Anesthesia

- Oral or nasal endotracheal intubation
- Avoid muscle relaxants so that cranial nerves VII, X, XI, XII can be monitored
- No antibiotics unless pharynx is entered
- Routine anesthetic monitoring unless a secreting paraganglioma
- If a secreting tumor
  - Ensure that adrenergic system was adequately blocked in the preoperative phase
  - Monitor blood pressure with arterial line
  - Have appropriate drugs available to control blood pressure fluctuations
- Blood: either Grouped and Screened, or cross matched
- Brain oxygenation can be monitored particularly with Shamblin 3 tumor resections *(Figures 12 a, b)*

Surgical equipment to have available

- Bipolar electrocautery
- Vascular sutures and vascular loops to place around vessels and nerves
- Vascular forceps
- Lahey vascular clamp *(Figure 13)*



Figure 13: Lahey vascular clamp

Surgical technique

- Place the patient supine with neck extended and turned to the opposite side
- Inject local anesthetic with 1/100000 adrenaline along the incision line, especially preauricularly
- Sterilize the face and neck
- Drape the patient but keep the corners of the mouth and eye exposed to monitor facial movement if a transparotid approach is to be employed

- Open the neck as indicated in *Figure 14*. The incision for the transcervical approach is made at the level of the hyoid bone. The parotid incision may be delayed until it is found that the transcervical approach does not provide adequate access

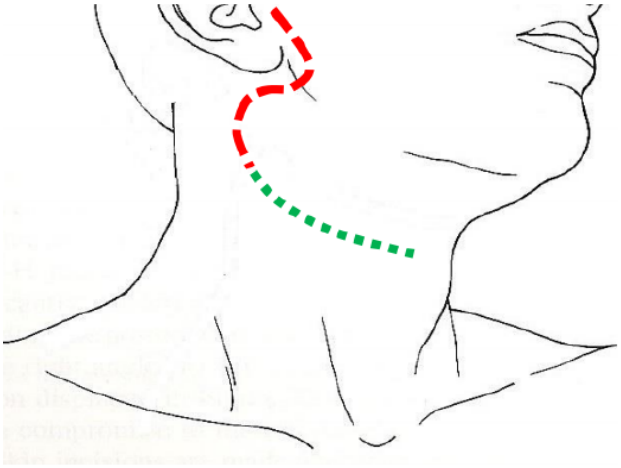


Figure 14: Skin incisions: Green for transcervical +/- submandibular approach; add red incision for transparotid approach

Transcervical approach(Figure 15)

- The transcervical approach is suited to paragangliomas extending up to the level of the styloid process
- Expose the upper neck via a transverse skin crease incision at the level of the hyoid bone (Figure 14)
- Extend the skin incision posteriorly over the sternocleidomastoid muscle
- Divide the platysma muscle taking care not to injure the greater auricular nerve which should be preserved
- Ligate and divide the external jugular vein just anterior to the greater auricular nerve to improve access to the upper neck
- Identify the paraganglioma, taking care not to traumatize its thin-walled surface vessels (Figure 15)
- Proceed to identify as many of the following anatomic structures around the paraganglioma (Figure 16)
    - Common carotid artery
    - Carotid bifurcation
    - Internal carotid artery
    - External carotid artery
    - Internal jugular vein
    - Posterior belly of digastric muscle
    - Hypoglossal nerve
    - Descendens hypoglossi
    - Vagus nerve
    - Accessory nerve
    - Sympathetic trunk
    - Superior laryngeal nerve
- One may opt to place vascular loops around the major vessels for vascular control should a vascular injury occur *(Figure 6)*
- Use a combination of sharp dissection and bipolar cautery to dissect nerves free that are trapped in the surface of the mass, most commonly the hypoglossal nerve *(Figure 17)*

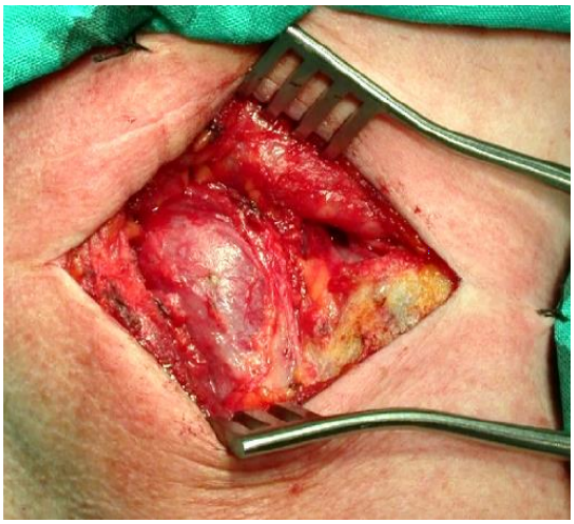


Figure 15: Carotid body tumor exposed in right neck

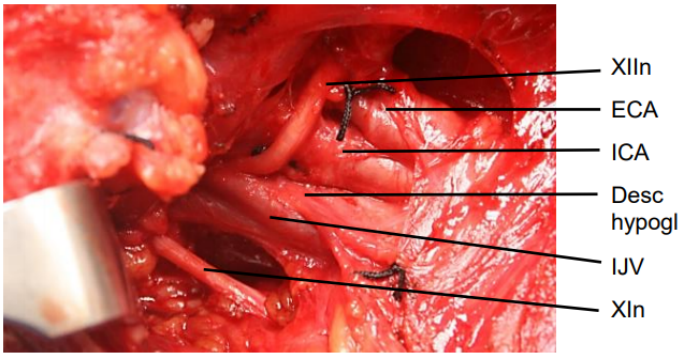


Figure 16: Structures around a paraganglioma; the sympathetic trunk is found on the posterior aspect of the carotid sheath

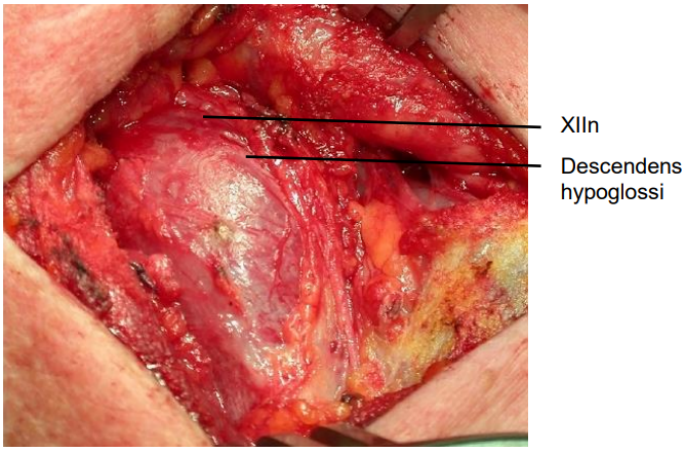


Figure 17: XIIn and descendens hypoglossi running in the surface of the paraganglioma, having to be dissected free

- Next direct your attention to the periphery of the mass at the common, internal or external carotid arteries or the carotid bifurcation
- Establish a subadventitial dissection plane on the artery (Figure 18)
- Dissect the mass off the arteries with scissors keeping in this subadventitial plane (Figures 18, 19, 20)

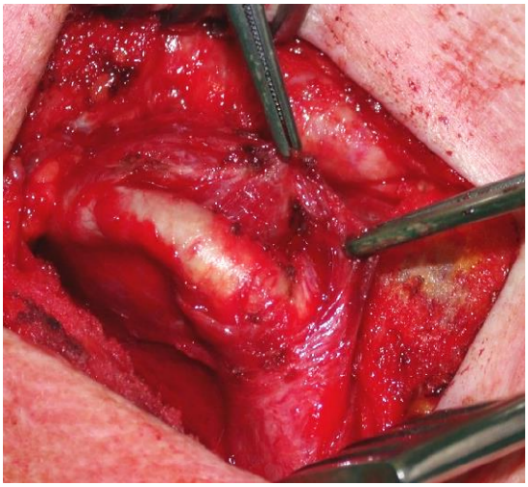
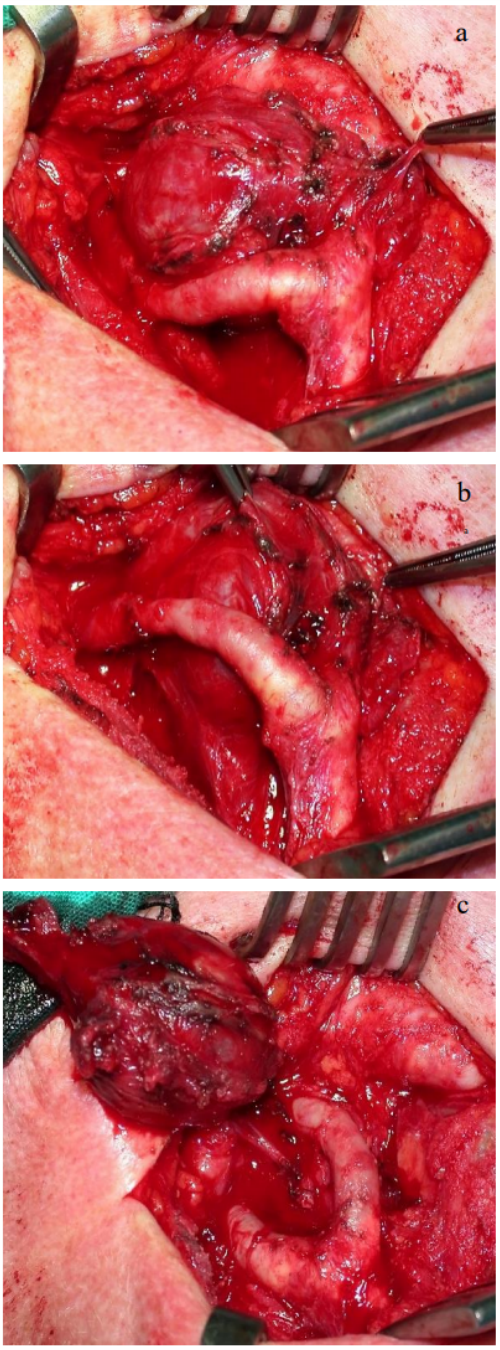


Figure 18: Freeing the paraganglioma from the internal carotid artery in a subadventitial dissection plane



Figures 19a, b, c: Freeing the paraganglioma from the carotid bifurcation and external carotid artery in a subadventitial plane



Figure 20: Resected carotid body tumor

Surgical tips

- Identify and preserve the nerves listed above during the course of the dissection
- Maintain a dry surgical field at all times by using bipolar cautery and ties for hemostasis
- Avoid excessive cautery on the carotid wall as this may weaken the artery and cause it to rupture; also, in the postoperative phase a pseudoaneurysm may form and only rupture days later
- Avoid excessive manipulation or rotation of the carotid vessels as this may cause thrombosis or release plaque or emboli causing a stroke
- Be very careful not to injure the arterial wall when dissecting within the carotid bifurcation
- The surgeon may elect to divide and ligate or oversew (with proline) the external carotid artery and to resect external carotid artery with the tumor; avoid dividing the artery close to the bifurcation as it is more difficult to ligate the artery at this point, there may be plaque at the bifurcation, and the artery may tear if ligated too close to the bifurcation
- Be prepared to have to repair the carotid vessels if traumatized, so have vascular sutures, vascular forceps and a Lahey vascular clamp available in the operating room *(Figure 21)*. Depending on your own experience it may be prudent to have your vascular surgical colleague on standby



Figure 21: After subadventitial dissecttion the remaining carotid wall was too thin and the risk of subsequent aneurysmic blow-out was judged too high; hence the common carotid (vertical arrow) to internal carotid (horizontal arrow) was replaced with a Dacron ® interposition graft and the external carotid was ligated. During this procedure the ForeSight system ® provided information of the patency of the circle of Willis and brain oxygenation. The patient did well postoperatively

Gaining additional exposure *(Figure 12)*

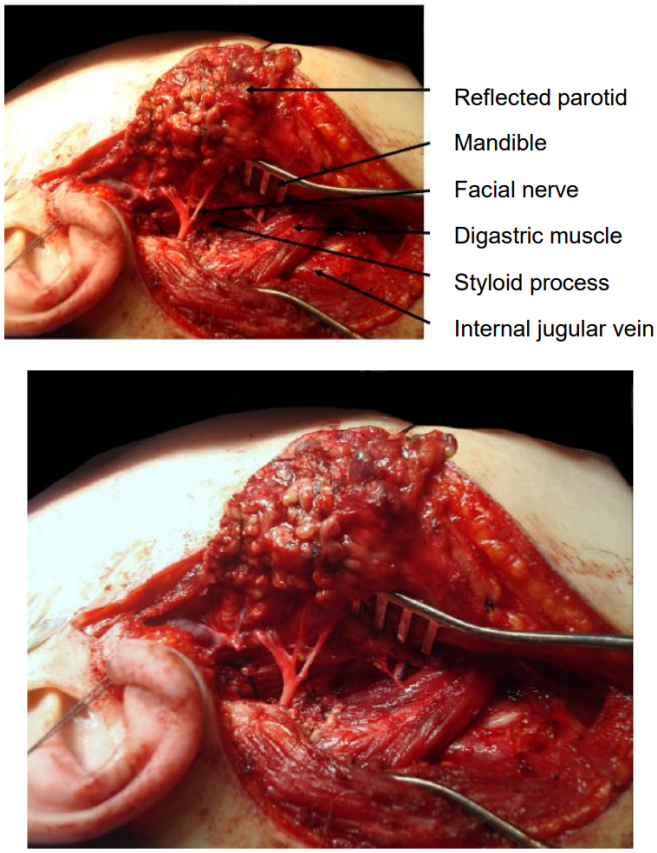
Additional exposure may be achieved by adding one or more of the following approaches to the transcervical approach:

- Transecting posterior belly of digastric muscle
- Transparotid approach
- Transcervical-submandibular approach
- Mandibulotomy of vertical ramus

Transecting posterior belly of digastric

- The posterior belly of the digastric muscle may either be retracted superiorly or divided to provide additional access medial to the parotid gland and the facial nerve
- Take care not to injure the facial nerve as it bifurcates the angle between the styloid process and the digastric muscle

Transparotid approach



Figures 22a, b: Transparotid access

- Elevate the superficial lobe of the parotid gland off the trunk of the facial nerve up to the pes anserinus and retract the gland anteriorly (Figure 22)
- Free the facial nerve from the deep lobe of the parotid gland
- Excise the deep parotid lobe in the retromandibular sulcus (Figure 22)
- This exposes the styloid process
- Immediately deep to the styloid are the contents of the poststyloid PPS including the internal carotid artery
- Access can be further improved by excising the styloid process with a bone nibbler, dividing the stylomandibular ligament, and retracting the mandible anteriorly (taking care to avoid excessive tension on the facial nerve), and inferiorly by dividing the posterior belly of the digastric and “styloid muscles” (Figures 23, 24)

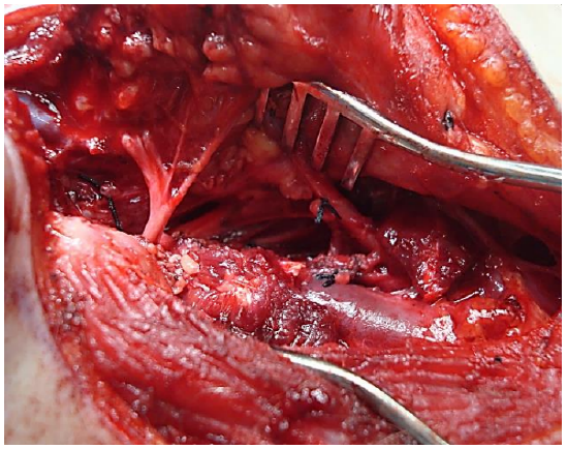


Figure 23: Additional access by transecting digastric muscle and styloid apparatus

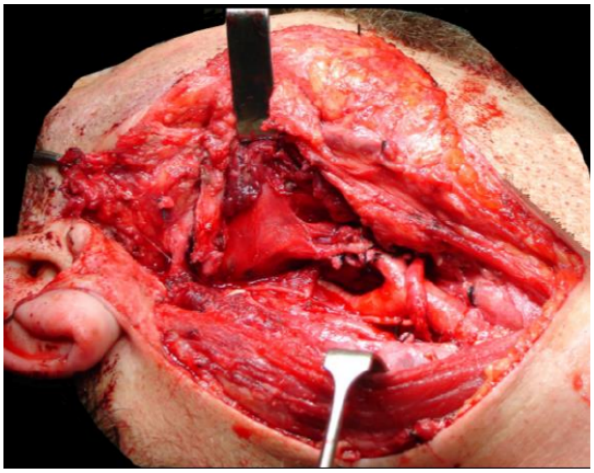


Figure 24: Wide access to PPS following resection of large glomus vagale tumor

Transcervical submandibular approach(Figure 25)

Tumors extending anteriorly may require combinations of transparotid, transcervical and transcervical submandibular approaches. Transecting the posterior belly of the digastric muscle and/or the “styloid muscles” further improves access.

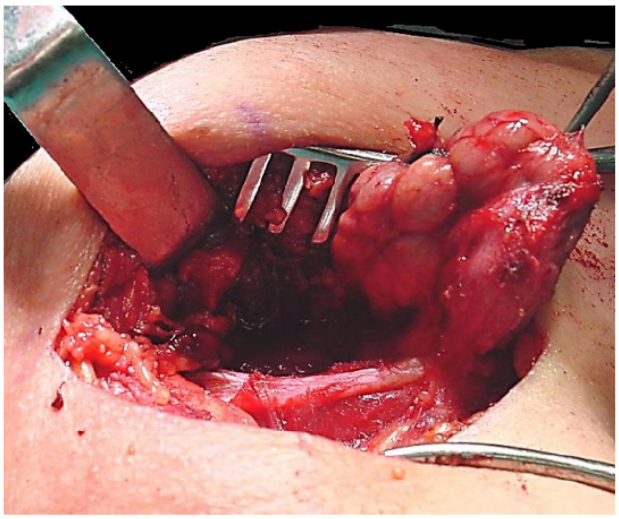


Figure 25: Additional access by dividing the facial artery where it appears above digastric, and displacing submandibular gland anteriorly

Closure

- Insert a closed suction drain
- Close the skin in a normal fashion

Postoperative care

- Remove suction drains when <50 mL drainage / 24 hrs
- Check that patient swallows without aspirating before introducing oral feeding

Complications

- Hematoma
- Cranial nerve injuries VII, IX, X, XI, XII
- Sympathetic trunk injury
  - First bite syndrome
  - Horner's syndrome
- Cerebrovascular accident
- Carotid artery injury causing false aneurysm or blowout

Glomus vagale / vagal paraganglioma

Unlike carotid body tumors, glomus vagale tumors generally displace the carotid vessels anteriorly *(Figures 26, 27, 28)*. They may extend through the skull base as a dumbbell tumor. Therefore, imaging to demonstrate the anatomical relationship of the internal carotid artery to the mass is essential to permit surgical planning and to safely perform the surgery.

Because the vagus nerve is generally sacrificed with the resection *(Figure 28d)*, some patients may elect to adopt a watchful waiting approach to preserve voice function for as long as possible.

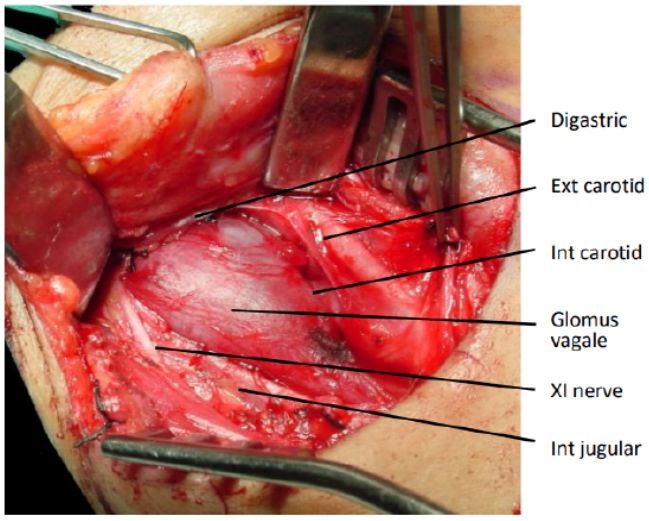
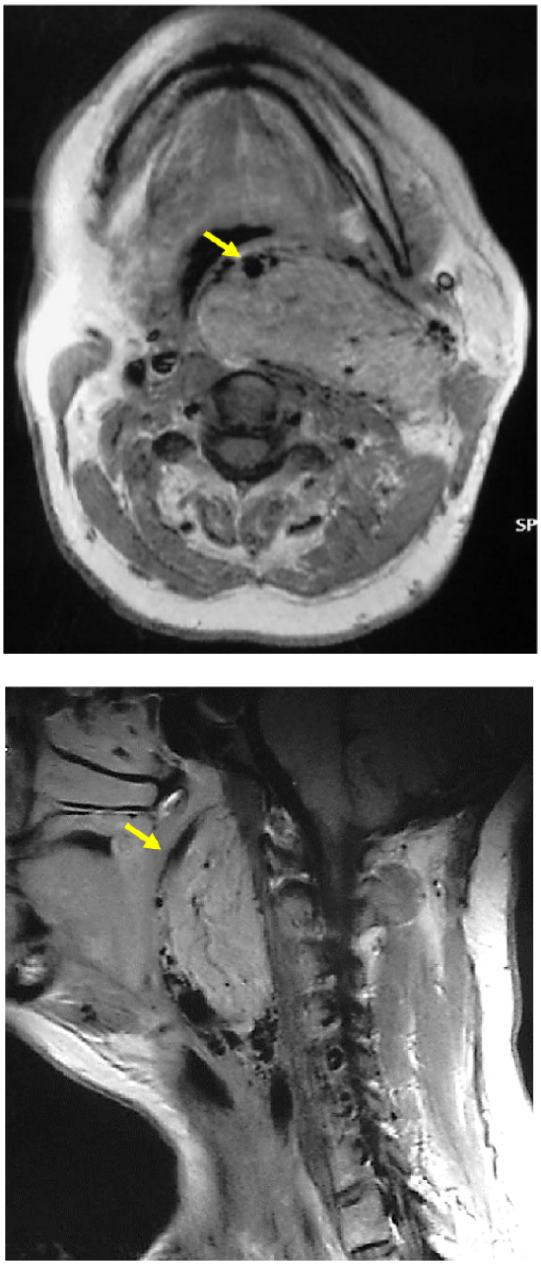


Figure 26: Glomus vagale tumor located between the internal jugular vein and the internal carotid artery



Figures 27a, b: Glomus vagale tumor displacing the internal carotid artery (yellow arrow) anteriorly

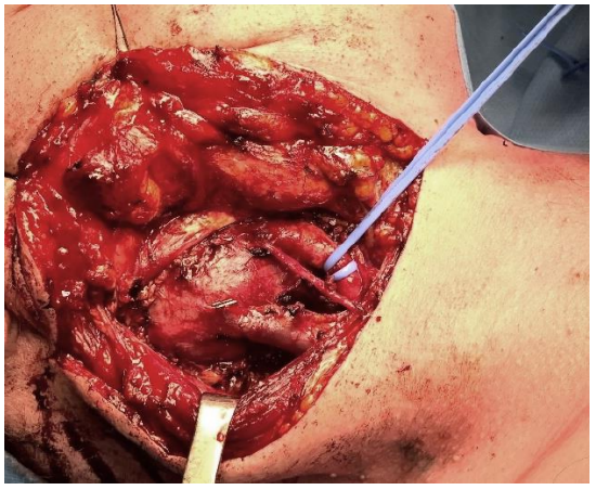


Figure 28a: Secreting glomus vagale tumor between carotid artery and jugular vein; descendens hypoglossi nerve visible

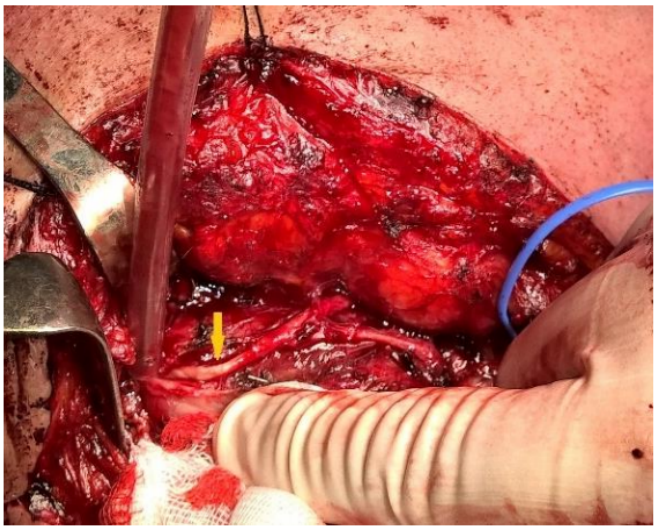


Figure 28b: Dissecting the XIIn out of glomus vagale tumor capsule

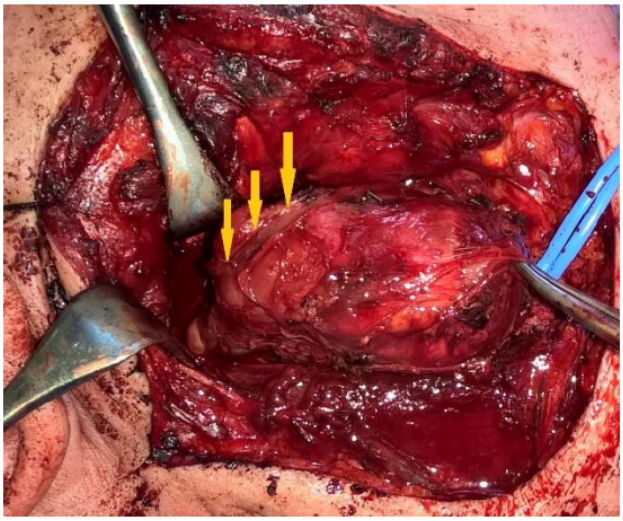


Figure 28c: Glomus vagale tumor being removed; note groove from which XII nerve was dissected (arrows)



Figure 28d: Resected specimen of secreting glomus vagale tumor with the clamp holding the transsected vagus nerve

References

1. Mendenhall WM, Amdur RJ, Vaysberg M, Mendenhall CM, Werning JW. Head and neck paragangliomas. Head Neck 2011;33:1530-4
2. van der Mey AG, Frijns JH, Cornelisse CJ et al. Does intervention improve the natural course of glomus tumors? A series of 108 patients seen in a 32-year period. Ann Otol Rhinol Laryngol 1992;101:635-42
3. Langerman A, Athavale SM, Rangarajan SV, Sinard RJ, Netterville JL. Natural history of cervical paragangliomas: outcomes of observation of 43 patients. Arch Otolaryngol Head Neck Surg. 2012 Apr;138(4):341-5
4. Foote RL, Pollock BE, Gorman DA et al. Glomus jugulare tumor: tumor control and complications after stereotactic radiosurgery. Head Neck 2002;24:332- 8
5. Verniers DA, Keus RB, Schouwenburg PF, Bartelink H. Radiation therapy, an important mode of treatment for head and neck chemodectomas. Eur J Cancer 1992;28A:1028-1033
6. Suarez C, Rodrigo JP, Bodeker CC et al. Jugular and vagal paragangliomas: Systematic study of management with surgery and radiotherapy. Head Neck 2013 Aug;35(8):1195 -204
7. Suarez C, Rodrigo JP, Mendenhall WM et al. Carotid body paraganglio - mas: a systematic study on manage - ment with surgery and radiotherapy. Eur Arch Otorhinolaryngol 2014 Jan;271(1):23 -34
8. Martin TP, Irving RM, Maher ER. The genetics of paragangliomas: a review. Clin Otolaryngol 2007;32:7 -11

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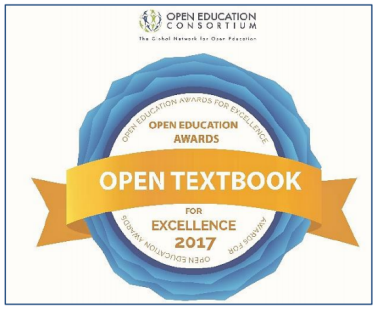
Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Vincent Vander Poorten MD PhD MSc
Professor
Otorhinolaryngology, Head & Neck
Surgery
University Hospitals Leuven
Department of Head and Neck Oncology
KU Leuven, Belgium
vincent.vanderpoorten@uzleuven.be

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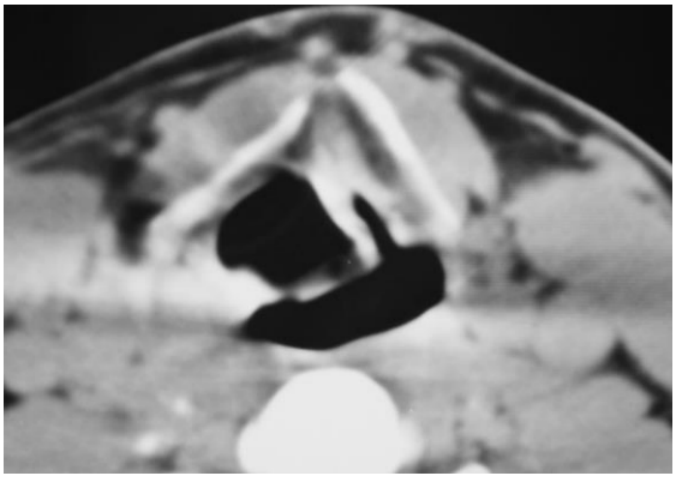
1.11: Surgery for Laryngocoeles (Laryngoceles)

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Laryngoceles/laryngoceles are dilatations of the saccule of the laryngeal ventricle. They are therefore ***supraglottic cysts***, the walls of which are lined by ciliated pseudostratified cylindrical epithelium with variable numbers of goblet cells.

Internal laryngoceles are limited to the larynx and confined medially by the false vocal cord, and laterally by the lamina of the thyroid cartilage. *(Figures 1-3).*



Figures 1: Axial views of air-filled internal laryngocele, confined by the false cord medially and the thyroid lamina laterally

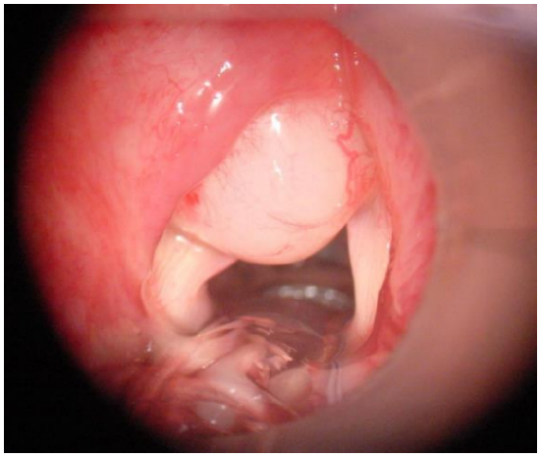


Figure 2: Internal laryngocele

Combined laryngoceles extend superiorly and laterally into the neck through the thyrohyoid membrane (between the hyoid bone and the superior edge of the thyroid cartilage) in close proximity to the internal branch of the superior laryngeal nerve and superior laryngeal artery *(Figures 4, 5, 6).*

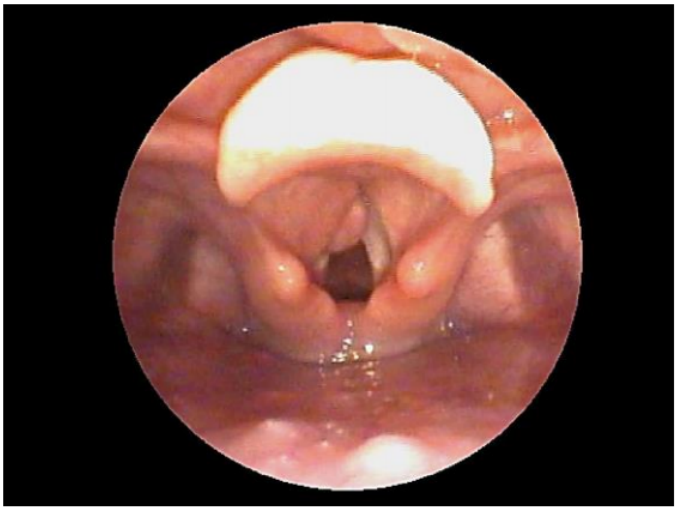
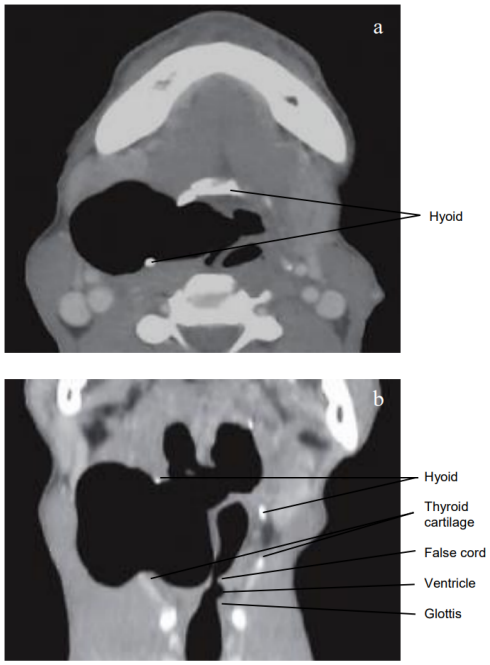
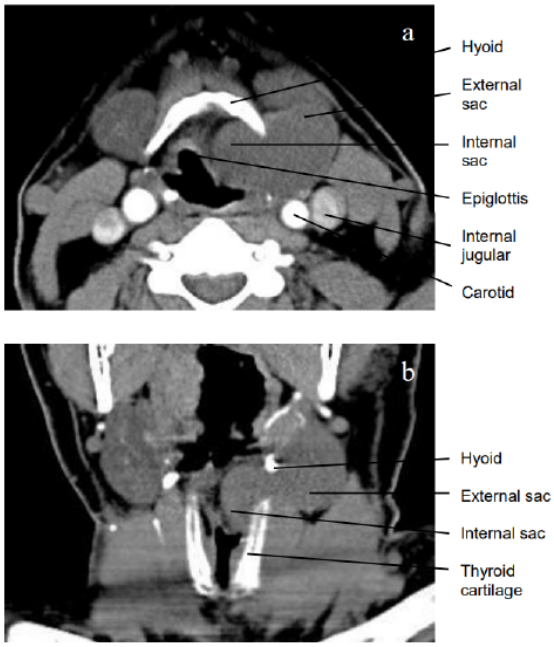


Figure 3: Internal laryngopyocele



Figures 4a, b: Axial and coronal views of combined laryngocele with wide communication with the larynx 1



Figures 5 a, b: Fluid-filled combined laryngocele

Laryngoceles are filled with air when they retain a communication with the laryngeal lumen *(Figures 1, 4)*; when they become isolated from the laryngeal lumen, they become fluid-filled *(Figures 3, 5)* or infected (laryngopyocele) *(Figure 6)*.

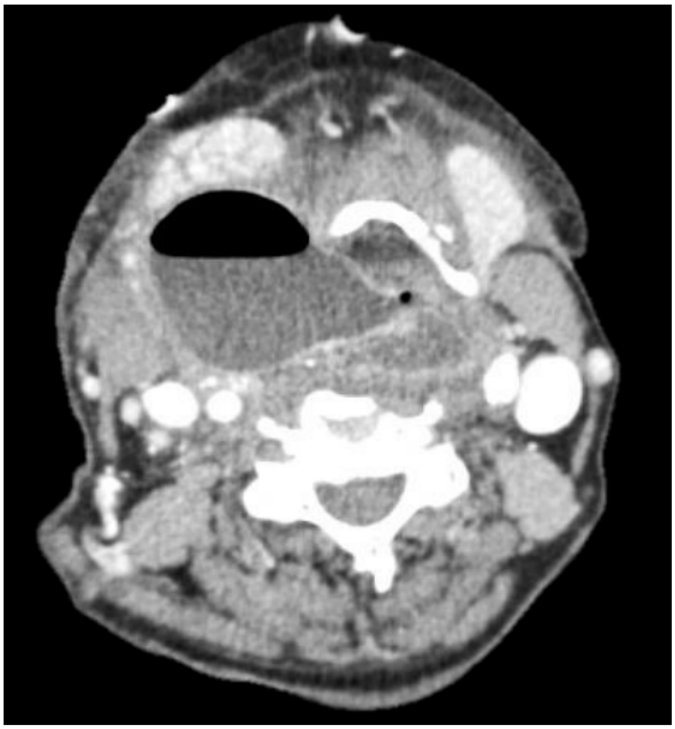


Figure 6: Laryngopyocele causing airway obstruction

Although not an uncommon incidental postmortem finding, laryngoceles are generally asymptomatic. Patients may present with ***voice change*** or a ***lateral swelling*** in the neck overlying the thyrohyoid membrane which may visibly distend when increasing intraluminal pressure *e.g.* glassblowers and trumpet or reed instrument players *(Figures 7a, b)*.

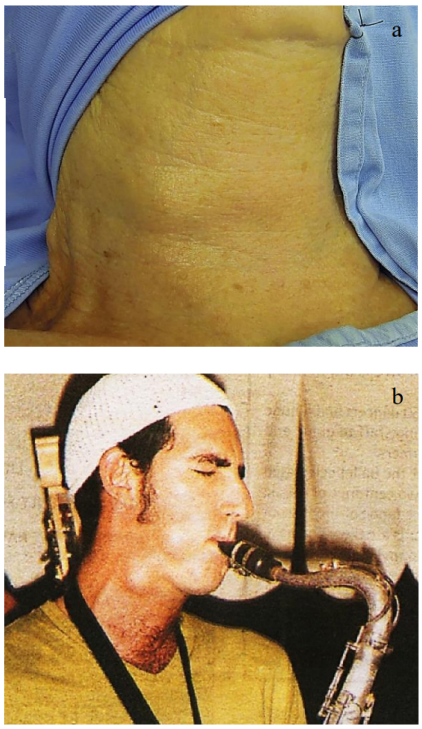


Figure 7a, b: Visible laryngoceles

Patients, especially those with laryngopyoceles, may present with ***acute airway obstruction*** *(Figures 6, 8)*. Occasionally a laryngocele may be the presenting symptom of laryngeal ***malignancy*** obstructing the saccule.

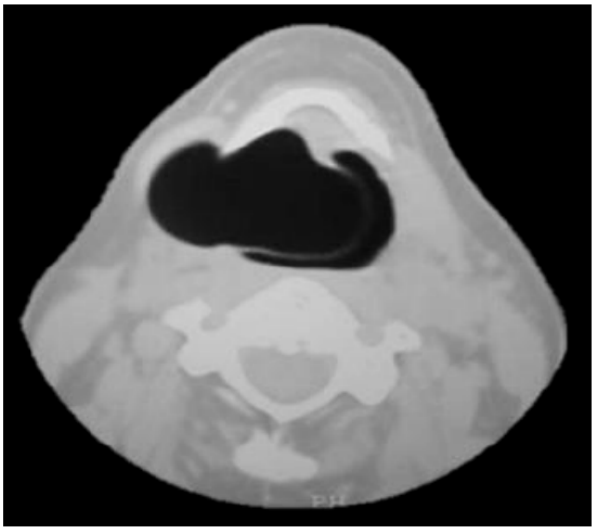


Figure 8: Large air-filled laryngocele obstructing the laryngeal vestibule 2

Surgical Anatomy

The saccule or appendix of the ventricle is present in most larynges. It arises anteriorly in the ventricle and extends superiorly through the paraglottic space with the ventricular fold (false cord) situated medially and the thyroid lamina laterally *(Figure 9)*.

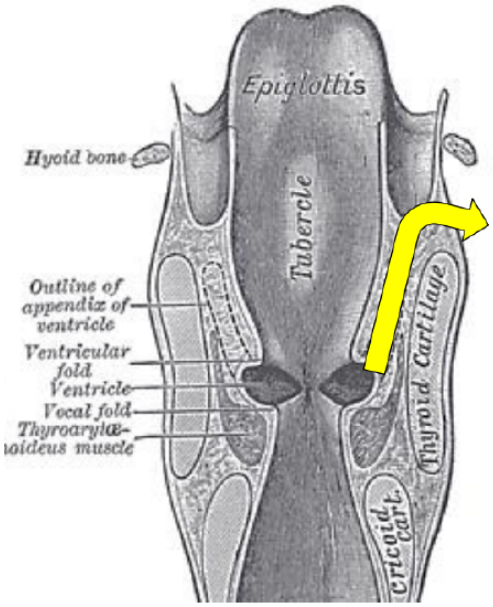


Figure 9: Saccule/ appendix of ventricle and course of laryngocele (yellow arrow)

The thyrohyoid membrane extends between the body and greater cornua of thehyoid bone, and the superior rim of the thyroid cartilage. It is pierced by the internal branch of the superior laryngeal nerve and the superior laryngeal branch of the thyroid artery *(Figures 10, 11)*.

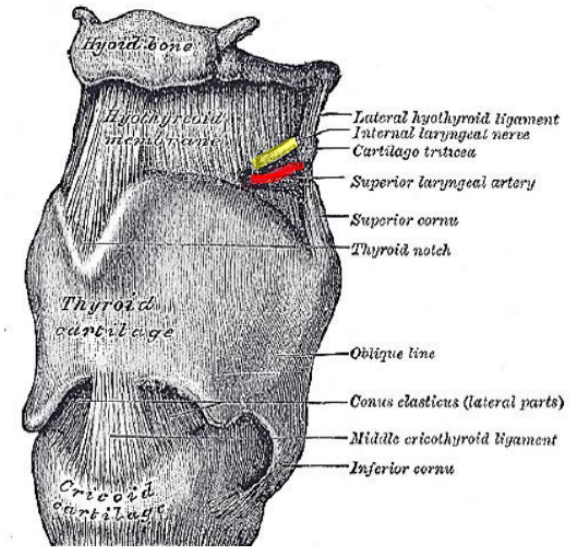


Figure 10: Superior laryngeal nerve, superior laryngeal artery and thyrohyoid membrane

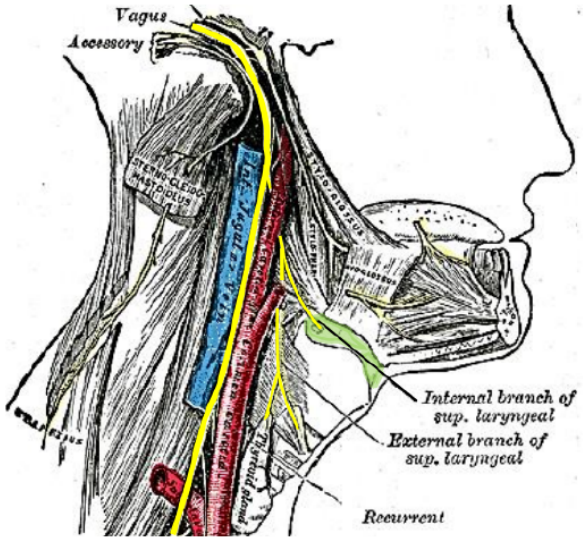


Figure 11: Note how superior laryngeal nerve courses medial to internal carotid artery before piercing the thyrohyoid membrane (green)

The ***superior laryngeal nerve*** is at risk of injury when resecting a laryngocele due to its intimate relationship with the external component of the cyst. It arises from the ganglion nodosum of the vagus nerve, descends alongside the pharynx, passes behind the internal carotid artery, and divides into external and internal branches. The internal branch crosses the thyrohyoid membrane and pierces it, accompanied by the superior laryngeal artery, and provides sensory innervation to the larynx *(Figure 11)*.

The ***superior laryngeal artery*** is encountered during surgery and can either be preserved or sacrificed. It is a branch of the superior thyroid artery *(Figure 12)*.

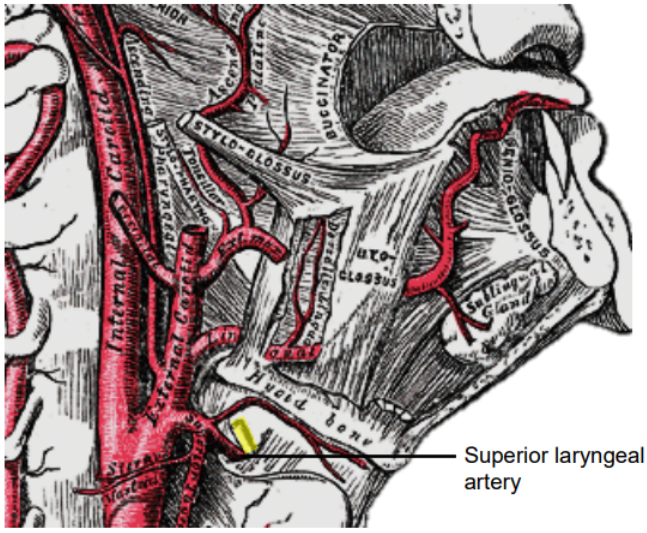


Figure 12: The superior laryngeal artery branches off the superior thyroid artery

The ***muscles*** encountered during resection of the external component of a laryngocele are illustrated in *Figure 13*. The thyrohyoid muscle is draped over the cyst and may have to be divided; the omohyoid can be retracted anteriorly or divided; and the sternomastoid retracted posteriorly.

Imaging

The differential diagnosis of a combined laryngocele includes a branchial cyst, neck abscess, cold abscess (tuberculosis), lymphoadenopathy, and a laterally located thyroglossal duct cyst. An internal laryngocele can be confused with a carcinoma centered deep in the ventricle which bulges the ventricular fold upwards and medially, and other unusual non-ulcerating masses such as intralaryngeal plasmacytoma, lymphoma and minor salivary gland malignancy.

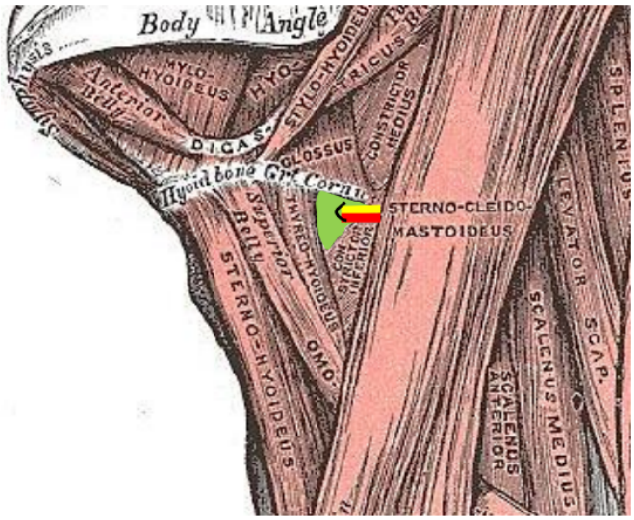


Figure 13: The thyrohyoid, omohyoid and sternomastoid muscles surround the external component of the laryngocele (thyrohyoid membrane in green)

CT scan will however distinguish between air- and fluid-filled cysts and solid masses. CT evidence of a cyst extending through the thyrohyoid membrane is pathognomonic of a combined laryngocele. ***MRI*** yields similar information.

Management

This depends on the significance of the symptoms and signs, and the size and extent of the laryngocoele. Laryngoscopy is done to exclude the possibility of underlying malignancy in the larynx.

Needle aspiration

An ***acutely inflamed combined cyst*** may first be aspirated percutaneously with a needle and treated with appropriate antibiotics to avoid doing a suboptimal resection in a septic field; needle aspiration may also be employed as an emergency measure to relieve ***acute airway obstruction***.

Internal Laryngoceles(Figures 1-3)

Small, asymptomatic laryngoceles do not require surgical intervention. Symptomatic internal laryngoceles and saccular cysts are widely de-roofed/uncapped or excised endoscopically, ideally with CO_2 laser. Larger internal laryngoceles, especially if recurrent, can also be excised by an external approach (see below).

Combined Laryngoceles

- The surgery is done under general anesthesia with endotracheal intubation taking care not to rupture the cyst
- Place a transverse skin incision in a skin crease over the thyrohyoid membrane, from the anterior border of the sternocleidomastoid to the midline of the neck *(Figure 14)*



Figure 14: Skin incision over the cyst between hyoid bone and thyroid cartilage

- Elevate subplatysmal flaps to expose submandibular salivary gland superiorly, omohyoid muscle anteriorly and sternocleidomastoid muscle posteriorly

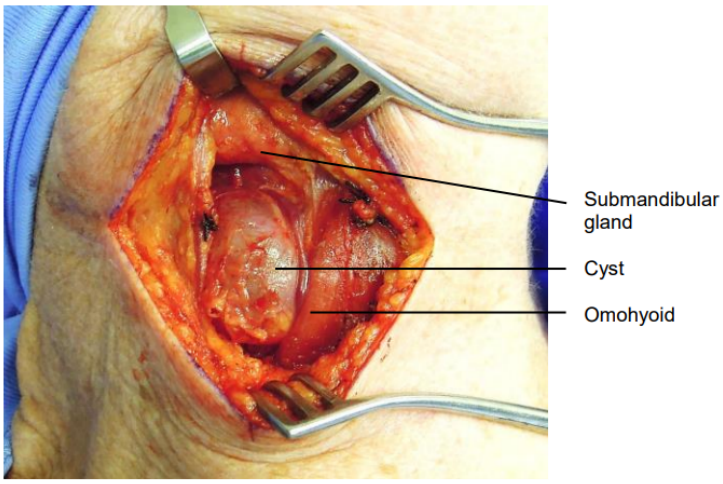


Figure 15: Expose cyst and define the surrounding structures

- Using careful sharp and blunt dissection, find the dissection plane on the thin cyst wall and identify the superior thyroid (STA) and superior laryngeal arteries (SLA) behind the cyst *(Figure 16)*

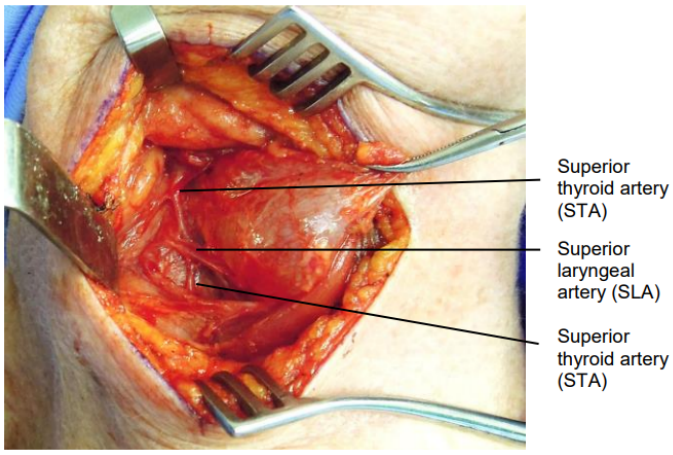


Figure 16: Expose superior thyroid and superior laryngeal arteries

- Identify the superior laryngeal nerve (SLN); it emerges deep to the superior thyroid artery *(Figure 17)*

- Reflect the cyst upwards and retract the omohyoid and thinly stretched thyrohyoid muscles anteriorly to expose thyroid lamina. If necessary, transect the thyrohyoid muscle that overlies the cyst for additional exposure *(Figure 18)*

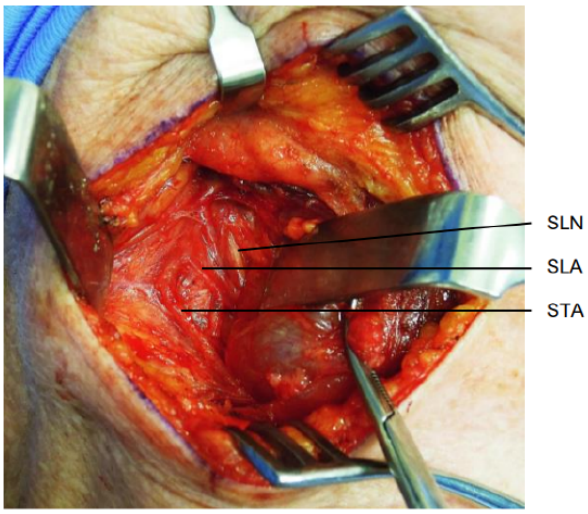


Figure 17: Identify the superior laryngeal nerve (SLN) where it emerges deep to the superior thyroid artery

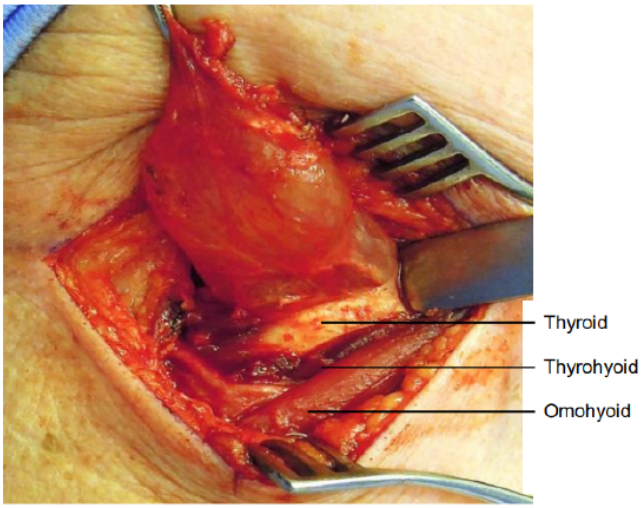


Figure 18: Retract omohyoid and thyrohyoid muscles to expose top edge of thyroid cartilage

- Free the cyst from the perichondrium on the medial aspect of the thyroid lamina and deliver it from the paraglottic space. Carefully peel the cyst off the internal branch of the superior laryngeal nerve and from the mucosa overlying the medial aspect of the aryepiglottic fold, and deliver the cyst *(Figures 19, 20)*
- Inspect the wound for tears or breaches in the mucosa which, if present, are repaired with absorbable sutures
- Administer 24hrs' perioperative antibiotics should mucosa be breached
- Insert a suction/pencil/corrugated drain and close the wound
- Because mucosal defects would be supraglottic, postoperative surgical emphysema and airway obstruction are unusual

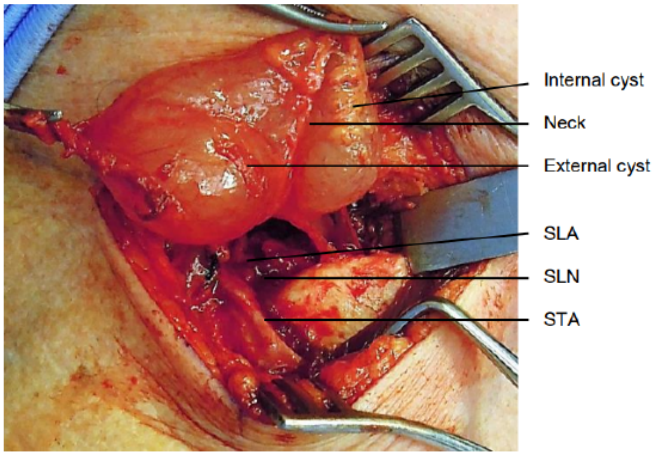


Figure 19: Free cyst from the superior laryngeal artery (SLA), superior laryngeal nerve (SLN) and deliver it from paraglottic space

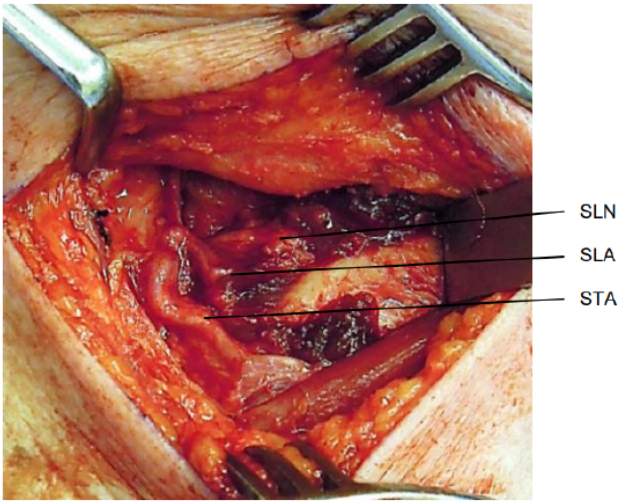


Figure 20: Final view of key structures

To gain additional exposure to the internal component of the cyst in the paraglottic space

- Incise the thyroid perichondrium along the superior and posterior margins of the thyroid lamina *(Figure 21)*
- Reflect the perichondrium from the lateral aspect of the thyroid lamina with a Freer dissector
- Remember that the vocal cord is situated midway between the thyroid notch and the lower edge to the thyroid cartilage; therefore, make the horizontal cartilage cut above this point
- Cut through the cartilage with a knife/ oscillating saw, taking care not to enter the larynx *(Figure 21)*
- Remove and discard the posterosuperior quadrant of the thyroid lamina to gain access to the internal component of the laryngocele *(Figure 22)*
- Following removal of the cyst, suture the perichondrial flap back to its original position

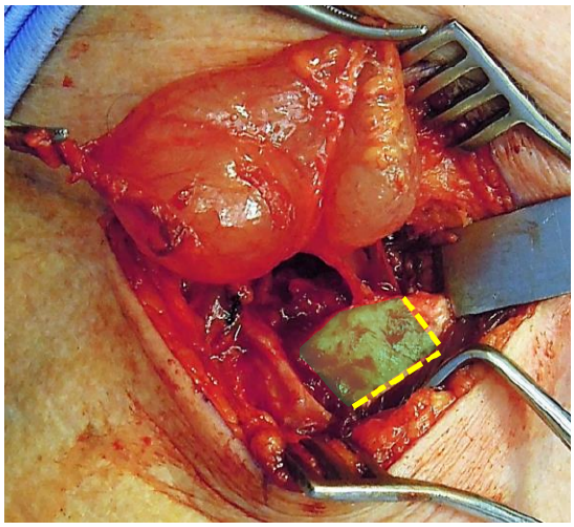


Figure 21: Cuts (yellow line) in thyroid cartilage to remove posterosuperior quadrant of thyroid cartilage (green)

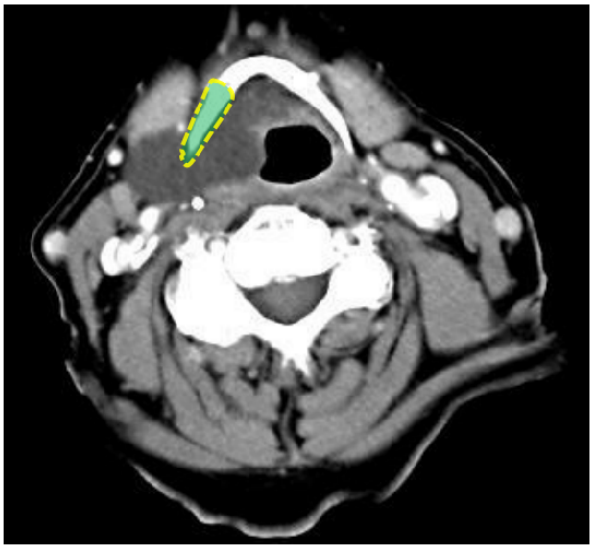


Figure 22: Note how removal of thyroid lamina improves access to internal component of laryngocele

References

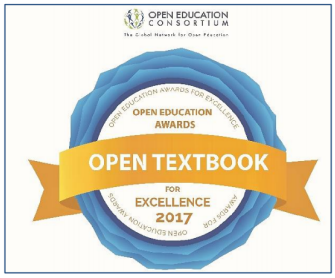
1. Pinho M da C, et al. External laryngocele: sonographic appearance - a case report. Radiol Bras. 2007 Aug; 40(4): 279-82 http://dx.doi.org/10.1590/S0100- 39842007000400015
2. de Paula Felix JA, Felix F, de Mello LFP. Laryngocele: a cause of upper airway obstruction. Rev. Bras. Otorri nolaringol. 2008 Feb [cited 2013 Mar 09]; 74(1): 143-6. http://dx.doi.org/10.1590/S0034- 72992008000100023

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.12: Laryngectomy - Total

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Total laryngectomy is generally done for advanced cancers of the larynx and hypopharynx, recurrence following (chemo)radiation, and occasionally for intractable aspiration and advanced thyroid cancer invading the larynx.

Although it is an excellent oncologic procedure and secures good swallowing without aspiration, it has disadvantages such as having a permanent tracheostomy; that verbal communication is dependent on esophageal speech, and/or trachepesophageal fistula speech or an electrolarynx; hyposmia; and the psychological and financial/ employment implications. Even in the best centers, about 20% of patients do not acquire useful verbal communication.

Prelaryngectomy decision making

The surgeon needs to consider the following issues before embarking on a laryngectomy.

1. ***What will be the tumor resection lines?*** As the initial incisions into the pharynx are done from externally without having the tumor in view, the surgeon must carefully assess the valleculae, base of tongue and the pyriform fossae for tumor involvement, to avoid cutting into tumor when entering the pharynx. Involvement of the base of tongue may also prompt the surgeon to opt for a retrograde laryngectomy (commencing the laryngectomy at the tracheostomal end of the specimen). In the absence of CT or MRI imaging, one can palpate and assess tumor involvement of the pre-epiglottic space and base of tongue under general anesthesia by placing one index finger in the valleculae, and the other on the skin of the neck just above the hyoid bone. The fingers should normally virtually meet, unless there is tumor in the preepiglottic space or vallecula or base of tongue.
2. ***Is thyroidectomy required?*** Both hypothyroidism and hypoparathyroidism are common sequelae of total laryngectomy, particularly following postoperative radiation therapy, and may be difficult to manage in a developing world setting. Twenty-five percent of laryngectomy patients become hypothyroid following hemithyroidectomy; and 75% if postoperative radiation is added. However, both thyroid lobes may be preserved unless Level 6 nodes need to be resected with subglottic and pyriform fossa carcinoma, or when there is intraoperative or radiological evidence of direct tumor extension to involve the thyroid gland.
3. ***Will a pectoralis major flap be required?*** A capacious pharynx is essential for good swallowing and fistula speech. Should tumor involve the hypopharynx, especially when it extends distally towards the cricopharyngeus, then the expertise must be available to possibly augment the pharyngeal repair with a pectoralis major flap. Pectoralis major muscle flaps are also frequently used to overlay the pharyngeal repair with salvage laryngectomy to encourage spontaneous closure of pharyngo-cutaneous fistulae when they occur.
4. ***Is elective neck dissection required?*** With advanced laryngeal squamous cell carcinoma requiring laryngectomy, elective lateral neck dissection (Levels 2-4), either ipsilateral (glottic carcinoma) or bilateral (supraglottic, medial wall of pyriform fossa, bilateral glottic carcinoma) is recommended, with conversion to modified neck dissection should cervical metastases be found intraoperatively. Level 6 is included in subglottic and pyriform fossa carcinoma to clear the paratracheal nodes.
5. ***Is the patient suitable for tracheo-esophageal speech?*** This decision is based on assessment of cognitive function, motivation, financial ability to pay for replacement speech prostheses, and proximity to speech services.
6. ***Are there synchronous primaries or distant metastases?*** Total laryngectomy has significant morbidity and should only be done if panendoscopy and CXR/CT chest exclude metastases or 2nd primaries.

Anesthesia

Intubation: The operation is done under general anesthesia. The ENT surgeon must be present to assist with a possibly difficult intubation. If a difficult intubation is anticipated, then either do an awake tracheostomy, or infiltrate skin and trachea with local anesthesia/vasoconstrictor, in preparation for a possible emergency tracheostomy.

Preoperative tracheotomy: Tracheotomy may have been required for airway obstruction. It is not an independent indication for postoperative radiation therapy unless tumor was entered at the time of tracheotomy. If a tracheostomy has already been done, then ask the anesthetist to reintubate through the larynx with an orotracheal tube once the patient has been anesthetized as this facilitates dissection in the lower neck and speeds up the surgery.

Perioperative antibiotics: Commence perioperative antibiotics before putting knife to skin, and continue for 24 hrs.

Surgical anatomy

Figures 1 & 2 illustrate all the muscles that will be divided during laryngectomy.

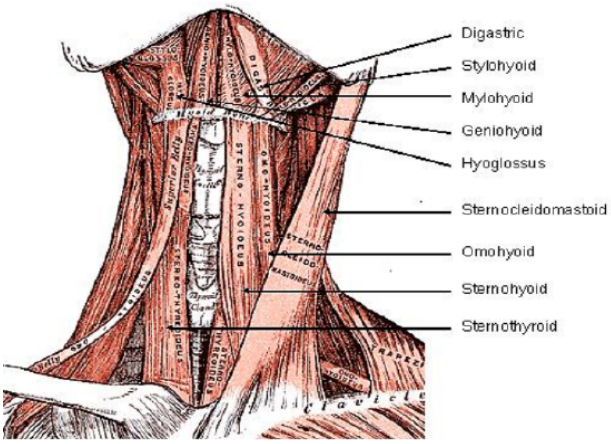


Figure 1: Supra- and infrahyoid muscles

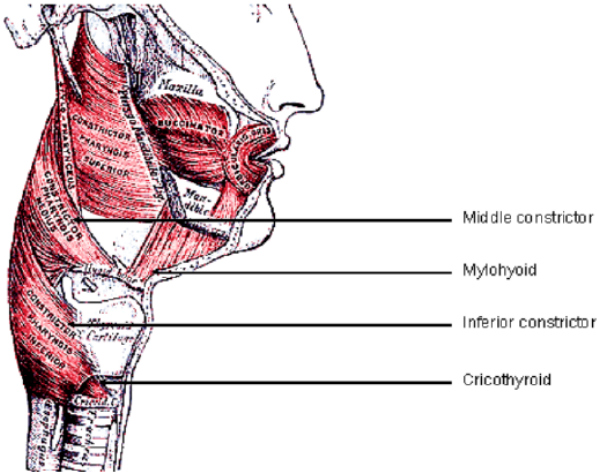


Figure 2: Middle and inferior pharyngeal constrictors

Surgical steps

Positioning: Extend the neck

Incisions for apron flap (Figures 3a, b)

The horizontal limb of the flap is placed approximately 2 cm above the sternal notch. An ellipse of skin around a preexisting tracheostomy is included with the resection. With a simple laryngectomy the vertical incisions are placed along the anterior borders of sternocleidomastoid muscles. For a laryngectomy with neck dissection(s), either a wider flap overlying the sternocleidomastoid muscles is made *(Figure 3a)*, or a narrow flap with inferolateral extensions is made *(Figure 3b)*. The latter has the disadvantage of a trifurcation which is more prone to wound breakdown and exposure of the major cervical vessels.



Figure 3a: Wide apron flap to accommodate neck dissections



Figure 3b: Narrow apron flap for laryngectomy, with lateral extensions for neck dissections

Flap elevation (Figure 4)

- Cut through the superficial layer of investing fascia and platysma muscles. The platysma is often absent in midline. Take care not to injure the external and anterior jugular veins
- Elevate the apron flap in a subplatysmal plane, remaining superficial to the external and anterior jugular veins
- Dissect the flap superiorly up to approximately 2 cm above the body of the hyoid bone

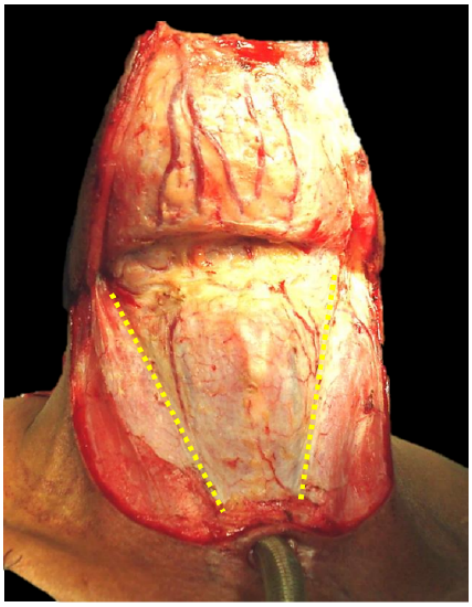


Figure 4: Elevated apron flap and incisions through investing layer of cervical along anterior borders of sternocleidomastoid muscles

Freeing up the larynx

- Free up one side of the larynx at a time
- Stand on the side of neck that is being dissected
- Ligate and transect the anterior jugular veins suprasternally and above the hyoid
- Incise the investing layer of cervical fascia along the anterior border of the sternocleidomastoid muscle *(Figure 4)*
- Retract the sternocleidomastoid muscle laterally
- Identify the sternohyoid and omohyoid muscles
- Transect the omohyoid muscle medial to where it crosses the internal jugular vein *(Figure 5)*

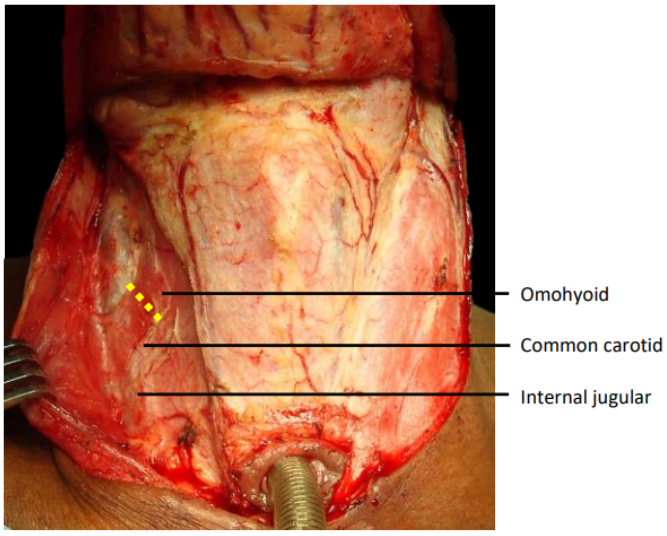


Figure 5: Transect omohyoid along yellow line

- Identify the dissection plane between carotid sheath, and larynx and thyroid gland and open this plane with sharp and blunt finger dissection to expose the prevertebral fascia *(Figure 6)*

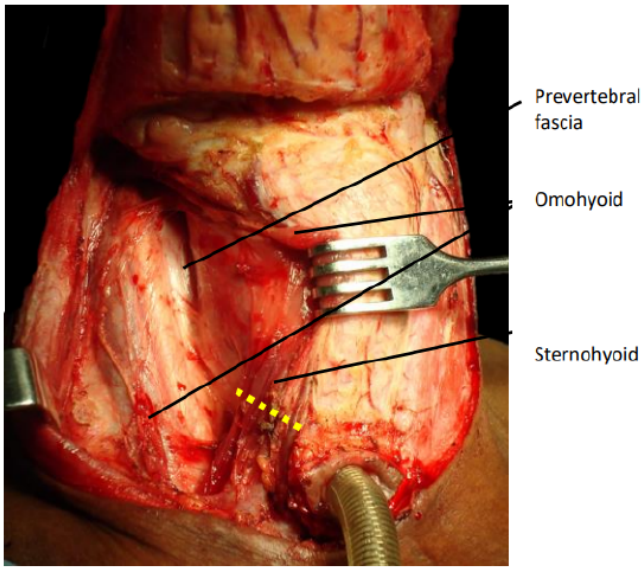


Figure 6: Transect sternohyoid muscle to expose sternothyroid muscle

- Transect the sternohyoid muscle with electrocautery wherever convenient *(Figure 6)*
- Identify the sternothyroid muscle and carefully divide it below larynx *(Figure 6)*. It is a broad, thin muscle, so take special care not to injure the thyroid gland and its rich vasculature which is immediately deep to muscle
- Carefully elevate and reflect the superior cut end of the sternothyroid muscle from the thyroid gland using electrocautery dissection *(Figure 7)*

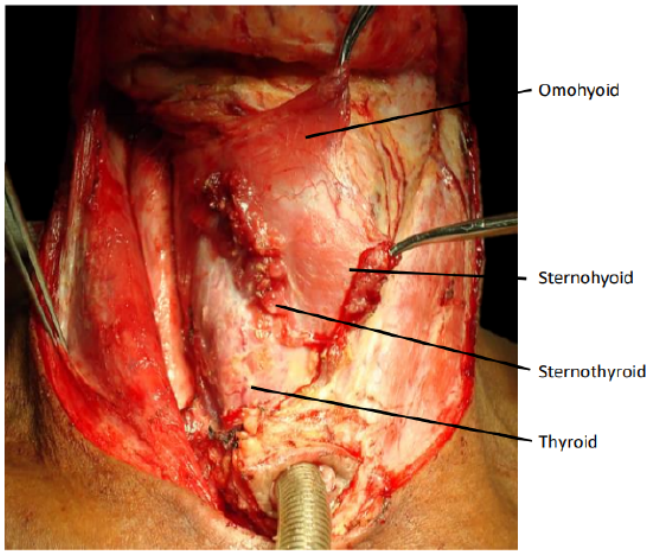


Figure 7: Transect & elevate sternothyroid to expose thyroid gland

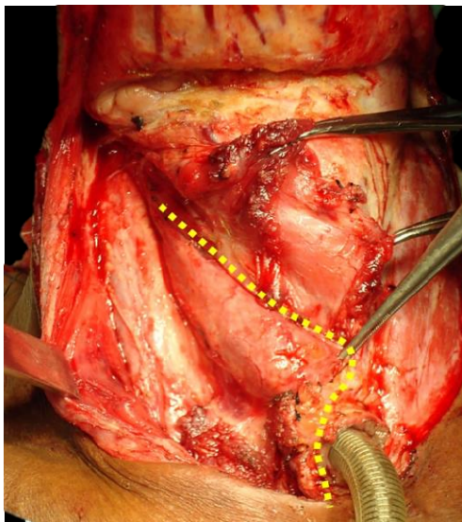


Figure 8: Divided sternothyroid retracted to expose thyroid. Line indicates course of dissection of thyroid gland and along midline of trachea

- Divide the thyroid isthmus with electrocautery
- Divide and strip the tissues overlying the cervical trachea vertically in the midline to avoid injuring the inferior thyroid veins
- Carefully reflect the thyroid lobe off the trachea, cricoid and inferior constrictor with electrocautery *(Figure 9)* while inspecting for and excluding direct laryngeal tumor extension to the thyroid gland
- Identify and transect the recurrent laryngeal nerve *(Figure 10)*
- Identify the esophagus and tracheoesophageal groove *(Figure 10)*

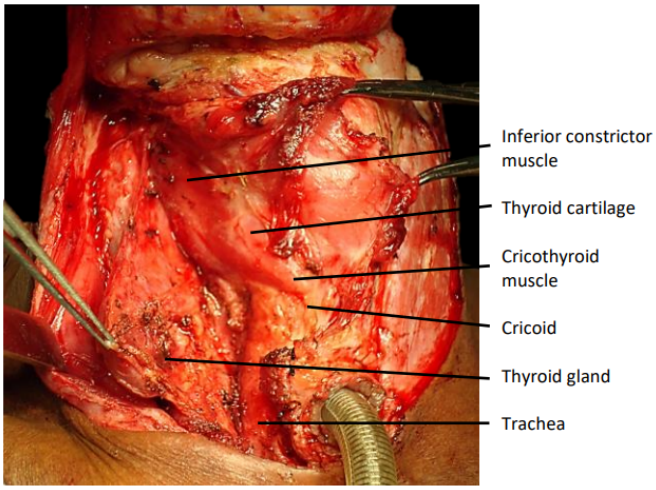


Figure 9: Thyroid gland has been mobilized from larynx and trachea

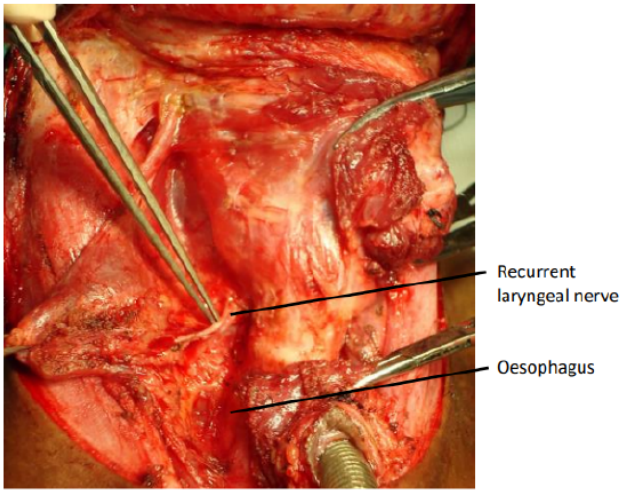


Figure 10: Identify esophagus, and divide recurrent laryngeal nerve

- Identify and divide the superior larynxgeal branch of superior thyroid artery, and reflect and preserve the superior thyroid pedicle from the larynx *(Figure 11)*
- Identify and divide the superior laryngeal nerve

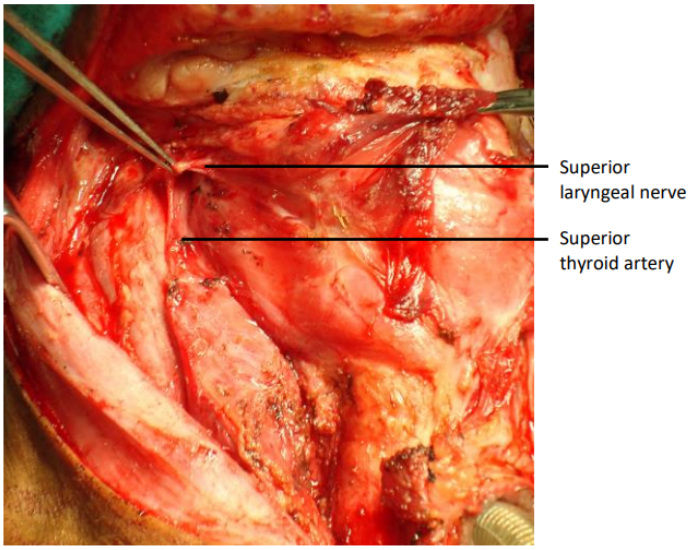


Figure 11: Identify and divide superior laryngeal branch of superior thyroid artery

- Rotate the larynx to the contralateral side, and identify the posterior border of the thyroid ala *(Figure 12)*

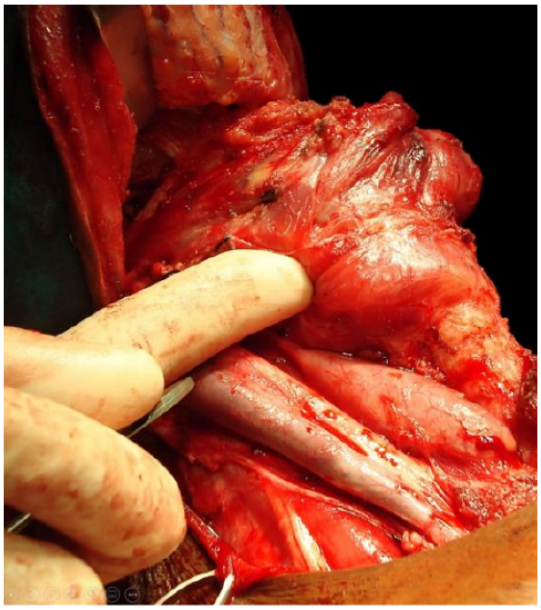


Figure 12: Rotate the larynx with a finger placed behind the thyroid ala

- Divide the inferior pharyngeal constrictor muscle and thyroid perichondrium with electrocautery at, or just anterior to the posterior border of the thyroid ala *(Figure 13)*
- Strip the lateral wall of the pyriform fossa off the medial aspect of the thyroid ala in a subperichondrial plane with a swab/sponge held over a fingertip, or with a Freer's elevator, *only on the side of the larynx opposite to the cancer (Figure 14)*. On the side of the cancer, this step is omitted to ensure adequate resection margins.

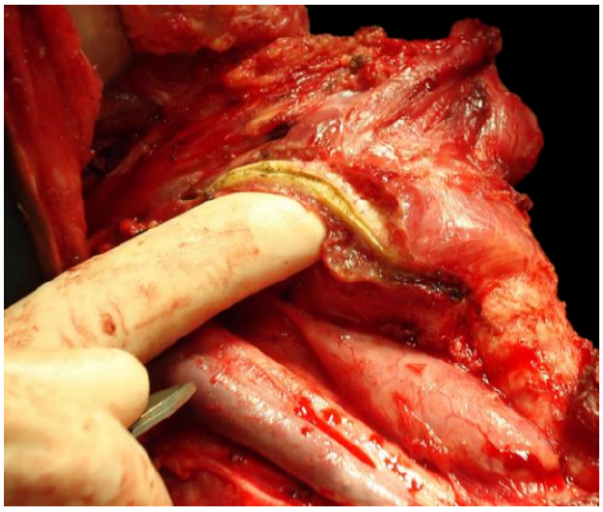


Figure 13: Divided inferior pharyngeal constrictor and thyroid perichondrium

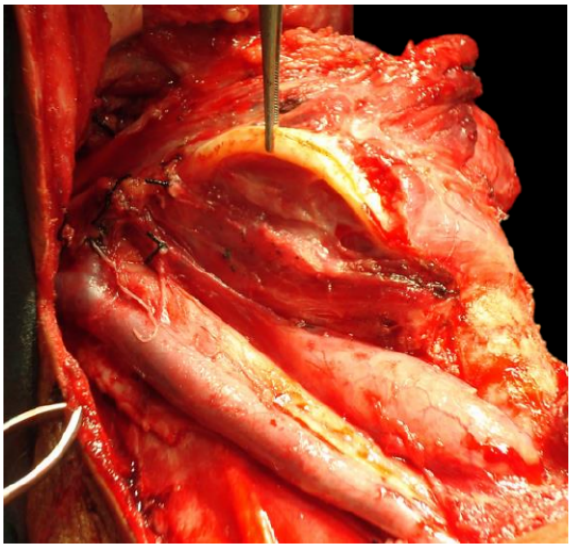


Figure 14: Pyriform fossa mucosa stripped from thyroid lamina

The surgeon then crosses to the opposite side of the patient and repeats the above operative steps.

Suprahyoid dissection

The following description applies to laryngeal cancer not involving the pre-epiglottic space, vallecula or base of tongue. When tumor does involve vallecula, pre-epiglottic space and/or base of tongue, then the pharynx is entered via the opposite pyriform fossa or a retrograde laryngectomy is done, commencing the dissection inferiorly at the tracheostomy (see later)

- Identify the body of the hyoid bone
- Remember that the hypoglossal nerves and lingual arteries lie just deep to the greater cornua/horns of the hyoid bone
- Divide the suprahyoid muscles with electrocautery along the superior border of the body of the hyoid bone *(Figure 15)*

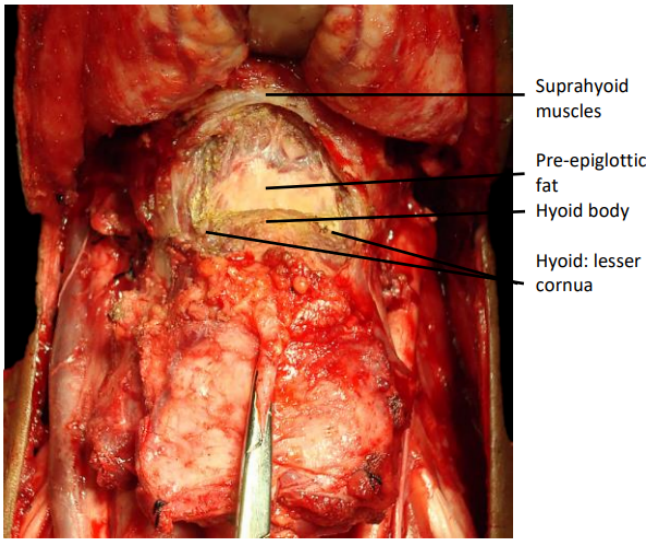


Figure 15: Transection of suprahyoid muscles from hyoid body

- Initially do not dissect lateral to the lesser cornua, as the hypoglossal nerves and the lingual arteries are located deep to the greater cornua of the hyoid bone
- Release the digastric tendon and stylohyoid ligament and muscle from the lesser cornu of the hyoid. The hyoidthen become more mobile and can be retracted inferiorly, away from the hypoglossal nerves
- Rotate the hyoid bone to the contralateral side, and identify the position of the greater cornu/horn of the hyoid bone *(Figure 16)*

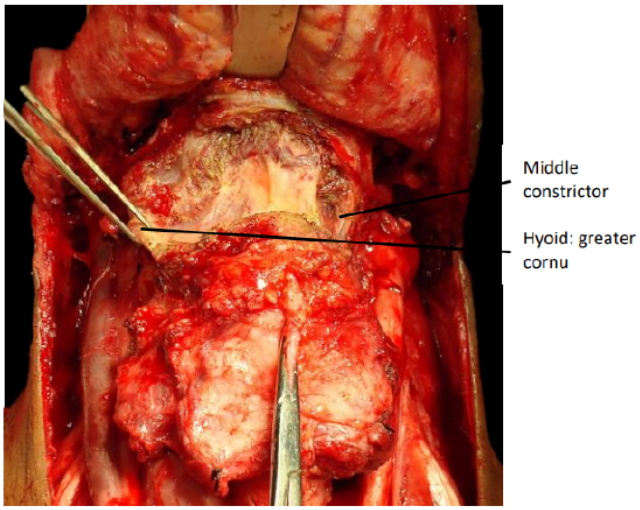


Figure 16: Identify greater cornu

- The hyoglossus and middle constrictor muscles are next released from the greater cornu with diathermy *(Figure 16)*
- Divide the soft tissue on the medial aspect of the tips of the greater cornua of the hyoid with scissors to free the greater cornua of the hyoid bilaterally *(Figure 17)*. Hug the inner aspect of the greater cornua to avoid the hypoglossal nerves. If a neck dissection has been done, the hypoglossal nerves will already be visible
- Dissect transversely with diathermy along the superior margin of the body of the hyoid bone, and along the superior margin of the pre-epiglottic space
- Identify the hyoepiglottic ligament in the midline

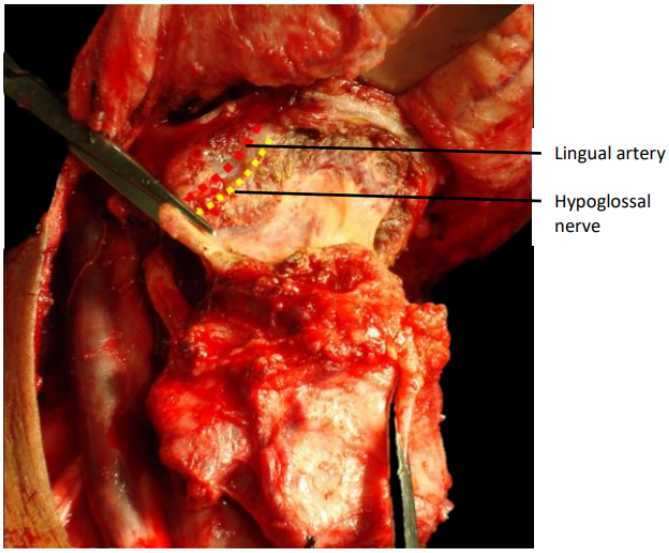


Figure 17: Releasing greater cornu

- Dissect along the hyoepiglottic ligament and strip the vallecular mucosa from the anterior surface of the epiglottis *(Figure 18)*

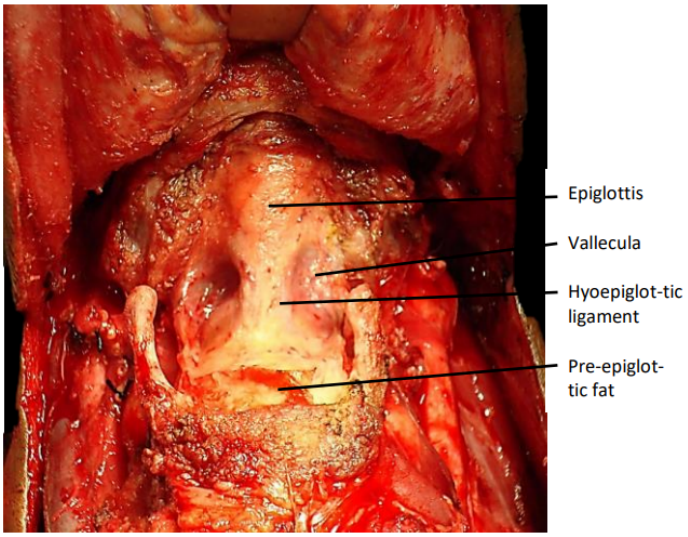


Figure 18: Suprahyoid approach to valleculae

- Enter the pharynx by incising the mucosa along the superior margin of the epiglottis *(Figure 19)*

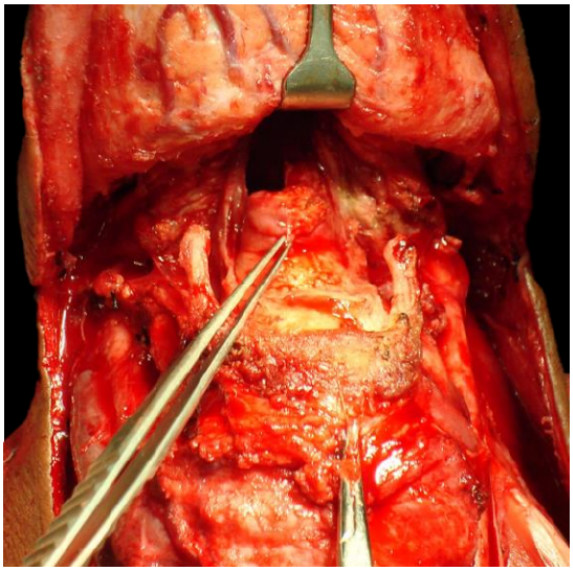


Figure 19: Entering vallecula

Tracheostomy

- A tracheostomy is done at this stage to mobilize the larynx and to facilitate the laryngeal resection
- Ask the anesthetist to preoxygenate the patient
- Incise the trachea transversely between the $3^{rd}/4^{th}/5^{th}$ tracheal rings or below a preoperative tracheostomy
- With a small trachea, incise the lateral tracheal walls in a superolateral direction to bevel and enlarge the tracheostoma
- Place a few 3-0 vicryl half-mattress sutures between the anterior wall of the transected trachea and the skin to approximate mucosa to skin
- Puncture and deflate the cuff of the endotracheal tube, and cut the tube in the pharynx, and remove the distal end of the tube through the pharyngotomy
- Insert a flexible endotracheal tube *e.g.* armoured tube into the tracheostoma. Avoid inserting the tube too deeply as the carina is quite close to the tracheostoma. Fix the tube to the chest wall or drapes with a temporary suture so that it does not become displaced, attach the sterile anesthesia tubing and resume ventilation

Laryngeal resection

- Inspect the subglottis through the tracheostoma to ensure that the tracheal tumor resection margin is adequate
- Move to the head of the operating table

- Retract the epiglottis and larynx anteriorly through the pharyngotomy, and inspect the larynx and the tumor
- Commence laryngeal resection contralateral to the tumor using curved scissors with points located anteriorly/ upwards to avoid inadvertently resecting too much pharyngeal mucosa
- Cut along the lateral border of the epiglottis on the less involved side, to expose the hypopharynx
- Repeat this on the side of tumor with at least a 1 cm mucosal margin around the tumor
- On the less involved side, cut through the lateral wall of the pyriform fossa and hug the arytenoids and cricoid to preserve pyriform sinus mucosa *(Figure 20)*. The superior laryngeal neurovascular pedicle is transected if not previously addressed
- Repeat on the tumor side

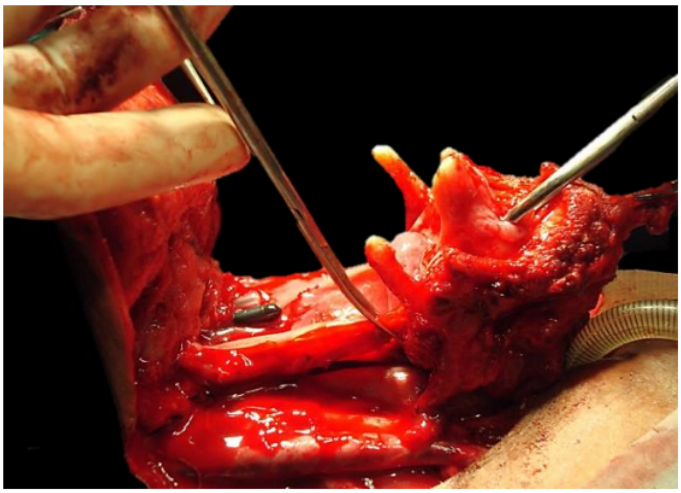


Figure 20: Resect the larynx preserving maximum amount of pharyngeal mucosa

- Join the left and right pyriform incisions by tunneling below and cutting the postcricoid mucosa transversely *(Figure 21)*

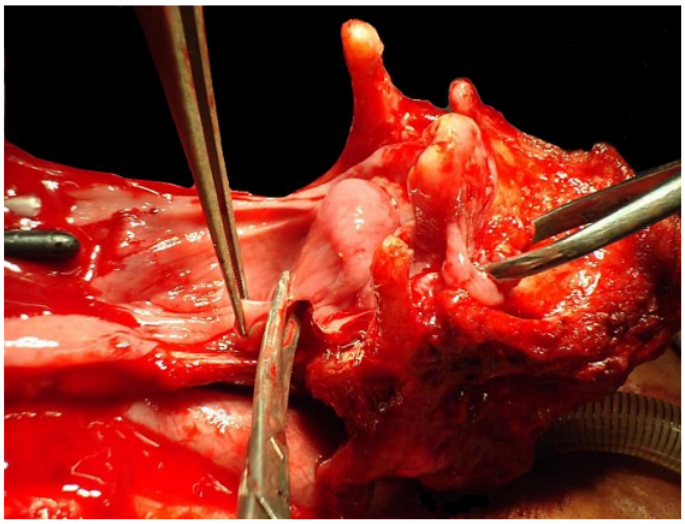


Figure 21: Transverse postcricoid cut

- Separate the posterior wall of the larynx (cricoid, tracheal membrane) from the anterior wall of the esophagus by dissecting with a scalpel along the avascular plane between that exists between esophagus and trachea/cricoid *(Figure 22)*. Take care to stop just short of the tracheostoma.

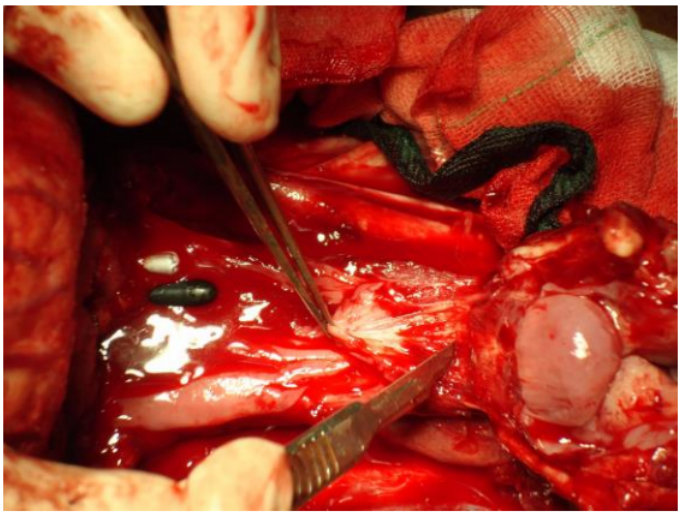


Figure 22: Dissecting in the avascular plane between esophagus and trachea

- Transect the posterior wall of the trachea, and remove the larynx *(Figure 23)*
- Inspect the laryngectomy specimen for adequacy of resection margins, and resect additional tissue if indicated

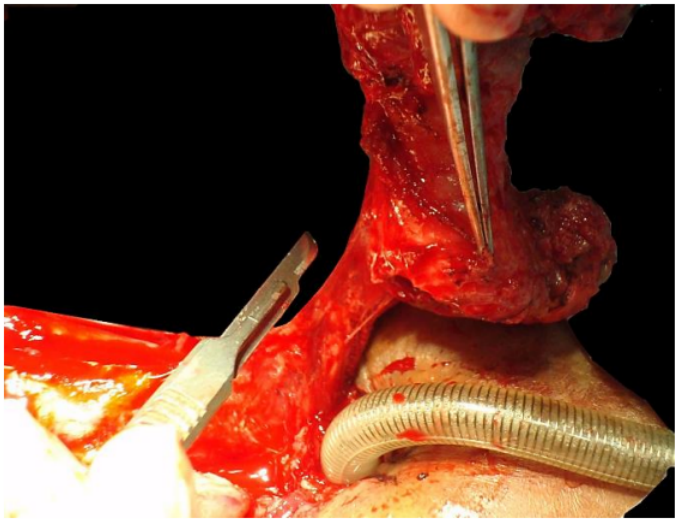


Figure 23: Transect trachea and remove larynx

Retrograde laryngectomy

- This involves commencing the laryngeal resection inferiorly at the tracheostomy site; it is recommended when tumor involves the pre-epiglottic space and/or base of tongue, to ensure an adequate suprahyoid resection margin. Some surgeons routinely do retrograde laryngectomy
- Free the hyoid bone and the lateral borders of the thyroid cartilage as described above
- Incise the trachea at about the level of the $3^{rd}/4^{th}$ tracheal rings, insert an armored endotracheal tube and remove the orotracheal tube *(Figure 24)*

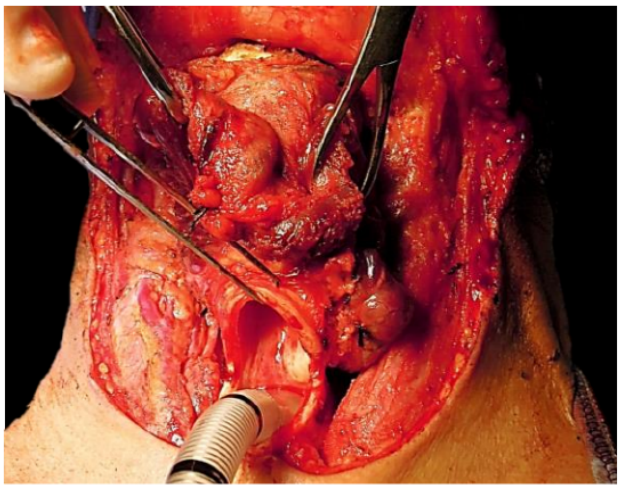


Figure 24: Trachea incised

- Transect the thin membranous posterior tracheal wall (Figure 25)

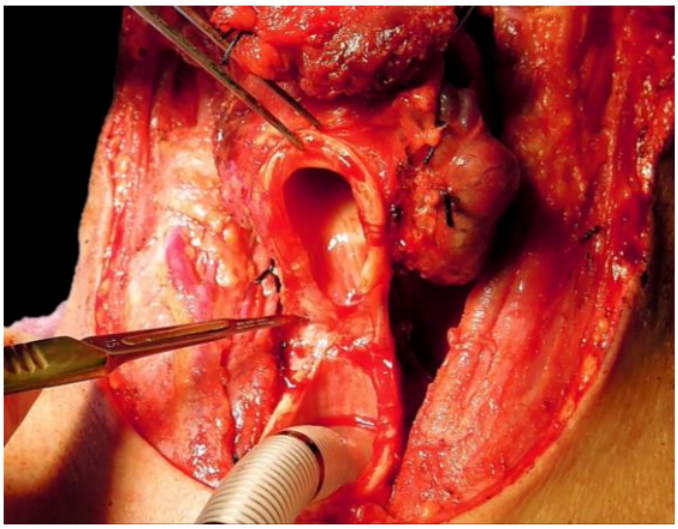


Figure 25: Transecting posterior tracheal wall to expose anterior wall of esophagus

- Find the dissection plane between trachea and esophagus and dissect cephalad in this well-defined plane with a scalpel until the posterior aspect of the cricoid and the posterior cricoarytenoid muscles come into view *(Figure 26)*

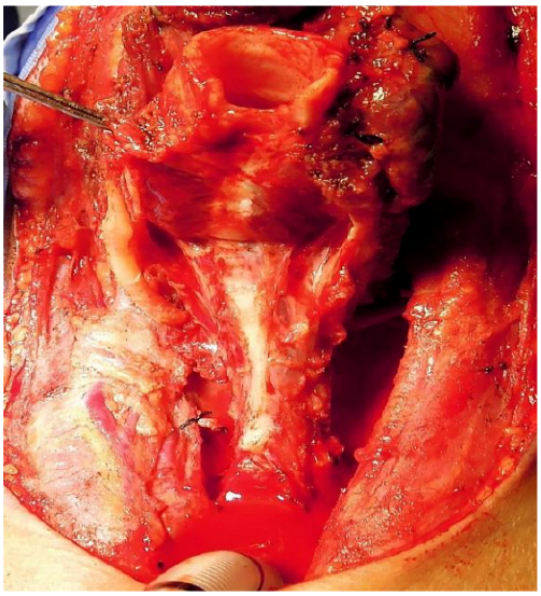


Figure 26: Esophagus, thyroid laminae, cricoid and posterior cricoarytenoid muscles exposed

- Transversely incise the pharyngeal mucosa about 1 cm below the upper border of the cricoid lamina to enter the postcricoid hypopharynx *(Figure 27)*

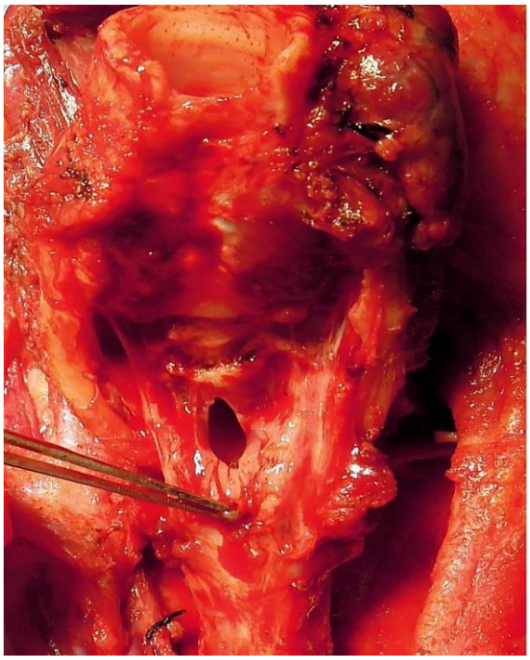


Figure 27: Entering the postcricoid area of the pharynx

- Extend the incision to the pyriform fossa contralateral to the cancer
- Once the cancer can be seen through the pharyngotomy, incise the pyriform fossa mucosa on the involved side
- By placing an index finger across the vallecula to palpate the upper extent of the cancer one can proceed to transect the base of tongue with an adequate margin

Pharyngo-esophageal myotomy

- Optimizing speech and swallowing requires a capacious and floppy pharynx
- Always perform a pharyngoesophageal myotomy to prevent hypertonicity of the pharyngoesophageal segment
- Insert an index finger into the esophagus *(Figure 28)*
- With a sharp scalpel, divide all the muscle fibers down to the submucosa, and distally to the level of the tracheastoma *(Figure 28)*. The myotomy may be done in the midline or to the side



Figure 28: Cricopharyngeal myotomy

Tracheo-esophageal fistula

- Tracheo-esophageal speech is the best form of alaryngeal communication
- A tracheo-esophageal fistula is created before closing the pharynx
- Pass a curved artery forceps through the pharyngeal defect along the esophagus and tent up the anterior wall of esophagus/posterior tracheal wall 5-10 mm below the superior margin of the tracheostoma. Placing the fistula too low makes changing the prosthesis difficult
- Cut down onto the tip of the artery forceps with a scalpel, and pass the tip of the forceps through the fistula into the tracheal lumen
- Hold the tip of a 14-gauge Foley urinary catheter with the artery forceps and pull the catheter through the fistula into the esophagus and pass it through the pharyngeal defect *(Figure 29)*. Then advance the catheter down the esophagus. Avoid accidental displacement of the catheter by injecting 5 mL water into the bulb and by fixing the catheter to the skin with a suture
- The catheter acts as a stent to allow the fistula to mature in preparation for fitting a tracheo-esophageal prosthesis, and is initially used for stomagastric feeding
- An alternative method is to insert a speech prosthesis *ab initio*, and to feed the patient via a nasogastric tube, or a catheter passed through the speech prosthesis (Postlaryngectomy vocal and pulmonary rehabilitation)
- Divide the sternal heads of the sternomastoid muscles to create a flattened peristomal contour and to facilitate digital stomal occlusion *(Figure 30)*.

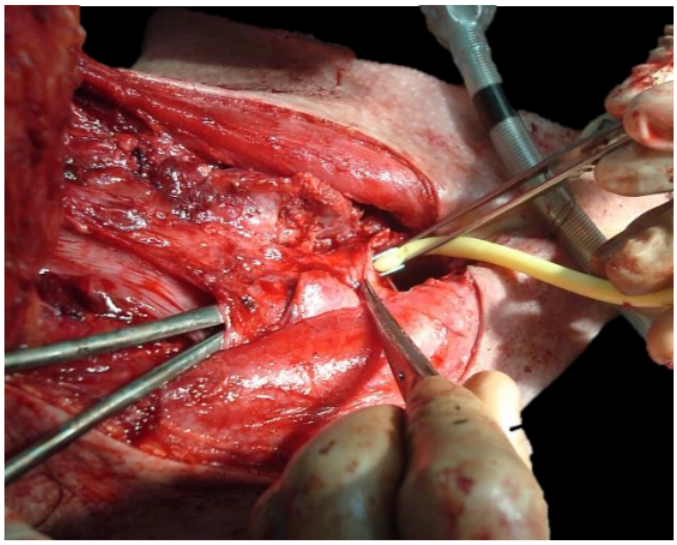


Figure 29: Creation of tracheo-esophageal fistula

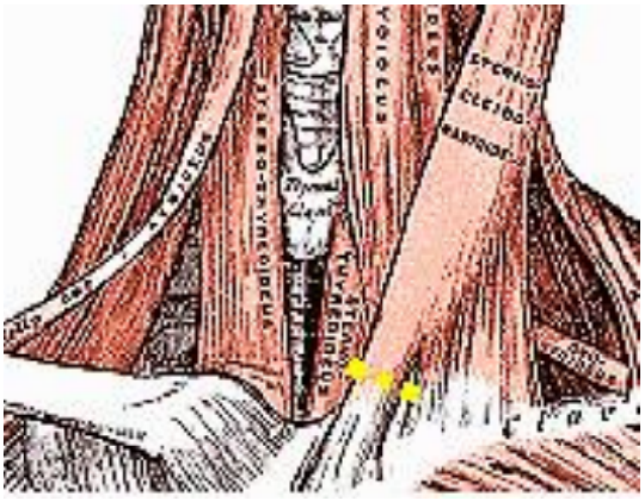


Figure 30: Division of sternal heads of sternomastoid to flatten peristomal area

Pharyngeal closure

- At least 2.5 cm transverse diameter of residual pharyngeal mucosa is required for primary pharyngeal closure. The teaching that the minimum pharynx required is that which may be closed over a nasogastric tube is incorrect, as the neopharynx is then too narrow for adequate swallowing and voicing
- A horizontal/transverse closure is preferred as it maximizes the capacity of the pharynx *(Figures 31)*. Only if there is undue tension on the suture line, then do T-shaped closure, keeping the vertical limb as short as possible

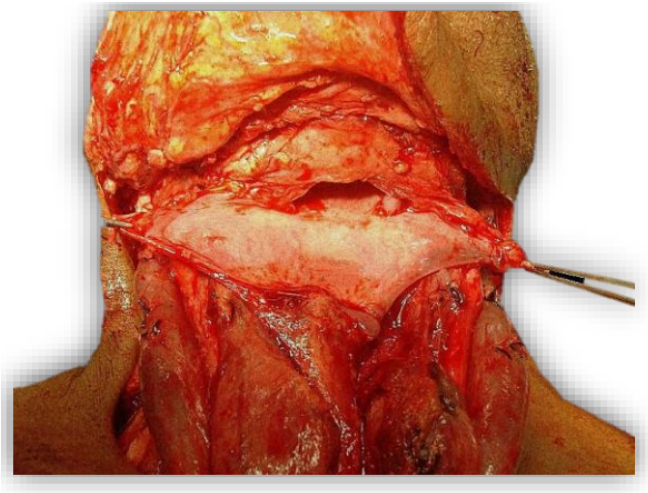


Figure 31: Pharynx well-suited to a transverse closure

- Take care not to injure the lingual arteries when suturing the pharynx, as injury to the arteries may lead to necrosis of the tongue
- A 3-layered pharyngeal closure is suggested (Video)
  - 1st layer: 3-0 vicryl running modified Connell or true Connell technique (Invert mucosa) (Figure 32)
  - 2nd layer: 3-0 vicryl running suture of submucosa and muscle
  - 3rd layer: Approximate inferior constrictors and suture constrictors to suprahyoid muscles with interrupted 3-0 vicryl

Final steps

- Ask the anesthetist to do a Valsalva manoeuvre to detect bleeding and a chyle leak
- If there is excessive, lax suprastomal skin that may occlude the tracheostomy when the patient flexes the neck, then trim a crescent of suprastomal skin from the edge of the apron flap

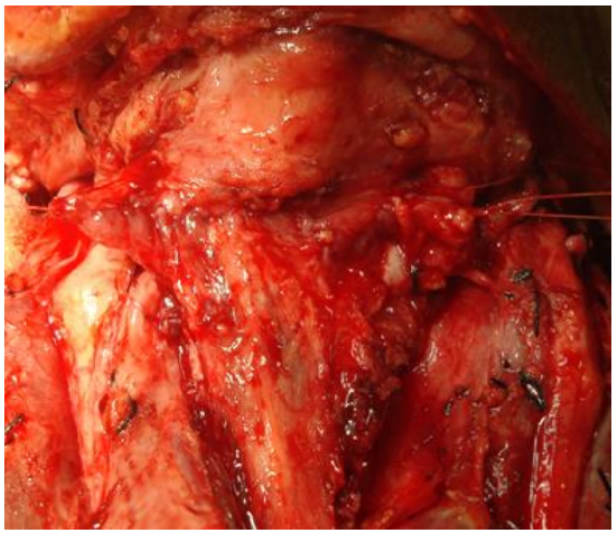


Figure 32: Completed 1st layer of transverse closure of pharynx

- Suture the skin to the edge of the tracheostomy with half-mattress interrupted 3-0 vicryl sutures
- Seal the trifurcation at the lateral edge of the stoma with a suture as indicated below *(Figure 33)*

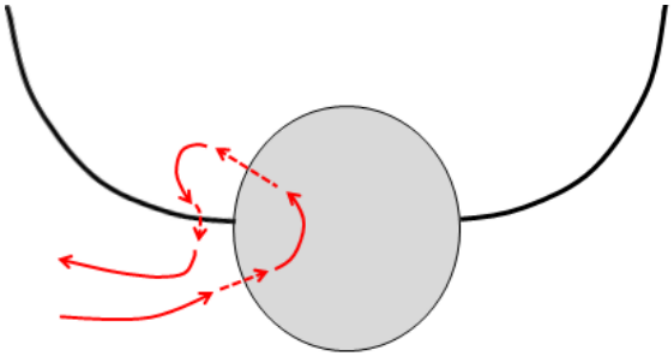


Figure 33: Suture technique to seal trifurcation between skin and side of tracheostoma

- Insert a ¼" suction drain
- Irrigate neck with sterile water
- Reapproximate the platysma with 3-0 vicryl running sutures
- Close the skin with a running nylon suture or with skin staples
- Suction blood from trachea
- Insert a cuffed tracheostomy tube, and suture it to skin

Postoperative care

- Antibiotics x 24 hours
- Omeprazole (20mg/day) via Foley or mouth x 14 days to reduce risk of developing pharyngocutaneous fistulae (*See references*)
- Chest physiotherapy
- Remove suction drains when <50 mL drainage per 24 hours (See references)
- Day 1: Mobilize to chair, remove urinary catheter
- Day 2: Commence oral feeding. Early oral feeding is safe, and does not cause pharyngocutaneous fistulae (*See references*)

Early feeding protocol	
Day 1	Intravenous general maintenance solution & stomagastric feeds
Day 2	Clear oral fluids & stomagastric feeds
Day 3	Free oral fluids
Day 4	Soft diet
Day 5	Normal diet

- Day 7: Remove sutures
- Day 10: Insert speaking valve; no anesthetic required *(Figures 34, 35)*
- Cover the stoma with a bib *(Figure 36)*

Pharyngeal reconstruction

Following resection of large pyriform fossa tumours *(Figure 37)* or tumors that extend close the cricopharyngeus, or involve the postcricoid area, only a narrow strip of mucosa may remain to reconstruct the neopharynx. If the residual pharyngeal mucosa is <2.5 cm in width, then additional tissue is required to avoid pharyngeal stenosis, dysphagia and poor speech *(Figure 38)*. Reconstructive options include pectoralis major, latissimus dorsi and supraclavicular flaps, or microvascular free tissue transfer flaps (radial forearm, anterolateral thigh).



Figure 34: Stoma and Foley catheter feeding tube one week following surgery

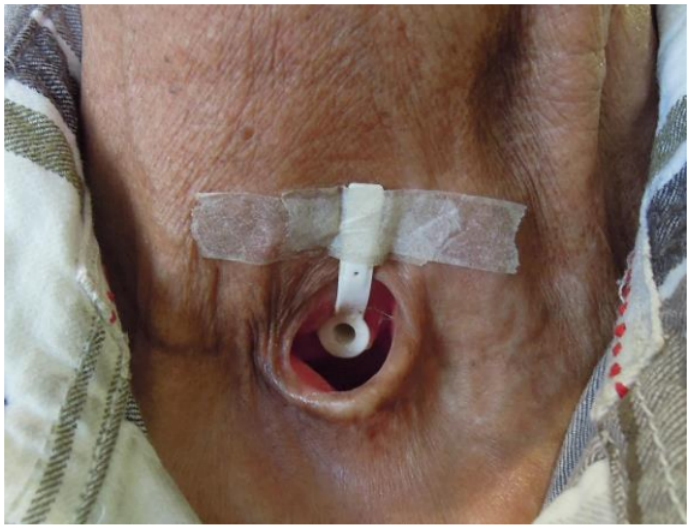


Figure 35: Speaking valve



Figure 36: Bib

All these flaps can be used to augment the pharyngeal repair, or when the pharynx has been completely resected, may be tubed to entirely replace the pharynx *(Figures 39 – 42)*.

Following pharyngeal reconstruction with a flap, a contrast swallow X-ray is done on about day 7 to exclude an anastomotic leak before commencing oral feeding.

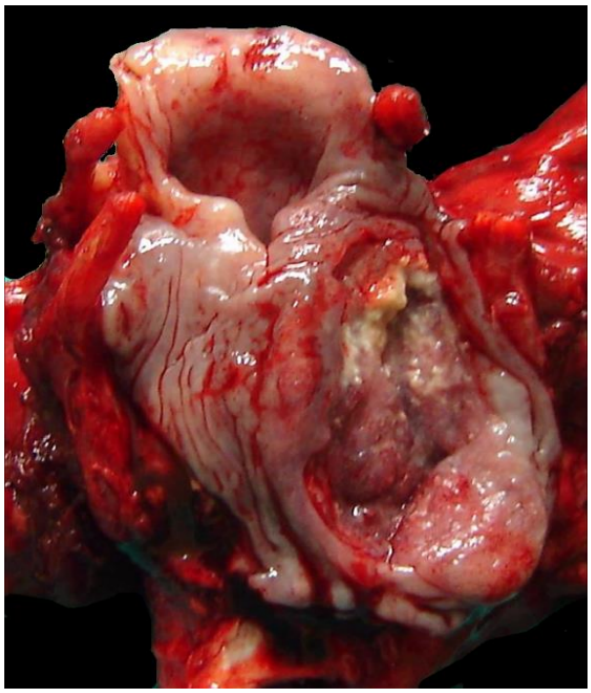


Figure 37: Large carcinoma of hypo-pharynx that requires pharyngeal reconstruction

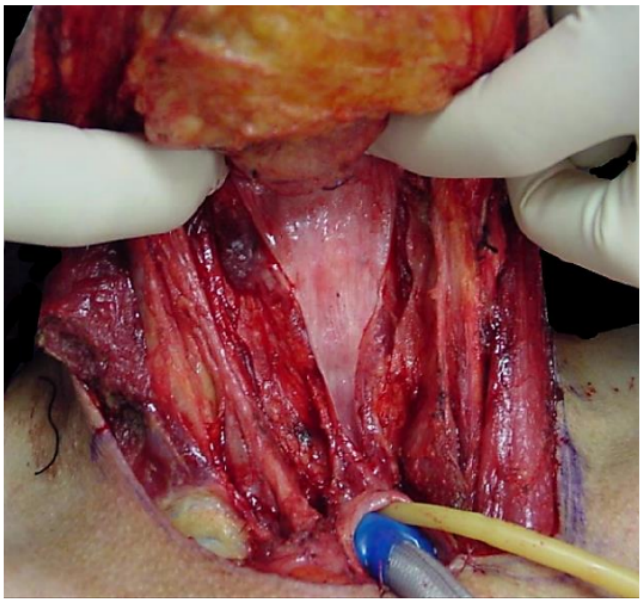


Figure 38: Insufficient pharyngeal mucosa for primary closure of pharynx

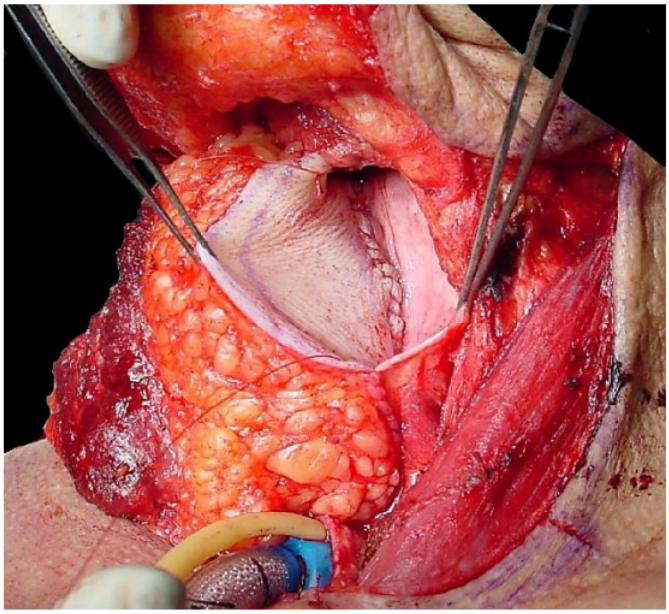


Figure 39: Pectoralis major augmentation of pharynx

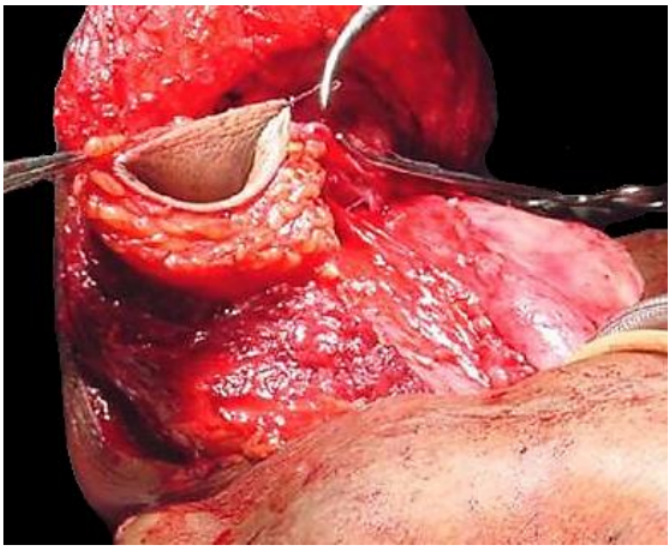


Figure 40: Tubed pectoralis major flap

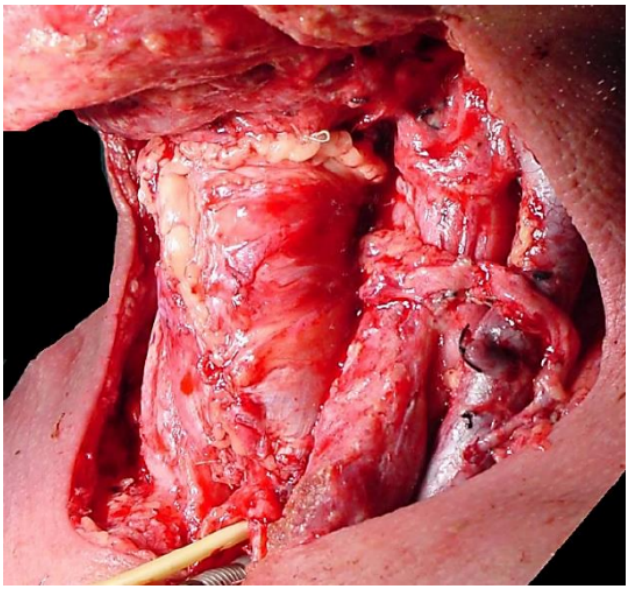


Figure 41: Tubed anterolateral thigh flap

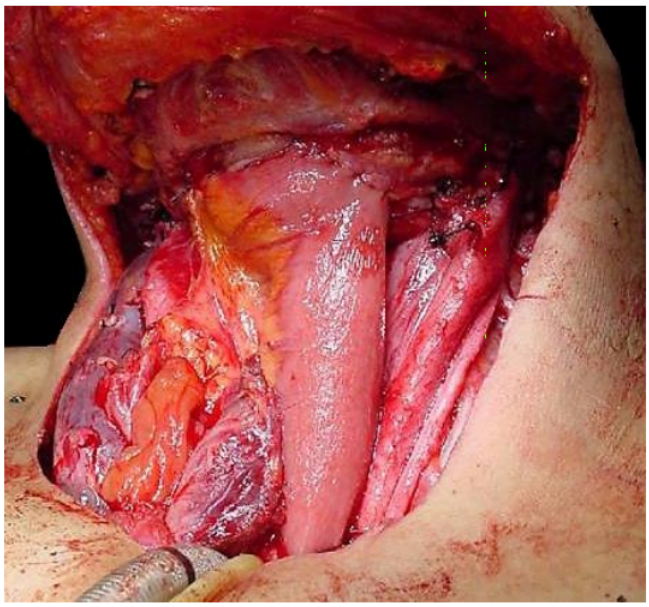


Figure 42: Free jejunal flap

Useful references

- Stephenson K, Fagan JJ. The effect of perioperative proton pump inhibitors on the incidence of pharyngocutaneous fistula following total laryngectomy: a prospective randomized controlled trial. Head Neck 2015 Feb;37(2):255-9
- Aswani J, Thandar MA, Otiti J, Fagan JJ. Early oral feeding following total laryngectomy. J Laryngol Otol. 2009; 123:333-338
- A practical guide to post-laryngectomy vocal and pulmonary rehabilitation - Fourth Edition: Postlaryngectomy vocal and pulmonary rehabilitation
- Fagan JJ, Lentin R, Oyarzabal MF, S Iaacs, Sellars SL. Tracheoesophageal speech in a Developing World Community. Arch Otolaryngol 2002, 128 (1): 50-3
- Fagan JJ, Kaye PV. Management of the thyroid gland with laryngectomy for cT3 glottic carcinomas. Clin Otolaryngol, 1997; 22: 7-12
- Harris T, Doolarkhan Z, Fagan JJ. Timing of removal of neck drains with head and neck surgery. Ear Nose Throat J. 2011 Apr; 90(4):186-9
- Fagan JJ, Lentin R, Quail G. International Practice of Laryngectomy Rehabilitation Interventions - A Perspective from South Africa. Curr Opin Otolaryngol Head Neck Surg. 2013 Jun;21(3):199-204

- Quail G, Fagan JJ, Raynham O, Krynauw MH, John LR, Carrara MH. The effect of cloth stoma covers on tracheal climate of laryngectomy patients. Head Neck. 2016 Apr;38 Suppl 1:E480-7

Clinical Practice Guidelines

- Cancer of Glottis: https://developingworldheadandneckcancerguidelines.com/index-page-glottic-cancers/
- Cancer of Supraglottis: https://developingworldheadandneckcancerguidelines.com/index-page-supraglottic-cancers/
- Cancer of Hypopharynx: https://developingworldheadandneckcancerguidelines.com/index-page-hypopharyngeal-cancers/

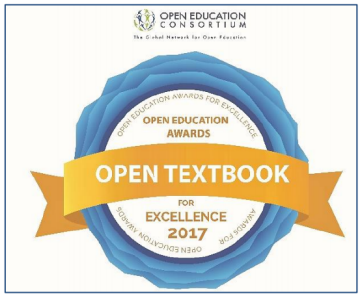
Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za





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1.13: Management of Salvage Laryngectomy Defects and Related Wound Complications

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Ryan Orosco and Eben Rosenthal

The goal of this chapter is to provide a working framework for the management of fistulae and complex wounds related to salvage total laryngectomy (sTL).

sTL is an effective oncologic intervention for recurrence following (chemo)radiation therapy, but is frequently associated with postoperative wound problems including salivary fistulae, infection, stomal dehiscence, and strictures etc. Overarching therapeutic goals in the acute postoperative period of sTL are optimization of wound healing, prevention of pharyngocutaneous fistulae, avoidance of prolonged hospitalization, and initiation of oral intake. Wound breakdown and fistula formation are associated with functional problems such as dietary restrictions, limited communication, and stricture formation

Steps to avoid and/or manage wound healing complications in the radiated neck are a critical element of achieving these objectives. However how to avoid wound healing complications in these high risk patients remains controversial and there is no consensus as to optimal preventative strategies. A stepwise approach can be summarized as follows:

1. Prevention
2. Conservative Management
3. Negative Pressure Dressings
4. Reconstruction
    - Regional flaps
    - Free tissue

There is however evidence that use of vascularized tissue for pharyngeal reconstruction at the time of sTL can help prevent and diminish complications[1]. When complications do occur, management is sometimes escalated in a conservative manner. A more aggressive approach with tissue transfer may be required if conservative interventions fail or may be instituted early on in “unsafe” neck wounds.

Prevention

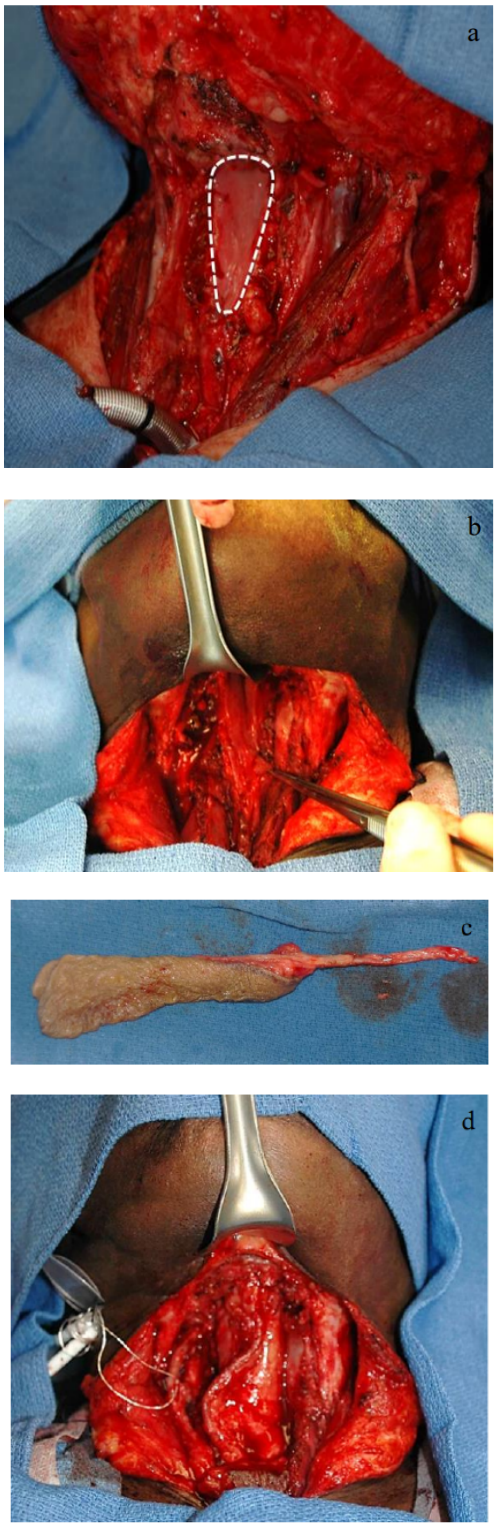
Although primary mucosal closure is technically possible in some sTL cases, several factors are known to predispose to fistulae and wound breakdown. These include ***hypothyroidism, bilateral neck dissection, and previous chemotherapy***[2]. Once a fistula occurs, it is associated with significantly longer hospital stay and stricture rates[3,4]

Contrast (barium) swallow radiographs are commonly employed postoperatively to exclude a leak and has a high specificity (approx. 94%), although the sensitivity is lower (approx. 26%). If a swallow test is negative, it is still possible that a leak will manifest later[3]. Therefore swallow studies should be done based on clinical suspicion rather than routinely.

Many tertiary institutions consider sTL an indication for ***vascularized tissue placement***, usually a radial free forearm flap, but pectoralis major muscle overlay flaps or anterolateral free thigh flaps are also commonly employed. In a study of over 350 patients undergoing sTL at 7 high-volume academic centers, patients were grouped as either primary closure, pectoralis onlay flap, or closure with a free flap. Notably, most vascularized tissue flaps were interposed free flaps. Multivariate analysis demonstrated a significantly lower fistula rate with either flap technique. Furthermore, those patients who underwent closure using vascularized tissue could be managed without surgical intervention after occurrence of a fistula, and healed faster[1]. In other series, the use of onlay myofascial pectoralis major flaps were not superior to inlay myocutaneous flaps[5]. A recent meta-analysis of 33 studies from 2000 to 2013 reported a fistula rate of 14.3% (N=326 of 2177) for primary total laryngectomy and 28% in sTL. If a flap-reinforced closure was utilized, the fistula rate was much lower in the salvage setting (10%)[6]. A flap may be used even when there is sufficient mucosa to close the defect primarily.

Though no consensus exists as to the optimal choice of vascularized tissue with sTL, free tissue transfer is often preferred. Although a range of vascularized tissues have been used, including free anterolateral thigh and rectus abdominis flaps, interposition

radial free forearm flaps are most commonly used *(Figure 1)*.



Figures 1a-d: Typical pharyngeal defects; RFFF; RFFF in place

After total laryngectomy with neck dissection(s), a wound is ideal for reconstruction, and the donor vessels are accessible for microvascular anastomosis. If one has a good reconstructive team, the authors favor using a free flap, reserving the pectoralis major flap for potential salvage repair should the flap fail, to cover exposed major vessels, and for emergent procedures.

Intraoperative fluorescence angiography may offer improvements in the surgeon's ability to identify poor vascularity of the soft tissues that may indicate patients at-risk for impaired wound healing. Intraoperative fluorescence angiography uses systemically injected indocyanine green (5 - 10 mg, IV push) to measure the relative perfusion in tissues and has been shown to have value in breast reconstructive surgery, and may similarly have applications in head and neck reconstruction.

Use of ***antibiotics remains controversial***, as there is no data to support antibiotics given for longer than 24 hours after surgery.

Conservative management

When wound complications occur following sTL, the wound management strategy evolves over time based on the response to medical or surgical interventions *(Figure 2)*.

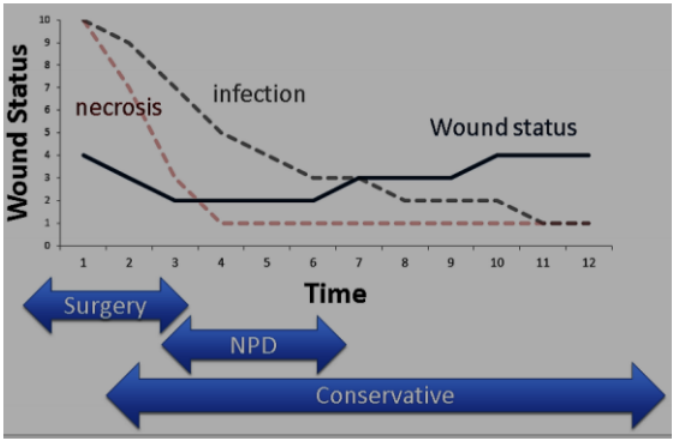


Figure 2: Management of wound breakdown after total laryngectomy (NPD = Negative pressure dressings)

Antibiotics are generally not indicated for uncomplicated fistulae. Once a cervical infection does occur, diagnosis (fistula, cellulitis, abcess, etc) should be determined before antibiotics are administered as it could mask a significant issue that will delay definitive management.

Surgical interventions for diagnostic and therapeutic reasons are based on ***bedside evaluation***; CT scans are generally not needed. Contraindications to conservative wound management generally include a significant amount of infected tissue, and exposed large caliber vessels at risk of hemorrhage.

Initial danger signs usually manifest on Days 5-8 and may include lethargy, sweats, and cervical erythema (usually above the suture line).

The ***following days to weeks*** usually involve ***aggressive debridement and removal of necrotic tissue***, which is often the source of infection.

Following ***initial wound debridement, conservative wound management*** is instituted as an inpatient with ***wound dressings applied until the wound can be considered "safe"*** for discharge (no risk of great vessel rupture). Conservative wound therapies in radiated wounds usually require 5-8 days of inpatient care to see the wound improve, and several months of home care to achieve maximal healing. Wound dressings frequently consist of ***wet-to-dry saline dressing changes or negative pressure wound care*** *(Table 1)*.

Management option	Indication	Contra-indication	Treatment setting	Usual duration of therapy
Conservative	Safe wound	Exposed large vessel	Home / In-patient	3-4 months
Negative pressure dressing	Marginal wound	Necrotic debris	Inpatient for fistula/trach Outpatient for cutaneous	Inpatient: 4-10 days Outpatient: 2-4 weeks
Surgical reconstruction	Carotid blowout risk Mature wound	Active infection Recurrent cancer	Tertiary care setting	Inpatient: 7-14 days

Table 1: Management options of wound breakdown after sTL

If the wound ***does not show improvement within several days***, then definitive management should be planned to protect the great vessels using a ***pectoralis major muscle onlay flap*** and ***maintaining a patent pharyngocutaneous fistula***.

Negative pressure dressings

Negative pressure dressings promote wound healing by applying a vacuum through a special sealed dressing. The continuous vacuum draws out fluid from the wound and increases blood flow to the area. *(Figure 3)*. Although the negative pressure dressings will not achieve anything that conservative management will not do over time, they do accelerate wound healing by 20-40%.

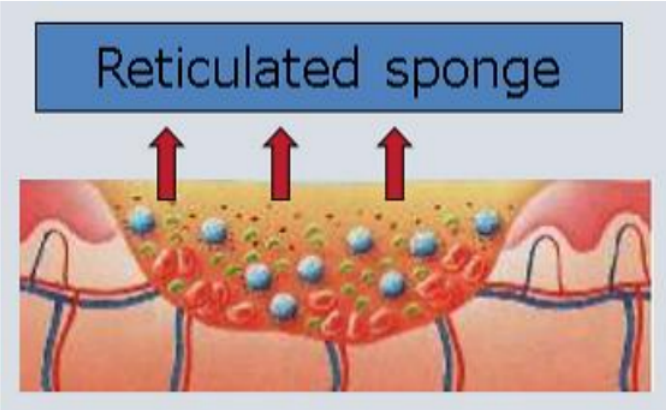


Figure 3: Negative pressure dressing application of subatmospheric pressure using an electrical pump

The mechanism of action for negative pressure dressings is not well understood, but it is thought reduce bacterial content, improve blood supply, and promote contraction of the wound. Possible mechanisms of negative pressure dressings include:

- Removing secretions
- Debridement
- Reducing bacterial content
- Improving blood flow

General indications for negative pressure dressings include stomal seeding from a salivary fistula, non-healing wounds, exposure of great vessels, donor site skin grafts, and to support reconstructive tissues in a compromised wound. Negative pressure dressings should not be used if there is active infection or necrotic tissue.

Negative pressure dressings can be used to manage complex wounds. They can be directly applied to active pharyngocutaneous fistulae to accelerate healing in softtissue[7], as intraluminal dressings during secondary pharyngeal repairs[8], and can be placed directly over major vessels or a vascular pedicle.

Negative pressure dressings have 4 basic components:

1. ***Dressing or filler material*** that is shaped to the wound contours and directly applied to the wound. It may consist of reticulated sponge *(Figure 4)* gauze, or honeycombed textiles. It can be safely placed over large, exposed vessels, free flap pedicles, and other "at risk" areas[7, 8].
2. ***Occlusive plastic tape dressing*** is applied over the sponge and taped to the surrounding skin to create an airtight sealed cavity over the wound *(Figure 4)*
3. ***Plastic tubing*** that connects the sealed airtight cavity over the wound with the vacuum pump *(Figure 5)*
4. ***Vacuum pump or wall suction*** to generate a constant negative pressure varying between −125 and −75 mmHg depending on the material used and patient tolerance *(Figure 6)*



Figure 4: Application of adherent plastic sheeting over a foam filler (Wikipedia)



Figure 5: Example of tubing arrangement



Figure 6: Example of a vacuum pump (Wikipedia)

Using negative pressure dressings on the neck presents significant challenges due to the presence of a tracheostomy or tracheostoma, pharyngocutaneous fistula, hair, poor skin quality, and contamination with saliva, all of which make it difficult to achieve an occlusive seal.

Negative pressure dressings are changed every 3-6 days. Generally, 4-10 days of inpatient therapy is required, followed by 2- 4 weeks' outpatient wound care.

Negative pressure dressings are sometimes not used due to cost (sponges are often cheap, but pump rentals in the USA can cost hundreds of dollars/day). When considering use of negative pressure dressings, the associated costs should be balanced against the cost savings and quality of life of a potentially shorter inpatient hospital stay.

Aggressive management

Escalation to reconstruction is the next level of complexity in the wound management strategy *(Table 1)*. Indications include imminent risk of carotid or internal jugular bleeding, or a very mature wound ready for definitive repair. Relative contraindications to flap repair include active infection or recurrent / persistent cancer.

Because of the simplicity of the ***pectoralis flap*** in postoperative sTL wound situations, ***free tissue transfer*** is less commonly used.

In a vessel-depleted neck, the ***pectoralis major flap*** or less commonly the latissimus dorsi flap may be used. The pectoralis major flap is particularly well suited for emergent and urgent postoperative wound complications as it done using standard equipment with the patient in a supine position, and without specialized nursing at any time of the day or night, and it is a very robust flap. Therefore the authors use the pectoralis major flap as a backup flap to manage sTL complications rather than a primary reconstructive strategy.

There are situations in which ***free tissue transfer*** is ideal for the management of sTL complications. Dissection of quality donor vessels is however paramount, and preparation of donor vessels suitable for microvascular anastomosis may be challenging in an unfavorable postoperative wound in a previously irradiated neck, particularly in the presence of sepsis, and may lead to exposure of additional segments of the carotid artery.

In a vessel-depleted neck it is worth considering using the ***internal mammary vessels*** as they are generally well protected from cardiovascular disease. Access is achieved by removing a short section of the 2nd rib as it joins the sternum. It is usually better to use the right side in case there is future need for cardiac revascularization.

Summary and conclusions

- Delayed reconstruction following sTL wound complications is challenging and emphasises the importance of implementing preventative strategies in this high risk patient population
- Use vascularized tissue reconstruction as a preventative strategy to manage sTL defects
- Reconstruction at the time of tumor extirpation decreases salivary fistula rates and limits the duration of complications when they do occur
- Given availability of the required expertise and facilities, free flap reconstruction is the preferred technique for upfront reconstruction

- The pectoralis major flap is however a reliable, simple flap that can be used in emergent or unanticipated circumstances
- Management of complex wounds following sTL progresses through a stepwise algorithm aimed at the creation of a safe wound and promotion of subsequent healing
- Wound debridement and management of active infection should be followed by conservative wound dressings and sometimes negative pressure dressings

References

1. Patel, U.A., et al., Impact of pharyngeal closure technique on fistula after salvage laryngectomy. JAMA Otolaryngol Head Neck Surg, 2013. 139(11): p. 1156-62
2. Andrades, P., et al., Fistula analysis after radial forearm free flap reconstruction of hypopharyngeal defects. Laryngoscope, 2008. 118(7):1157-63
3. Sweeny, L., et al., Incidence and outcomes of stricture formation postlaryngectomy. Otolaryngol Head Neck Surg, 2012. 146(3):395-402
4. Withrow, K.P., et al., Free tissue transfer to manage salvage laryngectomy defects after organ preservation failure. Laryngoscope, 2007. 117(5): 781-4
5. Khan, N.A., et al., Fistula rates after salvage laryngectomy: comparing pectoralis myofascial and myocutaneous flaps. Laryngoscope, 2014. 124(7):1615-7
6. Sayles, M. and D.G. Grant, Preventing pharyngo-cutaneous fistula in total laryngectomy: a systematic review and meta-analysis. Laryngoscope, 2014. 124(5):1150-63
7. Asher, S.A. et al., Negative pressure wound therapy in head and neck surgery. JAMA Facial Plast Surg, 2014. 16(2):120-6
8. Asher, S.A., et al., Intraluminal negative pressure wound therapy for optimizing pharyngeal reconstruction. JAMA Otolaryngol Head Neck Surg, 2014. 140(2):143-9
9. Rosenthal, E.L., et al., Use of negative pressure dressings in head and neck reconstruction. Head Neck, 2005. 27 (11):970-5
10. Shreenivas, S., J.S. Magnuson, and E.L. Rosenthal, Use of negative-pressure dressings to manage a difficult surgical neck wound. Ear Nose Throat J, 2006. 85(6):390-1

Authors

Ryan K Orosco, MD
Instructor of Otolaryngology
Division of Head and Neck Surgery
Department of Otolaryngology
Stanford University, CA, USA
orosco@stanford.edu

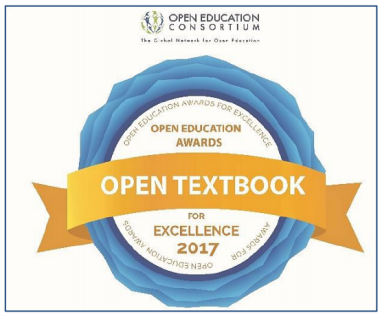
Eben L. Rosenthal, MD
Ann and John Doerr Medical Director
Stanford Cancer Center
Professor of Otolaryngology, Stanford
University School of Medicine
875 Blake Wilbur Drive
C-2213 Stanford, CA 94305
elr@stanford.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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Zenon Yeung, Johan Fagan

Tracheoesophageal fistula (TOF) speech is the optimal method for postlaryngectomy speech rehabilitation *(Figures 1-3)*.

Advantages include:

- No external device required
- Doesn't rely on a battery
- More natural, intelligible voice
- Uses patient's tidal volume ~500mL as energy, and therefore allows the patient to speak louder with a more sustained voice without any pauses

However, problems do arise from time-to-time with the TOF and tracheoesophageal voice prosthesis[1,2]

- Enlarging fistula around prosthesis causing leakage of saliva and food and aspiration pneumonia *(Figure 4)*
- Leakage of saliva and food through the prosthesis
- Granulations around the prosthesis
- Failure of tracheoesophageal speech due to pharyngoesophageal segment spasm
- Fungal colonization of the prosthesis causing it to leak
- Dislodgement and aspiration of the prosthesis into the tracheobronchial tree
- Obstructed swallowing secondary to the prosthesis
- Failure of tracheoesophageal speech because of lack of motivation and cost of the prostheses

When the fistula enlarges with leakage of saliva and food around the prosthesis, or a decision is made to discontinue fistula speech and the TOF is no required, the TOF needs to be allowed to close or be closed.

Risk factors for an enlarging TOF include[3]

- Local infection
- Erosion by a feeding tube
- Ventilatory cuff injury
- Tracheal or esophageal malignancy
- Caustic or foreign body ingestion

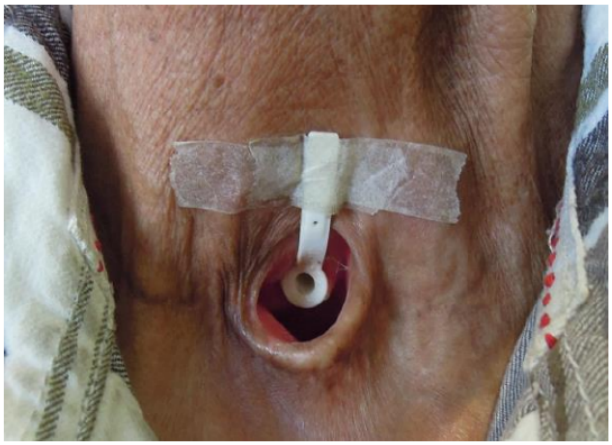


Figure 1: Voice prosthesis in situ



Figure 2: Occluding tracheostomy for voicing

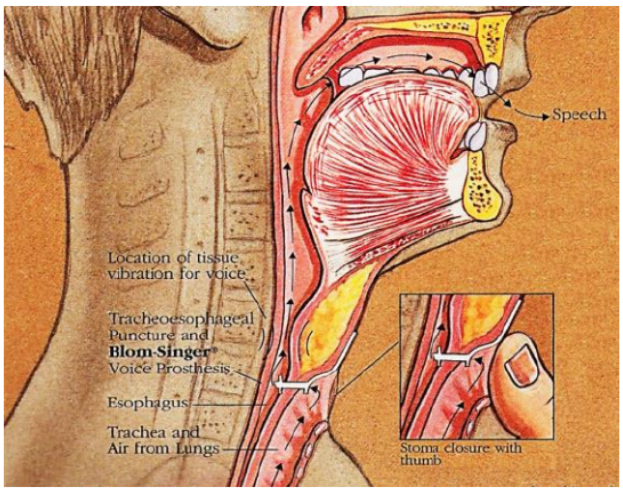


Figure 3: Mechanism of fistula speech (Adapted from Current Status of Voice Restoration Following Total Laryngectomy)



Figure 4: Very large TOF with the nasogastric feeding tube visible in the esophagus

Conservative management

- Most enlarged TOFs causing salivary leaks respond to conservative measures to ***shrink the diameter of the fistula*** such as ***reducing the size of the prosthesis*** or replacing it with a ***smaller sized urinary catheter***
- Some patients may have to ***abandon tracheoesophageal speech*** because of continued leakage with aspiration, or failed phonation.[2] In such cases the prosthesis is removed and the patient is fed via a nasogastric feeding tube until the fistula seals spontaneously, usually within 2 weeks after removal of the prosthesis
- If the fistula ***remains patent but is small, silver nitrate*** or ***electrical cauterization*** may be applied to the fistula[4]
- Alternative methods include

- Insertion a silicone septal button[5]
- Purse-string suture around the TOF
- Fat[6] / collagen / Teflon injection around the TOF[7]

Surgical closure of TOF

If above conservative treatments fail, or there is a very large TOF as in *Figure 4*, surgical closure of a TOF becomes necessary. Repuncture with placement of a new tracheoesophageal prosthesis is possible sometime after closure of the problematic fistula. Candidates for surgical closure should also be counseled about alternative methods of voice rehabilitation *e.g.* esophageal speech and electrolarynx.

When planning closure of a TOF, ***assess the size of the stoma*** for the presence of stomal stenosis so that ***stomaplasty*** can be performed at the time of closure of the TOF.

TOFs are notoriously difficult to close, and the success rate is highly variable[7] due to the poor blood supply of the irradiated and fibrotic tissue. Various methods of TOF closure have been reported:

- Layered closure
- Muscle rotation flaps (Sternocleidomastoid, pectoralis major)
- Free or pedicled fasciocutaneous flaps (radial forearm free flap[3], deltopectoral[8], supraclavicular flaps)

However, use of flaps is limited by the bulkiness of the flaps

The method described below is simple and does not require any flaps, unless closure of the esophageal defect will result in esophageal stenosis and requires reconstruction with a flap for that reason.

Surgical steps

- The procedure is performed under general anesthesia with intermittent apnea
- Intubate the patient via the tracheostoma with a small armored endotracheal tube
- Insert a nasogastric tube
- Prepare and drape to leave the neck exposed from the mandible down to the upper chest
- Local anesthetic with adrenaline is injected around edge of the tracheostoma
- Make a circumferential incision around the stoma with a 15 blade *(Figure 5)*
- Dissect 360 degrees along the wall of the trachea for a few centimeters, using electrocautery and dissecting scissors *(Figure 5)*

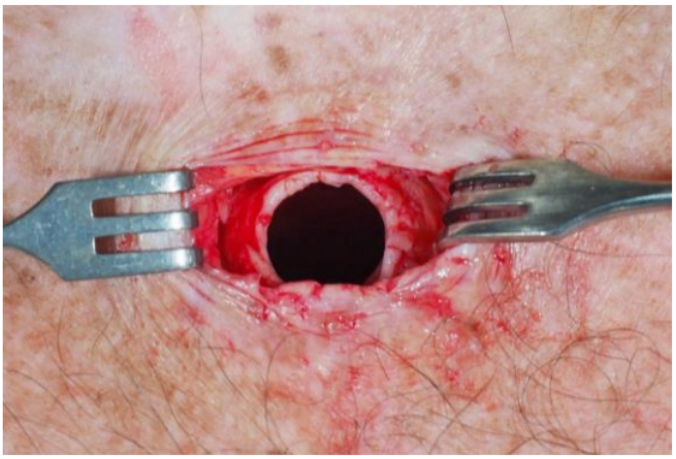


Figure 5: Tracheostoma incised circumferentially and for a few centimeters along the wall of the trachea

- Posteriorly, dissect carefully with scissors in a plane between the membranous part of the trachea and the anterior wall of the esophagus *(Figure 6)*
- Avoid accidentally opening into the esophagus
- Continue the dissection inferiorly beyond the TOF *(Figure 6)*; dense fibrosis between the trachea and esophagus can make identification of the TOF difficult

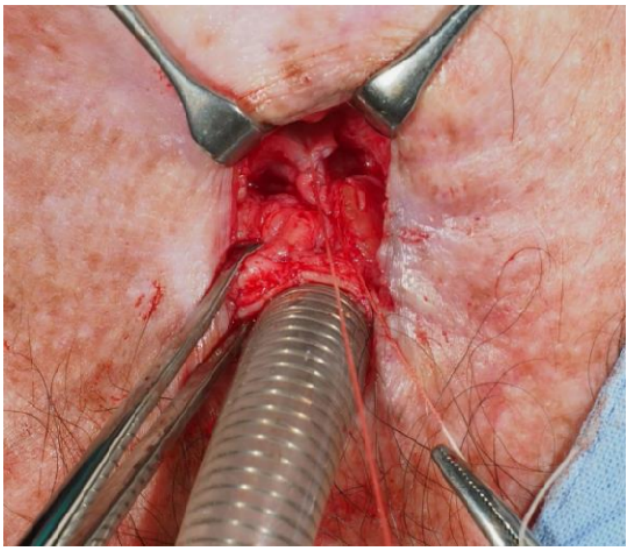


Figure 6: TOF identified and divided. The esophageal defect is being closed with 3-0 Vicryl sutures

- With the fistula identified, it is divided. Leakage of saliva or mucus may be seen from the esophageal side
- Oversew the esophageal mucosa with interrupted 3-0 absorbable Vicryl
- Resect the proximal trachea beyond the TOF
- Mobilize the trachea so that it comfortably reaches the skin surface *(Figure 7)*
- Suture the trachea to the skin edge with 2-0 Vicryl or Nylon stitches using a modified mattress technique
- No drain is required

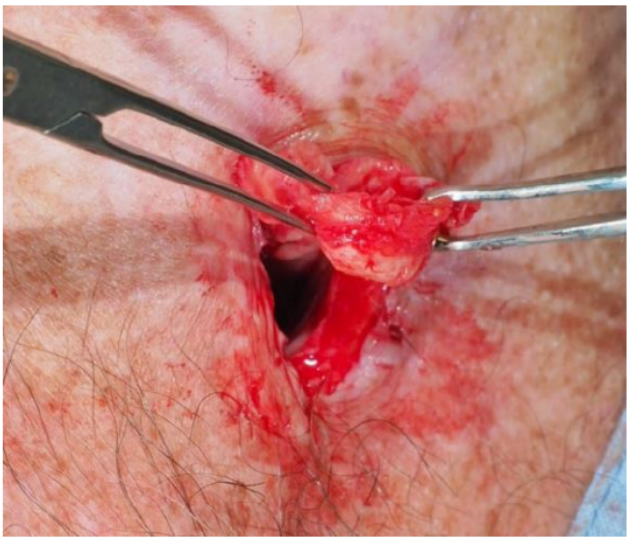


Figure 7: Trachea is mobilized and proximal tracheal rings are resected inferior to the level of the TOF



Figure 5: Tracheostoma is closed with 2-0 Vicryl or Nylon stitches using modified mattress sutures

Postoperative Care

- Patient is kept nil by mouth for 5-7 days, and fed via the NGT
- A secondary TOF can be made once the wounds have healed and matured, not sooner than a month after surgery
- Reinserting a prosthesis too soon may result in the prosthesis having to be replaced with a shorter length prosthesis as the scar matures

Case of exposed common carotid artery

This case illustrates the ***proximity of the common carotid artery to the trachea***, and the need to maintain a dissection plane on the tracheal wall. The patient had a very large tracheoesophageal fistula that had developed spontaneously some years after surgery and radiation therapy *(Figures 4, 6)*. During the dissection the common carotid artery was noted to be covered by only a thin layer of scar tissue in the left lateral wall of the tracheostoma with the tracheal rings having resorbed *(Figure 7)*. The trachea was stuck down and fibrotic, and mobilizing the trachea was not possible.



Figure 6: Large tracheoesophageal fistula with nasogastric tube visible in the midline

The carotid artery was carefully exposed over a length of 3 cm *(Figure 7)*. The esophageal fistula was repaired with 3-0 Vicryl.

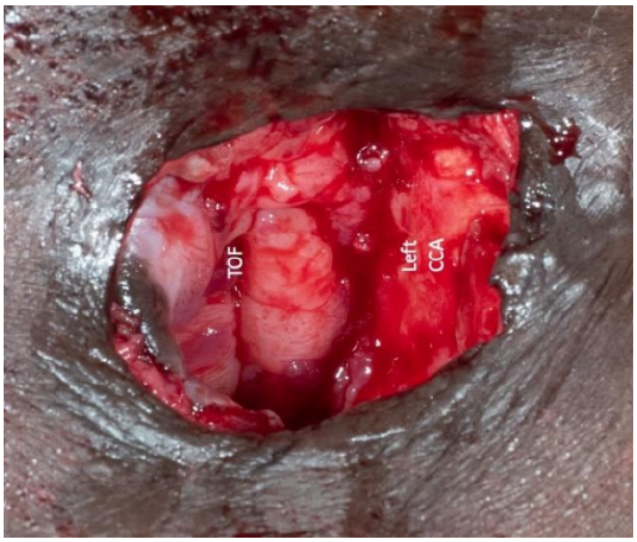


Figure 7: After dissecting the trachea around the stoma, we noted a medialized left common carotid artery (CCA) situated in the lateral wall of the tracheostoma

A supraclavicular flap was designed *(Figures 8-10)* and tunneled into the stoma to cover and isolate the carotid from the tracheostoma to avoid carotid artery blowout in the future.



Figure 8: Supraclavicular flap design



Figure 9: Raised supraclavicular island flap

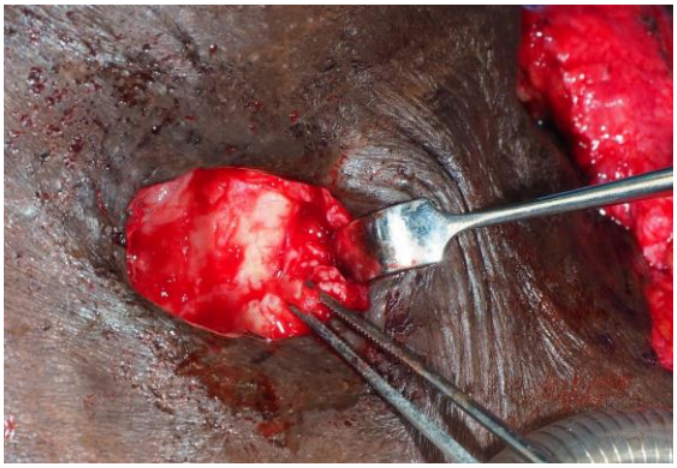


Figure 10: Exposed common carotid artery before flap inset



Figure 11: Supraclavicular flap inset to cover the exposed common carotid and overlay the oesophageal repair

References

1. Myers EN. Closure of Tracheoesophageal Fistula. Ch 51 - Operative Otolaryngology, Head and Neck Surgery 2 nd Ed. (2008) ISBN: 9780323248013
2. Stafford FW. Current indications and complications of tracheoesophageal puncture for voice restoration after laryngectomy. Curr Opin Otolaryngol Head Neck Surg. 2003;11(2):89-95
3. Wreesmann VB, Smeele LE, Hilgers FJ, Lohuis PJ. Closure of tracheoesophageal fistula with prefabricated revascularized bilaminar radial forearm free flap. Head Neck. 2009;31(6):838-42
4. Hosal SA, Myers EN. How I do it: closure of tracheoesophageal puncture site. Head Neck. 2001;23(3):214-6
5. Schmitz S, Van Damme JP, Hamoir M. A simple technique for closure of persistent tracheoesophageal fistula after total laryngectomy. Otolaryngol Head Neck Surg. 2009;140(4):601-3
6. Perie S, Ming X, Dewolf E, St Guily JL. Autologous fat injection to treat leakage around tracheoesophageal puncture. Am J Otolaryngol. 2002;23(6):345-50
7. Moerman M, Vermeersch H, Heylbroeck P. A simple surgical technique for tracheoesophageal fistula closure. Eur Arch Otorhinolaryngol. 2004;261 (7):381-5
8. Murono S, Ishikawa E, Nakanishi Y, et al. Closure of tracheoesophageal fistula with prefabricated deltopectoral flap. Asian J Surg. 2016;39(4):243-6

Author

Wing Chi Zenon Yeung MBChB (CUHK),
FHKCORL, FHKAM, FRCSEd (ORL)

Associate Consultant
United Christian Hospital and Tseung
Kwan O Hospital, Hong Kong SAR
Honorary Clinical Assistant Professor
Department of Otorhinolaryngology, Head and Neck Surgery
The Chinese University of Hong Kong
Hong Kong SAR
dr.zenon.yeung@gmail.com

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.15: Laryngofissure Technique

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Johan Fagan

Laryngofissure, also known as median thyrotomy, refers to vertically splitting the thyroid cartilage in the midline to gain access to the endolarynx. It provides good exposure to both anterior and posterior laryngeal structures with very minor morbidity *(Figure 1)*.

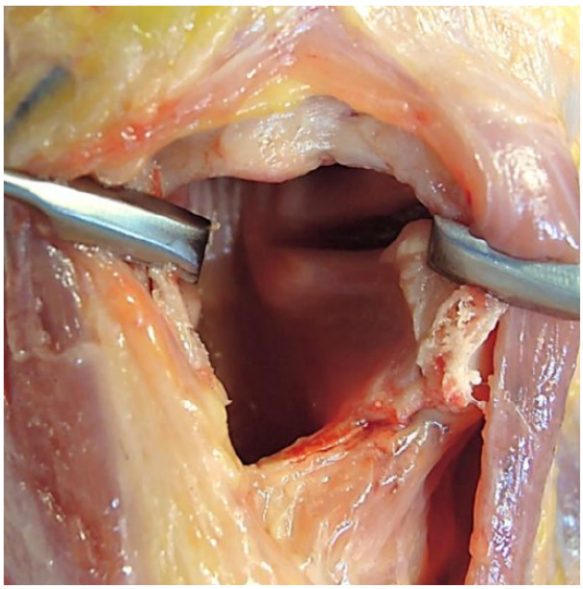
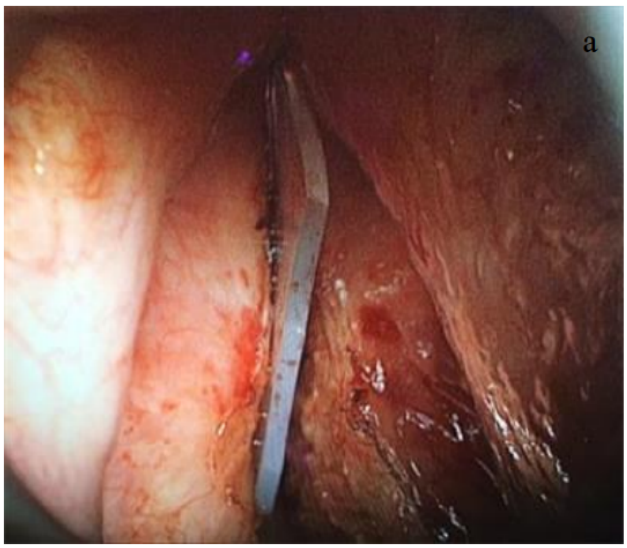


Figure 1: Good exposure to both anterior and posterior laryngeal structures

Indications for laryngofissure

Laryngofissure has largely been supplanted by transoral microsurgery. Yet it remains relevant in settings where endolaryngeal approaches are not possible due to lack of suitable microlaryngeal instrumentation and/or CO_2 laser capabilities. Other indications include the following:

- Transoral approach not possible due to anatomical constraints
- Laryngeal trauma (evacuate hematoma, repair lacerated or avulsed vocal cords, or insert a laryngeal stent)
- Cordectomy for T_1/T_2 glottic cancer
- Excising benign laryngeal tumors and masses
- Arytenoidectomy and lateralization of vocal cord for vocal cord paralysis
- Laryngeal stenosis and webs including insertion of a laryngeal keel for an anterior web *(Figure 2)*





Figures 2a, b: Laryngeal keel for anterior web

Relative contraindications

- Tumor involving thyroid cartilage and anterior commissure
- Laryngeal papillomatosis as laryngofissure may disseminate papillomata into the tissues of the neck

Surgical technique

- Because the airway is entered (clean contaminated wound), the patient must have perioperative (24 hours) broad spectrum antibiotics
- Tracheostomy is done to permit surgical access to the endolaryngeal structures and to secure the airway until postoperative swelling has abated
- Perform direct laryngoscopy to assess the laryngeal pathology
- Position the patient with neck extended
- Make a transverse skin crease incision midway between the thyroid prominence and the cricoid *(Figure 3)*

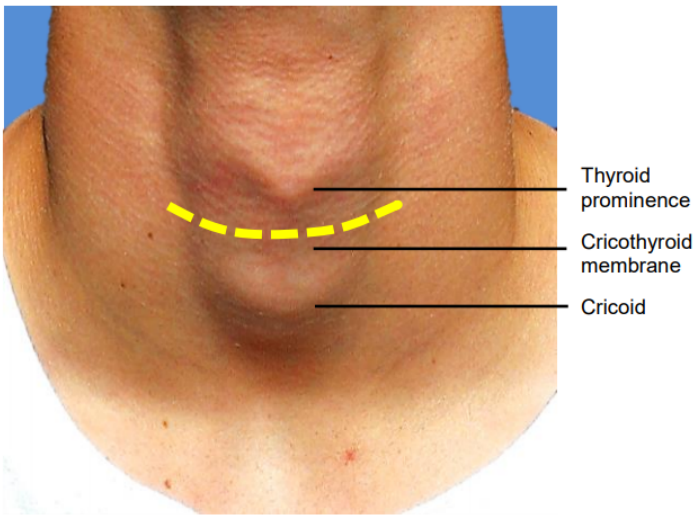


Figure 3: Surface anatomy and incision (yellow line)

- Raise skin flaps superiorly and inferiorly (platysma is generally absent in the midline)
- Incise the midline raphe between the sternohyoid muscles to expose thyroid cartilage *(Figure 4)*
- Clear all the soft tissue off the thyroid cartilage, cricothyroid membrane and cricoid in the midline *(Figure 5)*
- Expose the cricoid cartilage and cricothyroid membrane
- Incise thyroid perichondrium vertically in the midline and strip it off the cartilage to expose a midline strip of cartilage

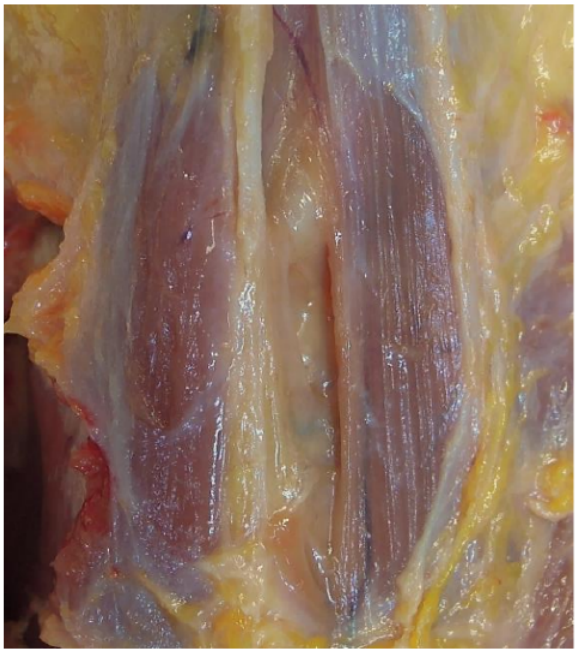


Figure 4: Raphe between sternohyoid muscles has been divided to expose the thyroid cartilage

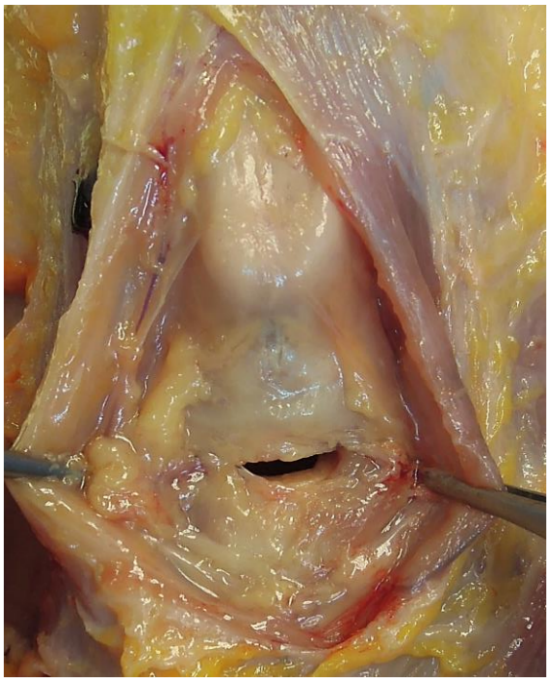


Figure 5: Thyroid cartilage, cricothyroid membrane and cricoid exposed in midline and cricothyrotomy incision visible

- Make a transverse cricothyrotomy incision through the cricothyroid membrane *(Figure 5)*. Anticipate some bleeding from the cricothyroid artery, a small branch of the superior thyroid artery which courses across the upper part of the cricothyroid membrane and communicates with the artery of the opposite side *(Figure 6)*

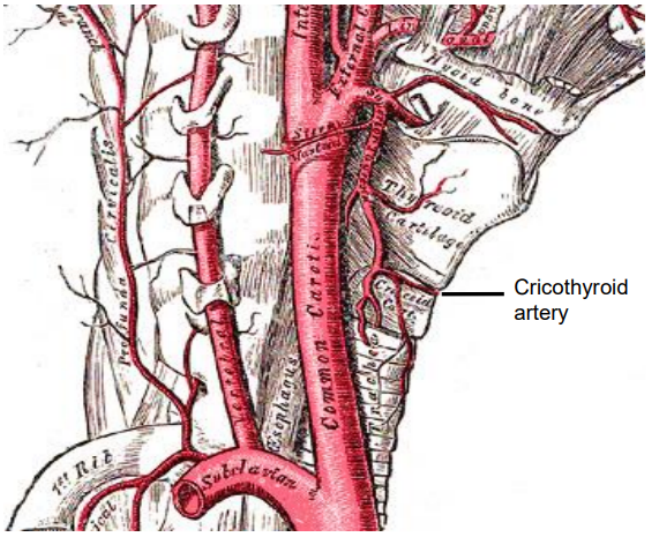


Figure 6: Cricothyroid artery branching from the superior thyroid artery

- Precisely determine the position of the anterior commissure, so that the thyrotomy is made through the anterior commissure. If this is not achieved, then either vocal cord will be damaged. The position of the anterior commissure can be determined by passing the tips of a small curved artery forceps through the cricothyrotomy, and cephalad between the vocal cords. By elevating the thyroid cartilage anteriorly with closed tips of the artery forceps, the artery will lodge in the anterior commissure, indicating precisely the line in which the thyrotomy should be made
- Vertically divide the thyroid cartilage in the midline aiming for the upturned tips of the artery forceps. This can be achieved with a scalpel; in older people with ossified cartilage it can be done with an oscillating saw or a heavy pair of scissors *(Figure 7)*
- Part the cut ends of the thyroid cartilage and inspect the endolarynx using an operating microscope or loupes if necessary *(Figures 8, 9)*



Figure 7: Completed thyrotomy

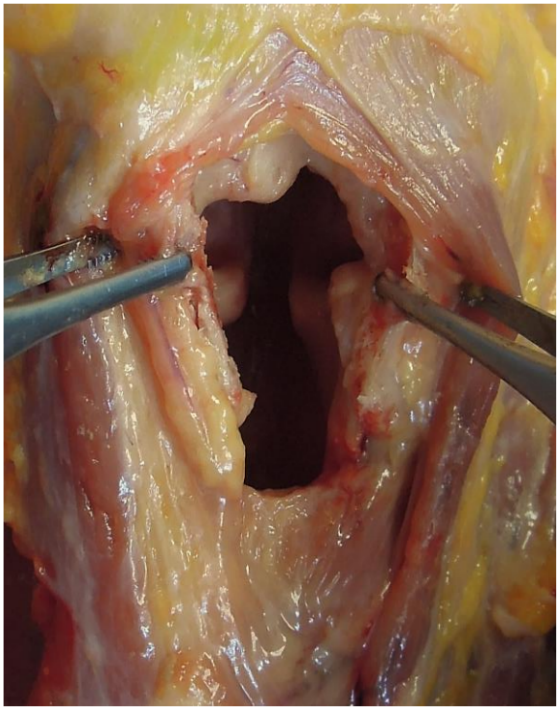


Figure 8: Note excellent view of the false vocal cords, ventricles, true cords and posterior larynx

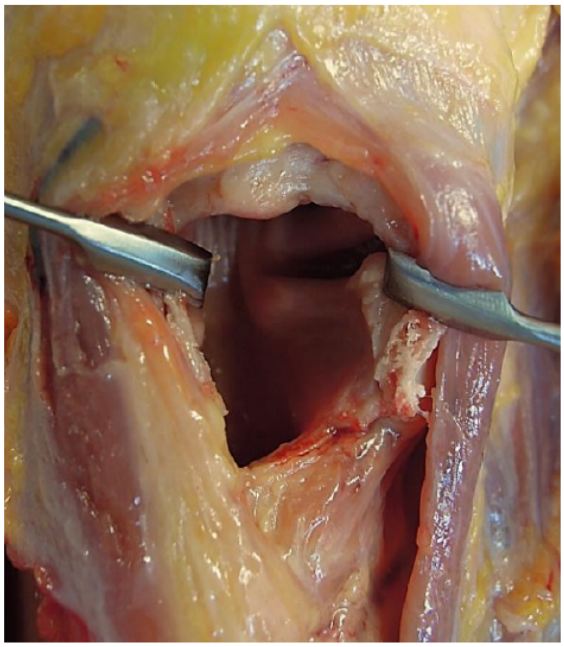


Figure 9: Note excellent view of false vocal cord, ventricle, true cord and subglottis

- A lesion of the glottis may then be excised under direct vision *(Figures 10, 11)*
- Reattach the anterior ends of the vocal cords to the cut edges of the thyroid cartilage with permanent monofilament material *e.g.* nylon to prevent retraction and shortening of the cords
- If there is a concern about webbing across the anterior commissure due to denuding of both vocal cords, a silastic keel can now be placed and secured *(Figure 2)*
- Reapproximate the cut edges of the cartilage accurately by using sutures or miniplates
- Suture the thyroid perichondrium
- Reapproximate the strap muscles in the midline
- Insert a pencil or corrugated drain to avoid surgical emphysema
- Suture the skin
- Remove the tracheostomy tube once the airway is adequate

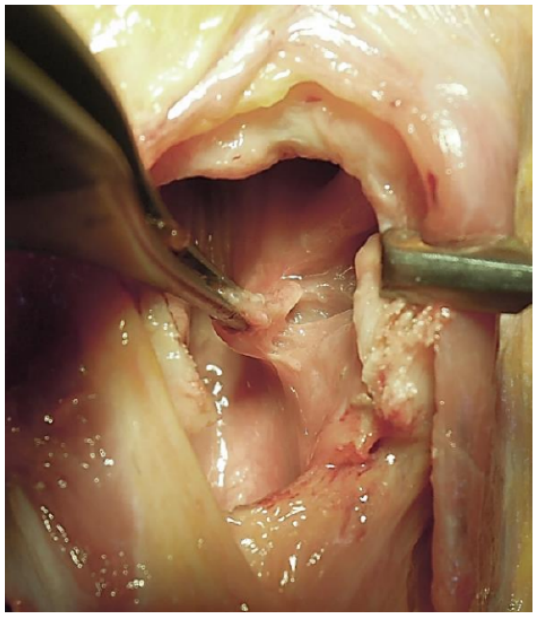


Figure 10: Lesion of glottis being excised

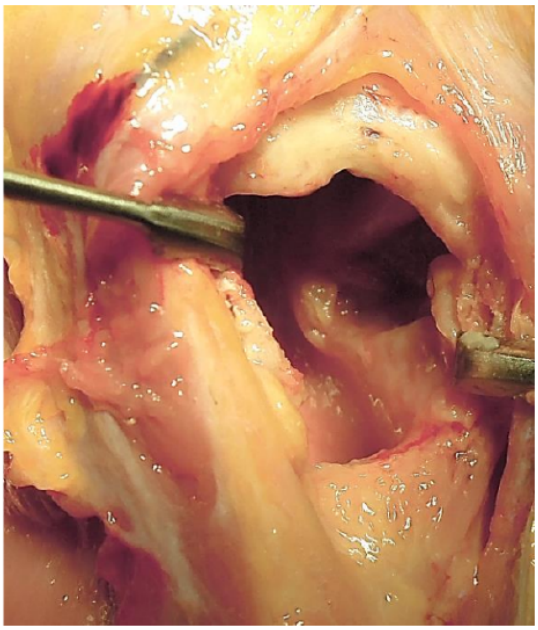


Figure 11: Cordectomy defect

Complications

- Webbing of anterior commissure; this is due to failure to reapproximate the vocal cords to the anterior edges of the laryngofissure, or not inserting a silastic keel when the opposing mucosae of the vocal cords have been traumatized
- Non-healing thyrotomy *e.g.* following previous radiation therapy
- Laryngocutaneous fistula: this generally closes spontaneously
- Malunion of the thyrotomy may cause a poor voice

Useful reference

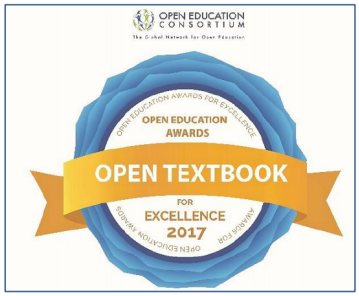
AfHNS Clinical Practice Guidelines for Glottic Cancers in Developing Countries and Limited Resource Settings

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.16: Laryngectomy - Supraglottic

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Jonas Johnson

The treatment of cancer of the supraglottic larynx is in a continual state of evolution. Clinicians are anxious to provide patients with the best possible functional outcome while controlling tumor. Therapeutic options for patients with cancer limited to the supraglottic region of the larynx include transoral microsurgical resection, chemoradiation therapy, open horizontal supraglottic laryngectomy and supracricoid laryngectomy.

Supraglottic laryngectomy was first introduced to the United States of America over 50 years ago. It effectively controls limited cancer involving the supraglottic portion of the larynx. The overwhelming majority of patients undergoing supraglottic laryngectomy can swallow by mouth 10-14 days after surgery. However, the risk of aspiration pneumonia is significant in patients with inadequate cough and poor pulmonary reserve. It is therefore not appropriate for patients with cardiopulmonary compromise which is so significant that they cannot temporarily tolerate moderate amounts of aspiration. This group of patients should not be offered this procedure.

Patient Assessment

Tumor characteristics

All patients with cancer of the supraglottic larynx require careful pretreatment evaluation which should include laryngoscopy as well as imaging. The ideal candidates are those patients with tumor confined to the supraglottic larynx without involvement of either arytenoid. Cervical metastatic disease is highly prevalent for cancers of the supraglottic cancers. This risk is to both sides of the neck inasmuch as the larynx should be considered a midline structure. Routine bilateral functional neck dissection of Levels 2, 3, and 4 is therefore advocated for all patients treated with surgery. Patients with bulky or bilateral metastases at presentation are considered a relative contraindication to supraglottic laryngectomy because of the predictable need for postoperative adjuvant radiation. Most patients can tolerate radiation therapy after supraglottic laryngectomy; however, it almost invariably compromises function with increased risk of aspiration.

Resection of tumor extension from the aryepiglottic fold to the medial wall of the pyriform sinus can be accomplished with modifications to become a partial laryngopharyngectomy. Tumor extension to the vallecula and tongue base can be accommodated, but this kind of tumor involvement will require partial tongue base resection, which in turn, will compromise functional outcome. Additionally, tongue base involvement almost always will call for postoperative irradiation, which, once again, is poorly tolerated after supraglottic laryngectomy.

The ***only absolute contraindication*** to supraglottic laryngectomy is spread through the paraglottic space inferiorly, such that the plane of resection through the ventricles would result in residual tumor or spread to involve both arytenoids. Under these circumstances, therapeutic alternatives include chemoradiation therapy or total laryngectomy.

Patient physiologic considerations

The patient's cardiopulmonary function is an essential criterion which requires evaluation when considering supraglottic laryngectomy. All patients require temporary tracheotomy which allows the treatment team to provide suctioning and to help treat aspiration. However, patients with poor pulmonary reserve should not undergo supraglottic laryngectomy. There are no concrete, objective guidelines for eligibility such as arterial blood gases or spirometry. In general, patients with good functional capacity such that they can walk up a flight of stairs comfortably, can tolerate a supraglottic laryngectomy. Patients who cannot ambulate will, in general, not tolerate supraglottic laryngectomy.

Operative steps

The procedure is done under general anesthesia. A prophylactic antibiotic is administered.

The patient is positioned in the supine position with the neck slightly extended on a shoulder roll. A superiorly based apron flap is planned such that the horizontal portion of the apron overlies the second or third tracheal ring *(Figure 1)*. The ***apron flap*** is

elevated just underneath the platysma muscle.

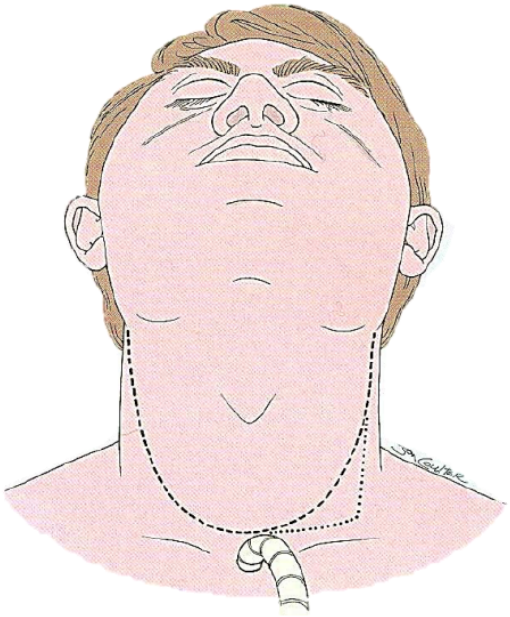


Figure 1: Supraglottic laryngectomy is accomplished through a superiorly based apron flap. The inferior aspect of the flap should not be extended past the midclavicular line because subsequent ischemia may be associated with wound dehiscence

Tracheotomy is then accomplished. Under most circumstances this is facilitated by division and ligation of the thyroid isthmus.

Bilateral neck dissection is done in all patients. In the absence of identifiable pathologic adenopathy, elective neck dissection should remove the fatty lymphatic aponeurosis in Levels 2, 3 and 4. Level 2b superior to the spinal accessory nerve need not be dissected. The spinal accessory nerve, jugular veins, and sternocleidomastoid muscles are preserved.

The ***suprahyoid strap muscles*** are released from the superior surface of the hyoid bone with diathermy. The infrahyoid strap muscles are subsequently released approximately 1 cm below the inferior insertion of the muscles to the hyoid bone and reflected inferiorly to expose the thyroid cartilage.

The ***external perichrondrium*** of the thyroid cartilage is then released along the superior and lateral aspects of the thyroid laminae such that it can be reflected inferiorly *(Figure 2)*.

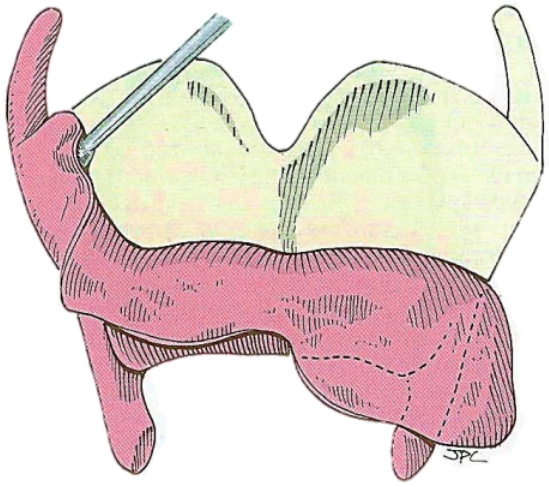


Figure 2: The external perichondrium of the thyroid cartilage is incised along its superior insertion and reflected intact as an inferiorly based flap

The ***cartilage is then cut horizontally*** with an oscillating saw *(Figure 3)*, recalling that the intention is to resect the larynx through the ventricle *(Figure 4)*. This requires that the cut be made approximately midway between the thyroid notch and the lower border

of the thyroid cartilage. The cartilage cut may be slanted laterally toward the superior cornu on the less involved side which allows for preservation of the constrictor insertion.

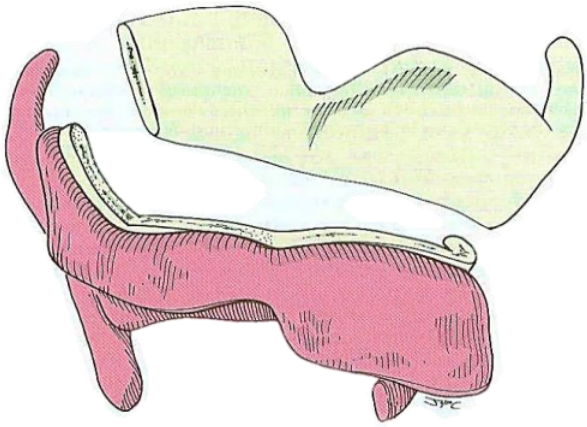


Figure 3: The cartilage incision is carried horizontally midway between the thyroid notch superiorly and the inferior border of the thyroid cartilage in the midline to include the greater cornu of the thyroid cartilage on the side of the lesion. The greater cornu may be preserved on the side contralateral to the lesion or may be excised according to the judgment of the surgeon

Pharyngotomy is done through the vallecula when tumor is confined to the supraglottic larynx. This allows subsequent mucosal cuts to be made under direct vision.

Mucosal incisions are made laterally along the aryepiglottic folds and then across the face of the arytenoids to resect the entire epiglottis and false vocal folds. The inferior cuts are made horizontally through the laryngeal ventricles to connect the mucosal cuts with a cartilage cut *(Figure 4)*.

The resected specimen is carefully evaluated and frozen sections done to assure complete tumor removal *(Figure 5)*.

Hemostasis must be complete. This may be especially difficult along the cut edge of the tongue base where intermittent suture ligatures are recommended.

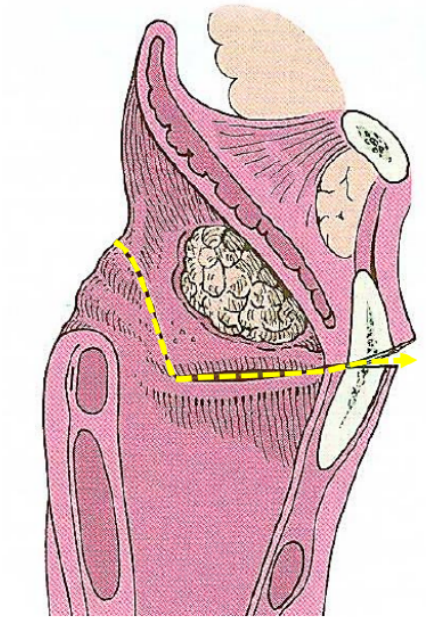


Figure 4: Mucosal cuts are made under direct vision. Inferiorly, the cut is made through the ventricle at the level of the true vocal cord. Posteriorly, the mucosal incision is made across the face of the arytenoid unless extension of tumor requires an extended procedure

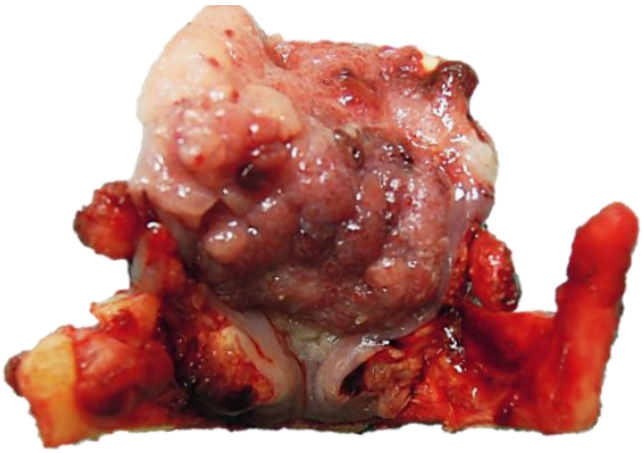


Figure 5: Specimen includes epiglottis, hyoid bone, false vocal cords and upper half of thyroid cartilage

A ***nasogastric tube*** is inserted before the closure is accomplished.

Reconstruction starts with approximation of the tongue base to the glottic larynx in such a way that the tongue base is set back over the glottis to reduce the potential for aspiration *(Figure 6)*. This requires that the yellow fibrofatty aponeurosis of the tongue base be directly approximated to the external perichrondrium of the thyroid cartilage. If difficulty is observed with tearing of the external perichrondrium, the sutures may be directed through residual thyroid cartilage. This initial layer of closure is then reinforced by approximating the suprahyoid musculature to the infrahyoid muscles. The closure is carried laterally to assure there is no evidence of salivary leak in the area of the pyriform sinus.

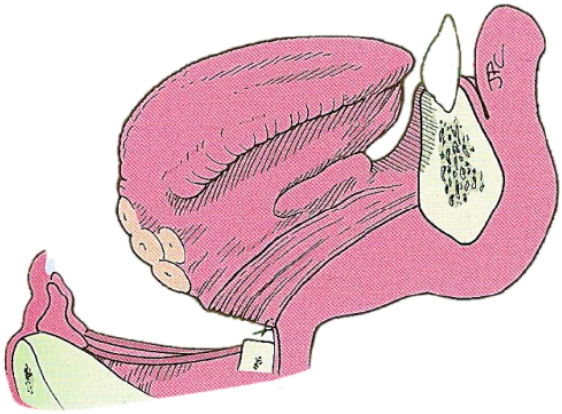
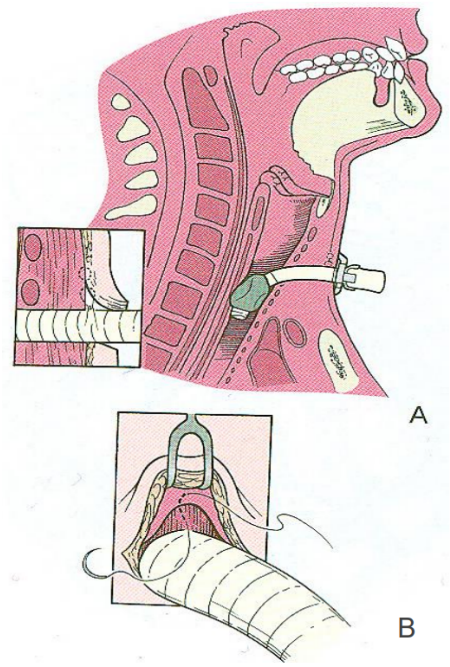


Figure 6: The external perichondrium of the thyroid cartilage is approximated to the fibroaponeurotic layer of the tongue base. This sets the tongue back over the glottis

After closure, ***suction drains*** are placed in either side of the neck and over the mucosal suture line and brought out through separate stab wounds.

The ***apron flap is then redraped***. Great care is taken to assure that the ***tracheotomy site is isolated*** from the potential spaces in both sides following neck dissection by suturing *(Figures 7A & B)*. Failure to isolate the tracheotomy from the potential space created by the neck dissection may result in transmission of contaminated mucus from the trachea underneath the cervical flap and subsequent wound infection.

The anesthesia tube is removed and replaced with a ***cuffed tracheotomy tube***.



Figures 7A & B: At completion of the procedure, the tracheotomy site must be isolated from the potential dead space created through flap elevation and neck dissection

Postoperative Management

Care is taken to assure the integrity of the suction drains. Routine tracheotomy care is instituted. All patients are ambulated as soon as possible to assure restoration of tidal volume and prevention of atelectasis.

The ***tracheotomy tube can be removed*** when the patient demonstrates that he/she can protect the airway and is no longer aspirating. This usually takes 7-14 days. One practical method is to deflate the cuff of the tracheotomy tube when the patient is seated. Most patients will have some temporary aspiration which can be suctioned. Thereafter it should be determined if the patient can tolerate an uninflated tracheotomy tube without excessive coughing and aspiration for 24hrs. Having achieved this milestone, the cuffed tracheotomy tube should be removed and replaced with a smaller tracheotomy tube without a cuff, which can be plugged so that the patient breathes past the tube and through the larynx, to ascertain if the patient's airway is satisfactory to allow decannulation.

The overwhelming majority of patients will tolerate an ***oral diet*** best when the tracheotomy site has healed. Introduction of an oral diet before the tracheotomy site is closed is difficult because the tracheotomy is associated with a less effective cough, tethering of the larynx, and diminished proprioception such that aspiration is more likely.

Following recovery from the acute phases of healing, supraglottic laryngectomy patients have remarkably good ***voice*** with few limitations to diet.

Recovery is significantly, and sometimes severely, challenged when ***postoperative irradiation therapy*** is required. Radiation causes lymphoedema and stasis, which compromises swallowing and may cause airway obstruction. Therapeutically induced obstructive sleep apnoea has been reported under these circumstances.

Patients who have had ***prior irradiation*** therapy can tolerate supraglottic laryngectomy. However, the healing is slower, recovery of deglutition is prolonged and some element of chondroradionecrosis of the residual thyroid cartilage may be observed. All these factors can be treated, and a successful functional outcome will be achieved in properly selected patients.

Cancer of Supraglottis: Clinical Practice Guidelines

https://developingworldheadandneckcancergui delines.com/index-page-supraglottic-cancers/

Author

Jonas T. Johnson, M.D.
Dr Eugene N. Myers Professor & Chairman

Department of Otolaryngology
Eye and Ear Institute
200 Lothrop Street, Suite 500 Pittsburgh, PA 15213, USA
johnsonjt@upmc.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.17: Laryngectomy - Vertical Partial

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Jonas Johnson

Management of small tumors involving the true vocal folds can be contentious. Tumor control is achieved in over 95% of patients presenting with T1 glottic cancer employing external beam radiation therapy, vertical hemilaryngectomy, or transoral endoscopic resection. Given adequate resources, the weight of evidence favors endoscopic transoral resection as the most cost-effective approach with very high rates of tumor control.

Patient Selection

Young patients presenting with involvement of the anterior commissure or partial impairment of motion (T2) and those who have failed attempts at curative irradiation therapy for small glottic lesions may be suitable candidates for ***vertical partial laryngectomy***.

When the tumor requires removal of the ***anterior commissure***, the proper term for this procedure is ***frontolateral partial laryngectomy***. Frontolateral vertical hemilaryngectomy can be accomplished to include one arytenoid and, when necessary, both true vocal folds. Under these circumstances, some surgeons may choose ***supracricoid partial laryngectomy with cricohyoidoepiglottopexy*** to manage extensive cancer of the anterior commissure involving both vocal cords and the paraglottic space.

Vertical partial laryngectomy is ***not suitable*** for tumors involving the supraglottic larynx and the paraglottic space. Similarly, it is not appropriate for patients with greater than 10 mm of subglottic extension. Involvement of both arytenoids is also a strict contraindication.

Patients presenting with multifocal lesions, diffuse dysplasia and carcinoma in situ, involvement of the arytenoids and the posterior commissure, and those in whom poor health compromises suitability for surgery may be better served with external beam irradiation.

Preoperative Planning

When considering surgical intervention for cancer involving the true vocal cords, precise staging and patient selection are crucial for good outcomes. High resolution fine-cut CT compliments microlaryngoscopy and examination under anesthesia.

In the setting of failed prior irradiation therapy, the surgeon must be aware of the potential for multifocal persistent cancer. In general, the entire field of the original tumor should therefore be considered for removal.

Careful preoperative tumor mapping employing flexible fiberoptic endoscopy and fine cut CT allows the surgeon to estimate the extent of resection and the reconstructive needs of each individual patient. For instance, patients requiring frontolateral hemilaryngectomy in which both arytenoids are intact and 80% of one vocal cord can be maintained will require no added tissue for reconstruction. Conversely, if an arytenoid is resected or if more than 20% of the contralateral vocal fold must be removed, some reconstruction must be undertaken to afford good swallowing without aspiration and to allow adequate diameter of the lumen for respiration.

Operative steps

The procedure is undertaken under general anesthesia. Perioperative prophylactic antibiotics are administered. Tracheotomy is accomplished through a separate incision. A second horizontal incision is made at approximately the level of the thyroid notch *(Figure 1)*.

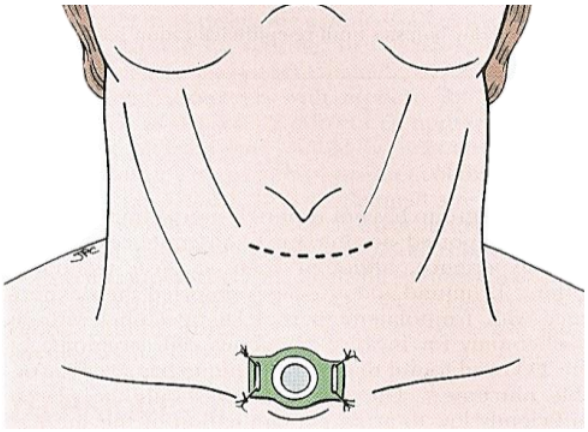


Figure 1: Incision for vertical partial laryngectomy. Care should be taken to ensure separation of the tracheostomy incision from that required for the partial laryngectomy

Skin flaps are elevated superiorly to the hyoid and inferiorly to the cricoid cartilage. The strap muscles are then elevated, exposing the thyroid lamina.

The external perichrondrium of the thyroid cartilage is incised at the midline and a posteriorly-based perichrondrial flap is elevated bilaterally *(Figures 2 & 3)*. The extent of the elevation should reflect the intended thyroid cartilage resection.

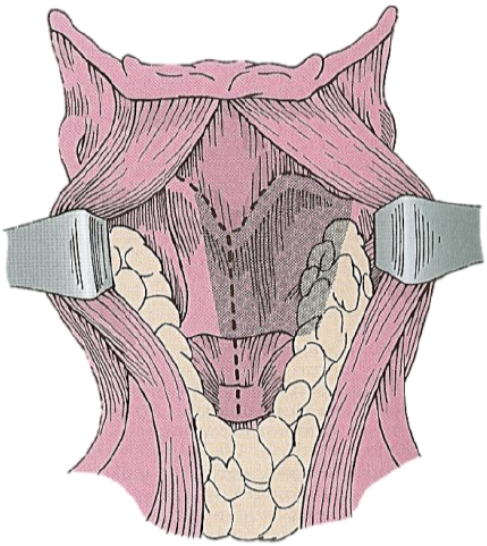


Figure 2: Incision of the perichondrium to expose the thyroid ala

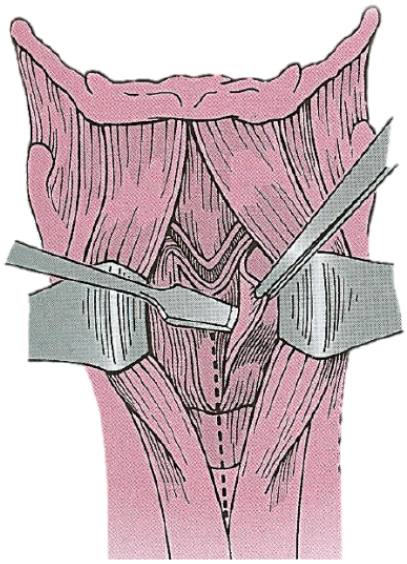


Figure 3: Elevation of the perichondrium with the overlying strap muscles

Vertical cuts are then made through the thyroid cartilage, maintaining as much of the posterior lamina of the cartilage as basic oncologic principles will allow *(Figure 4)*.

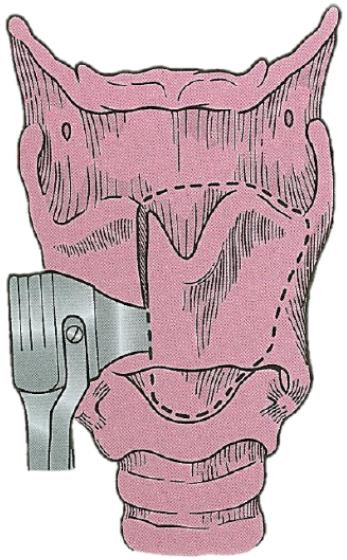


Figure 4: The vertical cartilage cuts are designed to correspond with soft tissue resection margins within the larynx

It is essential that the cartilage cuts be made perpendicular to the plane of the cartilage and that soft tissue cuts be made with a knife (not with a saw) *(Figure 5)*.

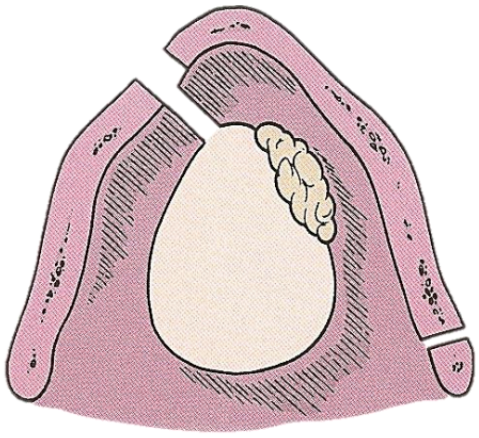


Figure 5: The cartilage cuts must be perpendicular to the cartilage to allow for corresponding soft tissue cuts in the larynx

A wide cricothyrotomy allows access to the subglottis such that the surgeon working with a headlight and a knife can visualize the undersurface of the vocal cords and to place the initial cut to allow a 2 mm margin from the tumor without unnecessarily removing uninvolved vocal fold. The thyrotomy is then opened widely such that the cut across the posterior aspect of the involved vocal fold can be accomplished with a 2 mm margin and the specimen removed. New margins from both sides of the vocal cord should be submitted for frozen section assessment. A nasogastric tube is introduced and fixed to the nasal septum with a suture.

When two-thirds or more of one vocal fold has been preserved, no extra soft tissue reconstruction is required. The free end of the residual vocal fold must be fixed anteriorly to the residual thyroid cartilage with a vicryl suture *(Figure 6)*.

Reconstruction is accomplished by closing the external perichondrium in the midline *(Figure 7)*. The strap muscles are reapproximated in the midline as the second layer of closure.

A ***Penrose drain*** is inserted. Suction drains should be avoided because they will tend to pull secretions through the wound. The skin is reapproximated in layers and a cuffed tracheotomy tube is introduced.

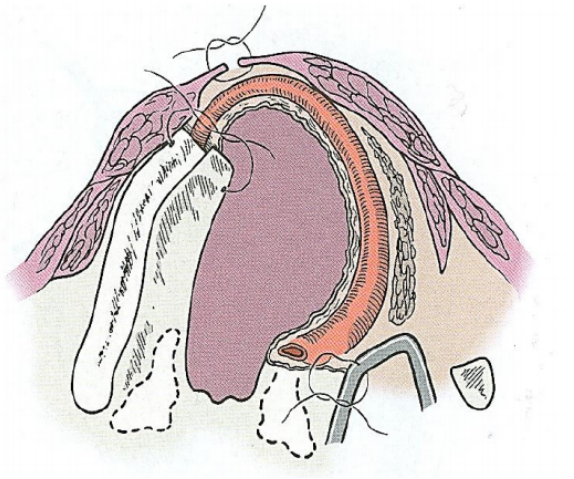


Figure 6: Reattachment of the vocal cord remnant to the thyroid ala

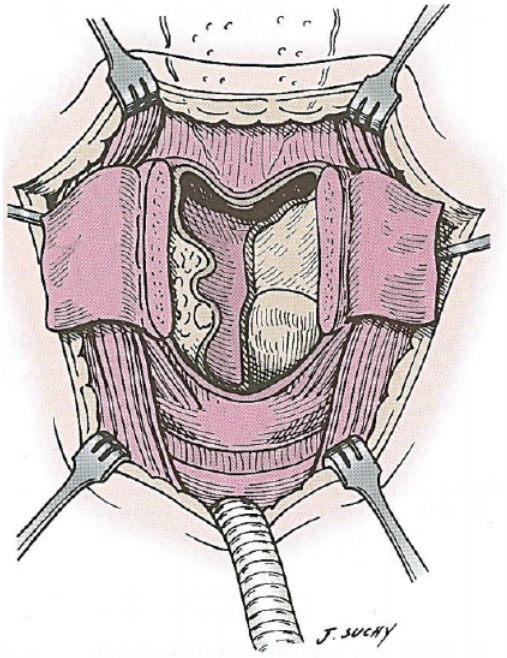


Figure 7: The remaining larynx after the specimen has been removed. Closure is initiated by suturing the external perichondrium in the midline

Reconstruction Considerations

When more than 80% of the contralateral vocal fold cannot be maintained, some form of tissue reconstruction is required to reconstitute the lumen to maintain an adequate airway. I prefer employing an epiglottopexy. The petiole of the epiglottis is grasped with an Allis forceps, and the hyoepiglottic ligament freed such that the epiglottis can be mobilized and pulled inferiorly and fixed to the superior surface of the cricoid cartilage *(Figures 8 & 9)*.

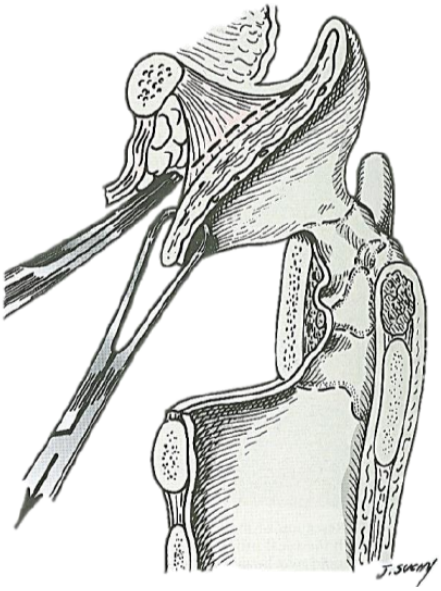


Figure 8: Epiglottopexy: The lingual surface of the epiglottic cartilage is undermined in the subperichondrial plane to divide the hyoepiglottic ligament

When tumor considerations require removal of the body of the arytenoid, it, too, must be reconstructed. The critical aspect is to re-establish the height of the arytenoid to prevent secretions from flowing directly from the pharynx into the larynx. A multitude of techniques have been reported employing cartilage, muscle or just fat. The tissue needs to be fixed to the top of the cricoid and then covered by advancing mucosa from the medial wall of the pyriform sinus over the reconstructive materials. Patients requiring arytenoid reconstruction invariably have prolonged recovery and temporary dysphagia.

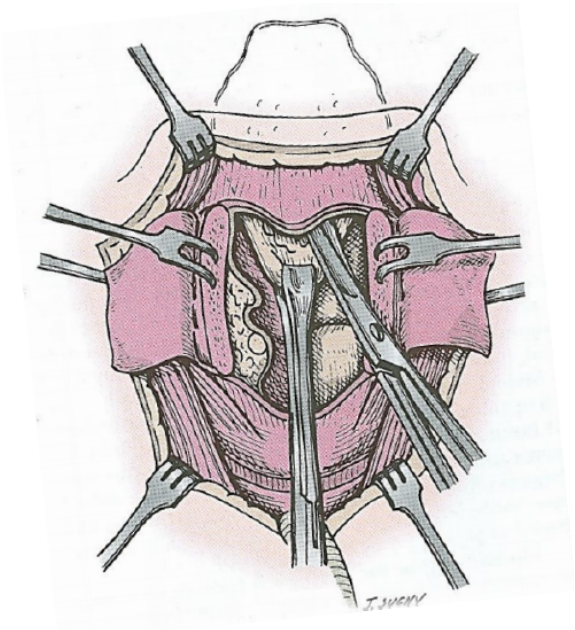


Figure 9: Epiglottopexy: The epiglottis is pulled inferiorly

Postoperative Care

At completion of the procedure, the patient should have a cuffed tracheotomy tube in place with the balloon inflated. Antibiotic administration is terminated on the first postoperative morning. The patient's nutritional needs are supported by feeding through a nasogastric tube.

The dressing supporting the Penrose drain should be changed for good hygiene. The drain can be removed when it is no longer producing mucoid secretions. Ordinarily that occurs on the third or the fourth postoperative day.

Routine tracheotomy care is provided. The tracheotomy cuff should be maintained inflated for 4-5 days to divert coughed secretions through the tracheotomy tube rather than into the newly reconstructed wound.

On the fifth postoperative day, the tracheotomy cuff can be deflated. This allows the treatment team to determine if the patient can protect his own airway without aspiration. Patients who have previously been treated with radiation therapy may have a delayed decannulation process. If the patient tolerates deflating the cuff on the tracheotomy tube, the treatment team can change the tracheotomy tube to a smaller, uncuffed tube. The adequacy of the reconstructed airway can be tested by plugging the tracheotomy tube. Patients who tolerate this overnight are candidates for decannulation. Soft foods are reintroduced, and the patient can be discharged.

Salvage following radiation: Special considerations and problems

The most common call for frontolateral partial hemilaryngectomy in the era of transoral endoscopic technology is to treat patients with persistent cancer after having had radiation therapy. Such patients have increased edema, slower healing, and a high incidence of chondritis. The drain frequently needs to be maintained beyond the first week. Antibiotic administration should be instituted for cellulitis and erythema. Return to oral eating is often delayed and the nasogastric tube may need to be maintained for 2-3 weeks. Under these circumstances, most patients can be discharged to home with home nursing and care of the tracheotomy and nasogastric tube until the wound has stabilized, edema has resolved, at which time the treatment team can proceed with the decannulation and oral feeding process.

Therapeutic Expectations

Partial vertical hemilaryngectomy is highly effective (>90%) in properly selected patients. Surgical removal of previously irradiated tumors always has the potential that multifocal tumor is overlooked and if not completely removed, will recur.

All patients having open partial laryngectomy have dysphonia postoperatively. The overwhelming majority of patients do however have a serviceable voice.

Longstanding dysphagia and aspiration are unusual if both arytenoids are preserved or, when one arytenoid has been removed, it has been appropriately reconstructed.

Failure to properly reconstruct the glottis after resection of most of both vocal folds will result in laryngeal stenosis. Prevention is the key to relief of this problem. The treatment team must recognize the need for extra soft tissue and incorporate the reconstruction at the time of resection. Reconstructing the stenotic larynx is beyond the scope of this chapter.

Useful reference

https://developingworldheadandneckca...ottic-cancers/

Author

Jonas T. Johnson, M.D.
Eugene N. Myers
Professor & Chairman
Department of Otolaryngology
Eye and Ear Institute
200 Lothrop Street Suite
500, Pittsburgh, PA 15213, USA
johnsonjt@upmc.edu

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Alejandro Castro, Javier Gavilán

Supracricoid laryngectomy consists of *en bloc* resection of both vocal cords, the paraglottic spaces and the thyroid cartilage *(Figure 1)*. It was first described by Majer in 1959[1] and Piquet in 1974[2]. It is used for the treatment of selected early and locally advanced glottic and transglottic carcinoma in an oncologically safe manner, while preserving laryngeal function *i.e.* swallowing (airway protection), breathing and phonation.

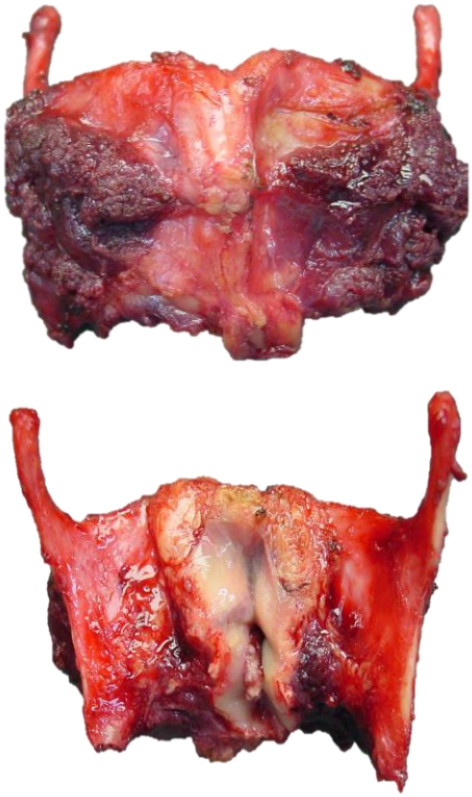


Figure 1: Typical supracricoid laryngectomy specimen

Indications and limitations

Supracricoid laryngectomy is used to treat glottic carcinoma affecting one/both vocal cords, including cancers with deep invasion of the paraglottic space and altered vocal cord mobility. The epiglottis and pre-epiglottic space can be included in the specimen, allowing for resection of transglottic tumors that invade the supraglottic and glottic regions. One arytenoid can also be resected. However combined resection of the epiglottis and one arytenoid usually results in poor functional outcomes and increases the chance for aspiration and delayed decannulation.

Types of supracricoid operations

With supracricoid laryngectomy the hyoid bone is approximated directly to the cricoid with three sutures *(Figures 2a-c)*. Types of supracricoid laryngectomy are illustrated below *i.e.* cricohyoidoepiglottopexy (CHEP), cricohyoidopexy (CHP), and tracheocricohyoidoepiglottopexy *(Figures 2a-c)*. With tracheocricohyoidoepiglottopexy the anterior cricoid is resected for an additional tumor margin anteriorly.

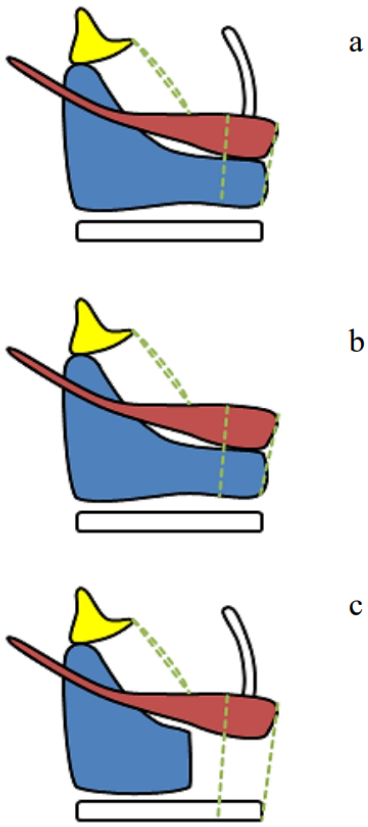


Figure 2: Cricohyoidoepiglottopexy (a), cricohyoidopexy (b), and tracheocricohyoidoepiglottopexy (c)

Function

Key functional outcomes are airway, phonation and swallowing without aspiration. Phonation and swallowing depend on the arytenoids being able to tilt forwards and make contact with the base of the tongue; to breathe the arytenoids tilt posteriorly to open the airway *(Figures 3, 4)*.

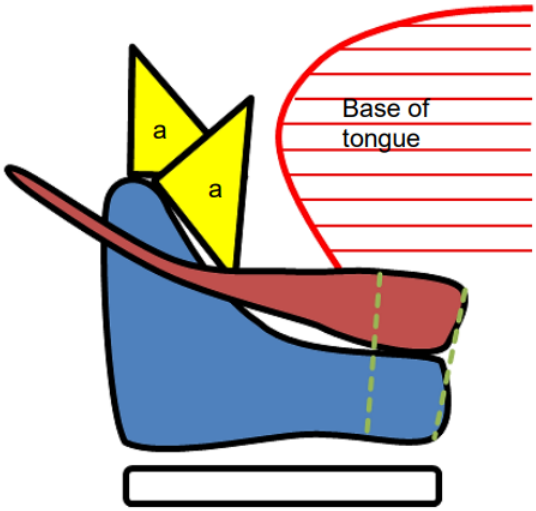


Figure 3: Arytenoids tilt forwards and backwards for phonation, swallowing and breathing

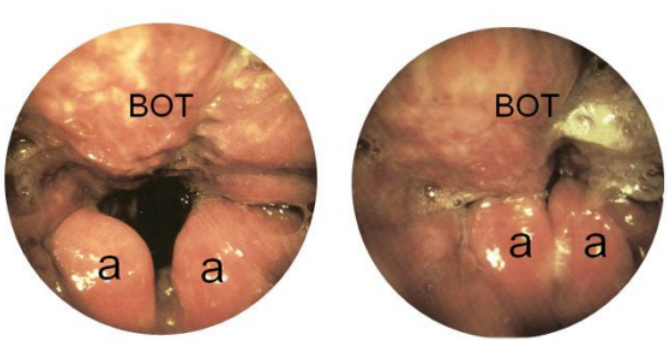


Figure 4: Arytenoids tilt backwards and forwards for breathing, phonation, swallowing

Cricoarytenoid unit(Figures 5, 6)

An intact cricoarytenoid unit is critical for function. It comprises the arytenoid mounted on an intact posterior cricoid ring, with a functioning recurrent laryngeal nerve and lateral and posterior cricoarytenoid muscles. Ideally one should preserve both cricoarytenoid units; sacrificing one unit increases the chance of disabling aspiration in the cases where the epiglottis is resected.

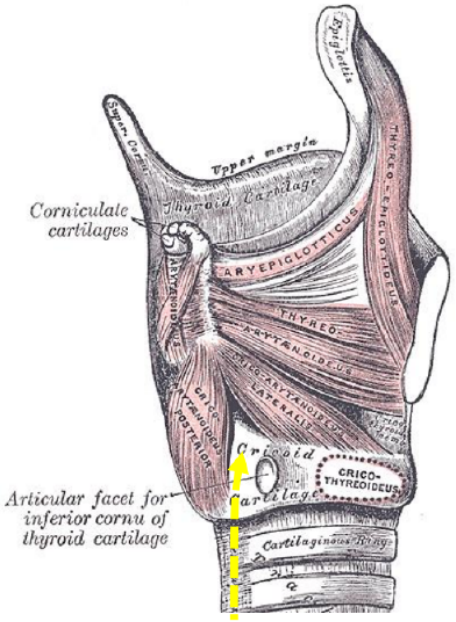


Figure 5: Anatomy of the cricoarytenoid unit and the course of the recurrent laryngeal nerve (yellow arrow) directly behind the articular facet of the inferior cornu of the thyroid cartilage

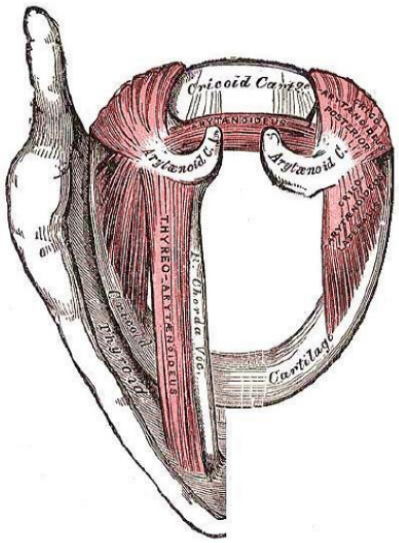


Figure 6: Right side illustrates the situation after supracricoid laryngectomy with preserved cricoarytenoid unit

Preoperative Evaluation

Careful selection of candidates is the key to success of supracricoid laryngectomy. Both tumor and patient factors must be taken into account to ensure satisfactory oncologic and functional outcomes.

1. Tumor factors

TNM classifications were not developed to guide the indications for different surgical techniques; other factors should be taken into account when considering supracricoid laryngectomy. In general, supracricoid laryngectomy is indicated for T_1 and selected $T_{2\text{-}3}$ glottic as well as selected $T_{2\text{-}4a}$ supraglottic cancers. Nevertheless supracricoid laryngectomy is usually appropriate, for example, for virtually any T_2 glottic cancer but it is contraindicated for those rare T_2 glottic cancers with extensive subglottic extension.

Two types of vocal cord immobility should be taken into account when considering supracricoid laryngectomy

- *Tumors that invade the paraglottic space and "fix" the vocal cord, but with some preserved mobility of the arytenoid:* These tumors can usually be resected by supracricoid laryngectomy as resection of the arytenoid is likely to produce a negative margin
- *Cricoarytenoid joint invasion:* This must be suspected when the arytenoid is "frozen". Supracricoid laryngectomy is not recommended as even resecting the arytenoid is unlikely to yield a negative margin

The extent of the tumor relative to the resection limits of supracricoid laryngectomy must be considered

- *Inferiorly: Superior border of cricoid cartilage:* Routine intraoperative frozen section is strongly recommended to ensure negative mucosal margins at the superior border of the cricoid cartilage. Some authors describe partial or complete resection of the anterior cricoid arch[3, 4]. Although this might be oncologically safe, in our hands it compromises the functional results and should be performed only in very carefully selected cases *(Figure 2c)*
- *Superiorly: Epiglottis or tongue base, depending on the upper extent of the tumor:* The epiglottis and pre-epiglottic space can be included in the resection *(Figure 2b)*. Although limited extension to the base of the tongue can be excised, resection should not extend beyond the circumvallate papillae as the base of the tongue plays a critical role with laryngeal closure during swallowing *(Figures 3, 4)*
- *Laterally: Pyriform sinus:* Limited resection of the medial wall of the pyriform sinus can be accomplished. However, wide resection which includes the lateral wall may compromise swallowing
- *Posteriorly (midline): The interarytenoid space must be free of tumor:* It is strongly recommended to preserve both arytenoids when the epiglottis is included in the resection. At least one mobile arytenoid must always be preserved
- *Thyroid cartilage:* As the paraglottic spaces and thyroid cartilage are resected *en bloc*, involvement of only the inner perichondrium is not a contraindication However, more extensive invasion of the thyroid cartilage is a contraindication to supracricoid laryngectomy. Yet cancers of the anterior commissure invading thyroid cartilage in the midline may be considered for supracricoid laryngectomy.

Careful preoperative evaluation should be undertaken to ensure that the primary tumor falls within these above mentioned limits. As a rule, indirect (fiberoptic) and/ or direct laryngoscopy are adequate for this purpose. CT scan or other imaging techniques may help in some cases, particularly to determine extralaryngeal extension through thyroid cartilage.

Extending the resection beyond the above mentioned parameters reduces the chance of functional success (aspiration and/or inability to be decannulated) and should be performed only in very carefully selected patients. Employing supracricoid laryngectomy with too advanced tumors or relying on postoperative radiotherapy to treat positive margins is unacceptable as it increases recurrence rates and reduces survival.

Frozen section should always be used with any type of open partial laryngectomy. With supracricoid laryngectomy, it should be obtained to confirm oncologic safety of every close margin, and routinely at the level of the cricoid. ***Patients should agree preoperatively that total laryngectomy will be performed if negative margins cannot be obtained.***

Neck dissection can be performed simultaneously. T_{1-2} glottic cancer without evidence of neck metastases can be treated with supracricoid laryngectomy without neck dissection. Elective ipsilateral neck dissection is advocated for locally advanced, purely glottic tumors (vocal cord fixation). Bilateral neck dissection is recommended in all patients with tumor invading the supraglottis regardless of T and N stage.

2. Patient factors

Patients need to learn new ways to swallow after removal of part of the larynx. Every patient undergoing supracricoid laryngectomy will experience aspiration of varying degrees during the initial postoperative days. ***Age*** is an important consideration as the brain's plasticity decreases with age as does a patient's ability to learn new swallowing techniques. Classically, 65-70 years is considered the cut-off for open partial laryngectomy. However, a ***patient's general status*** is more important than age itself, and successful results have been reported in older patients[5, 6].

Careful evaluation of ***comorbidities*** is important to ensure successful functional outcomes. The cough reflex is of critical importance to deal with aspiration. In our series, up to 15% of patients developed pneumonia[7]. ***Pulmonary and cardiac reserve*** is crucial to overcome this complication. Some authors recommend routine preoperative pulmonary function tests[8, 9]. We believe that a detailed clinical history is adequate, focusing attention on symptoms relating to chronic obstructive pulmonary disease *e.g.* dyspnoea when walking up a flight of stairs and types of medication.

Supracricoid laryngectomy operation

The operation is done under general anesthesia with the patient in a supine position. Antibiotics are given perioperatively.

1. Surgical approach

- A U-shaped cervical incision is made. The vertical limbs of the incision start a few centimetres above the hyoid bone and run along the anterior borders of the sternocleidomastoid muscles. The horizontal limb passes 2-3 cm above the sternal notch
- If neck dissection is planned, the Ushaped incision runs from mastoid-tomastoid close to the posterior border of the sternocleidomastoid muscle to create a broader flap. Neck dissections are done before the laryngectomy
- A superiorly based subplatysmal apron flap is elevated to expose the supraand infrahyoid muscles of the neck *(Figures 7, 8)*

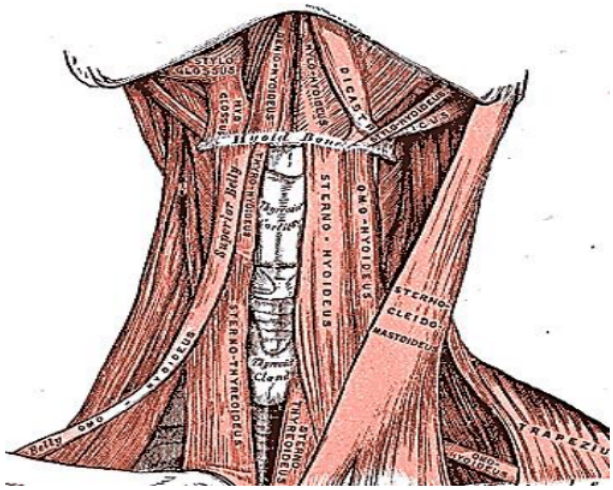


Figure 7: Infra- and suprahyoid muscles

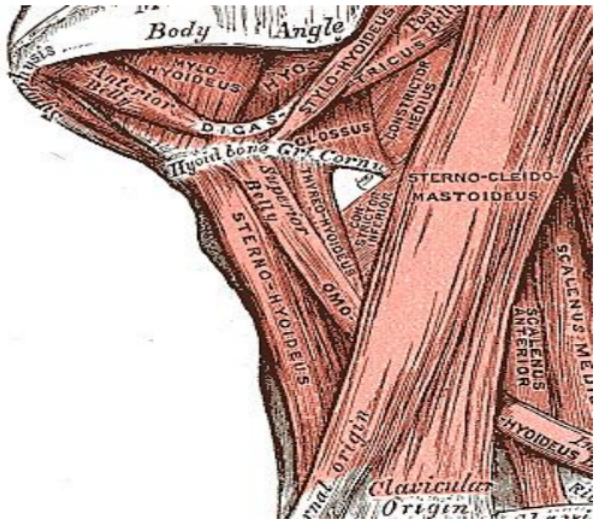


Figure 8: Infra- and suprahyoid muscles

- Detach the sternohyoid muscles from the hyoid bone and reflect them inferiorly to the level of the 1st tracheal ring *(Figure 9)*
- Retract the omohyoid muscles laterally *(Figure 10)*
- Detach the thyrohyoid muscles from the hyoid and reflected them inferiorly to their insertions on the thyroid cartilage *(Figure 10)*
- Section the sternothyroid muscles at the inferior border of the thyroid cartilage *(Figure 11)*

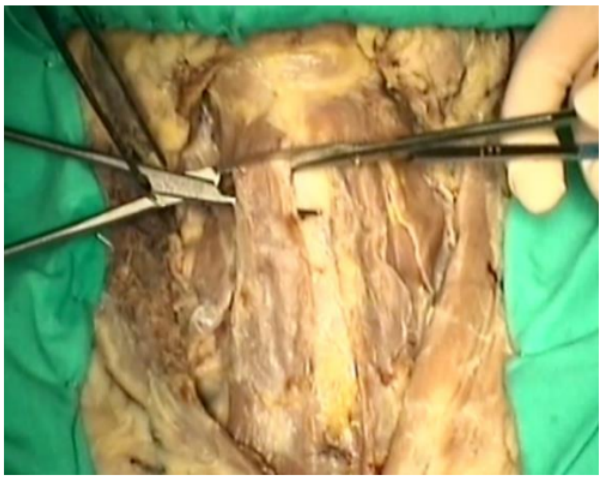


Figure 9: Divide sternohyoid muscle



Figure 10: Retract omohyoid and divide thyrohyoid muscle

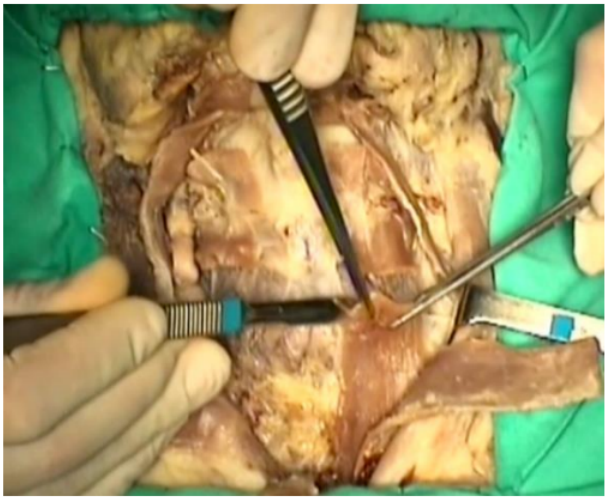


Figure 11: Divide sternothyroid muscle

- Exposed, ligate and divide the isthmus of the thyroid gland
- Dissect both thyroid lobes off the larynx and trachea to expose the thyroid and cricoid cartilages, as well as the first tracheal rings *(Figure 12)*
- Stop the dissection posteriorly at the level of the inferior cornu of the thyroid cartilage to avoid injuring the recurrent laryngeal nerves *(Figure 5)*

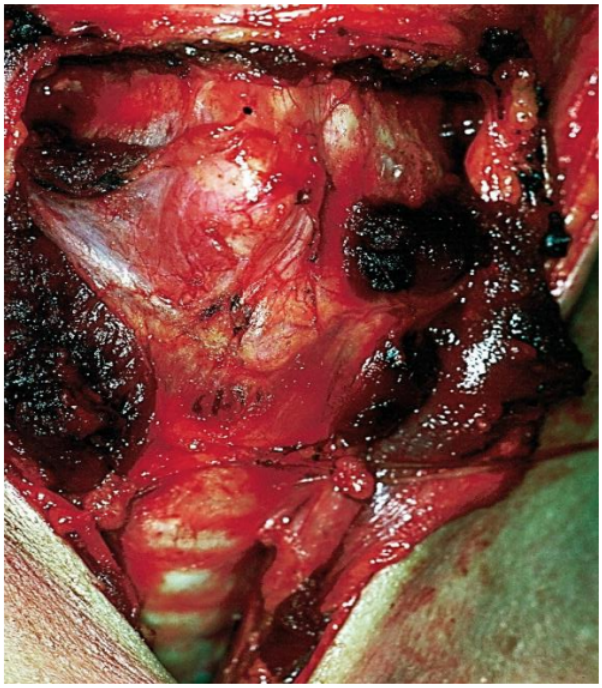


Figure 12: Surgical view of exposed larynx with strap muscles reflected. Thyroid lobes have been dissected and retracted laterally exposing the larynx and the first tracheal rings. Note that the anterior wall of the trachea has been dissected to facilitate cricohyoidopexy at the end of the surgery

- Identify, ligate and divide the superior laryngeal artery and vein over the thyrohyoid membrane *(Figure 13)*
- One may preserve the internal branch of the superior laryngeal nerve when the epiglottis and pre-epiglottic space are preserved (Some authors report better swallowing when supraglottic sensation is preserved, but in our opinion preservation of the internal branch of the superior laryngeal nerve does not improve swallowing)



Figure 13: Divide superior laryngeal vessels

- Rotate the larynx with a hook placed at the posterior border of the thyroid cartilage *(Figure 14)*
- Identify and divide the lateral thyrohyoid ligament *(Figure 14)*



Figure 14: (Right side) Rotate the larynx with a hook placed at the posterior border of the thyroid cartilage and divide the lateral thyrohyoid ligament at its insertion on the superior cornu of the thyroid cartilage

- Divide the inferior constrictor muscle along the posterior border of the thyroid cartilage *(Figures 15a, b)*
- When reaching the inferior cornu, direct this cut obliquely in an anteroinferior direction to follow the anterior border of the cornu in order to protect the recurrent laryngeal nerve which lies close to the posterior aspect of the inferior cornu *(Figure 15a)*
- Expose the pyriform sinus submucosa after cutting the inferior constrictor muscle and dissect it from the inner perichondrium of the thyroid lamina *(Figure 15b)*

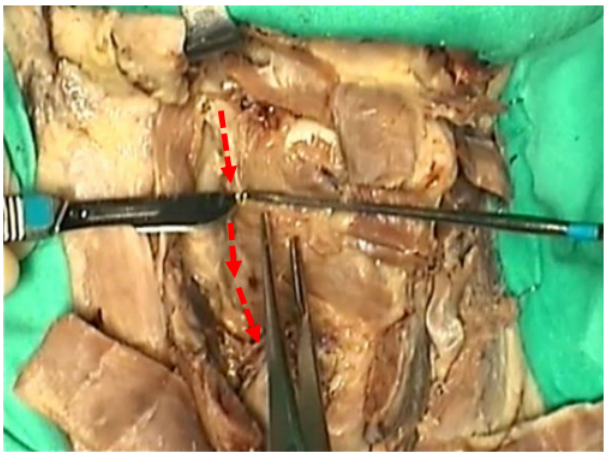


Figure 15a: Divide the inferior constrictor muscle. Traction on the muscle is generated by rotating the larynx with a hook placed at the posterior border of the thyroid cartilage. The dotted red line marks the course of the cut. Note that the cut turns anteriorly as it approaches the inferior cornu to protect the recurrent larynxgeal nerve

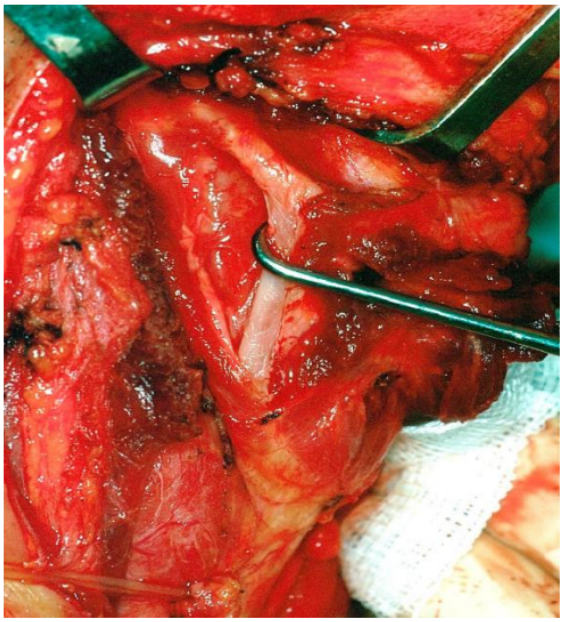


Figure 15b: The inferior constrictor muscle has been divided over the lateral border of the right thyroid ala exposing the submucosa of the pyriform sinus

- Place a submucosal stitch in the pyriform sinus without violating the mucosa, and leave it in place; this stitch is used later during reconstruction *(Figures 16, 31)*

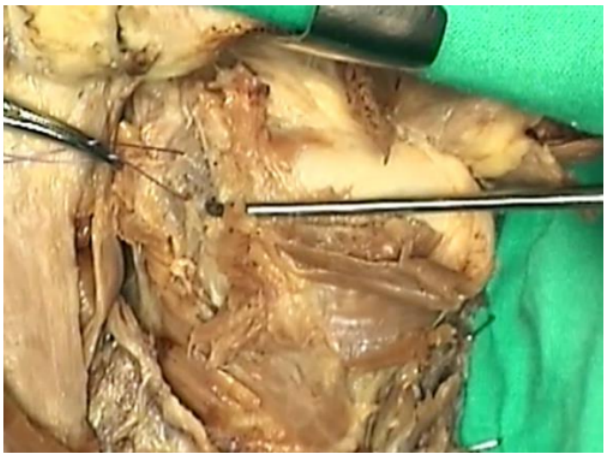


Figure 16: A suture is passed through the pyriform sinus submucosa

- Separate the thyroid and cricoid cartilages. The recurrent laryngeal nerve is close to the cricothyroid joint and may be injured at this point. We recommend transecting the inferior cornu of the thyroid cartilage at its base with scissors while the assistant steadies the thyroid and cricoid cartilages to avoid the blades slipping *(Figure 17)*.

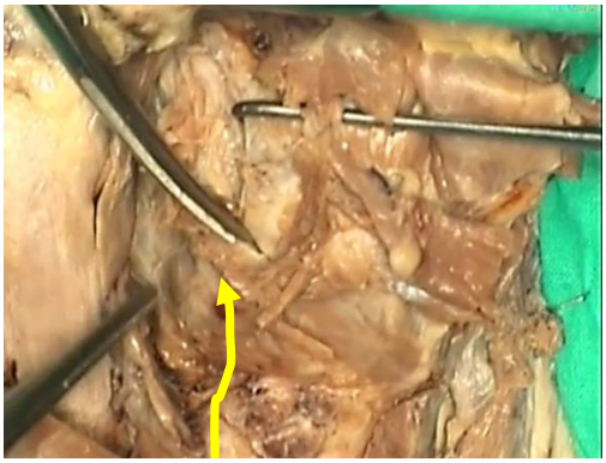


Figure 17: The larynx is rotated with a hook. The inferior cornu of the thyroid cartilage is divided with scissors taking the course of the recurrent laryngeal nerve (yellow line) into consideration

- Repeat the same surgical steps on opposite side either simultaneously or sequentially
- Free the thyroid cartilage from its attachments so that it can be easily displaced in any direction

2. Resecting the larynx

The supracricoid laryngectomy specimen is resected by means of two horizontal and two vertical cuts *(Figure 18)*

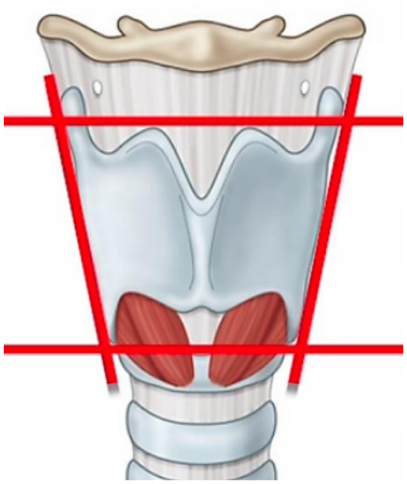


Figure 18: Horizontal and vertical cuts

Inferior horizontal cut

- Make a wide cricothyrotomy at the level of the superior border of the anterior cricoid arch, extending from one inferior thyroid cartilage cornu to the other *(Figures 19 a)*
- Retract the cricothyroid membrane and directly inspect the inner surface of the cricoid cartilage
- Obtain frozen sections of this margin
- Remove the orotracheal tube and insert a new tube through the cricothyrotomy; this facilitates the subsequent steps of the operation *(Figures 19b)*

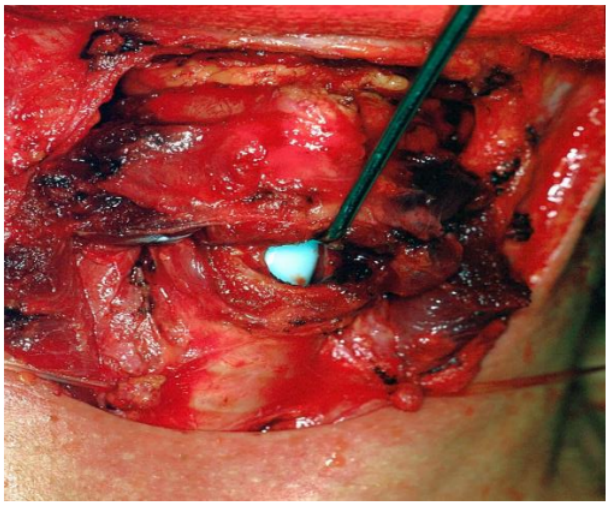


Figure 19a: Surgical view of the inferior horizontal cut. Note that the endotracheal tube is still in place

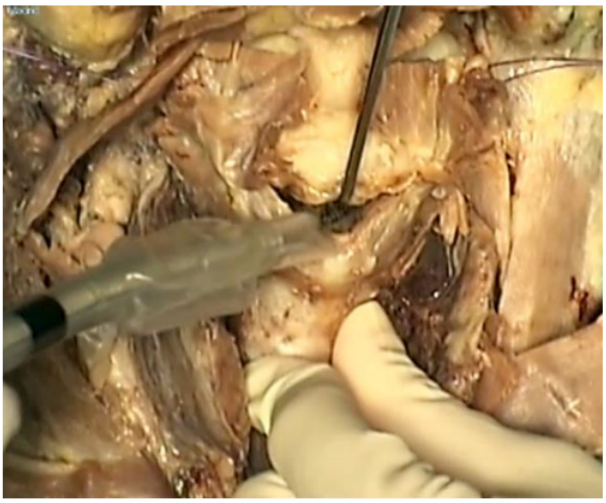


Figure 19b: Inferior horizontal cut (cricothyrotomy); the orotracheal tube is removed and a new tube is inserted through the cricothyrotomy

Superior horizontal cut

This can be made at two different levels, depending on the superior extension of the tumor

- ***Tumors not invading epiglottis (cricohyoidoepiglottopexy)*** *(Fig 20a-e)*
  - Make the cut at the level of the superior border of the thyroid lamina through the thyrohyoid membrane and epiglottis
  - Place a #11 scalpel in the midline, perpendicular to the larynx
  - Stab the scalpel through the epiglottic cartilage into the pharyngeal lumen taking care not to injure the posterior pharyngeal wall
  - Cut laterally first to one side, then the other to create a clean horizontal cut above the ventricular bands and the epiglottic petiole, which are included in the specimen *(Figures 20a-e)*
  - Obtain frozen section at this margin if needed

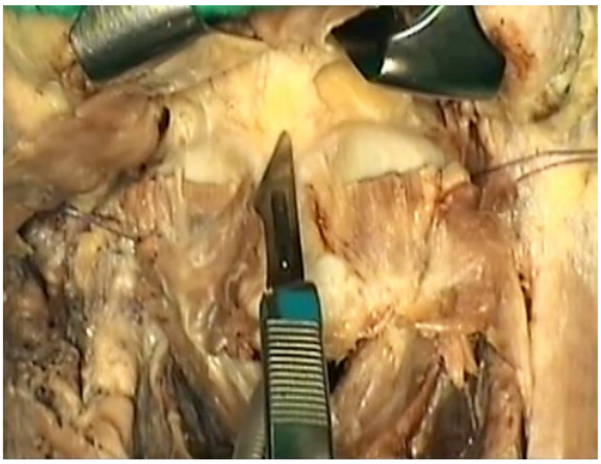


Figure 20a: Superior horizontal cut for epiglottis-preserving approach. Scalpel is inserted in the midline immediately above the superior border of the thyroid cartilage

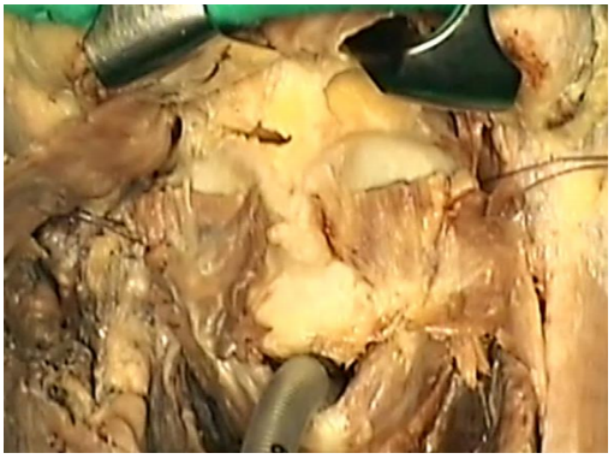


Figure 20b: A cut is been made to one side

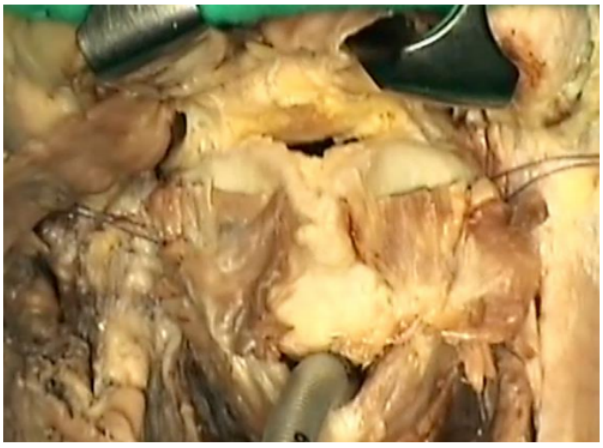


Figure 20c: The cut is completed on the contralateral side

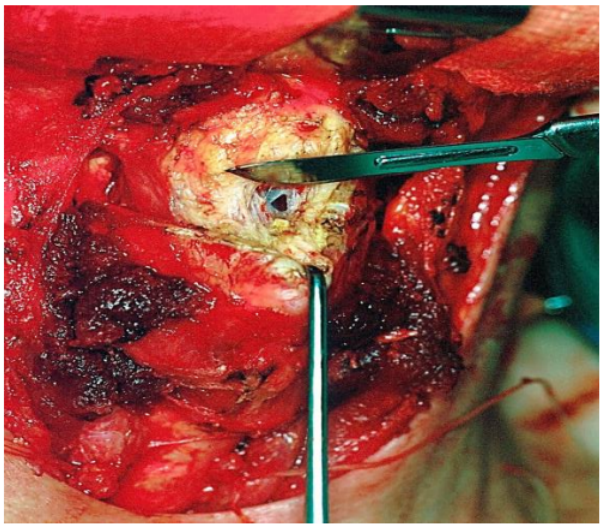


Figure 20d: Surgical view of the superior horizontal cut. The mucosa is opened in the midline before the cut is completed

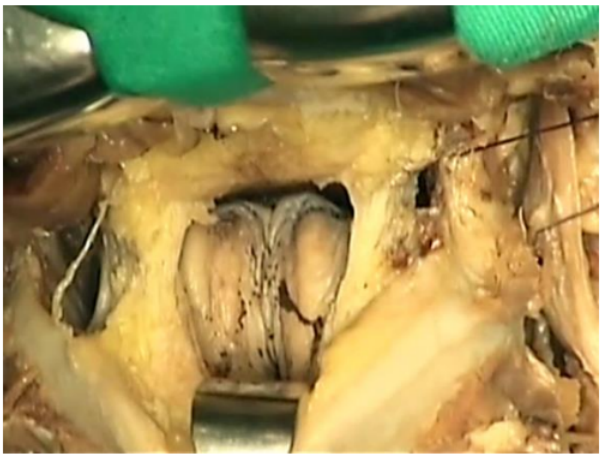


Figure 20e: Arytenoids visible through superior horizontal cut

- ***When the entire epiglottis and preepiglottic space need to be resected (cricohyoidopexy)*** *(Figures 21a-c)*
  - Make a superior infrahyoid horizontal cut (not into the pharynx)
  - Using sharp dissection with scissors, remove tissue from the preepiglottic space until the submucosa of the valleculae is reached
  - Make an opening in the mucosa of the vallecula on one side, as far from tumor as possible
  - Introduced a blade of the scissors inside the pharynx through the opening, with the other blade remaining outside
  - Cut across both valleculae from side-to-side
  - Introduce a finger into the pharynx through the mucosal opening to palpate the tumor, or directly inspect the tumor to assure a macroscopically free margin o Obtain frozen sections whenever the tumor approaches the resection margins

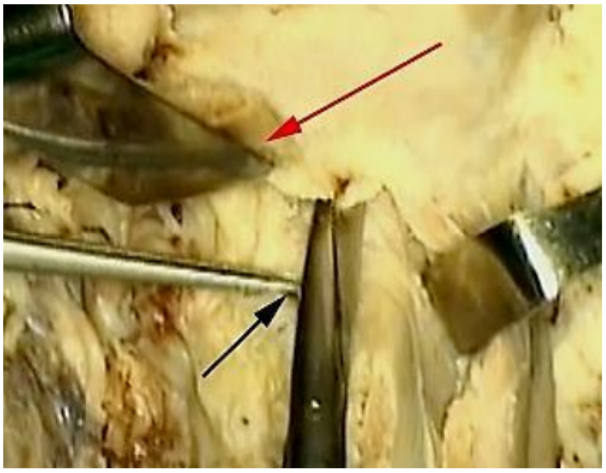


Figure 21a: Superior horizontal cut for a supracricoid laryngectomy with removal of epiglottis. The hyoid is retracted superiorly (red arrow) and traction with forceps (black arrow) is applied to the preepiglottic fat. The pre-epiglottic space is dissected by cutting with scissors against the inner aspect of the hyoid bone

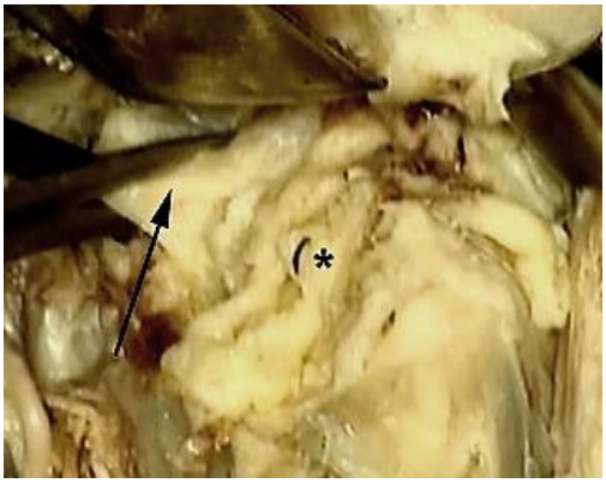


Figure 21b: The submucosa of the vallecula (arrow) is exposed. The fat of the preepiglottic space is included in the resection (asterisk)

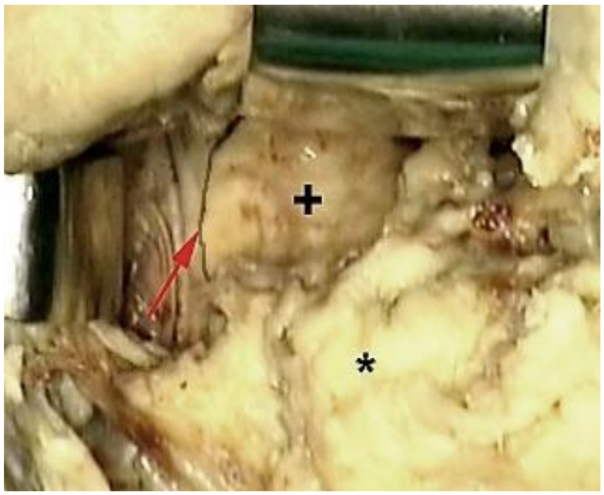


Figure 21c: The cut runs across both valleculae to expose the lingual surface of the epiglottis. Note the fat of the pre-epiglottic space (asterisk), the lingual surface of the epiglottis (+), and the posterior pharyngeal wall and free margin of the epiglottis (red arrow).

1st Vertical cut(Figures 22a, b)

- The 1st vertical cut is made on the side opposite to the tumor; it connects the lateral ends of the superior and inferior horizontal cuts
- The surgeon moves to the head of the patient to look inside the larynx through the superior horizontal cut
- Identify all structures by direct vision and/or palpation before cutting
- Introduce one blade of the scissors through the opening of the superior horizontal cut, while the other blade crosses over the lateral soft tissues of the larynx *(Figure 22a)*
- Cut through the aryepiglottic fold (if epiglottis is included in the specimen)
- Cut along the anterior surface of the arytenoid *(Figure 22b)*

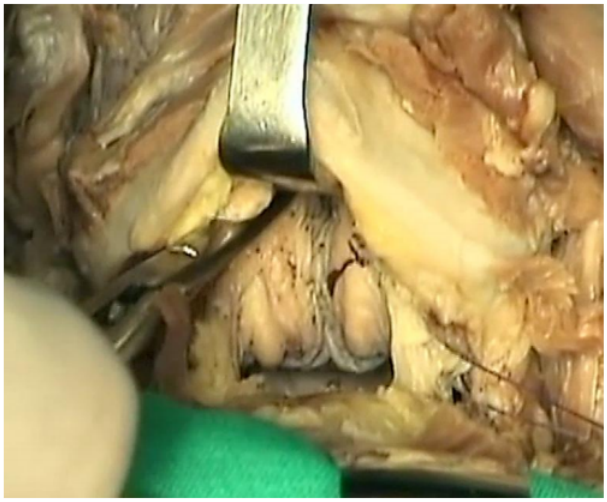


Figure 22a: (View from head of table). The surgeon moves to the head of the patient to perform the 1 st vertical cut through the superior horizontal cut. One blade of the scissors is inside the larynx and the other over the lateral laryngeal soft tissues

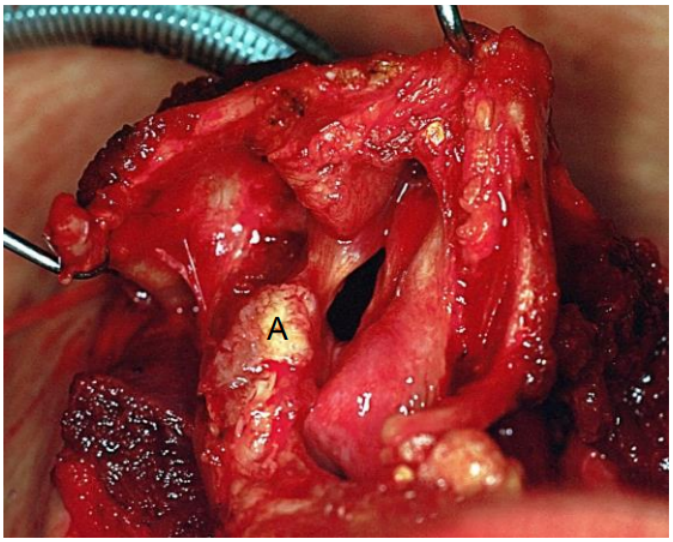


Figure 22b: Surgical view of the larynx from the head of the table. The first vertical cut has been made along the anterior surface of the left arytenoid (A). The left vocal cord is still in place. The right side remains untouched

- Cut the vocal ligament where it attaches to the vocal process
- Cut vertically through the subglottis and along the superior aspect of the cricoid up to the lateral edge of the cricothyrotomy

2nd Vertical cut

- The surgeon then moves back to the patient's side
- Grip the thyroid laminae with the fingers of both hands, fracture the thyroid cartilage down the midline and open the larynx like a book to expose the endolarynx and the tumor *(Figure 23a)*

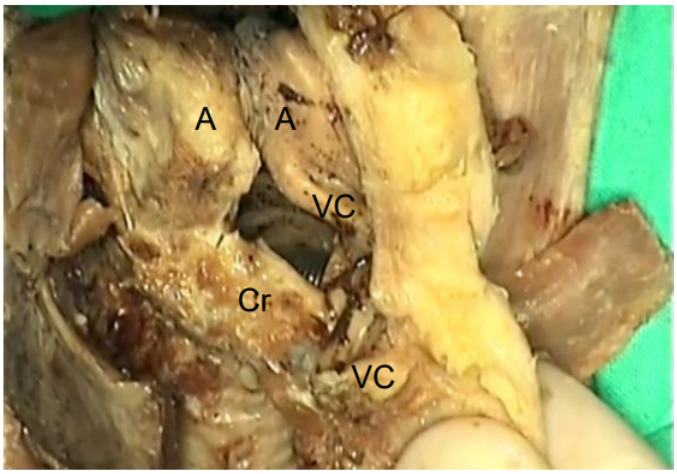


Figure 23a: Thyroid cartilage has been fractured in midline to expose arytenoids (A), cricoid (Cr) and vocal cords (VC)

- Make the 2nd vertical cut as on the 1st (non-tumor) side using a #15 scalpel under direct vision, ensuring free margins *(Figures 23b, c, d)*
- If needed, the arytenoid is resected, providing that the epiglottis has been preserved
- Frozen section of the margins is encouraged
- This completes the resection, leaving in place the cricoid cartilage, hyoid bone, arytenoid cartilages and epiglottis depending on the extent of the resection *(Figure 24)*.

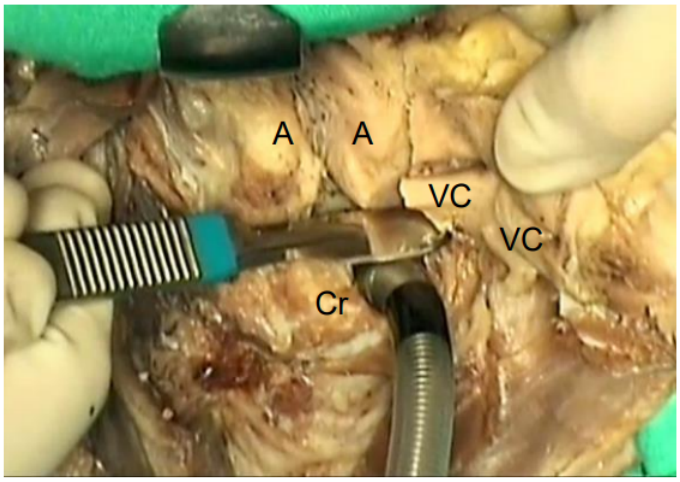


Figure 23b: The endotracheal tube is inserted through the cricothyrotomy. The 2nd vertical cut is being made with a scalpel; Arytenoids (A), cricoid (Cr) and vocal cords (VC)

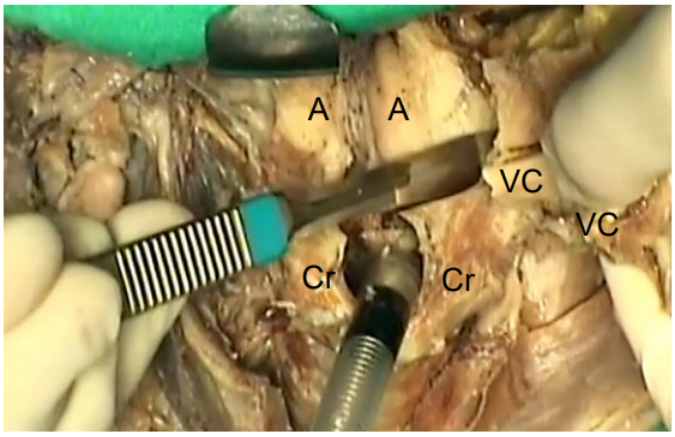


Figure 23c: Final stage of vertical cut

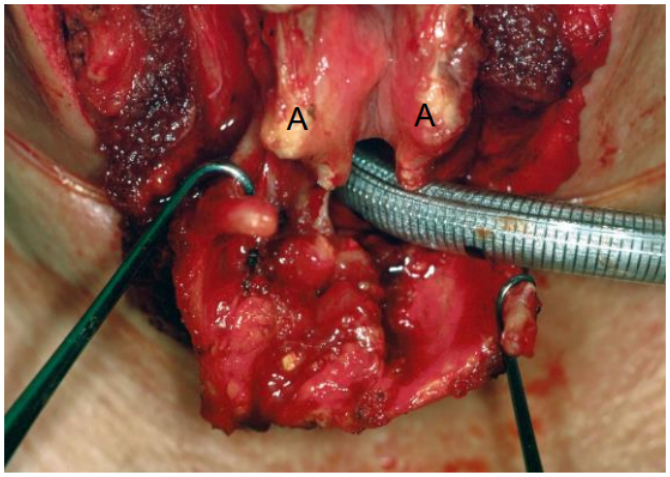


Figure 23d: Surgical view of the larynx before completing the resection. The vertical cut on the left side has been completed. The right vocal cord is the only structure still retaining the larynx in place (A = arytenoid)

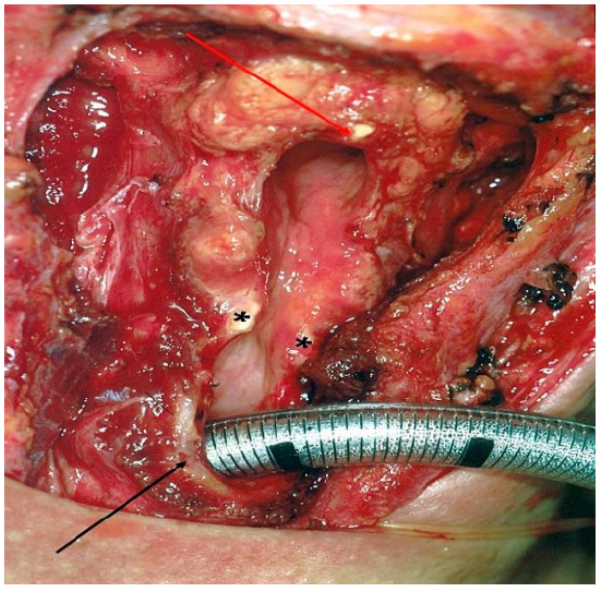


Figure 24: Surgical view of the remaining larynx: Preserved epiglottis (red arrow); vocal processes of arytenoids (asterisks); and cricoid arch (black arrow)

The resected specimen includes the “voice box”: thyroid cartilage, both vocal cords, and both ventricular bands *(Figures 1, 25)*. One arytenoid or the epiglottis may also be included depending on tumor extension.

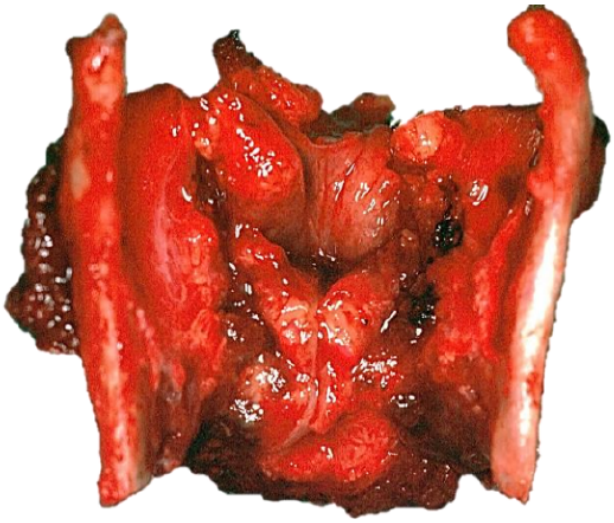


Figure 25: The surgical specimen includes the thyroid cartilage with both vocal cords and ventricular bands

3. Tracheostomy and feeding tube

- To allow one to pull the cricoid up to the level of the hyoid bone, mobilize the trachea by dissecting bluntly with a finger along the anterior tracheal wall taking care not to disturb the tracheal vasculature that enters through its lateral walls *(Figure 26)*



Figure 26: Dissecting bluntly with a finger along the anterior tracheal wall

- While maintaining the cricoid in this position, create a tracheostomy at the level of the suprasternal skin incision (usually $4^{th}/5^{th}$ tracheal rings) *(Figure 27)*

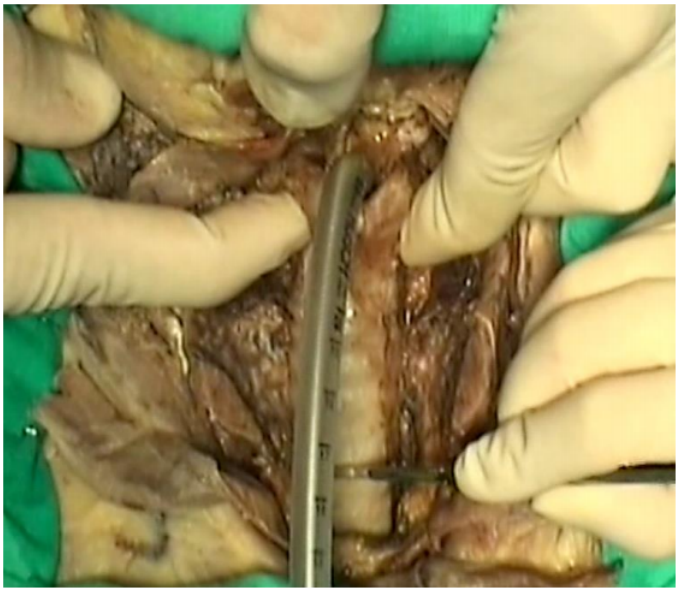


Figure 27: With cricoid abutting hyoid, create a tracheostomy at the level of the suprasternal skin incision

- Resite the endotracheal tube into the new tracheostoma *(Figure 28)*
- Insert a nasogastric feeding tube under direct vision of the hypopharynx to ensure its proper positioning

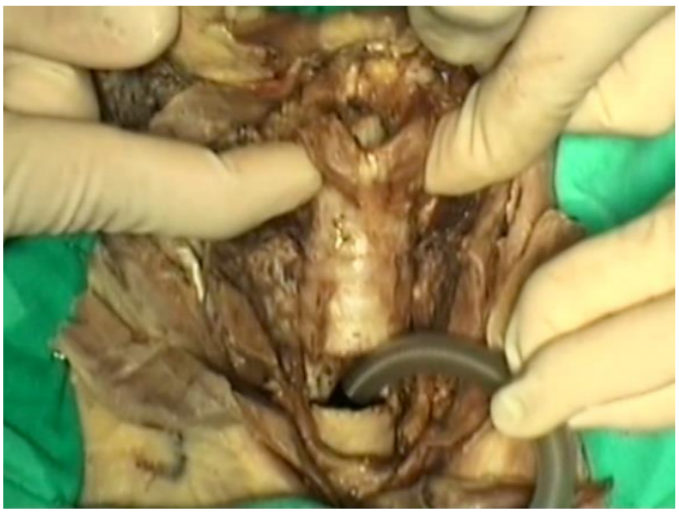


Figure 28: Resiting the endotracheal tube into the new tracheostoma

4. Reconstruction

Arytenoids

- Place two 3-0 vicryl sutures between the superior aspects of the arytenoids and the cricoid arch *(Figures 2, 29)*

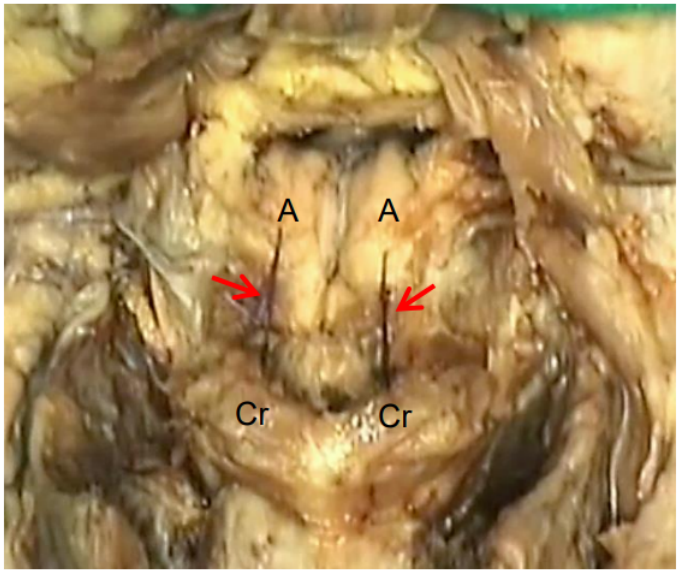


Figure 29: Sutures (red arrows) are placed between each vocal process and the cricoid (Cr) to pull the arytenoids (A) forwards. Do not tie them too tightly as their role is simply to prevent posterior rotation of the arytenoids during healing

- Do not tie the sutures too tightly
- The sutures avoid posterior rotation of the arytenoid and allow healing to occur in the correct position; by maintaining the arytenoids in a more anterior position, closure of the laryngeal entry during deglutition is improved[10]

Closing the airway

- *Cricohyodopexy/CHP* (epiglottis resected) or *cricohyoidoepiglottopexy / CHEP* (epiglottis preserved) is used to close the airway
- Pass three #1 vicryl sutures around the cricoid arch and the body of the hyoid
- One suture is placed in the midline and the other two are placed 0.5 cm to each side *(Figures 2, 30a-e)*



Figure 30a: Cricohyoidoepiglottopexy

- The needle is passed from outside through the cricotracheal membrane and is directed submucosally through the posterior surface of the cricoid arch *(Figure 30b)*
- It re-enters again through the inferior border of the sectioned epiglottis, runs 1-2 cm between the epiglottic cartilage and the pre-epiglottic fat and exits through the pre-epiglottic fat *(Figure 30c)*

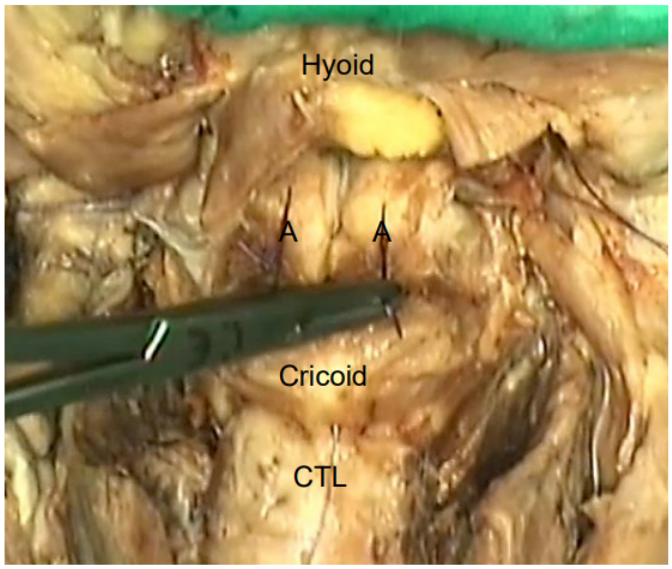


Figure 30b: The needle is passed through the cricotracheal ligament (CTL), runs submucosally on the posterior surface of the cricoid arch, and exits at its superior border; note sutures pulling arytenoids (A) forwards

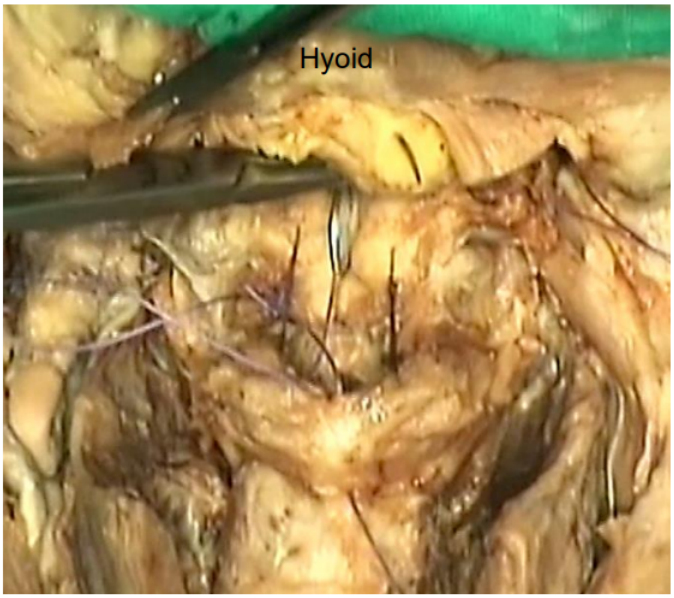


Figure 30c: The same needle re-enters between the epiglottic cartilage and preepiglottic fat, runs a few cm parallel to the anterior surface of the epiglottis, and exits through the epiglottic fat below the hyoid

- Finally, it surrounds the posterior and superior aspect of the body of the hyoid bone and exits above the bone through the suprahyoid musculature *(Figure 30d)*

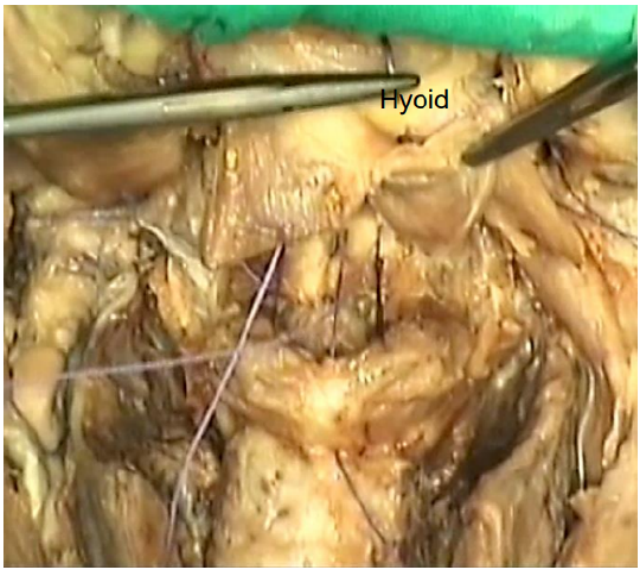


Figure 30d: Finally, the needle re-enters and passes behind the hyoid body, and exits through the suprahyoid muscles

- If the epiglottis has been preserved, it is important that the suture runs 1-2 cm parallel to the epiglottic cartilage in order to prevent inversion of the epiglottis that may compromise the outcome[11]. If the epiglottis has been resected, the sutures are passed around the cricoid cartilage and hyoid bone submucosally in a similar manner
- The 1st throw of the knots of the two lateral sutures are tightened simultaneously by the surgeon and the assistant
- Tighten the midline suture; while maintaining tension on the two other sutures, throw at least 3 knots on every suture to avoid dehiscence of the pexy *(Figure 30e)*
- Align the anterior borders of the cricoid and the hyoid; if this is not done then the size of the neoglottis is reduced and the functional outcome may be compromised

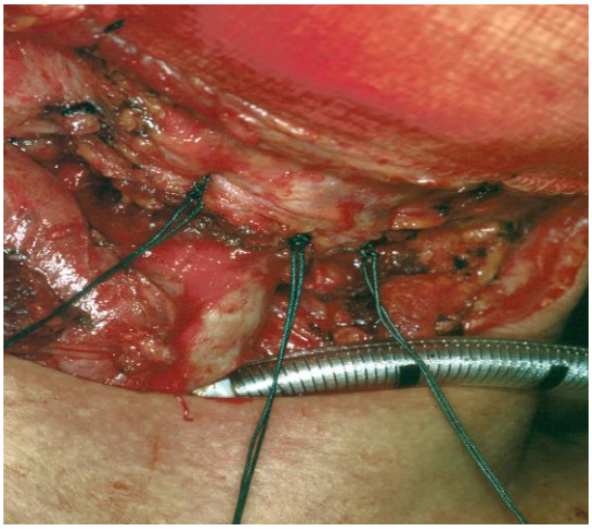


Figure 30e: Surgical view of the 3 pexy stitches after being tied

Pyriform sinuses

- With loss of support of the thyroid laminae, the pyriform sinuses lose their shape and collapse
- Sutures were earlier inserted into the submucosa of the pyriform sinuses during the approach stage of the operation *(Figure 16)*
- To restore the shape of the sinuses, use these sutures to hitch the outer surfaces of the pyriform sinuses to each side of the pexy *(Figure 31)*

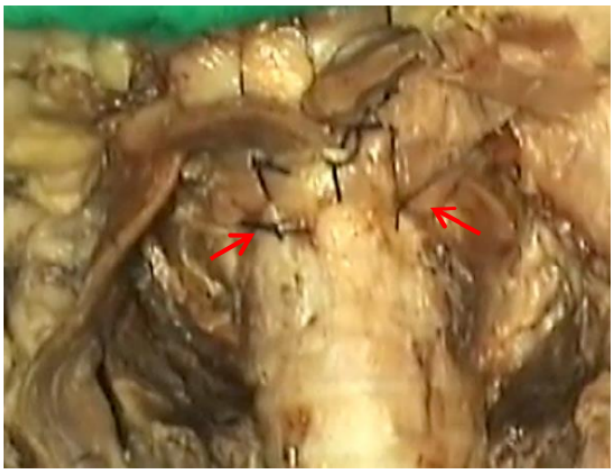


Figure 31: After performing the cricohyoido(epiglotto)pexy the pyriform sinuses are pulled forwards by suturing the stitches (red arrows) to the anterior tracheal wall

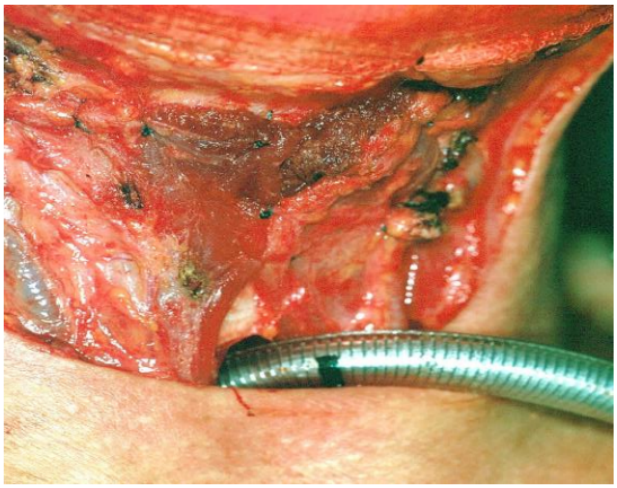


Figure 32: The strap muscles are sutured over the cricohyoidoepiglottopexy. The tracheostomy is secured in its final position

- Suture the strap muscles to the hyoid bone with vicryl to cover the pexy *(Figure 32)*
- Insert a single suction drain that crosses the midline; bilateral drains are inserted if neck dissections have been done
- Suture the skin, leaving a gap in the lower midline to introduce a cuffed tracheostomy tube

Postoperative Care

- A slightly compressive dressing is placed around the neck and changed every day for 5-7 days
- Drains are maintained for 2-3 days
- Some surgeons use prophylactic antibiotics during the 1st postoperative days, but we do not think it necessary unless there are factors that may favor infection
- Tracheostomy tube
  - The cuff is deflated 24 hrs after surgery
  - Significant coughing is guaranteed for 5-10 min
  - If the cough persists after a few minutes, the cuff is reinflated and the maneuver is repeated 24 hrs later
  - The sooner that the cuff can be left deflated, the quicker the recovery will be
  - An uncuffed fenestrated tracheostomy tube is inserted as soon as the patient tolerates the cuff deflated for 24-48 hours
  - The tube is plugged as soon as it is comfortably tolerated
  - The tracheostomy tube is removed when the patient tolerates a plugged tube for 24-48 hrs continuously (including at night). This usually happens 7-14 days after surgery
  - The tracheostomy wound is occluded with a dressing while it heals by second intention
- Swallowing
  - Provide nutrition by nasogastric feeding tube

- If no complications have occurred, attempt oral nutrition on Day 10
- Use “supraglottic swallow” and the “chin tuck” techniques, starting with yogurt or custard consistencies. The patient takes a deep breath and holds it, lowers the head until the chin touches the chest, introduces a small volume of food and swallows twice while maintaining this position, elevates the head and coughs immediately after the 2nd swallow, and subsequently breathes normally. After 2-3 attempts a significant cough will be noted. The patient then rests for 1-2 hours and tries again
- As swallowing is progressively better tolerated, the supraglottic swallow and chin tuck techniques are abandoned
- A noticeable improvement in swallowing occurs when the tracheostomy tube is removed
- Thicker and more liquid consistencies are gradually introduced
- Once oral intake is adequate to ensure correct nutrition, the feeding tube is removed (usually 10-20 days after surgery)
- This process is prolonged following resection of the epiglottis or one arytenoid

Radiotherapy

If required, postoperative radiotherapy is commenced when the healing process is complete *i.e.* 3-4 weeks after surgery. The authors used to leave the tracheostomy tube *in situ* until the end of radiotherapy as many patients develop oedema that requires endoscopic resection (*e.g.* with CO_2 laser) prior to definitive decannulation. Swallowing rehabilitation is also retarded by radiotherapy, and some patients need a new feeding tube during this period.

Outcomes

Several large series[12-16] have demonstrated that the oncologic results of supracricoid laryngectomy are equivalent to those of total laryngectomy, providing that candidates are properly selected and negative margins are obtained on frozen section. The authors previously reported a 5-year actuarial local control rate of >90% for T_1- T_2 tumors, and *ca.* 70% for T_3 tumors [17].

Laryngeal function is maintained in a large proportion of patients. Decannulation and adequate oral intake are achieved in >90% of patients[7, 12, 13, 18].

Quality of life has been shown to be better than that of patients submitted to total laryngectomy with tracheoesophageal puncture[16]. In a previous study, the authors reported excellent voice and swallowing in a group of patients as measured by the *Voice Handicap Index* and the *MD Anderson Dysphagia Inventory*[7].

Comparison with other treatments

The indications for supracricoid laryngectomy overlap with those of vertical partial laryngectomy and its permutations. However, while voice after vertical laryngectomy is very breathy, patients undergoing supracricoid laryngectomy preserve a rough but powerful voice with excellent phonation times. For this reason, supracricoid laryngectomy has displaced vertical laryngectomy techniques in the authors’ standard surgical armamentarium. Supraglottic carcinoma without glottic invasion is more properly treated with horizontal supraglottic laryngectomy, as voice quality is much better than after supracricoid laryngectomy. However, the latter allows one to treat supraglottic tumors with glottic invasion with open partial laryngectomy. In recent decades, transoral endoscopic laser resection of early and advanced carcinoma has been described. The main advantages of endoscopic procedures are the avoidance of tracheostomy in some patients and quicker swallowing rehabilitation. However, limited exposure may compromise a surgeon’s ability to obtain negative margins in bulky tumors, whereas long-term functional results do not differ from those of open partial laryngectomy. Moreover, the cost of a laser or a robot limits its application in many developing countries. Chemoradiation is often considered to be a more sophisticated treatment for laryngeal cancer. Although the overall survival is considered similar to total laryngectomy, local recurrence generally requires salvage surgery. The local control reported by the largest series of supracricoid laryngectomies for locally advanced carcinoma is superior to that reported by the main studies of nonsurgical treatment[19, 20]. Moreover, chemoradiated patients experience late toxicity that worsens their quality of life. Finally, the cost of chemoradiation is far higher than that of supracricoid laryngectomy. Total laryngectomy has been the classic treatment for laryngeal carcinoma for many years. While total laryngectomy patients experience excellent swallowing and voice can be successfully restored by different procedures[21], the presence of a permanent tracheostoma is an unavoidable handicap that worsens their quality of life[16, 22, 23].

Summary of authors’ routine practice

- Unilateral vocal cord cancers with preserved mobility and minimal invasion of the contralateral cord and/or ventricular band are treated by endoscopic resection (or laryngofissure if adverse anatomical features exist)
- More advanced glottic cancers are resected by supracricoid laryngectomy

- Supraglottic cancers without glottic invasion are managed by horizontal supraglottic laryngectomy (only small supraglottic tumors are endoscopically resected)
- Supracricoid laryngectomy is used for supraglottic cancer that invades the glottis
- Chemoradiotherapy is offered to patients that cannot be managed with any form of partial laryngectomy due to tumor or patient factors
- Total laryngectomy is currently considered a first line treatment for laryngeal and hypopharyngeal cancer when a tumor exceeds the limits of partial laryngectomy and presents with adverse factors for chemoradiation (bulky, cartilage invasion), or when the patient's age or comorbidities contraindicate other surgical or non-surgical treatments

Conclusions

Supracricoid partial laryngectomy is a versatile technique for the treatment of glottic and transglottic carcinoma. The oncologic results are supported by several long-term series. Long-term functional results are comparable to transoral procedures in the treatment of T_1-T_2 glottic tumors, and to chemoradiation protocols in T_3-T_4 glottic and transglottic tumors. However, careful selection of candidates is mandatory to achieve these results.

References

1. Majer EH, Rieder W. [Technic of laryngectomy permitting the conservation of respiratory permeability (cricohyoidopexy)]. Ann Otolaryngol. 1959; 76:677-81
2. Piquet JJ, Desaulty A, Decroix G. [Cricohyoido-epiglottopexy. Surgical technic and functional results]. Ann Otolaryngol Chir Cervicofac. 1974;91 (12):681-6
3. Laccourreye O, Ross J, Brasnu D, Chabardes E, Kelly JH, Laccourreye H. Extended supracricoid partial laryngectomy with tracheocricohyoidoepiglottopexy. Acta Otolaryngol. 1994;114-(6):669- 74
4. Yang H, Shen W, Xiong X. [Extended supracricoid partial laryngectomy with tracheocricohyoidoepiglottopexy and tracheocricohyoidoglottopexy]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2008;22(18):840-1
5. Allegra E, Franco T, Trapasso S, Domanico R, La Boria A, Garozzo A. Modified supracricoid laryngectomy: oncological and functional outcomes in the elderly. Clin Interv Aging. 2012; 7:475-80
6. Schindler A, Favero E, Capaccio P, Albera R, Cavalot AL, Ottaviani F. Supracricoid laryngectomy: age influence on long-term functional results. Laryngoscope. 2009; 119(6):1218-25
7. Castro A, Sanchez-Cuadrado I, Bernal-dez R, Del Palacio A, Gavilan J. Laryngeal function preservation fol-lowing supracricoid partial laryngec-tomy. Head Neck. 2012;34(2):162-7
8. Joo YH, Sun DI, Cho JH, Cho KJ, Kim MS. Factors that predict postoperative pulmonary complications after supracricoid partial laryngectomy. Arch Otolaryngol Head Neck Surg. 2009; 135(11):1154- 7
9. Chow JM, Block RM, Friedman M. Preoperative evaluation for partial laryngectomy. Head Neck Surg. 1988; 10(5):319-23
10. Seino Y, Nakayama M, Okamoto M, Hayashi S. Three-dimensional computed tomography analysis of neoglottis after supracricoid laryngectomy with cricohyoidoepiglottopexy. J Laryngol Otol. 2012;126(4):385-90
11. Nakayama M, Okamoto M, Seino Y, Miyamoto S, Hayashi S, Masaki T, et al. Inverted epiglottis: a postoperative complication of supracricoid laryngec-tomy with cricohyoidoepiglottopexy. Auris Nasus Larynx. 2010;37(5):609-14
12. Chevalier D, Laccourreye O, Brasnu D, Laccourreye H, Piquet JJ. Cricohyoidoepiglottopexy for glottic carcinoma with fixation or impaired motion of the true vocal cord: 5-year oncologic results with 112 patients. Ann Otol Rhinol Laryngol. 1997;106(5):364-9
13. Mercante G, Grammatica A, Battaglia P, Cristalli G, Pellini R, Spriano G. Supracricoid Partial Laryngectomy in the Management of T3 Laryngeal Cancer. Otolaryngol Head Neck Surg. 2013 Aug 6. [Epub ahead of print]
14. Page C, Mortuaire G, Mouawad F, Ganry O, Darras J, Pasquesoone X, et al. Supracricoid laryngectomy with cricohyoidoepiglottopexy (CHEP) in the management of laryngeal carcinoma: oncologic results. A 35-year experience. Eur Arch Otorhinolaryngol. 2013;270(6):- 1927-32
15. Pinar E, Imre A, Calli C, Oncel S, Katilmis H. Supracricoid partial laryngectomy: analyses of oncologic and functional outcomes. Otolaryngol Head Neck Surg. 2012;147(6):1093-8
16. Weinstein GS, El-Sawy MM, Ruiz C, Dooley P, Chalian A, El-Sayed MM, et al. Laryngeal preservation with supracricoid partial laryngectomy results in improved quality of life when compared with total laryngectomy. Laryngoscope. 2001; 111(2):191-9
17. Sanchez-Cuadrado I, Castro A, Bernaldez R, Del Palacio A, Gavilan J. Oncologic outcomes after supracricoid partial laryngectomy. Otolaryngol Head Neck Surg. 2011;144(6):910-4

18. Cho KJ, Joo YH, et al. Supracricoid laryngectomy: oncologic validity and functional safety. Eur Arch Otorhinolaryngol. 2010;267(12):1919-25
19. Forastiere AA, Goepfert H, Maor M, et al. Concurrent chemotherapy and radiotherapy for organ preservation in advanced laryngeal cancer. N Engl J Med. 2003; 349(22):2091-8
20. Wolf GT. Induction chemotherapy plus radiation compared with surgery plus radiation in patients with advanced laryngeal cancer. The Department of Veterans Affairs Laryngeal Cancer Study Group. N Engl J Med. 1991; 324(24):1685-90
21. Torrejano G, Guimaraes I. Voice quality after supracricoid laryngectomy and total laryngectomy with insertion of voice prosthesis. J Voice. 2009; 23(2):240-6
22. Herranz J, Gavilan J. Psychosocial adjustment after laryngeal cancer surgery. Ann Otol Rhinol Laryngol. 1999; 108(10):990- 7
23. Singer S, Danker H, Guntinas-Lichius O, Oeken J, Pabst F, Schock J, et al. Quality of life before and after total laryngectomy: Results of a multicenter prospective cohort study. Head Neck. 2014 Mar;36(3):359-68. doi: 10.1002/hed.23305

Clinical practice guidelines

- Cancer of Glottis - https://developingworldheadandneckcance rguidelines.com/index-page-glotticcancers/
- Cancer of Supraglottis - https://developingworldheadandneckcance rguidelines.com/index-page-supraglotticcancers/
- Cancer of Hypopharynx - https://developingworldheadandneckcance rguidelines.com/index-pagehypopharyngeal-cancers/

Authors

Alejandro Castro, MD
Department of Otolaryngology
La Paz University Hospital
Madrid, Spain
alejandro.castro@idipaz.es

Javier Gavilán, MD
Professor and Chairman
Department of Otolaryngology
La Paz University Hospital
Madrid, Spain
javier.gavilan@salud.madrid.org

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.19: CO2 Laser Transoral Microsurgery (TLM) for Cancers of the Upper Aerodigestive Tract

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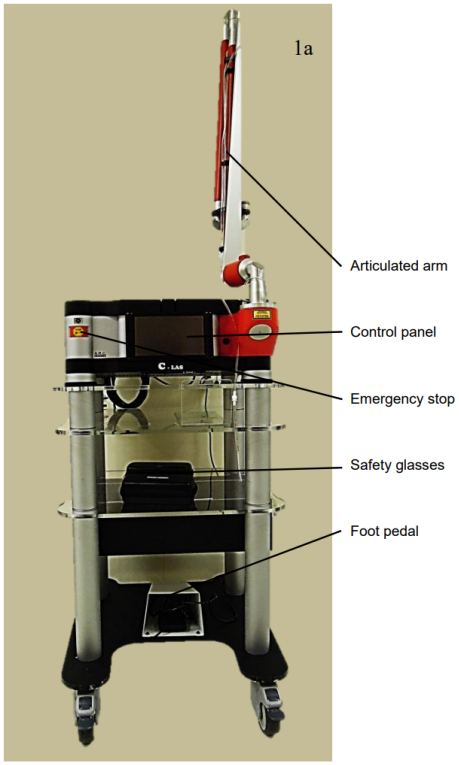
Johan Fagan, Wolfgang Steiner

CO_2 laser is used to resect or vaporize benign and malignant lesions of the upper aerodigestive tract. This chapter focuses on transoral CO_2 laser technique using a micromanipulator attached to an operating microscope. The advantages of using CO_2 laser with an operating microscope are microsurgical precision, excellent intraoperative detail, and a dry surgical field; the functional outcomes in terms of swallowing and speech exceed that of traditional external surgical approaches.

Surgeons must familiarize themselves with the laser machine, its settings and delivery systems, and its tissue effects prior to attempting to use it clinically.

CO_2 laser machine (Figure 1)

Surgical lasers convert radiation energy into heat at the point of contact of the focused radiation with the tissue. The laser beam is generated in a gas-containing discharge tube. The light beam is collimated (coherent), is of a single wavelength (monochromatic), and can be reflected and hence manipulated by mirrors, and focused by passing it through lenses. Because CO_2 laser falls outside the visible light spectrum and is therefore invisible, the laser machine generates a red diode laser aiming beam that is focused at the same working distance as the microscope to indicate to the surgeon where the beam is directed. The laser beam is directed along a spring-loaded articulated arm which connects to a beam applicator. The articulated arm has mirrors at each articulation; therefore, one has to handle the articulated arm with great care so as not to disturb the alignment of the mirrors. The laser is fired when the foot pedal is depressed.





Figures 1a, b: CO_2 laser: Wet drapes protect the patient

Beam applicators

The laser beam exits the end of the articulated arm and is delivered to the tissue via a handpiece, laser bronchoscope or a micromanipulator attached to an operating microscope (*Figures 2*, *3*, *4*).

Handpiece (*Figure 2*): This is generally used for excising or vaporizing skin lesions or lesions in the oral cavity and oropharynx. Suction tubing is attached to a suction port located on the side of the instrument to extract smoke and laser plume. The tip extension maintains the correct distance from the tissue to keep the laser beam correctly focused.



Figure 2: Laser handpiece



Figure 3: Laser bronchoscope



Figure 4: Micromanipulator attached to operating microscope

Micromanipulator (*Figures 4, 5*): The micromanipulator has a mirror located in the view path of the surgeon. The surgeon directs the laser beam precisely onto the desired tissue target. The coarse and fine focus settings are used to focus or defocus the laser beam and to set the spot size.

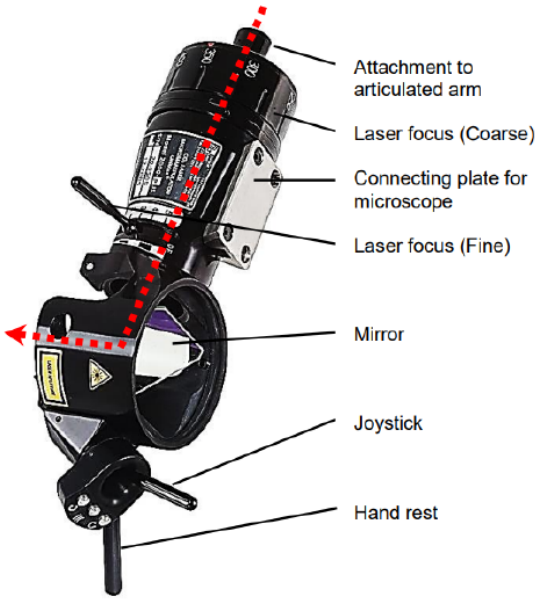


Figure 5: Micromanipulator that attaches to operating microscope (Path of laser beam indicated by red broken line)

CO_2 laser settings

Laser settings are selected according to the type of tissue to be lasered (cartilage / muscle / mucosa), the desired depth of the laser cut, the need for hemostasis, and the need to avoid excessive heating of tissue. The surgeon can optimize the benefits of CO_2 laser by adjusting:

- Laser Power Density (PD)
  - Watts
  - Laser spot size at its optimal focal distance
- Total duty cycle

Figure 6 illustrates a typical control panel of a laser machine. Settings available to the surgeon (left-to-right) include continuous vs. pulsed beam, lengths of pulses (milliseconds), time intervals between pulses, brightness of the aiming beam; power (Watts); and "Laser standby" or "Laser ready" settings. Spot size is set with the focus setting of the micromanipulator.

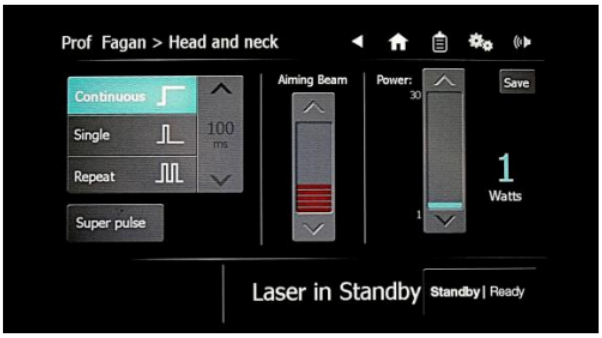


Figure 6: Example of laser control panel

Laser Power Density (PD)

Laser Power Density (PD) is a key surgical parameter. It is affected by the distance from the tissue, the diameter of the beam (laser spot size), and the number of Watts (Joules/sec); all these parameters can be controlled by the surgeon.

Key formulae to remember are:

- Power Density (PD) = Watts (W)/cm ^{2}
- Watts (W) = Joules/sec

By controlling PD, the surgeon can maximize the benefits of CO_2 laser surgery (*Table 1*).

Power density	Effect on tissues
0-500	Heating
500-1500	Contracture, denaturing
1500-5000	Ablation, partial vaporisation
5000-20000	Incision, complete vaporisation
20000-100000	Rapid deep incision

Table 1: Relationship between PD and tissue effects [1]

To achieve complete vaporization, the surgeon should aim for 4500 PD at the tissue interface. *Table 2* illustrates how critical the number of Watts and laser spot size are to PD.

	Spot size			
	0.2mm	0,4mm	0.8mm	1,4mm
5 watts	16000	4000	1000	300
10 watts	32000	8000	2000	600
15 watts	48000	12000	3000	900
20 watts	64000	16000	4000	1200

Table 2: PD according to spot size and watts [1]

Power (Watts)

This is selected by the surgeon every time the laser machine is used and can be preprogrammed for different types of surgery. A laser machine with power settings of up to 40W is recommended for head and neck surgery.

Laser spot size

The smaller the spot size, the less the range of depth of focus at which the laser cuts effectively and the more accurately the laser must be focused. Spot sizes of 0.5-0.8 mm provide a comfortable compromise between depth of focus and cutting ability.

To coagulate bleeding vessels, PD must be adjusted to a level at which tissue is no longer vaporized, but is only heated and blood vessels are coagulated (*Table 1*); *Table 2* illustrates how increasing spot size by defocusing the laser beam reduces the PD.

Total duty cycle

The ***total duty cycle*** is the total time that laser energy interacts with target tissues

This can be regulated in several ways (*Figure 6*):

- Continuous wave (CW): Continuous emittance of laser energy while the foot pedal is depressed
- Pulsed settings: Energy emitted as discrete pulses; the lengths, frequencies and time intervals between pulses can be selected by the surgeon
  - Single pulse: Single energy burst emitted every time the foot pedal is depressed
  - Repeat pulse: Repeated energy bursts emitted while the foot pedal is depressed
  - Super pulse (SP): Several thousand energy bursts of very high peak power laser pulses emitted per second while the foot pedal is depressed. The peak power of the bursts may be a few hundred watts, but the wattage shown on the laser machine reflects the average power transferred over time. The bursts are spaced far enough apart for efficient tissue cooling to occur between pulses; this reduces thermal damage to surrounding tissue and minimizes charring. For more coagulation, switch from SP to CW

Laser/tissue interaction

CO_2 laser is absorbed almost completely by intracellular water and causes vaporization of water and cells. Because 99% of heat that is generated is lost in the vapor that is released, peripheral tissue injury and necrosis are limited to <0.01 mm; this allows one

to preserve laryngeal function, to limit postoperative swelling and pain, and for pathologists to be able to interpret resected tissues for margins.

Safety & Laser fires (*Table 3*)

Laser fire is a very rare but potentially fatal complication of transoral laser microsurgery. Special care must be taken to avoid this catastrophe (*Table 3*). CO2 laser is invisible, reflects off smooth surfaces, can cause photothermal injury to patients and staff; and can cause fires by igniting flammable materials such as drapes, plastics, oxygen, and flammable cleaning solutions. Fire may also occur if the beam ignites the endotracheal tube (only if FiO_2 too high), or when "flaming" occurs when lasering carbonized tissue as when cutting through cartilage at high watts.

Safety precautions (Surgical)
• Place laser warning signs outside the operating room • Cover windows and securely close doors while the laser is "on" or in "standby" mode • Personnel and patients must use eye protection specific for CO_2 laser; it should also be available at entrances to the room; standard prescription eyeglasses are sufficient for CO_2 laser; side-guards are recommended • Tape the patient's eyes shut and apply moist pads • Do not use alcohol or flammable cleaning prep solutions or in the operating room • Use flame retardant materials and drapes • Keep an open container filled with water or saline immediately available to douse a laser fire • Placed moistened swabs/sponges adjacent to the path of the laser beam to protect surrounding tissues and structures • Minimize the possibility of a "blow-torch effect" by carefully protecting endotracheal tubes with wet cloth or neuro patties • The locking key to laser machine should be accessible only to persons trained in the use of laser; it should not be stored in or on the laser machine, but kept in secure location; some lasers have electronic keypads • Keep the laser turned off or in "standby" mode unless in use • Instruments should have brushed, beaded or sand-blasted surfaces to prevent reflection of the laser beam • The surgeon should give the anaesthetist prior warning to reduce the FiO2 before the laser is activated
Safety precautions (Anaesthetic)
• "Nonflammable" endotracheal tubes may be used (all tubes are flammable) • Fill the cuff of the endotracheal tube with saline coloured with methylene blue (Senior author (WS) prefers air, not saline) • Maintain inspired oxygen (FiO_2) as low as clinically feasible (<30%$Fi0_2$) • Wait a few minutes for the oxygen concentration in the airways to drop before approving activation of the laser • Avoid nitrous oxide if possible
Laser airway fire
• Turn off laser at emergency switch • Turn off all anaesthetic gases • Remove swabs and flammable materials from the airway • Immediately remove the endotracheal tube if intubated • Pour saline down the airway
Fire extinguished
• Re-establish ventilation • Use air/oxygen at lowest FiO_2 that maintains oxygenation • Avoid 100% O_2 if possible • Examine endotracheal tube to see if fragments left in airway • Consider bronchoscopy

Table 3: Laser safety precautions and management of laser fires

Because CO_2 laser is absorbed and "neutralised" by water, wet swabs and patties are used and the cuff of the endotracheal tube may be filled with saline. To reduce the risk of airway fire, it is critical that the anesthetist keeps the FiO_2 at a minimum (+/- 30%) to avoid a blow-torch effect if the oxygen in the airways is ignited. It is advisable that an open bowl of water/ saline be kept at hand to douse a laser fire.

Anesthesia for CO_2 laser surgery

The principal anesthetic challenges are to use endotracheal tubes that permit the surgeon to work in the confined space of the larynx and pharynx, and to eliminate the risk of laser fire (*Table 3*).

Gases: Avoid nitrous oxide if possible and maintain inspired oxygen FiO_2 as low as is clinically feasible; this requires continuous monitoring of the patient's oxygenation by pulse oximetry. The surgeon must notify the anesthetist before activating the laser and give the anesthetist enough time to reduce the delivered oxygen concentration to a minimum, to stop using nitrous oxide, and then to wait a few minutes for the oxygen concentration in the airways to drop to a safe concentration.

Airway: The airway may be maintained in several ways:

- Endotracheal intubation (nasal or oral)
- Intermittent jet ventilation; lasering is done during apnoeic intervals
- Intermittent extubation with lasering done during apnoeic intervals (2^{nd} author's preference over jet ventilation)
- Open airway
  - Spontaneous breathing of anesthetic gases administered through the suction port of the laryngoscope
  - Intravenous anesthesia
- Tracheostomy (rarely)

It is important that the surgeon discusses with the anesthetist the optimal method of maintaining an airway for the specific patient e.g. nasotracheal intubation may be best for base of tongue cancer but is problematic for an endolaryngeal tumor as it fixes the position of the endotracheal tube.

Endotracheal tubes: All tubes are flammable; no tube is therefore "safe". The problem is not the type of tube but perforating the tube when the O_2 concentration in the tube is too high. The authors use regular PVC tubes, but take special care to protect them with a strip of wet cloth cut from e.g. surgical drapes (*Figure 7*), or with neuropatties.



Figure 7: Tube protected by strip of wet cloth

The drawbacks of "laser tubes" are that they have thicker walls and are expensive. PVC tubes with 5 mm inner diameter are more flexible, less expensive and pose no increased risk for fire if the FiO_2 is <30%. The cuff of the tube may be filled with saline tinted with methylene blue to act as a marker for cuff puncture, and to flood the airway with saline to prevent a fire when the cuff is punctured by the laser. The 2^{nd} author (W.S.) however prefers to fill the cuff with air because it is easier to rapidly extubate a patient in case of emergency, and to avoid fluid running into the bronchi when a fluid-filled cuff is perforated.

Surgical Instrumentation

To prevent reflection of the laser beam, instruments with beaded or mat surfaces are used (*Figure 8*). Adequate tumor exposure is critical to TLM; an integrated suction channel to remove smoke is essential. ***It is therefore crucial that a variety of laryngoscopes and pharyngoscopes is available*** (*Figure 8*).



Figure 8: Laryngopharyngoscope (a), oropharyngoscope (b), laryngoscopes (c, d), light carrier (e), laryngoscope holder (f), graspers (g), insulated suckers (h), microforceps (i), coagulation forceps (j), diathermy lead (k), and ligaclip applicators to left and right (l) (Karl Storz)

- ***Distending laryngopharyngoscope***: To access lesions in the hypopharynx and supraglottic larynx (*Figures 8a*, *9*)
- ***Distending oropharyngoscope***: To access lesions in the tongue base, vallecula and lingual epiglottis; note the side-flaps that keep the endotracheal tube and soft tissues out of the surgical field (*Figures 8b*, *10*)



Figure 9: Distending laryngopharyngoscope



Figure 10: Distending oropharyngoscope

- ***Large laryngoscope***: To access endolaryngeal, upper tracheal and hypopharyngeal lesions (*Figures 8c*, *11*)

- ***Small laryngoscope***: Laryngoscope is smaller and longer; used for difficult exposures such as anterior commissure, subglottis and upper trachea (*Figures 8d*, *11*)
- ***Light carrier*** (*Figure 8e*)
- ***Laryngoscope holder*** (*Figure 8f*)
- ***Grasping forceps***: Different sizes (*Figure 8g*)



Figure 11: Larger & small laryngoscopes

- ***Suction tubes***: insulated for monopolar diathermy (*Figure 8h*)
- ***Microforceps*** (for small vocal fold lesions): (*Figure 8i*)
- ***Coagulation forceps*** (*Figure 8j*)
- ***Diathermy cable*** (*Figure 8k*)
- ***Liga clip applicators (left & right)*** (*Figure 8*l)
- ***Weerda diverticuloscope***: For Zenker's diverticulum and for carcinoma of the hypopharynx extending to the upper esophagus (*Figure 12*)

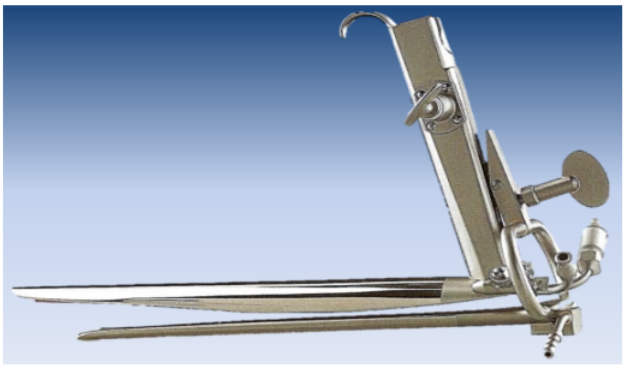


Figure 12: Weerda diverticuloscope

- ***Adjustable supporting plate for laryngoscope holder***: This avoids placing pressure on the patient's chest; the support can be moved away from the midline to angulate the laryngoscope if necessary (*Figure 13*)



Figure 13: Adjustable supporting plate for laryngoscope holder

Operating room setup (*Figure 14*)



Figure 14: Typical operating room setup

A typical setup has the ***anesthetic machine placed at the patient's feet***; this requires extensions for anesthetic tubing and intravenous lines. A camera is attached to the microscope so that the assistant and nurses can follow the procedure on a monitor. ***Two suction systems*** are required, one attached to the laryngoscope to extract smoke from the surgical field and the other attached to the hand-held suction tube. ***Monopolar diathermy*** should be available for laser procedures other than mid-cord T1 glottic carcinomas.

Preparation of operative site

- Wound scrubs and paints should be aqueous or non-flammable
- Ensure that surgical prep solution does not puddle on or around the patient
- Use draping and gown material that is flame retardant or non-flammable, or wet it with water
- Surround the scope with moistened towels, sponges or cotton to reduce the possibility of fire or burns to the patient's face

Surgical exposure

Surgical exposure is a critical element of TLM. It may prove sometimes impossible to proceed with TLM due to inadequate access

- Place patient in supine position with neck extended
- Check that the head is resting on the bed and not suspended in mid-air
- Check for loose or crowned teeth
- Insert gum guard
- Do panendoscopy to exclude synchronous malignancies
- Insert laryngoscope / laryngopharyngoscope / oropharyngoscope and expose the tumor
- Several different scopes may have to be used to best visualize the tumor during the course of an operation
- Suspend scope with the laryngoscope holder
- It may be necessary for the assistant to press on the larynx, or to place tapes attached to the theater table across the neck to displace the larynx posteriorly
- Rarely an external approach is required for access. This may be achieved by passing the laryngoscope through a suprahyoid approach into the vallecula (*Figure 15*); or by doing a partial laryngofissure, cutting only through the upper half of the thyroid cartilage so as not to disrupt the anterior commissure (*Figure 16*)



Figure 15: Suprahyoid approach to the vallecula

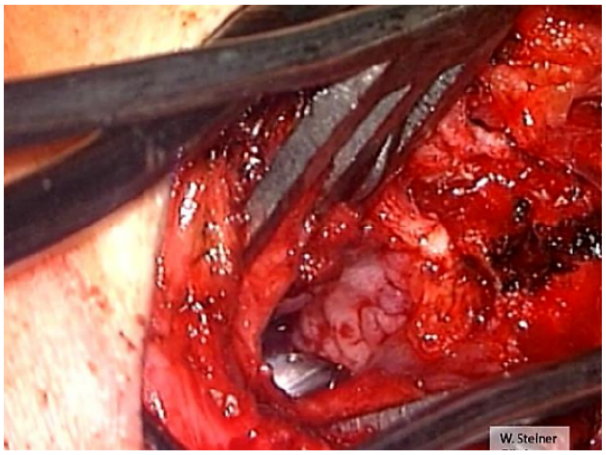


Figure 16: View of glottic cancer via a partial laryngofissure

Principles of CO_2 laser surgery

CO_2 laser may be used to incise, excise or vaporize (ablate) tissue. Novices should start by operating on simpler cases e.g. smaller tumors of the aryepiglottic fold, supraglottis, or medial wall of piriform fossa. Important principles of CO_2 laser surgery include:

1. ***Correct laser settings***: Selecting spot size, focus, power, and superpulse/ pulsed/continuous mode, are important in order to achieve the desired effects, and may have to be altered during the course of an operation for different tissues, or to achieve coagulation, cutting or vaporisation effects etc
2. ***Tension***: Constant traction must be applied to the tissue to expose the dissection plane, maintain good exposure and facilitate dissection
3. ***Hand speed***: The surgeon should maintain a relatively slow, smooth hand speed
4. ***Hemostasis***:
    1. Laser does not cut through blood; keep the field dry with suction / suction cautery / coagulation forceps / liga clips
    2. Use liga clips, not suction dia thermy, for large vessels to avoid postoperative bleeding
5. ***Charring***: Charring is reduced by generating less heat by using the superpulse setting. Wipe carbon off the surgical field with a wet cotton ball to maximize the vaporization effect on target tissue
6. ***Minimize peripheral tissue injury***: (Super)pulse as opposed to CW setting avoids excessive heating of tissue
7. ***Avoid desiccation of tissues***: Use normal saline or water to wet tissues to be lasered as CO_2 laser interaction is improved if tissue is well hydrated
8. ***Test the alignment of the aiming beam with that of the laser beam***: This is important especially when using CO_2 laser in otology as the margin for error is much more critical; direct the laser at a wet, wooden tongue depressor to check the alignment
9. ***Past-pointing***: Avoid the possibility of past-pointing of the laser beam as this may burn tissue or cause laser fires. Be aware of reflection of the laser beam off instruments and scopes, and ensure that the backstop e.g. neuro patty is correctly positioned to protect the endotracheal tube

10. ***Resecting structures for improved access***: Resecting suprahyoid epiglottis improves access to the pre-epiglottic space and to tumors on the laryngeal surface of the epiglottis. Although resecting the false vocal cord improves access to the laryngeal ventricle both for resection and follow-up, the benefit of improved access must be weighed against possible functional deficits as the preserved false vocal cord can be used to produce a good voice after glottectomy. A small laryngoscope introduced from laterally will in most cases adequately expose the ventricle; only with tumors spreading up to cartilage (T3) may it therefore be necessary to sacrifice the false vocal cord
11. ***Debulking***: This is a key TLM technique and allows the surgeon to create space within which to move tissues around and to apply traction to tissue, or to resect a bulky tumor through an endoscope (*Figure 17*). The debulked tissue is discarded, and only the deeper tissue along the tumor margins are sent for histology to determine the adequacy of the resection



Figure 17: Example of tumor that has to be debulked before oncologic resection can commence

12. ***Hydrodissection***: Water can be used as a barrier to penetration of the laser beam. Dissecting in the plane of Reinke's space or around nerves and vessels can be facilitated by infiltrating saline solution into Reinke's space or into tissue planes around nerves and vessels. Hemostasis can be promoted by injecting a solution containing epinephrine
13. ***Interface between tumor and normal tissue*** (*Figure 18*): The surgeon distinguishes tumor from normal tissue when transecting tumor by checking the pliability of the tissues (tumor is rigid), and by the colors of the tissues (tumor chars and is brown / black when transected with laser)



Figure 18: Note clear demarcation between dark brown transected tumor and pale-colored normal tissue of paraglottic space

14. ***Bread slicing***: (*Figure 19*) In order to ensure an adequate oncological deep margin, but to minimize impairment of voice quality by not resecting too much tissue, the surgeon needs to precisely determine the tumor depth and to resect along the deep aspect of the tumor under high magnification. This is achieved by serially sectioning (bread slicing) the tumor. This is applicable to all tumors other than very superficial (Tis or T1) tumors which are simply peeled off the vocal ligament staying in Reinke's space
15. ***Orientating specimens***: Take special care not to lose the orientation of specimens when removing them from the patient.

Specimens are pinned to small cut-outs of cork floor tiles that are placed in formaldehyde so that the pathologist can orientate the specimen (*Figure 20*).

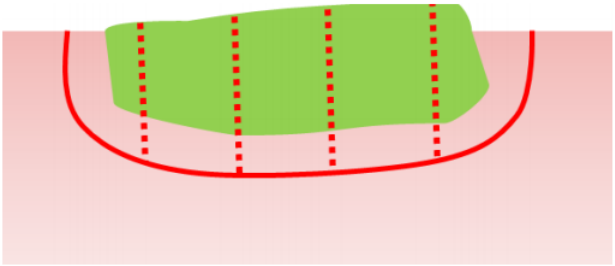


Figure 19: Bread slicing the tumor to evaluate tumor depth and guide depth of resection



Figure 20: Specimens are pinned to cutouts of cork floor tiles so that pathologist can orientate the specimen

16. Tumor topography: Include a detailed drawing on the pathology form and in the patient's notes of the precise location of all the resected specimens

What is an adequate resection margin?

This is a controversial topic, and one that may cause surgeons a great deal of anxiety as to whether the patient should be returned to the operating room for an additional resection, whether simply to advise close surveillance, or whether to recommend adjuvant irradiation. Factors that play a role in reaching such a decision include tumor location, size, function (voice and swallowing), patient fitness, extent of the initial resection e.g. onto cartilage or carotid, not knowing precisely where the positive or close margin is located, and the reliability of regular follow-up. Frozen section may be useful with larger resections e.g. base of tongue and hypopharynx; yet pathologists are reticent to do frozen sections on small resections e.g. T1 glottic cancers, as it makes it difficult to comment definitively on adequacy of margins. The surgeon's impression of the adequacy of a resection as seen through the microscope is also important; he/she may elect to adopt a watchful waiting approach even when tumor is reported to be "present at the margin", with the knowledge that cells are denatured and killed adjacent to the incision during laser excision; such a watchful waiting approach applies especially to small mid-vocal fold carcinomas that can be carefully monitored and reoperated on timeously without adversely affecting prognosis.

Glottic Carcinoma

The challenge for the laser surgeon is to strike the correct compromise between an oncologically adequate resection and preservation of voice quality. The new laser surgeon should initially select smaller tumors and progress to larger tumors only once he/she has gained a good understanding of the endoscopic "insideout" surgical anatomy of the larynx and has become proficient with laser surgery technique. We do not advise voice rest after surgery except for superficial defects of the membranous cord.

Classification of laser cordectomy

The European Laryngological Society proposed a useful classification of endoscopic cordectomy in 2000 (*Table 3*, *Figure 21*) [2].

Cordectomy	Type	Resected tissue
Subepithelial	I	Epithelium
Subligamental	II	Epithelium, Reinke's space, vocal ligament
Transmuscular	III	Through vocalis muscle
Total	IV	
Extended	Va	Contralateral vocal fold, anterior commissure
	Vb	Arytenoid
	Vc	Subglottis
	Vd	Ventricle

Table 3: European Laryngological Society classification of endoscopic cordectomy [2]

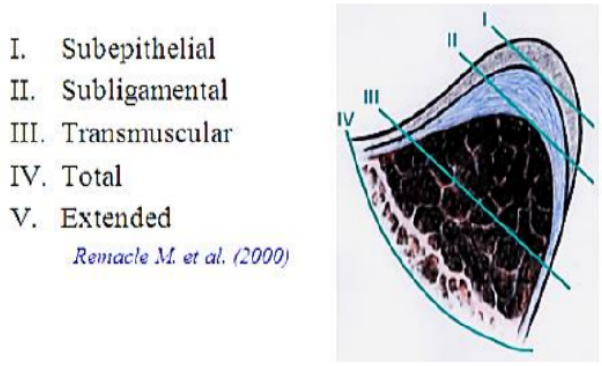


Figure 21: Classification of cordectomy [2]

One can anticipate an excellent speaking voice following Type I or subepithelial resection of T1s and T1 cancers of the membranous vocal fold (*Figures 22, 23*).

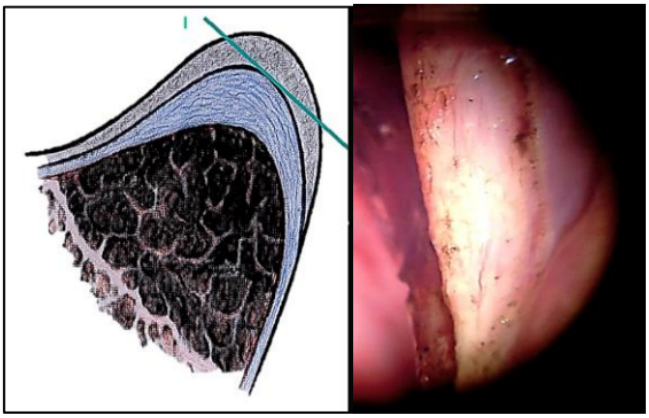


Figure 22: Type I cordectomy; note intact vocal ligament

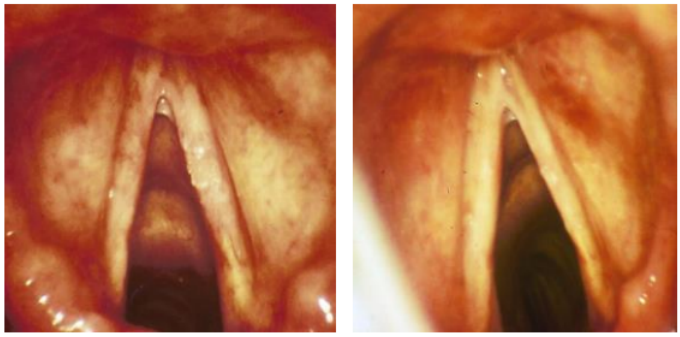


Figure 23: Type I cordectomy: Pre- and postoperatively

Figures 24 & 25 illustrate T1 glottic cancers that required Type II cordectomy and subsequent “new cord” formation due to a scar band; such patients can be expected to have a good, though not quite normal quality voice.

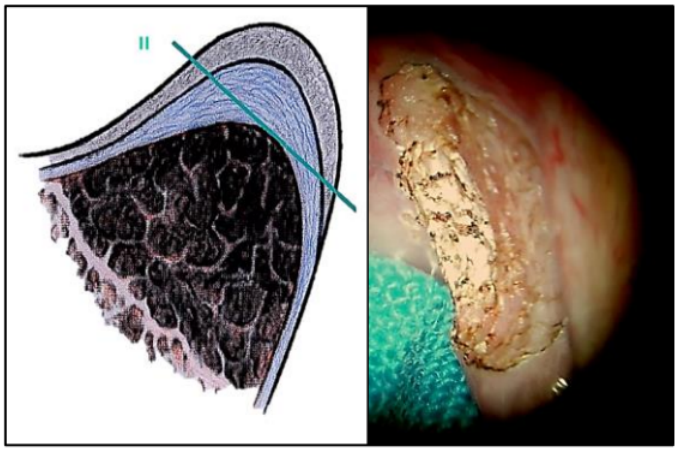


Figure 24: Type II cordectomy

Figure 25: T1 glottic carcinoma required Type II cordectomy; final result

Figure 26 illustrates transmuscular or Type III cordectomy for T2 glottic carcinoma. This defect is subsequently filled by a scar band leading to a very adequate speaking voice.

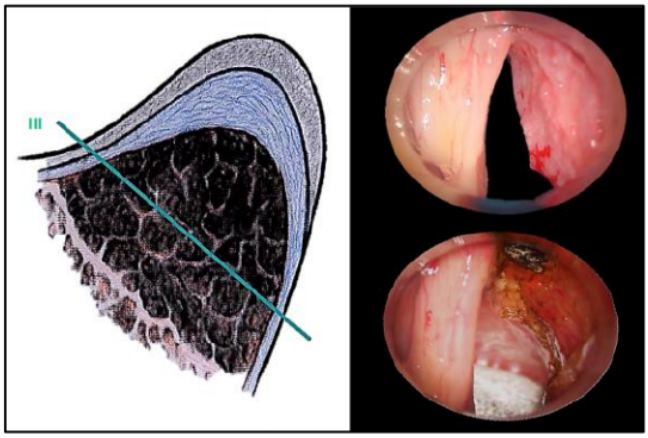


Figure 26: Type III cordectomy

With Type IV cordectomy the resection extends onto thyroid cartilage with loss of volume of the hemilarynx and less predicttable voice outcome (*Figure 27*).

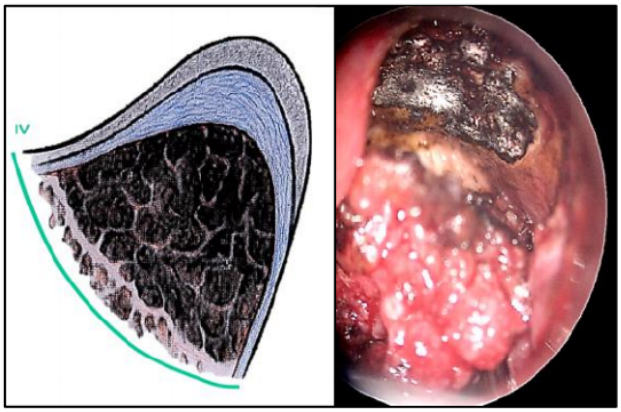


Figure 27: Type IV cordectomy

This applies to patients who undergo complete resection of the paraglottic space for T3 glottic carcinoma. Such patients may have to phonate using the false vocal cords and may produce a good voice; hence the value of preserving the false vocal cords if possible.

Superficial lesions of membranous cord

The objective is to do a Type 1 resection, and to restore a normal speaking voice. Resection margins of <1 mm are acceptable, as with close follow-up, recurrences can be resected without affecting oncologic outcome. Set the laser at its smallest spot size, low power (1.5-3W) and CW superpulse mode; this allows a very precise dissection with minimum lateral thermal injury to the tissues. Surgery is done under high magnification. The initial incision is made only through epithelium (*Figure 28*).

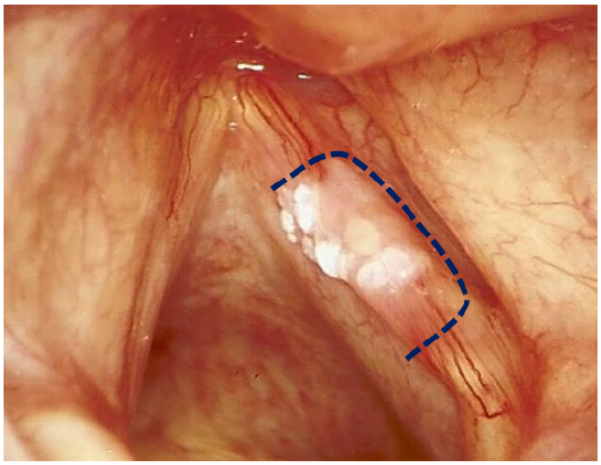


Figure 28: Initial incision for Type 1 cordectomy

The cut edge of the epithelium is picked up with microforceps and the tumor is dissected off the vocal ligament, taking care to remove and pin the tumor to the cork without losing spatial orientation (*Figure 20*).

Deeper lesions of membranous cord

With deeper tumors requiring Types II-IV resections the objective is to do an adequate resection (>1 mm margin), and to maintain an adequate speaking voice (*Figure 29*).

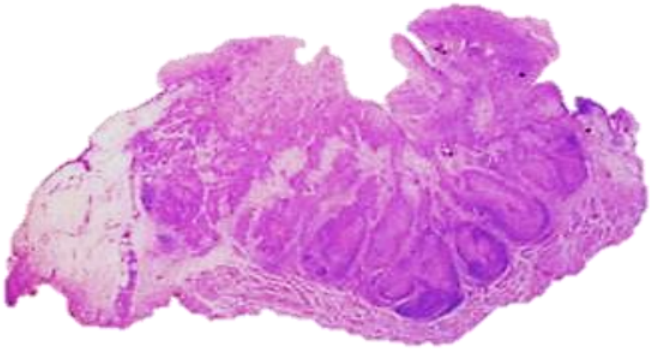


Figure 29: Example of margins required

Set the laser at its smallest spot size, power of 3-5 W and superpulse mode; this allows a very precise dissection with minor lateral thermal injury. Surgery is done under high magnification. It is imperative to bread slice the tumor in order to determine the depth of the tumor and the deep resection plane, and to remove it in sections (*Figures 18, 19, 30, 31*).

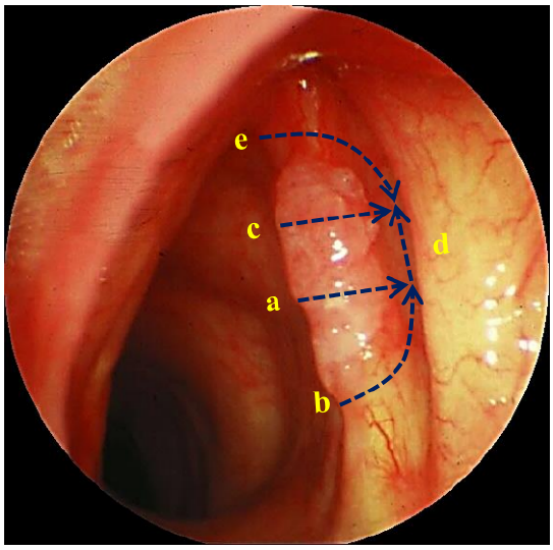


Figure 30: Example of sequence of incisions for a partial cordectomy

It is generally easiest to 1st remove the posterior segment, especially if access to the anterior commissure if poor (*Figure 32*).

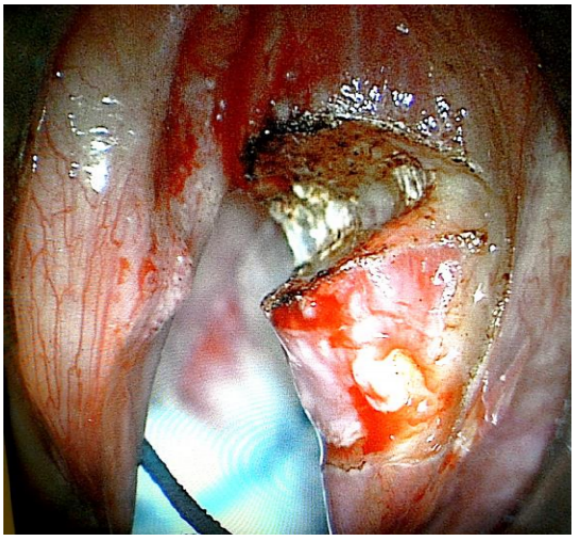


Figure 31: Tumor has been transected to determine depth of invasion

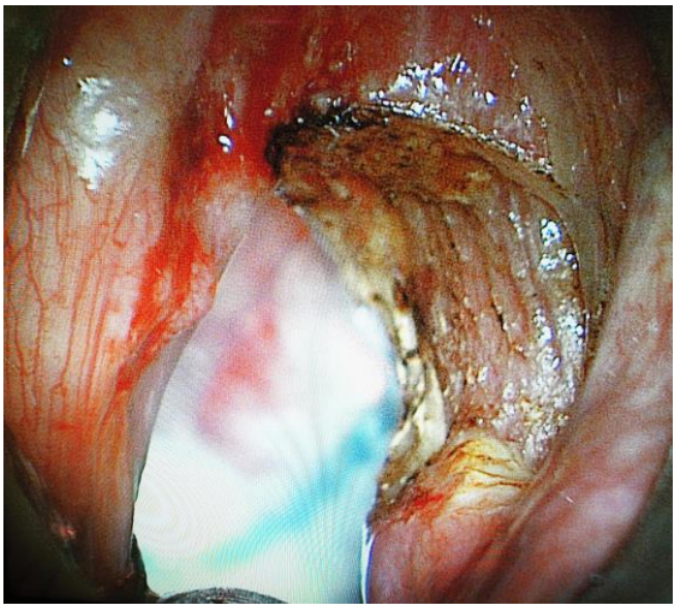


Figure 32: Type 3 resection of posterior half of tumor

Bleeding may be encountered especially when dissecting adjacent to, or below, the anterior commissure and lateral to the vocal process of the arytenoid. Small vessels may be coagulated by defocusing the laser beam. More brisk bleeding is controlled using monopolar or bipolar coagulation forceps. Avoid using suction diathermy on the vocal fold. Take care to remove and pin the tumor segments to the cork without losing spatial orientation, and to make a detailed drawing of the orientation of the segments in the patient records and on the pathology request form. It is also useful to paint the basal area (deep margin) blue, and to ask of the pathologist to determine whether the painted area is free of tumor.

Anterior commissure

The authors do not consider anterior commissure cancer to be a contraindication to laser resection. However, some surgeons consider involvement of the anterior commissure to be a contraindication for laser resection and advocate vertical, supracricoid or even total laryngectomy.

The following needs to be considered when managing cancers of the anterior commissure with laser resection:

- Proximity to thyroid cartilage: This makes it difficult to obtain wide margins and raises the possibility of cartilage invasion (*Figure 33*). The authors do not routinely obtain imaging but follow the tumor during the resection and may resect cartilage with CO_2 laser if necessary. Once the vocal ligaments have been severed from the cartilage with the laser, the surgeon can strip the tissues in a plane deep to perichondrium up to the inferior margin of the cartilage, and then defocuses the laser and “sterilises” the cartilage of any residual cancer cells (*Figure 34*).

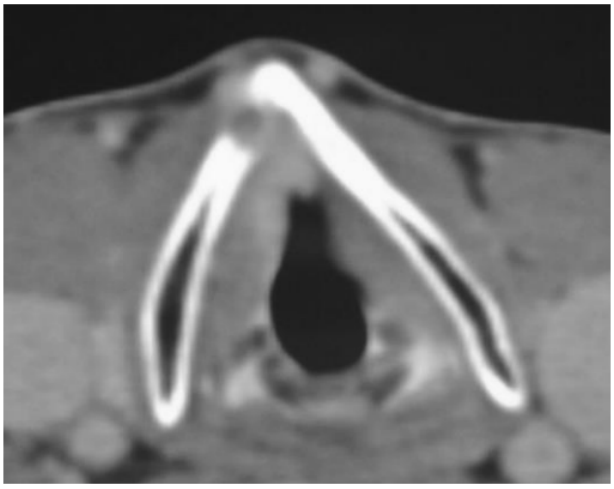


Figure 33: Extension through thyroid cartilage

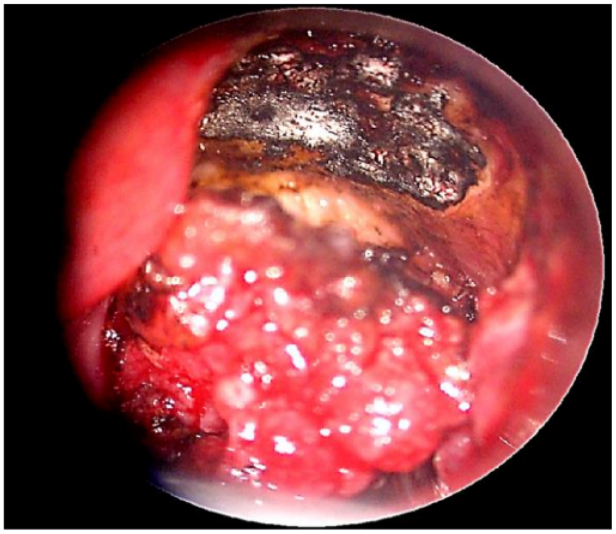


Figure 34: Tissues stripped in subperichondrial plane and cartilage “sterilised” of cancer cells

- Subglottic tumor extension below thyroid cartilage and through cricothyroid membrane (*Figures 35, 36*):

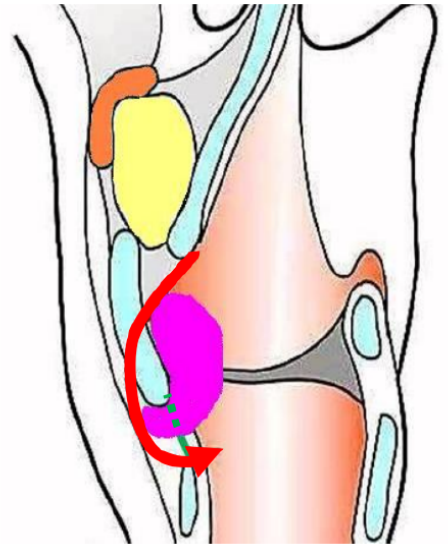


Figure 35: Subglottic extension through cricothyroid membrane; endo-scopic resection (red line)

The surgeon follows the tumor endoscopically. Thyroid cartilage may have to be resected with laser to improve exposure and for resection of extralaryngeal tumor; resection may extend to just deep to the skin of the neck if needed (*Figure 36*)

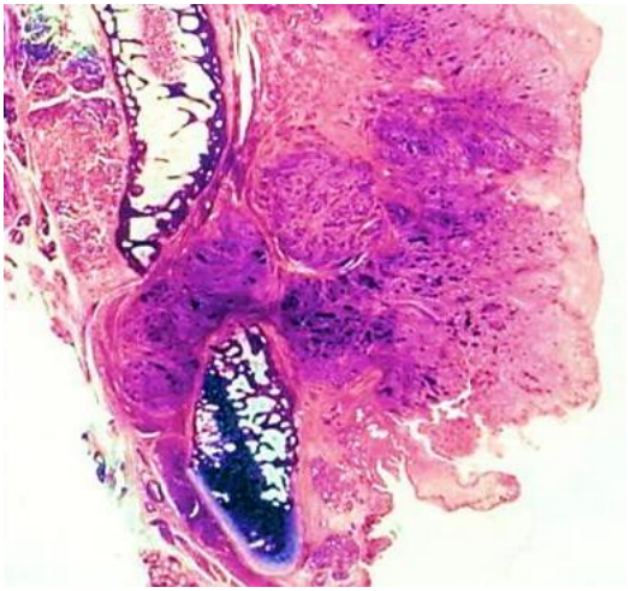


Figure 36: Tumor escaping between thyroid and cricoid cartilages

Webbing of anterior commissure causing poor voice (*Figure 37*): Webbing occurs when the anterior ends of both vocal cords are denuded or resected (*Figure 38*). This can be avoided by doing a two-stage resection, initially resecting only up to the midline, and completing the resection of the 2nd vocal cord tumor about a month later (*Figure 39*).

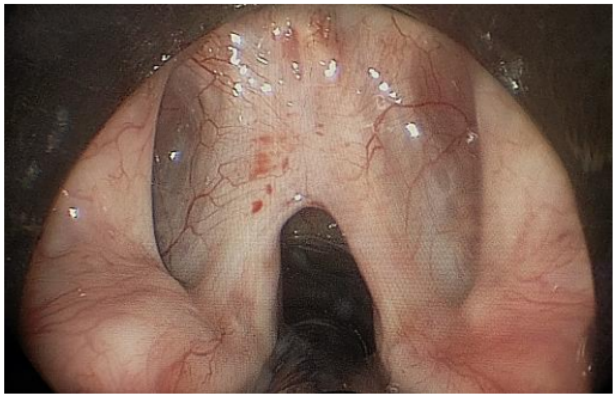


Figure 37: Webbing of commissure

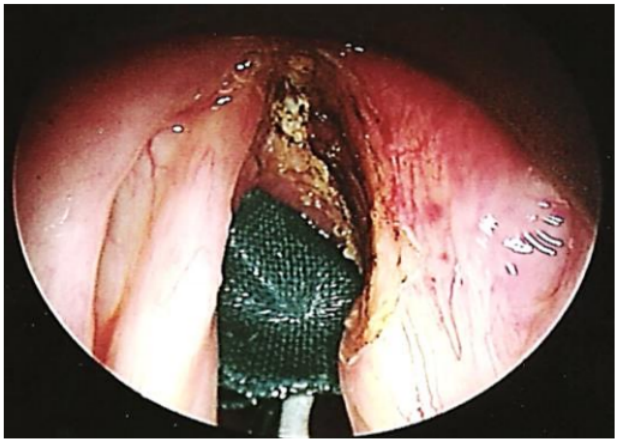


Figure 38: Denuding both vocal cords makes webbing likely

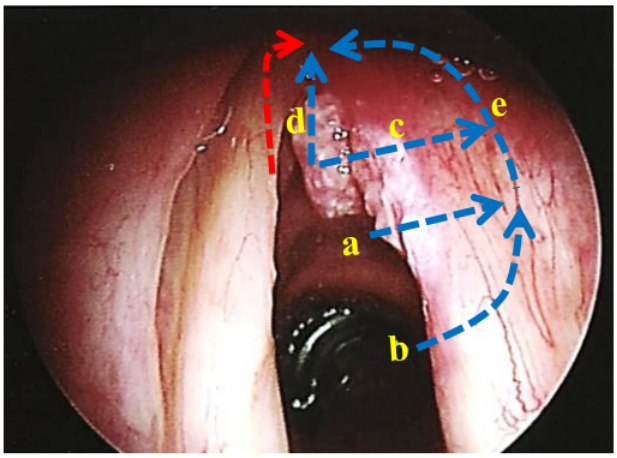
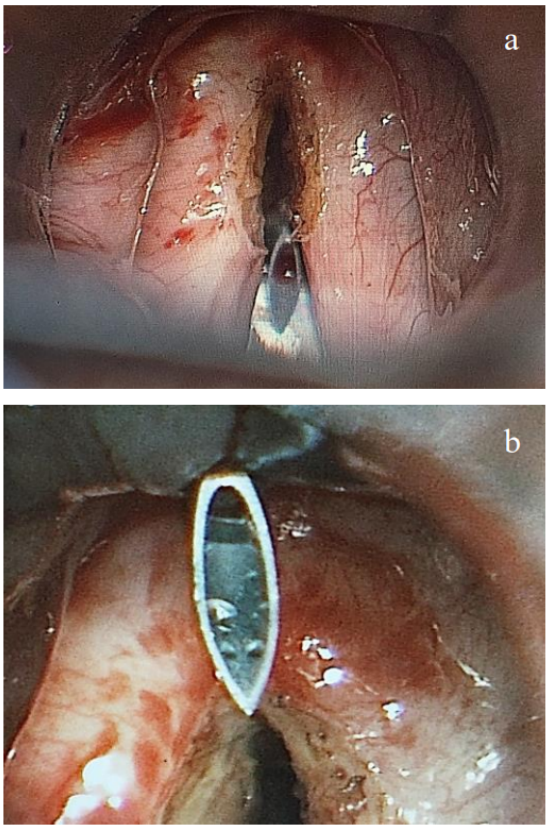


Figure 39: Typical sequence of initial (blue) and 2nd stage (red) resections of anterior commissure tumor to avoid webbing

It may be difficult to correct a web. Simply dividing the web with laser invariably leads to a new web. An option is apply Mitomycin C after excising of the scar tissue with laser, or to divide the web with laser and to place a silastic keel for 3 weeks to allow the cut edges to epithelialize [3] (*Figures 40, 41, 42*). The keel is fixed into position with sutures that are passed through needles passed from externally above and below the anterior commissure [3]. Keels can be cheaply made in the operating room either by folding cellotape back onto itself over a nylon suture (*Figure 40*), or by weaving a suture through the edge of a silastic sheet (*Figure 41*).



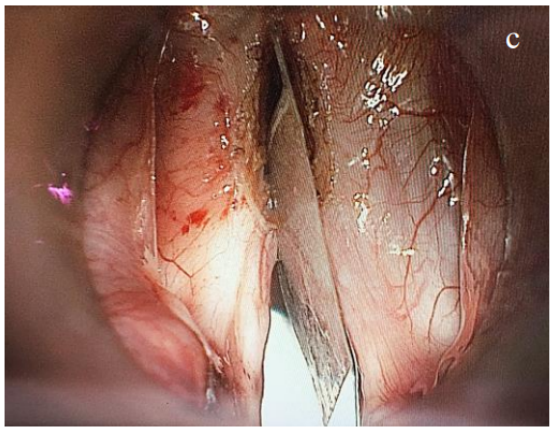


Figure 40: Web has been divided and needle passed through thyroid cartilage below anterior commissure (a); Second needle above commissure (b); Keel made from cellotape folded onto itself over a suture, tied into place (c)

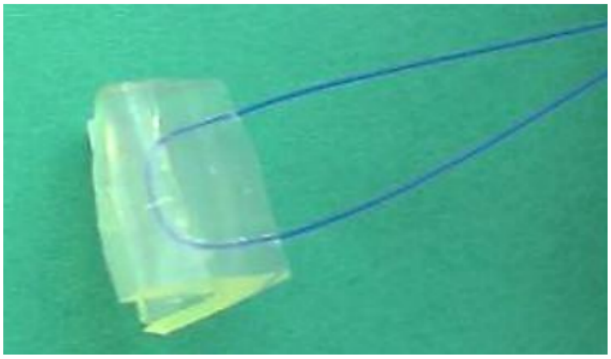


Figure 41a: Simple keel made by weaving a "double-armed" (needle attached to each end) 4/0 nylon/ prolene suture through a thin silastic sheet

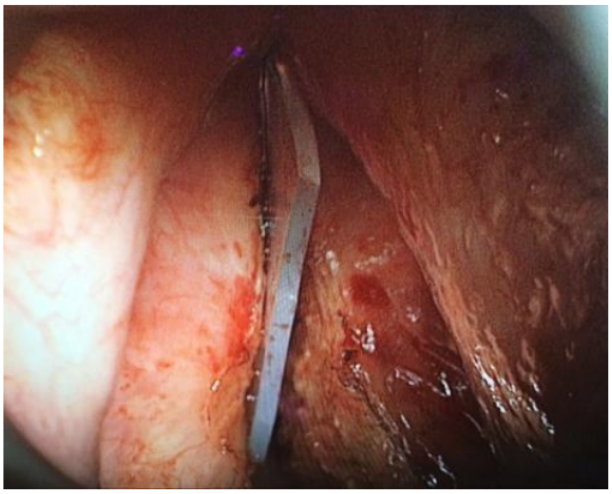


Figure 43, 44).

Supraglottic carcinoma

Supraglottic carcinoma is resected using a distending laryngopharyngoscope (*Figure 9*), graspers, and liga clip applicators to clip the superior laryngeal vessels that traverse the pharyngoepiglottic folds. Because the vocal cords are not being operated on, the surgeon sets the laser at a higher power (>5W), slightly larger spot size, and on superpulse mode to both cut and coagulate. Surgery is done under high magnification, maintaining >5 mm from the edge of the tumor. Provided a neck dissection is not done simultaneously, antibiotics are not generally required.

Cancer of suprahyoid epiglottis

The suprahyoid epiglottis can be resected with only transient and relatively minor difficulty with swallowing (aspiration) that settles once postoperative pain resolves.

Cancer of infrahyoid epiglottis and false vocal cords

Postoperative aspiration is minor when compared to open supraglottic laryngectomy; the nasogastric tube is usually removed within a few days. The resection is adapted to the tumor and may e.g. involve only removing one half of the epiglottis

- Insert a distending laryngopharyngoscope with the anterior blade in the vallecula, and open it widely
- Determine the extent of the tumor and plan the resection
- Remove the suprahyoid epiglottis for exposure and to remove the suprahyoid component of the tumor
  - Make a curved incision in the vallecula (*Figures 45, 46*)
  - Bisect the suprahyoid epiglottis in a sagittal plane, cutting through tumor if need be (require higher power setting to cut through epiglottis (*Figure 45*)
  - Cut transversely across the epiglottis at the level of the hyoid (*Figure 46*)
  - Remove the left and/or right segments of the suprahyoid epiglottis
- Readjust the position of the distending laryngopharyngoscope to improve access to the infrahyoid component of the tumor
- Incise the pharyngoepiglottic folds, taking care to identify the branches of the superior laryngeal vessels. Although small vessels can be coagulated with the angled grasping coagulation forceps, resist the temptation to coagulate the superior laryngeal artery with electrocautery; rather apply 2 ligaclips to the artery before dividing it with laser
- Preepiglottic dissection (*Figure 46*)
  - Cut transversely into the avascular preepiglottic fat, preserving a layer of fat on the anterior aspect of the specimen as a resection margin
  - Palpate with the sucker to determine the position of the hyoid bone and the superior edge of the thyroid cartilage
  - Cut down onto and expose the thyroid cartilage
- Bisect the infrahyoid epiglottis in a sagittal plane, cutting through tumor if need be (require higher power setting to cut through epiglottis)
- Follow the tumor e.g. through the thyrohyoid membrane; thyroid cartilage may also be resected
- Remove tumor in as many segments as is required, taking care to maintain their orientation for the pathologist
- Frozen section may be used to direct the extent of the resection
- Secure hemostasis with monopolar suction cautery or coagulation forceps, preferably bipolar

Hypopharyngeal carcinoma

Cancers of the piriform fossa may extend medially into paraglottic space, cricoid and cricoarytenoid joint; anteriorly into preepiglottic space; and laterally to invade thyroid cartilage, and behind thyroid lamina, to the soft tissues of the neck and the carotid sheath (*Figure 47*).

At diagnostic endoscopy assess

- Depth and mobility of tumor
  - Tumors clearly limited to mucosa are easily resected
  - Deeply invasive tumors of the lateral wall need additional CT +/ MRI imaging as deeply invasive tumors infiltrating soft tissue around the carotid artery are not amenable to laser excision
- Whether lateral wall tumor extends behind thyroid lamina (*Figures 49, 50*)
  - Proximity of carotid sheath
  - ***Need to delay neck dissections by 2 weeks to avoid thru'-and-thru' fistula into the neck***
- The distal extent of tumor as one should attempt to avoid a circumferential resection at the narrow cricopharyngeus region as this may cause a stricture

Resection technique

Surgery is done under high magnification through laryngoscopes and a distending laryngopharyngoscope (*Figure 9*) using graspers, and liga clip applicators to clip the superior laryngeal vessels that traverse the pharyngoepiglottic folds. Maintain a distance of 5-10 mm from the mucosal edge of the tumor. Because the vocal folds are not being operated on, the surgeon sets the laser at a higher power (>5W), slightly larger spot size, and on CW mode so as to both cut and coagulate tissue. Reduce the power when dissecting posterior to the thyroid lamina in the region of the carotid sheath. Both authors have on occasion exposed the carotid artery during

resection for hypopharyngeal cancers without any adverse effects; the vessel was either left uncovered or sealed with fibrin tissue glue. The tumor is excised in segments, taking care to orientate the specimens relevant for histology of the deep margins for the pathologist. With major resections insert a nasogastric feeding tube under direct vision to avoid the tube transgressing the tumor bed and entering the soft tissues of the neck or arrange for a PEG. Provided a neck dissection is not done simultaneously, antibiotics are not required.

Figures 51 & 52 show examples of piriform fossa and postcricoid cancers both before resection and after healing have occurred.

Base of tongue (BOT) (*Figures 53, 54*)

Functional outcomes are superior to external surgical resections. Depending on anatomical factors, accessing BOT tumors for laser excision may be very easy or impossible (other than in the hands of the expert using small scopes.

Key issues relating to BOT cancer resection:

- Obtain a CT, or preferably an MRI scan, both in axial and sagittal planes to assess
  - Tumor depth
  - Anterior deep extension of tumor
  - Involvement of pre-epiglottic fat
- Insert a nasotracheal tube to improve access and protect it with a wet cloth or a neuro patty
- Apply anterior traction to the tongue with a suture passed through the tongue
- Use a distending oropharyngoscope (*Figures 10a, b*) +/ large laryngoscope +/ tonsil gag for access
- With long procedures, relieve pressure of the scope from time-to-time to restore blood circulation to the tongue
- Do not sacrifice both lingual arteries as the tongue may infarct
- Do not sacrifice both hypoglossal nerves as the patient will then be an oral cripple (dysphagia and dysarthria)
- Resect the tumor in multiple segments
- Frozen section is used to guide the surgery as margins may not be as clearly visible as with laryngeal cancer
- Orientate the resected segments accurately for the pathologist to comment on margins
- No flaps are required, as the defect heals spontaneously
- Tracheostomy is generally not required
- With big resections that include resecting the epiglottis, a nasogastric tube is inserted for feeding
- When expecting persistent deglutition problems e.g. with extended resections for large tumors requiring adjuvant radiotherapy, a PEG should be considered early

Oral cavity and oropharynx

Oral and oropharyngeal lesions may be excised with CO_2 laser using the microscope. All lesions should be ***excised*** for histological evaluation i.e. not vaporized. *Figures 55a & b* illustrate the excellent functional outcome after leaving a tumor bed to heal following laser excision.

Figures 56a & b illustrate resection of cancer of the soft palate.

CO_2 laser for benign disease

Laryngocoeles and saccular cysts

Internal laryngoceles and saccular cysts do very well with wide marsupialization with CO_2 laser and removing the contents of the cyst with a sucker (*Figures 57, 58*).

Viral papillomatosis (*Figure 59*)

The objectives of surgery for viral papillomatosis are not to eradicate all virally infected tissue, but to maintain airway and voice. The most popular techniques are CO_2 laser and microdebriders. Ablation of papillomata is done with CO_2 laser on a low power setting and by slightly defocusing the beam to create a larger spot size. Surgery should be conservative to preserve voice.

Papillomata at the anterior commissure present a challenge in terms of avoiding webbing and a poor voice. One may elect to stage the treatment at the anterior commissure by ablating only one side at a time to avoid webbing. Tracheal papillomata can be ablated using the microscope by advancing a smaller and longer laryngoscope between the vocal cords; or by using a laser bronchoscope (*Figure 3*).

Intubation granuloma

Intubation granulomas originate on the traumatized vocal process of the arytenoid (*Figure 60*).

Only if they do not resorb after a few months and remain symptomatic are they removed, taking care not to expose the cartilage to reduce the likelihood of recurrence (*Figure 61*).

Paralysed vocal cords

With surgery done to relieve airway obstruction due to bilateral vocal fold paralysis, the patient must be forewarned about the trade-off of airway vs. voice quality, and that a 2nd operation may be required should the airway still not be adequate. While some surgeons prefer initially to do unilateral posterior cordectomy, the 2nd author routinely does bilateral posterior cordectomy as in his experience this yields a good outcome both in terms of airway and voice.

The surgery is done around a small (5 mm) endotracheal tube with the laryngoscope placed behind the tube so as to expose the posterior larynx. CO_2 laser is used to excise only the vocal process of the arytenoid (posterior 1/3 of vocal fold) and a variable amount of tissue lateral to the vocal process (*Figure 62*). It is important that the anterior 2/3 (vibrating part) of the vocal fold be preserved to optimize voice quality.

The final result is only apparent months after the surgery once fibrosis and healing have matured. The voice quality is usually very adequate as there is improved airflow through the larynx due to the larger airway, and because surgery is limited to the posterior glottis (*Figure 63*).

Subglottic and tracheal stenosis

CO2 laser is best suited to thin webs. The surgery is done by passing the smaller, longer laryngoscope past the vocal folds. Anesthesia is done with an open airway, either having the patient breathing spontaneously with intravenous anesthesia, or with intermittent jet ventilation; the 2nd author prefers using intermittent extubation with the surgery done during apnoeic intervals. The stricture is incised in a radial fashion, preserving mucosal bridges between the cuts (*Figures 64*).

Pharyngeal pouch (Zenker's diverticulum)

Endoscopic diverticulotomy involves dividing the "party wall" between the esophagus and the diverticulum, as well as the cricopharyngeus muscle which is located within the superior part of the "party wall" (*Figure 65*). It may be performed with a stapler (*Figure 66*) or with CO_2 laser. The 2nd author (W.S) has preferred CO_2 laser endoscopic diverticulotomy for the past 30 years. Both techniques have proven to be effective and safe.

CO_2 laser is particularly useful for pouches of <4 cm because the stapler does not divide the distal 1-2 cm of the party wall due to its design (*Figure 65*).

The operation is done with a Weerda diverticuloscope (*Figure 68*). It is not always possible to insert the scope due to anatomical limitations. In inexperienced hands the Weerda scope is a particularly dangerous instrument as it may be difficult to insert and may penetrate the posterior pharyngeal wall or the pouch causing cervical sepsis and mediastinitis (*Figure 69*).

Surgical steps for laser diverticulotomy

- Determine the anatomy of the pouch and the location of the opening of the esophagus with rigid esophagoscopy
- Pass the closed end of the Weerda scope into the pouch taking care not to perforate the thin wall of the pouch
- Open the blades, and retract the scope until the esophageal opening appears anteriorly (A trick to make it easier to locate the esophageal opening is to first place a suction catheter or cannula in the esophageal opening)
- Pass the anterior blade of the Weerda scope into the esophagus and keep the posterior blade in the pouch
- Distract the blades further to bring the party wall into view, and suspend the scope
- Clear the pouch of food debris
- Insert a wet strip of cloth into the esophagus to protect it from injury due to past pointing of the laser
- Set the laser at 5W, CW mode and small spot size
- Transect mucosa and cricopharyngeus muscle of the party wall (*Figure 70*)
- Stop the dissection 5 mm from the fundus of the pouch
- Broad spectrum antibiotics are given perioperatively
- Introduce free fluids on Day 1; progress to a soft and then solid diet over the course of a week (Some surgeons elect to insert a nasogastric feeding tube for 2 days)

Complications of laser surgery

Patients have surprisingly little pain following laser resections. They commonly mention having to clear their throats for a few weeks due to discharge from the surgical bed.

Early complications

- Dental: Use a gum guard to protect the teeth, and check for crowns or implants and explain the risks to the patient before surgery
- Oropharyngeal trauma: It is not uncommon to cause minor tears of the tonsillolingual mucosa when having difficulty with endoscopic access
- Lingual nerve: Prolonged upward traction on the base of the tongue can cause transient sensory change of the oral tongue due to traction injury to the lingual nerve
- Bleeding: It is important to apply liga clips, and not to cauterize, major vessels. Though infrequent, this can be a catastrophic event, especially when it originates from the lingual, superior laryngeal or carotid arteries
- Surgical emphysema: This occurs mainly in the setting of surgery in the subglottic region e.g. resection through the cricothyroid membrane and is treated conservatively; it occurs with small defects, as air is then trapped in the soft tissues. To avoid emphysema one can press on the larynx during extubation and subsequently apply a bandage around the neck
- Airway obstruction: This is an uncommon event; hence prophylactic tracheostomy is only rarely indicated
- Aspiration: This does not occur with cordectomies but may complicate supraglottic laryngectomy and BOT resections. It is rarely a persistent problem and occurs less frequently than with open resections. Initial management may include good pain control, thickened foods (rather than liquids); and temporary nasogastric tube or PEG feeding
- Laser burns: This occurs when the tissues e.g. facial skin, are not properly protected with wet drapes
- Airway fire: This is an extremely rare event and is entirely preventable

Late complications

- Granuloma (*Figure 71*): This occurs especially where cartilage has been exposed e.g. at the anterior commissure and the vocal process of the arytenoid. It generally resolves with time, but may require biopsy if it cannot be distinguished from tumor recurrence
- Chondronecrosis: This rarely occurs when cartilage has been exposed or excised, especially after salvage surgery in a post chemoradiation setting. The patient is treated with antibiotics and microlaryngoscopy to remove mucus and sequestra, and by sterilizing the remaining cartilage with the laser to improve healing and to exclude residual tumor (*Figure 72*)
- Stricture: This occurs very rarely with tumor surgery. *Figures 73a-c* illustrate a patient who developed a complete stricture in the region of the cricopharyngeus following circumferential excision of a tumor of the hypopharynx; the stricture was bypassed with a jejunal free flap

Suggested Reading

- Endoscopic Laser Surgery of the Upper Aerodigestive Tract: With Special Emphasis on Cancer Surgery. W Steiner, P Ambrosch (2000) ISBN-10: 08657- 7996, ISBN-13: 978-0865779969
- Transoral Laser Microsurgery for Cancer of the Upper Aerodigestive Tract (incl. DVD): Steiner W. 2013 (Distributed at no charge by Karl Storz, Tuttlingen)
- American Society for Laser Medicine and Surgery http://www.aslms.org/public/standardpsgs.shtml
- Apfelbaum JL et al. Practice advisory for the prevention and management of operating room fires: an updated report by the American Society of Anesthesiologists Task Force on Operating Room Fires. Anesthesiology. 2013 Feb;118(2):271-90

References

1. Peter H. Eeg. CO2 Lasers: The Four Keys to Success. Veterinary Practice News Posted: May 23, 2011 http://www.veterinarypracticenews.co m/vet-dept/small-animal-dept/c02- lasers-the-four-keys-to-success.aspx
2. Remacle M et al. Endoscopic cordectomy. A proposal for a classification by the Working Committee, European Laryngological Society. Eur Arch Otorhinolaryngol. 2000;257(4):227-31
3. Lichtenberger G, Toohill RJ. New keel fixing technique for endoscopic repair of anterior commissure webs. Laryngoscope 1994:104 (6):771–4

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Wolfgang Steiner MD, Hon.
FRCS (Engl) Professor
Em. & Past Chairman
Dept of ENT, Head & Neck Surgery
University of Goettingen
Göttingen, Germany
wolfgang.p.steiner@googlemail.com

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1.20: Neck Dissection- Modified and Radical

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Neck dissection removes potential or proven metastases to cervical lymph nodes. It is a complex operation and requires a sound knowledge of the 3-dimensional anatomy of the neck.

Indications

Neck dissection may be **elective** (END) when done for clinically occult metastases, **therapeutic** (clinical metastases) or may be a **salvage** procedure (previously treated neck with surgery +/ radiation). END is indicated when the risk of having occult cervical nodal metastases exceeds 15-20%.

Nodal Levels

The neck is conventionally divided into 6 levels; Level *VII* is in the superior mediastinum *(Figure 1)*.

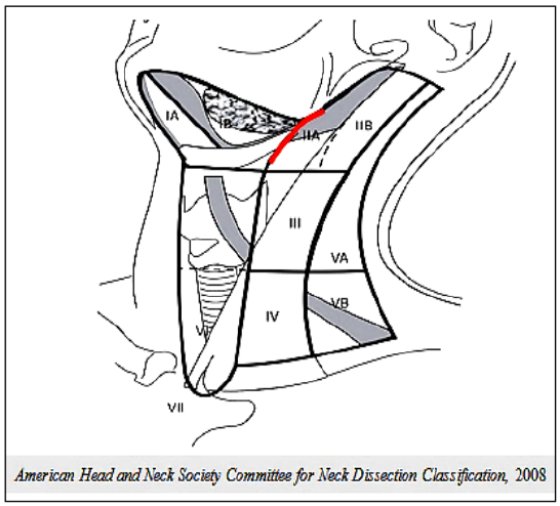


Figure 1: Classification of cervical nodal levels (Consensus statement on the classification and terminology of neck dissection. Arch Otolaryngol Head Neck Surg 2008; 134: 536–8)

Level I is bound by the body of the mandible above, the stylohyoid muscle posteriorly, and the anterior belly of the contralateral digastric muscle anteriorly. The revised classification *(Figure 1)* uses the posterior margin of the submandibular gland as the boundary between Levels I and II as it is clearly identified on ultrasound, CT, or MRI. *Level I* is subdivided into *Level Ia*, (submental triangle) which is bound by the anterior bellies of the digastric muscles and the hyoid bone, and *Level Ib* (submandibular triangle).

Level II extends between the skull base and hyoid bone. The posterior border of the sternocleidomastoid defines its posterior border. The stylohyoid muscle (alternately the posterior edge of the submandibular gland) defines its anterior border. The accessory nerve (XIn) traverses Level II obliquely and subdivides it into *Level IIa* (anterior to XIn) and *Level IIb* (behind XIn).

Level III is located between the hyoid bone and the inferior border of the cricoid cartilage. The sternohyoid muscle marks its anterior limit and the posterior border of the sternocleidomastoid its posterior border.

Level IV is located between the inferior border of the cricoid cartilage and the clavicle. The anterior boundary is the sternohyoid muscle, and the posterior border is the posterior border of sternocleidomastoid.

Level V is bound anteriorly by the posterior border of the sternocleidomastoid, and posteriorly by the trapezius muscle. It extends from the mastoid tip to the clavicle and is subdivided by a horizontal line drawn from the inferior border of the cricoid cartilage into *Level Va* superiorly, and *Level Vb* inferiorly.

Level VI is the anterior, or central, compartment of the neck. It is bound laterally by the carotid arteries, superiorly by the hyoid bone, and inferiorly by the suprasternal notch.

Neck Dissection Classification

Neck dissection operations are classified according to the cervical lymphatic regions that are resected *(Figures 1, 2).*

Selective neck dissection (SND) is done for N_0 necks (no clinical evidence of neck nodes) or for very limited cervical metastases *(Figure 2)*. Central neck dissection encompasses only Level VI *(Figure 1).*

Comprehensive or therapeutic neck dissection involves surgical clearance of Levels 1-V and may either be a radical *(RND)* or modified *(MND) neck dissection*. RND includes resection of sternocleidomastoid muscle (SCM) and accessory nerve (XIn) and internal jugular vein (IJV). MND preserves SCM and/or XIn and/or IJV. MND type I entails preservation of 1/3, usually XIn; MND type II entails preservation of 2/3, usually XIn and IJV; with MND type III all 3 structures are preserved. MND type II is most commonly done and is oncologically acceptable in the absence of adherence of cervical nodal metastases to XIn or IJV.

Extended neck dissection includes additional lymphatic groups (parotid, occipital, Level VI, mediastinal, retropharyngeal) or non-lymphatic structures (skin, muscle, nerve, blood vessels etc.) not usually included in a comprehensive neck dissection.

It has been proposed that neck dissections be more logically and precisely described and classified by naming the structures and the nodal levels that have been resected. (Ferlito A, Robbins KT, Shah JP, *et al*. Proposal for a rational classification of neck dissections. *Head Neck*. 2011;33(3):445- 50)

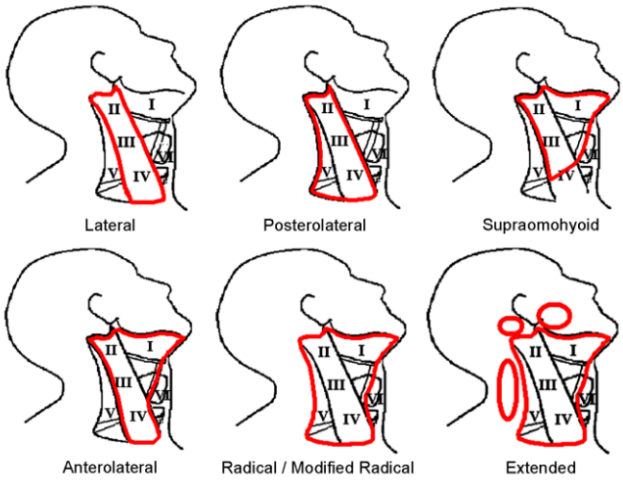


Figure 2: Common types of neck dissection

Modified neck dissection: Operative steps

The detailed step-by-step description of neck dissection that follows refers to a right sided MND type I or II.

RND involved the same surgical steps, other than that the IJV is double ligated superiorly and inferiorly with silk and with a silk transfixion suture passed through the vein, taking care not to include the vagus nerve (Xn) in the ligature.

Anesthesia, positioning and draping

The operation is done under general anesthesia without muscle relaxation as eliciting movement on mechanical or electrical stimulation of the marginal mandibular, hypoglossal (XIIn) and accessory nerves assist with locating and preserving these nerves. It is a clean operation unless the upper aerodigestive tract is entered, and antibiotics are therefore not required. With an experienced surgeon, blood transfusion is rarely required.

The patient is placed in a supine position with the neck extended and turned to the opposite side. Surgical draping must allow monitoring for movement of the lower lip with irritation of the marginal mandibular nerve, and must provide access to the clavicle inferiorly, the trapezius muscle posteriorly, the tip of the earlobe superiorly and the midline of the neck anteriorly. The drapes are sutured to the skin.

Incisions and flaps

Incisions should take into consideration access that may be required to resect the primary tumour, cosmetic factors, and the blood supply to the flaps. Flaps are elevated in a subplatysmal plane with a knife or with monopolar electrocautery. Making the flaps too thin may compromise the blood supply to the skin flaps.

Figure 3 demonstrates incisions commonly used for MND done in association with cancers of the oral cavity, oropharynx, nasal cavity sinuses and skin cancers of the midface. The transverse skin incision can be extended across to the opposite side with bilateral neck dissections or can be extended superiorly to split the lower lip in the midline to gain access to the oral cavity. Care should be taken not to place the trifurcation of the incision over the carotid artery, as skin loss at this point may expose the carotid artery with its attendant risks.

Figure 4 demonstrates the hockey stick incision. This can be extended into a preauricular skin crease and is particularly useful for combined parotidectomy and neck dissection. It has the advantage that the scar of the vertical limb along the anterior border of the trapezius can be hidden by long hair. Care must be taken in patients who have been previously irradiated as the posteroinferior corner has a tenuous blood supply and may slough, having to heal by secondary intention.

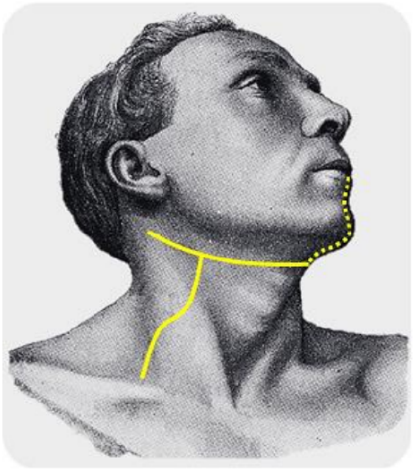


Figure 3: Incisions for neck dissection combined with oral cavity cancer resection

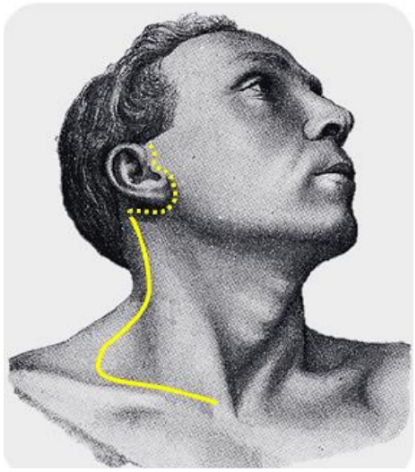


Figure 4: Hockey-stick incision for neck dissection combined with parotidectomy

With laryngectomy patients, MND can be done either via a wide apron flap, or by lateral extensions from the apron flap (Figures 5, 6).



Figure 5: Wide apron flap



Figure 6: Apron flap with lateral extensions

Neck dissection: Operative steps

Figure 7 shows a completed right-sided MND type II. The superimposed numbers indicate the sequence of the main operative steps that will be referred to in the description of the surgery that follows.

Step 1 (Figure 7)

The neck is opened via a horizontal incision placed in a skin crease at about the level of the hyoid bone. The incision is made through skin, subcutaneous fat, and platysma muscle. Identify the external jugular vein and greater auricular nerve overlying the sternocleidomastoid muscle (SCM) *(Figure 8)*.

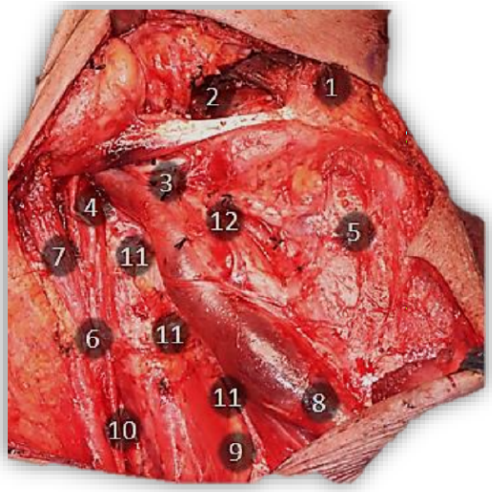


Figure 7: Completed right MND type II with sequence of operative steps



Figure 8: Note platysma muscle (transected), and the external jugular vein and greater auricular nerve overlying the SCM

Next the superior flap is elevated with cautery until the submandibular salivary gland is identified. The submandibular gland fascia is then incised inferiorly over the gland to avoid injury to the marginal mandibular nerve *(Figure 9)*.

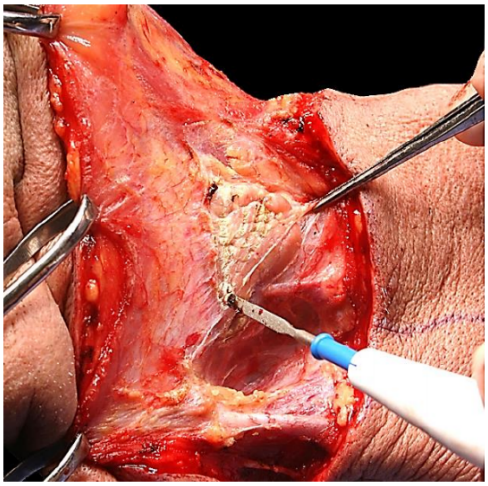


Figure 9: Incision of submandibular salivary gland capsule

The surgeon then resects the fat and lymph nodes from the submental triangle (Level Ia). A subplatysmal dissection of the overlying skin is extended to the opposite anterior belly of digastric muscle, taking care not to injure the anterior jugular veins. The submental triangle is resected inferiorly to the hyoid bone with electrocautery. The deep plane of dissection is the mylohyoid muscles *(Figures 10 & 11)*.

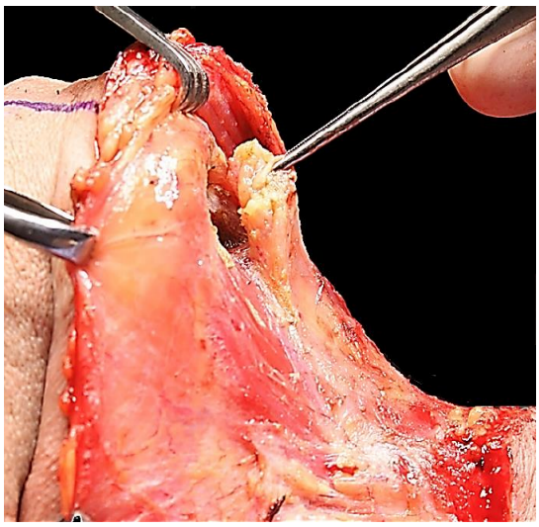


Figure 10: Resection of submental triangle

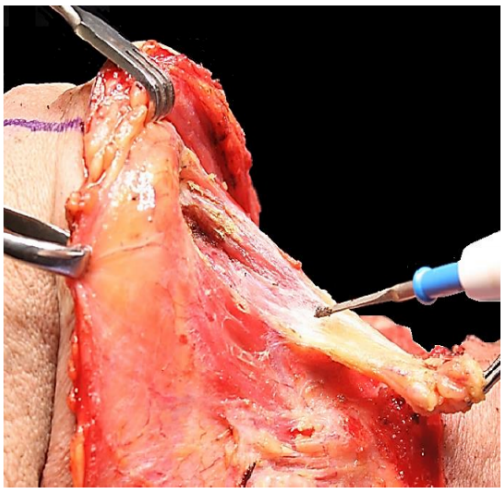


Figure 11: Resection of submental triangle onto mylohyoid muscles

Step 2 (Figure 7)

The surgeon next addresses Level Ib of the neck. Because the marginal mandibular nerve runs in an extracapsular plane, the submandibular gland capsule is dissected from the gland in a superior direction in a subcapsular plane *(Figure 9)*. The marginal mandibular nerve does not need to be routinely identified. The assistant however watches for twitching of the lower lip, as this indicates proximity of the nerve. The facial artery and vein are identified by blunt dissection with a fine hemostat *(Figure 12)*. The marginal mandibular nerve crosses the facial artery and vein *(Figure 12)*.

Next attention is directed at the fat and lymph nodes tucked anteriorly and deeply between the anterior belly of digastric and mylohyoid muscle. These nodes are especially important to resect with malignancies of the anterior floor of mouth. To resect these nodes one retracts the anterior belly of digastric anteriorly and delivers the tissue using electrocautery dissection with the deep dissection plane being the mylohyoid muscle *(Figures 12, 13)*.

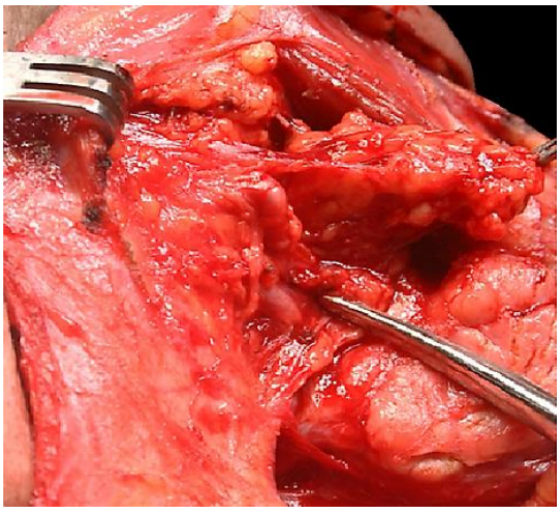


Figure 12: The submandibular gland has been dissected in a subcapsular plane; the marginal mandibular nerve is seen crossing the facial artery and vein (at tip of hemostat); fat and nodes are delivered from the anterior pocket deep to the digastric

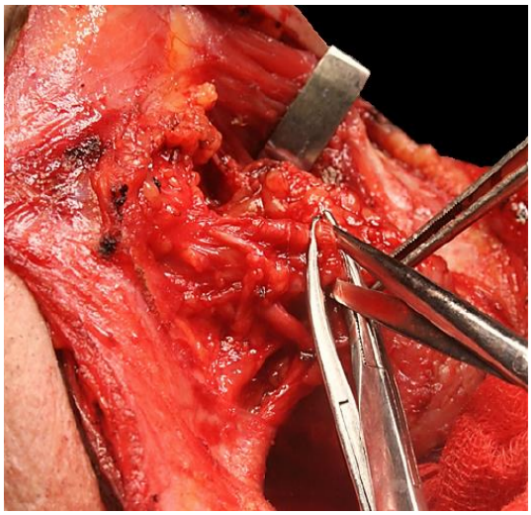


Figure 13: Dividing the facial vessels below the marginal mandibular nerve

Other than the nerve to mylohyoid and vessels that pierce the muscle that are cauterized or ligated, there are no significant structures until the dissection reaches the posterior free margin of the mylohyoid muscle. Next attention is directed at the region of the facial artery and vein. The surgeon palpates around the facial vessels for facial lymph nodes; if present, they are dissected free using fine hemostats, taking care not to traumatize the marginal mandibular nerve. The facial artery and vein are then divided and tied close to the submandibular gland so as not to injure the marginal mandibular nerve *(Figure 13)*.

This frees up the gland superiorly, which can then be reflected away from the mandible *(Figure 14)*.

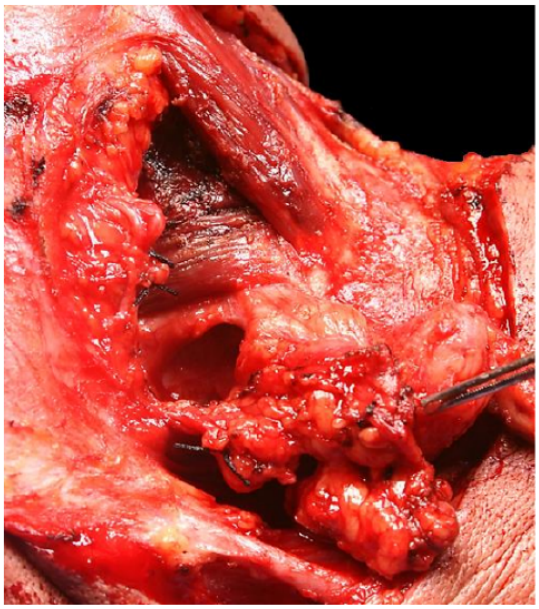


Figure 14: Marginal mandibular nerve visible over divided facial vessels; gland reflected inferiorly; mylohyoid muscle widely exposed

Next the surgeon addresses the lingual nerve, submandibular duct, and XIIn. The mylohyoid muscle is retracted anteriorly, and the clearly defined dissection plane between the deep aspect of the submandibular gland and the fascia covering the XIIn is opened. This is done with finger dissection taking care not to tear the thinwalled veins accompanying XIIn.

The XIIn is now visible in the floor of the submandibular triangle *(Figure 15)*.

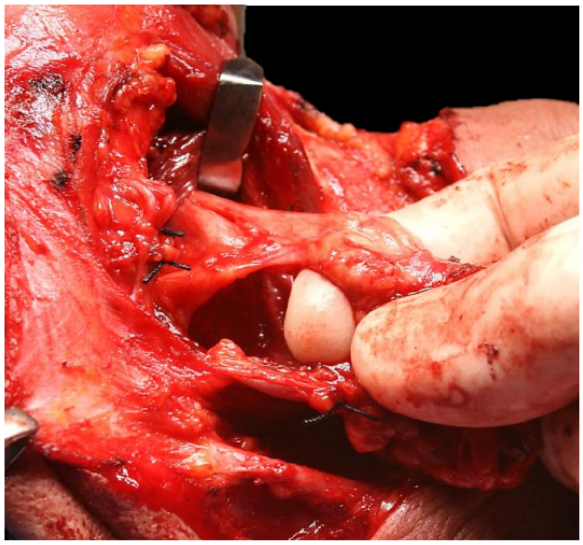


Figure 15: Finger dissection delivers the submandibular gland and duct and brings the lingual nerve into view. The proximal stump of the facial artery is visible at the tip of the thumb, and the XIIn behind the nail of the index finger

Inferior traction on the gland brings the lingual nerve and the submandibular duct into view *(Figure 15)*. The submandibular duct is separated from the lingual nerve, divided and ligated *(Figures 16, 17)*.

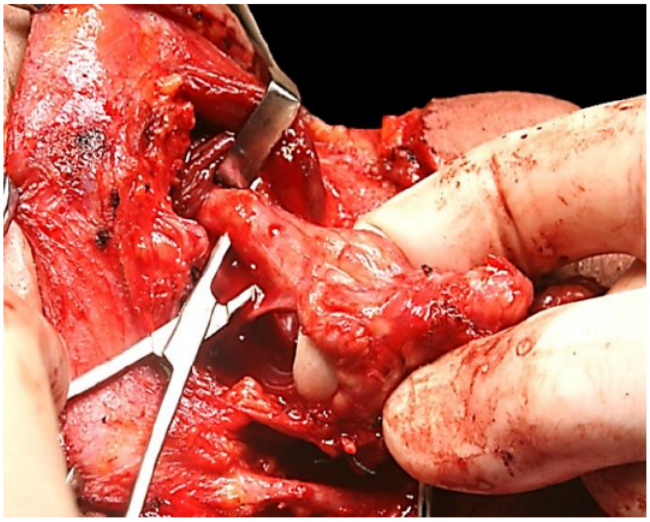


Figure 16: Submandibular duct

The submandibular ganglion, suspended from the lingual nerve, is clamped, divided and ligated, taking care not to cross-clamp the lingual nerve *(Figure 17)*.

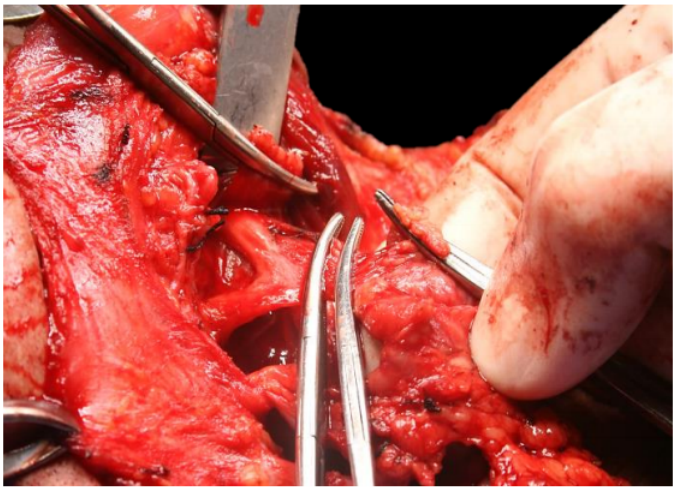


Figure 17: Separating the submandibular ganglion from the lingual nerve

The facial artery is divided and ligated just above the posterior belly of digastric *(Figure 18)*.

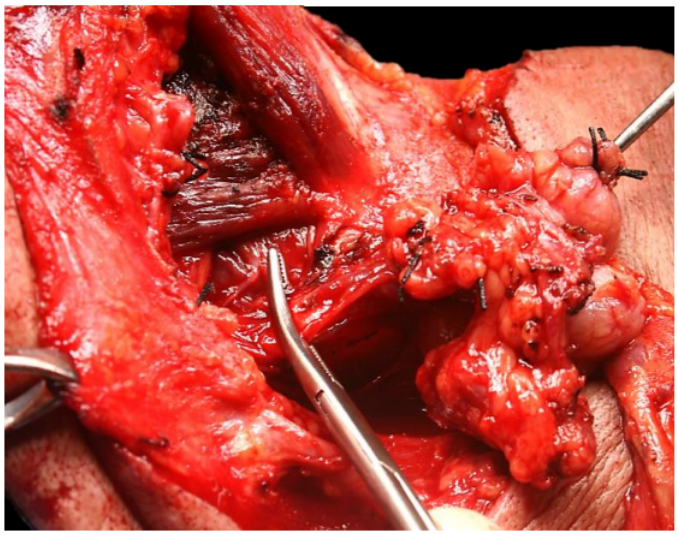


Figure 18: Clamping and dividing the facial artery just above the posterior belly of digastric

Note: A surgical variation of the above technique is to preserve the facial artery by dividing and ligating the 1-5 small branches that enter the submandibular gland. This is usually simple to do, it reduces the risk of injury to the marginal mandibular nerve and permits the use of a buccinator flap based on the facial artery *(Figure 19)*.

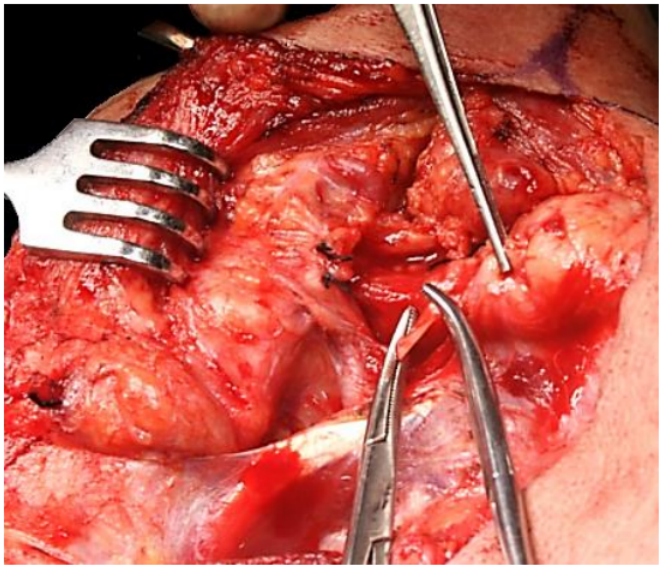


Figure 19: Facial artery has been kept intact; a branch is being divided

Step 3 (Figure 7)

This step entails identifying the XIIn in Level IIa and freeing and tracing the XIIn posteriorly where it leads the surgeon directly to the internal jugular vein (IJV). First divide the fascia along the lateral aspect of the digastric *(Figure 20)*.

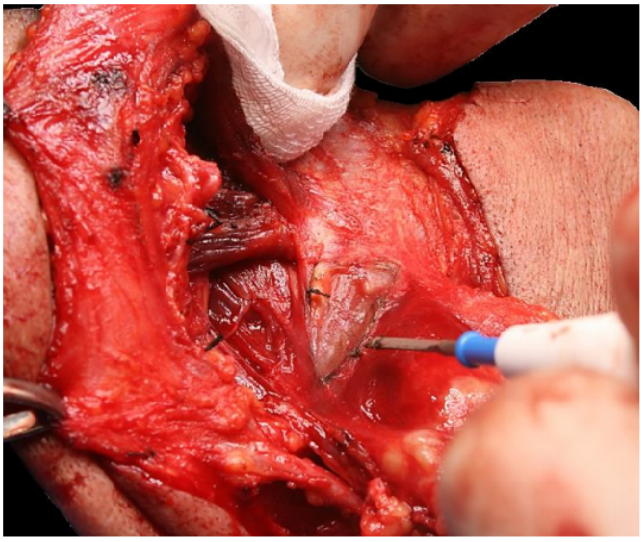


Figure 20: Divide the fascia overlying the posterior belly of the digastric muscle

Then divide the external jugular vein *(Figure 21)*.

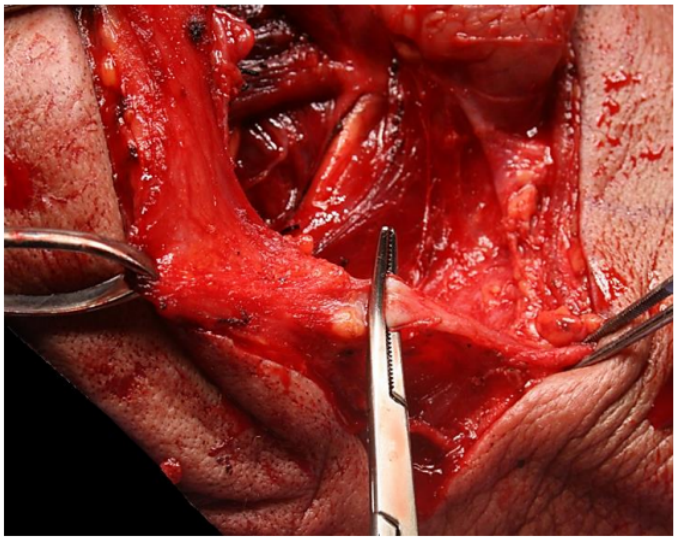


Figure 21: Divide the external jugular vein

Continue to expose the posterior belly of digastric along its entire length, taking care not to wander above the muscle as this would jeopardise the facial nerve *(Figure 22)*. This step is the key to facilitating subsequent exposure of the IJV and XIn.

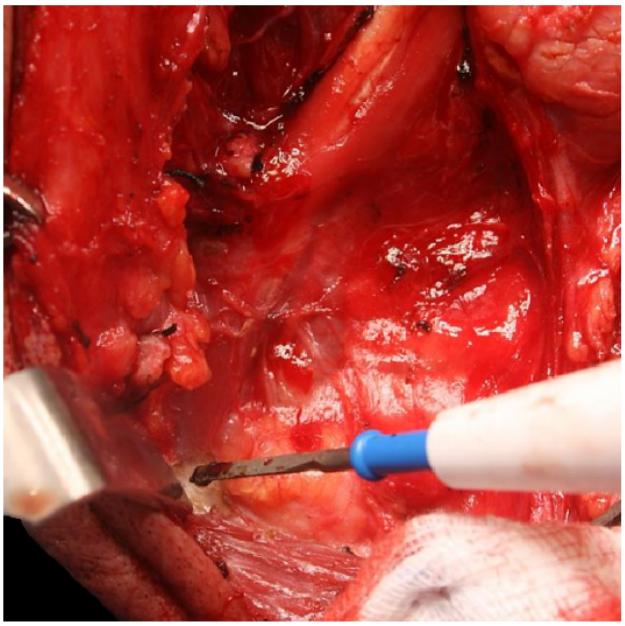


Figure 22: Dissect the entire length of the digastric

Next identify the XIIn below the greater cornu of the hyoid bone before it crosses the external carotid artery. It is generally more superficial than expected and is located just deep to the veins that cross the nerve. Carefully dissect in a posterior direction and divide the veins to expose the XIIn *(Figure 23)*.

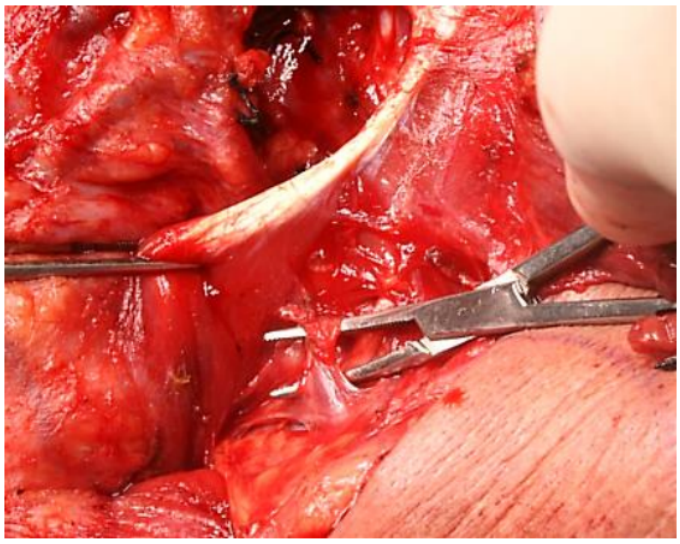


Figure 23: Dividing the veins that cross the XIIn

After the nerve has crossed the external carotid artery, identify the sternomastoid branch of the occipital artery that tethers the XIIn *(Figure 24)*.

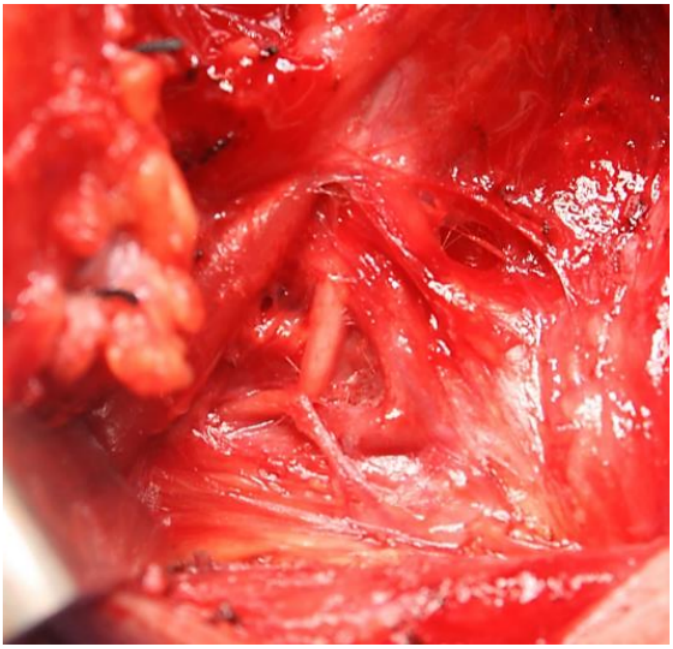


Figure 24: Sternomastoid branch of occipital artery tethering the XIIn

Dividing this artery releases the XIIn *(Figure 25)*. The nerve then courses vertically and leads the surgeon directly to the anterior border of the IJV *(Figure 25)*.

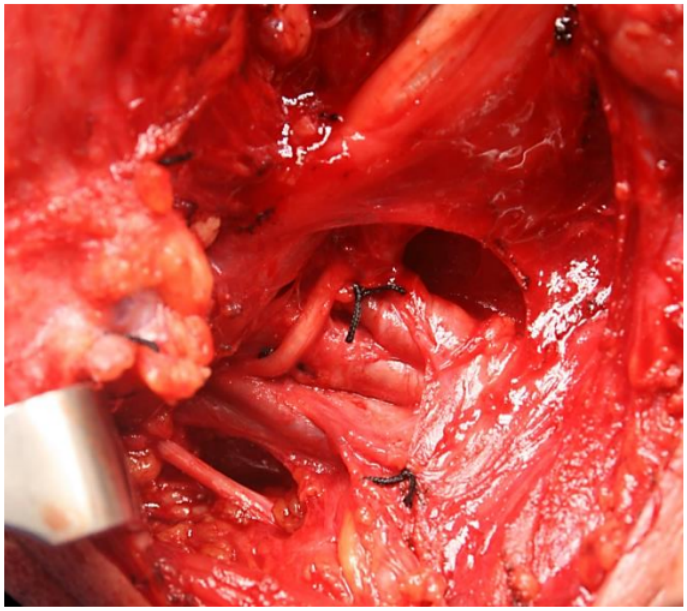


Figure 25: Dividing the sternomastoid branch of the occipital artery frees the XIIn that then leads directly to IJV. Note the XIn and the tunnel created behind IJV

Step 4 (Figure 7)

Using dissecting scissors or a hemostat to part the fatty tissue in Level II, the surgeon next identifies the XIn which may course lateral, medial or very rarely through the IJV *(Figure 26)*.

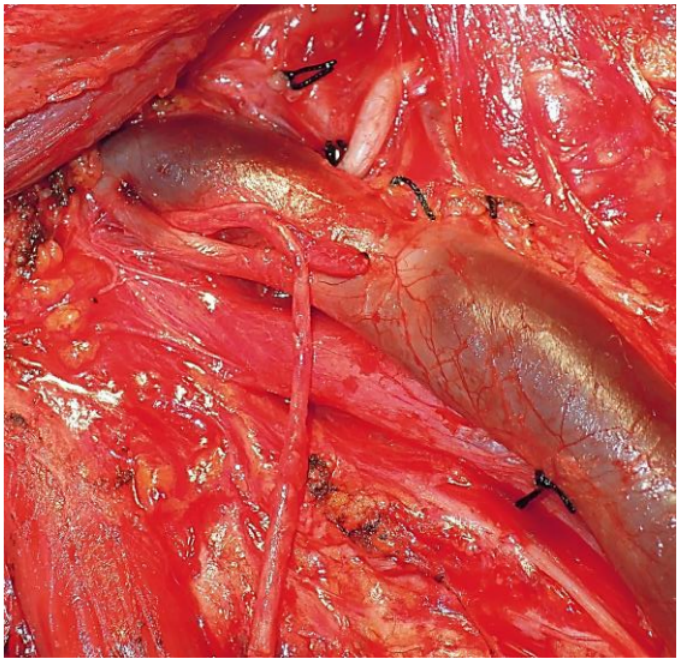


Figure 26: XIn passing through the IJV

Create a tunnel immediately posterior to the IJV *(Figure 25)*. This maneuver speeds up the subsequent dissection of Level 2 (Steps 4 & 7). The transverse process of the C1 vertebra can be palpated immediately posterior to the XIn and IJV and serves as an additional landmark for these structures in difficult surgical cases. Note that the occipital artery crosses the IJV at the top of Level II, branches of which may need to be cauterized should they be severed while dissecting in Level II.

Step 5 (Figure 7)

Surgery now is directed at the anterior neck. The surgeon raises an anteriorly based subplatysmal flap and exposes the omohyoid muscle and the SCM muscle inferiorly down the clavicle, leaving the anterior jugular vein in the elevated flap *(Figure 27)*. The anterior margin of the omohyoid corresponds with the anterior margin of the neck dissection.

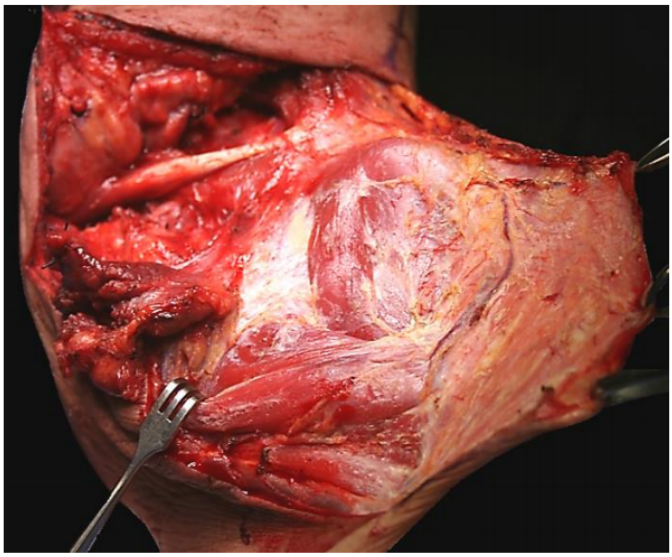


Figure 27: Anteriorly based flap elevated to expose the omohyoid and SCM

The omohyoid is divided with cautery and freed up posteriorly with the surrounding fatty tissue of Levels II and III *(Figure 28)*. Finger dissection deep to the omohyoid after it disappears behind the SCM exposes the carotid sheath.

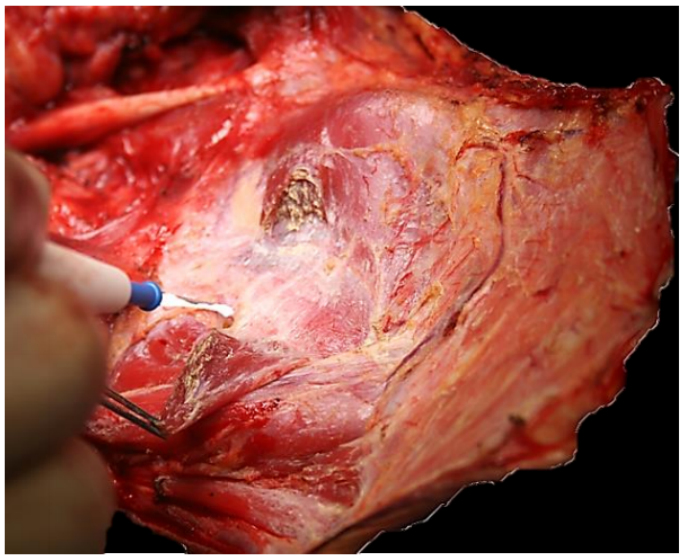


Figure 28: Dividing the omohyoid and clearing Levels II and III

Step 6 (Figure 7)

The surgeon elevates a posteriorly based flap using electrocautery or a knife, with good counter traction provided by an assistant. The platysma is often absent posteriorly and the flap may be very thin. Placing the index finger behind the flap permits the surgeon to gauge the thickness of the flap and avoid “buttonholing” the skin *(Figure 29)*.

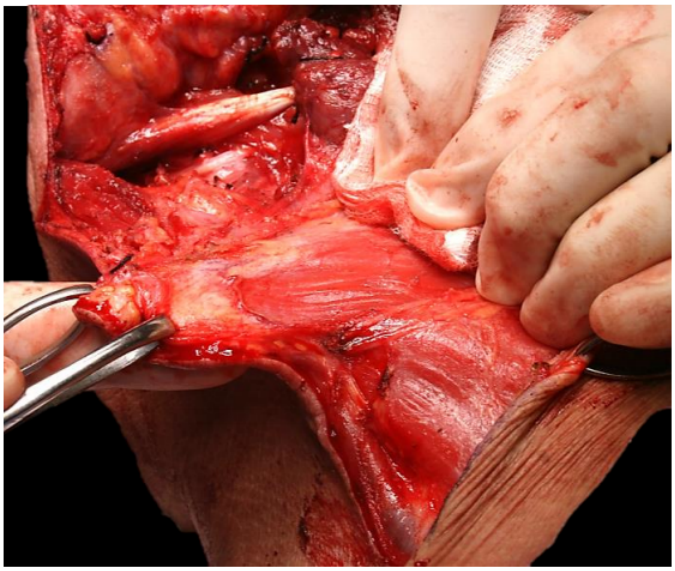


Figure 29: Technique of elevating the posterior skin flap

Take care not to elevate the external jugular vein or the greater auricular nerve with the flap, but to leave them lying on the SCM muscle. Movement of the shoulder is noted as one approaches the XIn or the trapezius muscle. The dissection continues until the anterior border of trapezius is reached *(Figure 30)*. In a thin patient the XIn may be extremely close to skin. Note that the XIn, unlike branches of the cervical plexus, passes deep to the trapezius muscle.

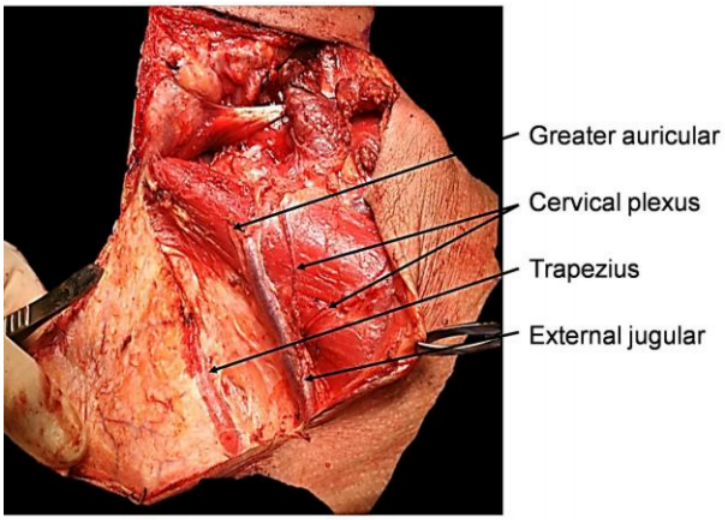


Figure 30: Posterior flap fully elevated to the trapezius muscle

Step 7 (Figure 7)

This step involves dissecting out the XIn and mobilizing Level IIb. The XIn is identified by dissecting with a hemostat at the posterior border of the SCM muscle, approximately 1-2 cm posterior to the point where the greater auricular nerve curves around the muscle *(Figure 31)*. The nerve is often located by seeing movement of the shoulder due to mechanical stimulation of the nerve. The XIn passes through the SCM, unlike the cervical plexus that passes deep to the muscle. It is dissected up-ward through the SCM muscle by tunnel-ing though the muscle over the nerve with a hemostat, and the cutting the muscle with diathermy *(Figure 32)*. The lesser occipital nerve (C2) crosses the XIn at the inferior margin of the SCM *(Figure 33)*. Take care not to mistake it for the XIn when dissecting superiorly through the SCM muscle.

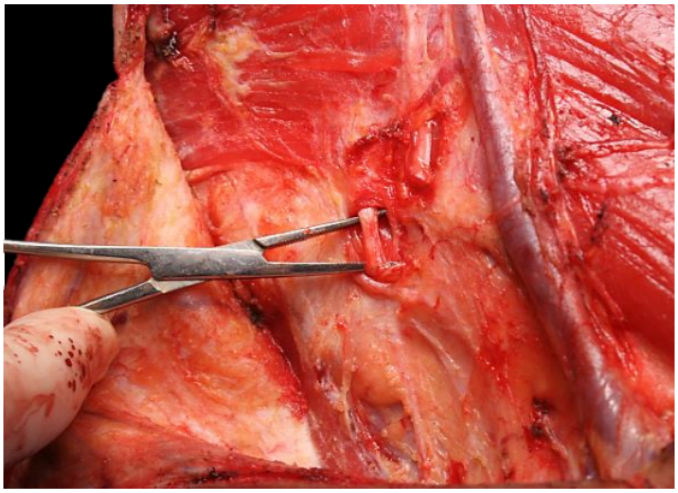


Figure 31: The XIn is located 1-2 cm behind the greater auricular nerve

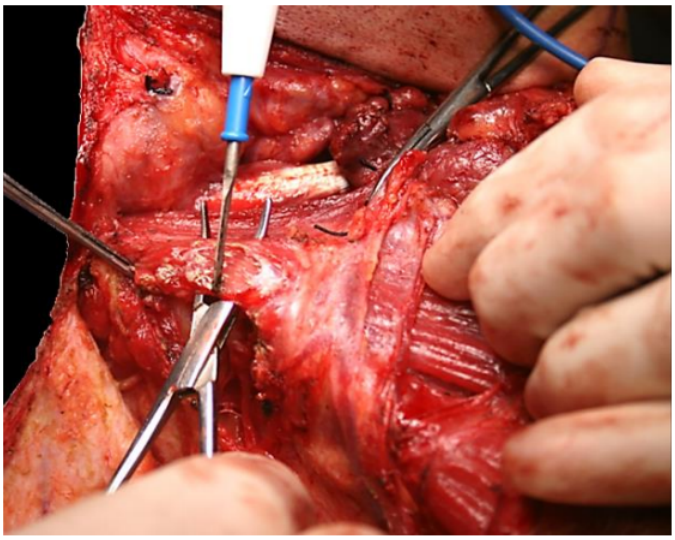


Figure 32: XIn is dissected upward through the SCM muscle

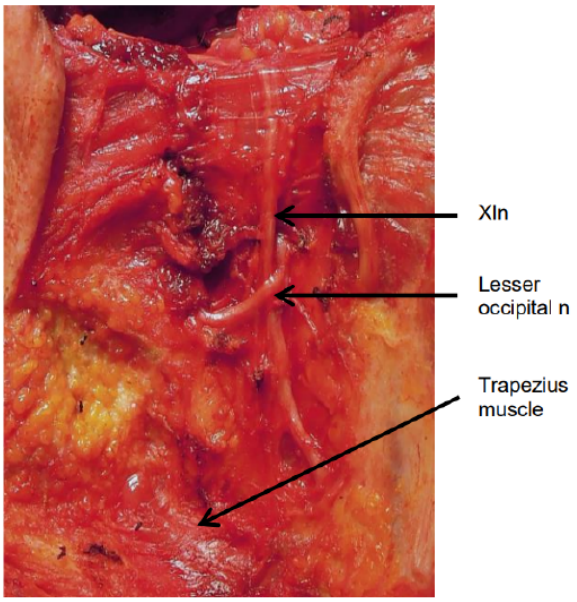


Figure 33: The lesser occipital nerve (C2) can be confused with the XIn

Once the XIn has been exposed up to and freed from the IJV, expose the nerve distally to where it disappears behind the trapezius muscle, and then free the nerve completely and section the branches to SCM *(Figure 34, 35)*.

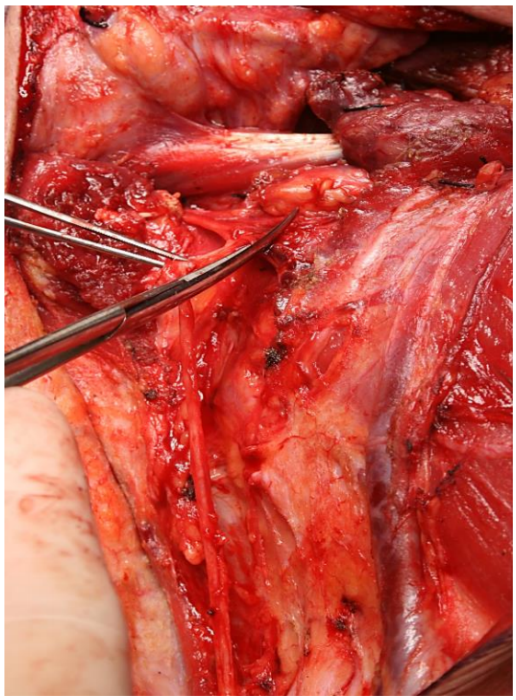


Figure 34: Free the XIn and divide its branches to SCM

Step 8: (Figure 7)

This step involves dissection of Level IIb and transposition of the XIn. The SCM is divided below the mastoid. This exposes fat at the top of Level IIb. The dissection is carried deeper until the deep muscles of the neck that run in a posteroinferior direction appear. The only structure that can be injured here is the occipital artery, and this is simply ligated or cauterized. The dissection is then directed posteroinferiorly, where the greater occipital nerve (C1) is divided *(Figure 36)*.

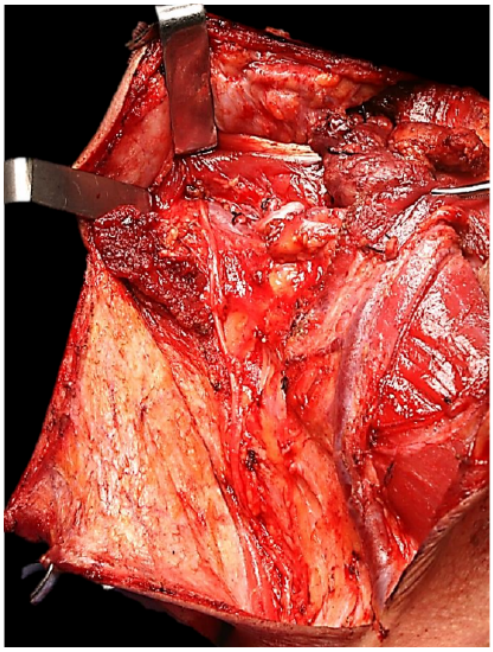


Figure 35: Operative field at end of Step7; note divided SCM along course of XIn

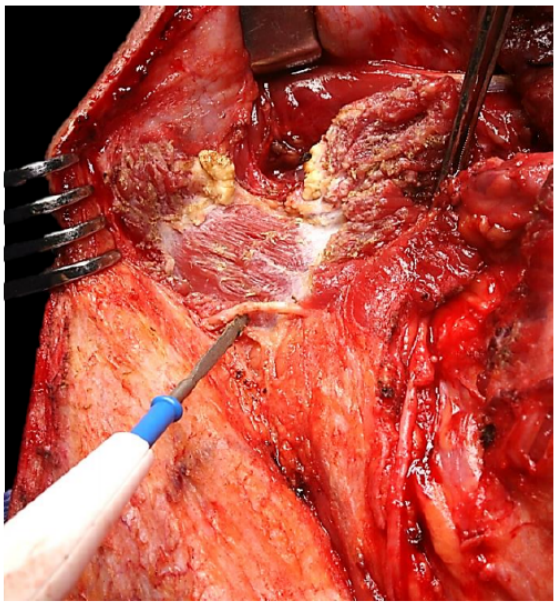


Figure 36: Division of SCM and identification and division of greater occipital nerve and deep muscles of the neck

The contents of Level IIb and IIa are then dissected off the deep muscles of the neck deep to the epimysium until the upper branches of the cervical plexus come into view *(Figure 37)*. The XIn is now trans-located posteriorly *(Figure 38)*. Figure 39 illustrates the status of the neck dissection at this point.

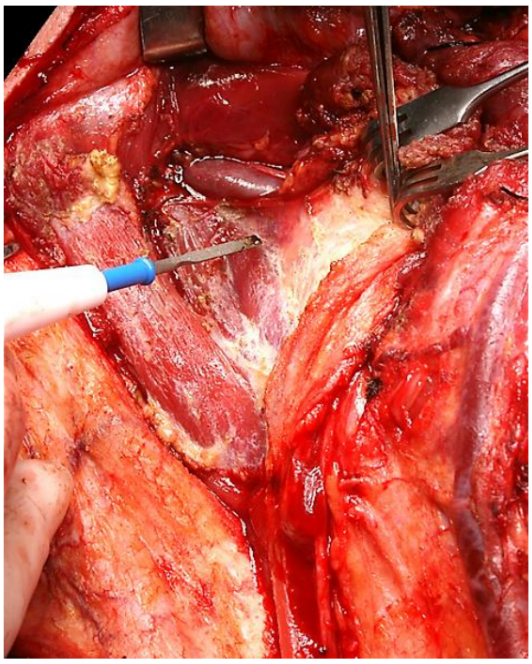


Figure 37: Dissecting Level II

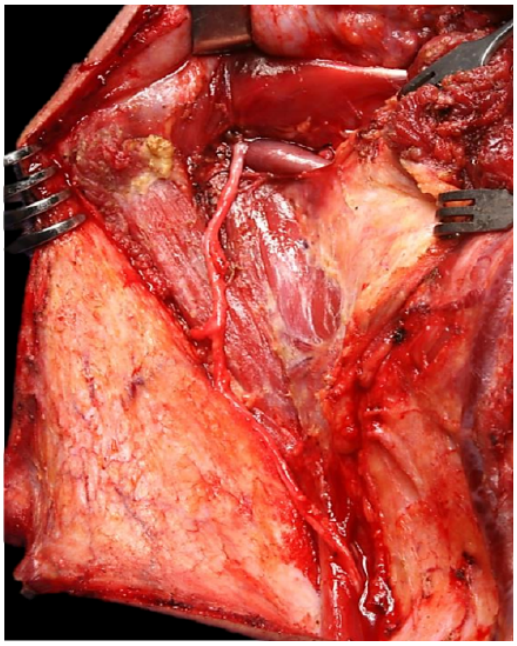


Figure 38: The XIn has been translocated posteriorly

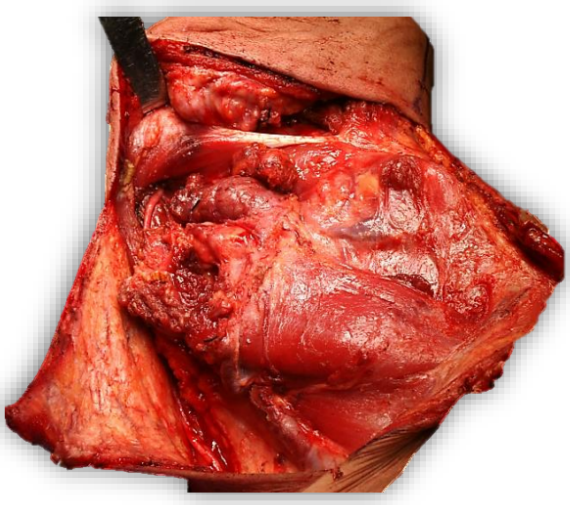


Figure 39: Status of neck dissection before proceeding to Step 9. Note the transected SCM superiorly

Step 9: (Figure 7)

The clavicular and sternal heads of the SCM are next divided with cautery just above the clavicle *(Figure 40)*.

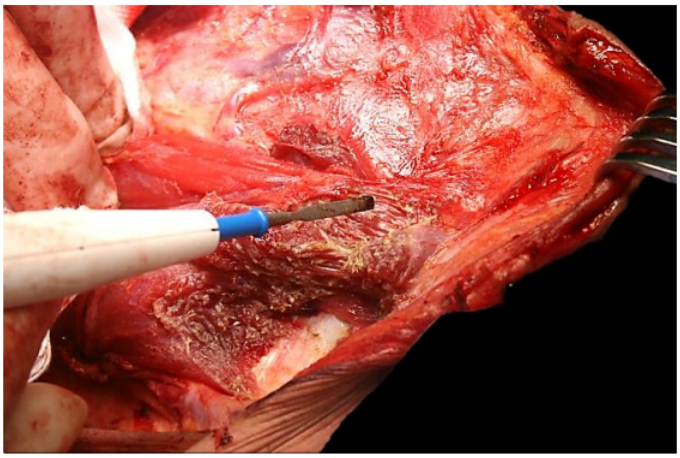


Figure 40: Transecting the sternal head of the SCM

The surgeon applies continuous traction to the muscle during the dissection to part the muscle fibres as they are transected and to visualise the IJV immediately deep to the muscle *(Figure 41)*. A scalpel is used to cut through the carotid sheath onto the IJV *(Figure 41)*.

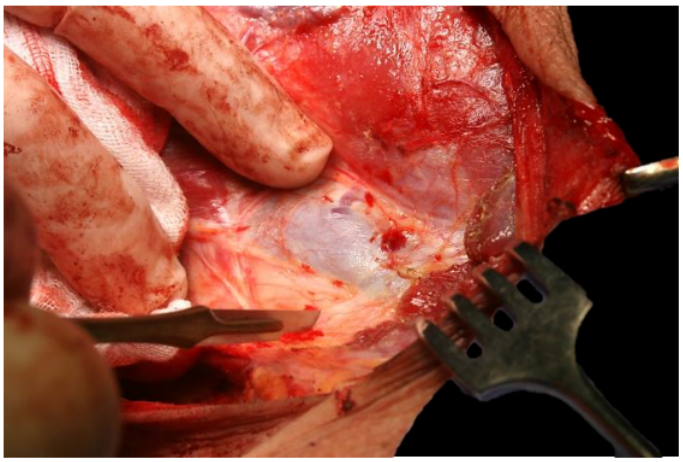


Figure 41: Exposing the IJV by incising the carotid sheath

Take care not to dissect immediately lateral to the IJV, as the right lymphatic duct (right neck) or thoracic duct (left neck) may be injured leading to a troublesome chyle leak *(Figure 42)*.

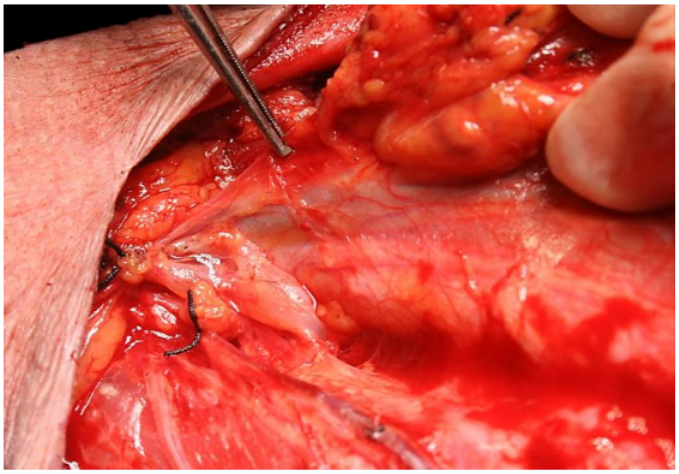


Figure 42: A distended thoracic duct immediately lateral to the carotid artery and IJV in the (L) neck

Next identify the external jugular vein and the omohyoid muscle *(Figure 43)*.

The external jugular vein is divided and ligated, followed by division of the omohyoid with cautery *(Figures 44, 45)*.

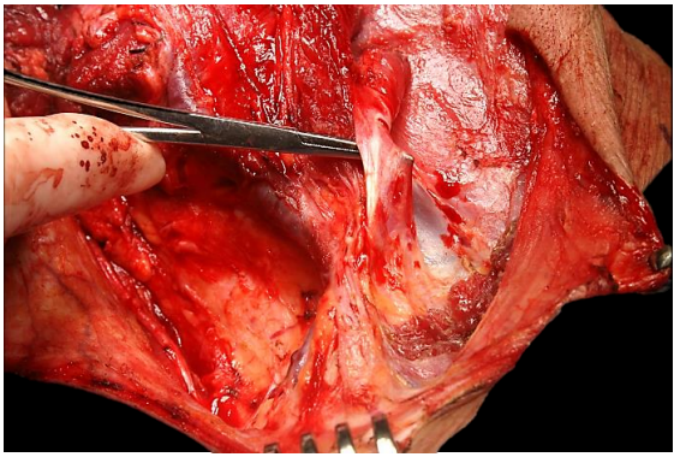


Figure 43: The hemostat is under the omohyoid; the external jugular vein is more posteriorly

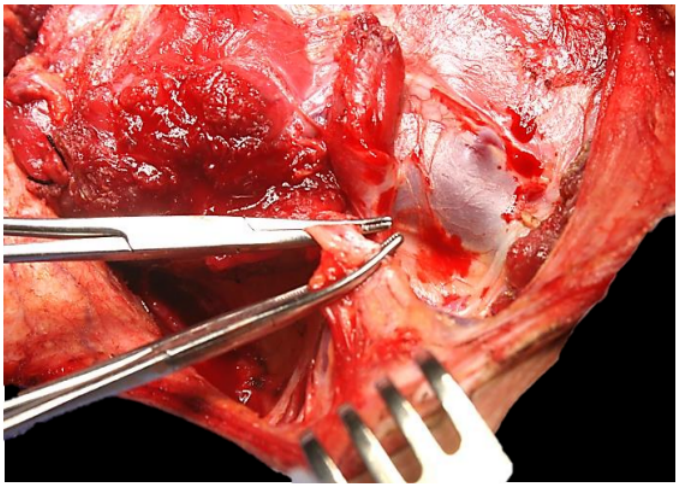


Figure 44: External jugular vein is divided

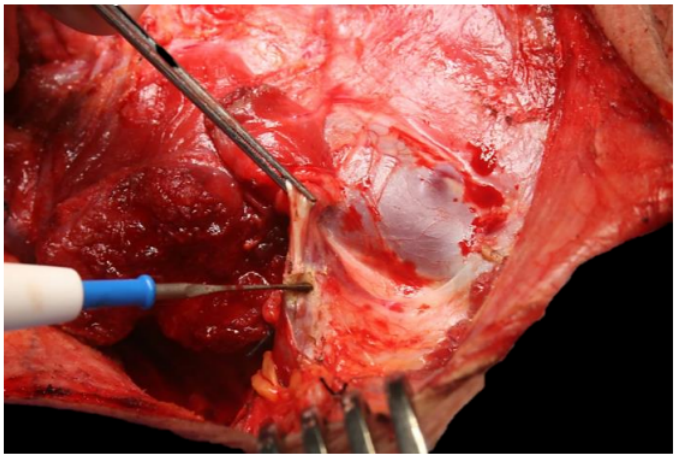


Figure 45: Division of the omohyoid with cautery

The surgeon then incises the fascia overlying the supraclavicular fat just above the clavicle, once again steering clear of the right lymphatic duct or thoracic duct *(Figure 46)*.

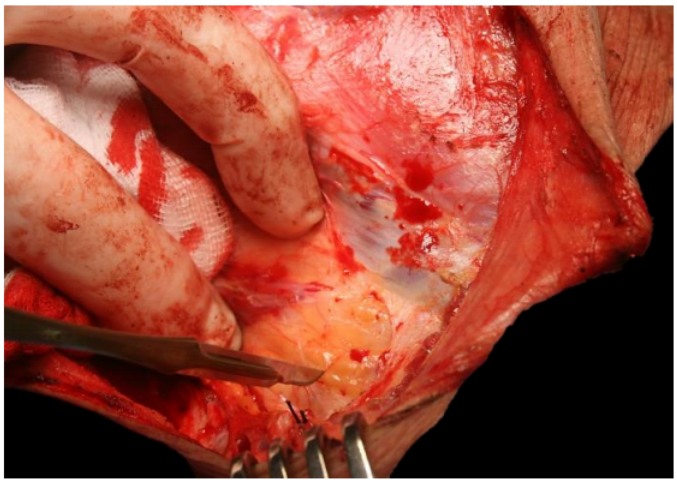


Figure 46: Exposing the supraclavicular fat

Once the fat has been exposed, a finger can be used to expose the fascia covering the brachial plexus *(Figure 47)*. The finger is then swept medially to expose the phrenic nerve, laterally towards the axilla and superiorly along the carotid sheath. Take care not to tear the transverse cervical vessels with the medial sweep.

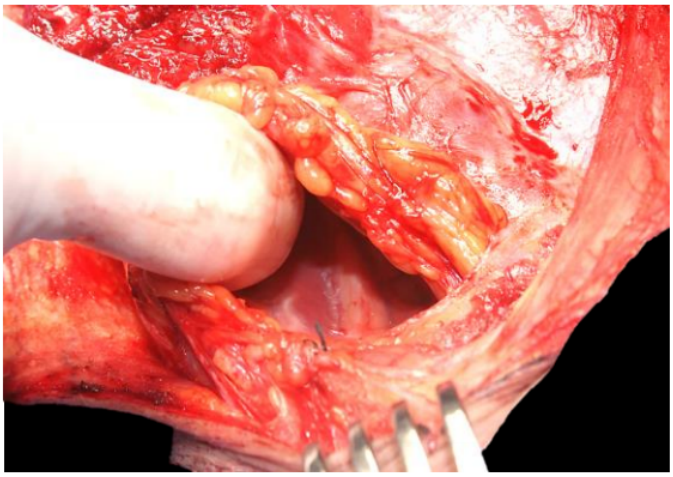


Figure 47: Exposing the brachial plexus

Step 10: Supraclavicular vascular pedicle (Figure 7)

This step involves freeing the inferolateral part of Level V. First identify and divide the supraclavicular nerves, which are branches of the cervical plexus *(Figure 48)*.

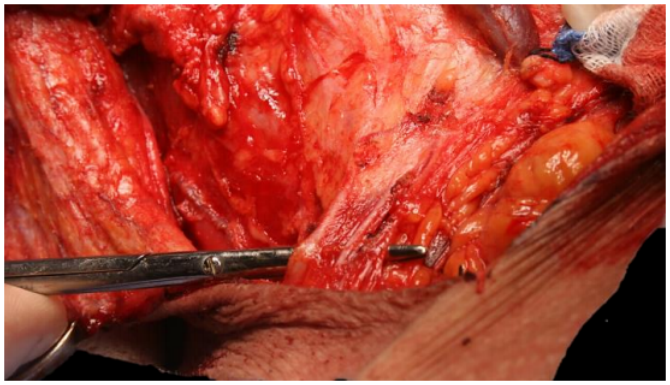


Figure 48: The supraclavicular nerves

Next incise the fatty vascular pedicle containing the transverse cervical artery and vein *(Figure 49)*.

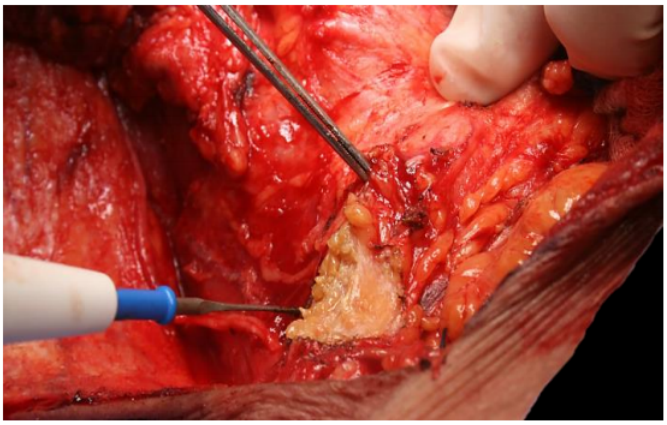


Figure 49 Note the proximity of the XIn (below the diathermy) when dividing the vascular pedicle.

Figures 50 and 51 demonstrate the isolation and division of the transverse cervical artery and its proximity to the XIn

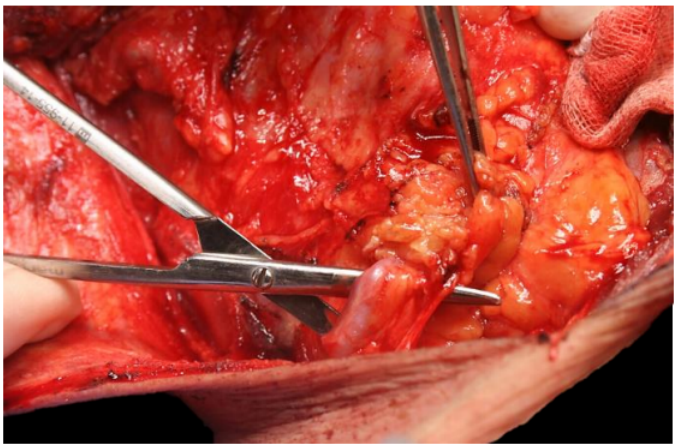


Figure 50: Transverse cervical vessels

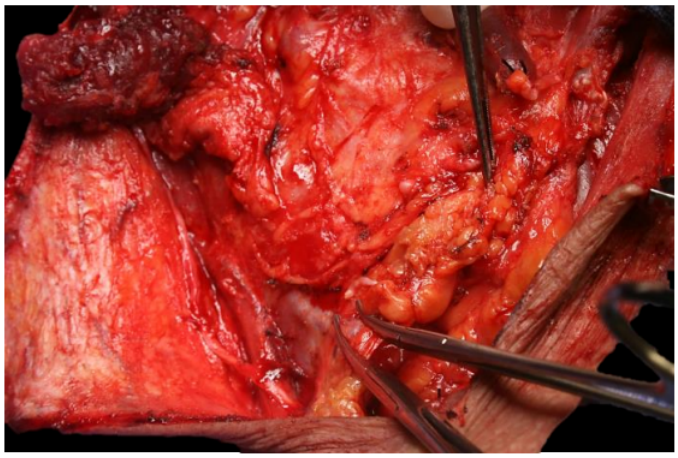


Figure 51: Division of transverse cervical vessels

Step 11: (Figure 7)

This part of the neck dissection involves anterograde dissection of Levels II – V and is done with a scalpel. The assistant maintains firm anterior traction on the neck dissection specimen, and the surgeon establishes a subepimysial dissection plane on the deep muscles of the neck, except over the brachial plexus where the overlying fascia is retained to protect the nerves *(Figure 52).*

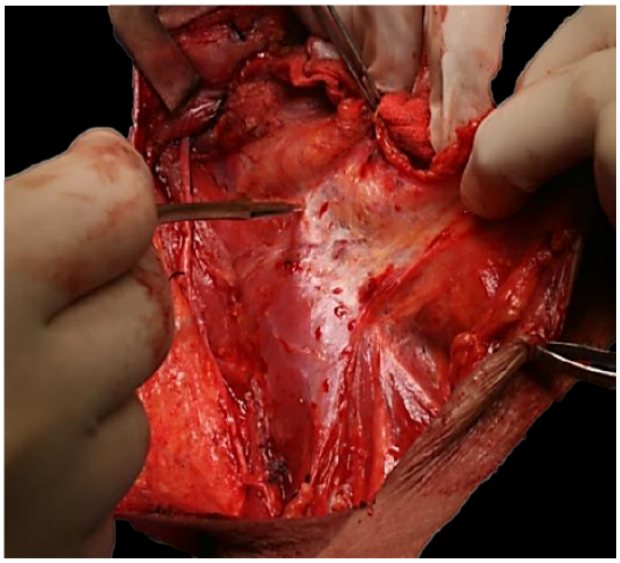


Figure 52: Anterograde dissection of Levels II – V

The dissection proceeds over a broad front until the entire cervical plexus has been exposed.The phrenic nerve is identified as it descends obliquely across the scalenius anterior muscle, deep to the prevertebral layer of deep cervical fascia *(Figure 53)*.

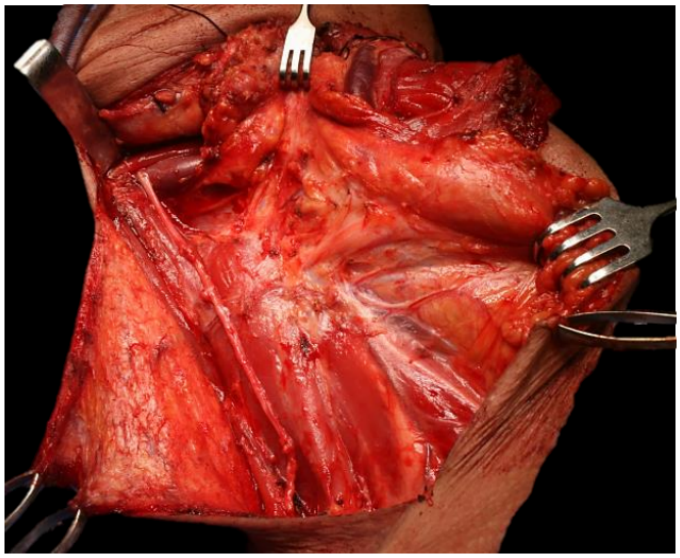


Figure 53: Dissection up to the cervical plexus; note the phrenic nerve running parallel to the IJV.

The cervical plexus nerves are each divided, taking care not to injure the phrenic nerve *(Figure 54)*.

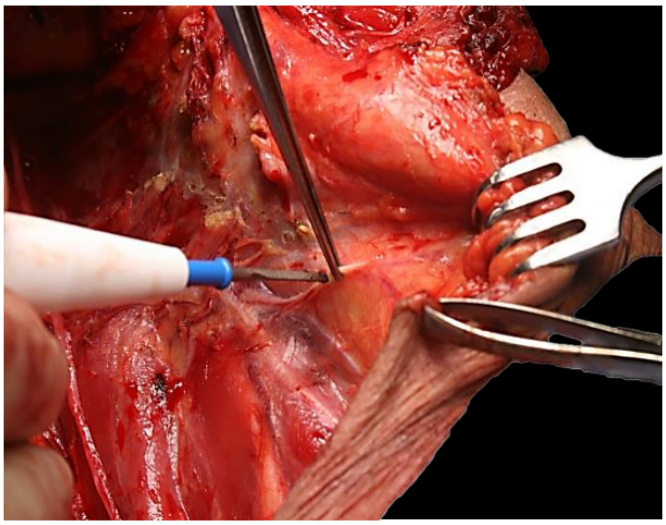


Figure 54: Division of nerves of cervical plexus, staying well clear of the phrenic nerve

This brings the carotid sheath containing common and internal carotid arteries, the vagus nerve and the IJV into view *(Figure 55)*.

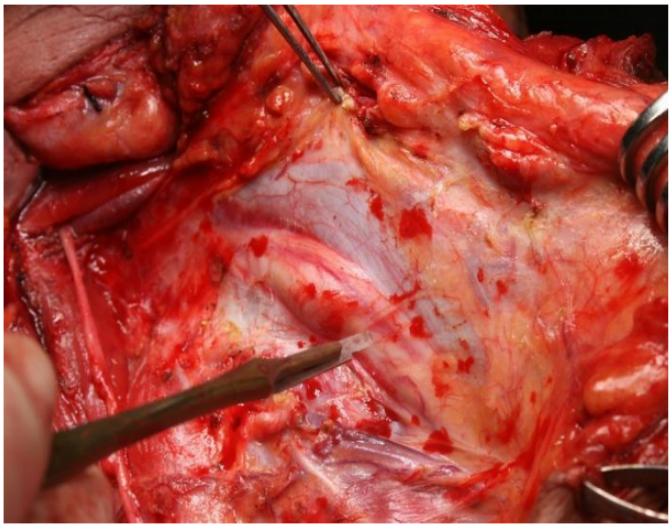


Figure 55: The common carotid artery, the vagus nerve and IJV

The carotid sheath is incised along the full course of the vagus nerve, and the neck dissection specimen is stripped off the IJV while remaining inside the carotid sheath. The *ansa cervicalis*, which courses either deep or superficial to the IJV may be preserved *(Figure 56)*. Inferiorly the pedicle adjacent to the IJV containing fat, thoracic or right lymphatic duct, and transverse cervical artery and vein is divided, taking care not to include the vagus or phrenic nerves in the pedicle *(Figure 57)*.

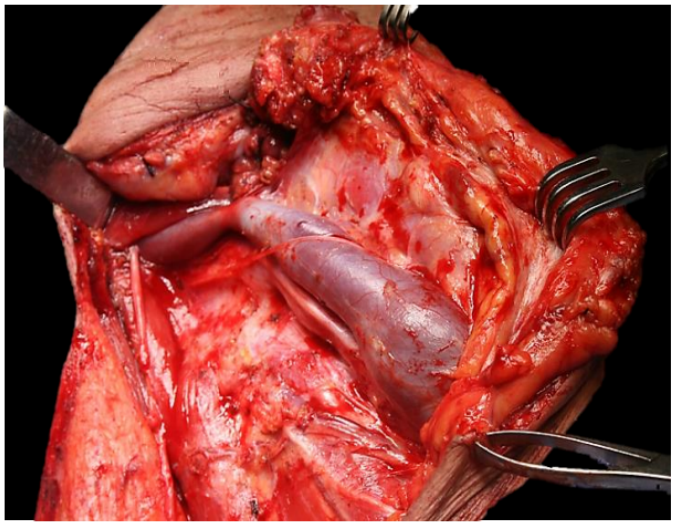


Figure 56: The neck dissection specimen has been stripped off the carotid, vagus and IJV in a plane deep to the carotid sheath; the ansa cervicalis has been preserved

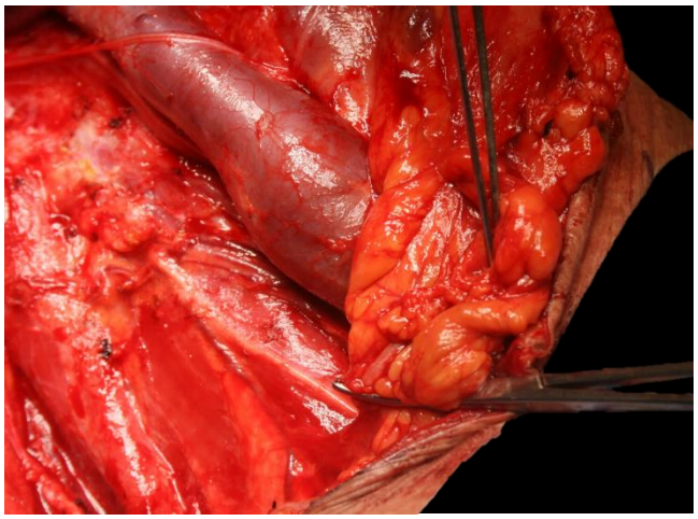


Figure 57: Inferiorly the pedicle adjacent to the IJV is divided; note the proximity of the phrenic nerve

Step 12: (Figure 7)

The final step is to strip the neck dissection specimen off the infrahyoid strap muscles, to identify and preserve the superior thyroid vascular pedicle, and to deliver the neck dissection specimen *(Figure 58)*

Closure

The neck is irrigated with water, the anesthetist is asked to do a valsalva maneuver to elicit unsecured bleeding vessels and chyle leakage, and a 5 mm suction drain is inserted. The neck is closed in layers with continuous vicryl to platysma and sutures/staples to skin

Postoperative care

The drain is maintained on continuous suction e.g. low-pressure wall suction, until the drainage volume is <50 mL /24 hrs.

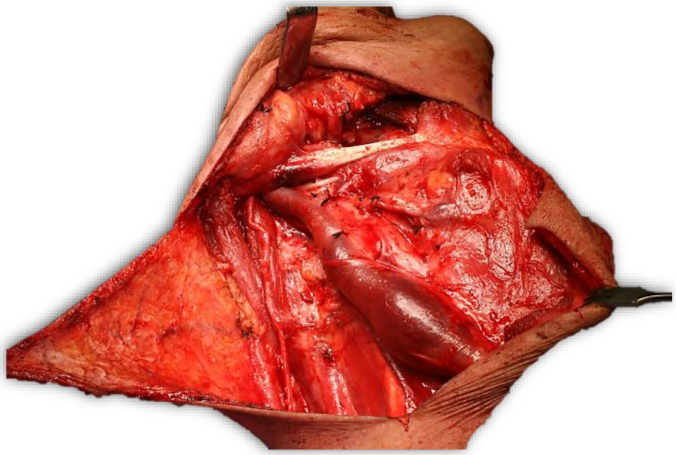


Figure 58: Completed MND type 2; note the superior thyroid pedicle and ansa cervicalis

Useful References

- Robbins KT, Shaha AR, Medina JE, et al. Consensus statement on the classification and terminology of neck dissection. Arch Otolaryngol Head Neck Surg 2008;134: 536–8
- Ferlito A, Robbins KT, Shah JP, et al Proposal for a rational classification of neck dissections. Head Neck. 2011 Mar;33(3):445-50
- Harris T, Doolarkhan Z, Fagan JJ. Timing of removal of neck drains following head and neck surgery. Ear Nose Throat J. 2011 Apr;90(4):186-9

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

THE OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY
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1.21: Neck Dissection Using the Fascial Plane Technique

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Patrick J Bradley & Javier Gavilán

The importance of identifying the presence of metastatic neck disease with head and neck cancer is recognized as a prominent factor determining patients' prognosis. The current available techniques to identify disease in the neck all have limitations in terms of accuracy; thus, elective neck dissection is the usual choice for management of the clinically N0 neck (cN0) when the risk of harboring occult regional metastasis is significant (≥20%)[1]. Methods available to identify the N+ (cN+) neck include imaging (CT, MRI, PET), ultrasound-guided fine needle aspiration cytology (USGFNAC), and sentinel node biopsy, and are used depending on resource availability, for the patient as well as the local health service. In many countries, certainly in Africa and Asia, these facilities are not available or affordable. In such circumstances patients with head and neck cancer whose primary disease is being treated surgically should also have the neck treated surgically.

Employing fascial planes as a concept to perform excision of neck nodal areas is based on specific anatomic concepts regarding the relationship between the lymphatic structures and their distribution within the tissues of the neck[2-4]. It is crucial that the anatomical description of the fascial layers is reviewed as its understanding is essential to understand the rationale and surgical technique of the procedure.

This technique for performing a neck dissection was proposed by Osvaldo Suárez, an Argentinean professor of anatomy and otolaryngologist, in the early 1960s; he proposed the term "vaciamento ganglionar functional" or "functional neck dissection"[2,3]. While he himself only published his work in Spanish, this procedure was popularized in the English world in the mid-20th century by Etore Bocca, an Italian otolaryngologist, and his colleagues[5].

Fascial compartments allow the removal of cervical lymphatic tissue by separating and removing the fascial walls of these "containers" along with their contents from the underlying vascular, glandular, neural, and muscular structures.

Anatomical basis

The basic understanding of fascial planes in the neck is that there are two distinct fascial layers, the ***superficial cervical fascia***, and the ***deep cervical fascia*** *(Figures 1A-C)*.

Superficial cervical fascia

The superficial cervical fascia is a connective tissue layer lying just below the dermis. Surgically it is indistinct from the fatty tissue that surrounds it. The neck is one of the few places where it splits to surround the muscles of facial expression. The space deep to this layer contains fat, neurovascular bundles and lymphatics. It does not constitute part of the deep neck space system.

Deep cervical fascia(Figures 1A-C)

The deep cervical fascia encloses the deep neck spaces and is further divided into 3 layers, the ***superficial, middle and deep layers of the deep cervical fascia.***

Superficial layer of deep cervical fascia(Figure 1A)

The superficial layer of the deep cervical fascia arises posteriorly from the vertebral spinous processes and ligamentum nuchae. It surrounds the entire neck, splitting to enclose the trapezius muscle, the omohyoid muscle, parotid gland, sternocleidomastoid muscle and the strap muscles. Anteriorly this fascia is attached to the hyoid bone. The inferior attachments of the fascia are the acromion of the scapula, the clavicle and the sternum. The fascia remains split in two layers until it attaches to the sternum; thus, the superficial layer attaches to the anterior surface of the sternum and posterior layer to the posterior surface of the sternum.

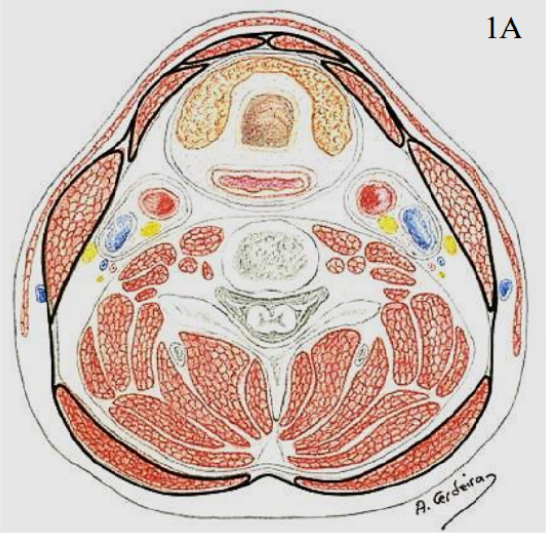


Figure 1A: Horizontal cross-section of neck at level of 6 th cervical vertebra showing superficial layer of deep cervical fascia

Deep layer of deep cervical fascia (Figure 1B)

The deep layer of the deep cervical fascia is also called ***"pre-vertebral fascia"*** because it constitutes a prominent layer just in front of the vertebral column. This fascia also arises posteriorly from the transverse and spinous processes of the cervical vertebrae and the ligamentum nuchae. It passes laterally around the prevertebral and postvertebral muscles and covers the scalene muscles anteriorly, then passes in front of the vertebral body and forms a thick layer from which it receives its name. This thick fascial layer forms the floor of the posterior triangle of the neck, and anterior to the vertebral bodies, it provides a base on which the pharynx, esophagus, and other cervical structures glide during swallowing and neck movements.

The cervical plexus emerges from between the scalene muscle bundles. The phrenic nerve crosses obliquely on the anterior surface of the anterior scalene muscle from lateral to medial and lies deep to the prevertebral fascia. The cervical and brachial nerve plexuses and the sympathetic trunk are invested by the prevertebral fascia, which forms the floor of the lateral triangle of the neck. The consequences of elevating the prevertebral fascia during neck dissection, beyond merely increasing the devastation wrought by the surgical exercise, can be severe. ***If this fascia is raised, there is risk of injuring what lies deep in the fascia, notably the cervical and brachial plexus, the sympathetic trunk, and the phrenic nerve.***

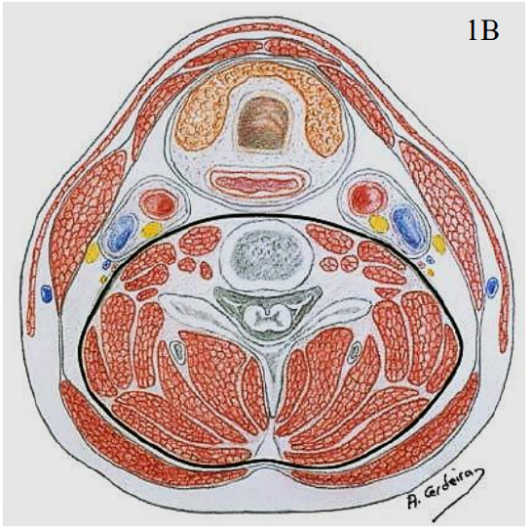


Figure 1B: Horizontal cross-section of neck at level of 6th cervical vertebra showing deep layer of deep cervical fascia

Middle layer of deep cervical fascia (Figure 1C)

The middle layer of the deep cervical fascia or ***"pretracheal fascia"*** has two divisions, muscular and visceral. The ***muscular division*** surrounds the strap muscles (sternohyoid, sternothyroid, thyrohyoid, omohyoid) and the adventitia of the great vessels.

The ***visceral division*** surround the constrictor muscles of the pharynx and esophagus to create the buccopharyngeal fascia and the anterior wall of the retropharyngeal space. Both the muscular and visceral divisions contribute to the carotid sheath. The middle layer also envelopes the larynx, trachea, and thyroid gland. It attaches to the base of the skull superiorly and extends inferiorly as low as the pericardium via the carotid sheath.

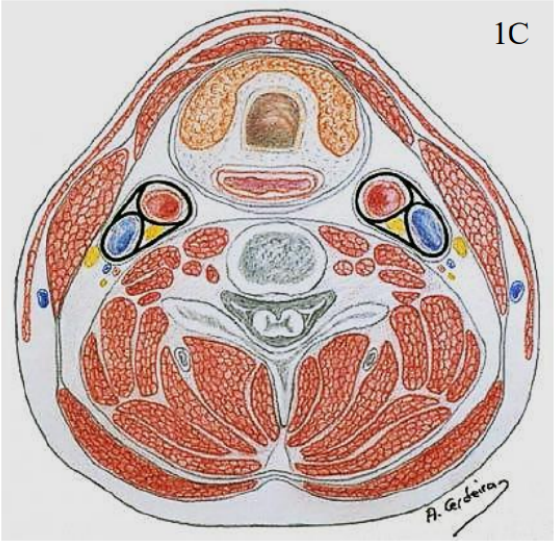


Figure 1C: Horizontal cross-section of neck at level of 6th cervical vertebra showing carotid sheaths

Indications for fascial plane technique

To ensure oncologic safety, fascial plane surgery requires that all nodal disease be confined within lymphatic tissues

- Ideally suited to N0 necks at high risk of harbouring occult metastases e.g oral cavity, oropharynx, and supraglottis
- Can be performed simultaneously on both sides of the neck without increasing morbidity
- May be considered when nodes measure < 2.5-3.0 cm in greatest diameter, and are discrete and mobile (with caution)
- Small aggregated or matted nodes that are mobile (with caution)

Contraindications

- Large nodes > 3.0 cm (usually fixed)
- Previously treated neck, either surgically or non-surgically

Should a surgeon be concerned that nodal disease is exhibiting aggressive features e.g. soft tissue invasion or fixity, then the procedure should be converted to a “modified radical neck dissection”.

Surgical technique

The technique described below encompasses all the cervical levels and aims to preserve major non-lymphatic structures. To facilitate teaching, the surgical steps are sequentially detailed. However, depending on the clinical situation, the operation may be modified so that only the cervical levels most at risk of harboring metastases are included in the dissection.

The operation is performed under general anesthesia, with the patient in the supine position and the neck fully extended. Elevating the upper half of the operating table to 30º reduces bleeding.

The surgery is best performed by dissecting along the fascial planes with a scalpel; the fascial planes of the neck are mainly avascular and can be easily followed with the scalpel. It is essential that an assistant apply firm countertraction on the tissues to permit easy, speedy and effective surgical forward progressive progress to be achieved.

Incisions and flaps

The placement and type of skin incision(s) depend on the site of the primary tumor and whether the primary tumor and the neck are to be addressed synchronously, or whether the neck dissection is being performed alone, and whether the neck dissection is to be unilateral or bilateral. Naturally the personal bias of the surgeon should also be considered.

After the skin incision, subplatysmal skin flaps are elevated, preserving the superficial layer of the cervical fascia. The limits of tissue elevation are similar to those of the classic radical neck dissection (Figures 2A, B).

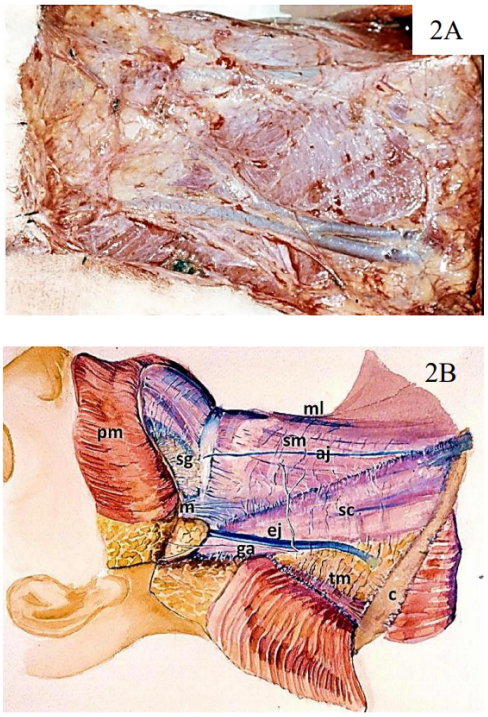


Figure 2: (A) Surgical view of right neck after skin flaps have been elevated. (B) Boundaries and anatomic landmarks of a complete right sided neck dissection (ml: Midline; bm: Inferior border of mandible; c: Clavicle; tm: Trapezius muscle; ga: Greater auricular nerve; sc: Sternocleidomastoid muscle; sm: Strap muscles; pm: Platysma muscle; ej: External jugular vein; aj: Anterior jugular vein; sg: Submandibular gland

Dissecting the sternocleidomastoid (SCM) muscle

This step completely unwraps the SCM from its surrounding superficial layer of deep cervical fascia. Before approaching the fascia of the SCM muscle, the external jugular vein is ligated and divided. Dissection of the SCM commences with a longitudinal incision in the fascia along the entire length of the muscle (Figure 3).

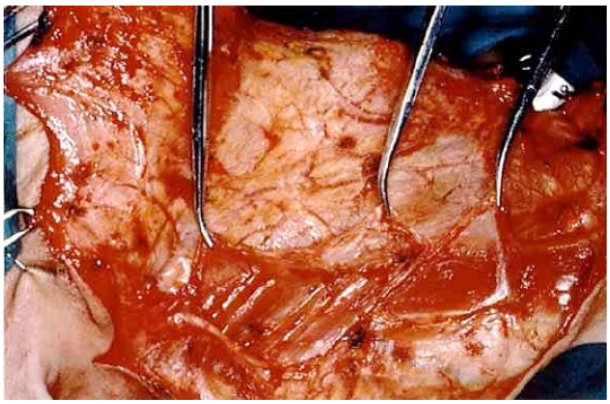


Figure 3: Longitudinal incision over the entire length of the posterior border of the SCM muscle. The fascia is being retracted anteriorly with hemostats

This incision is placed near the posterior border of the muscle. With the application of several hemostats the fascia is retracted anteriorly while the surgeon carries out the subfascial dissection toward the anterior margin of the muscle. Fascial retraction should be performed with extreme care since the thin superficial layer of the cervical fascia is the only tissue now included in the specimen (Figure 4).

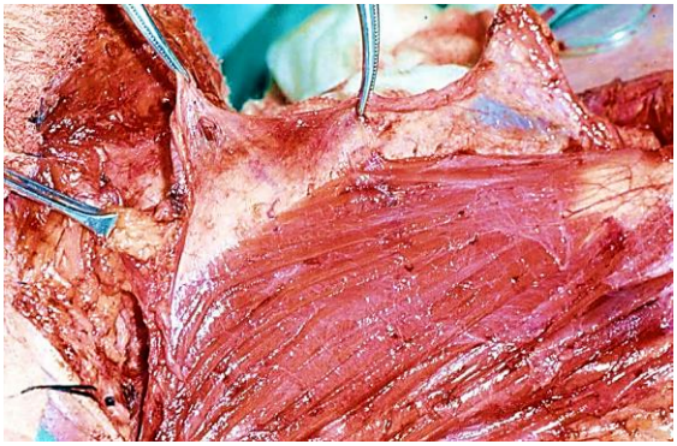


Figure 4: The fascia dissected from the SCM muscle

When the dissection reaches the anterior border of the SCM, the muscle is retracted posteriorly to continue the dissection over its medial surface (Figures 5 A, B).

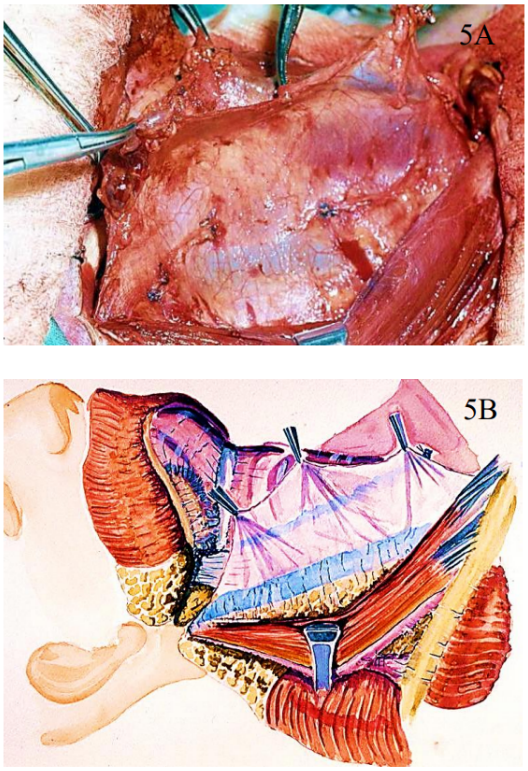


Figure 5: (A) Dissection of SCM muscle continues over its medial surface. (B) The contents of the carotid sheath can be seen shining through the fascia

As the deep medial surface of the muscle is approached, small perforating vessels are identified entering the muscle through the fascia. These are cauterised sequentially, allowing the surgeon to continue mobilizing the entire medial surface of the SCM muscle. Attention and care needs to be increased when dissecting the upper half of the SCM muscle where the spinal accessory nerve (SAN) enters the muscle, approximately at the junction of the upper and middle thirds of the muscle. The transverse process of the atlas serves as a useful anatomic landmark to locate the SAN (Figure 6).

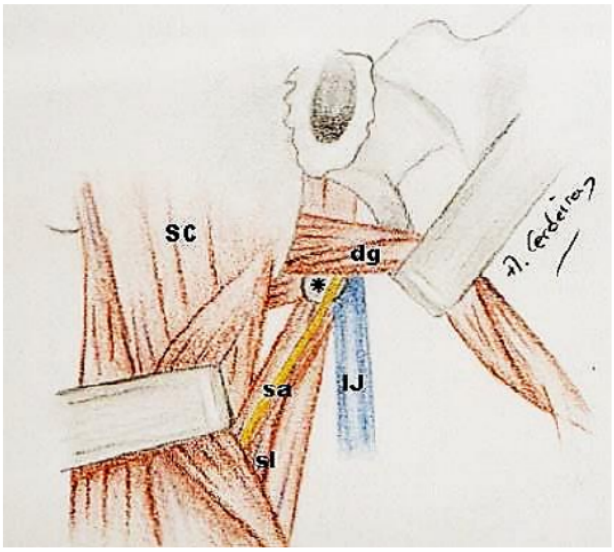


Figure 6: Anatomic landmarks to locate the spinal accessory nerve in its course between the internal jugular vein and the SCM muscle on the right side. (*: Transverse process of atlas; sa: Spinal accessory nerve; IJ: Internal jugular vein; dg: Digastric muscle; sl: Splenius capitis and levator scapulae muscles; SC: SCM muscle

As the dissection progresses posteriorly along the entire length of the SCM muscle, the internal jugular vein is seen through the fascia of the carotid sheath (Figure 5). The use of wet sponges aid to identify the fascia that still covers the posterior border of the SCM muscle. This fascia must be dissected posteriorly and slightly medially underneath the muscle, to meet the anterior dissection. This maneuver completely releases the muscle from its surrounding fascia.

Including the posterior triangle of the neck in the dissection requires a combined approach, both posterior and anterior to the SCM muscle (Figure 7).

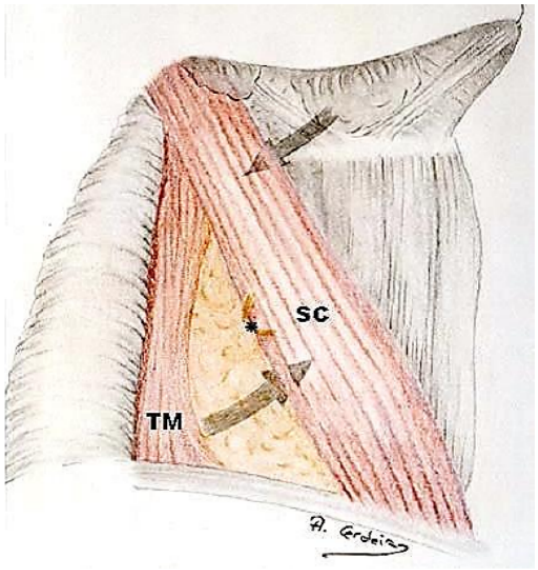


Figure 7: Schematic view of the approach to the neck for a complete neck dissection. Above Erb's point the operation is performed anterior to the SCM muscle. The lower part of the posterior triangle is approached posterior to the SCM muscle. (SC: Sternocleidomastoid muscle; TM: Trapezius muscle; *: Erb's point

In the upper half of the neck (above Erb's point) the dissection is performed anterior to the SCM muscle, whereas in the lower half of the neck (below Erb's point) the dissection is performed posterior to SCM muscle. The tissue dissected from the lower half of the neck (supraclavicular fossa) is then be passed beneath the SCM muscle to join the main part of the specimen. When the posterior triangle is not included in the resection, the whole dissection can be performed from anterior to the SCM muscle.

Dissecting the submandibular triangle

The next step is to resect the submental and submandibular lymph nodes (Levels 1a, b). This level is at risk in patients with cancers of the oral cavity and oropharynx, but is unlikely to be involved in patients with larynx, hypopharynx and thyroid cancers. The submandibular gland does not need to be resected as, unlike the parotid gland, there are no lymph nodes within the substance of the gland [6].

After the flaps have been raised the submandibular gland is visible through the superficial layer of cervical fascia in the upper part of the surgical field. The fascia is incised at the level of the lower border of the submandibular gland from the midline to the tail of the parotid gland as for a gland removing procedure. Then the facial vein is ligated and divided, and is reflected upwards by the superior ligature to displace and preserve the marginal mandibular branch of the facial nerve (Figure 8).

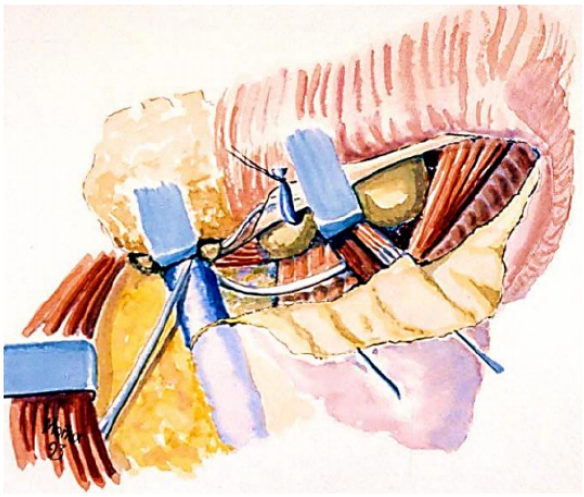


Figure 8: Protecting the marginal mandibular branch of the facial nerve by elevating the distal stump of the ligated facial vein over the mandible

The retromandibular vein and the external jugular vein are ligated and divided. Now, instead of including the submandibular gland within the specimen, its fascia is reflected inferiorly while the gland is retracted superiorly (Figure 9).

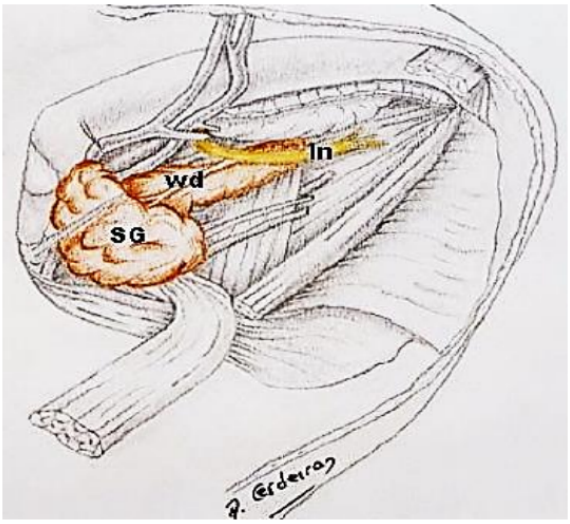


Figure 9: Anatomic relations of the lingual nerve in the submandibular triangle. (ln: Lingual nerve; SG: Submandibular gland; wd: Wharton's duct)

The fibrofatty tissue containing the submandibular nodes is grasped and dissected off the submandibular triangle preserving the gland. The dissection may be continued medially to include the submental nodes but this is seldom required in tumors that allow preservation of the submandibular gland.

The dissection is continued over the digastric and stylohyoid muscles. These muscles are retracted superiorly and the fascial sheath is easily dissected from the subdigastric and upper jugular spaces.

The hypoglossal nerve is identified (*Figure 10*) and the dissection is continued along the nerve, carefully dividing and ligating the lingual veins as they may be a troublesome source of bleeding.

The specimen is reflected inferiorly and the fascia over the digastric and stylohyoid muscles is incised from the midline to the tail of the parotid gland. Following the posterior belly of the digastric muscle the stylomandibular ligament is transsected (*Figure 11a*).

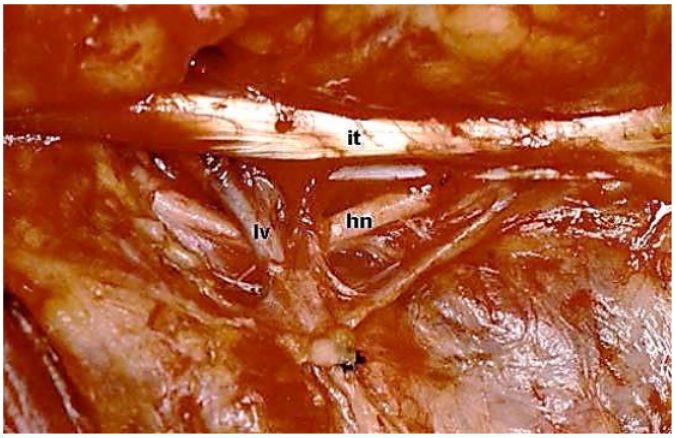


Figure 10: The hypoglossal nerve is identified underneath the intermediate tendon of the digastric muscle. A lingual vein can be seen crossing superficial to the nerve (hn: Hypoglossal nerve; it: Intermediate tendon of the digastric muscle; lv: Lingual vein crossing hypoglossal nerve)

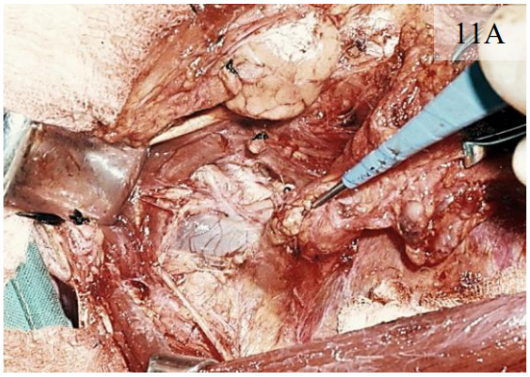
At this level, the retromandibular vein, the posterior auricular vein and the external jugular vein are identified, ligated and divided according to their anatomical distributions. Depending on the lower extension of the tail of the parotid gland, part of the gland may also be included in the resection. This facilitates visualisation of the upper jugular nodes as well as includes in the specimen the infraparotid lymph nodes.

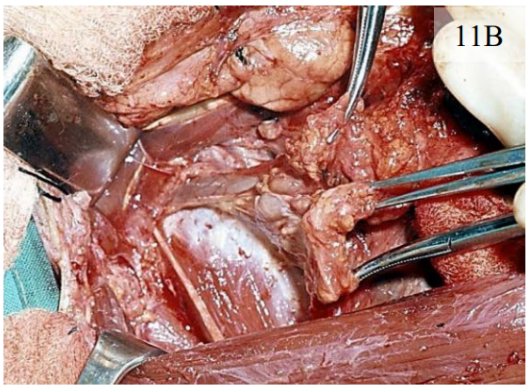
The dissected tissue is finally retracted inferiorly and dissected free from the subdigastric and upper jugular spaces. The specimen at this stage includes the submental and submandibular lymph nodes (Level I), and the uppermost jugular nodes (Level IIa).

Dissecting spinal accessory nerve (SAN)

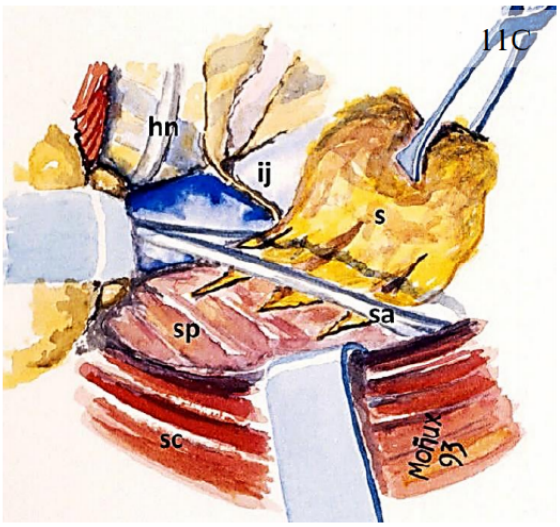
The SAN runs within the “soft tissue” of the neck, so that one must divide the tissue overlying the nerve, rather than to follow a fascial plane. Dissecting the SAN is usually performed with scissors rather than a scalpel because of the loose consistency of the tissue in this area and the restricted access. The SCM muscle is retracted posteriorly and the posterior belly of the digastric muscle is retracted superiorly with a retractor. It is important to identify the entire SAN between the SCM muscle and the internal jugular vein (IJV). Usually the IJV lies immediately behind the proximal portion of the nerve. Occasionally the nerve may go behind the vein or even cross it (*Figures 11a-c*).

Once the SAN has been exposed, the tissue lying superior and posterior to the nerve is dissected free from the splenius capitis and levator scapulae muscles. When the dissected tissue (Level IIb) reaches the level of the SAN it is passed beneath the nerve to be removed in continuity with the main part of the specimen (*Figure 11b*).





Then the specimen is further freed by making an incision into the tissues located below the entrance of the SAN into the SCM muscle, down as far as the level of Erb's point.



Figures 11 A-C: The "spinal accessory manoeuvre" allows removal of the tissue lying posterior and superior to the nerve in continuity with the rest of the specimen. (A) The nerve is exposed between the SCM muscle and the internal jugular vein. (B) The fibrofatty tissue lying posterior and superior to the nerve is passed beneath the nerve. (C) Artist's view of the "spinal accessory manoeuvre" on the right side of the neck. (sa: Spinal accessory nerve; ij: Internal jugular vein; s: Specimen; sc: SCM muscle; sp: Splenius capitis muscle)

Dissecting posterior triangle of neck

To facilitate exposure of supraclavicular area (Level Vb), this region is approached from posterior to the SCM muscle (Figure 12). The loose fibrofatty tissue of the supraclavicular fossa and absence of well-defined dissection planes within this area make knife dissection ineffective, and it is best performed with scissors and blunt dissection.

The SCM muscle is retracted anteriorly and the external jugular vein is divided and ligated inferiorly in the neck if this had not be done previously. The dissection proceeds from the anterior border of the trapezius muscle in a medial direction including the lymphatic contents of the supraclavicular fossa. At the upper margin of this area is where damage to the SAN is most likely to occur.

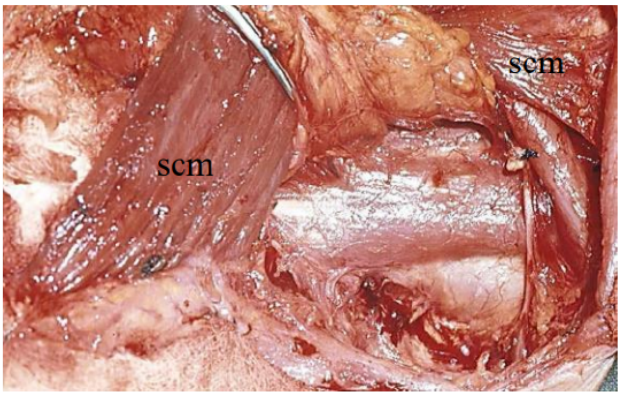


Figure 12: Dissection of the supraclavicular fossa. The SCM muscle (scm) is retracted anteriorly and the dissection proceeds posterior to the muscle until the scalene muscles are identified

The omohyoid muscle is next identified; its fascia is dissected off the muscle so that is may be removed with the contents of the posterior triangle. The muscle may be transected if necessary but may be retracted inferiorly to identify the transverse cervical vessels deep to the omohyoid muscle.

The deep layer of the cervical fascia overlying the levator scapulae and scalene muscles now comes into view. The brachial plexus is easily identified because it appears between the anterior and middle scalene muscles (*Figure 13*).

Remaining superficial to the scalene fascia (deep layer of the cervical fascia) prevents injuring the brachial plexus and the phrenic nerve. Dissection proceeds medially until the anterior border of the SCM muscle is reached. The muscle is retracted posteriorly and the dissection is continued anterior to the muscle towards the carotid sheath.

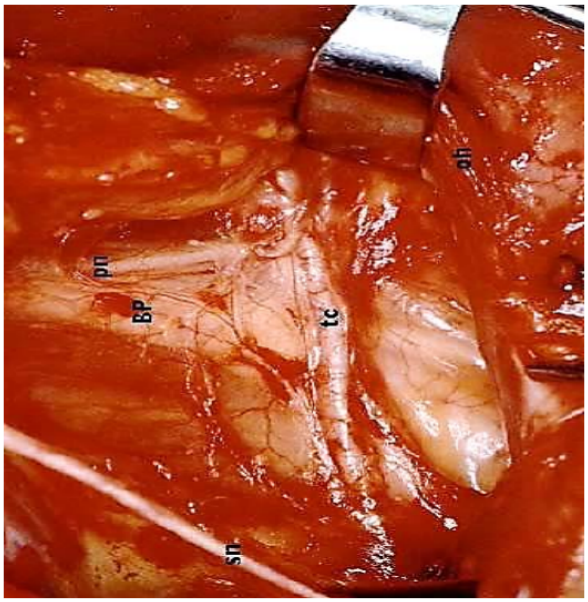


Figure 13: Anterior view of the anatomic landmarks of the right supraclavicular fossa. (BP: Brachial plexus; pn: Phrenic nerve; tc: Transverse cervical artery; sn: Supraclavicular branch of cervical plexus; oh: Omohyoid muscle retracted inferomedially)

Dissecting the deep cervical muscles

As the dissection proceeds medially towards the carotid sheath, several branches of the cervical plexus are found over the deep muscles of the neck (Figures 14 and 15A).

Optimal shoulder function may be preserved if the deep branches of the 2nd, 3rd, and 4th cervical nerves are preserved, as they may communicate with the SAN. There are also similar anastomoses from the 3rd, 4th and 5th cervical nerves to the phrenic nerve – these should also be preserved. Preservation of these nerves is best achieved by keeping the dissection superficial to the scalene fascia.

Continuing the dissection posterior to the carotid sheath carries a high risk of damage to the sympathetic chain.

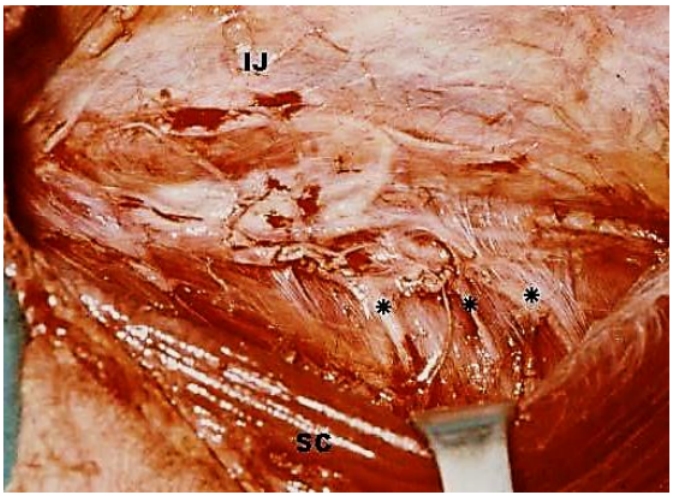
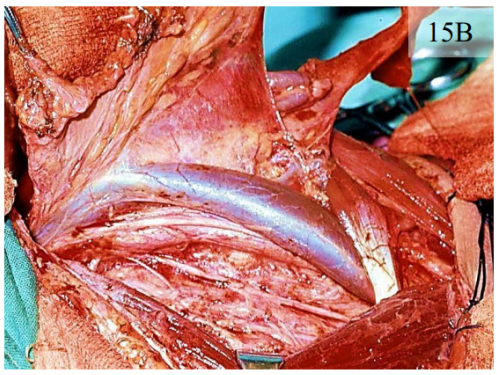


Figure 14: Lateral view of the deep branches of the cervical plexus that have been preserved on the right side (SC: SCM muscle; IJ: Internal jugular vein; *: Deep branches of cervical plexus)





Figures 15A, B: Dissecting carotid sheath

Dissecting the carotid sheath

This part of the dissection is best executed with a knife while applying adequate countertension to the tissues. The surgical specimen is grasped with hemostats and retracted medially, while the surgeon uses a gauze pad in the non-dominant hand to pull laterally over the deep cervical muscles.

An incision is made with the scalpel along the entire length of the carotid sheath over the vagus nerve. The fascia is then dissected from the internal jugular vein. This is achieved by continuously passing the knife blade up and down along the wall of the internal jugular vein along its entire length. The fascia can be seen parting from the vein after each pass of the blade, until the internal jugular vein is completely released from its fascial covering (Figure 15B).

The facial, lingual, and thyroid veins are next clearly identified, ligated, and divided to complete the isolation of the internal jugular vein.

Dissection of the carotid sheath has two danger points for surgeons – at the top and the bottom of the dissection. The surgeon must be extremely cautious to avoid injuring the vein at these two points as traction exerted at these two points to facilitate dissection of the fascial envelope produces a folding of the wall of the internal jugular vein that is easily cut at the touch of the scalpel blade.

Low in the neck, the terminal portion of the thoracic duct on the left, and the right lymphatic duct – when present – also are within the boundaries of the dissection and must be preserved.

Following release of the internal jugular vein from its fascia, the dissection proceeds medially over the carotid artery. The specimen is now completely separated from the great vessels, remaining attached only to the strap muscles.

Dissecting the strap muscles

This may be the last step or may already have been performed at an earlier stage of the operation, depending on the preference surgeon or the location of the primary tumor. The midline of the neck constitutes the medial margin of the neck dissection.

This the superficial layer of the deep cervical fascia is incised in the midline from the upper border of the surgical field to the sternal notch. The anterior jugular vein is identified, ligated, and divided at both ends of the surgical field. The fascia is now dissected from the underlying strap muscles. The dissection starts at the upper part of the surgical field and continues in a lateral and inferior direction. The sternohyoid and omohyoid muscles are completely freed from their fascial coverings (Figures 16 A, B).

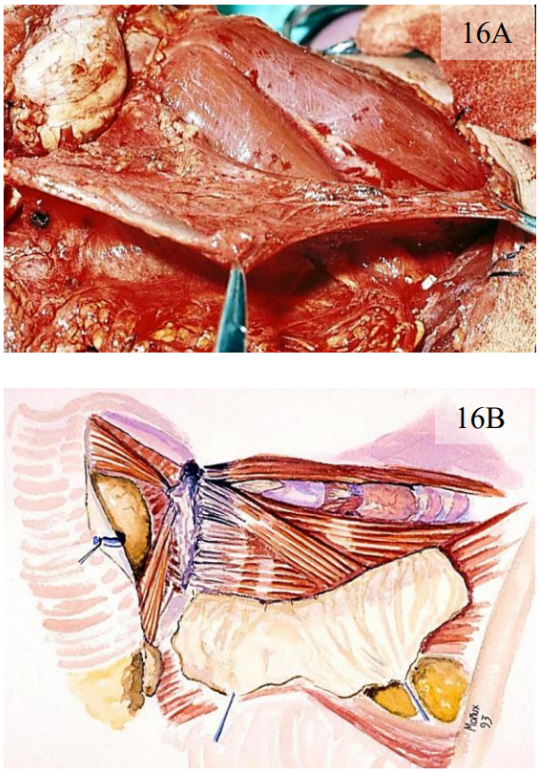


Figure 16: (A) Dissection of strap muscles. (B) Artist's view of dissection of the fascia covering the strap muscles

At this point the specimen is almost free and any remaining vessels - arteries or veins - should be ligated and divided unless required for some other procedure such as anastomosis of a free flap!

Dissecting the central compartment

During dissection of the central compartment (Level VI), the recurrent laryngeal nerves must be identified and followed upwards to the larynx and downwards to the upper mediastinum. The lobe of the thyroid, if being preserved, makes such surgery difficult, as preservation of the parathyroid glands is extremely important with its functioning blood supply.

Closure of wound

The neck is carefully inspected for bleeding points and retention of sponges etc. The entire wound is irrigated with saline (Figure 17).

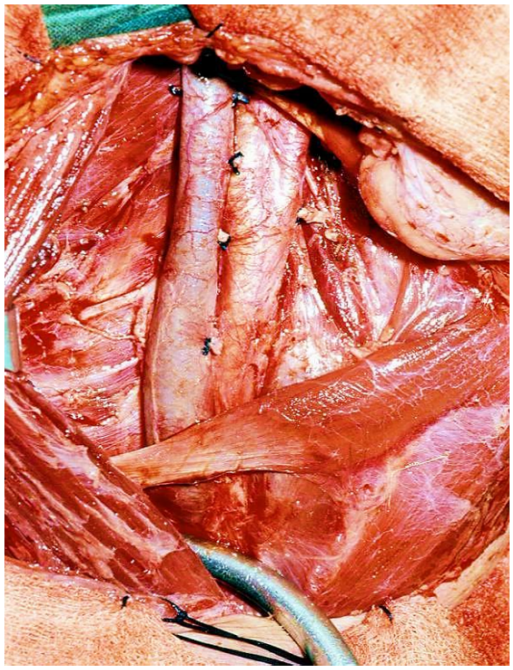


Figure 17: Image of the right neck after a neck dissection. Note the preserved submandibular gland

The skin is closed in two layers over a large suction drain. The platysma is sutured with absorbable buried sutures, and the skin closure with skin clips.

Comment

While the term functional neck dissection has not been included in more recent classifications of neck dissection, the procedure as described is eminently suited to elective selective neck dissections (Level I, II, III and IV) and for therapeutic selective neck dissections for N1 necks.

Video

- Download: Functional neck dissection technique
- YouTube: https://www.youtube.com/watch?v=sdq QxbZMLlA

Other Open Access Atlas neck dissection chapters:

- Modified and radical neck dissection technique
- Selective neck dissection operative technique

References

1. De Bree R, Takes RP, Castelijns JA, Medina, JE, Stoeckli SJ, Mancuso AA, Ferlito A. (2015). Advances in diagnostic modalities to detect occult lymph node metastases in head and neck squamous cell carcinoma. Head Neck, 37(12), 1829-39
2. Gavilán J, Herranz J, Martin L, Functional neck dissection: the Latin approach. Operative Techniques in Otolaryngology 2004;15: 168 -75
3. Ferlito A, Gavilán J, Buckley J, et al. Functional neck dissection: fact and fiction. Head Neck 2001; 23; 804-8
4. Gavilán J, Heranz J, De Santo LW, Gavilán C: Functional and selective neck dissection. New York Thieme, 20025. Bocca E, Pignataro O, Sasaki CT, Functional neck dissection. A description of operative technique. Arch Otolaryngol 1980; 106: 524-7 6.

Dhiwakar M, Ronen O, Malone J, et al. Feasibility of submandibular gland preservation in neck dissection: a prospective anatomic-pathologic study. Head Neck 2011;33-(5): 603-9

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Authors

Patrick J Bradley, MBA
FRCS Emeritus
Honorary Professor of Head and Neck Oncologic Surgery
Nottingham University Hospitals
Queens Medical Centre Campus
Nottingham, England
pjbradley@zoo.co.uk

Javier Gavilán, MD
Professor and Chairman
Department of
Otolaryngology La Paz University Hospital
Autonomous University of Madrid
Madrid, Spain
javier.gavilan@salud.madrid.org

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.22: Thyroglossal Duct Cyst

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

The surgical management of thyroglossal duct remnants (TGDRs) requires an understanding of the embryology of the thyroid gland, as failure to include the embryological course of the thyroid gland in the surgical resection increases the probability of recurrence.

Relevant Embryology

The thyroid gland originates in the base of the tongue at the foramen caecum. In early embryonic life the base of the tongue is adjacent to the pericardial sac. As the embryo unfolds, TGDRs may remain anywhere between the pericardial sac and the foramen caecum. A persistent thyroglossal duct courses through the base of the tongue from the foramen caecum. It then passes inferiorly, anterior to, and rarely through, the hyoid body, and often has a diverticulum that hooks below and behind the hyoid, before it courses towards a thyroglossal duct cyst or the thyroid gland *(Figure 1)*.

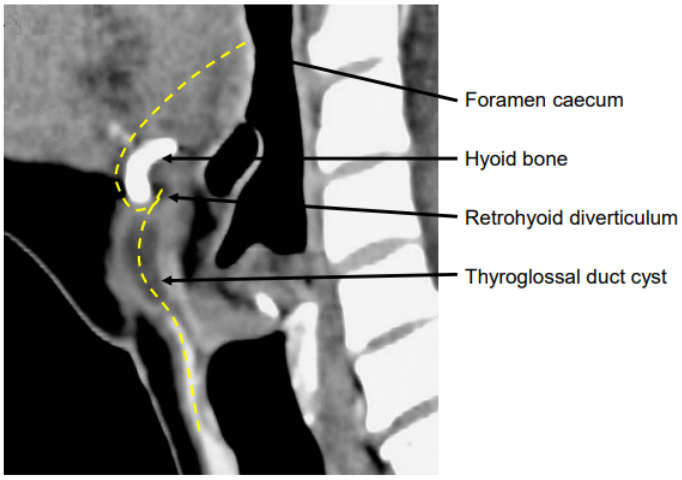


Figure 1: Typical course of thyroglossal duct remnants (yellow line)

The suprahyoid ductal segment may have a branching pattern like the tips of a broom *(Figure 2)*. These multiple ductules communicate with secretory glands in the base of the tongue and might drain directly into the mouth.[1]

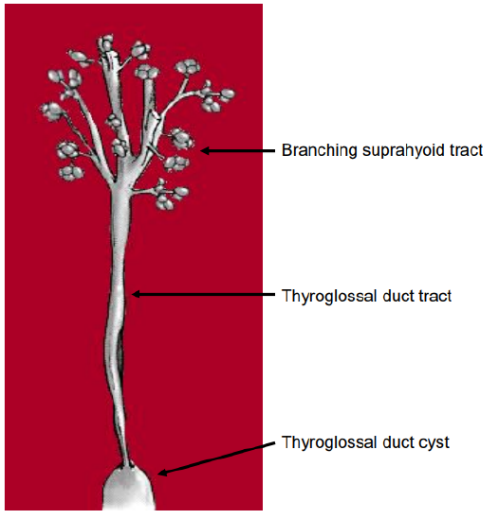


Figure 2: Schematic representation of the suprahyoid duct branching within the muscle of the base of tongue

Clinical presentation

TGDRs may present at any age as a cyst *(Figure 3, 4)*, abscess, sinus, fistula or tumor, anywhere along the embryological course of the thyroid gland.



Figure 3: Thyroglossal duct cyst in thyrohyoid region

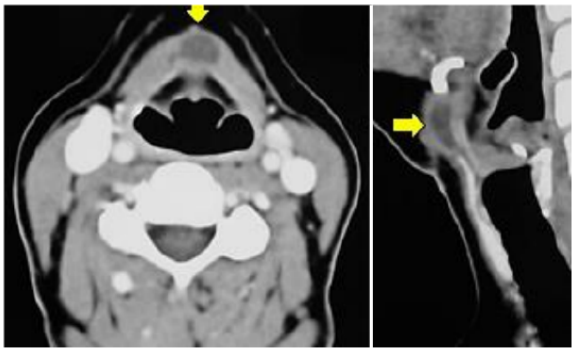


Figure 4: Thyroglossal duct cyst in thyrohyoid region

Patients classically present with a mobile, painless mass in the midline of the neck in proximity of the hyoid bone. Occasionally a cyst may be off the midline *(Figures 5, 10)*.

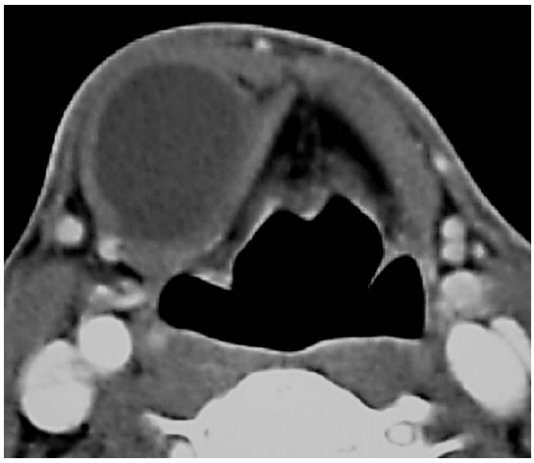


Figure 5: Thyroglossal duct cyst to left of midline overlying lamina of thyroid cartilage

Figure 6 illustrates the distribution of thyroglossal duct cysts.[1]

A cyst generally moves upward during deglutition or protrusion of the tongue because of its close anatomical relation to the hyoid bone. This is considered a reliable diagnostic sign as it distinguishes it from other midline neck masses such as a lymph node or a dermoid cyst (*Figure 7*).

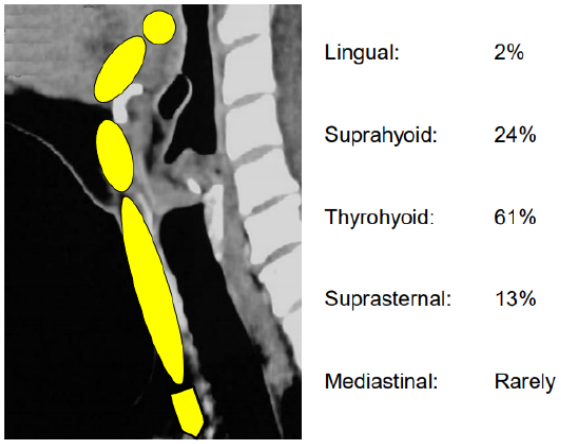


Figure 6: Distribution of thyroglossal duct cysts

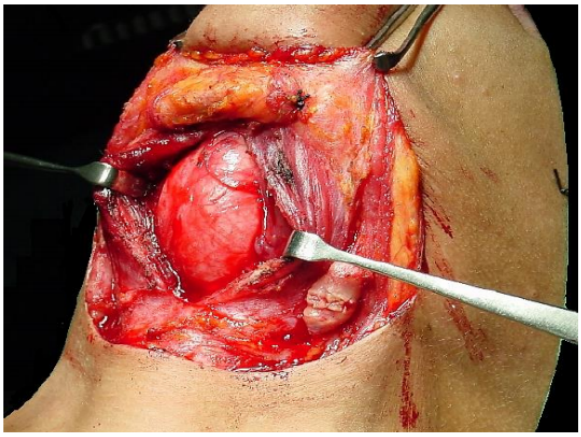


Figure 7: Dermoid cyst

A lingual thyroid usually presents as a mass in the base of the tongue (*Figures 8, 9*); this may be the patient's only thyroid tissue in the majority of cases.

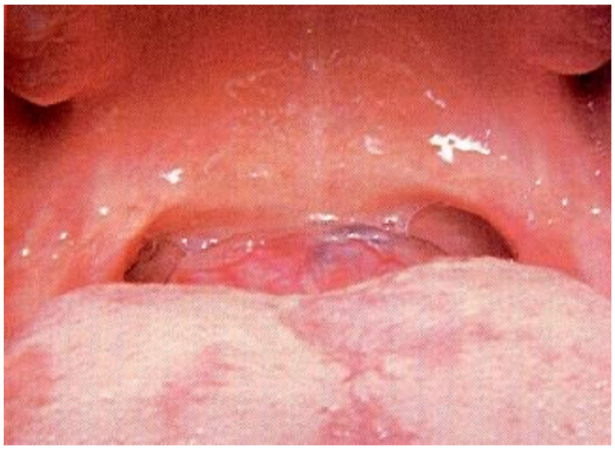


Figure 8: Lingual thyroid



Figure 9: CT scan of lingual thyroid

Preoperative evaluation

The principal issues to determine prior to surgery are:

Is it a TGDR? Unlike other midline masses, only TGDRs are treated with a Sistrunk operation. Therefore, it is important to exclude other causes of midline masses prior to surgery such as dermoid cysts and lymph nodes.

Is it the patient's only thyroid tissue? Occasionally a TGDR comprises the only functioning thyroid tissue, and its removal results in hypothyroidism. Ultrasound examination to establish the presence of normal thyroid tissue is a simple investigation. Should imaging not be possible, the surgeon should explore the neck to determine the presence of a normal thyroid gland.

Is the patient hypothyroid? The majority of patients with lingual thyroids are hypothyroid. Therefore patients with lingual thyroids should have a TSH level determined prior to surgery.

Does the TGDR contain thyroid cancer? Thyroid cancer occurs in only about 1% of operated TGDRs. A solid component and/ or calcification on ultrasound examination should raise the possibility of carcinoma, most commonly papillary. However, even if the diagnosis of thyroid cancer is suspected it does not alter the type of surgery (Sistrunk operation).

Surgical principles

- It is imperative to achieve a complete resection of the TGDR and its embryonic tract to avoid symptomatic recurrence
- A thyroglossal cyst abscess should initially be aspirated and treated with antibiotics, not incised and drained, to facilitate complete resection once the infection has settled

Sistrunk operation

The Sistrunk operation is the standard of care for TGDRs. It includes resection of entire embryological tract i.e. the thyroglossal duct cyst, the central portion of the body of the hyoid bone, and a broad (>1 cm) core of suprahyoid muscle extending up to / close to the foramen caecum.

The following description is for a cyst in the thyrohyoid region:

- Make an incision in a skin crease over the cyst. Note that the platysma muscle may be absent in the midline, so take care not to puncture the cyst (*Figure 10*)
- Raise superior and inferior flaps in subplatysmal planes. The superior flap should be raised to approximately 2 cm above the body of the hyoid bone
- Identify the infrahyoid strap muscles that are stretched over the superficial aspect of the cyst
- Divide the cervical fascia vertically in the midline, separate the infrahyoid strap muscles, and expose the cyst (*Figure 11*)
- Divide the mylohoid and geniohyoid muscles just above the body of the hyoid bone with diathermy remaining between the lesser cornua of the hyoid so as not to place the hypoglossal nerves or lingual arteries at risk of injury (*Figure 12*)

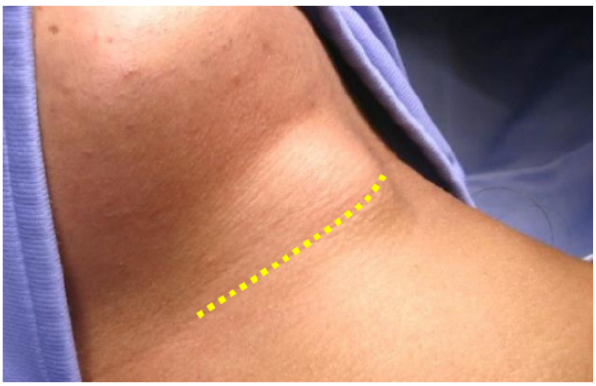


Figure 10: Initial skin crease incision

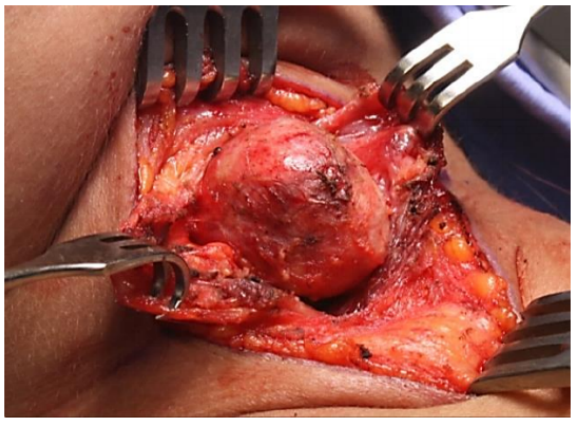


Figure 11: Expose and part infrahyoid strap muscles overlying cyst

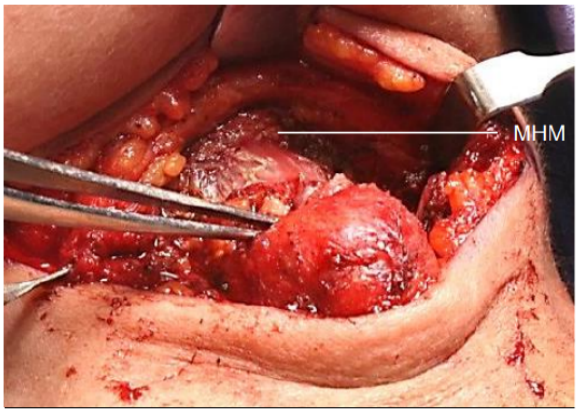


Figure 12: Divide mylohoid (MHM) and geniohyoid muscles just above body of hyoid bone

- Divide the inferior attachments of the thyroglossal duct cyst, and mobilize the deep aspect of the cyst from the thyrohyoid membrane up to the hyoid bone with sharp dissection (*Figure 13*)
- Expose the hyoid bone on either side of the cyst (*Figure 14*)

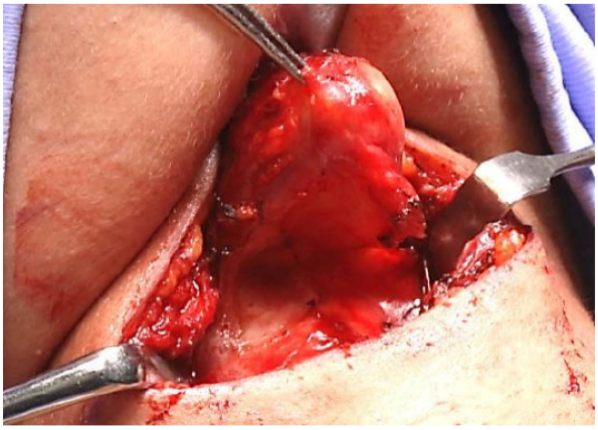


Figure 13: Mobilize deep aspect of cyst from thyroid cartilage and thyrohyoid membrane

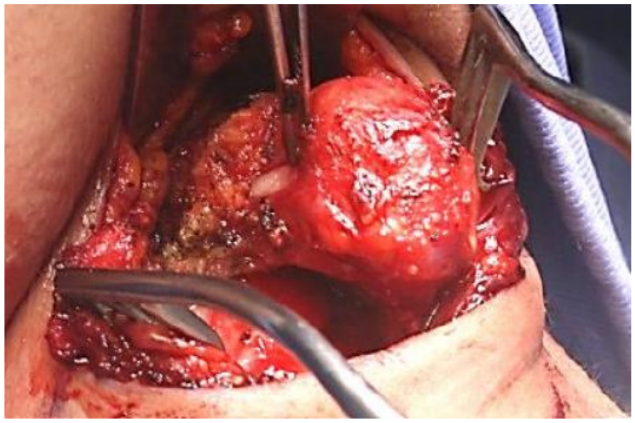


Figure 14: Expose hyoid bone on either side of cyst

- Divide the hyoid bone about 1 cm to each side of the midline with heavy scissors (children) or a bone cutter (*Figures 15, 16*)

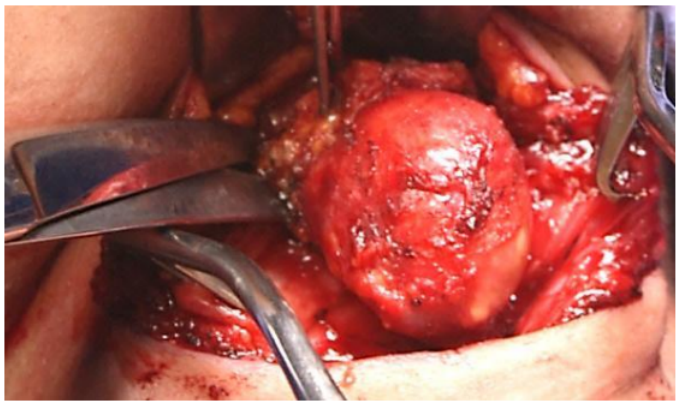


Figure 15: Dividing hyoid bone

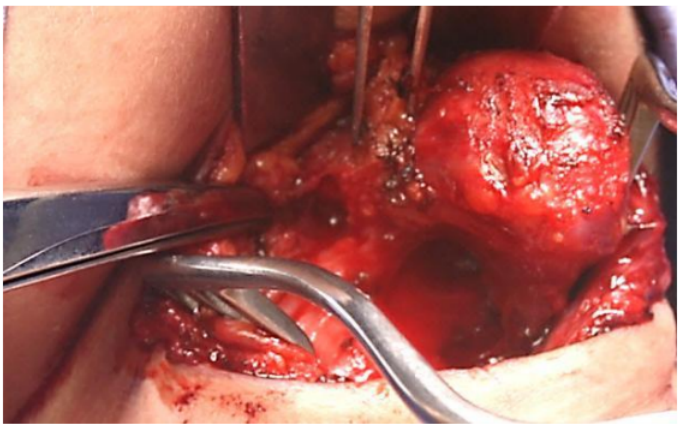


Figure 16: Divided hyoid bone

- Next resect the suprahyoid thyroglossal duct. Do not attempt to identify the thyroglossal duct, as branches of the duct may be transected in the process increasing the likelihood of recurrence
- Using monopolar diathermy resect a 2 cm wide core of tongue tissue (hyoglossus) in continuity with the remainder of the operative specimen, including the hyoid bone, directed at an angle of approximately 45^{o} in the sagittal (vertical) plane towards the foramen caecum (*Figures 17*, *18*, *19*)
- If in doubt about the required direction, place a finger in the mouth and on the foramen caecum as a guide. It is remarkable how much base of tongue tissue can be resected without interfering with speech or swallowing. Note the proximity of the hyoid bone to the vallecula. Should the vallecula or base of tongue be accidentally entered, simply close the defect with vicryl sutures from the neck side.

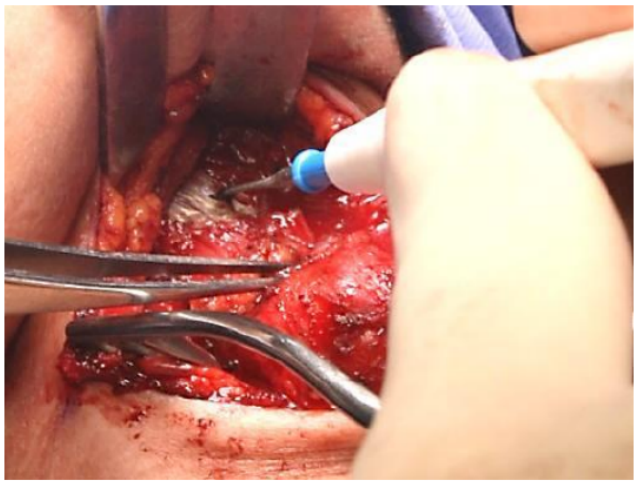


Figure 17: Resect a 2 cm wide core of tongue (hyoglossus) tissue



Figure 18: Superimposed image (yellow) illustrates direction of suprahyoid dissection and extent of final resection; note proximity of vallecula to hyoid

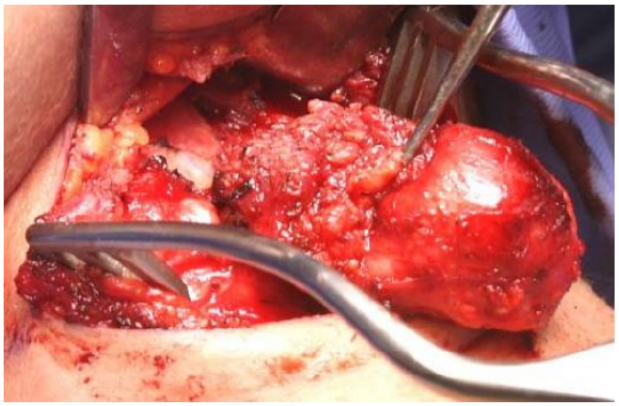


Figure 19: Core of tongue (hyoglossus) tissue extending up to just short of foramen caecum

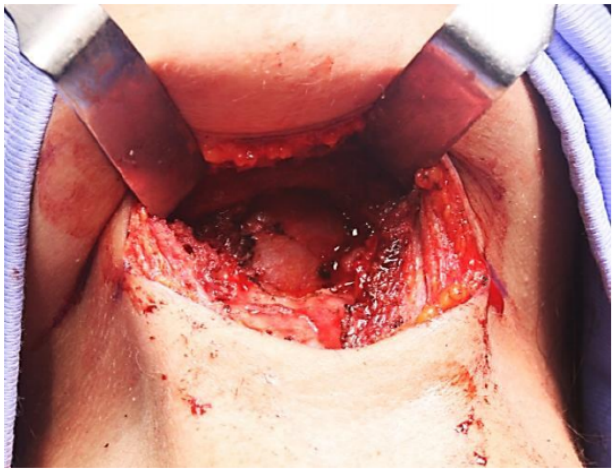


Figure 20: Final defect in base of tongue up to just short of forman caecum with free floating cut ends of hyoid bone



Figure 21: Resected specimen

- The tongue defect (*Figure 20*) is then partially obliterated with vicryl sutures. The two cut ends of the hyoid are not approximated, but left floating free. The supra- and infrahyoid muscles are approximated in a transverse plane, as is the platysma muscle, and the skin is closed over a drain
- Antibiotics are not required unless the oral cavity has been entered

Recurrent TGDR

Managing recurrent TGDR becomes challenging because cysts may be multifocal with the presence of fibrosis, distorted surgical landmarks and possible absence of hyoid bone. It is important to obtain an accurate description of the original surgery to determine whether the hyoid bone and suprahyoid tissues had been resected. An MRI scan should be done to serve as a roadmap for the surgeon to find residual TGDRs (*Figure 21*).

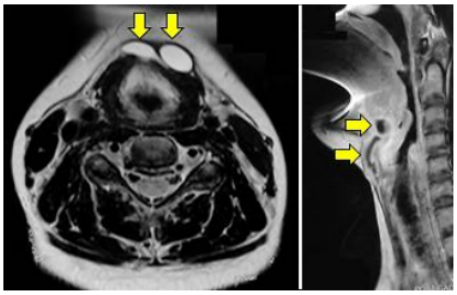


Figure 22: MRI of recurrence demonstrating multiple cysts

Reference

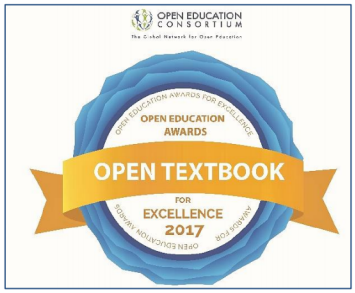
Mondin V, Ferlito A, Muzzi E, Silver CE, Fagan JJ, Devaney KO, Rinaldo A. Thyroglossal duct cyst: Personal experience and literature review. Auris Nasus Larynx 35 (2008) 11–25

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.23: Thyroidectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Eugenio Panieri & Johan Fagan

Thyroidectomy is a very common operation. The most frequent indications for surgery are uncertainty about the nature of a thyroid mass, or treatment of a large goitre causing compressive symptoms, thyroid cancer, or thyrotoxicosis refractory to medical management.

Surgical Anatomy

A detailed knowledge of thyroid anatomy is a prerequisite for thyroid surgery. Particular attention needs to be paid to identifying and preserving the recurrent laryngeal nerve (RLN), the external branch of the superior laryngeal nerve (SLN) and the parathyroid glands.

Thyroid gland

The gland consists of two lateral lobes joined anteriorly by the isthmus which typically overlies the 2nd and 3rd tracheal rings *(Figures 1, 2)*.

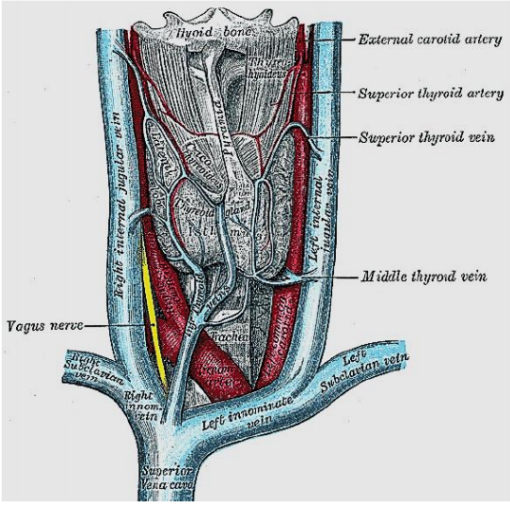


Figure 1: Anatomy of thyroid gland, pyramidal lobe and relations to carotid sheath and vasculature

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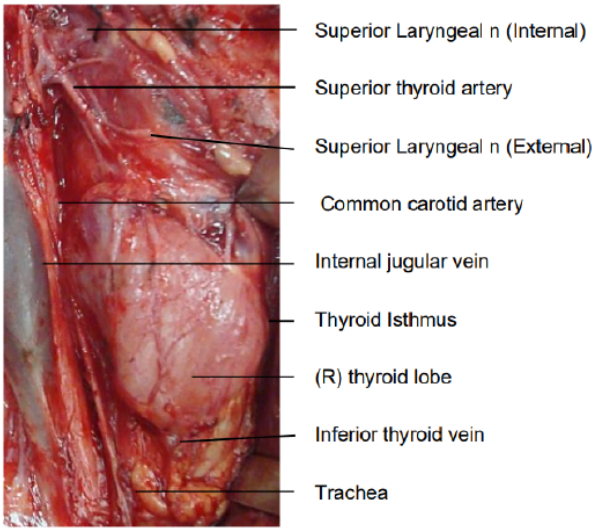


Figure 2: Anatomy of thyroid gland

The pyramidal lobe is a superior extension near the midline and is present in up to 70% of cases *(Figure 1)*.

The thyroid is encased by a fine capsule of pretracheal fascia which is part of the middle layer of deep cervical fascia. The fascial layers fuse to form Berry's ligament which posteromedially firmly attaches the thyroid to the trachea.

The gland encircles the anterior and lateral aspects of the cervical trachea and is applied to the surface of the larynx. Lateral to the gland are the carotid sheath (common carotid artery, internal jugular vein and vagus/Xn) and the sternocleidomastoid (SCM) muscle *(Figures 1, 2)*. Anterior to the thyroid are the infrahyoid strap muscles (sternohyoid and sternothyroid) *(Figure 3)*. The deep/medial anatomical relations are the thyroid (caudad to attachment of sternothyroid muscle to oblique line) and cricoid cartilages, trachea, inferior constrictor and cricothyroid muscles, esophagus, superior and inferior thyroid arteries, and RLNs *(Figures 3, 4, 5)*.

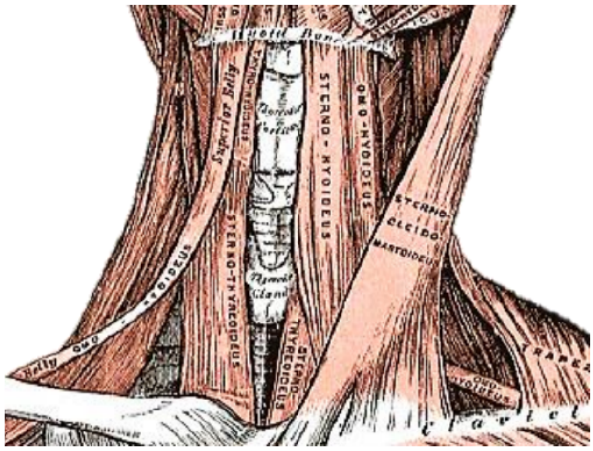


Figure 3: The superficial relations of the thyroid are the infrahyoid strap muscles (sternohyoid and sternothyroid) and SCM

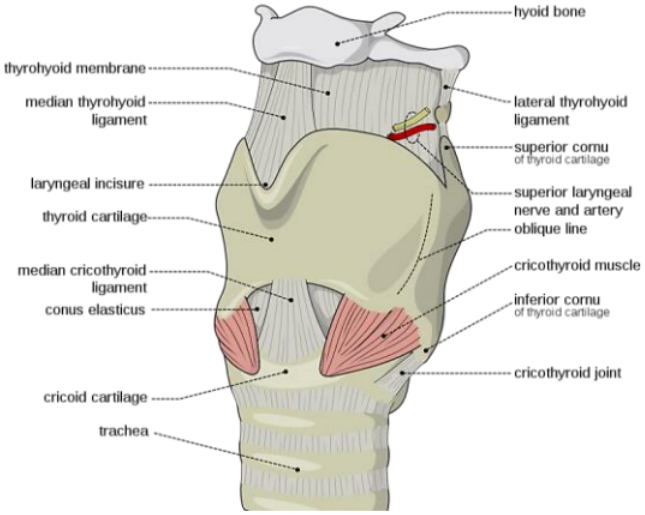


Figure 4: Structures deep to thyroid gland: Note the oblique line to which the sternothyroid muscle inserts and which defines the anterosuperior limit of the thyroid (Wikipedia)

The thyroid gland weighs 15-25 g. The thyroid lobes are normally cone-shaped and measure approximately 5 cm in length and 2-3 cm in width in both transverse and anteroposterior dimensions.

The *Tubercle of Zukerkandl* is a pyramidal enlargement of the lateral edge of the thyroid lobe that stems from the fusion of the lateral and medial thyroid anlages *(Figure 6)*. It is recognisable in up to 75% of thyroids. It is anatomically closely related to the RLN, the inferior thyroid artery, Berry's ligament and the superiorparathyroid gland. The tubercle usually projects lateral to the RLN. Elevating the tubercle allows the RLN to be readily located. Less commonly the RLN courses lateral to an enlarged tubercle; this places the nerve at risk of injury. The superior parathyroid gland, also derived from the 4th branchial cleft, is commonly located close to and cephalad to the tubercle.

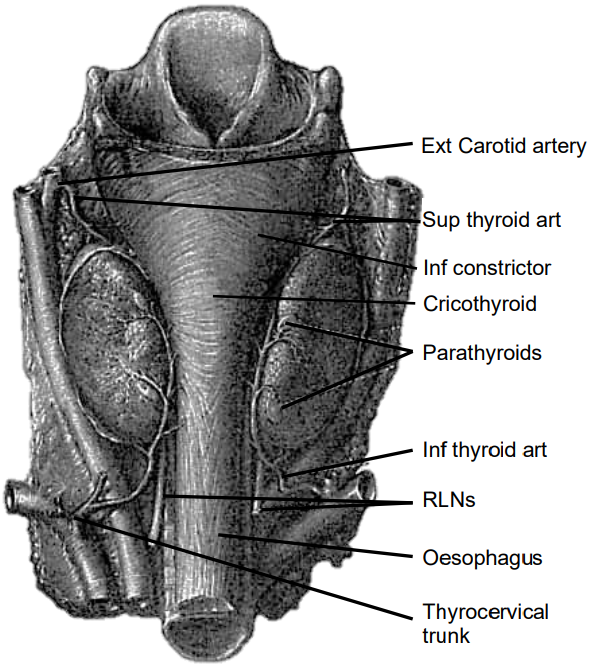


Figure 5: Posterior view of the thyroid gland demonstrating the deep / medial anatomical relations, the RLNs and the superior and inferior thyroid arteries

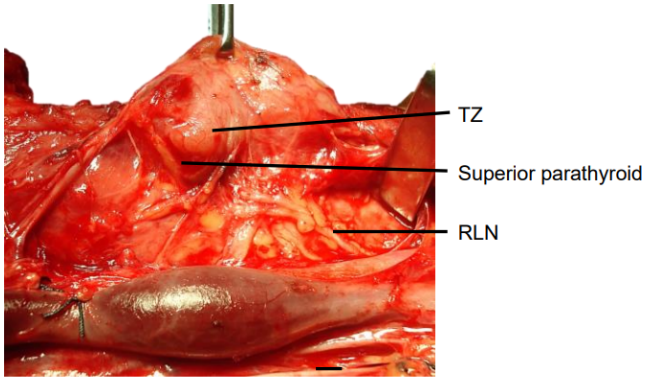


Figure 6: Tubercle of Zuckerkandl (TZ) and its relationship to the superior parathyroid gland and RLN

Blood supply

The **arterial supply** is based on the superior thyroid (STA) and inferior thyroid (ITA) arteries. Occasionally the ***thyroideaima*** artery is encountered inferiorly but is seldom of surgical relevance. It arises from the innominate artery or aortic arch and ascends along the front of the trachea.

The **superior thyroid artery (STA)** is the first branch of the external carotid artery *(Figures 2, 5, 7)*. It courses over the external surface of the inferior constrictor muscle of the pharynx, entering the gland posteromedially just below the highest point of the upper pole where it usually is located superficial to the external branch of the SLN *(Figure 2)*. Its branches communicate with the ITA and cross to the contralateral thyroid lobe via the thyroid isthmus.

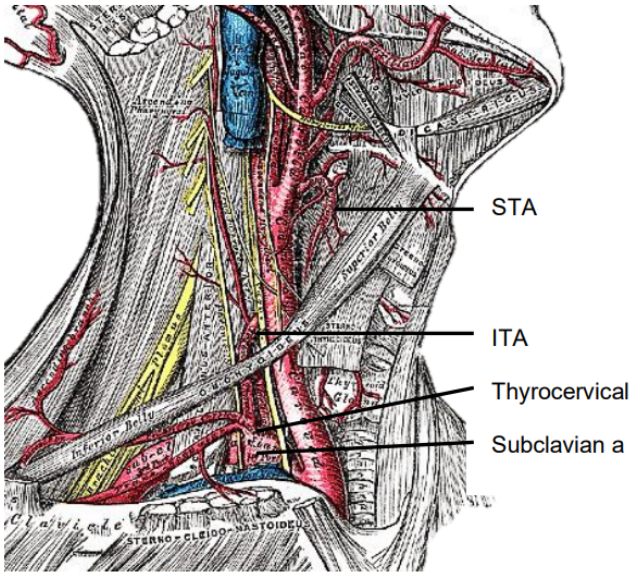


Figure 7: Superior thyroid artery (STA), subclavian artery, thyrocervical trunk and inferior thyroid artery (ITA)

The **inferior thyroid artery** (ITA) is a branch of the thyrocervical trunk which originates from the subclavian artery *(Figures 5, 7)*. It courses superiorly along the surface of the anterior scalene muscle before it turns medially behind the carotid sheath from where it reaches the inferior pole of the thyroid *(Figure 5)*. It provides blood supply to the thyroid, upper esophagus and trachea, and is the sole arterial supply to all the parathyroid glands, both superior and inferior. The relationship of the ITA and RLN is reviewed later.

Venous drainage is quite variable and occurs via a capsular network of thin-walled, freely intercommunicating veins which drain through the **superior thyroid veins** (adjacent to the STA), the **inferior thyroid veins** (exit the inferior pole), and the **middle thyroid vein(s)**, which course laterally to drain directly into the internal jugular vein *(Figure 1)*. The middle thyroid vein is surgically most relevant; it is encountered early during thyroid mobilization, and failure to secure it causes bothersome bleeding.

Lymphatic drainage parallels the venous drainage and occurs to the lateral deep cervical and pre- and paratracheal lymph nodes *(Figure 8)*. Understanding the pattern of nodal drainage is particularly important in managing patients with thyroid cancer since the cervicocentral compartment is most commonly involved in metastatic thyroid cancer.

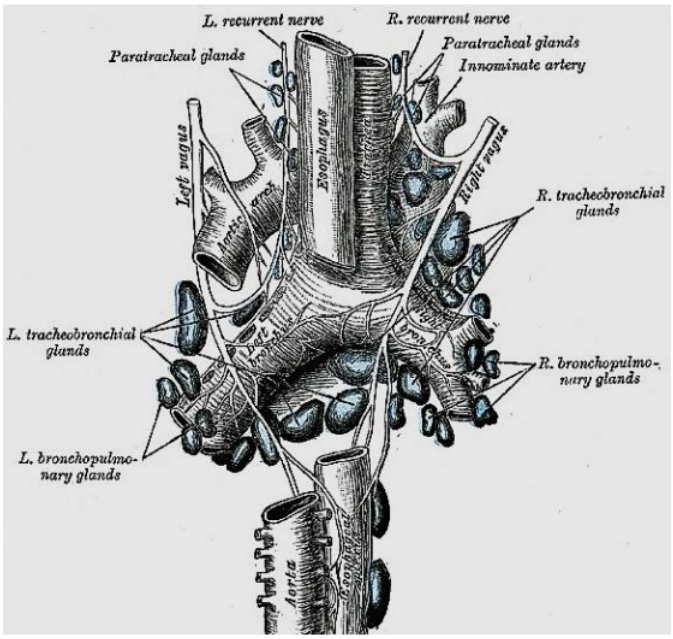


Figure 8: Posterior view of the course of the lymphatics and RLNs

Recurrent Laryngeal Nerve (RLN)

During thyroid surgery, identification and preservation of the RLN and all of its divisions is essential to minimise morbidity. The RLN innervates all the intrinsic muscles of the larynx except the cricothyroid muscle (SLN) and provides sensory innervation to the larynx. Even minor neuropraxia may cause dysphonia; irreversible injury confers permanent hoarseness. The reported incidence of RLN injury during thyroidectomy is 0 - 28% and is the most common reason for medicolegal claims following thyroidectomy.

The RLNs originate from the Xn. After circling around the subclavian artery (right) and aortic arch (left) the RLNs ascend superiorly and medially toward the tracheoesophageal groove *(Figures 8, 9)*. The right RLN enters the root of the neck from a more lateral direction. Its course is less predictable than that of the left RLN. The RLNs enter the larynx deep to the inferior constrictor muscles and posterior to the cricothyroid joint.

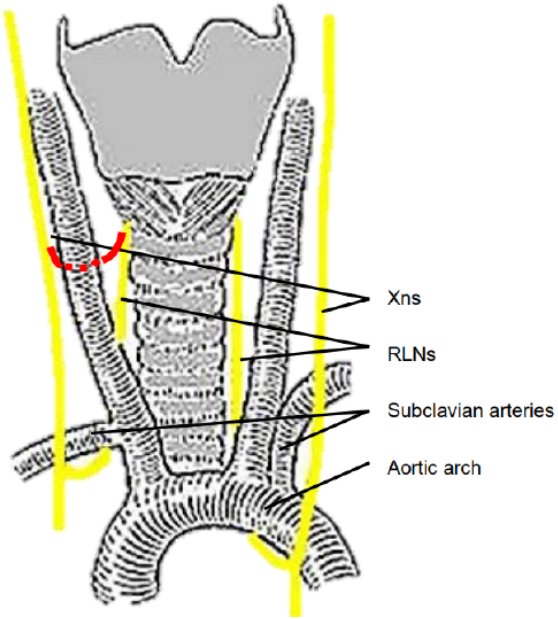


Figure 9: Typical anatomical course of RLNs (Non-recurrent RLN in red)

The RLN may be non-recurrent in approximately 0.6% of patients *i.e.* does not pass around the subclavian artery, but branches from the Xn higher in the neck, passing directly to the larynx close to the superior thyroid vessels *(Figure 9)*. This aberration almost always occurs on the right side and is associated with a retro-esophageal subclavian artery.

Knowledge of the anatomical relationships of the RLN to the tracheoesophageal groove, ligament of Berry, and ITA is essential. The course of the RLN with respect to the ITA is quite variable. Most commonly it crosses behind the branches of the artery, more predictably so on the left. However, the nerve may pass deep to, superficial to, or between the terminal branches of the ITA. Up to twenty anatomical variations have been described. In *Figure 10* the RLN is seen to pass anterior to the artery.

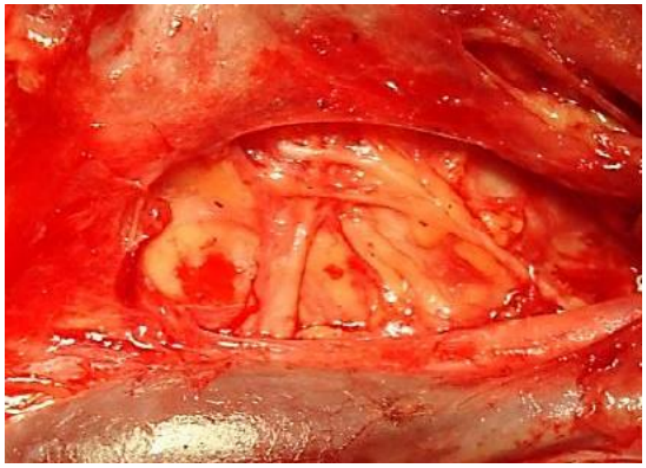


Figure 10: RLN passing over the inferior thyroid artery (right neck, thyroid reflected medially)

The majority of RLNs are located within 3 mm of *Berry's ligament*; rarely the nerve is embedded in it, and more commonly lies laterally to it.

Classically, the RLN is identified intraoperatively in *Simon's triangle*, which is formed by the common carotid artery laterally, the esophagus medially, and the ITA superiorly *(Figure 11)*.

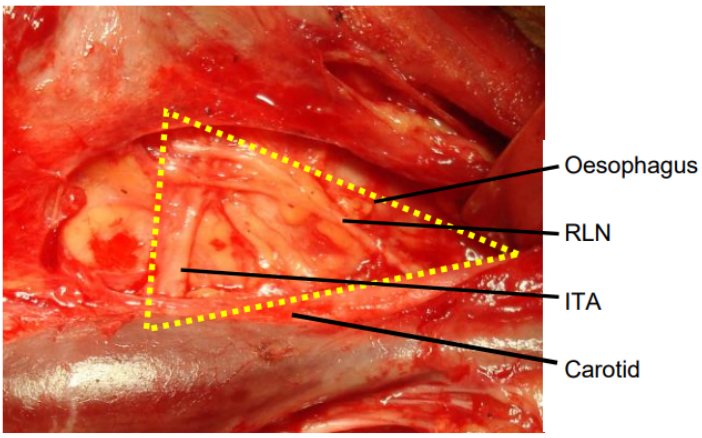


Figure 11: RLN crossing Simon's triangle formed by esophagus, inferior thyroid artery (ITA) and common carotid artery (right neck, thyroid reflected medially)

The *Tubercle of Zukerkandl* may also be used as an anatomical landmark to identify the nerve *(Figure 6)*. The RLN generally courses between this structure and the trachea. However, this relationship can vary with enlargement of the tuberculum thereby placing the nerve at risk during exploration.

Superior Laryngeal Nerve (SLN)

The SLN is a branch of the Xn and has both an external and internal branch *(Figures 2, 12)*. The ***internal branch*** is situated above and outside the normal field of dissection; it is sensory and enters the larynx through the thyrohyoid membrane. The ***external branch*** innervates the cricothyroid muscle, a tensor of the vocal cord. Injury to the SLN causes hoarseness, decreased pitch and/or volume, and voice fatigue. These voice changes are more subtle than those relating to a RLN injury, and are frequently underestimated and not reported. The external branch of the SLN is at risk because of its close proximity to the STA *(Figures 12, 13)*. Understanding its relationship to the upper pole of the thyroid and the STA is crucial to preserving its integrity.

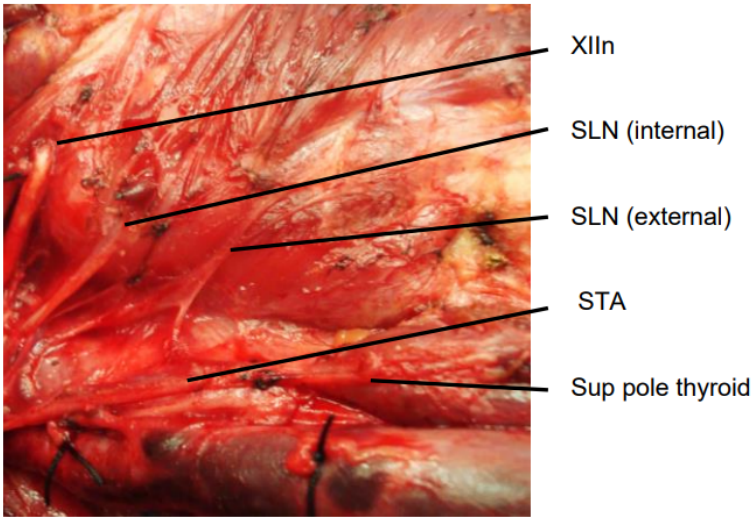


Figure 12: Anatomical relations of internal and external branches of right SLN to superior thyroid artery and to superior pole of thyroid

The usual configuration is that the nerve is located behind the STA, proximal to its entry into the superior pole of the thyroid. The relationships of the nerve to the superior pole and STA are however extremely variable. Variations include the nerve passing between the branches of the STA as it enters the superior pole of the thyroid gland; in such cases it is particularly vulnerable to injury.

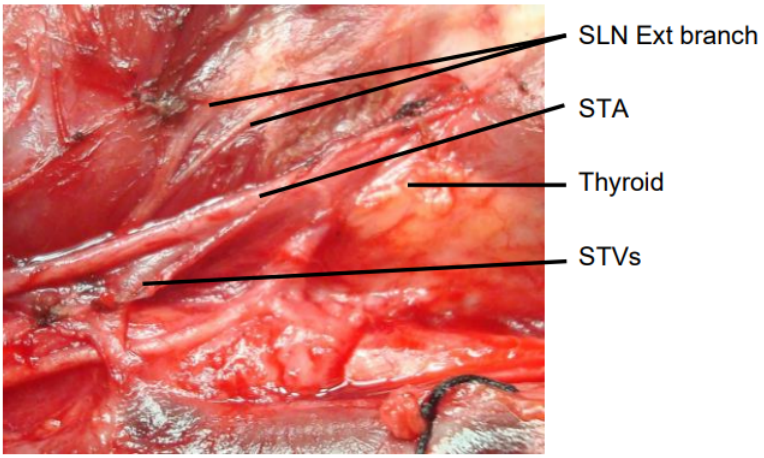


Figure 13: Note close proximity of external branch of SLN to STA and thyroid vein and to superior pole of thyroid gland

Parathyroid glands

There are typically four parathyroid glands; however, supernumerary glands have been reported. The parathyroid glands are generally symmetrically located in the neck. Their characteristic golden color varies from yellow to reddish brown, and permits them to be distinguished from the pale-yellow color of adjacent lymph nodes, thymus, mediastinal fat, and the dark-red thyroid parenchyma. They are usually oval and measure 3–8 mm. The ***ITA is the predominant vascular supply*** to both the upper and lower parathyroids. Consequently dividing the trunk of the ITA is discouraged as it places all the parathyroids on that side at risk of ischemic injury.

The ***superior parathyroid glands*** originate from the 4th pharyngeal pouch and attach to the posterior surface of the caudally migrating thyroid. They have a much shorter migration distance compared to the inferior parathyroid glands; this accounts for their more predictable location. They are embryologically and anatomically closely related to the *Tubercle of Zuckerkandl* and are usually located at the level of the upper two-thirds of the thyroid, in a posterior position, about 1 cm above the crossing point of the RLN and inferior thyroid artery *(Figure 6)*. Ectopic positions of the superior parathyroid glands such as in the posterior neck, retropharyngeal and retroesophageal spaces and intrathyroidally are very uncommon (1%).

The dorsal wing of the 3rd pharyngeal pouch gives rise to the ***inferior parathyroid glands***. They join the thymus as it travels caudally and medially to its final position in the mediastinum. This accounts for the fact that they are usually found in a plane ventral to that of the superior parathyroid glands, and that ectopic inferior parathyroid glands can be found anywhere along this large area of descent up to the superior border of the pericardium. Their commonest location is between the lower pole of the thyroid and isthmus, equally commonly on the anterior or the posterolateral surfaces of the lower pole of the thyroid (42%, *Wang et al*); or in the lower neck in proximity to the thymus (39%). Other locations are: lateral to the thyroid or within the carotid sheath (15%), within the mediastinal thymic tissue and the pericardium (2%).

If the RLN's course is viewed in a coronal plane, then the superior parathyroid gland is located deep (dorsal) and the inferior parathyroid superficial (ventral) to the plane of the nerve (*Figures 14a, b*).

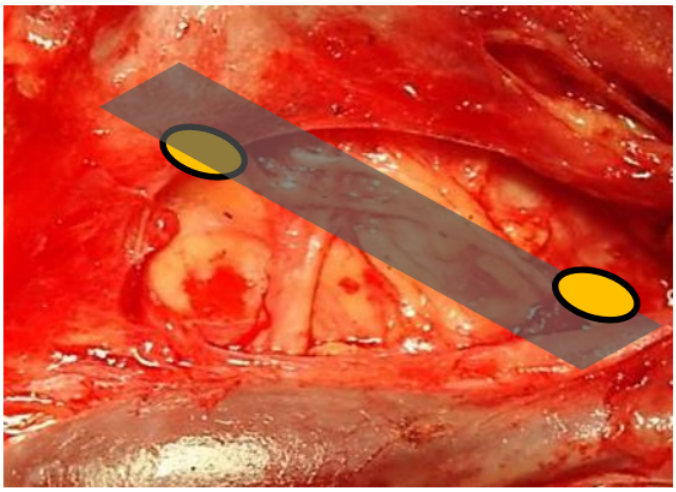


Figure 14a: The superior parathyroid gland lies deep (dorsal) and the inferior parathyroid superficial (ventral) to a coronal plane along course of RLN

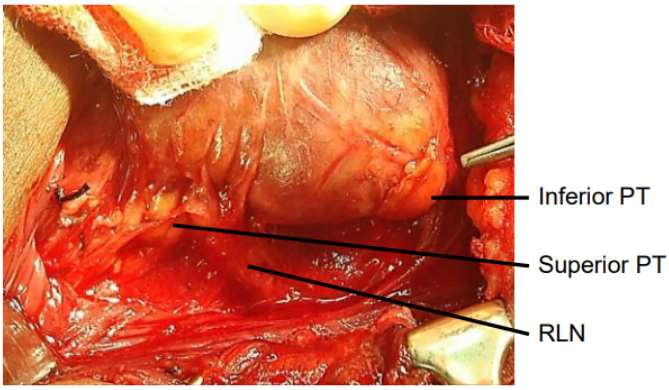


Figure 14b: The superior parathyroid gland lies deep (dorsal) and the inferior parathyroid superficial (ventral) to a coronal plane along the course of the RLN

Types of thyroidectomy

Thyroid lobectomy: Either lobe is removed, usually with a small segment of the thyroid isthmus; the contralateral lobe is left undisturbed. It is most commonly performed as a diagnostic procedure for a thyroid nodule of uncertain nature. It may be a sufficient for cure in some cases of thyroid carcinoma with favorable prognostic criteria.

Subtotal thyroidectomy: 90-95% of thyroid tissue is removed bilaterally, leaving a small (1x2 cm) thyroid remnant in situ overlying the RLN. This operation has slowly lost favor as it is by its very nature inexact, is prone to recurrence of the thyroid pathology, and in expert hands does not result in lower rates of RLN injury when compared to total thyroidectomy.

Total thyroidectomy: Both right and left lobes, isthmus and pyramidal lobe (when present) are removed; no macroscopic thyroid tissue is left *in situ*. This is the procedure of choice for the treatment of thyroid carcinoma and is commonly performed for a MNG with compressive symptoms, or for thyrotoxicosis.

Subtotal vs. total thyroidectomy for differentiated thyroid carcinoma

Bilateral RLN injury causing airway compromise and hypoparathyroidism causing hypocalcemia in situations where monitoring serum calcium and treating hypocalcemia with calcium and Vitamin D are not possible may have ***fatal consequences***. Regardless of surgical expertise, the complication rates rise with the extent of resection. Unilateral thyroid lobectomy rarely causes RLN injury and almost never causes significant hypoparathyroidism. Subtotal thyroidectomy preserves the blood supply to the ipsilateral parathyroid glands and reduces the risk of hypocalcaemia. Total thyroidectomy is however associated with both increased short- and long-term morbidity relating to RLN paralysis and hypocalcemia, particularly in an occasional thyroid surgeon's hands. Shortterm complication rates for total thyroidectomy occur in 10-40% of patients; long-term complications (mainly hypoparathyroidism) occur in 5-20%. Most thyroidectomies are done in general hospitals by surgeons not specializing in endocrine surgery; complication rates have been reported to correlate with the number of thyroidectomies done. In the absence of convincing

evidence that total thyroidectomy confers survival benefit in favorable differentiated thyroid cancers (especially when I^{131} therapy is not available), coupled with the morbidity and mortality of total thyroidectomy, the occasional thyroid surgeon or the surgeon practicing in a setting where calcium monitoring and replacement are suboptimal may therefore elect rather to perform thyroid lobectomy or subtotal thyroidectomy for differentiated thyroid cancer.

Pre-operative evaluation

Ultrasonography (US) permits accurate distinction between the common thyroid pathologies and is the imaging technique of choice for a thyroid mass. Neoplasms typically cause focal enlargement within a normal gland ("solitary nodule"). Features strongly suggestive of thyroid carcinoma are hypoechogenicity, increased and haphazard vascularity patterns within the lesion, microcalcifications, irregular margins, elevated height-to-width ratio, and regional lymphadenopathy. A multinodular goitre (MNG) typically shows multiple hyper- or isoechoic nodules, some cystic changes and coarse macrocalcifications involving both thyroid lobes.

Focal thyroid masses or suspicious lymphadenopathy should be investigated by ***fine needle aspiration cytology***.

All patients with thyroid complaints must undergo ***thyroid function tests*** as clinical manifestations of thyrotoxicosis or hypothyroidism are notoriously unreliable. Thyrotoxicosis must first be controlled medically before surgical intervention. Failure to do so may precipitate a thyroid storm.

CT scans are helpful in selected cases, particularly with a MNG with a suspected retrosternal component *(Figure 15)*, or when uncertainty exists about the extent of tracheal compression *(Figure 16)*.



Figure 15: Coronal CT scan demonstrating retrosternal extension



Figure 16: Tracheal compression on CT scan

Thyroid uptake scans may be requested in cases of thyroid enlargement with thyrotoxicosis but are not routinely done as they seldom add more information to that available from the US.

Laryngoscopy: It is medicolegally prudent to document vocal cord function prior to thyroid surgery; it is essential in patients with symptoms of dysphonia.

Preoperative consent

Scar: The incision is generally well concealed if made within a natural skin crease, but tends to descend with ageing.

Airway obstruction/wound hematoma: 1% of thyroidectomy patients develop stridor postoperatively, either due to airway edema or a hematoma.

Voice changes: It is essential for the patient to have a clear understanding of the risk of postoperative voice change. While most are subtle and recover fully, approximately 1% of patients will have permanent hoarseness. The risk is highest for patients having surgery for carcinoma, large retrosternal goitres, and with repeat surgery.

Hypoparathyroidism: Transient postoperative hypocalcemia occurs in about 20% of total thyroidectomy patients. Permanent hypocalcemia occurs following 1-5% of total thyroidectomies.

Hypothyroidism: Hypothyroidism occurs uncommonly (5%) with thyroid lobectomy. It is common practice to routinely check TSH levels approximately 6-8 weeks after surgery to identify such cases before it manifests clinically. It is self evident that a patient will be hypothyroid following total thyroidectomy. The clinical effects only become apparent once the preexisting thyroid hormone levels drop; this generally becomes evident 3-4 weeks following surgery. Thyroxine replacement therapy is routinely instituted immediately postoperatively to prevent hypothyroidism. The exception is if total thyroidectomy has been performed for a well-differentiated carcinoma and I^{131} therapy is envisaged; a hypothyroid state is deliberately induced in such patients until the I^{131} therapy has been administered.

Anesthesia, positioning and draping

- General anesthesia with endotracheal intubation
- Prophylactic antibiotics are not indicated
- Neck slightly hyperextended by placing a bolster between the scapulae
- Head stabilized on a head-ring
- Table tilted to 30º anti-Trendelenberg position to reduce venous engorgement
- Head is free-draped to allow turning of the head

Surgical technique

Skin incision *(Figure 17)*: A curvilinear incision is placed in a skin crease two fingerbreadths above the sternal notch between the medial borders of the sternocleidomastoid muscles.

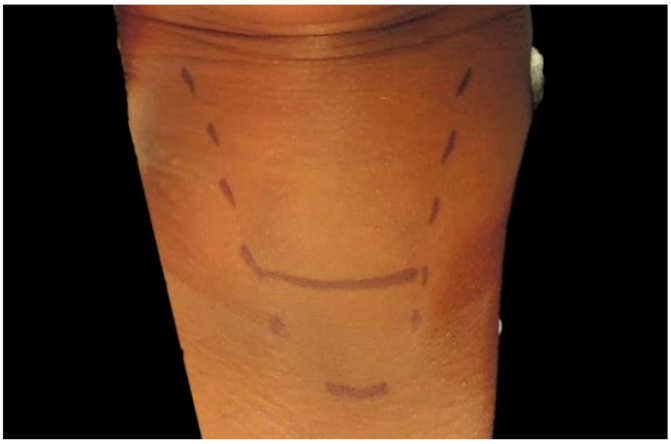


Figure 17: Curvilinear skin incision two fingerbreadths above the sternal notch

Placing the incision too low causes an unsightly low scar over the heads of the clavicles when the extended neck is returned to its normal position. The width of the incision may need to be extended for large goiters or for a lateral lymph node dissection.

Subplatysmal flaps: Subcutaneous fat and platysma are divided, and a subplatysmal dissection plane is developed superiorly (platysma is often absent in the midline) remaining superficial to the anterior jugular veins, up to the level of the thyroid cartilage above, and the sternal notch below *(Figure 18)*.

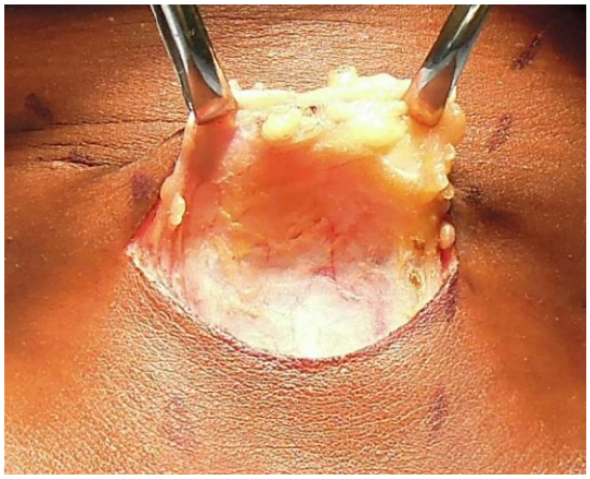


Figure 18: Subplatysmal flaps elevated

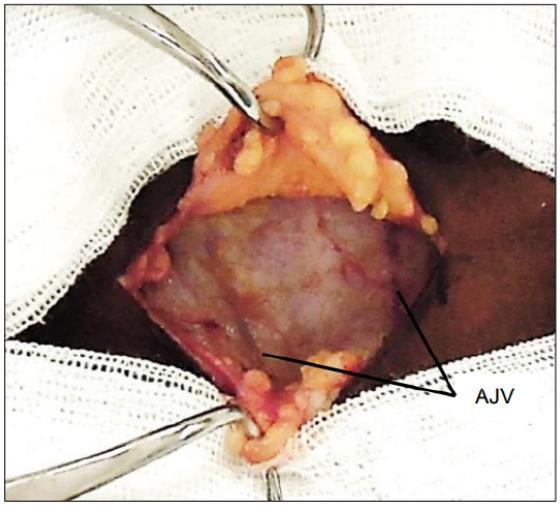


Figure 19: Subplatysmal skin flaps held with Jowell's retractor. Note anterior jugular veins (AJVs)

The skin flaps are secured to a fixed retractor (e.g. Jowell's retractor) to expose the thyroid region for the remainder of operation *(Figure 19)*.

Separating strap muscles and exposing the anterior surface of thyroid: The fascia between the sternohyoid and sternothyroid muscles is divided along the midline with diathermy or scissors *(Figure 20)*. This is an avascular plane, though care must be taken not to injure small veins occasionally crossing between the anterior jugular veins, particularly inferiorly. The infrahyoid (sternohyoid, sternothyroid and omohyoid) strap muscles are retracted laterally with a right-angled retractor. With massive goiters the strap muscles may be divided to improve access.

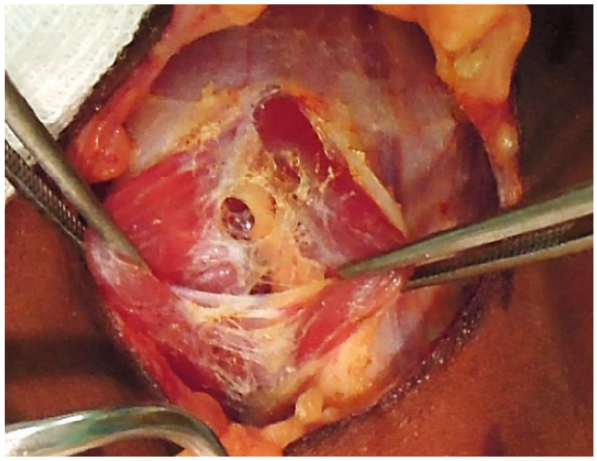


Figure 20: Fascia between sternohyoid and sternothyroid muscles divided to expose thyroid gland

It is usual at this stage for the surgeon to move to the side of the table opposite to the thyroid lobe to be resected.

Medially rotating the thyroid: Using gentle digital retraction the surgeon rotates the thyroid gland medially *(Figure 21)*.

Dividing the middle thyroid vein(s) *(Figure 21)*: The first important vascular structure to come into view is the middle thyroid vein(s), which is tightly stretched by medial rotation of the gland. It is divided between hemostats and ligated with a 3/0 tie. This permits further mobilization of the gland and delivery of the bulk of the lobe into the wound.



Figure 21: Medial rotation of (R) thyroid lobe exposes the middle thyroid vein



Figure 22: Dividing the middle thyroid vein

Dividing the STA *(Figure 23)*: The retractors are repositioned to allow full visualization of the superior pole of the thyroid. This brings the STA into view. The author does not routinely identify the external branch of the SLN, but simply takes great care to divide the artery as close to the thyroid parenchyma as possible so as to avoid injury to nerve. The superior arterial pedicle is double ligated with 2/0 or 3/0 tie.

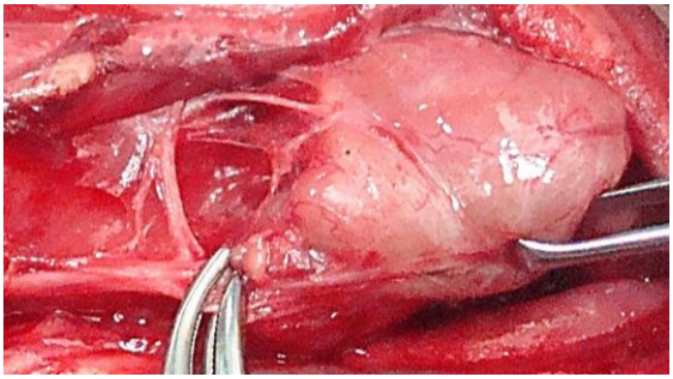


Figure 23: Dividing STA pedicle below external branches of SLN

Identifying superior parathyroid gland *(Figure 24, 25)*: Full mobilization and anterior delivery of the superior pole of the thyroid brings the region of the superior parathyroid gland into direct view. The superior parathyroid gland is normally located at the level of the upper two-thirds of the thyroid, in a posterior position and closely related to the *Tubercle of Zuckerkandl*, and about 1 cm above the crossing point of the recurrent laryngeal nerve and inferior thyroid artery.

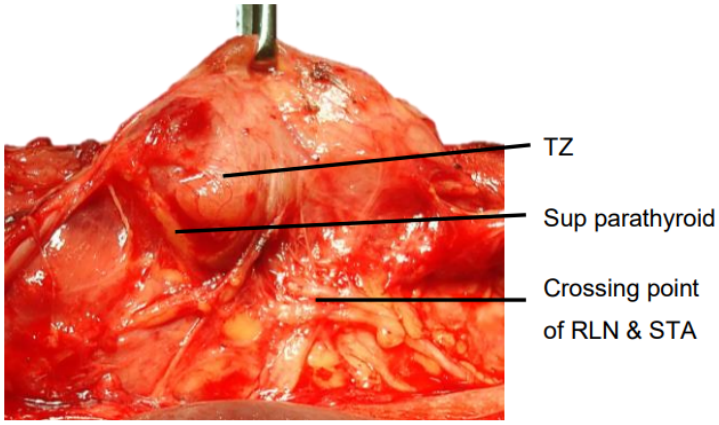


Figure 24: Position of superior parathyroid relative to Tubercle of Zuckerkandl (TZ), RLN and STA

If the RLN's course is viewed in a coronal plane, then the superior parathyroid gland lies deep (dorsal) to the plane of the nerve *(Figures 14a, b)*. It has a characteristic rich orange/yellow color *(Figure 25)*. The (occasional) parathyroid surgeon may find the parathyroids difficult to identify especially if there has been bleeding in the surgical field, so care must be taken to ensure meticulous hemostasis. The gland must remain *in situ* with blood supply intact. This is best achieved by carefully dissecting it off the posterior aspect of the thyroid gland, and using short bursts of bipolar cautery to control bleeding.

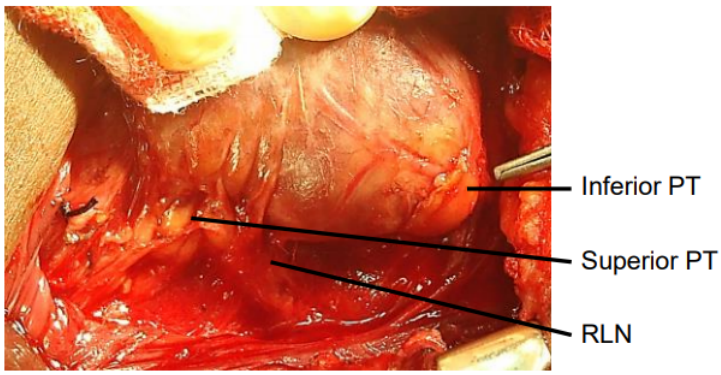


Figure 25: Superior and inferior parathyroids (PT)

Dividing inferior thyroid veins *(Figure 26)*: The retractors are again repositioned to expose the lower neck and the inferior thyroid vein(s). The veins are divided, and ligated. This exposes the trachea and permits full delivery of the thyroid gland outside the wound.

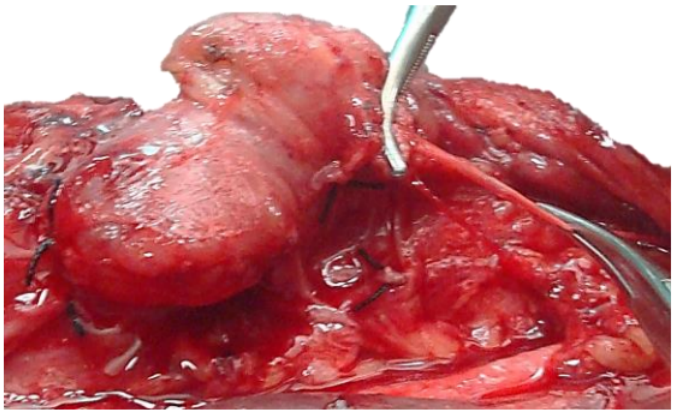


Figure 26: Inferior thyroid vein being divided

Identifying inferior parathyroid gland: The inferior parathyroid glands are normally located between the lower pole of the thyroid and the isthmus, most commonly on the anterior or the posterolateral surface of the lower pole of the thyroid (42%, *Wang et al*), or

located in the lower neck in proximity to the thymus (39%).

If the RLN's course is viewed in a coronal plane then the inferior parathyroid is superficial (ventral) to the plane of the nerve *(Figures 14a, b)*. The inferior gland may now become visible on the inferior aspect of the lower pole of the thyroid or within the thyrothymic ligament *(Figure 25)*. Care must be taken to preserve it in situ and to avoid damaging its ITA blood supply.

Identifying the RLN: The thyroid is rotated medially; lateral retraction is applied to the carotid artery and jugular vein. The RLN is located by carefully dissecting/ teasing apart the tissues in *Simon's triangle* which is formed by the common carotid artery laterally, the esophagus medially, and the inferior thyroid artery superiorly *(Figure 11)*. Others favor finding the nerve at its point of entry into the larynx approximately 0.5 cm caudad to the inferior cornu of the thyroid cartilage. The nerve must remain undisturbed and *in situ i.e.* is not skeletonised or handled.

Pericapsular dissection of branches of ITA: It is best to individually divide and ligate (3/0 ties) all the branches of the ITA at the capsule of the thyroid so as to reduce the risk of handling the RLN. Avoid all forms of cautery to avoid thermal injury to the nerve.

Dividing Ligament of Berry *(Figure 27)*: The posteromedial aspect of the thyroid gland is attached to the side of the cricoid cartilage and to the 1st and 2nd tracheal rings by the posterior suspensory ligament/ *Ligament of Berry*. The RLN is in close proximity (<3 mm) to the ligament and usually passes posterior to the ligament and must be identified before the ligament is divided with sharp dissection to free the thyroid from trachea. Carefully dissect thyroid tissue from the trachea in the region of Berry's ligament.

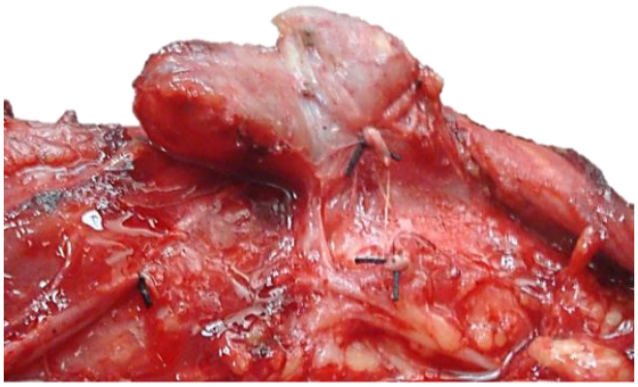


Figure 27: Ligament of Berry still needs to be divided

Dividing the thyroid isthmus: When doing a thyroid lobectomy the isthmus is cross-clamped with a hemostat and divided. The residual remnant is over-sewn using a continuous, interlocking technique *(Figure 28)*.

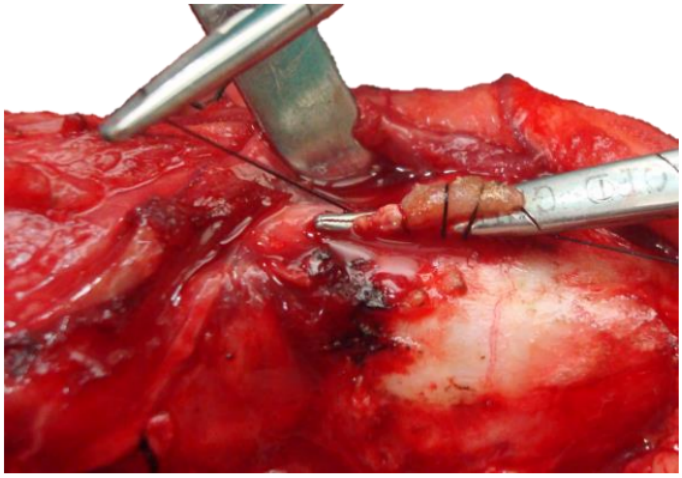


Figure 28: Over-sewing the thyroid isthmus

With **total thyroidectomy** the above surgical steps are simply repeated on the opposite side.

Wound closure

- The wound is irrigated
- A *Valsalva* maneuver is done to elicit venous bleeding, and hemostasis is achieved
- Wound drainage is not routinely required; where deemed necessary a suction drain is positioned in the thyroid bed and brought out through a laterally placed skin puncture
- The strap muscles are approximated for 70% of their length, and the platysma is closed with interrupted absorbable 3/0 sutures
- A subcuticular skin closure is achieved with an absorbable monofilament suture
- A light dressing is applied

Postoperative care

- The patient is monitored overnight for bleeding and airway obstruction
- The intravenous line is removed and a normal diet is taken as tolerated
- If a drain has been placed it is removed when drainage is <50 mL/24 hrs
- Following total thyroidectomy, serum PTH must be recorded at 24 hours postoperatively. If the PTH reading is low, then calcium and Vitamin D1α are commenced even in the absence of symptoms of hypocalcaemia. If PTH assays are unavailable the calcium levels are monitored postoperatively.

Additional points

Devascularised parathyroid: Should a parathyroid gland accidentally have been devascularized or come free during dissection it should be reimplanted. This is particularly important when performing total thyroidectomy. It is stored in saline until the conclusion of the thyroidectomy, then cut into 1 mm cubes and placed in small pockets within the sternocleidomastoid muscle.

Retrosternal goiter: Presentation, workup and technique: Retrosternal goiters may present with airway compression, stridor, and effort intolerance; venous congestion of the head and neck region is not uncommon. A CT scan is indicated as US is not ideal for the evaluation of mediastinal pathology. It is essential to exclude other causes of a mediastinal mass such as lymphoma, thymoma or teratoma. Additional steps required for removal of a large retrosternal goiter include:

- Full neck extension
- Skin incisions are unchanged
- Transection of the strap muscles (sternohyoid & sternothyroid) greatly facilitates exposure of the middle thyroid vein and STA
- Digitally dissecting the gland in the mediastinum with concomitant traction of the already-mobilized superior pole will always result in delivery of the gland into the neck wound
- A delivery instrument such as a sterile spoon or Kielland's obstetric forceps has been reported to facilitate this step, although this has never proven necessary in the authors' experience
- It is MOST UNCOMMON for a thoracotomy to be required
- See chapter: Surgery for retrosternal goitres

Postoperative stridor: Early stridor may be encountered due to a hematoma and/or airway edema; more uncommonly it occurs due to bilateral RLN injury or tracheomalacia. Delayed onset may be due to hypocalcaemia (tetany).

Hematoma: Avoid large, bulky dressings so as not to conceal a hematoma. A large hematoma is a surgical emergency as it may cause airway obstruction.

Seroma: Small seromas are very common and are simply followed clinically and allowed to resorb. Larger, symptomatic seromas may be (repeatedly) aspirated under sterile conditions.

RLN injury: Unilateral RLN paralysis presents as a breathy voice and hoarseness, and less commonly as dysphagia and aspiration. It may not be immediately apparent depending on the resting position of the vocal fold. Bilateral RLN paralysis usually manifests immediately following extubation with stridor or airway obstruction. Should the patient be unable to maintain an adequate airway then emergency tracheostomy or cricothyroidotomy is indicated. Subsequent management depends on the surgeon's knowledge of whether the RLNs were seen to be intact and hence the likelihood of vocal fold function to recover. Options might include a watchful waiting approach for up to a year or CO_2 laser cordotomy/arytenoidectomy.

Continuous electrophysiologic monitoring of the RLN during thyroid surgery: Recent studies have shown that intraoperative monitoring can assist with finding the RLN, but some pitfalls limit its usefulness: there is no consensus about which types of electrodes should be used for EMG registration which is the best method for recording nerve action, or which EMG parameters

should be selected as predictive of postoperative vocal cord dysfunction. The technology is not widely available, and most endocrine surgeons achieve equivalent RLN morbidity rates without it.

Tracheomalacia: This is characterized by flaccidity of the tracheal cartilages which in turn causes tracheal wall collapse. It is thought that a longstanding goiter can act as an external support structure for the trachea and predispose to secondary tracheomalacia. Thyroidectomy unmasks tracheomalacia causing respiratory obstruction. In clinical practice this is an uncommon cause of airway obstruction after thyroidectomy.

Thyroid specific hemostatic devices *(Figure 29):* The last decade has seen the introduction of thyroid specific hemostatic devices *(Ultrasonic scissors / Harmonic Scalpel and Ligasure Device)*, which achieve safe hemostasis and avoid the need for multiple ligatures *(Figure 29)*.

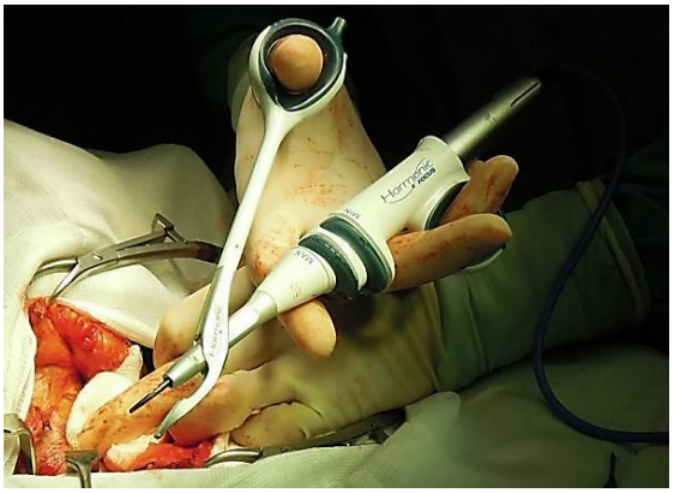


Figure 29: Harmonic Scalpel

A number of randomized trials have shown equivalence between the commercially available products, and a significant reduction in operating time without an increase in complications when compared to standard thyroidectomy technique. The 1st author uses the *Harmonic Scalpel* as a means of sealing and transecting vessels and to reduce surgical operating time.

Minimally Invasive Thyroid Surgery: A number of techniques have evolved in an attempt to reduce the extent of skin incisions and bring the putative benefits of minimally invasive techniques to thyroid surgery. Minimally invasive thyroidectomy can be performed via a limited 2-3 cm neck incision with the visual assistance of an endoscope, specially designed retractors and a harmonic scalpel. An alternative approach is to place incisions for 3-4 ports in the axilla and periareolar regions to avoid a neck scar altogether. The clinical benefits are marginal at best, but they will continue to be driven by patient demand and the industry. Only patients with small thyroid nodules are suitable for such a surgical approach.

Useful References

1. Mohebati A, Shaha AR. Anatomy of thyroid and parathyroid glands and neurovascular relations. *Clin Anat.* 2012;25(1):19-31
2. Bliss RD, Gauger PG, Delbridge LW. Surgeon's Approach to the Thyroid Gland: Surgical Anatomy and the Importance of Technique. *World J Surg.* 2000;24(8):891-7
3. Wang C. The anatomic basis of parathyroid surgery. *Ann Surg.* 1976; 183:271–5

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Surgery for intrathoracic (retrosternal) goiters

Parathyroidectomy

Thyroidectomy under local and regional (cervical plexus block) anesthesia

AfHNS Clinical Practice Guidelines for thyroid nodules and cancers in Developing Countries and Limited Resource Settings

Key Open Access Article: Zafereo M, Yu J, Onakoya PA, et al. African Head and Neck Society Clinical Practice guidelines for thyroid nodules and cancer in developing countries and limited resource settings. Head & Neck. 2020;1–11

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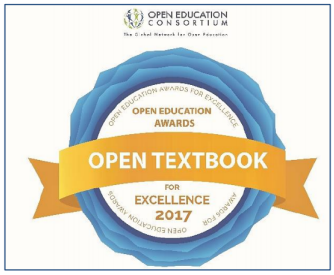
Eugenio Panieri MBChB, FCS
Head: Oncology / Endocrine Surgery Unit
Associate Professor
Division of General Surgery
University of Cape Town
Cape Town, South Africa
eugenio.panieri@uct.ac.za

Author and Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.24: Surgery for Intrathoracic (Retrosternal) Goiter

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Ricard Simo, Iain Nixon, Enyunnaya Ofo

Retrosternal, substernal and intrathoracic goitre is a subgroup of multinodular goiter (MNG). The most commonly recognised and appropriate term is intrathoracic goitre (IG) and for the purpose of this chapter this is the term that is used.

IG presents specific challenges in relation to preoperative evaluation and surgical management. Classic indications for surgery include pressure and cosmetic effects, and higher-than-expected rates of incidental malignancy in a MNG with retrosternal and intrathoracic extension[1].

Multinodular goiter (MNG)(Figure 1)



Figure 1: Example of MNG

MNG refers to an enlarged thyroid gland with multiple nodules. Challenges specific to MNG include evaluating the patient, determining the risk of malignancy within the multiple nodules, selecting patients who require surgery, and planning an appropriate surgical approach to address the disease without undue risk of complications. MNG is generally presumed to be a response to oversecretion of *Thyroid Stimulating Hormone (TSH)*. The thyroid hyperplasia is probably due to reduced production of thyroid hormones relative to the metabolic demand of the body. This can be due to a congenital or an acquired defect.

Morphological and molecular studies suggest a degree of polyclonal etiology. MNGs are sometimes familial and one study suggests linkage to a DNA mother as chromosome 14q[2].

Not all MNGs require surgery. Palpable nodules occur in 4-7% of adults[3]. With the advent of high-resolution ultrasound (USS), nodules and nodular thyroids are detected in 50-70% of adults[4]. In noniodine deficient patients, ultrasound can detect thyroid nodules in >20% of people, and multiple nodules in 9%. Rates are higher in females and in older patients[2,4]. This suggests that an increasing number of patients with MNG will be encountered in an ageing population.

Intrathoracic Goiter (IG)

Concept and Classification

Haller first provided an anatomical description of the IG in 1794; since then it has been given several names and descriptions *e.g.* retrosternal, substernal, retroclavicular and intrathoracic goiter. Numerous classifications have been used *(Table 1)*. Authors have compared these definitions in an attempt to define its utility and allow for sensible comparisons[5]. *Huins et al* indicated a need to apply 3 grades depending on the relationship of the IG to the aortic arch and the right auricle. More recently *Rios et al* critically analyzed all classifications to determine the most useful definition of IG for predicting intra-operative as well as postoperative

complications. They found that most definitions can be ignored as they are not clinically relevant and concluded that Katlic's definition[6] was the most useful for predicting the need for a possible sternotomy to remove an IG[7].

	Year	Journal	No. of Patients	Definition
Clinical	N/A	N/A	201	Clinical Position
Hsu	2000	WJS	201	Manubrium
Kocher	1900	Not published	199	Retrosternal
Torre	2005	Am Surg	199	Sternal fork
Eschapase	1989	Thoracic Surgery	191	Mediastinum
Lahey	1920	JAMA	182	Surgical approach
Lindskog	1957	JAMA	98	4th thoracic vertebra
Crile	1909	Not published	98	Aortic arch
Desouza et al	1983	J Otolaryn-gol	52	>50% gland is IT
Katlic et al	1985	Ann Thorac Surg	52	>50% gland is IT
Sancho et al	2006	Arch Surgery	12	Subcarinal
Huins	2005	Int J Surgery	Review	Reclassifica-tion
Rios	2010	Surgery	Review	Surgical value

Table 1: Classifications of IG after Rios et al [2]

Risk of malignancy

For a thyroid gland to reach sufficient size to pass into the mediastinum, the pathological processes involved must have been present for many years. It is therefore unsurprising that the vast majority of surgical specimens demonstrate benign pathology. The rate of malignancy in reported surgical series is low (6-21%)[8, 9, 10, 11] . However, it is important to consider malignancy as it may significantly alter management.

Clinical presentation

It is not uncommon for IG to manifest in the elderly and many patients are relatively asymptomatic. The thoracic inlet, bound by the clavicles, 1st rib, sternum and vertebrae, contains many vital structures. In addition to the prevertebral muscles, the trachea, esophagus, carotid and jugular vessels all pass through this region. As the thyroid gland enlarges, an increasing percentage of the cross-sectional area of the inlet is occupied by the goiter, leaving less room for other structures. Pressure symptoms tend to develop in low-pressure areas in the first instance, and a feeling of difficulty swallowing is a common initial symptom. As the compression increases, along with increasing *dysphagia*, pressure on the trachea can lead to deformity of the tracheal rings and *airway compression*. In extreme cases, pressure on the venous structures of the neck can cause *superior vena cava syndrome*, although this is rare (5%)[8]. It manifests with distension of the veins in the neck, edema of the face and arms, shortness of breath and dysphagia. Elderly patients often have unrelated comorbidities and require a thorough preoperative evaluation and careful surgical planning and technique.

Airway and tracheomalacia

Airway management may not be straightforward, although truly difficult intubations are uncommon[9]. Cooperation between surgeon and anesthetist is crucial to avoiding problems at this critical stage of the procedure. The majority are amenable to endotracheal intubation, as the endotracheal tube stents the trachea open.

Some patients have symptoms that vary with ***head position***. With the neck fully extended, the goitre is pulled upwards towards the thoracic inlet, and this might compromise the airway. In such cases an awake fiberoptic intubation may be required to allow the neck to be flexed during intubation.

Tracheomalacia is caused by longstanding pressure on the trachea and becomes evident only on completion of surgery. It manifests as stridor following extubation. It is uncommon, and postoperative tracheostomy is rarely required (2%); tracheostomy is more commonly required following ***traumatic intubation causing edema*** rather than for tracheomalacia[9].

Indications for surgery

- ***Symptomatic (compression)***
  - Dysphagia
  - Airway compression
  - Superior vena cava syndrome
- ***Incidental***: Detected with chest X-ray, USS, CT, MRI or PET
- ***Malignancy*** (suspected or confirmed)

Appropriate management should take into consideration the size of the goiter, the degree of aerodigestive tract compression, concerns about malignancy, and comorbidities.

With compressive symptoms, surgery provides the only means of relief and provides tissue for histological analysis. For the few patients with malignancy, resection is the mainstay of therapy, and permits adjuvant radioiodine treatment to be used when indicated.

Indications for surgery in patients in whom IG is incidentally found are unclear. As imaging becomes more widely used, an increasing number (up to 40%) of IGs are detected incidentally during workup of other diseases[8,10]. Some authors consider the mere presence of an IG as an indication for surgery[9] whereas others question the need for surgery in all cases especially if malignancy is not suspected[11]. ***Decision-making regarding surgery in such patients should be individualised.*** For example, a patient with an asymptomatic IG detected on imaging to stage an incurable aggressive malignancy clearly is not a candidate for surgery. In contrast, an otherwise well patient with asymptomatic tracheal compression and an excellent life expectancy will be a good surgical candidate. Surgery in this clinical setting prevents progression of airway symptoms.

The difficult patient is one with little/no comorbidities and asymptomatic disease, with early tracheal compression. Such patients should be made aware of the risks and benefits of both a conservative and a surgical approach. Interval imaging often provides critical information about the trajectory of the disease which assists with decision making in borderline cases.

Preoperative evaluation

Once it has been decided that surgery is indicated, then preoperative evaluation focuses on the following:

Comorbidities: Because many patients are elderly, those requiring an extracervical approach (sternotomy / thoracotomy) need to be carefully assessed as to their general fitness for surgery. Electrocardiography, echocardiography and assessment of lung function should be considered in those requiring sternotomy, and in all other patients with significant cardiorespiratory disease as part of assessment prior to anesthesia.

Assessment of thyroid tumor: Patients should have a full head and neck examination with particular focus on the presence of cervical lymphadenopathy. Ultrasound is used to assess the central and lateral neck.

Fine Needle Aspiration Cytology (FNAC): Even though the incidence of malignancy with retrosternal MNG is low, (ultrasound guided) FNAC assessment may identify malignancy preoperatively and allow for better counselling and preoperative planning of the extent of surgery.

Thyroid and parathyroid function: Thyroid function tests and serum calcium levels are done. Hyperthyroid patients with are medically managed to achieve euthyroidism prior to surgery to prevent a life threatening thyrotoxic crisis during or after surgery. This usually involves thionamide antithyroid drugs, or potassium iodide (40 mg three times daily for 10 days) +/- beta-blockade (*e.g.* propranolol 40-80 mg three times per day).

Vocal cord function: Assessing vocal cord function by indirect or flexible laryngoscopy in the awake patient is essential, not only for medicolegal reasons, but also to determine the function of the contralateral RLN to pre-empt possible airway compromise postoperatively.

Imaging the trachea: In patients with stridor due to tracheal compression, imaging is required to determine the site and length of the tracheal narrowing both for the anesthetist and the surgeon. Even though CT or MRI is preferred, an AP Xray may give a good indication *(Figure 3)*.

Imaging the mediastinum (Figures 4, 5): The relationship of a goiter to the trachea, esophagus and great vessels is readily appreciated on imaging, and guides the surgical approach (cervical +/- sternotomy) which may require the input of other surgical teams, as well as provides invaluable information to the anesthetist about the presence of laryngotracheal compression and likely problems with endotracheal intubation.



Figure 3: X-ray shows tracheal compression and displacement to the right

Patients with (suspected) retrosternal thyroid should have cross-sectional imaging (CT or MRI) with intravenous contrast to define its size, position and anatomical relationships to mediastinal structures. Imaging helps to demonstrate the tissue planes surrounding the thyroid mass. Any evidence of extrathyroidal extension should be considered as evidence of malignancy and the surgical approach tailored accordingly[8].

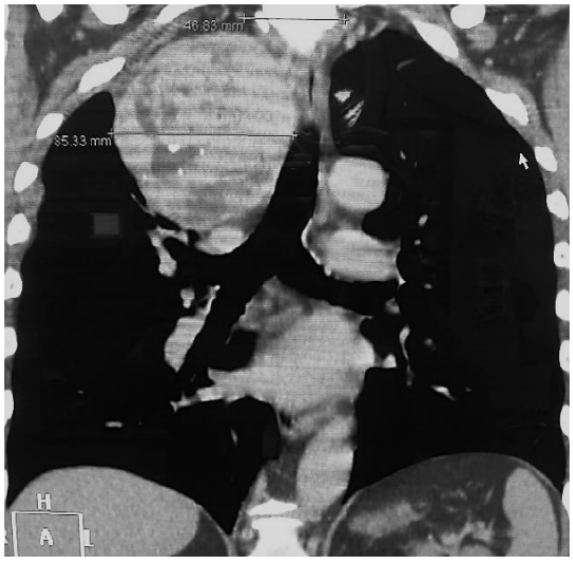


Figure 4: CT of intrathoracic goiter MNG with displacement of trachea to left side

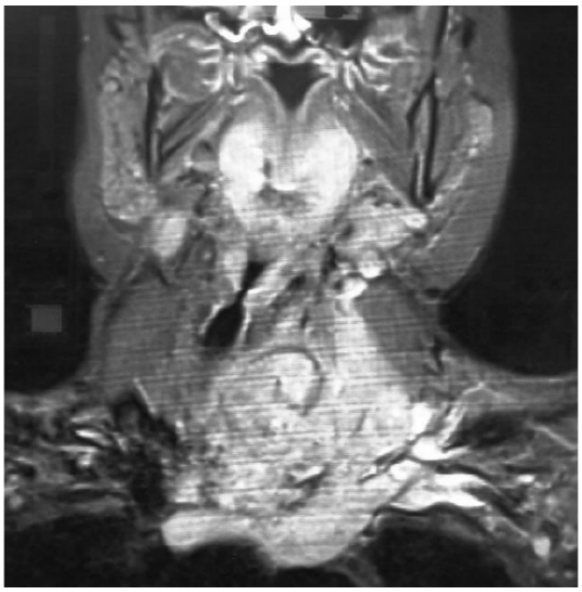


Figure 5: MRI of malignant tumor with poorly defined tissue planes and invasion of internal jugular and brachiocephalic veins

Coagulation status: Exclude clotting disorders to reduce bleeding, discontinue anticoagulants *e.g.* warfarin or *clopidogrel* and substitute with heparin if required

Multidisciplinary team meeting: Once a patient satisfies the indications for IG surgery the multidisciplinary team must set aside time to ensure that the patient and conditions are favorable to proceed and to plan to minimize complications. IG can be associated with significant laryngotracheal compression resulting in difficult orotracheal intubation. Prior to surgery, the surgeon and anesthetist must discuss the airway plan and jointly review the imaging.

Consent

Informed consent is essential. Complication rates from IG surgery are low in experienced hands, but when they do occur, they may be associated with significant morbidity and/or mortality. Patients need to be aware of these risks, especially in the context of an asymptomatic patient with benign disease who may elect to delay surgery and be managed conservatively. However in the context of retrosternal goiter, patients should also be aware that with continued growth, delaying an operation may make future surgery technically more challenging, thus potentially increasing the risk of complications.

Prior to discussing specific risks of surgery, patients are informed of general anesthetic (GA) risks. When the goitre is associated with significant tracheal compression, orotracheal tube intubation may be difficult, and patients should be enlightened that initial airway management may be challenging, though with appropriate preoperative planning and medical/surgical personnel, this should not be insurmountable.

IG surgery is associated with a number of potential life-threatening complications although in specialized centers complication rates are usually low (<5% for bleeding, infection, permanent recurrent laryngeal nerve (RLN) and external branch of superior laryngeal nerve (EBSLN) paralysis and hypoparathyroidism)[12,13]. However it is important that the operating thyroid surgeon regularly audits his/her own complication rates, and informs patients of their own outcomes.

The functional implications of RLN palsy include altered voice, aspiration, or airway obstruction if bilateral. EBSLN palsy may also cause vocal fatigue and impairment of voice pitch and projection. Unrecognized hypoparathyroidism and consequent hypocalcemia may be life threatening. Permanent hypoparathyroidism requires lifelong calcium +/- vitamin D supplementation. In addition, patients need to be made aware of the need for lifelong thyroxine with total thyroidectomy, and unless undergoing a robotic or other minimally invasive approach, that they will have a neck scar that in some ethnic groups, such as Asians or Afro-Caribbeans may become hypertrophic or form keloid. Regardless of surgical approach, there will also be numbness above or below the incision and that may be permanent.

IT surgery may require median sternotomy to remove the superior mediastinal component. Thoracic surgeons usually perform the sternotomy. Patients need to be aware that although uncommon (<5% of patients) complications from median sternotomy may include trauma to mediastinal structures, pneumothorax, pneumomediastinum, mediastinitis, sternal dehiscence, and osteomyelitis.

Anesthesia

Patient position: We previously alluded to possibly worsening airway obstruction by extending the neck; this situation may require blind fiberoptic intubation in an awake patient.

Intubation technique: Extrinsic tracheal compression is generally 'soft 'in nature and can easily be overcome by gentle insertion of an endotracheal tube, which may need to be one size smaller than what is usually used for a patient. Occasionally a stiff introducer may be required to forcefully advance the tube past a narrowed tracheal segment. To avoid the dreaded emergency scenario of 'can't intubate, can't ventilate' at induction of anesthesia in a paralyzed patient, the anesthetist may choose to perform an awake fiberoptic oral/nasal tracheal intubation with the aid of topical local anesthesia.

Choice of endotracheal tube: The anesthetist must be aware of the presence, degree and level of compression of the trachea to select and appropriate diameter, and length of tube. A double lumen endotracheal tube may be required to permit selective pulmonary ventilation. Cases where extensive mediastinal dissection is anticipated require an experienced anesthetist with appropriate head and neck or thoracic anesthetic expertise, as these tubes can be challenging to place in patients with a difficult airway.

Neuromonitoring: Neuromonitoring of the recurrent laryngeal nerve reduces palsy rates with difficult thyroidectomy, such as in retrosternal goitre surgery[14]. Where nerve monitoring is to be employed, longacting muscle relaxants must be avoided so as not to interfere with neural monitoring; short acting agents can be used for induction of anesthesia.

Extubation: At the end of surgery, tracheal compression from a longstanding goiter may cause a degree of tracheamalacia; in our experience extubation is almost always possible. In the highly unlikely event that the patient experiences airway obstruction on extubation due to tracheomalacia, the patient should be reintubated for a minimum of 72 hours until a leak is observed around the endotracheal tube and a tracheostomy performed if necessary[20].

Postoperative monitoring: Patients with significant cardiorespiratory disease requiring median sternotomy are at higher risk of postoperative complications and require close monitoring after surgery in a high dependency or intensive care setting.

Choice of Surgical Approach

Surgery for IG poses significant intra- and postoperative challenges and should ideally be done by experienced surgeons who are part of a multidisciplinary team and have the knowledge and ability to deal with intra- and postoperative complications of the surgery.

Total vs hemithyroidectomy?

Total thyroidectomy is indicated for bilateral thyroid gland enlargement. However, in patients with unilateral enlargement or in whom there is a significant risk to the RLN or parathyroid function, thyroid lobectomy is a perfectively acceptable option as most goiters will be benign[9]. Total thyroidectomy is also contraindicated in settings where thyroid and/or calcium replacement therapy and monitoring is not possible as is the case in many developing countries.

Cervical vs. Extracervical approach?

- Cervical: Suitable for ***95% of IGs***.
- ***Extracervical***: The need for sternotomy increases greatly if a significant proportion of the gland is located in the mediastinum or the IG is in a retrotracheal or retro-esophageal position, or if the intrathoracic component is significantly larger than the cervical one. The main indications for an extracervical approach therefore are giant intrathoracic extension, recurrent goiters, presence of malignancy with extrathyroidal extension, extension posterior to trachea and esophagus, extension between trachea and esophagus, Isolated mediastinal goiters and intrathoracic goiters with diameter greater than the diameter of the thoracic inlet.

Surgical Technique

Management of RLN: The RLN should always be identified. With large goiters, localization of the nerve can be challenging due to distortion of the anatomy. It is not uncommon for the nerve to be riding over a hyperplastic nodule, making it particularly vulnerable. With this in mind, surgeons must be familiar with localizing the RLN either at the cricothyroid joint *(Figure 6)* or laterally at the level of the inferior thyroid artery (ITA).

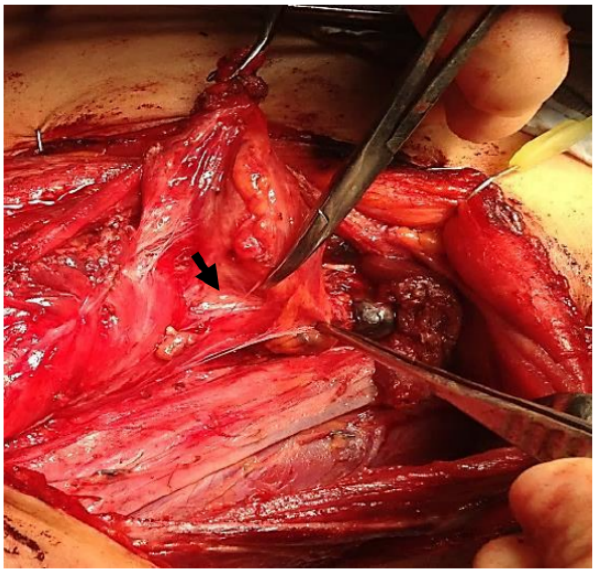


Figure 6: Right recurrent laryngeal nerve (arrow) identified at cricothyroid joint and followed distally using “toboggan technique” as described by Charles Proye

Neuromonitoring: Neuromonitoring for neoplastic MNG is a valuable technique to identify and safely preserve the RLN.

Parathyroid glands: It is imperative to ensure that every effort is made to identify and preserve at least the superior glands which have a more constant anatomical position in close relationship with the ITA. With surgery for large MNGs the parathyroids may be displaced due to aberrant growth of the thyroid gland.

Berry’s ligament: Dissection of Berry’s ligament is one of the most delicate steps of thyroid surgery due to its vascularity and close relationship to the RLN. It is imperative that minimal traction be applied when holding the thyroid lobe to avoid traction injury to the nerve. The ligament is dissected from the nerve with fine instruments, usually with judicious use of bipolar diathermy and fine scalpel dissection.

The following surgical approaches will now be described:

1. ***Cervical***
2. ***Extracervical***
    - Combined cervical & midline sternotomy
    - Combined cervical & lateral thoracotomy

1. Cervical Approach

Surgery for MNG can be challenging due to distortion of anatomy, difficult exposure, and involvement of vital structures.

- ***Incisions:*** In patients with MNG with retrosternal extension, make a generous ***extended Kocher incision*** in the lower neck; the Kocher incision, placed midway between the cricoid and sternal notch, is extended in a skin crease up to the anterior border of the trapezius muscle *(Figure 7)*.

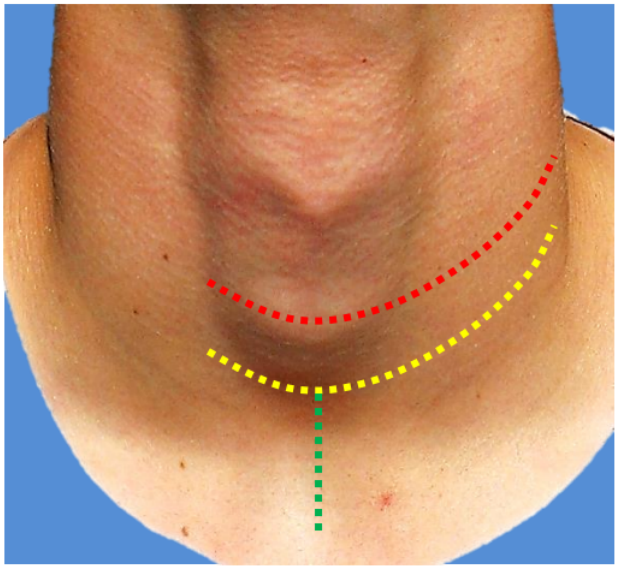


Figure 7: Extended Kocher's incision (yellow), Modified Kocher's incision (red), and vertical incision for sternotomy (green)

If, however, a lateral neck dissection is done then a ***modified extended Kocher incision*** is preferred *(Figure 7)*; this a similar incision as described above, other than that the incision is placed centered over the cricoid prominence to permit exposure of the neck up to the mandible. If a ***midline sternotomy*** is required, then a minor vertical incision is added *(Figure 7)*

- Elevate ***subplatysmal flaps*** laterally up to the trapezius muscle and inferiorly to the clavicle and the sternal notch to allow access to the goiter at the thoracic inlet
- ***Thyroid isthmus:*** Identify and skeletonize and divide the isthmus. If a lobectomy is to be done, the ***isthmus is divided early*** as this facilitates the cervical dissection. With very big bilateral goiters, this can be done early for the same reason, so the procedure becomes essentially two lobectomies. With total thyroidectomy the dissection should ***start with the smaller lobe*** as facilitates subsequent dissection of the larger lobe. In selected cases, following lobectomy on the side of the smaller lobe, divide the isthmus to allow better mobilization of the dominant lobe, reducing cervical pressure and helping to locate the RLNs and the parathyroid glands more easily
- ***Strap muscles:*** In large MNGs, the strap muscles, in particular the sternothyroid, may be divided to achieve better control of regional veins, improve exposure to the lateral aspect of the goiter and superior vascular pedicle, and to provide better access to mobilize the goiter and to visualize the anatomical structures that must be preserved
- ***Middle thyroid vein:*** Identify, dissect, ligate and divide the middle thyroid vein. Avoid rough manipulation of the gland as this may avulse the vein from the internal jugular vein
- ***Superior thyroid pole:*** Dissect the thyroid lobe from the prethyroid strap muscles and divide the sternothyroid muscle for access to the upper pole. Identify the superior thyroid pole and ligate the individual superior thyroid vessels close to the gland to avoid injury to the external branch of the superior laryngeal nerve. Dissect the superior pole from its attachments to the cricothyroid muscle
- ***RLN:*** Once the upper pole is dissected and mobilized, the RLN is identified at the cricothyroid junction and dissected in a caudal direction tunneling the tissue surrounding the nerve with a fine-tipped mosquito dissector *(Figure 6)*. The RLN is dissected inferolaterally as much as the approach allows it under the common carotid artery and brachiochepalic artery and gently controlled with a rubber vessel sling. However, depending on the shape and size of the goiter, the nerve may also be identified in the lateral or inferior position in Beahr's triangle and followed cranially to the cricothyroid joint and caudally to the mediastinum *(Figure 8)*.

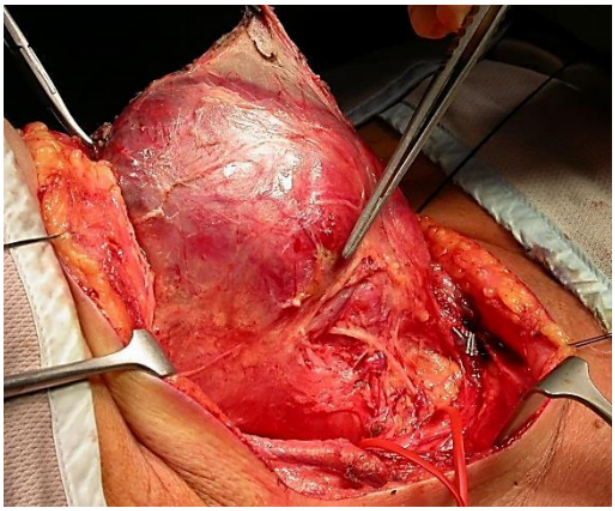


Figure 8: Right RLN identified at Beahr's triangle and followed cranially to cricothyroid joint

- ***Thyroid lobectomy:*** Free the thyroid lobe from its cervical attachments (esophagus & trachea) as much as possible up to the thoracic inlet so that it is freed from its superior mediastinal attachments
- ***Parathyroid glands:*** The parathyroid glands are closely related to the thyroid and may inadvertently be removed even by experienced surgeons. It is more likely to occur with retrosternal goiter surgery as the altered anatomy makes it difficult to locate the parathyroid glands. Every attempt should be made to identify the parathyroid glands in their usual positions close to the inferior thyroid artery and RLN, while preserving their blood supply. The excised thyroid gland should also be carefully inspected for the presence of a parathyroid glands that should then be re-implanted into the sternomastoid muscle

2. Extracervical Approaches

- ***Combined Cervical & Midline sternotomy***
- ***Combined Cervical & Lateral Thoracotomy***

Extracervical approaches require an understanding and experience of surgical techniques to access the mediastinum and the pleural spaces as well as having a dedicated and expert multidisciplinary team including (cardio)thoracic surgeons.

Combined Cervical & Midline Sternotomy

Indications for sternotomy are based on the anatomical relationship of the goitre to mediastinal structures. The indications have already been described above. It comprises 3 main stages:

1. *Cervical stage*
2. *Sternotomy and mediastinal stage*
3. *Thoracic inlet stage*

1. ***Cervical Stage***
    1. Make a standard Kocher (transverse) skin incision *(Figure 7)*
    2. Elevate subplatysmal flaps
    3. Proceed with the dissection as previously described under "*Cervical approach"*
2. ***Sternotomy and Mediastinal Stage***
    1. Completely expose the chest and prepare the skin from neck-to-umbilicus and axilla-to-axilla
    2. Make a midline incision from the cervical wound to the xiphisternum in a T-fashion *(Figure 7)*
    3. Incise the subcutaneous fat down to the sternal periosteum with cautery or a scalpel
    4. Identify the midline superiorly at the sternal notch, inferiorly at the xiphisternum and midway along the sternum by digitally palpating the intercostal spaces
    5. Make a linear incision in the sternal periosteum from top-to-bottom with electrocautery keeping precisely in the midline in preparation for the saw *(Figure 9)*
    6. Divide the xiphisternum with curved Mayo scissors and the suprasternal ligament with electrocautery *(Figure 10)*
    7. Bluntly dissect with a finger and sweep retrosternally at the top and bottom ends of the sternum to expose and prepare a space for the path of the saw

8. Instruct the anesthetist to stop ventilating the patient while the sternum is split along its length with the saw
9. Resume ventilation and control bleeding from the periosteal edges with electrocautery
10. Insert a Holmes-Sellors retractor to expose the mediastinum

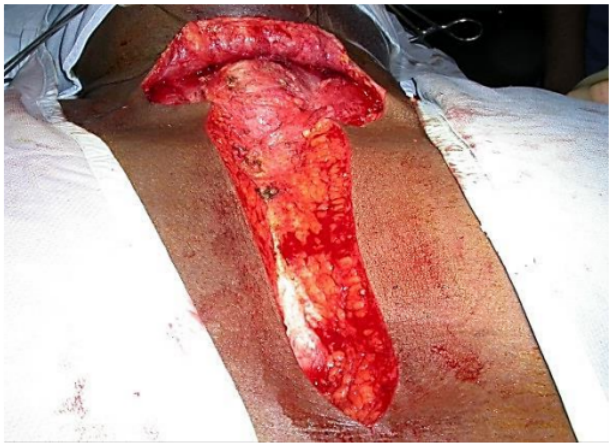


Figure 9: T-shaped cervico-thoracic incision

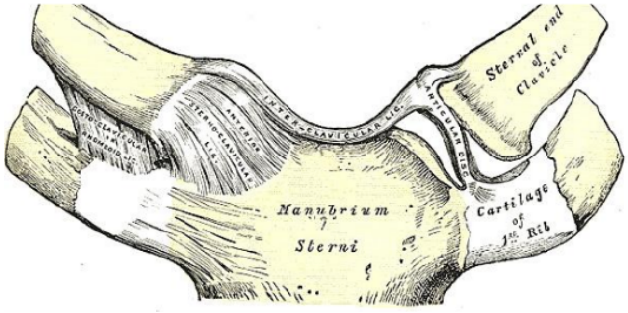


Figure 10: Suprasternal / interclavicular ligament



Figure 11: Holmes-Sellors retractor

- Inspect the mediastinum to clarify the location and extent of the goiter
- Identify the brachiocephalic or innominate vessels and control them with soft rubber vascular slings if necessary
- Take care to minimize unnecessary pleural or pericardial breaches especially if malignancy is suspected. In such cases it is advisable to start the dissection as caudally as possible to clear out mediastinal fat containing lymph nodes
- Once the goiter is identified and mediastinal vessels controlled, commence the dissection in an extracapsular plane anteriorly-to-inferiorly, ligating any extracapsular vessels that are encountered (*Figure 12*)
- Proceed posteriorly and laterally with the dissection
- Deliver the goiter in an upward direction until the thoracic inlet is reached
- Inspect the cavity for bleeding, achieve hemostasis, and ensure that no mediastinal structures have inadvertently been injured

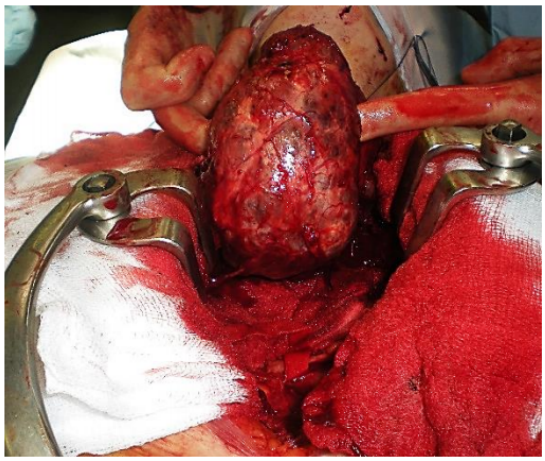


Figure 12: Mediastinal stage with mediastinal dissection of the IG

3. Thoracic inlet stage

- With the thyroid gland mobilized superiorly and inferiorly, commence the dissection to mobilize the gland at the thoracic inlet
- This is the narrowest part of the dissection and leaving it until last allows for easier mobilization of the gland. It also allows better visualization of the RLN which should be carefully dissected from the remaining gland
- Once the thyroidectomy is completed, the wound is washed with warm saline solution. Hemostasis is achieved and a Valsalva manoeuvre is used to ensure that there are no bleeding points
- One or two 28 FG Rocket ® mediastinal drains are inserted up to the level of the thoracic inlet, so the neck also drains adequately, and set at 2-3 kilopascal negative pressure
- Close the wound in layers with absorbable sutures for the platysma and strap muscles
- Close the sternum with several standard titanium wires
- Close the sternal skin incision with subcuticular non-absorbable sutures and with metallic staples for the cervical incision

Combined Cervical & Lateral Thoracotomy

This approach has 2 main stages:

i. Cervical Stage

ii. Thoracotomy, and posterior mediastinal dissection stage It is indicated when a goiter extends into the posterior mediastinum and reaches the posterior pleura and a midline sternotomy would not provide enough space to dissect the goiter from such a posterior location (Figure 13).



Figure 13: IG with extension to posterior pleura

i. Cervical Stage

- The cervical stage follows the same steps as previously described
- Free the thyroid from its cervical attachments (esophagus and trachea) into the thoracic inlet as much as is possible, and from its upper mediastinal attachments
- Amputate the cervical portion of the thyroid using e.g. a Harmonic Scalpel
- Pack 2 or 3 layers of Surgicel ® Fibrillar absorbable hemostat between the RLN and the intrathoracic portion of the goitre to protect the nerve during the final stages of the thoracotomy approach

ii. Thoracotomy & posterior mediastinal dissection stage

- Reposition the patient in a lateral position, but rolled back to simultaneously allow access to the anterior neck and the thoracotomy as needed
- Make a high posterolateral thoracotomy, usually on the right side as the aortic arch and its branches impede access on the left side
- Divide latissimus dorsi and preserve serratus anterior
- Enter the chest through the 4th intercostal space (*Figure 14*)



Figure 14: Lateral thoracotomy with exposure of posterior pleura and posterior aspect of IG

- It is generally necessary to separate the goiter from the superior vena cava anteriorly and from the trachea, taking care not to injure the phrenic nerve
- Take special care not to injure the right RLN as it recurs around the great vessels at the thoracic inlet. The layer of Surgicel ® fibrillar protects the nerve at this stage
- Divide Sibson's fascia as doing so usually makes it possible to join the thoracic and cervical dissections
- Lower down, the innominate vein is often stretched across the goiter; when mobilizing it, take care not to tear the vein or to avulse the veins draining the goiter
- Mobilize the goiter; this is usually best achieved by gentle blunt dissection of the pseudocapsule to avoid tearing the goiter and its feeding veins
- Control bleeding from the vascular surface with packing during the dissection, or with bipolar cautery
- Once the excision is complete, care is taken to ensure hemostasis
- The wound is washed with warm normal saline solution
- A size 28 FG Rocket ® chest drain is inserted and set at 2-3 kilopascals of negative pressure
- The wound is then closed in layers in a standard fashion.
- In the postoperative period regular chest physiotherapy is given to prevent postoperative pneumonia.

Consequences & Complications

Postoperative complications are infrequent in experienced units but need to be recognized and managed timeously to minimize morbidity and mortality.

Post-extubation airway obstruction

With bilateral surgery, transient or permanent bilateral RLNs paralysis may cause life threatening airway obstruction. It may not always be immediately evident following extubation but should be suspected with stridor and respiratory compromise following total thyroidectomy, or with a unilateral procedure in a setting of preexisting contralateral RLN palsy. In cooperative patients, flexible laryngoscopy confirms the diagnosis. Management depends on the degree of respiratory compromise and the surgeon's level of confidence that the RLN paralysis is transient or permanent. This is why neuromonitoring is useful, as a nerve for which an intact monitoring circuit had been confirmed with pre- and post-dissection vagal stimulation will invariably recover [15]. A decision then has to be made to either to institute conservative measures (e.g. supplemental oxygen, adrenaline nebulisers) and to closely monitor the patient's airway, or to reintubate the patient or to do a tracheostomy.

Bleeding & Hematoma

Bleeding may manifest as increased drain output (e.g. >100 mL in <1 hour) and/or an expanding neck hematoma. Both situations require immediate re-exploration of the neck to arrest bleeding to avoid both airway and cardiovascular compromise. Most hematomas occur in the 1 st 24 hours; bilateral surgery has a higher risk compared to thyroid lobectomy. Life-threatening hematomas are uncommon and occurs in <1% of cases [31]. Preoperative evaluation should have identified patients at high risk of bleeding such as those on anticoagulants. An expanding neck hematoma reduces venous return and can quickly cause airway obstruction due to laryngeal edema. Management includes early recognition and immediate evacuation of the hematoma and arresting the source of the bleeding. Airway management may require a tracheostomy or cricothyroidotomy if endotracheal intubation is unsuccessful.

Hypocalcemia

The parathyroid glands may inadvertently be removed even by experienced surgeons. The excised thyroid gland should carefully be inspected for the presence of parathyroid glands that should then be reimplanted into the sternomastoid muscle. Hypoparathyroidism needs to be detected to prevent cardiovascular and neurological complications from hypocalcemia. Following total thyroidectomy, it is common practice to check the adjusted serum calcium levels 6 and 12 hours postoperatively. Levels <1.9 mmol/L should prompt intravenous calcium to be administered (usually 10mls of 10% calcium gluconate over 10-15 minutes) to prevent cardiovascular and neurological consequences of hypocalcaemia. When the surgeon strongly suspects that the parathyroids were compromised during surgery e.g. following central compartment neck dissection, one may elect to commence oral calcium supplements +/- vitamin D immediately postoperatively. Serum parathyroid hormone (PTH) levels can be checked to determine the need for long-term oral calcium supplementation. Patients sent home on oral calcium should be closely followed up to ensure that an appropriate early calcium weaning protocol is followed in patients (majority) that recover normal parathyroid function.

Seroma

Seromas may be reduced if neck drains are used [16], and not removed too early. Despite appropriate drain management, seromas however still occur. Seromas usually settle within 4-6 weeks. Active management by repeated aspiration is only required when for compressive symptoms or cosmetic concerns.

Infection

Because thyroidectomy is a "clean" operation, infection is uncommon and prophylactic antibiotics are not recommended [13]. When it does occur, it usually settles with antibiotics that cover Staphylococcal and/ or Streptococcal bacteria. Very rarely is incision and drainage of an abscess required.

Vocal cord dysfunction

Voice change occurs commonly following thyroidectomy. It is not necessarily due to injury to the RLN but is often caused by laryngeal edema from the endotracheal tube, and postsurgical venous congestion of the larynx. Apart from altered voice that occurs with RLN injury, patients may experience ***swallowing difficulty, aspiration***, and life-threatening ***stridor*** with bilateral RLN paralysis

Vocal cord paralysis due to RLN injury is a potentially serious complication. In cases of retrosternal goitre, the external branch of the superior laryngeal nerve (EBSLN) and RLN are at greater risk due to being displaced by the tumor; this makes anatomical recognition more difficult. Additionally the maneuvers required to deliver a large goiter render the RLN more susceptible to stretching or compression.

Always examine the vocal cords at follow-up not only to assess functional outcome of the surgery, but also because of implications of a paralyzed RLN for swallowing and future contralateral surgery.

When the RLN has obviously been ***transected intraoperatively***, most agree that a tension-free repair of the RLN should be performed.

Airway and swallowing dysfunctions are managed in the perioperative period depending on the ***status of the contralateral RLN***. However, when vocal cord paralysis occurs when the RLN was noted to be anatomically intact at completion of surgery (+/- normal function confirmed with neuromonitoring), then re-exploration is not indicated as the paralysis is invariably temporary. Dexamethasone may possibly reduce the rate of temporary RLN palsy [17].

With ***bilateral RLN injury***, airway compromise is to be expected. Management is dictated by the intraoperative assessment of the RLNs. If the nerves were intact, then patients should be reintubated and managed in a critical care setting with intravenous steroids and a trial of extubation attempted after 48 hours.

Voice therapy by a speech and language therapist/pathologist is an essential aspect of management of RLN or EBSLN injury. Principles of voice therapy include ensuring understanding and knowledge of laryngeal function and rationale of therapy; voice care, managing glottal insufficiency; improving vocal fold adduction; reducing transglottic airflow and improving subglottic air pressure; preventing supraglottic hyperfunction; optimizing resonance and pitch; reducing aspiration; and improving airway clearance. This is best initiated as early as possible for best outcomes. In a small minority of patients with permanent unilateral vocal cord paralysis that do not respond to voice therapy, a variety of vocal cord ***medialization procedures*** can improve voice and swallowing.

Most patients in whom bilateral RLN injury is recognized intraoperatively require immediate tracheostomy to secure a safe airway. Further management depends on patient and tumor factors. Further interventions may not be indicated in patients with advanced disease or significant comorbidities. Laser cordotomy may allow decannulation of fit, motivated patients with reasonable pulmonary reserve.

Thyroid hormone replacement

Hemithyroidectomy is associated with a 12-35% risk of hypothyroidism [18, 19]. Hence patients should have thyroid functions checked within 6-8 weeks. Risk factors for hypothyroidism include high-normal serum TSH levels, lower free thyroxine levels and Hashimoto's thyroiditis [20, 21]. Lifelong thyroid hormone replacement is required following total thyroidectomy, usually in the form of oral levothyroxine, with doses adjusted over a 2-8 weeks to achieve optimum therapeutic levels.

Tracheomalacia

Tracheomalacia refers to weakness of the tracheal wall following resection of a goiter. Although weakness of the cartilaginous trachea has been attributed to longstanding compression causing ischemic damage, the pathophysiology remains poorly understood.

Tracheomalacia causing airway obstruction is very rare. A soft, easily collapsible trachea following goiter resection should be noted on palpation, following which a tracheostomy should be performed to secure the airway. If tracheomalacia was suspected intraoperatively and the patient develops airway obstruction following extubation, it is important to exclude bilateral RLN paralysis. If bilateral RLN paralysis has been excluded, repeat endotracheal intubation is done with a trial of extubation after 48 hours. Waiting 48 hours allows paratracheal fibrosis to occur that reduces tracheal collapse from negative intratracheal pressures. However, one should have a low threshold for tracheostomy for medium to long-term airway management.

Relevant Open Access chapters

Thyroidectomy

Parathyroidectomy

Thyroidectomy under local and regional (cervical plexus block) anesthesia

AfHNS Clinical Practice Guidelines for thyroid nodules and cancers in Developing Countries and Limited Resource Settings

References

1. Nixon IJ, Simo R. The neoplastic goitre. Curr Opinion Otolaryngol Head Neck Surg 2013;21(2):143-9
2. Association BT. Guidelines for the Management of Thyroid Cancer (2nd Edition). In: Physicians RCo, editor. 2nd ed. Great Britain: The Lavenham Press, Suffolk; 2007. p92

3. Ezzat S, Sarti DA, Cain DR, Braun-stein GD. Thyroid incidentalomas. Prevalence by palpation and ultrasonography. Arch Intern Med 1994;154 (16):1838-40
4. Brix TH, Hegedus L. Genetic and environmental factors in the aetiology of simple goitre. Ann Med 2000;32 (3):153-6
5. Rios A, Rodriguez JM, Balsalobre MD, Tebar FJ, Parrilla P. The value of various definitions of intrathoracic goiter for predicting intra-operative and postoperative complications. Surgery 2010; 147(2):233-8
6. Rugiu MG, Piemonte M. Surgical approach to retrosternal goitre: do we still need sternotomy? Acta Otorhinolaryngologica Italica: Organo ufficiale della Societa Italiana di Otorinolaringologia e Chirurgia Cervico-faciale 2009;29(6):331-8
7. Huins CT, Georgalas C, Mehrzad H, Tolley NS. A new classification system for retrosternal goitre based on a systematic review of its complications and management. Int J Surg 2008;6 (1):71-6
8. Katlic MR, Grillo HC, Wang CA. Substernal goiter. Analysis of 80 patients from Massachusetts General Hospital. Am J Surg 1985;149(2):283-7
9. Cohen JP. Substernal goiters and sternotomy. Laryngoscope 2009;119(4): 683-8
10. Coskun A, Yildirim M, Erkan N. Substernal goiter: when is a sternotomy required? Int Surg 2014;99(4):419-25
11. Vasica G, O'Neill CJ, Sidhu SB, Sywak MS, Reeve TS, Delbridge LW. Reoperative surgery for bilateral multinodular goitre in the era of total thyroidectomy. Br J Surg 2012;99(5): 688-92
12. White ML, Doherty GM, Gauger PG. Evidence-based surgical management of substernal goiter. World J Surg 2008;32 (7):1285-300
13. McKenzie GA, Rook W. Is it possible to predict the need for sternotomy in patients undergoing thyroidectomy with retro sternal extension? Interactive Cardiovascular and Thoracic Surgery 2014;19(1): 139-43
14. Goncalves FJ, Kowalski LP. Surgical complications after thyroid surgery performed in a cancer hospital. Otolaryngol Head Neck Surg 2005;132(3): 490-4
15. Randolph GW, Kobler JB, Wilkins J. Recurrent laryngeal nerve identification and assessment during thyroid surgery: laryngeal palpation. World J Surg 2004;28(8):755-60
16. Darr EA, Randolph GW. Management of laryngeal nerves and parathyroid glands at thyroidectomy. Oral Oncol 2013; 49(7): 665-70
17. Hisham AN, Lukman MR. Recurrent laryngeal nerve in thyroid surgery: a critical appraisal. ANZ J Surg 2002;72 (12):887-9
18. Atkinson HS, S. Nerve monitoring in thyroid and salivary gland surgery. J ENT Masterclass 2013;6(1):99-103
19. Sancho JJ, Kraimps JL, Sanchez-Blanco JM, et al. Increased mortality and morbidity associated with thyroidectomy for intrathoracic goiters reaching the carina tracheae. Arch Surg 2006;141(1):82-5
20. Randolph GW, Dralle H, Abdullah H, et al. Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international stan dards guideline statement. Laryngoscope 2011;121 Suppl 1:S1-16
21. Lorente-Poch L, Sancho JJ, Ruiz S, Sitges-Serra A. Importance of in situ preservation of parathyroid glands during total thyroidectomy. Br J Surg 2015;102 (4):359-67

Authors

Ricard Simo FRCS (ORL-HNS)
Consultant Otorhinolaryngologist, Head & Neck Surgeon
Guy's and St Thomas' Hospital NHS Foundation
Trust and Honorary Senior Lecturer
Guy's, King's and St Thomas' Medical School
London, United Kingdom
ricard.simo@gstt.nhs.uk

Iain J. Nixon, MBChB, FRCS (ORLHNS), PhD
Consultant Otorhinolaryngologist, Head & Neck Surgeon
Edinburgh Royal Infirmary, United Kingdom
iainjnixon@gmail.com

Enyunnaya Ofo FRCS (ORL-HNS), PhD
Consultant Otorhinolaryngologist, Head & Neck Surgeon
St George's University Hospital
London, United Kingdom
eofo@hotmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.25: Parathyroidectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Eugenio Panieri & Johan Fagan

Parathyroidectomy is indicated for primary hyperparathyroidism and for secondary hyperparathyroidism refractory to medical treatment *(Figures 1, 2)*.



Figure 1: Typical parathyroid adenoma



Figure 2: Giant sized adenoma

Surgical Anatomy

A detailed knowledge of parathyroid anatomy is essential to perform parathyroidectomy safely and effectively. Particular attention needs to be paid to identifying ectopic or unusually located glands and to avoid injury to important local structures, particularly the recurrent laryngeal nerve (RLN).

There are typically four parathyroid glands; supernumerary glands and <4 glands do occur. The parathyroids are generally located symmetrically in the neck in close proximity to the thyroid gland *(Figure 3)*.

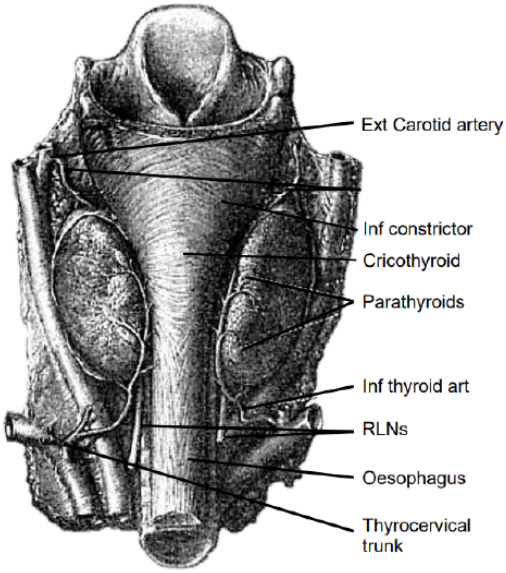


Figure 3: Posterior view of the thyroid gland demonstrating parathyroids, RLNs and superior and inferior thyroid arteries

Their characteristic golden-tan color varies from yellow to reddish brown. Their color permits for them to be distinguished from the pale-yellow lymph nodes, thymus, mediastinal fat, and the dark-red thyroid parenchyma. They have a diameter of about 3-8 mm and are usually oval-shaped, but may also be tear-shaped, drop-like, spherical, elongated, rod-like or flattened.

The ***superior parathyroid*** glands originate from the 4th pharyngeal pouch and adhere to the posterior surface of the caudally migrating thyroid. They have a much shorter distance to migrate than the inferior parathyroid glands; this would account for their more predictable location. They are embryologically and anatomically closely related to the *Tubercle of Zuckerkandl* and are usually found posteriorly at the level of the upper two-thirds of the thyroid about 1cm above the crossing point of the RLN and inferior thyroid artery (ITA) *(Figure 4)*.

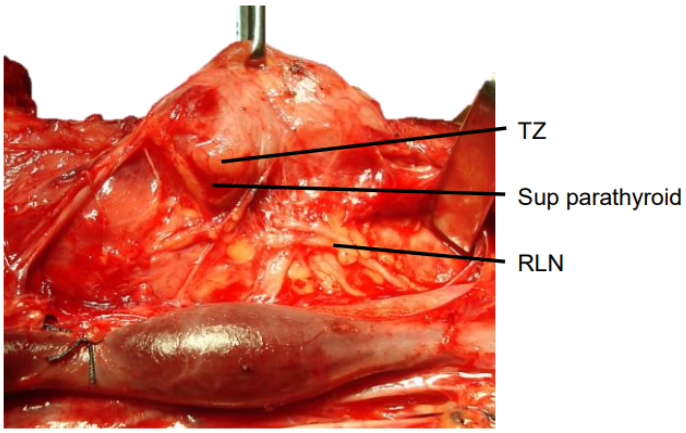


Figure 4: Tubercle of Zuckerkandl (TZ) and its relationship to the superior parathyroid gland and RLN

Ectopic superior parathyroids are uncommon (1%) and may be found in the posterior neck, retropharyngeal and retroesophageal spaces and intrathyroidally *(Figure 5)*.

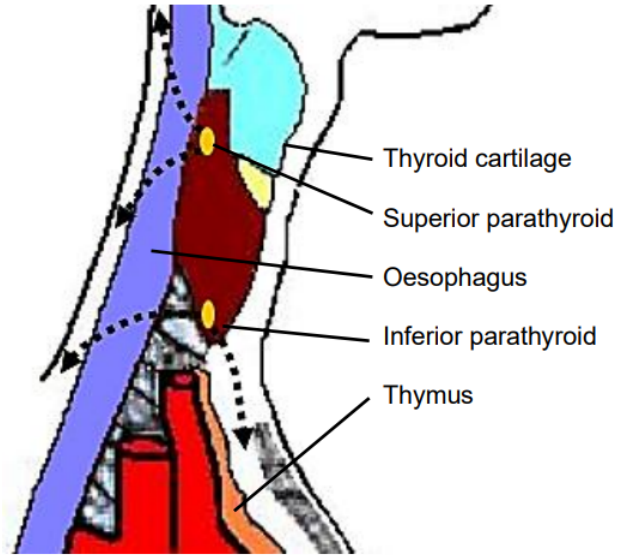


Figure 5: Ectopic parathyroids in retropharyngeal space and mediastinum

The ***inferior parathyroid glands*** arise from the dorsal wings of the 3rd pharyngeal pouches. They join the thymus as it migrates caudally and medially to its final position in the mediastinum. Ectopic inferior parathyroid glands can be found anywhere along this large area of descent from the proximal neck down to the superior border of the pericardium. Their commonest location is on the anterior or the posterolateral surfaces of the lower pole of the thyroid, between the lower pole of thyroid and thyroid isthmus (42%, *Wang et al*); or within the thyrothymic ligament in the lower neck in proximity to the thymus (39%). Other locations include lateral to the thyroid, within the carotid sheath (15%), or within mediastinal thymic tissue and pericardium (2%). *(Figure 5)*.

The inferior parathyroids are usually found in a plane more ventral to that of the superior glands. If the RLN's course is viewed in a coronal plane, then the superior parathyroid glands are located deep (dorsal) and the inferior parathyroid superficial (ventral) to the plane of the nerve *(Figures 6, 7)*.

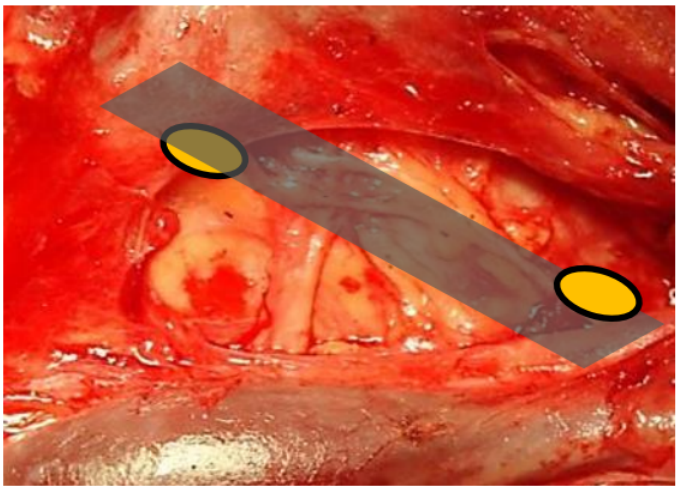


Figure 6: The superior parathyroid gland lies deep (dorsal) and the inferior parathyroid superficial (ventral) to a coronal plane along course of RLN

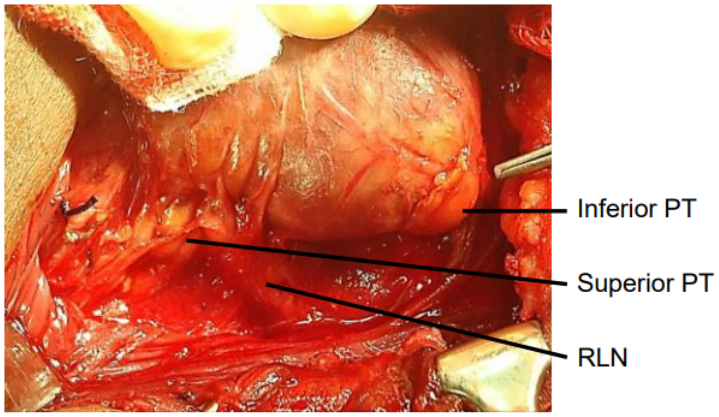


Figure 7: The superior and inferior parathyroids relative to a coronal plane along the course of the RLN

The ***inferior thyroid artery (ITA)*** is a branch of the thyrocervical trunk, which in turn arises from the subclavian artery *(Figures 3, 5)*. It is the ***predominant vascular supply to both the upper and lower parathyroids*** *(Figures 3, 8)*. Consequently, division of the main trunk of the ITA during thyroidectomy is discouraged as it places both parathyroids at risk of ischemic injury.

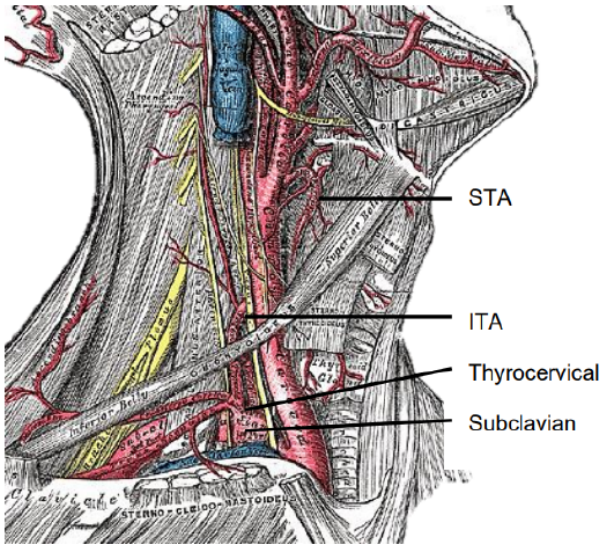


Figure 8: Superior thyroid artery (STA), subclavian artery, thyrocervical trunk and inferior thyroid artery (ITA)

The ITA courses superiorly along the surface of the anterior scalene muscle before turning medially behind the carotid sheath from where it reaches the inferior pole of the thyroid gland. It provides blood supply to the parathyroids, thyroid, upper esophagus and trachea. Its branches communicate with the superior thyroid artery (STA) and with the blood supply of the contralateral thyroid lobe via the thyroid isthmus.

The ***Recurrent Laryngeal Nerve (RLN)*** is a key structure in any exploration of the central neck. Identification and preservation of the RLN during thyroid and parathyroid surgery is essential to minimize morbidity. The RLN innervates all the intrinsic muscles of the larynx except the cricothyroid muscle (SLN) and provides sensory innervation to the larynx. Even minor neuropraxia may cause dysphonia; irreversible injury confers permanent hoarseness. The incidence of RLN injury during thyroidectomy is 0-28% and is the most common reason for medicolegal claims following thyroidectomy; the incidence of injury during parathyroidectomy is much lower.

The RLNs originate from the Xn. After circling around the subclavian artery (right) and aortic arch (left) the RLNs course superiorly and medially toward the tracheoesophageal groove *(Figures 9, 10)*. The right RLN enters the root of the neck from a more lateral direction and its course is less predictable than that of the left. The RLNs enter the larynx deep to the inferior constrictor muscles and posterior to the cricothyroid joint.

The RLN may be ***non-recurrent*** in approximately 0.6% of patients i.e. it does not pass around the subclavian artery but branches from the Xn higher up in the neck, passing directly to the larynx close to the superior thyroid vessels *(Figure 10)*. This aberration

almost always occurs on the right side and is associated with a retroesophageal subclavian artery.

Knowledge of the anatomical relationships of the RLN to the tracheoesophageal groove, ligament of Berry, and ITA is essential. The course of the RLN with respect to the ITA is quite variable. Most commonly it crosses behind the branches of the artery, more predictably so on the left. However, the nerve may pass deep to, superficial to, or between the terminal branches of the ITA. Up to twenty anatomical variations have been described. In *Figure 11* the RLN is seen to pass anterior to the artery.

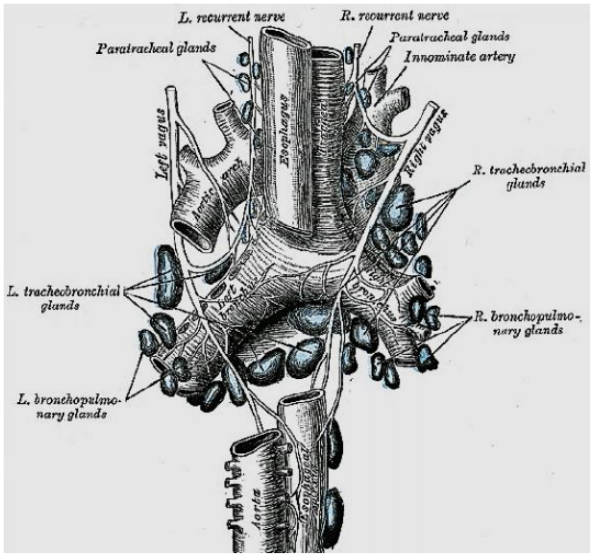


Figure 9: Posterior view of the course of the RLNs

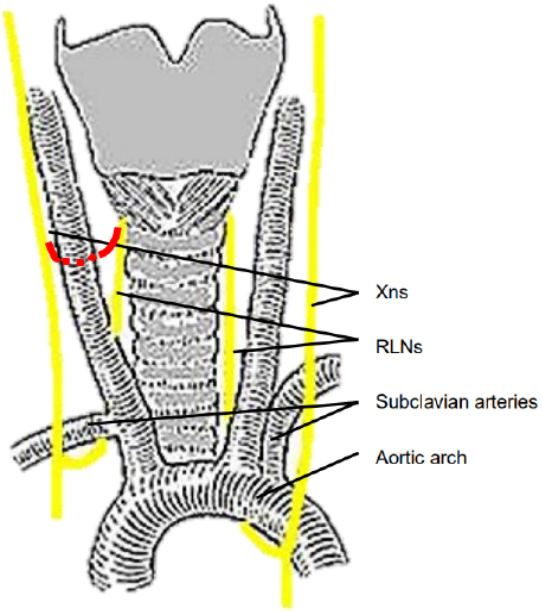


Figure 10: Typical anatomical course of RLNs (non-recurrent RLN in red)

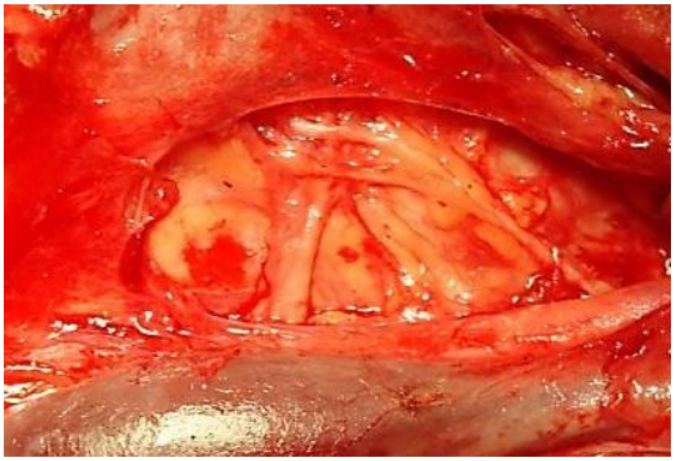


Figure 11: RLN passing over the inferior thyroid artery (right neck, thyroid reflected medially)

The majority of RLNs are located within 3 mm of *Berry's ligament*; rarely the nerve is embedded in it, and more commonly lies lateral to it.

Classically, the RLN is identified intraoperatively in *Simon's triangle*, which is formed by the common carotid artery laterally, the esophagus medially and the ITA superiorly *(Figure 12)*.

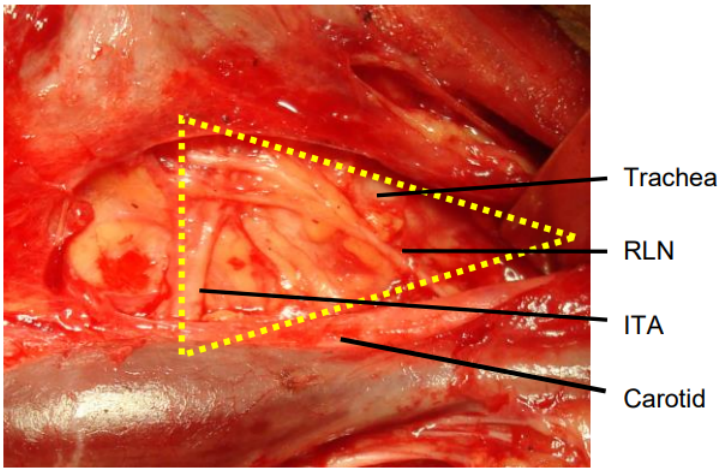


Figure 12: RLN crossing Simon's triangle formed by trachea, ITA and common carotid artery

The *Tubercle of Zukerkandl* may also be used as an anatomical landmark to identify the nerve *(Figure 4)*. The RLN generally courses between this structure and the trachea. However, this relationship can vary with enlargement of the tuberculum thereby placing the nerve at risk during surgical exploration.

Superior Laryngeal Nerve (SLN)

The SLN is a branch of the Xn and has both an external and internal branch *(Figures 13, 14)*. The ***internal branch*** is situated above and outside the normal field of dissection; it is sensory and enters the larynx through the thyrohyoid membrane.

The ***external branch*** innervates the cricothyroid muscle, a tensor of the vocal cord. Injury to the SLN causes hoarseness, decreased pitch and/or volume, and voice fatigue. These voice changes are more subtle than those relating to RLN injury are frequently underestimated and not reported. The external branch is at risk because of its close proximity to the STA *(Figures 13, 14)*. Understanding its relationship to the upper pole of the thyroid and the STA is crucial to preserving its integrity.

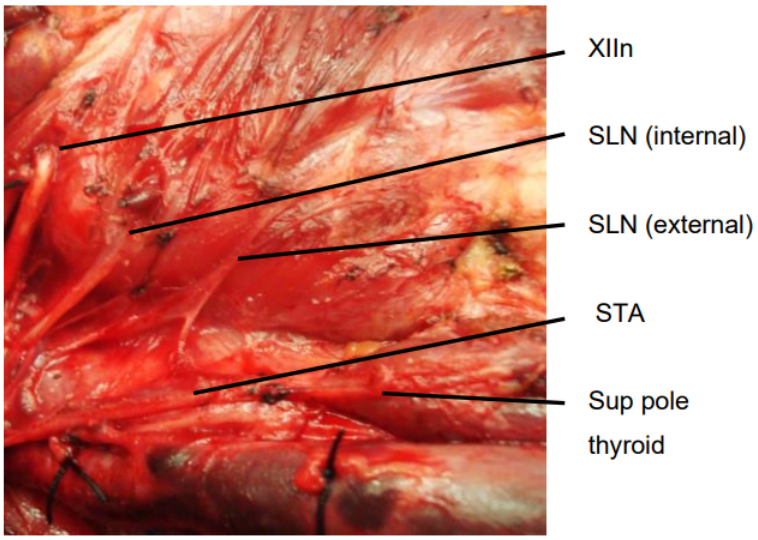


Figure 13: Anatomical relations of internal and external branches of right SLN to STA and to superior pole of thyroid

The usual configuration is that the nerve is located behind the STA, proximal to its entry into the superior pole of the thyroid. The relationship of the nerve to the superior pole and STA is however extremely variable. Variations include the nerve passing between the branches of the STA as it enters the superior pole of the thyroid gland; in such cases it is particularly vulnerable to injury.

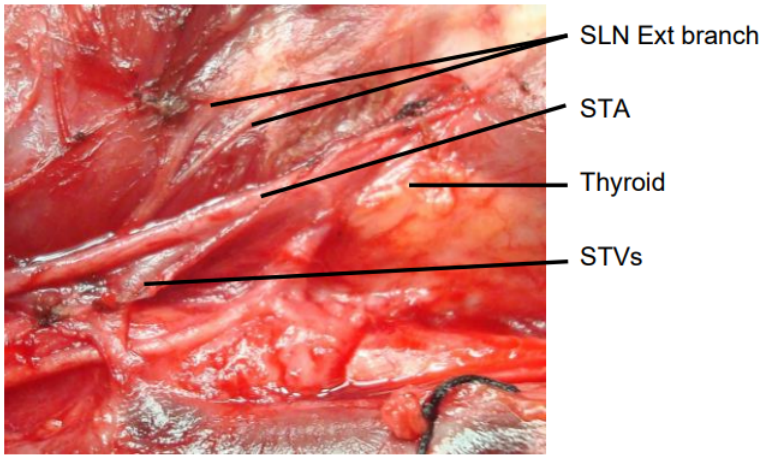


Figure 14: Note close proximity of external branch of SLN to STA and thyroid vein and to superior pole of thyroid gland

Types of parathyroidectomy

Focused parathyroidectomy: This is the usual procedure for a well-localised solitary adenoma. The offending gland is removed through a limited incision with direct exposure of the previously imaged parathyroid adenoma.

Bilateral neck exploration: In cases of unsuccessful preoperative localisation the surgeon explores the necks fully, identifies all four parathyroid glands and removes the adenoma.

Subtotal parathyroidectomy: This is indicated with parathyroid hyperplasia when all the glands have the capacity for increased parathyroid hormone (PTH) production. This occurs in secondary and tertiary hyperparathyroidism and in the unusual situation of primary hyperparathyroidism due to multiple gland hyperplasia. The three largest glands are removed and a small remnant of the most normal-looking gland is either left *in situ* or transplanted to an ectopic site, typically the forearm.

Total parathyroidectomy: All parathyroid tissue is removed. This may be done as a salvage procedure in cases of recurrent secondary hyperparathyroidism.

Preoperative evaluation: Primary hyperparathyroidism

Endocrine diagnosis: The diagnosis of primary hyperparathyroidism hinges on identifying an inappropriately raised PTH assay in the presence of elevated serum calcium. It is not unusual for hypercalcaemia symptoms of primary hyperparathyroidism to be non-

specific and vague; hence it is often underestimated. Typical presentations include recurrent renal calculi, progressive bone density loss, pathological fractures, ill-defined musculoskeletal complaints, neurocognitive impairment, and unexplained abdominal pain; or it may present as a hypercalcemic crisis. While the diagnosis of primary hyperparathyroidism is not difficult to make for surgeons well versed in endocrine disorders, the occasional parathyroid surgeon is well advised to consult an endocrinologist prior to proceeding with surgery.

SestaMIBI scan: This is a nuclear medicine imaging technique with the highest sensitivity and specificity for identification of primary hyperparathyroid adenomas and is the authors' investigation of choice. The use of Technetium^{99m} (Tc^{99m}) sestamibi for parathyroid imaging has led to a steady refinement of imaging. The accuracy is determined by the scanning technique employed; the dual-isotope (I^{123}/ Tc^{99m} sestamibi) scan provides better accuracy than the simpler sestamibi washout method. The pathological parathyroid can be localised preoperatively with great confidence allowing for a quicker and more focused neck exploration. Recent data would suggest that the combination CT99mTc-sestamibi-SPECT (reported sensitivity and specificity of up to 88% and 99% respectively) is the best approach for preoperative localisation with single gland disease. Unfortunately, these favorable results do not apply to all patients with parathyroid disease. It is important to note that failed localisation does not exclude primary hyperparathyroidism and is not a contraindication for surgical exploration.

Ultrasonography (US): The thyroid and surrounding structures can be evaluated with US. It has gained popularity due to the ease of the technique; many endocrine surgeons have the expertise to evaluate the neck in their own offices. Resolution has improved with newer generation equipment. The weaknesses of US are similar to 99mTc-sestamibi i.e. deep superior glands, ectopic glands and too-small glands are difficult to localise, and the mediastinum is inaccessible.

CT and MRI: CT and MRI are not indicated as first line investigations, but may be useful to evaluate parathyroid adenomas with non-localizing imaging studies or previously operated necks.

Preoperative evaluation: Secondary hyperparathyroidism

This diagnosis requires identification of an inappropriately raised PTH assay in the presence of an abnormally elevated serum phosphate-to-calcium ratio. The serum calcium typically falls within the normal range. Secondary hyperparathyroidism is almost always diagnosed in patients with chronic renal failure. Rarer causes include osteomalacia, rickets, and malabsorption. Secondary hyperparathyroidism contributes significantly to renal osteodystrophy and is associated with accelerated atherosclerosis, ectopic soft tissue calcification and skin ulcers in calciphylaxis. It contributes to a general feeling of malaise and musculoskeletal pain seen in chronic renal failure, and chronic pruritus. Close collaboration with a renal physician is essential to determine the best time for surgical intervention.

Preoperative consent

Scar: The incision is typically well-hidden within a natural skin crease of the neck but tends to descend with ageing.

Airway obstruction/wound haematoma: <1% of parathyroidectomy patients are stridulous postoperatively due to a haematoma, edema of the airway or injury to the RLNs.

Voice change: It is essential that the patient has a clear understanding of the risks relating to voice quality prior to surgery. While less common than with thyroidectomy, permanent RLN dysfunction does occur. The risk is highest with repeat surgery or with parathyroid carcinoma.

Hypocalcaemia: Transient hypocalcaemia occurs in approximately 20% of patients following successful removal of adenomas. Paradoxically the higher the levels of calcium and PTH preoperatively, the greater the postoperative drop in calcium. Most patients can be managed on oral calcium supplements until the remaining parathyroid glands re-equilibrate. Hypocalcaemia occurs in ***all cases of secondary hyperparathyroidism*** and requires proactive management with large doses of oral calcium supplements and Vitamin D1-α. Persistent symptoms require intravenous calcium supplementation.

Failed exploration: Some cases of hyperparathyroidism cannot be corrected surgically due to unusual pathology or failure to remove the pathological ectopic parathyroids; the risk of failed exploration is approximately 5%.

Anesthesia, positioning and draping

- General anesthesia with endotracheal intubation; local anesthesia is possible with confident preoperative localisation
- Prophylactic antibiotics are not required
- The neck slightly hyperextended by placing a bolster between the scapulae
- The head is stabilized on a head ring

- The table is tilted to 30º anti-Trendelenberg to reduce venous engorgement
- The head is free draped to allow turning of the head

Surgical technique

Because identification of parathyroid glands is reliant on subtle shades of colour and consistency, the recognition of parathyroid tissue can be impossible in a bloodied surgical field; meticulous haemostasis is therefore critical. Whilst parathyroidectomy is often simple and quick, it is not a procedure that can be rushed and should be booked early on an operating list to avoid undue pressure in terms of available operating time. The surgeon must be calm, unrushed and have a good assistant.

Skin incision: A curvilinear incision is placed in a skin crease approximately two finger breadths above the sternal notch between the medial borders of the sternocleidomastoid muscles *(Figure 15)*. It is seldom necessary to make the incision longer than 4-5cm. Well-localized glands can be resected via a smaller incision. Placing the incision too low causes an unsightly low scar over the heads of the clavicles when the extended neck is returned to its normal position.

Subplatysmal flaps: Subcutaneous fat and platysma are divided, and a subplatysmal dissection plane is developed superiorly (platysma is often absent in the midline) remaining superficial to the anterior jugular veins, up to the level of the thyroid cartilage above, and the sternal notch below *(Figure 16)*.

The skin flaps are secured with a fixed retractor *(Figure 17)*.



Figure 15: Curvilinear skin incision two finger breadths above the sternal notch

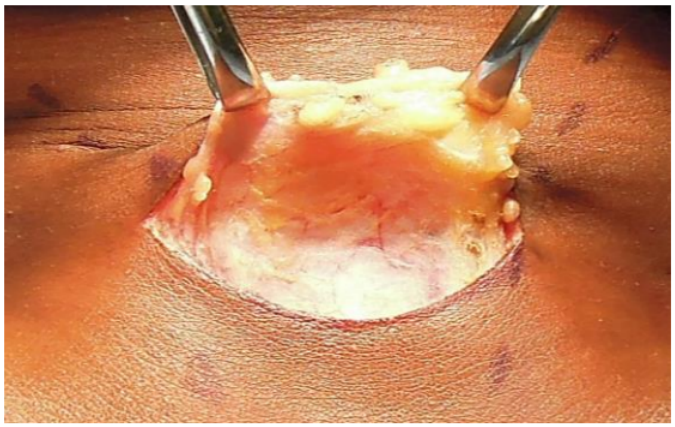


Figure 16: Subplatysmal flaps elevated

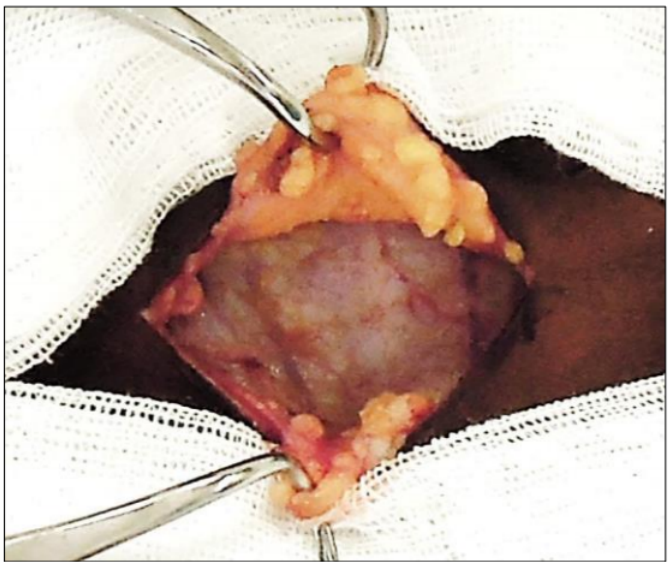


Figure 17: Subplatysmal skin flaps held with Jowell's retractor. Note anterior jugular veins (AJVs)

Surgical Approaches

1. ***Lateral approach*** involves dissecting along the medial border of the sternocleidomastoid muscle to the carotid sheath, and then medial to the sheath up to the thyroid region. This is employed in cases of confident preoperative localisation.
2. ***Anterior approach*** involves medial mobilization of the thyroid gland. This is used in cases of possible bilateral neck exploration. It is favored by the author and is ***described in more detail below.***

Separating strap muscles and exposing the anterior surface of thyroid: The fascia between the sternohyoid and sternothyroid muscles is divided in the midline with diathermy or scissors *(Figure 18)*. This is an avascular plane, though care must be taken not to injure small veins occasionally crossing between the anterior jugular veins, particularly inferiorly. The infrahyoid (sternohyoid, sternothyroid and omohyoid) strap muscles are retracted laterally with a right-angled retractor. In difficult cases the strap muscles may be divided to improve access.

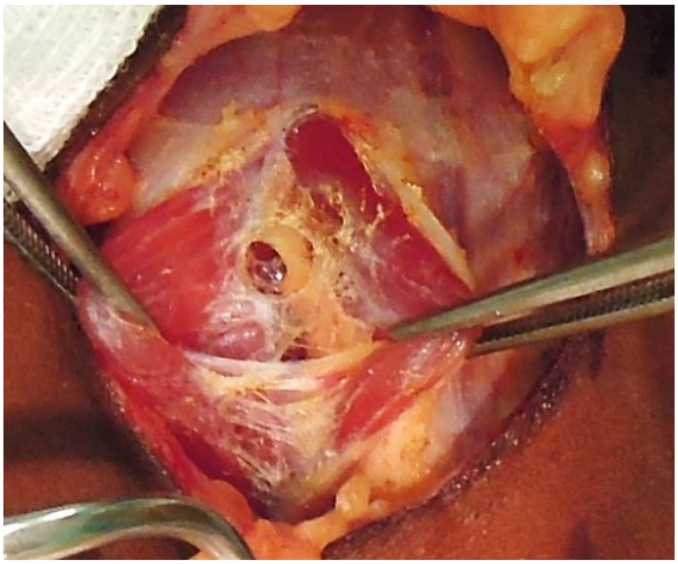


Figure 18: Fascia between sternohyoid and sternothyroid muscles divided to expose thyroid gland

It is usual at this stage for the surgeon to move to the side of the table opposite to the parathyroid to be resected.

Delivery of thyroid towards midline: The infrahyoid (sternohyoid, sternothyroid and omohyoid) strap muscles are retracted laterally with a right-angled retractor. The thyroid gland is delivered medially by applying gentle digital traction to the gland *(Figure 19)*.



Figure 19: Medial rotation of (R) thyroid lobe exposes the middle thyroid vein

Division of middle thyroid vein(s): The vein is the first key vascular structure to be encountered and is tightly stretched by medial traction on the gland *(Figure 19)*. Dividing the vein facilitates additional mobilization of the gland and permits delivery of the bulk of the thyroid lobe into the wound *(Figure 20)*. Although dividing it is not always essential, it is better to do so than to risk tearing it.

If the surgeon is confident about preoperative localisation then dissection is next directed at the parathyroid adenoma.

Identifying superior parathyroid: Full mobilization and anterior delivery of the upper pole of the thyroid brings the region of the superior parathyroid gland into direct view.



Figure 20: Dividing the middle thyroid vein

The superior parathyroid gland is normally located in a posterior position at the level of the upper two-thirds of the thyroid and is closely related to the *Tubercle of Zuckerkandl;* it is about 1cm above the crossing point of the RLN and ITA. If the RLN's course is viewed in a coronal plane, then the superior parathyroid gland lies deep (dorsal) to the plane of the nerve *(Figures 4, 6, 7)*. It has a characteristic rich orange/ yellow color *(Figures 21, 22)*. The (occasional) para-thyroid surgeon may find the parathyroids difficult to identify especially if there has been bleeding in the surgical field, so care must be taken to ensure meticulous haemostasis.

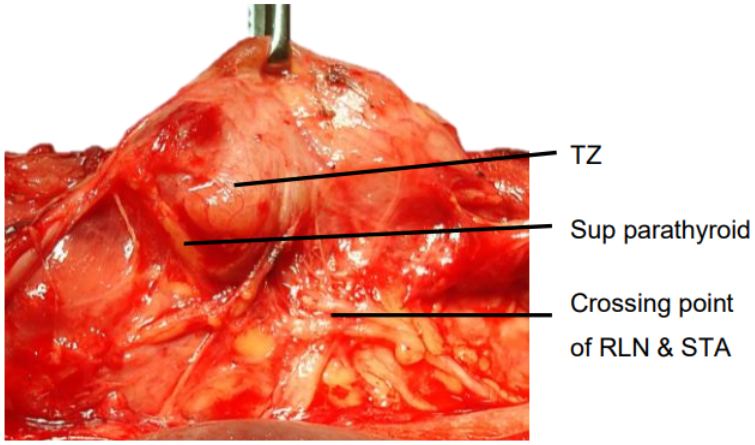


Figure 21: Position of superior parathyroid relative to Tubercle of Zuckerkandl (TZ), RLN and STA

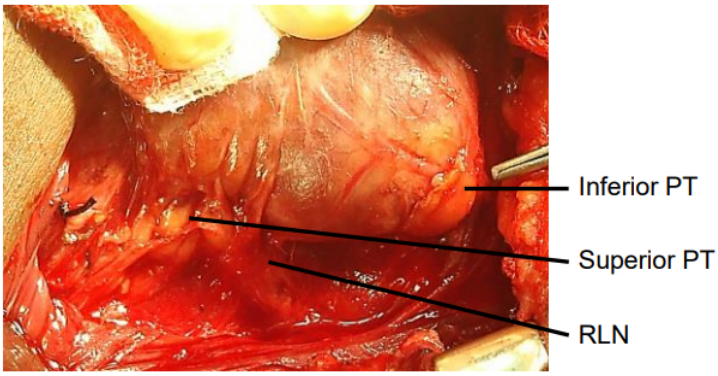


Figure 22: Superior and inferior parathyroids (PT)

The gland must remain *in situ* with blood supply intact. This is best achieved by carefully dissecting it off the posterior aspect of the thyroid gland and using short bursts of bipolar cautery to control bleeding. If the gland still cannot be identified, it is prudent to divide the STA and completely mobilize the upper pole of the thyroid. This will almost certainly bring the superior parathyroid into view.

Identification of inferior parathyroid: The inferior gland is initially looked for at the inferior aspect of the lower pole of the thyroid or within the thyrothymic ligament. If the RLN's course is viewed in a coronal plane then the inferior parathyroid is superficial (ventral) to the plane of the nerve *(Figures 6, 7, 21, 22)*. Its location is more varied than with the superior gland, but if it is at its expected location then it is generally simpler to identify. The inferior parathyroids are most commonly located between the lower pole of the thyroid and thyroid isthmus, most commonly on the anterior or posterolateral surfaces of the lower pole of the thyroid (42%, Wang *et al*), or may be located in the lower neck in proximity to the thymus (39%). Preserving it *in situ* avoids damaging the ITA blood supply.

Removal of adenoma: *(Figures 23, 24)* Once the abnormal parathyroid has been identified, it is removed. Parathyroid tissue can autotransplant if fragmented, so great care is taken to deliver an intact gland by delicately grasping its capsule until the vascular pedicle is identified. This is then be ligated with a 3/0 tie.

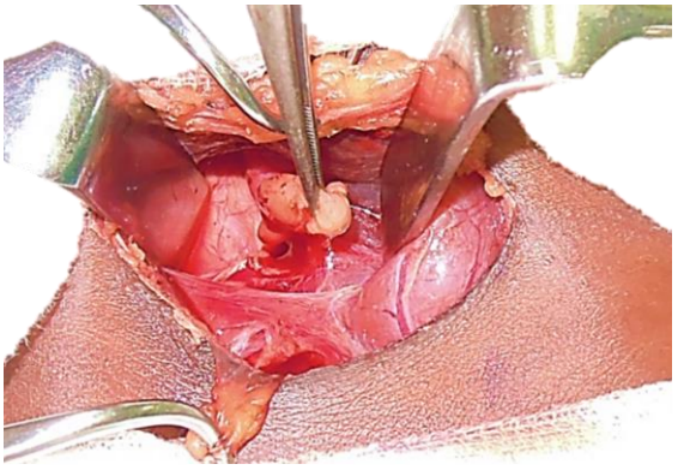


Figure 23: Right superior parathyroid adenoma being removed

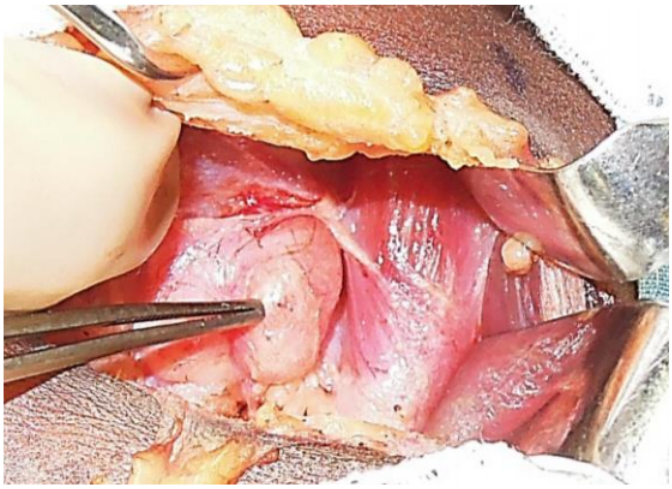


Figure 24: Right inferior parathyroid adenoma

Confirming successful removal: After identifying the parathyroid glands, it is essential to distinguish between normal and pathological glands. Simple rules of thumb are that increased size correlates with pathology, and that marked elevations of calcium and PTH levels are usually caused by larger adenomas. Adenomas are typically more rounded than normal parathyroid glands and have a darker, fleshy parenchymal appearance, sometimes described as similar to a “rat’s heart”. They are typically 1-2 cm in diameter and are significantly heavier than normal glands *(Figure 25)*. Occasionally small adenomas (<1 cm) and very large ones (up to 8 cm) are found *(Figure 1)*.

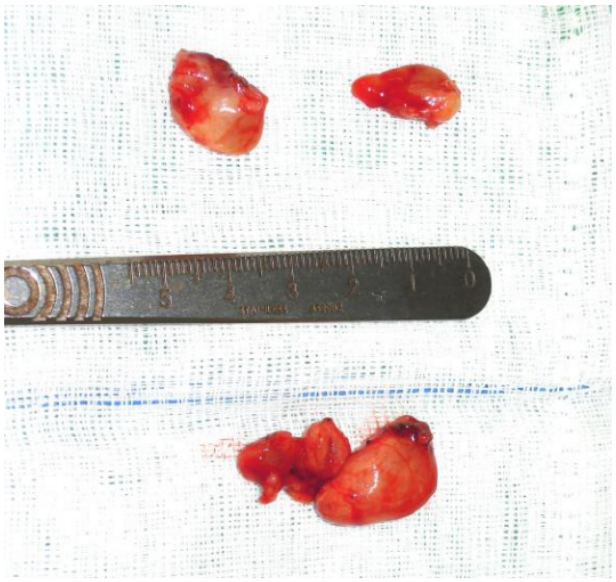


Figure 25: Typical parathyroid adenomas

The occasional parathyroid surgeon is well advised to confirm that abnormal parathyroid tissue has been removed as it is easy to mistake fat, lymph gland, thymus, a superficial thyroid nodule, or normal parathyroid for an adenoma, particularly if the dissection has been difficult. This can be done in two ways:

1. Routine frozen section histology. Distinguishing between parathyroid and other tissue is quick and simple to do; but it is not good for differentiating between normal parathyroid, hyperplastic parathyroid or adenoma.
2. Rapid intraoperative PTH assays (ioPTH) allow endocrine surgeons to record an immediate drop of PTH level as an accurate marker of surgical cure of hyperparathyroidism because of the short half-life of PTH. A large-bore peripheral IV line is used to draw blood for ioPTH levels both prior to (baseline) and following excision of the adenoma. From the time the blood is drawn, the assay takes approximately 15 minutes. It is essential to measure PTH levels as soon as possible to the time of resection of the adenoma as PTH measurements are labile and likely position dependent. A commonly used criterion for curative resection is a 50% drop in ioPTH levels (compared with baseline) at 5, 10, and 15 min following resection; a persistently elevated ioPTH indicates inadequate cure and necessitates further exploration. It requires access to a rapid ioPTH assay machine which should ideally be located in/ close to the operating room to avoid unnecessary delays.

The missing gland: Most parathyroid operations are simple, quick and rewarding for both surgeon and patient. However, on occasion parathyroid glands may be infuriatingly difficult to identify and tests the skill and patience of even the most experienced endocrine surgeon. Surgery is likely to be more complex in the following situations and the occasional parathyroid surgeon should consider referring such cases to an expert:

- Normocalcaemic hyperparathyroidism
- Failed/discordant preoperative localisation imaging
- Concomitant, large multinodular thyroid disease
- Failed previous exploration
- Family history suggestive of MEN syndrome

If exploration fails to reveal convincing evidence of a parathyroid adenoma, then two likely scenarios apply:

- All 4 parathyroids have been found, but none looks convincingly pathological: it is probable that the patient has four-gland hyperplasia, and a subtotal parathyroidectomy is indicated. Frozen section is invaluable to confirm that removed tissue is truly parathyroid tissue
- If 3 normal-looking glands have been identified it is probable that the missing gland is the adenoma and a more exhaustive search is required

A ***missing superior parathyroid gland*** is almost always located where it is meant to be *i.e.* in its *normal position* at the level of the upper two-thirds of the thyroid, in a posterior position, about 1 cm above the point where the RLN crosses the ITA. The surgeon needs to further mobilise the upper pole of the thyroid anteriorly. The parathyroid may be covered by a fine layer of thyroid

capsule; dissecting onto the thyroid parenchyma itself may release it and bring it into view. Should it still not be visible one then needs to transect the STA to fully mobilize the upper pole. If it still cannot be located, then one may be dealing with the rare situation of *ectopic retro-esophageal and retropharyngeal locations* and these regions need to be explored.

A ***missing inferior parathyroid gland*** poses more of a challenge as the anatomical variations are greatest. The following areas need to be systematically explored:

- Lower pole of thyroid.
- Thyrothymic ligament
- Simon's triangle, just below the ITA
- Thymectomy by applying traction to the thyrothymic ligament
- Lateral cervical space, behind the carotid sheath towards the posterior mediastinum
- Carotid sheath
- Retro-esophageal space

If this still fails to identify pathological glands it is then reasonable to abandon the procedure and to consider secondary exploration after more exhaustive imaging 6-12 months later.

Wound closure

- Irrigate the wound
- Do a Valsalva manoeuvre and check for bleeding
- Wound drainage is not routinely required
- Approximate the strap muscles in the midline along 70% of their lengths
- Close the platysma layer with interrupted absorbable 3/0 sutures
- Skin closure is achieved with a subcuticular absorbable monofilament suture
- A light dressing is applied

Postoperative care

- Keeping thorough records is invaluable in cases of recurrent hyperparathyroidism. Therefore, keep meticulous and detailed notes about the extent of the exploration noting which normal parathyroid glands were seen, precisely where they were located and what tissue was removed
- The intravenous line is removed, and a normal diet is taken as tolerated
- Following successful focussed parathyroidectomy the patient may be discharged the same day
- More complex cases are monitored overnight for bleeding or airway obstruction
- Serum PTH levels are routinely measured 24 hours postoperatively. A return to normal PTH levels confirms a successful operation. A hypocalcemic trough occurs 2-5 days postoperatively. Calcium and Vitamin D1α are commenced pre-emptively if the PTH reading is low

Specific Scenarios

Secondary hyperparathyroidism: Up to 90% of patients meeting criteria for haemodialysis have secondary hyperparathyroidism. Surgery is indicated for:

- Calciphylaxis
- Patient preference
- Medical observation not possible
- Failure of maximum medical therapy with persistent hypercalcaemia, hypercalcuria, PTH >800pg/mL and hyperphosphataemia
- Osteoporosis
- Progressive symptoms e.g. pruritus, pathologic bone fractures, ectopic soft tissue calcification, severe vascular calcification, and bone pain

Three different surgical procedures involving bilateral neck exploration are employed for patients with secondary hyperparathyroidism who fulfill criteria for surgery. Each operation has its proponents and an institutional history. There is no convincing evidence of superiority of any one approach:

- Subtotal parathyroidectomy i.e. removing 3½ glands and leaving a ½-gland remnant in situ (author's preference)
- Total parathyroidectomy (four-gland resection) with autotransplantation
- Total parathyroidectomy (four-gland resection) without autotransplantation

Repeat surgery for failed exploration: Such cases should be managed by surgeons well-versed in the subtleties of parathyroid surgery. The following issues need to be carefully considered before embarking on expensive investigations and repeat surgery:

- Is the diagnosis of primary hyperparathyroidism correct, or is there an alternative explanation for the endocrine abnormalities?
- Differentiate recurrent parathyroid disease from persistent hyperparathyroidism: did PTH levels drop following the 1st operation, or did they remain elevated?
- Obtain surgical notes of the primary procedure, histology reports, and postoperative endocrinology records

If a convincing case can be made for reexploration, then the most helpful imaging remains Tc 99m-sestamibi and cervical US. If both are negative, then a CT-scan may add useful information. Whilst potential ectopic locations of parathyroids should be considered, most missed parathyroid glands are located within the cervical region. Repeat neck exploration for persistent or recurrent disease can be very difficult as the normal tissue planes are scarred and it is associated with higher rates of injury to the RLN and permanent hypoparathyroidism. The lateral or ‘‘backdoor’’ approach (dissection between the anterior border of the sternocleidomastoid muscle and posterior border of the strap muscles) may be useful as it provides direct access to the posterior surface of the thyroid gland without encountering scar tissue from previous surgery done through the conventional anterior approach.

Radioguided parathyroidectomy: This technique may be helpful with complex repeat surgery, but the author does not use it for routine parathyroidectomy due to cost and logistic constraints. It is similar to other radioguided techniques such as sentinel lymph node biopsy. A parathyroid-specific radiotracer such as Tc99msestamibi is administered intravenously approximately 2 hours prior to surgery; this time delay allows for a high concentration of isotope to be retained within the parathyroid adenoma whilst it has started to wash out from other sites of uptake such the salivary glands and thyroid. A gamma camera is used intra-operatively to identify the adenoma.

Minimally invasive parathyroid surgery: Several techniques have been devised to reduce the length of the skin incision and to bring the putative benefits of minimally invasive techniques to thyroid and parathyroid surgery. Minimally invasive parathyroidectomy can be performed via a limited 2-3cm cervical incision with visual assistance of an endoscope, but since it can be performed with a similarly sized incision with direct visualization, this technique is not widely used.

Useful References

1. Mohebati A, Shaha AR. Anatomy of Thyroid and Parathyroid Glands and Neurovascular Relations. Clin Anat. 2012;25(1):19-31
2. Wang C. The anatomic basis of parathyroid surgery. Ann Surg. 1976; 183: 271–5
3. Fraser WD. Hyperparathyroidism. The Lancet. 2009;374:145–58
4. Adler JT, Sippel RS, Chen H. New Trends in Parathyroid Surgery. Curr Probl Surg. 2010;47(12):958-1017
5. Lew JI, Solorzano CC. Surgical Management of Primary Hyperparathyroidism: State of the Art. Surg Clin N Am. 2009;89:1205–25
6. Pitt SC, Sippel RS, Chen H. Secondary and Tertiary Hyperparathyroidism: State of the Art Surgical Management. Surg Clin N Am. 2009;89:1227–39

Thyroidectomy under local and regional (cervical plexus block) anesthesia

https://vula.uct.ac.za/access/conten...naesthesia.pdf

Author

Eugenio Panieri MBChB, FCS
Associate Professor
Division of General Surgery
University of Cape Town
Cape Town, South Africa
eugenio.panieri@uct.ac.za

2nd Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.26: Tracheostomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Tracheostomy refers to the creation of a communication between the trachea and the overlying skin. This may be done either by open or percutaneous technique. This chapter will focus on the open surgical technique in the adult patient.

Indications

Tracheostomy is done for airway obstruction, respiratory support (assisted ventilation), pulmonary hygiene, elimination of dead space, and treatment of obstructive sleep apnoea.

Preoperative evaluation

Level of obstruction: A standard tracheostomy will not bypass obstruction in the distal trachea or bronchial tree.

Anatomy of the neck: The surgeon should anticipate a difficult tracheostomy in patients with short necks, thick necks, and necks that cannot be extended due to e.g. rheumatoid or osteoarthritis of the cervical spine.

Coagulopathy: A coagulopathy should be corrected prior to surgery. If not completely corrected, then have electrocoagulation available at surgery to aid haemostasis.

Cardiorespiratory status: Patients with upper airway obstruction may have *cor pulmonale*, or respiratory acidosis. Some patients may be dependent on physiological PEEP to maintain O_2 saturation, or an elevated pCO_2 to maintain respiratory drive; relieving upper airway obstruction with a tracheostomy may paradoxically cause such patients to stop breathing and become hypoxic.



Figure 1: Tracheal deviation due to tuberculosis

Deviation of cervical trachea: A chest X-ray will alert the surgeon to tracheal deviation due to cervical and mediastinal tumors, or traction on the trachea due to fibrosis (*Figure 1*).

Laryngeal cancer: If airway obstruction is because of laryngeal cancer, then one should attempt not to enter the tumor during tracheostomy. This may require a lower tracheostomy if tumor involves the cervical trachea. It is prudent to send a sample from the tracheal window for histological examination as involvement by tumor might be useful information for the surgeon subsequently doing the laryngectomy.

Tracheostomy procedure

A tracheostomy is best done in the operating room with good lighting, instrumentation, suction, diathermy and assistance. Patients may cough on inserting the tracheostomy tube; hence eye protection is recommended to prevent transmission of infections such as HIV and hepatitis.

Anesthesia: Unless the patient can safely be intubated or the patient can be ventilated with a mask, a tracheostomy should be done under local anesthesia. If there is concern about the anesthetist's ability to maintain an airway, then the surgeon should be present during induction; the skin, soft tissue and trachea (into the lumen) should be infiltrated with local anesthesia with adrenaline before induction; and a set of tracheostomy instruments should be set out before induction of anesthesia so that an emergency tracheostomy can be done if required.

Positioning and draping

- Place the patient in a supine position with neck extended by a pillow or bag placed under the shoulders to deliver the trachea out of the thorax and to give adequate access to the cervical trachea.
- Such extension may not be possible in patients with neck injuries, or rheumatoid and osteoarthritis of the cervical spine.
- Some patients with impending airway obstruction may not tolerate a recumbent position; the tracheotomy may then be done with the patient in a sitting position with neck extended.
- Sterilize the skin of the anterior neck and chest and drape the neck.
- If the tracheostomy is being done under local anesthesia, the face be uncovered.

Surface landmarks (*Figure 2*)

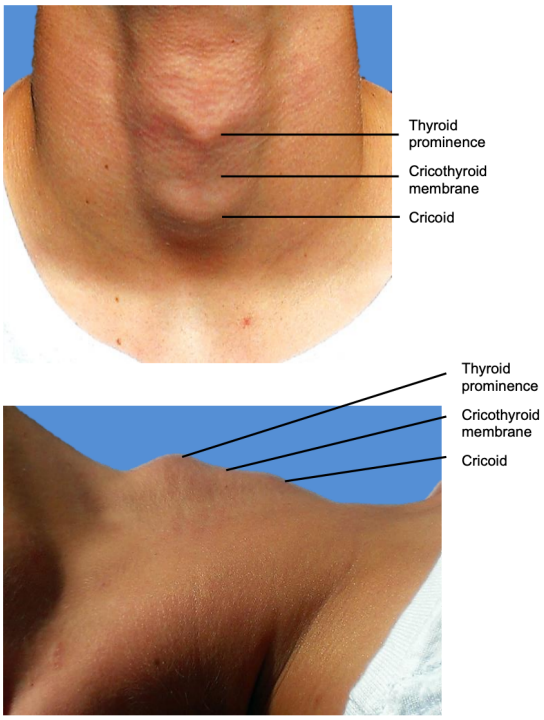


Figure 2: Surface anatomy

- The tracheostomy is created below the 1st tracheal ring to avoid subglottic stenosis as a result of scarring.
- Run your finger up the midline of the neck starting inferiorly at the sternal notch: the 1st prominence encountered is the thyroid isthmus, followed by the cricoid.
- Alternatively, identify the thyroid prominence or "Adam's apple". Moving inferiorly the finger slips into the depression of the cricothyroid membrane, followed by the solid prominence of the cricoid cartilage.



Figure 3: Minimum set of instruments.

- Minimum instruments: A minimum set of instruments is demonstrated in *Figure 3*.

Skin incision

- Make a horizontal incision one fingerbreadth below the cricoid prominence. It is cosmetically preferable to a vertical midline incision.
- Extend the incision through skin and subcutaneous tissue (platysma is generally absent in the midline).

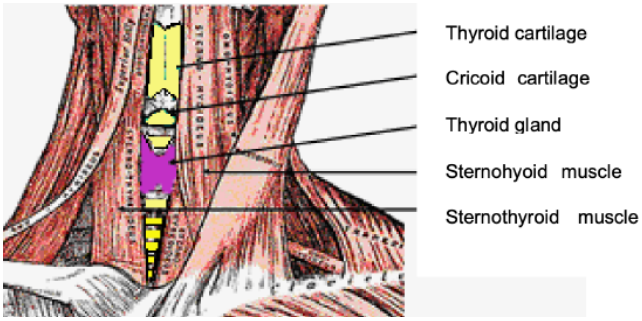


Figure 4: Infrahyoid strap muscles

- Take care not to transect the anterior jugular veins which are just superficial to the strap muscles within the investing cervical fascia. They can be preserved and retracted laterally (*Figure 4*).

Infrahyoid strap muscles

- *Figure 4* illustrates the infrahyoid strap muscles.
- Dissect towards the trachea by parting the tissues with scissors, remaining strictly in the midline in a vertical plane to avoid injury to the inferior thyroid veins.
- Identify the midline cervical fascial plane between the sternohyoid muscles.

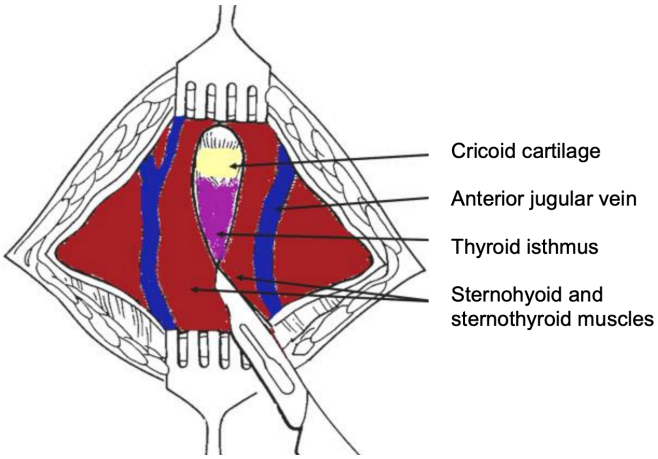


Figure 5: Exposure of anterior jugular veins and cervical fascia

- Divide this intermuscular plane by spreading with a pair of scissors (*Figure 5*).

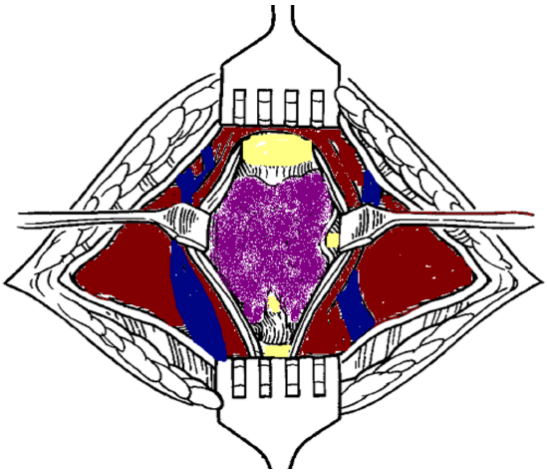


Figure 6: Retracting sternohyoid and sternothyroid muscles exposes the thyroid isthmus

- Repeat this manoeuvre to separate the sternothyroid muscles and retract the muscles laterally (*Figure 6*).
- The trachea and cricoid can now be palpated.

Thyroid isthmus

- The thyroid isthmus overlies the 2nd/3rd tracheal rings.

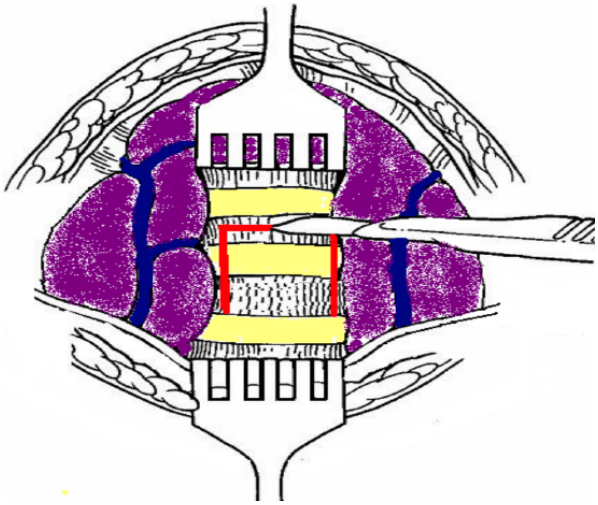


Figure 7: Thyroid isthmus retracted superiorly and an inferiorly based flap cut (along red lines) in anterior tracheal wall

- Retract the isthmus superiorly with Langenbeck retractors to expose the trachea (*Figure 7*).

- Only very rarely does the thyroid isthmus need to be doubly clamped, divided, and (suture) ligated, or if small, divided with eletrocautery.

Expose trachea

- Expose the infrathyroid trachea by carefully parting the overlying soft tissues with a pair of scissors, taking care not to tear the inferior thyroid veins.
- Ensure that the surgical field is completely dry before proceeding, as it is difficult to achieve haemostasis once the tracheostomy tube has been inserted.
- Should there be doubt about the location of the trachea, or there be concern it being confused with the carotid artery, aspirating air with a needle attached to a syringe will confirm its location.

Create a tracheostoma

- In the awake patient, inject lignocaine into tracheal lumen prior to incising the trachea and inserting the tube to reduce coughing.
- A tracheal hook inserted under a tracheal ring may be used to pull superiorly to deliver the trachea from the chest and to stabilize the trachea.
- The safest tracheostomy in adults is to create an inferiorly based flap raised from the anterior wall of the 3rd and 4th tracheal rings.

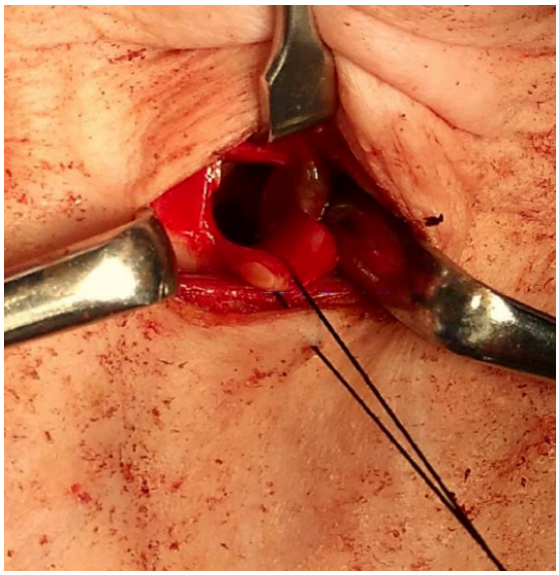


Figure 8: Flap reflected inferiorly with traction suture attached to flap

- A silk traction suture is passed through this anterior tracheal flap and loosely secured to the skin (*Figure 8*).
- Traction on the suture facilitates reinsertion of the tracheostomy tube in case of accidental decannulation and avoids the tube passing into a false tract anterior to the trachea (*Figure 8*).
- Alternately one may remove an anterior cartilage segment of the 2nd, 3rd or 4th tracheal rings.

Insertion of tracheostomy tube

- Assess the size of the trachea and select the largest cuffed tracheostomy tube that comfortably fits the tracheal lumen.
- Inject air into the inflatable cuff of the tracheostomy tube to test the integrity of the cuff.

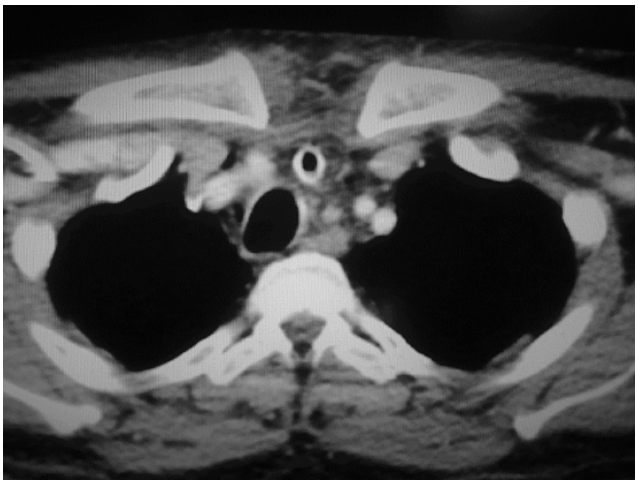


Figure 12: Tracheostomy tube visible in a paratracheal false tract

- Insert the introducer into the tracheostomy tube (*Figure 12*).
- If the patient has been intubated, the anesthetist slowly withdraws the endotracheal tube until the tip of the tube is visible in the stoma.
- Insert the tracheostomy tube into the tracheostomy under direct vision while applying traction to the silk traction suture attached to the tracheal flap.
- Ensure that the tube has been inserted into the tracheal lumen, and not into a false passage in the paratracheal soft tissues.
- Inflate the cuff, attach the anesthetic tubing.

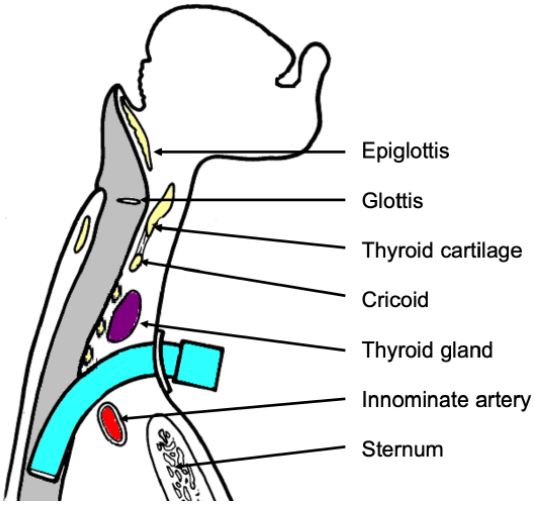


Figure 9: Position of tracheostomy tube

- Hand-ventilate while correct placement of the tube within the trachea is confirmed by checking the expired pCO_2, checking for chest movement or listening for breath sounds (*Figure 9*).
- Do not suture the skin tightly around the tracheostomy tube as this can promote surgical emphysema.

Securing the tracheostomy tube

- Thread tapes through the holes in the flanges of the tracheostomy tube and pass them around the neck.
- Tie them with the neck flexed.
- If the tapes are tied with the neck extended, then they will be too loose when the patient flexes the neck.



Figure 10: Tracheostomy tube secured with Velcro tape

- The ties should be tight enough to admit no more than a single finger under the tape (*Figure 10*).

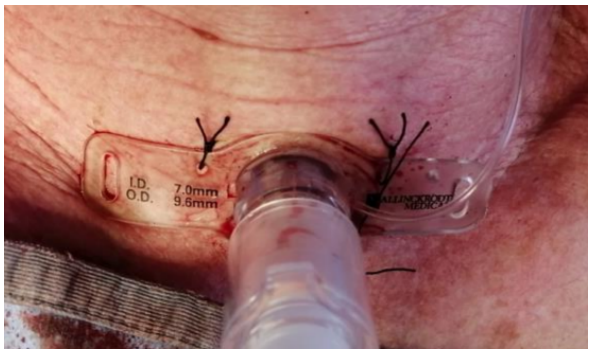


Figure 11: Tracheostomy tube sutured to suprastomal skin

- The author sutures the tracheotomy tube to the skin for the first few days until maturation of the tracheocutaneous tract (*Figure 11*).
- The sutures can then be removed, and only traditional tracheotomy tapes used.
- Following free microvascular transfer flap reconstruction, tracheostomy tapes should be avoided as tracheal tapes may cause jugular vein compression, thrombosis, venous outflow obstruction and flap failure; the tracheostomy should preferably be sutured to the suprastomal skin (*Figure 11*).

Pitfalls

Low tracheostomy: A tracheotomy should not be placed below the 4th tracheal ring as:

- The distance between the skin and the trachea increases inferiorly, which makes tracheal intubation more difficult.
- A low tracheostomy may compress and erode the innominate artery which passes between the manubrium sterni and the trachea (*Figure 9*). This may cause innominate artery erosion and fatal haemorrhage. This may be preceded by a so-called “sentinel bleed.”

High tracheostomy: It is important not to place the tracheotomy above the 2nd tracheal ring, as inflammation may cause subglottic oedema, chondritis of the cricoid cartilage, and subglottic stenosis.

Paratracheal false tract (*Figure 12*): Inadvertent extratracheal placement of the tracheostomy tube can be fatal. It is recognized by the absence of breath sounds on auscultation of the lungs, high ventilatory pressures, failure to ventilate the lungs, hypoxia, absence of expired CO_2, surgical emphysema, and an inability to pass a suction catheter down the bronchial tree, and on chest X-ray.

Surgical emphysema, pneumomediastinum, and pneumothorax: Injury to the pleural domes is more likely to occur in children, struggling patients and patients on positive pressure ventilation. It can be complicated by a tension pneumothorax. Hence auscultation of the chest and a CXR should be performed after tracheostomy, especially in ventilated patients. Surgical emphysema may also be promoted by suturing the tracheostomy wound around the tracheostomy tube.

Airway fire: Do not enter the trachea with diathermy as this may cause an airway fire in a patient being ventilated with a high concentration of oxygen.

Choice of Tracheostomy Tube



Figure 13: Plastic low pressure cuffed tracheostomy tube with outer cannula, inner cannula and introducer (L to R)

A variety of tube designs and materials are available. The choice of tube should conform to the indication for which it is to be used. ***All tubes should have an inner cannula***; this can safely be removed and cleaned without a need to remove the outer cannula and hence avoids risking losing the airway (*Figure 13*).

The following factors may influence the choice of tube:

Tube diameter: Because airway resistance is related to the 4^{th} power of the radius with laminar flow, and the 5^{th} power of the radius with turbulent flow, it is important to select a tube that that fits the trachea snugly. A range of sizes should be available. It also underscores the importance of keeping the tube clean, as accumulation of mucus increases airway resistance not only by reducing the diameter, but also by causing turbulent air flow.



Figure 14: Metal tracheostomy tube with outer cannula, inner cannula and introducer (L to R)

Tracheal seal: A cuffed, plastic tracheostomy tube is used to create a seal with the trachea in patients on positive pressure ventilation, and with fresh tracheostomy wounds (*Figure 13*) to prevent saliva or blood entering the lower airways. The cuffed tube may be replaced with an uncuffed tube, either plastic or metal (*Figure 14*) in patients who do not require positive pressure ventilation once the tract between the skin and the trachea has become well defined by granulation tissue at 48 hours, and tracheostomal bleeding has settled.

Tube material: Metal tubes are thinner walled, and hence have a better ratio of outer to inner wall diameter, thereby optimizing airway resistance (*Figure 14*).



Figure 15: Tracheostomy tube with adjustable flange

Tube length: Patients with very thick necks can be fitted with a tracheostomy tube with a flange that can be adjusted up or down the shaft of the tube (*Figure 15*). Tube length may also need to be adjusted when the carina is close to the tracheostoma or with tracheal stenosis or tracheomalacia distal to the tracheostoma that needs to be stented by the tube. Chest and neck X-rays are of value to determine the required length.

Tube shape: Laryngectomy patients require shorter tubes with a gentler curvature to conform to the stoma and the trachea.

Neck Flange: The neck flange should conform to the shape of the neck and fit snugly against the skin to avoid excessive tube movement, accidental decannulation, and soft tissue trauma.



Figure 16: Fenestrated tracheostomy tube



Figure 17: Speaking valve that fits onto the end of a tracheostomy tube and permits hands-free speech

Phonation: Patients with uncuffed tubes or fenestrated tubes (*Figure 16*) can phonate by occluding the end of the tracheostomy tube with a finger which permits air to bypass the tube and to pass through the larynx. Speaking valves fitted to the ends of tracheostomy tubes are one-way valves that open on inspiration, but close on expiration, thereby directing expired air through the larynx and permit hands-free speech (*Figure 17*). Fenestrated tubes with speaking valves are particularly well suited to patients with obstructive sleep apnoea, as they can have normal speech by day with the valve in place but uncap the tracheostomy tube at night to ensure unobstructed breathing.



Figure 18: Tracheostomy with suction port

Suction port: In patients with secretions pooling above the cuff e.g. a laryngectomy patient with a pharyngocutaneous fistula, one can protect the patient from aspirating saliva or feeds by inserting a tracheostomy tube with a suction channel that is connected to negative suction (*Figure 18*).

Postoperative care

Pulmonary oedema: This may occur following sudden relief of airway obstruction and reduction in high intraluminal airway pressures. It may be corrected by CPAP or positive pressure ventilation.

Respiratory arrest: This may occur immediately following insertion of the tracheostomy tube and is attributed to the rapid reduction in arterial pCO_2 following restoration of normal ventilation, and hence loss of respiratory drive.



Figure 19: Tracheostomy bib

Humidification: Tracheostomy bypasses the nose and upper aerodigestive tract which normally warms, filters, and humidifies inspired air. To avoid tracheal desiccation and damage to the respiratory cilia and epithelium and obstruction due to mucous crusting, the tracheostomy patient needs to breathe humidified warm air by means of a humidifier, heat and moisture exchange filter, or a tracheostomy bib (*Figure 19*).

Pulmonary Toilette: The presence of a tracheostomy tube and inspiration of dry air irritates the mucosa and increases secretions. Tracheostomy also promotes aspiration of saliva and food as tethering of the airway prevents elevation of the larynx during swallowing. Patients are unable to clear secretions as effectively as a tracheostomy prevents generation of subglottic pressure, hence making coughing and clearing secretions ineffective; it also disturbs ciliary function. Therefore, secretions need to be suctioned in an aseptic and atraumatic manner.

Cleaning the tube: Airway resistance is related to the 4^{th} power of the radius with laminar flow, and the 5^{th} power of the radius with turbulent flow. Therefore, even a small reduction of airway diameter and/or conversion to turbulent airflow as a result of secretions in the tube can significantly affect airway resistance. Therefore, regular cleaning of the inner cannula is required using a pipe cleaner or brush.

Securing the tube: Accidental decannulation and failure to quickly reinsert the tube may be fatal. This is especially problematic during the 1^{st} 48 hours when the tracheocutaneous tract has not matured and attempted reinsertion of the tube may be complicated by the tube entering a false tract. Therefore, the tightness of the tracheostomy tapes should be regularly checked. Traction sutures on the tracheal flap facilitate reinsertion of the tracheotomy tube.

Cuff pressures: When tracheostomy tube cuff pressures against the tracheal wall mucosa exceed 30 cm H_20, mucosal capillary perfusion ceases, ischemic damage ensues and tracheal stenosis may result. Mucosal injury has been shown to occur within 15 minutes. Therefore, cuff inflation pressures of >25 cm H_20 should be avoided. Several studies have demonstrated the inadequacy of manual palpation of the pilot balloon to estimate appropriate cuff pressures. Measures to prevent cuff related injury include:

- *Only to inflate the cuff if required* (ventilated, aspiration).
- *Minimal Occluding Volume Technique*: Deflate the cuff, and then slowly reinflate until one can no longer hear air going past the cuff with a stethoscope applied to the side of the neck near the tracheostomy tube (ventilated patient).
- *Minimal Leak Technique*: The same procedure as above, except that once the airway is sealed, slowly to withdraw approximately 1mL of air so that a slight leak is heard at the end of inspiration.
- *Pressure gauge*: Regular or continuous monitoring of cuff pressures.
- *Transport in unpressurized aircraft*: Fill the cuff with water or saline as the reduction in air pressure during flight causes an air-filled cuff to expand.

Decannulation

A tracheostomy tube can be removed once the cause of the airway obstruction has been resolved. If any doubt exists about adequacy of the airway e.g. following pharyngeal or laryngeal surgery, then the tracheostomy tube is first downsized so that the patient can breathe freely past the tube. The tube is then plugged. The patient should be closely observed during this time and may be monitored with pulse oximetry. If the patient can tolerate the tracheostomy tube being plugged overnight, it can then be removed. The tracheostomy wound is covered with an occlusive dressing, and generally heals within a week without suturing the skin.

Percutaneous dilational tracheostomy surgical technique

Cricothyroidomy

Pediatric tracheostomy

Closure of pediatric tracheocutaneous fistula – surgical technique

Author

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.27: Cricothyroidotomy and Needle Cricothyrotomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Cricothyroidotomy, also known as cricothyrotomy refers to the creation of a communication between airway and skin via the cricothyroid membrane. It may be achieved by needle cricothyrotomy or by open or percutaneous cricothyroidotomy technique. Advantages of cricothyroidotomy compared to tracheostomy include simplicity, speed, relatively bloodless field, minimal training required, and avoiding hyperextending the neck in patients with possible cervical spinal injury.

Indications

1. Airway obstruction proximal to the subglottis
2. Respiratory failure
3. Pulmonary toilette in patients unable to clear copious secretions
4. Bronchosopy

For indications (1) and (2), cricothyroidotomy is generally done as an ***emergency temporizing procedure*** when a patient cannot be intubated, or when tracheostomy would be too time consuming or difficult. Following cricothyroidotomy the patient should be ***intubated or a formal tracheostomy done within 24 hours*** to avoid complications such as glottic and subglottic stenosis.

Contraindications

- Inability to identify surface landmarks (thyroid cartilage, cricoid, cricothyroid membrane) due to e.g. obesity, cervical trauma
- Airway obstruction distal to subglottis e.g. tracheal stenosis or transection
- Laryngeal cancer: Other than for an extreme airway emergency, avoid a cricothyroidotomy so as not to seed the soft tissue of the neck with cancer cells
- Coagulopathy (other than emergency situation)

Cricothyroidotomy in children

The cut-off age beyond which surgical cricothyroidotomy can be safely performed is unclear. The most conservative cut-off age quoted is 12 years; in young children the cricothyroid membrane is smaller, the larynx is more funnel-shaped, rostral, and compliant and cricothyroidotomy may be more prone to causing subglottic stenosis. Hence needle cricothyrotomy (12-14 gauge cannula passed over a needle) is preferred.

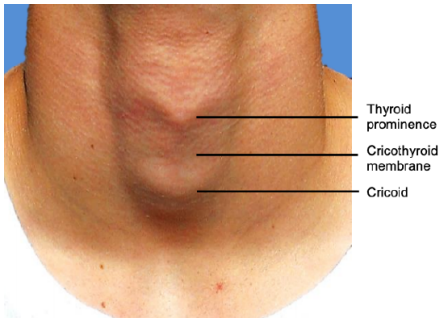


Figure 1a: Surface anatomy

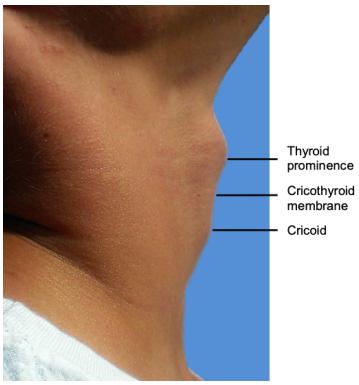


Figure 1b: Surface anatomy

Surface anatomy (*Figures 1a, b*)

With the neck in a neutral or extended position, identify the midline thyroid prominence or “Adam’s apple”. Moving inferiorly, the next solid prominence in the midline is the cricoid cartilage. Immediately above the cricoid the finger slips into the depression of the cricothyroid membrane.

Surgical Anatomy

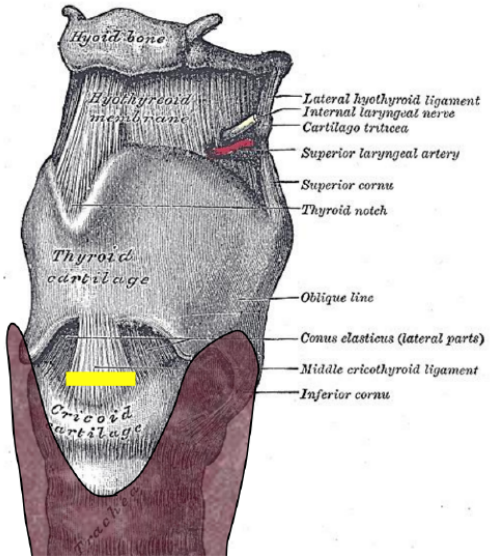


Figure 2: Relations of thyroid cartilage, cricothyroid membrane, cricoid cartilage, and thyroid gland (Brown) to location of cricothyroidotomy (Yellow line)

A cricothyroidotomy enters the larynx in the midline just below the vocal cords. The incision passes through skin, subcutaneous fat, middle cricothyroid ligament of cricothyroid membrane, and mucosa of subglottic larynx (*Figure 2*).

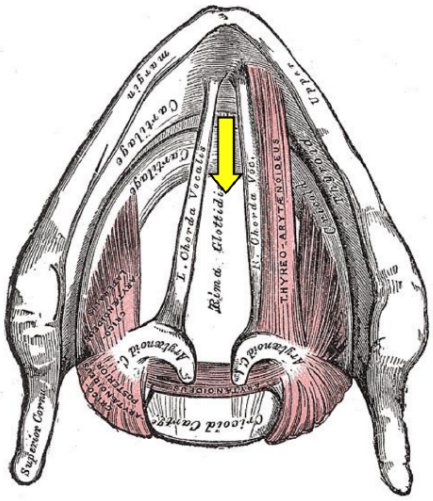


Figure 3: Note proximity of tube to vocal cords, and relationship to cricoid ring

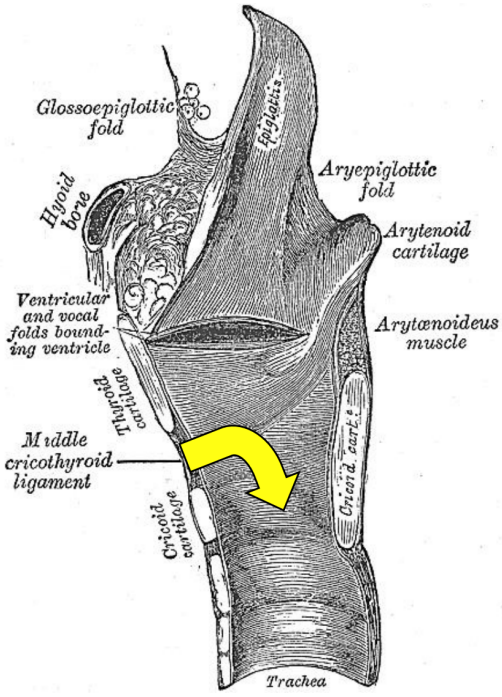


Figure 4: Note proximity of tube to vocal cords, and relationship to cricoid ring

The tube then passes through the cricoid ring, which is the narrowest part of the upper airway (*Figure 3, 4*).

The thyroid isthmus typically crosses the 2nd and 3rd tracheal rings, and is out of harm's way, unless a pyramidal thyroid lobe is present (*Figure 2*). The only blood vessels that may be encountered are the anterior jugular veins (off the midline), and the cricothyroid arteries.

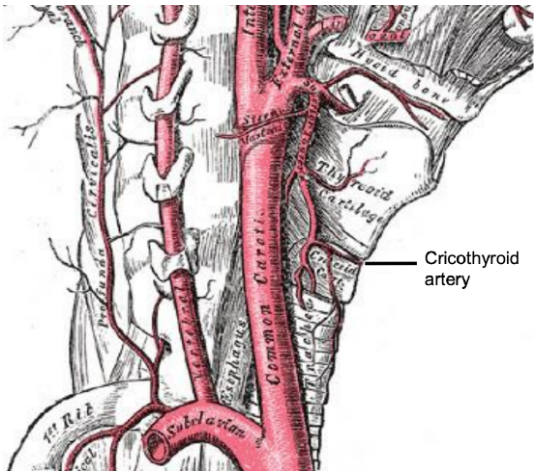


Figure 5: Cricothyroid artery

The ***cricothyroid artery*** is a small branch of the superior thyroid artery and courses across the upper part of the cricothyroid membrane and communicates with the artery of the opposite side (*Figure 5*). ***Therefore, incise the membrane along the superior margin of the cricoid***.

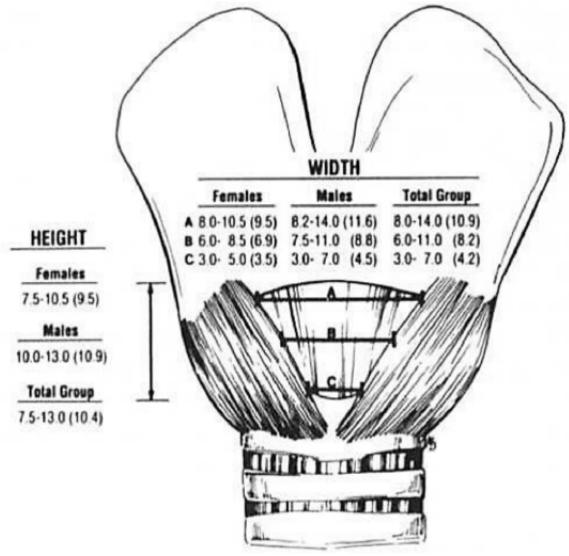


Figure 6: Dimensions of cricothyroid membrane: Range & mean values in millimetres[1]

The ***dimensions of the cricothyroid membrane*** have a bearing on the size of endotracheal or tracheostomy tube to be used; the outer diameter (OD) of the tube should not exceed the diameter of the cricothyroid opening so as to avoid injury to the larynx. Even though the cricothyroid membrane measures 30 mm in the horizontal plane, the gap between the cricothyroid muscles through which the tube must pass is much less (*Figure 6*). Based on studies of the dimensions of cricothyroid membranes[1,2,3] it has been recommended that a tube of no more than 9-10 mm OD be used[1]; This corresponds to a 7 mm ID tube. An alternative suggestion is to select a tube which is 1 mm smaller than would normally be used for orotracheal intubation[2]. If a Shiley tracheostomy tube is to be used, it should not exceed Size 4 (9.4 mm OD).

Needle cricothyrotomy

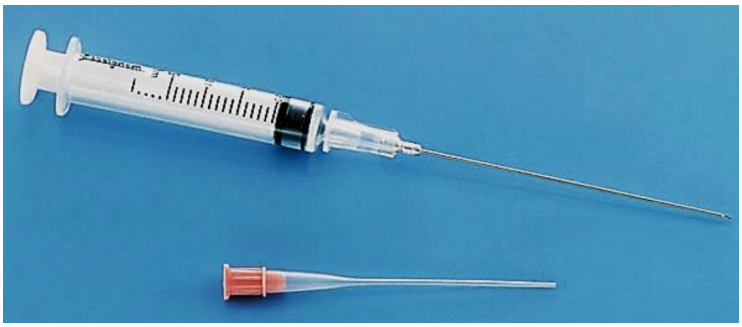


Figure 7: Example of intravenous cannula with needle removed from cannula

Needle cricothyrotomy using ***a 12 or 14- gauge cannula*** (*Figure 7*) is only employed as an interim measure in an extreme emergency when one is unable to do an open cricothyroidotomy, and in children.



Figure 8: Hand-controlled high-pressure jet ventilator

Ventilation may be effective if the cannula is attached to high pressure jet ventilation. Ventilation is controlled with a hand-operated jet injector (*Figure 8*) attached to central wall oxygen, tank oxygen, or the fresh gas outlet of an anaesthesia machine; or may be controlled with the oxygen flush valve of an anaesthesia machine.

However, such ventilation via needle cricothyrotomy will only suffice for approximately 45 minutes as it does not permit adequate ventilation and hence leads to an accumulation of CO_2; this can be particularly deleterious for head injury patients as hypoventilation causes raised intracranial pressure. ***Adult patients must therefore be either intubated or cricothyroidotomy or formal tracheostomy done within 45 minutes***.

Should jet ventilation not be available, one would attach either a ventilator or an ambubag to the cannula. ***However, ventilation with a low-pressure self-inflating resuscitation bag is ineffective within a minute or so.***

The cannula can be attached to an ambubag or ventilator in two simple ways:



Figure 9: Connection piece of 7.5 mm endotracheal tube attached to barrel of 2 or 3 mL syringe

1. Fit a 2 or 3 mL syringe to the cannula with plunger removed; insert the connection piece of a 7.5 mm ID endotracheal tube into the barrel of the syringe (*Figure 9*).
2. Fit a 10 mL plastic syringe to the cannula with plunger removed; insert an endotracheal tube into the barrel of the syringe and inflate the cuff (*Figure 10*).

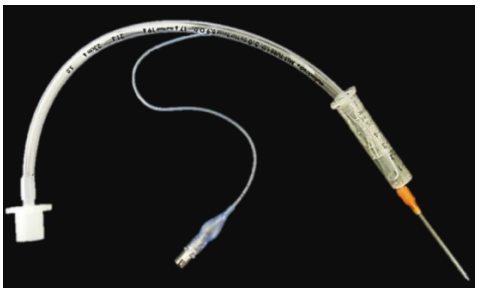


Figure 10: Insert an endotracheal tube into the barrel of a syringe and inflate the cuff

Complications of needle cricothyrotomy include pneumothorax, subcutaneous and mediastinal emphysema, bleeding, oesophageal puncture, and respiratory acidosis due to hypoventilation. Complete upper airway obstruction proximal to the cricothyrotomy is a contraindication to needle cricothyrotomy because of the risk of causing barotrauma to the lungs. Long term complications include subglottic stenosis and vocal cord injury.

Needle cricothyrotomy: Surgical steps

1. Position the patient supine with neck exposed and extended (if possible).
2. Identify surface landmarks i.e. thyroid cartilage, cricoid cartilage and cricothyroid membrane.
3. Prepare a sterile field.
4. Inject 1% lidocaine with 1:100 000 epinephrine into the skin and through the cricothyroid membrane into the airway to anesthetize the airway and suppress the cough reflex (if time to do so).
5. Fix the thyroid cartilage with the 1st & 3rd fingers of the non-dominant hand leaving the 2nd finger free to locate the cricothyroid membrane.
6. With the dominant hand, pass a 14- gauge intravenous cannula attached to a syringe filled with normal saline, through the cricothyroid membrane, directing it caudally at 450 (*Figure 11*). Bending the distal part of the needle can assist with directing the catheter along the tracheal lumen (*Figure 12*).
7. Apply negative pressure to the syringe as the needle is advanced. Air bubbles will appear in the fluid-filled syringe as the needle traverses the membrane and enters the trachea (*Figure 13*).
8. Advance the cannula and then retract the needle.
9. Attach jet ventilation and ventilate at 15 L/min.
10. Judge the adequacy of ventilation by movement of the chest wall and auscultation for breath sounds, and by pulse oximetry.



Figure 11: Fix the larynx and insert intravenous cannula at 45^{0}

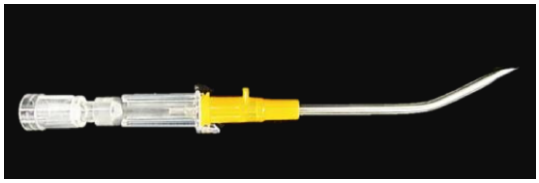


Figure 12: Cannula has been bent for easier access

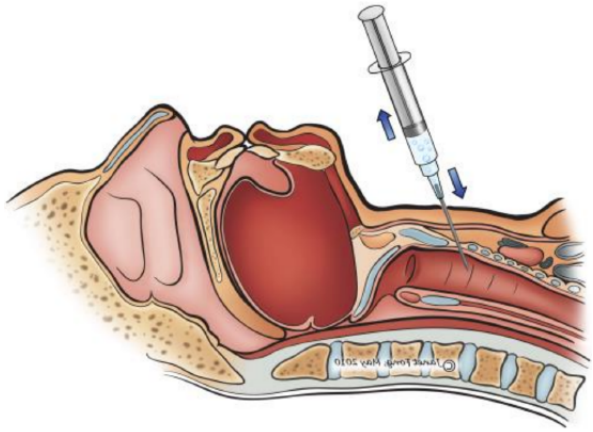


Figure 13: Air bubbles appear in the fluidfilled syringe as the needle traverses cricothyroid membrane[4]

Open Surgical Cricothyroidotomy

Preoperative evaluation

- *Level of obstruction*: Cricothyroidotomy will not bypass obstruction in the trachea or bronchial tree.
- *Coagulopathy*: Unless an emergency, a coagulopathy should be corrected prior to the procedure.
- *Surface anatomy of the neck*: Are the relevant landmarks palpable?

Preoperative preparation



Figure 14: Cricothyroidotomy kit for patients requiring airway support and ventilation: Small cuffed tracheostomy tube, syringe, scalpel, T-piece, lubricant gel, suture, tracheostomy tape

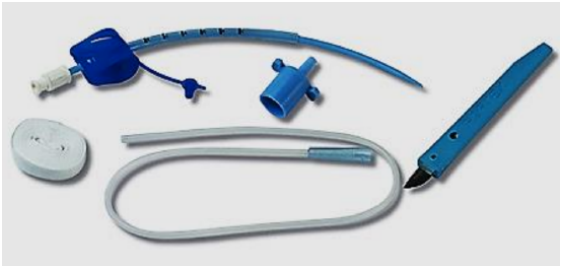


Figure 15: Mini-tracheostomy kit for patients only requiring lavage and suctioning of secretions: 4 mm uncuffed tracheostomy tube with introducer, scalpel, tracheostomy tape, connector piece and suction tubing

Prepacked cricothyroidotomy kits are available, both for patients requiring airway support (*Figure 14*) and for patients requiring access for suctioning excessive secretions (*Figure 15*). However, in an emergency airway situation no. 11 or 15 surgical blades, knife handle, curved artery forceps and thin endotracheal tube will do.

Open surgical cricothyroidotomy: Surgical steps

1. Position the patient supine with anterior neck exposed and extended (if possible).
2. Identify the surface landmarks i.e. thyroid cartilage, cricoid cartilage and cricothyroid membrane.
3. Prepare a sterile field.
4. Inject 1% lidocaine with 1:100 000 epinephrine into the skin, soft tissue and through the cricothyroid membrane into the airway to anesthetize the airway (if there is time).

5. Fix the thyroid cartilage with the 1st and 3rd fingers of the non-dominant hand leaving the 2nd finger free to palpate the cricothyroid membrane.
6. If the surface anatomy is well defined use the dominant hand to make a 1-2 cm transverse stab incision with a scalpel directly over and right through the cricothyroid membrane at the superior margin of the cricoid (*Figure 15*). In the more thickset patient, make a 3 cm vertical midline incision extending inferiorly from the thyroid prominence (*Figure 16*); dissect bluntly down to the cricothyroid membrane with the non-dominant index finger; move the finger from side-to-side to clearly feel the cricothyroid membrane.
7. Make a 1 cm transverse incision through the cricothyroid membrane along the superior edge of the cricoid, angling the scalpel cephalad so as to avoid injuring the vocal cords; await a distinct "pop" sensation as the scalpel pierces through the membrane and enters the larynx; the thick cricoid lamina is located directly posteriorly (*Figures 3, 4*).
8. Dilate the tract by passing a curved haemostat through the incision, angling it caudad through the cricoid ring and along the trachea taking care not to perforate the posterior wall of the trachea (*Figure 4*); alternatively insert a bougie through the tract into the airway.
9. Insert a tracheostomy or endotracheal tube (<7 mm ID), either directly or by railroading it over the bougie.
10. If using a cuffed tube, inflate the cuff with air.
11. Commence ventilation.
12. Confirm correct placement of the tube by observation of movement of the chest, auscultation, and end-tidal CO_2 if available.
13. Secure the tracheostomy tube by suturing it to skin and/or tracheal tape secured around the neck (*Figure 17*).

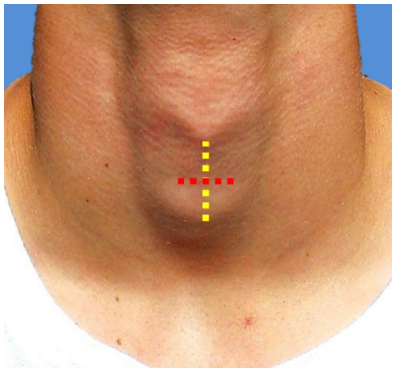


Figure 16: Horizontal or vertical skin incision



Figure 17: Tracheostomy tube secured with Velcro tape

Percutaneous Cricothyroidotomy using Seldinger Technique

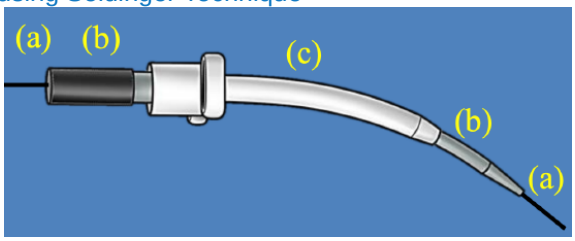


Figure 18: Cricothyroidotomy with Seldinger technique: guide wire (a); dilator (b); tracheostomy tube (c) (adapted from[4])

Percutaneous cricothyrotomy using a Seldinger technique requires a needle with dilator and guide wire (*Figure 18*).

Percutaneous cricothyroidotomy: Surgical steps

1. Position the patient supine with neck exposed and extended (if possible).
2. Identify surface landmarks i.e. thyroid cartilage, cricoid cartilage and cricothyroid membrane.
3. Prepare a sterile field.
4. Inject 1% lidocaine with 1:100 000 epinephrine into the skin and through the cricothyroid membrane into the airway to anesthetize the airway and suppress the cough reflex (if time to do so).
5. Fix the thyroid cartilage with the 1st & 3rd fingers of the non-dominant hand leaving the 2nd finger free to locate the cricothyroid membrane.
6. With the dominant hand, make a small stab incision in the skin with a scalpel over the cricothyroid membrane (*Figure 19*).
7. Pass a finder needle attached to a syringe filled with normal saline, through the cricothyroid membrane, directing it caudally at 450 (*Figure 20*).
8. Apply negative pressure to the syringe as the needle is advanced. Air bubbles will appear in the fluid-filled syringe as the needle traverses the membrane and enters the trachea.
9. Disconnect the syringe from the finder needle and insert the guide wire through the needle (*Figure 21*).
10. Retract and remove the needle once the guide wire has been advanced into the airway (*Figure 22*).
11. Pass the dilator and tracheostomy tube over the guide wire.
12. Jointly advance the dilator and tracheostomy tube over the guide wire into the airway (*Figure 23*).
13. Remove both dilator and guide wire leaving the tracheostomy tube in situ (*Figure 24*).
14. Secure the tracheostomy tube with tracheostomy tape.

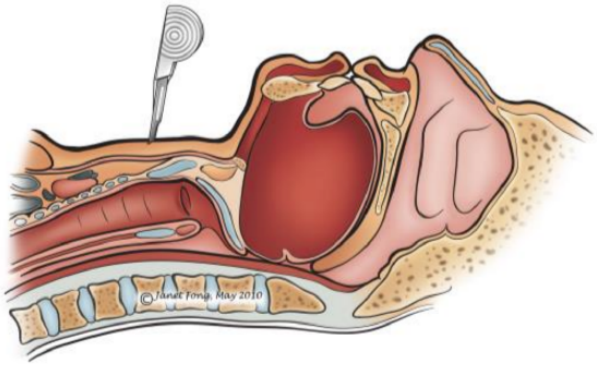


Figure 19: Stab incision over cricothyroid membrane[4]

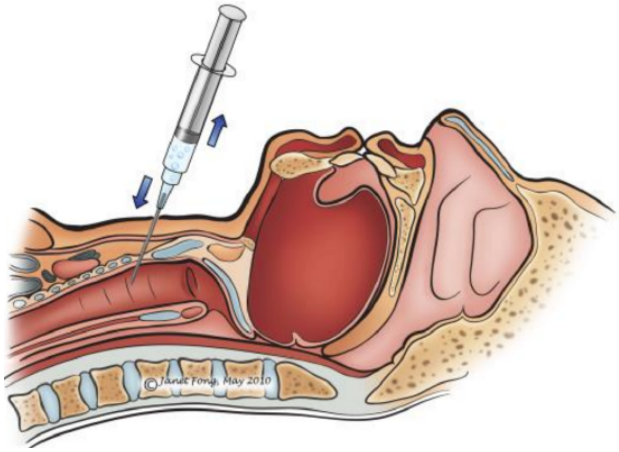


Figure 20: Pass needle through cricothyroid membrane[4]

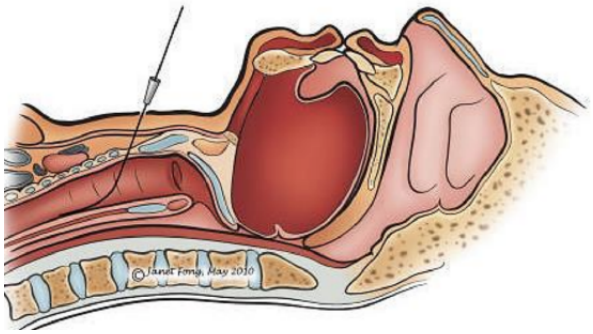


Figure 21: Insert guide wire through the needle[4]

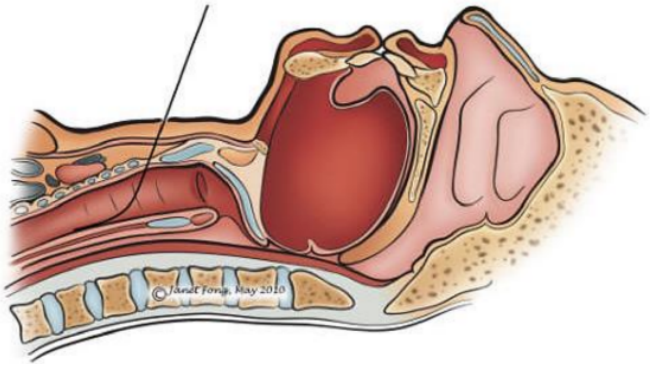


Figure 22: Remove the needle leaving guide wire in place[4]

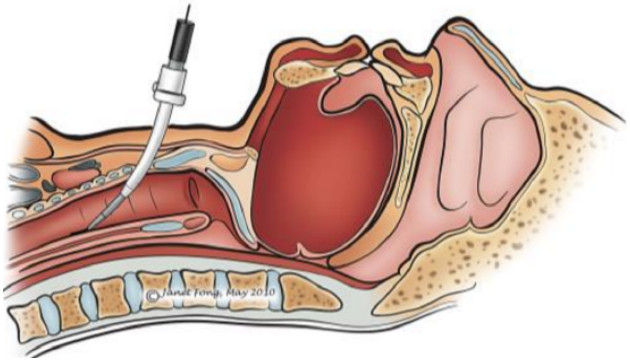


Figure 23: Jointly advance dilator and tracheostomy tube over guide wire[4]

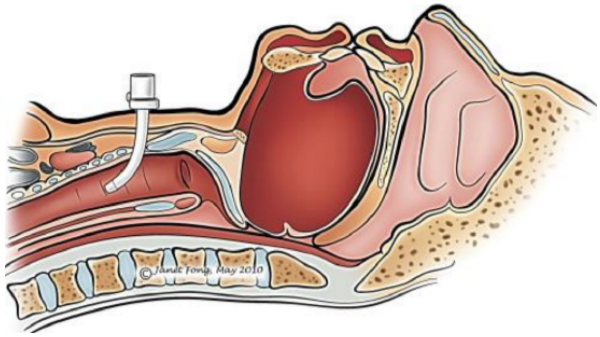


Figure 24: Tracheostomy tube in place[4]

Early Complications

- Bleeding
- Paratracheal false tract: Inadvertent extratracheal placement of the tracheostomy tube can be fatal. It is recognized by the absence of breath sounds on auscultation of the lungs, high ventilatory pressures, failure to ventilate the lungs, hypoxia, absence of expired CO_2, surgical emphysema, and an inability to pass a suction catheter down the bronchial tree, and on chest X-ray.

- Posterior tracheal wall perforation into oesophagus.
- Pneumothorax, surgical emphysema.
- Hypercarbia and barotrauma.

Late Complications

- Glottic or subglottic stenosis due to perichondritis and fibrosis of cricoid.
- Dysphonia
- Persistent stoma
- Tracheoesophageal fistula

Postoperative care

Pulmonary oedema: This may occur following sudden relief of airway obstruction and reduction of high intraluminal airway pressures. It may be corrected by CPAP or positive pressure ventilation.

Respiratory arrest: This may occur immediately following insertion of the tracheostomy tube and is attributed to the rapid reduction in arterial pCO_2 following restoration of normal ventilation, and hence loss of respiratory drive.

Humidification: A tracheostomy bypasses the nose and upper aerodigestive tract which normally warms, filters, and humidifies inspired air. To avoid tracheal desiccation and damage to the respiratory cilia and epithelium, and obstruction due to mucous crusting, the tracheostomy patient needs to breathe humidified warm air by means of a humidifier, heat and moisture exchange filter, or a tracheostomy bib.

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Cuff pressure: When tracheostomy tube cuff pressures against the tracheal wall mucosa exceed 30 cm H_20, mucosal capillary perfusion ceases, ischemic damage ensues, and tracheal stenosis may result. Mucosal injury has been shown to occur within 15 minutes. Therefore, cuff inflation pressures of >25 cm H_20 should be avoided. Several studies have demonstrated the inadequacy of manual palpation of the pilot balloon as a means to estimate appropriate cuff pressures.

Measures to prevent cuff-related injury include:

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- *Minimal Occluding Volume Technique*: Deflate the cuff, and then slowly reinflate until one can no longer hear air going past the cuff with a stethoscope applied to the side of the neck near the tracheostomy tube (ventilated patient)
- *Minimal Leak Technique*: The same procedure as above, except that once the airway is sealed, slowly to withdraw approximately 1 mL of air so that a slight leak is heard at the end of inspiration
- *Pressure gauge*: Regular or continuous monitoring of cuff pressures

References

1. Dover K, Howdieshell TR, Colborn GL. The dimensions and vascular anatomy of the cricothyroid membrane: relevance to emergent surgical airway access. Clin Anat. 1996;9(5):291-5
2. Bennett JD, Guha SC, Sankar AB. Cricothyrotomy: the anatomical basis. J R Coll Surg Edinb. 1996 Feb;41(1): 57-60
3. Little CM, Parker MG, Tarnopolsky R. The incidence of vasculature at risk during cricothyroidostomy. Ann Emerg Med. 1986 Jul;15(7):805-7

4. Dept. Anaesthesia & Intensive Care, The Chinese University of Hong Kong: http://www.aic.cuhk.edu.hk/web8/cricothyroidotomy.htm

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.28: Percutaneous Dilational Tracheostomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Thomas Deitmer, Johan Fagan

Percutaneous tracheostomy is a bedside procedure requiring a small surgical field and avoiding the need for an operating room. It was popularized in the 1990s as a minimally invasive technique requiring only a small skin incision. The widespread adoption of percutaneous techniques is in the opinion of the authors due to the possibility it gives ICU physicians to immediately perform a percutaneous tracheostomy for ventilation purposes once the need for tracheostomy has been identified, with its organizational and cost advantages.

Typically percutaneous tracheostomy is done by ICU physicians, although it should only be employed if a surgeon experienced with classic open tracheostomy and with coping with complications such as bleeding is immediately available to help.

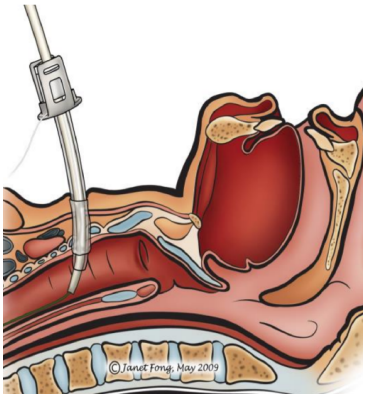


Figure 1: Tracheostomy tube being advanced over the trocar which has been passed over the guide wire (green)[1]. Note that the puncture site is too high…it should be below the 1st tracheal ring!

Percutaneous tracheostomy is similar to using a Seldinger technique to cannulate veins and arteries. The trachea is entered percutaneously with a thin needle through which a guide wire is advanced into the trachea. A bougie is passed over the guide wire and the tract between the skin and trachea is dilated until a tracheostomy tube can be advanced into the trachea (*Figure 1*). Unlike with conventional surgical tracheostomy, the trachea, thyroid gland and vascular structures cannot be visualized during placement of the tracheostomy or to achieve haemostasis should bleeding occur.

During the 1st weeks the tract between skin and trachea is unstable. The tract collapses with removing the tube during this time and makes reinserting a tube difficult and hazardous. Only after several weeks the tracheostomy tract is stabilized by granulation tissue making changing a tube possible.

Indications

Percutaneous dilational tracheostomy is indicated for selected ventilator-dependent patients in ICU, e.g. for prolonged transoral or transnasal endotracheal intubation.

Contraindications

Inability to palpate thyroid and cricoid cartilages: The tracheostomy should enter the trachea between the 1st and 3rd tracheal rings, and should avoid the cricoid and thyroid cartilages. It is therefore crucial that one is able to clearly palpate and identify the thyroid and cricoid cartilages. With a fat neck or a goiter one cannot always palpate the laryngeal and tracheal structures, and one ends up with a very long tracheostomy tract which may create complications.

Anatomical factors: Laryngeal and tracheal anatomy may vary widely depending on the patient and his/her age. A larynx situated in the thoracic inlet (laryngoptosis) makes all kinds of tracheostomy difficult and one gets critically close to big mediastinal vessels. In such cases open dissection under direct surgical vision is required.

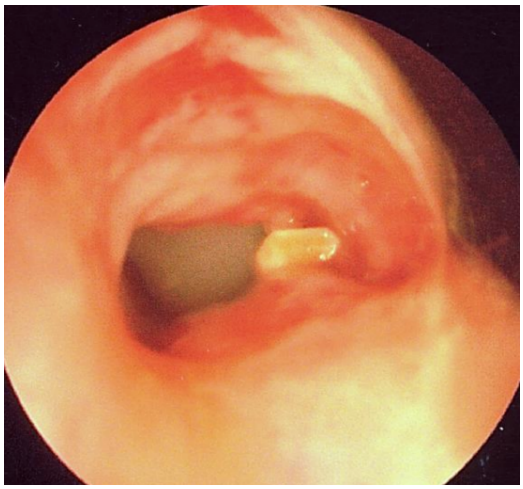


Figure 2: Fractured tracheal ring

Thyromegaly or suprasternal mass: Any mass between the skin and trachea such as an enlarged thyroid or a tumor is a contraindication to percutaneous tracheostomy. The thyroid gland and most tumors are vascular. Should bleeding occur following puncture and dilatation, one can compress the site. Subcutaneous bleeding may not be apparent with a tight skin collar. Bleeding can however enter the opened trachea as the hole in the trachea may be irregular especially in elderly patients with partial ossification of the tracheal rings that may even fracture (*Figure 2*).

Coagulation disorders: Percutaneous tracheostomy is contraindicated. The only means of hemostasis for bleeding from the tract is by compression with the dilating device or by exploring the neck.

Children: The authors do not advocate percutaneous tracheostomy in children <15 years of age as it is difficult to palpate the trachea because of its small diameter and because the cartilage rings are soft and compressible. Some force is also required to perforate the skin and trachea which diminishes the tracheal AP-diameter and increases the likelihood to perforate the paries membranaceus (very thin, vulnerable posterior tracheal wall).

Patients requiring a tracheostomy after leaving ICU: A percutaneous tracheostomy tract will collapse for several weeks when the tube is removed to be changed. In ICU there is expert care to maintain a tracheostomy e.g. humidification and frequent suctioning to prevent crusting and obstruction. The tracheostomy may have to be changed immediately if obstruction occurs. This may not be possible in fresh percutaneous tracheostomies for the reasons given; hence emergency transoral intubation may be required and must be at hand. Therefore, if a patient is planned to have a tracheostomy for longer than his/her presence in ICU, an open, stable, surgical tracheostomy must be done which permits simple tube changes. This would include patients with poor lung function requiring prolonged weaning, or patients with dysphagia and aspiration that need prolonged rehabilitation and a protective tracheostomy.

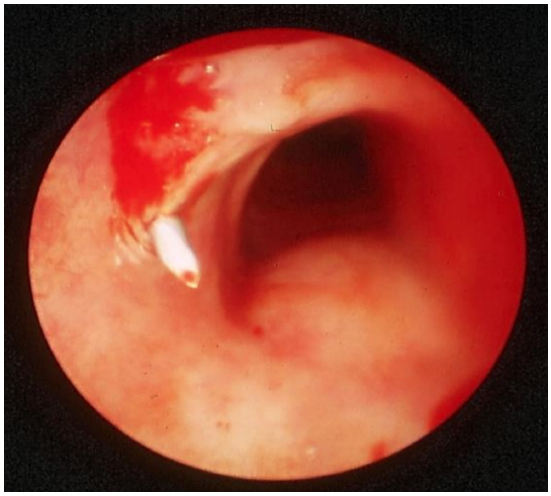


Figure 3: Puncture needle entering the sidewall of the trachea

Unavailability of flexible or rigid bronchoscope and/or ultrasound: Finding and entering the trachea with a pilot needle may be difficult. One can of course aspirate air and guess that you are within the trachea. This does not however ensure that the trachea has been entered in the midline as air will be aspirated even with a laterally placed puncture which is not at all suitable for a dilatation manoeuvre (*Figure 3*).

Therefore, the tracheal puncture must be controlled by endoscopic vision. This is best achieved with a ***flexible endoscope*** that is guided through the endotracheal tube while in situ. The endotracheal tube is withdrawn to clearly reveal the anatomy of the lower larynx and trachea. Alternatively, ***tracheoscopy*** can be performed with a rigid scope, in which case the endotracheal tube is pulled back and ventilation is secured through the rigid scope. ***Sonography*** may also be employed to ensure correct placement of the tracheal puncture.

Difficult airway: The patient must be easy to intubate in the event that alternative techniques of ventilation by oro- or nasotracheal intubation is required should the patient's airway obstruct following removal of the endotracheal tube e.g. with incorrect placement of the percutaneous tracheostomy, accidental decannulation, bleeding etc.

Emergency procedures: Dilational tracheostomy ***should not be used in airway emergencies***. Flexible or rigid tracheoscopy should be available (which is typically not the case in emergencies). Emergency access to the trachea should in such cases be achieved by cricothyroidotomy.

Surgical Technique: General principles

Several percutaneous dilational tracheostomy devices are commercially available. Each uses different tools and different surgical steps. It is advisable to stick to one system for reasons of quality assurance.

The trachea is first punctured with a small pilot cannula; next the tract is dilated into the trachea; finally the tracheostomy tube is inserted from externally into the trachea. It is strongly recommended that the tracheal puncture is done under endoscopic control. There is a technique that places the cannula from inside-to-outside as a translaryngeal pull-through technique.

- Three doctors are required: an ICU physician to take care of the patient's ventilation and sedation; an "endoscopist" to perform flexible tracheoscopy to direct the tracheal puncture and the insertion of the tube, and a "surgeon" to perform the percutaneous tracheostomy.
- Position the patient supine with neck extended by a pillow or sandbag placed under the shoulders in order to deliver the trachea out of the thorax and to give the surgeon adequate access to the cervical trachea. Such extension may not be possible in patients with neck injuries, or rheumatoid and osteoarthritis of the cervical spine.
- Palpate and identify the thyroid cartilage, cricoid cartilage and trachea, and exclude a large thyroid gland. The tracheostomy is created below the 1st tracheal ring, so as to avoid subglottic stenosis as a result of scarring. Therefore palpating to determine the location of the cricoid cartilage is important. When you run your fingers up the midline of the neck starting inferiorly at the sternal notch, you 1st encounter the prominence of the thyroid isthmus, followed by the cricoid.
- Infiltrate skin and subcutaneous tissues in the midline overlying about the 3rd tracheal ring with local anesthesia with adrenaline.
- Sterilize and drape the anterior neck as for a classic tracheostomy.



Figure 4: Red arrow indicates point of entry of endoscope into swivel adaptor of anesthetic tubing

- The "endoscopist" introduces a flexible scope into the endotracheal tube through a swivel adapter without interrupting the ventilation (*Figure 4*).
- Advance the endoscope to the tip of the endotracheal tube.
- Carefully retract the endotracheal tube into the larynx under endoscopic vision, taking care not to deflate the cuff of the endotracheal tube.

- Do not to remove the endotracheal tube so that one can advance the endotracheal tube immediately if controlled ventilation is required in a critically ill patient.
- The “surgeon” again palpates and locates the thyroid and cricoid cartilages.
- While fixing the larynx with fingers of the non-dominant hand, insert the small needle, aiming at the 2nd/3rd tracheal rings.

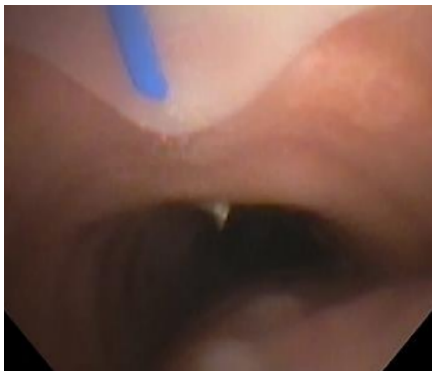


Figure 5: Entry of the needle into trachea in correct position[2]

- The “endoscopist” monitors entry of the needle into the trachea and ensures that it is the correct position (*Figure 5*).
  - Midline of trachea
  - Not too high (touching cricoid)
  - Not too low (creates very long tracheostomy tract between skin and trachea)
- Once satisfied with placement of the needle in the trachea, insert a guidewire through the needle and advance it into the tracheal lumen.

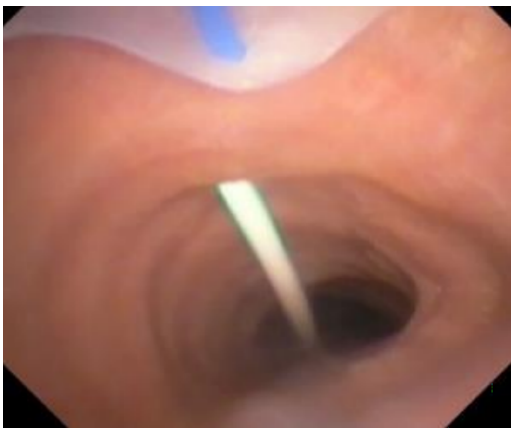


Figure 6: Guidewire in place following retraction of needle[2]

- Retract the needle leaving the guidewire in situ (*Figure 6*).
- Make a small skin incision at the point of insertion of the guide wire.



Figure 7: Dilating the tract

- Dilate the tract following the detailed instructions of the percutaneous tracheostomy kit being used (*Figure 7*).



Figure 8: Endoscopic view of Blue Rhino dilator entering the trachea[2]

- The “endoscopist” monitors the procedure from inside the trachea to ensure correct placement of the opening into the trachea, and to avoid fracture of cartilage, bleeding, or injury to the posterior tracheal wall (*Figure 8*).
- With the tract fully dilated, railroad the tracheostomy tube into its final position.
- Remove the dilator.

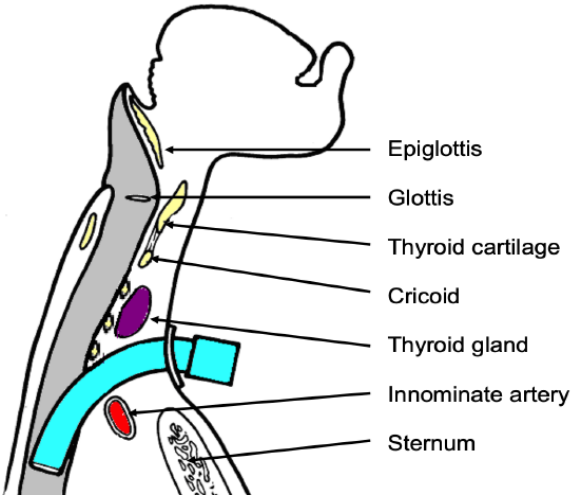


Figure 9: Position of tracheostomy tube

- Inflate the cuff, attach the anesthetic tubing, and hand-ventilate until correct placement of the tube within the trachea has been confirmed (*Figure 9*).
- Secure the tracheostomy tube to the neck with tapes. Thread the tapes through the holes in the flanges of the tracheostomy tube and pass it around the neck and tie them with the neck flexed.



Figure 10: Tracheostomy tube secured with Velcro tape

- If the ties are tied with the neck extended, they are too loose when the patient flexes the neck. The ties should be tight enough to admit no more than a single finger under the tape (*Figure 10*).
- Remove the endotracheal tube only once ventilation has been fully established and there are no immediate complications.

- If any doubt exists about correct placement of the tracheostomy tube, endoscopy of trachea should be done through the tracheostomy tube to confirm correct placement.

Commercial percutaneous tracheostomy kits

Commercially available kits vary principally in terms of the dilation instrumentation. Every device is delivered with detailed guidelines which should be referred to before use!



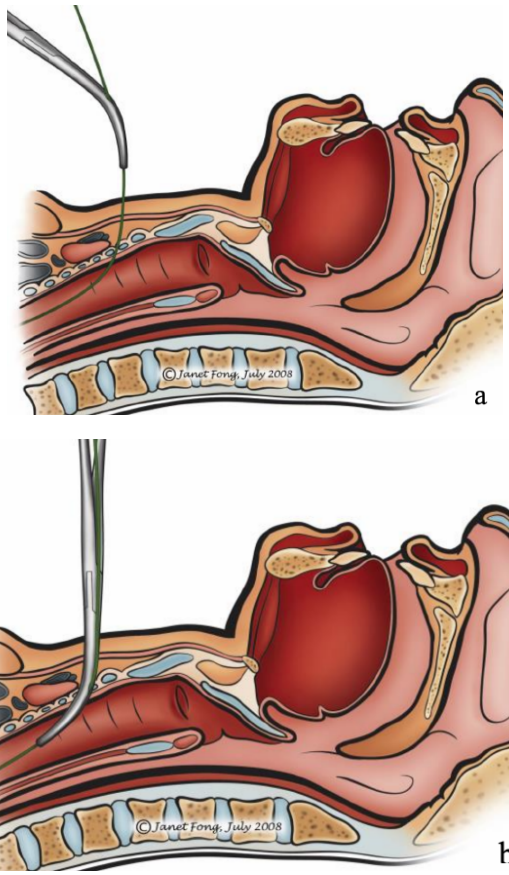
Figure 11: Ciaglia Blue Rhino kit contains needle, guide wire, and serial dilators

The *Ciaglia Blue Rhino & Dolphin systems* use serial dilators to dilate the tract over a guide wire, and the tracheostomy tube is advanced over the final dilator (*Figures 1, 11*).



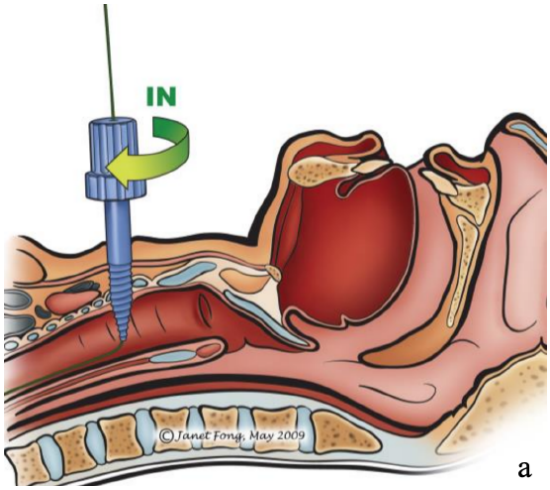


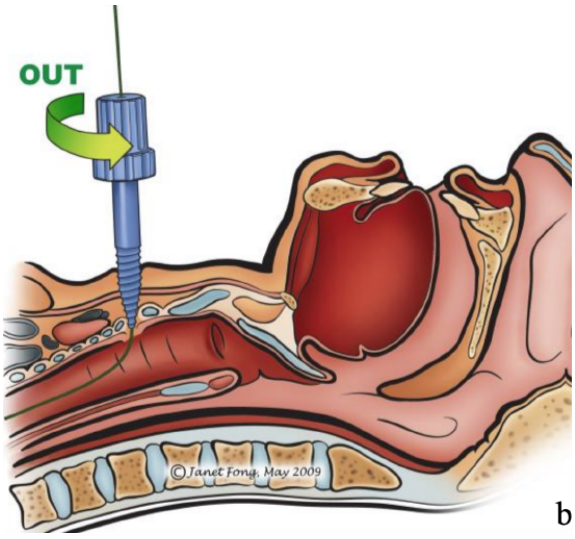
Figures 12a,b: Griggs kit with grooved forceps to accommodate the guidewire



Figures 13a,b: Forceps being advanced over the guidewire[1]

With the *Griggs and Rapitrach systems* the tract is dilated with forceps, which is grooved so that it can be advanced over a guidewire (*Figures 12*, *13*).





Figures 14a,b: The Percutwist system dilates the tract with a semi-sharp screw over a guide wire[1] Note that the puncture site is too high…it should be below the 1st tracheal ring!

The *Percutwist system* dilates the tract with a conically shaped, semi-sharp screw over a guide wire (*Figures 14a, b*).

The screw exerts a radial force to open the trachea. Using the screw avoids impressing the anterior tracheal wall and flattening the tracheal lumen in its AP-diameter and, hence injuring the posterior tracheal wall.

Unlike the systems described above, the Fantoni system employs a translaryngeal tracheostomy technique. The tracheostomy tube is inserted by passing it transorally and then inside-out out from the trachea to the cervical skin. The endotracheal tube must first be replaced with a smaller tube. The trachea is then punctured percutaneously with a small needle under endoscopic vision. A metal guide wire is passed through the needle into the trachea and out through the mouth. The end of the guide wire is attached to a special tracheostomy tube with a dilating metal tip where it connects to the guide wire. This device is then drawn through the oral cavity and the larynx into the trachea adjacent to the endotracheal tube, and out through to the neck, by pulling on the guide wire. As the tracheostomy tube ends up with its tip facing upwards towards the larynx, it must be rotated 180° for its tip to be directed towards the carina. This turning procedure is done with a special device and must be carried out very carefully not to injure the larynx or trachea.

Complications and its management

Some complications have already been mentioned under “Indications” and “Contraindications”.

Collapse of tracheostomy tract: The tracheostomy tract collapses every time a tracheostomy tube must be changed, especially in the initial weeks following percutaneous tracheostomy before the tract has matured. This may be particularly dangerous when accidental decannulation occurs in a tracheostomy-dependent patient outside an ICU setting. The solution is to create a formal surgical tracheostomy with a safe, stable tracheostomy tract in patients requiring a long-term tracheostomy.

Bleeding into neck or airway: This can be life-threatening when clots aggregate in the trachea and bronchi, even with the cuff inflated. When clots cannot be removed by suction, they have to be removed like foreign bodies by rigid endoscopy. Therefore if bleeding is encountered during the percutaneous procedure, it has to be converted to a formal surgical tracheostomy so that haemostasis can be achieved. Secondary bleeding also demands surgical revision.



Figure 15: Surgical emphysema



Figure 16: Pneumothorax

Surgical emphysema or pneumothorax (*Figures 15, 16*): Minor surgical emphysema of the neck can occur following surgical or percutaneous tracheostomy, is often self-limited and sometimes is not even clinically apparent, but apparent only on X-ray or CT-scan. As microbial contamination with air is possible, antibiotics are administered. If emphysema persists or extends into the mediastinum, or if there is a pneumothorax, the situation must be evaluated endoscopically to rule out tracheal perforation or other pathology requiring intervention. A pneumothorax may require an intercostal drain.



Figure 17: Nasal speculum used to reinsert a percutaneous tracheostomy tube

Accidental decannulation or displacement of tracheostomy tube: When a tracheostomy tube inadvertently slips out of the trachea it may not be possible to reinsert it if it occurs in the initial days after percutaneous tracheostomy because of an immature tracheostomy tract. One can try to probe and redilate the tract using percutaneous tracheostomy instruments or a nasal speculum (*Figure 17*), and reinsert the tracheostomy tube. In a ventilated patient one needs to immediately intubate the patient with an oro- or nasotracheal tube to continue ventilation. If one is unable to reinsert the tracheostomy, then a formal surgical tracheostomy should be performed.

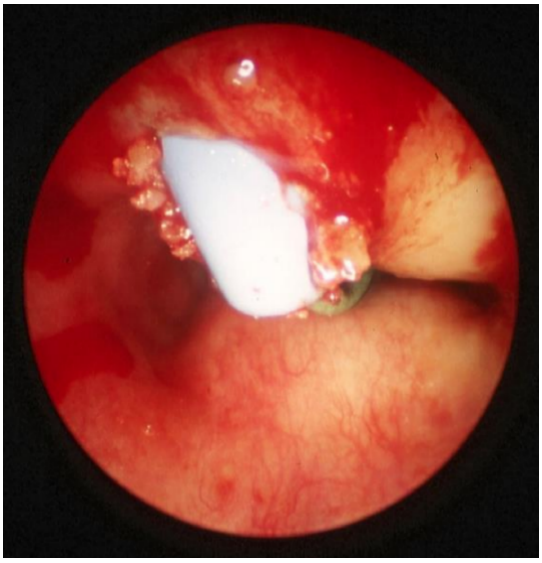


Figure 18: Guidewire impinging on the thin posterior wall of the trachea

Laceration of posterior tracheal wall: *Figure 18* illustrates how easy it is to lacerate the posterior tracheal wall. A laceration may be superficial, or can be deep into the mediastinum with fat visible on endoscopy. A laceration may be aggravated by pressure exerted by the cuff. It must be suspected when more and more air in the cuff is required to achieve a seal. The solution is that the cuff of the tracheostomy tube must not be situated over the defect in the posterior tracheal wall. This may require that the tube be advanced so that the cuff is positioned further down the trachea. The cuff position needs to be checked endoscopically and one should ensure that both lungs are ventilated. Alternatively one should reassess whether the patient can be decannulated in order that the lesion can heal without intervention other than broad spectrum antibiotics to prevent mediastinitis. If the above solutions are not feasible, a special endotracheal tube is inserted that straddles the tracheal bifurcation without exerting pressure on the lesion and allows ventilation of both lungs. Such tubes can be passed transorally but may be difficult to pass without further injuring a lacerated trachea. Alternatively one can perform a wide surgical tracheostomy and pass such a tube via the neck. In selected cases when such a special tube could not be placed without a leak, the author inserted 2 small endotracheal tubes via a tracheostomy, one for each lung. Positioning the tubes is difficult and must be controlled endoscopically. Special care must be taken for the tube not to obstruct the upper lobe of the right lung. As most such patients are critically ill, the prognosis of a major laceration of the posterior tracheal wall in a ventilated patient is generally poor.

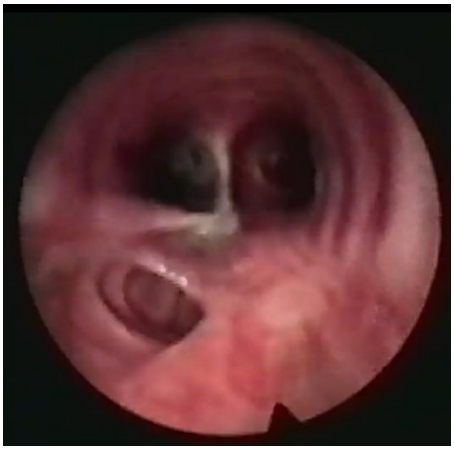


Figure 19: False tract extending posterior to the trachea just above the carina

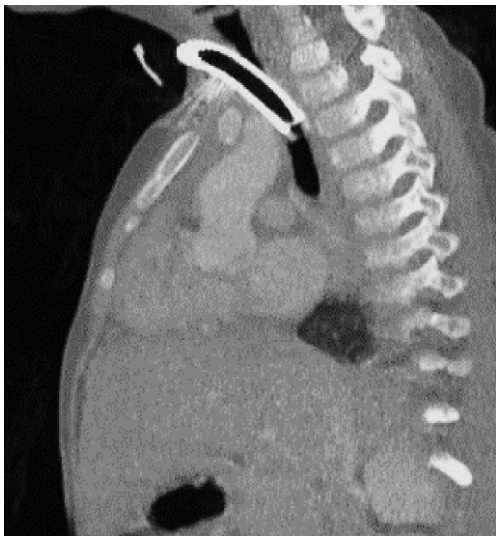


Figure 20: Note proximity of tracheostomy tube to innominate artery

False tract (Via falsa) (*Figure 19*): This occurs when a tracheostomy tube is inserted into a false tract ventral or lateral to the trachea. It may manifest as an inability to ventilate the patient or to pass a suction catheter through the tracheostomy into the lungs, high ventilation pressures, massive surgical emphysema, hypoxia and death. Endoscopy through the tube will verify that the tip of the tube is not in the tracheal lumen. The problem may be compounded by bleeding from lacerations of structures in the upper mediastinum e.g. veins, arteries or thyroid. The solution is that one should always check the position of the tracheostomy tube by one or more of the following means: use an endoscope during the percutaneous tracheostomy procedure to confirm correct placement of the puncture and tube; pass a suction tube into the lungs; ventilate the patient by hand and listen for breath sounds in both lungs; and order a chest X-ray to check the position if the tracheostomy tube and to exclude surgical emphysema, a pneumomediastinum and a pneumothorax. If the position of the tube remains in doubt, perform an open surgical approach, identify the trachea, and create a stable tracheostomy. If a false tract is found, attention must be directed especially to the space between the skin and the anterior tracheal wall as this access to the upper ventral mediastinum must be covered to protect the innominate artery or aberrant carotid to avert fatal bleeding (*Figure 20*).

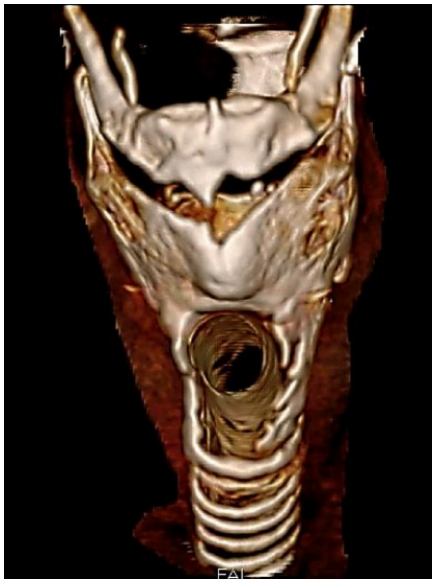


Figure 21: Sectio alta through cricoid



Figure 22: Sectio alta through cricothyroid membrane

High tracheostomy (Sectio alta): When a percutaneous tracheostomy is performed too high, it may violate the cricoid (*Figure 21*) or pass through the cricothyroid membrane (*Figure 22*), or in rare cases even enter the airway through the thyroid cartilage. This problem may be encountered in patients with massive laryngoptosis in whom the larynx sits in the suprasternal notch. Correct identification of the thyroid cartilage, cricothyroid membrane and cricoid can be difficult for inexperienced doctors and in patients with thick, short necks, or following prior surgery, or if the neck cannot be extended. For an inexperienced endoscopist, identification of the cricoid is difficult as well. A too-high tracheostomy may initially function well as the airway is secured. Significant problems arise after decannulation, as the airway manifests massive and irregular scarring with stenosis and/or functional problems relating to the vocal cords. Microbial inflammation of the cartilage may make it even worse. The solution is that should sectio alta be suspected, a clear diagnosis should be made by endoscopy and CT-scan or at least a lateral cervical X-ray. The situation must be addressed by creating a tracheostomy at the correct site. The “wrong” access must be closed and the airway reconstructed following the rules of reconstructive laryngeal surgery. In some cases internal stenting as is done after trauma may be necessary.



Figure 23: Tracheal stenosis on 3-D CT scan

Tracheal stenosis (*Figure 23*): This is a late complication of percutaneous tracheostomy. Once ventilation is no longer required the patient is decannulated and the tracheostomy site heals without complications. When the tracheal walls are partly destroyed by the procedure or by inflammation and chondritis, an unstable trachea results at the tracheostomy site (tracheomalacia) manifesting as stridor. This may not be clinically apparent immediately after decannulation, but may only manifest days, weeks or months later.

Therefore if a patient develops inspiratory stridor and respiratory distress even weeks or months after closure of a tracheostomy (percutaneous or surgical), then an endoscopic evaluation with a flexible or rigid endoscope is required. Flexible endoscopy with spontaneous breathing is recommended, as one can better diagnose tracheomalacia in the extrathoracic trachea with spontaneous breathing. A major stenosis requires rigid endoscopy and bougienage or balloon dilatation of the stenotic segment. Further treatment of such a stenosis must follow the art of treatment of tracheal stenosis which may include retracheostomy, a Montgomery tube, tracheal resection and end-to-end anastomosis, and rib cartilage grafting etc.

Concluding remarks

Percutaneous tracheostomy is often promoted as being “fast, safe, and easy” to perform. It is being performed more-and-more successfully and safely, especially when doctors adhere to the correct indications and contraindications. However in clinical practice one is seeing tendencies to expand indications which may sometimes be to the detriment of a typically critically ill patient, who may then experience additional problems as a consequence of injudicious use of a percutaneous as opposed to a formal surgical tracheostomy.

As the use of percutaneous tracheostomy increases, fewer physicians and surgeons have the expertise to perform a good surgical tracheostomy. In the era of percutaneous tracheostomy, surgical tracheostomies are typically reserved for difficult cases such as very thick necks, bleeding disorders or significant laryngoptosis. This makes it hard to teach young surgeons how to perform a good surgical tracheostomy, as a surgical tracheostomy is not an easy procedure for beginners to perform alone at 4 pm! In difficult cases it can be hard to identify the trachea and make a tracheal opening that is wide enough to allow for safe cannulation, but narrow enough not to cause tracheomalacia and later stenosis, at the former tracheostomy site.

Each procedure remains as good as the indication used to perform it!

Related chapters

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Author

Prof. Dr. med. Thomas Deitmer
Director
ENT Department
Klinikum Dortmund
Germany
thomas.deitmer@klinikumdo.de

Editor, Co-author

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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Johan Fagan



Figure 1: Bilateral inferior maxillectomy

Tumors of the hard palate and superior alveolus may be resected by inferior maxillectomy (*Figure 1*). A Le Fort 1 osteotomy may also be used as an approach to e.g. angiofibromas and the nasopharynx.

A sound understanding of the 3-dimensional anatomy of the maxilla and the surrounding structures is essential to do the operation safely. Hence the detailed description of the relevant surgical anatomy that follows.

Surgical Anatomy

Bony anatomy

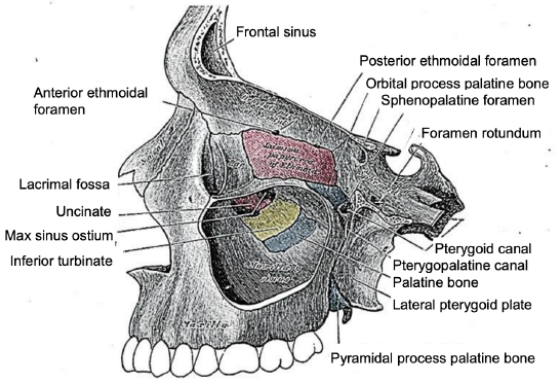


Figure 2: Lateral view of maxilla with windows cut in lateral and medial walls of maxillary sinus

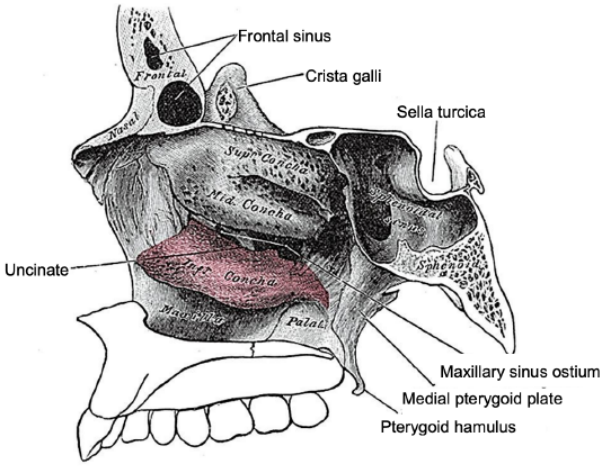


Figure 3: Bony anatomy of the lateral wall of the nose

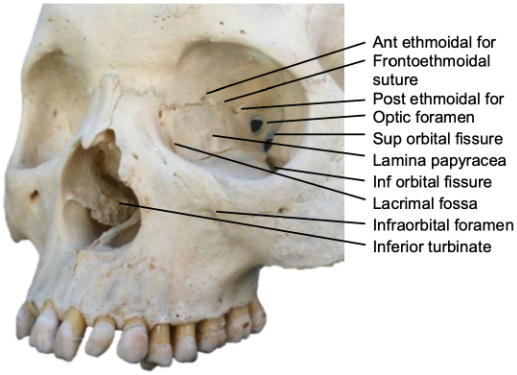


Figure 4: Bony anatomy in cadaver

Figures 2, 3 & 4 illustrate the detailed bony anatomy relevant to maxillectomy.

Critical surgical landmarks to note include:

- The floor of the anterior cranial fossa (fovea ethmoidalis and cribriform plate) corresponds with anterior and posterior ethmoidal foramina located, along the frontoethmoidal suture line.
- The proximity (5-11 mm) of posterior ethmoidal foramen and artery to the optic nerve within the optic foramen.

Figure 2 illustrates the bony anatomy of the lateral wall of the nose. The inferior turbinate (concha) may be resected with inferior maxillectomy, but the middle turbinate is preserved.

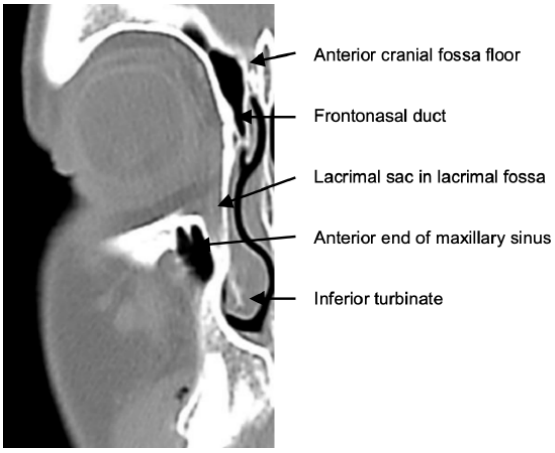


Figure 5: Coronal CT through lacrimal fossa

Figure 5 demonstrates the coronal anatomy at the anterior limit of a maxillectomy. Specifically note the lacrimal sac in the lacrimal fossa (*Figure 4, 5*) which may be transected at surgery, and the relative heights of the floors of the antrum and the nasal cavity.

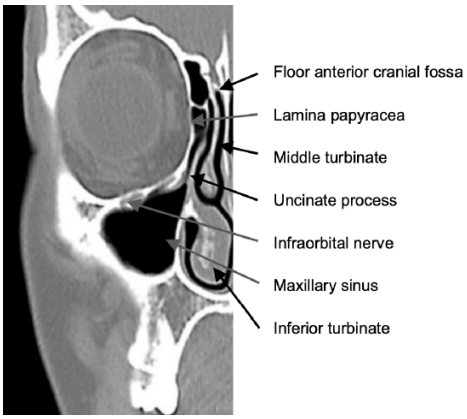


Figure 6: Anatomy in the coronal plane through the anterior ethmoids midway along a maxillectomy

Figure 6 demonstrates the coronal anatomy midway back along a maxillectomy. Specifically note the infraorbital nerve in the orbital floor, the thin lamina papyracea and the relative heights of the floors of the antrum and the nasal cavity.

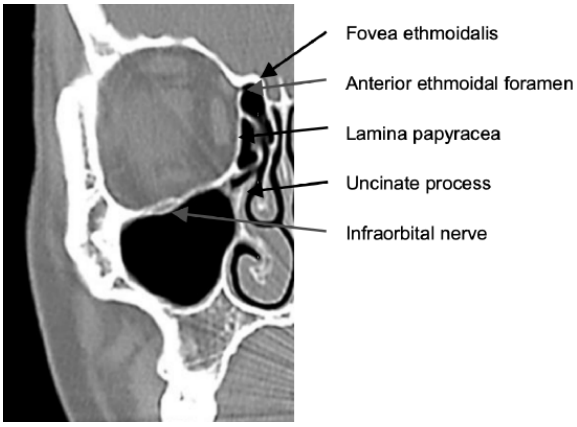


Figure 7: Note the position of the anterior ethmoidal artery where it passes through its foramen which is located in the frontoethmoidal suture line

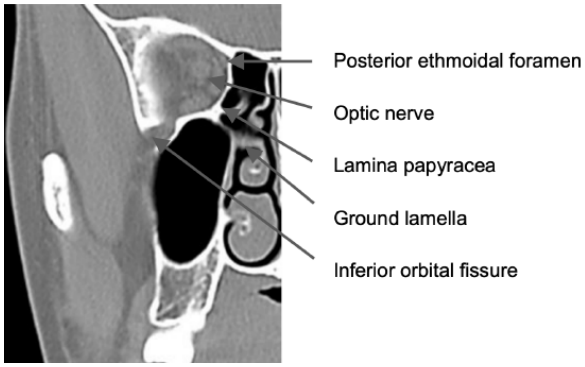


Figure 8: Coronal slice through posterior ethmoids demonstrating posterior ethmoidal foramen and optic nerve

Figures 7 & 8 demonstrate the value of using the anterior and posterior ethmoidal arteries and frontoethmoidal suture line (*Figure 4*) to determine the level of the floor of the anterior cranial fossa when opening the lamina papyracea from the orbital side during medial or total maxillectomy.

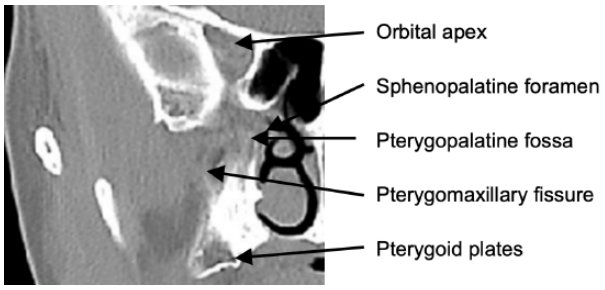


Figure 9: Coronal cut immediately behind the maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa

Figure 9 demonstrates the coronal anatomy immediately posterior to the maxillary sinus, which is in the plane through which an inferior or total maxillectomy is done, and in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure, and medially with the nasal cavity via the sphenopalatine foramen.

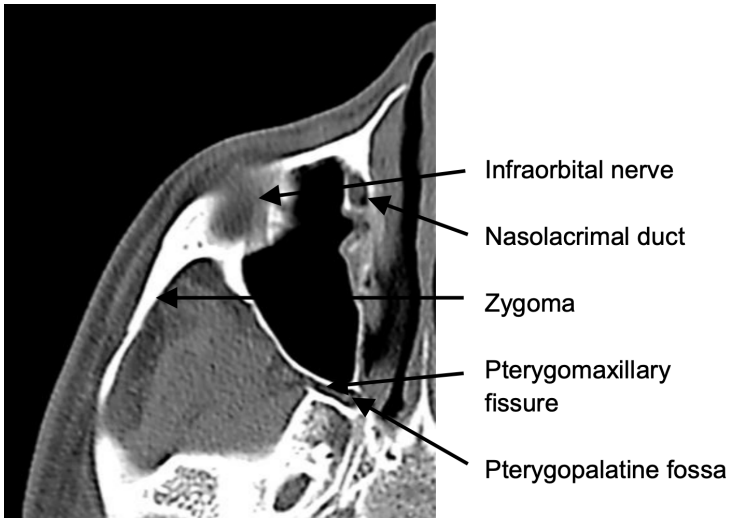


Figure 10: Axial cut at level of infraorbital nerve and orbital floor

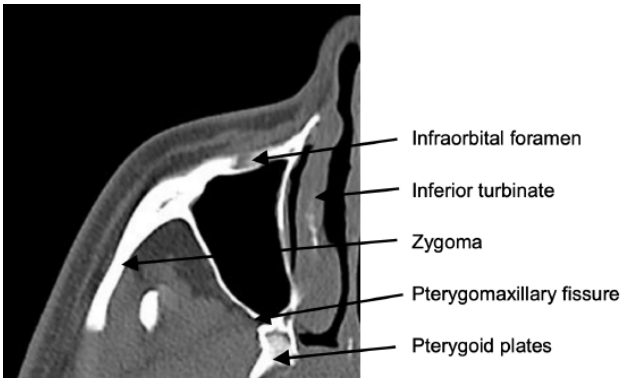


Figure 11: Axial cut at level of infraorbital foramen and pterygoid plates

Figures 10 & 11 show axial views of the anatomy of the maxillary sinus. The posterior resection lines of total and inferior maxillectomies pass through the pterygopalatine fossa and pterygomaxillary fissure and the anterior aspect of the pterygoid plates.

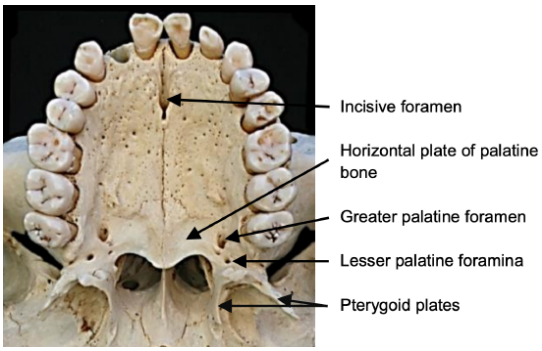


Figure 12: Anatomy of hard palate

The bony anatomy of the hard palate is illustrated in *Figure 12*.

Vasculature

An understanding of the blood supply of the maxilla permits the surgeon to anticipate when and where to encounter bleeding, and to plan the sequence of the surgery to reserve the bloodier parts of the surgery until last to minimize blood loss and to avoid blood obscuring the surgical field.

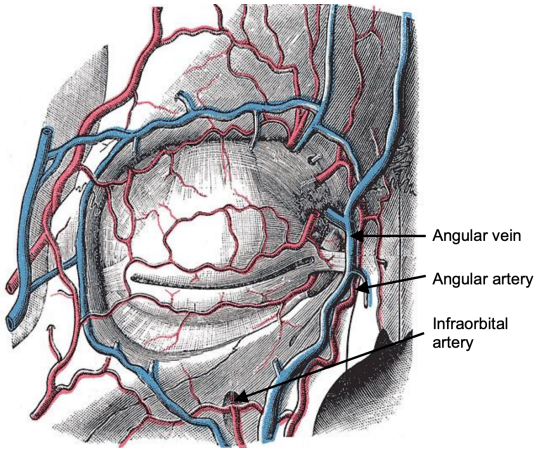


Figure 13: Vasculature around the orbit

The only significant vein encountered during maxillectomy is the ***angular vein*** (*Figure 13*) at the medial canthus.

The arterial blood supply to the maxilla and paranasal sinuses originates from both the external and internal carotid artery systems. During inferior maxillectomy one can expect to encounter some bleeding from the descending palatine artery, which originates from the maxillary artery in the pterygopalatine fossa, passes inferiorly through the pterygopalatine canal, and emerges from the greater palatine foramen as the greater palatine artery to supply the hard palate.

The arterial supply relevant to inferior maxillectomy is as follows:

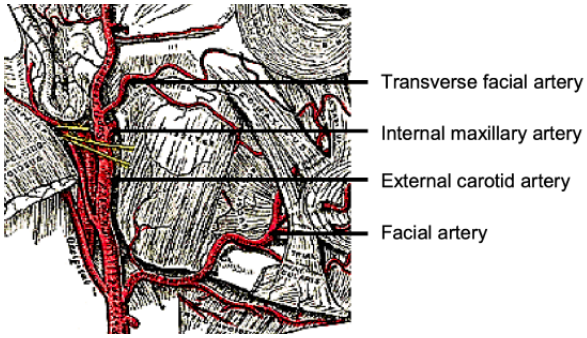


Figure 14: Facial artery and origin of internal maxillary artery, both branches of the external carotid artery

- ***Facial/external maxillary artery***, a branch of the external carotid artery, courses in the soft tissues of the face and past the medial canthus as the angular artery (*Figures 13 & 14*).

- ***Internal maxillary artery***, a branch of the external carotid artery (*Figures 14 & 15*), passes through the pterygomaxillary fissure to enter the pterygopalatine fossa.

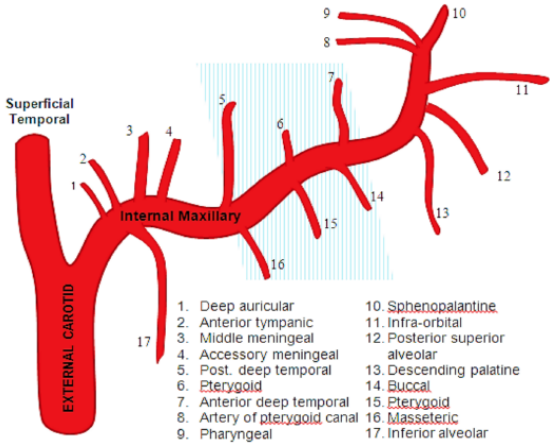


Figure 15: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa

Branches of the internal maxillary artery of surgical significance include:

- ***Greater palatine artery*** (descending palatine) (*Figure 15*): It passes inferiorly from the pterygopalatine fossa through the pterygopalatine canal (*Figure 2*) and emerges from the greater palatine foramen of the hard palate (*Figure 12*). It then runs anteriorly medial to the superior alveolus and enters the incisive foramen (*Figure 12*).
- ***Infraorbital artery***: It courses in the floor of the orbit/roof of antrum in the infraorbital groove and canal with the infraorbital nerve and exits anteriorly from the infraorbital foramen to supply the overlying soft tissues of the face (*Figures 13 & 15*).
- ***Sphenopalatine artery*** (*Figure 15*): It enters the nasal cavity through sphenopalatine foramen at the back of the superior meatus.
- ***Posterior lateral nasal arteries***: These originate from the sphenopalatine artery after passing through the sphenopalatine foramen.
- ***Posterior septal artery***: This is a branch of the sphenopalatine artery and crosses the posterior nasal cavity just above the posterior choana to end on the nasal septum; one branch descends in a groove in the vomer to enter the incisive canal and anastomose with the greater palatine artery.

Nerves

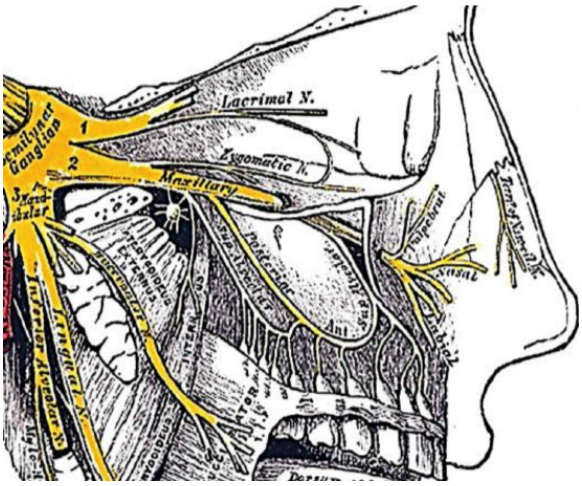


Figure 16: V2, pterygopalatine ganglion and infraorbital nerve

The ***maxillary division of V*** (V2) enters the pterygopalatine fossa via the foramen rotundum. The only branch of surgical significance is the ***infraorbital nerve***. It runs in the floor of the orbit/roof of the antrum to exit from the infraorbital foramen (*Figure 16*).

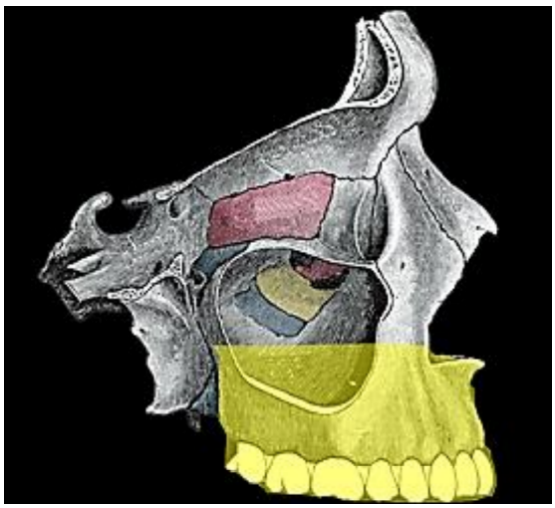


Figure 17: Yellow area indicates extent of bony resection of inferior maxillectomy

Inferior maxillectomy is employed with tumors limited to the palate and floor of the maxillary sinus and nasal cavity. It entails resection of the hard palate and may include the walls of the maxillary sinus and nasal floor and inferior turbinate but spares the orbital floor and ethmoid sinuses (*Figures 17*).

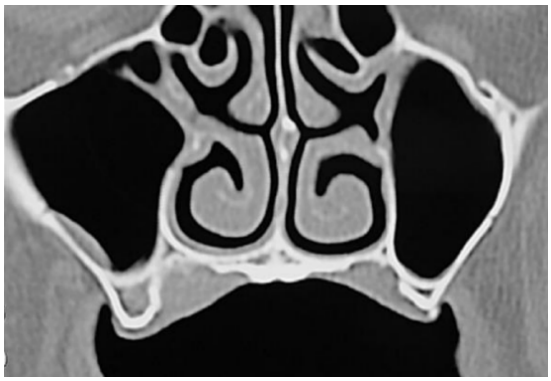


Figure 18: Mucoepidermoid carcinoma of hard palate suited to unilateral inferior maxillectomy with sparing of inferior turbinate and nasal septum



Figure 19: Polymorphous low grade adenocarcinoma of palate suited to unilateral inferior maxillectomy with resection crossing midline and including the base of the nasal septum



Figure 20: Adenoid cystic carcinoma of hard palate suited to inferior maxillectomy, including inferior turbinate

Coronal CT scanning is essential in order to determine the superior extent of a tumor to determine the suitability for an inferior maxillectomy (*Figures 18-20*).

Surgical steps

The following description refers to a tumor that requires resection of half the hard palate.

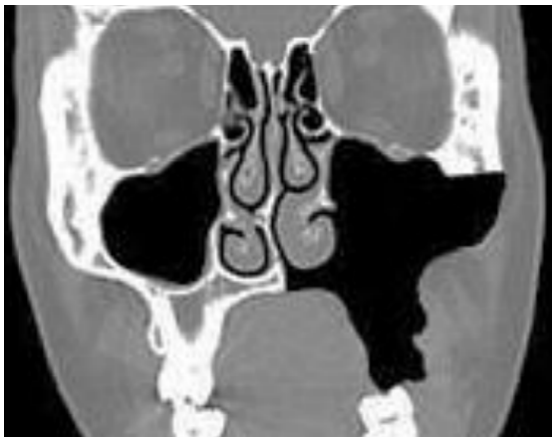


Figure 21: Coronal CT demonstrating bone removed with unilateral inferior maxillectomy (Inferior turbinate intact)

Figure 21 illustrates the extent of the bone resection following a unilateral inferior maxillectomy with preservation of the inferior turbinate.

Preoperative consent includes discussing facial incisions, potential injury to the infraorbital nerve, reconstructive options and the loss of dentition and ability to wear dentures or to have dental implants.

The operation is done under general anesthesia, with orotracheal intubation, or nasotracheal intubation if only half the palate is to be removed. A temporary ***tracheostomy*** is done to ensure an adequate airway in case soft tissue swelling or bleeding occurs. Perioperative broad-spectrum antibiotics are administered for 24 hours.

The operation may be considered in 3 stages: soft tissue dissection/bone exposure; bone resection; and closure/reconstruction.

Soft tissue dissection/bone exposure

It is important to ***complete the soft tissue dissection and bone exposure before doing any bone work*** to avoid excessive blood loss.

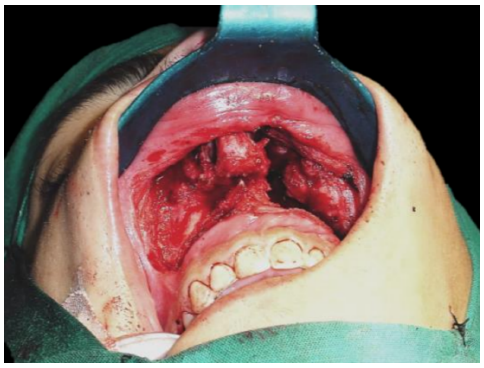


Figure 22: Midfacial degloving approach

- Inferior maxillectomy is done via a ***sublabial incision*** or a ***midfacial degloving approach*** (*Figure 22*).
- ***Local anesthetic with vasoconstrictor*** is injected along the planned mucosal or skin incisions.
- The ***sublabial mucosa*** is incised along the gingivobuccal sulcus with electrocautery.
- The ***soft tissues of the face*** are elevated off the face of the maxilla using cautery or an elevator, remaining hard on bone while doing so
- Expose the entire face of the maxilla.
- Stop the dissection superiorly at the infraorbital foramen taking care to preserve the infraorbital nerve and to avoid troublesome bleeding from the infraorbital artery.
- Next, free the soft tissues medially from the bone up to the ***anterior free margin of the nasal aperture*** with diathermy. Retract the nasal ala and incise the lateral wall of the nasal vestibule to expose the ipsilateral nasal cavity and inferior turbinate, taking care not to injure the inferior turbinate or septum to avoid bleeding.
- Using a tonsil gag in the mouth to retract the tongue, visualize the hard and soft palates and the tumor. Identify the maxillary tuberosity and the bony spines of the pterygoid plates immediately posterior to the tuberosity. Using electrocautery, incise the mucosa of the hard palate along the planned medial resection margin, and extend the sublabial incision laterally around the maxillary tuberosity, and into the groove between the tuberosity and the pterygoid plates.
- Palpate and define the posterior edge of the hard palate and divide the attachment of the soft palate to the hard palate with electrocautery, thereby entering the nasopharynx. Anticipate and coagulate bleeding from branches of the greater and lesser palatine arteries.

Bony resection (Figs 23-29)



Figure 23: Antrostomy

- An ***antrostomy*** is made in the anterior face of the maxilla with a hammer and gouge or a burr, entering the antrum through the thin bone of the canine fossa (*Figure 23*). A punch or bone nibbler is used to remove enough bone of the anterior wall of the maxillary sinus to evaluate the tumor extent in the antrum, but taking care to leave a margin of bone around the infraorbital foramen so as to protect the nerve and to avoid bleeding from the infraorbital vessels. Inspect the antrum and determine the extent of the tumor and plan the subsequent bony cuts.

- The ***inferior maxillectomy*** can now be done using sharp osteotomes and/or a powered saw. The extent of the bony resection is tailored to the tumor. ***The sequence of the osteotomies*** is planned to reserve troublesome bleeding to the end. The sequence may have to be adjusted depending on the location and extent of the tumor.



Figure 24: Anterior view of osteotomies



Figure 25: Lateral view of osteotomies, including through pterygomaxillary fissure

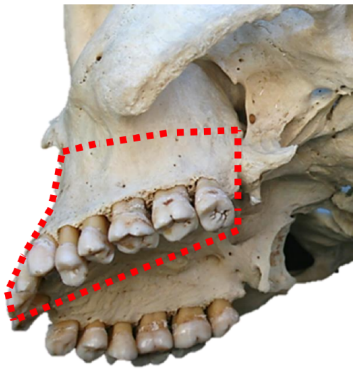


Figure 26: Osteotomies including osteotomy between maxillary tuberosity and pterygoid plates and of palate

- Perform an osteotomy through the lateral ***wall of the maxillary sinus*** with an osteotome, bone nibbler or powered saw (*Figures 24 -26*) up to its junction with the posterior antral wall.
- Perform an ***osteotomy*** through the anterior medial wall of the maxillary sinus up to the nasal vestibule with an osteotome, bone nibbler or powered saw (*Figures 24*).

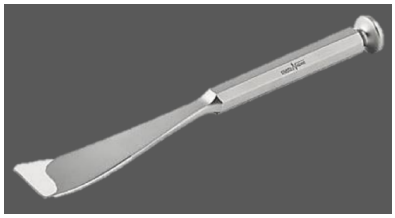


Figure 27: Curved osteotome

- ***Free the pterygoid plates*** with a curved osteotome (*Figure 27*) from the maxillary tuberosity along the posterior vertical line shown in *Figures 25 & 26*.

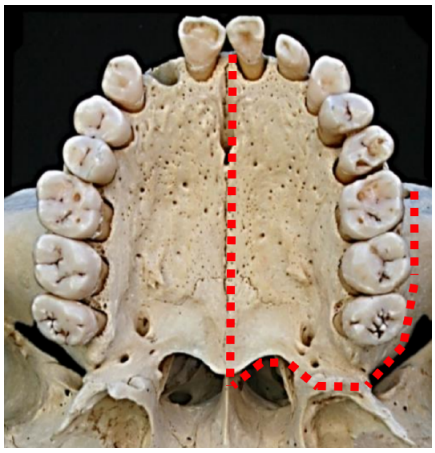


Figure 28: Palatal osteotomies. Note osteotomy passes between palate and pterygoid plates

- Perform a ***palatal osteotomy*** in a sagittal plane with an osteotome or saw, taking care not to traumatize and cause bleeding from the inferior turbinate and nasal septum when entering the nasal cavity (*Figures 24, 26, 28*).
- Should the palatal resection extend through the floor of the ipsilateral nasal cavity, then the ***lateral nasal wall*** needs to be divided parallel to the palate with scissors or an osteotome. Similarly, the ***nasal septum*** must be divided if the resection extends beyond the midline.

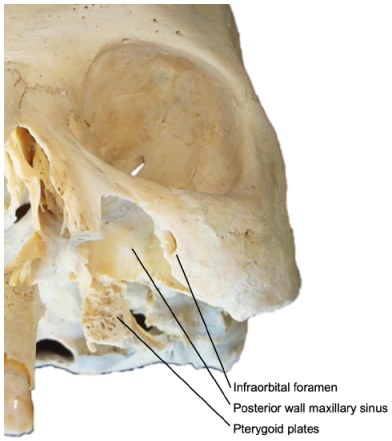


Figure 29a: Inferior maxillectomy defect



Figure 29b: Inferior maxillectomy defect

- The inferior maxillectomy specimen is then leveraged downwards, fracturing across the ***posterior antral wall*** in the process, and the specimen is removed (*Figures 29 a, b*).

- Hemostasis is obtained. The maxillary artery should be looked for as it might have been transected and gone into spasm and clipped or ligated.
- The specimen is inspected to determine the adequacy of the tumor resection margins.

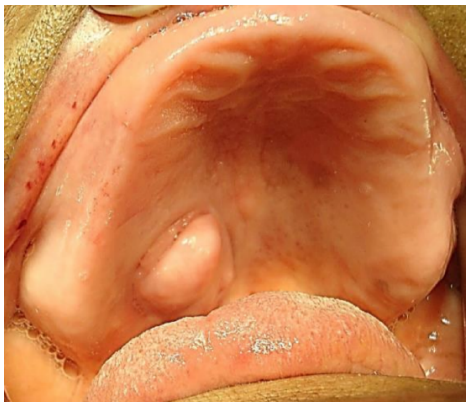


Figure 30a: Minor salivary gland tumor of hard palate

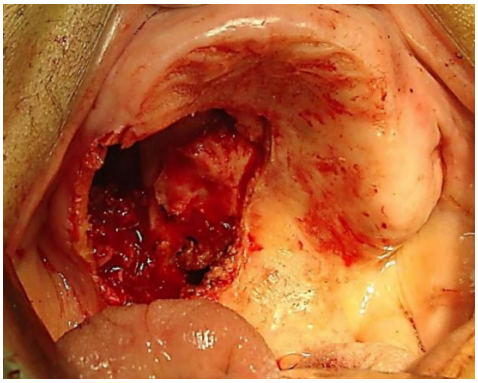


Figure 30b: Partial inferior maxillectomy suited to an obturator, or reconstruction with buccinator, temporalis muscle, nasolabial or radial free forearm flaps

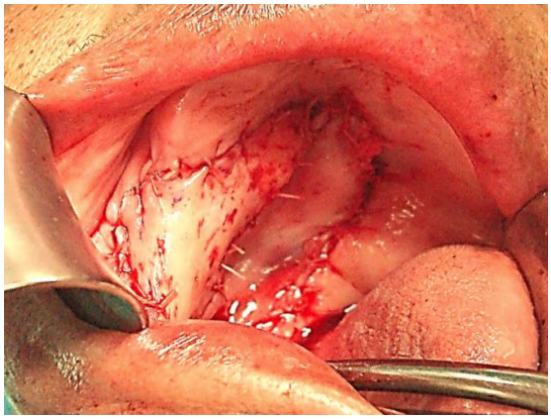


Figure 30c: Partial inferior maxillectomy defect closed with two flaps: buccinator myomucosal and local rotation flaps

Figures 30 a, b & c show a limited inferior maxillectomy for a minor salivary gland tumor which was reconstructed with a combination of a local rotation flap and a buccinator flap.



Figure 31a: Malignant melanoma of superior alveolus and hard palate



Figure 31b: Bilateral inferior maxillectomy for melanoma

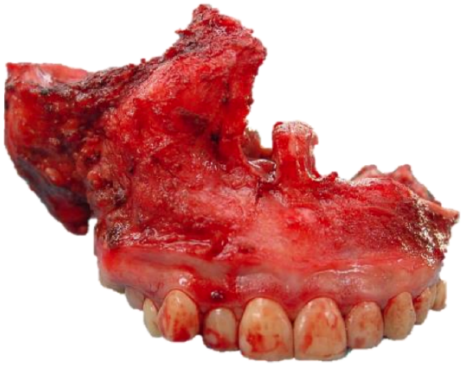


Figure 32: (L) inferior maxillectomy with (R) total maxillectomy for sarcoma crossing the midline of the palate

With more extensive tumors, bilateral inferior maxillectomy (*Figures 1*, *31a &*, *b*), or more extensive resections (*Figure 32*) may be required.

Closure/Reconstruction

The objectives are to restore palatal integrity to separate the oral cavity from the nose and antrum, to maintain midfacial projection, and to facilitate dental restoration. This may be achieved in the following ways:

1. *Denture*: Retention may be difficult
2. *Buccinator flap* (*Figure 30c*)
3. *Nasolabial flap* (*Figures 33*, *34*) *Temporalis muscle flap*: This is very well suited, but care must be taken not to injure the deep temporal arterial pedicle during maxillectomy (*Figure 33*). A bilateral flap can be used for bilateral inferior maxillectomy defects (*Figure 35*). It does however preclude the use of dentures.
4. *tRadial free forearm flap (+/- bone)*
5. *Anterolateral thigh free flap* (may be too bulky)
6. *Free fibula flap* (permits dental implants)
7. *Thoracodorsal artery scapular tip (TDAST) flap*



Figure 33: Flap turned in to reconstruct the defect



Figure 34: Nasolabial flap inset into the defect and donor site and lip-split closed

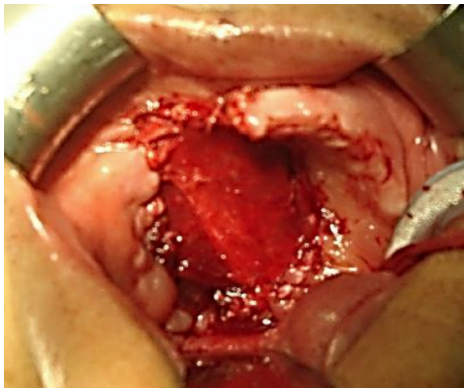


Figure 35: Reconstruction of inferior maxillectomy defect with temporalis muscle flap



Figure 36: Mucosalized bilateral temporalis muscle following bilateral inferior maxillectomy

Author & Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.30: Medial Maxillectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Medial maxillectomy refers to surgical resection of the medial and superomedial walls of the maxillary antrum. It is increasingly being done by transnasal endoscopic technique for suitable cases and when the required expertise and technology are available. This chapter will only deal with the open surgical medial maxillectomy technique.

Maxillectomy is potentially complicated by injuries to the orbital contents, lacrimal apparatus, optic nerve, ethmoidal arteries, intracranial contents, and may be accompanied by brisk bleeding. A sound understanding of the 3-dimensional anatomy of the maxilla and the surrounding structures is therefore essential. Hence the detailed description of the surgical anatomy that follows.

Surgical Anatomy

Bony anatomy

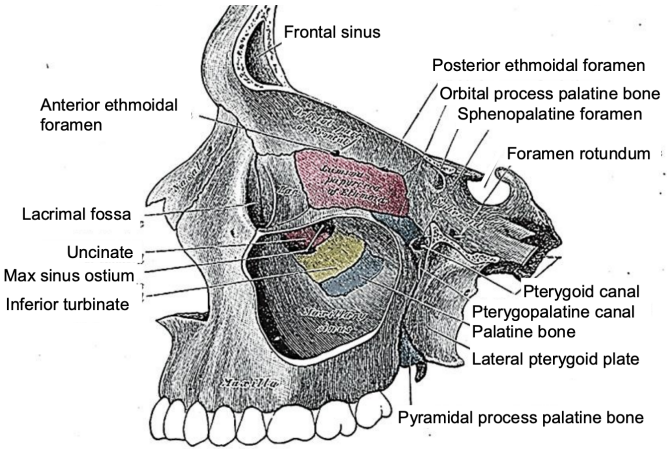


Figure 1: Lateral view of maxilla with windows cut in lateral and medial walls of maxillary sinus

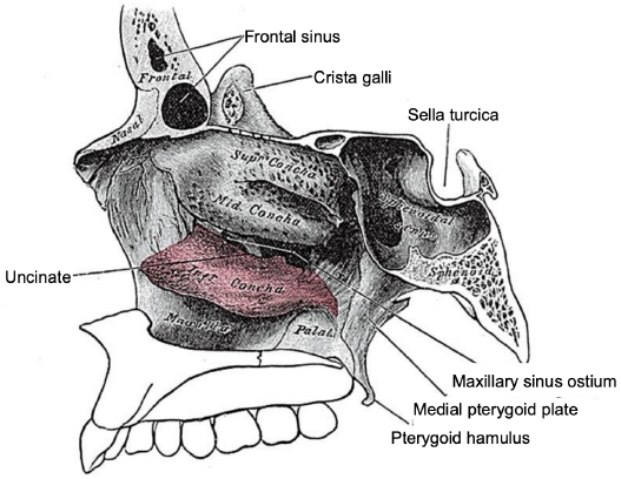


Figure 2: Bony anatomy of the lateral wall of the nose

Figures 1 & 2 illustrate the detailed bony anatomy relevant to medial maxillectomy. Critical surgical landmarks to note include:

- The level of the floor of the anterior cranial fossa (fovea ethmoidalis and cribriform plate) corresponds with anterior and posterior ethmoidal foramina located along the frontoethmoidal suture line.
- The proximity (5-11 mm) of posterior ethmoidal foramen and artery to the optic nerve within the optic foramen.

Figure 2 illustrates the bony anatomy of the lateral wall of the nose. The inferior turbinate (concha) is resected with a medial maxillectomy, but the middle turbinate is generally preserved, unless involved by pathology.

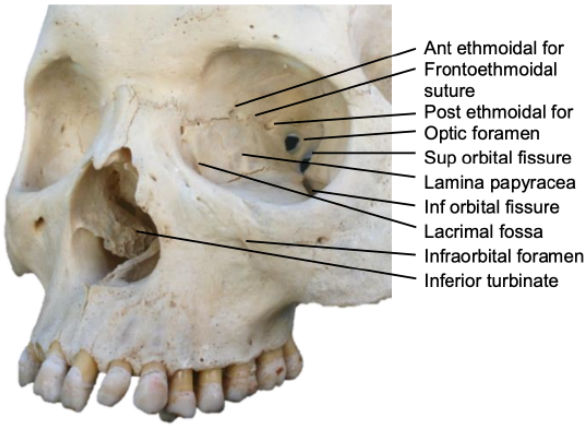


Figure 3: Bony anatomy in cadaver

Figure 3 demonstrates the anatomy of the medial wall of the nose in a cadaveric skull. Note in particular the thin lamina papyracea, the lacrimal fossa, the frontoethmoidal suture line and the anterior and posterior ethmoidal foramina and the infraorbital foramen.

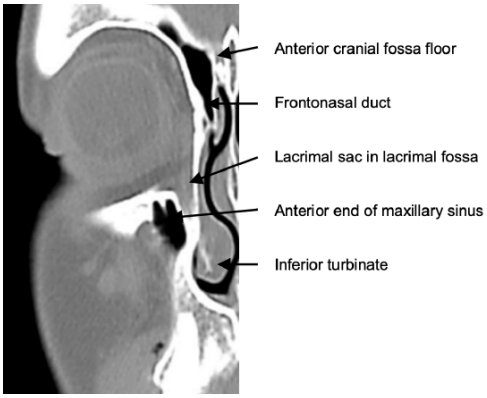


Figure 4: Coronal CT slice through lacrimal fossa

Figure 4 demonstrates the coronal anatomy at the level of the anterior extent of a medial maxillectomy. Specifically note the lacrimal sac, which is normally transected at surgery in the lacrimal fossa, and the relative heights of the floors of the antrum and the nasal cavity.

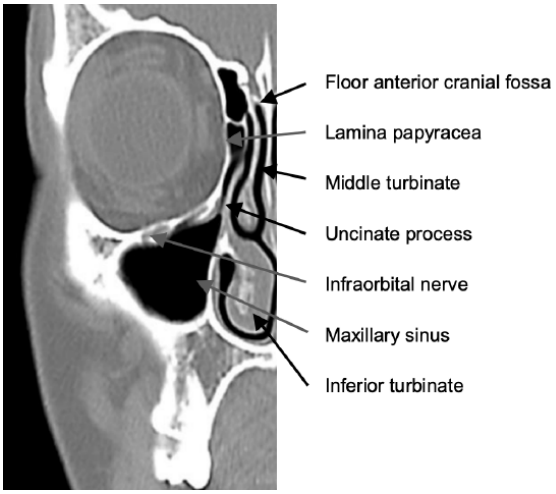


Figure 5: Anatomy in the coronal plane through the anterior ethmoids midway along a medial maxillectomy

Figure 5 demonstrates the coronal anatomy midway back along a medial maxillectomy. Specifically note the infraorbital nerve in the orbital floor, the thin lamina papyracea and the relative heights of the floors of the antrum and the nasal cavity.

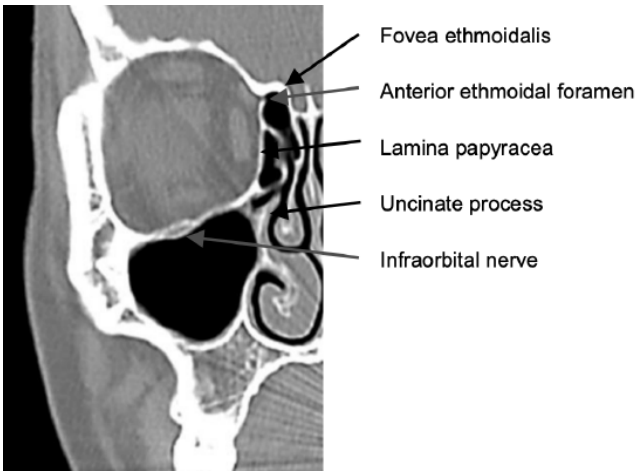


Figure 6: Note the position of the anterior ethmoidal artery where it passes through its foramen which is located in the frontoethmoidal suture line

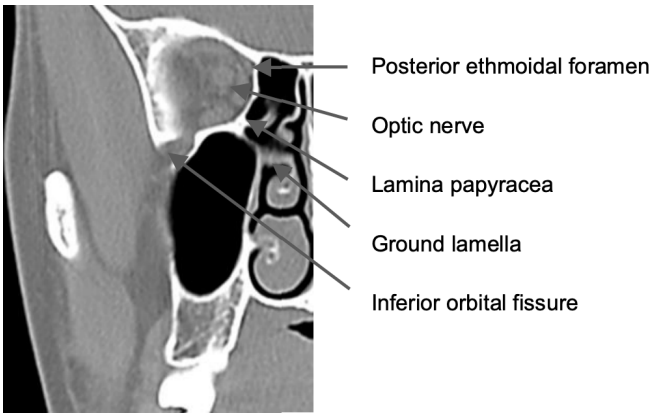


Figure 7: Coronal slice through posterior ethmoids demonstrating posterior ethmoidal foramen and optic nerve

Figures 6 & 7 demonstrate the value of using the anterior and posterior ethmoidal arteries and frontoethmoidal suture line to determine the level of the floor of the anterior cranial fossa when opening the lamina papyracea from the orbital side during medial maxillectomy.

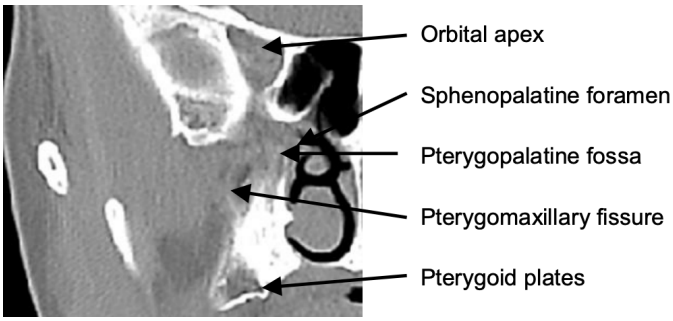


Figure 8: Coronal cut immediately behind the maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa.

Figure 8 demonstrates the coronal anatomy immediately posterior to the maxillary sinus, which is in the plane through which a total maxillectomy is done, and in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure, and medially with the nasal cavity via the sphenopalatine foramen.

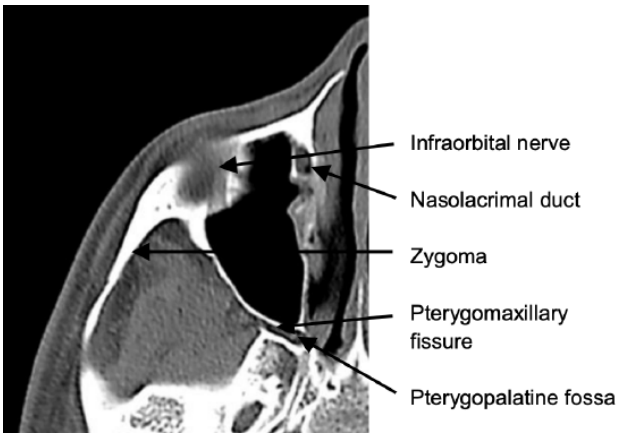


Figure 9: Axial cut at level of infraorbital nerve and orbital floor

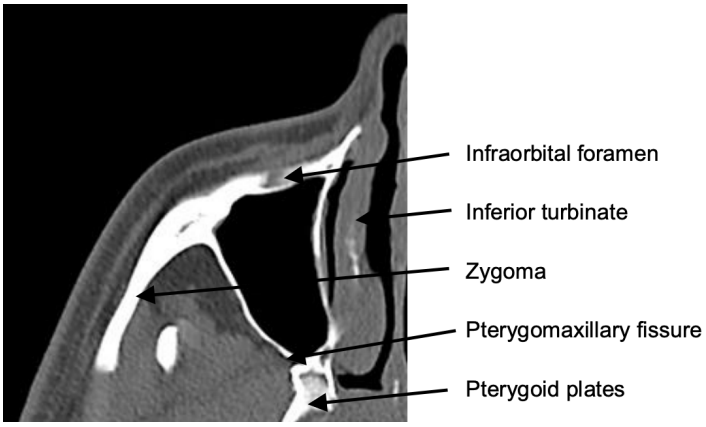


Figure 10: Axial cut at level of infraorbital foramen and pterygoid plates

Figures 9 & 10 show axial views of the anatomy of the maxillary sinus. The posterior resection lines of total and inferior maxillectomies pass through the pterygopalatine fossa and pterygomaxillary fissure and the anterior aspect of the pterygoid plates. Medial maxillectomy is done medial to the infraorbital nerve.

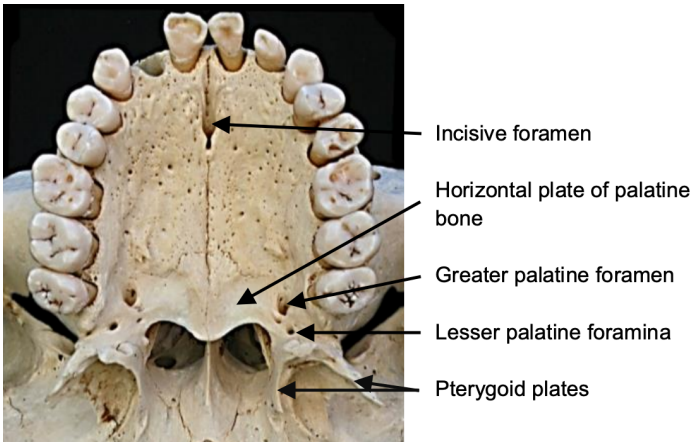


Figure 11: Anatomy of hard palate

The bony anatomy of the hard palate is illustrated in *Figure 11*.

Vasculature

An understanding of the blood supply of the maxilla permits the surgeon to anticipate when and where to encounter bleeding, and to plan the sequence of the surgery to reserve the bloodier parts of the surgery until last so as to minimize blood loss and to avoid blood obscuring the surgical field.

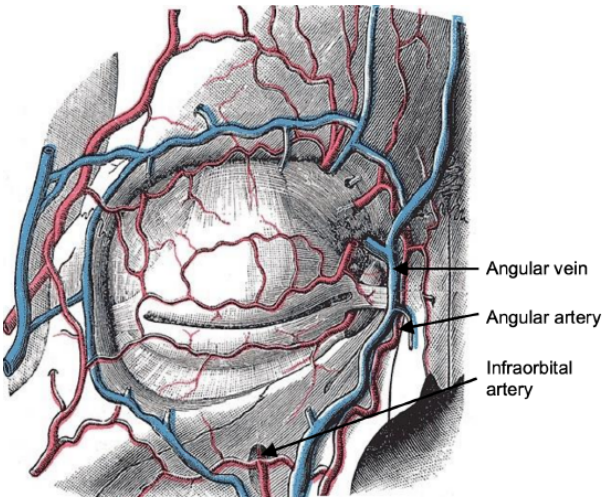


Figure 12: Vasculature around the orbit

The only significant vein encountered during maxillectomy is the ***angular vein*** (*Figure 12*) at the medial canthus.

The blood supply to the maxilla and paranasal sinuses originates both from the external and internal carotid artery systems. The arterial supply relevant to maxillectomy is as follows:

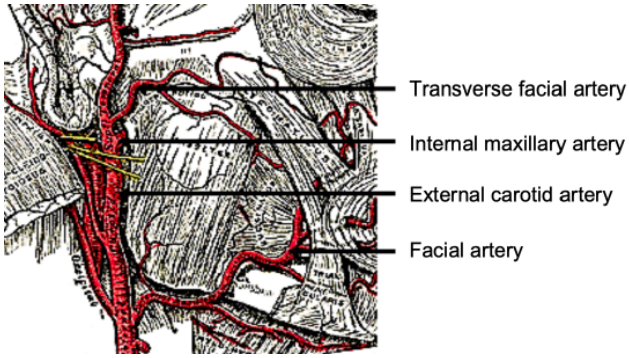
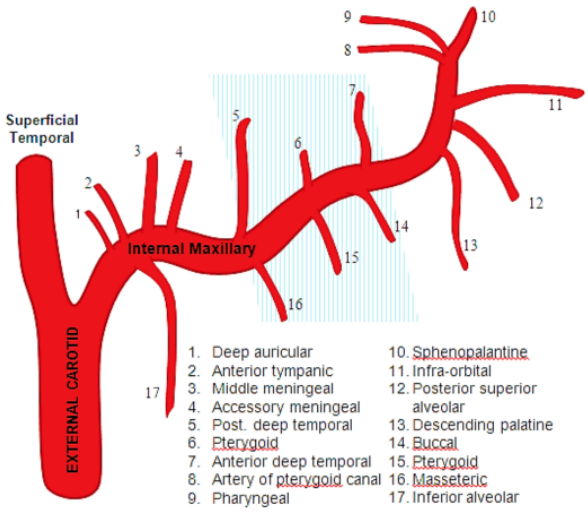


Figure 13: Facial artery and origin of internal maxillary artery, both branches of the external carotid artery

- ***Facial/external maxillary artery***, a branch of the external carotid artery courses in the soft tissues of the face and past the medial canthus as the angular artery (*Figures 12*, *13*).



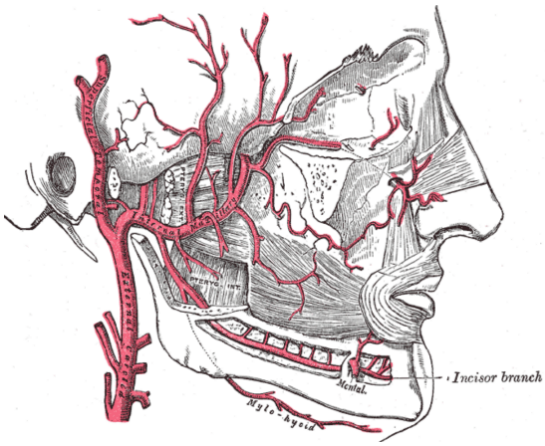


Figure 14a, b: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa

- ***Internal maxillary artery***, a branch of the external carotid artery (*Figures 13, 14a, b*), passes through the pterygomaxillary fissure to enter the pterygopalatine fossa.

Branches of the internal maxillary artery of surgical significance include:

- ***Greater palatine artery*** (descending palatine) (*Figure 14*): It passes inferiorly from the pterygopalatine fossa through the pterygopalatine canal (*Figure 1*) and emerges from the greater palatine foramen of the hard palate (*Figure 11*). It then runs anteriorly medial to the superior alveolus and enters the incisive foramen (*Figure 11*).
- ***Infraorbital artery***: It courses in the infraorbital groove and canal with the infraorbital nerve in the floor of the orbit/roof of antrum and exits anteriorly via the infraorbital foramen to supply the overlying soft tissues of the face (*Figures 12, 14*).
- ***Sphenopalatine artery*** (*Figure 14*): It enters the nasal cavity through sphenopalatine foramen at the back of the superior meatus where it gives origin to posterior lateral nasal branches.
- ***Posterior septal artery***: This is a branch of the sphenopalatine artery and crosses the posterior nasal cavity just above the posterior choana to end on the nasal septum; one branch descends in a groove in the vomer to enter the incisive canal and anastomose with the greater palatine artery.

Branches of the internal carotid artery of surgical significance include:

- ***Anterior ethmoidal artery***: It originates from the ophthalmic artery and enters the orbit through the anterior ethmoidal foramen (*Figure 3*) which is located 25 mm from the anterior lacrimal crest.
- ***Posterior ethmoidal artery***: It originates from the ophthalmic artery and enters the orbit through the posterior ethmoidal foramen (*Figures 3, 7*). It is located approximately 36 mm from the anterior lacrimal crest, and 12 mm (8-19 mm) from the anterior ethmoidal foramen.
- ***Ophthalmic artery***: It emerges with the optic nerve from the optic canal, 44 mm from the anterior lacrimal crest and approximately 6 mm (5-11 mm) from the posterior ethmoidal foramen.

Nerves

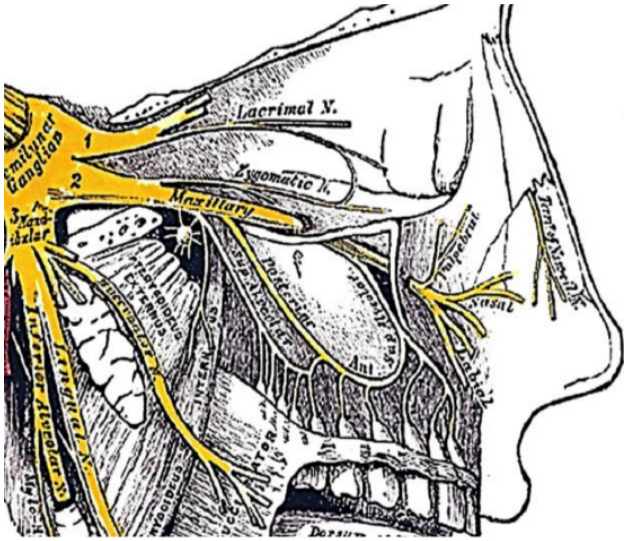


Figure 15: V2, pterygopalatine ganglion and infraorbital nerve

The ***maxillary division of V*** (V2) enters the pterygopalatine fossa via foramen rotundum. The only branch of surgical significance is the ***infraorbital nerve***. It runs in the floor of the orbit/roof of the antrum to exit from the infraorbital foramen (*Figure 15*). The only other major nerve that must be considered at maxillectomy is the ***optic nerve***.

Orbital structures

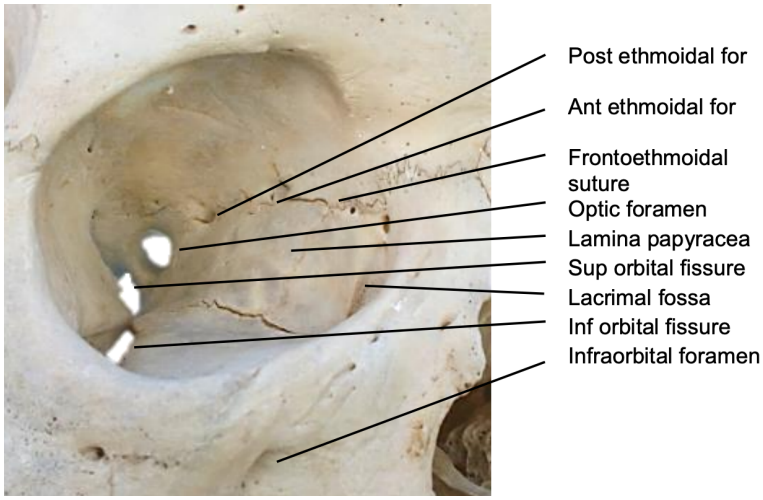


Figure 16: Right medial orbital wall

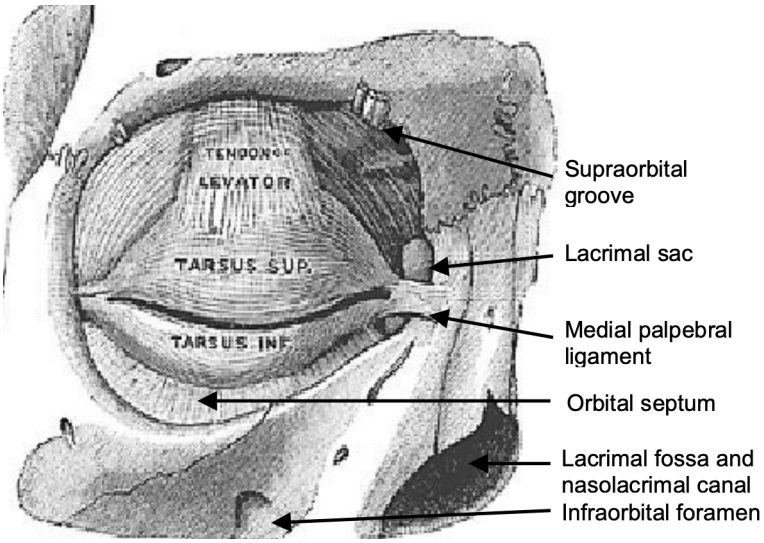


Figure 17: Right orbit showing medial palpebral ligament, orbital septum, lacrimal sac and lacrimal fossa

Figure 16 shows the detailed bony anatomy of the orbit. During dissection of the orbit, the following structures are encountered: medial palpebral ligament, orbital septum, lacrimal sac, periosteum, anterior and posterior ethmoidal arteries and inferior orbital fissure (*Figure 16*, *17*). Only when doing orbital exenteration is the superior orbital fissure encountered.

- ***Orbital septum*** (*Figure 17*): This connective tissue structure attaches peripherally to the periosteum of the orbital margin and acts as a diaphragm that retains the orbital contents. Laterally, it is attached to the orbital margin 1.5 mm anterior to the attachment of the lateral palpebral ligament to the lateral orbital tubercle. The septum continues along the superior orbital rim. Superomedially it crosses the supraorbital groove, passes inferomedially anterior to the trochlea, and follows the posterior lacrimal crest behind the lacrimal sac. It then crosses the lacrimal sac to reach the anterior lacrimal crest, passes inferiorly along the anterior lacrimal crest and then laterally along the inferior orbital rim.
- ***Medial palpebral ligament*** (medial canthal tendon) (*Figure 17*): This is a fibrous band that fixes the tarsi to the medial orbital wall. It is intimately related to the lacrimal drainage system. It lies anterior to the canaliculi, but a deep head inserts into the posterior lacrimal crest and onto the fascia of the lacrimal sac.

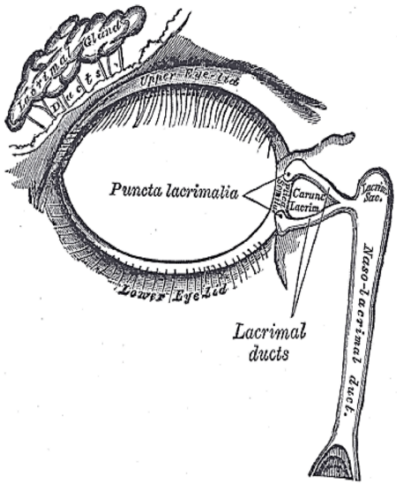


Figure 18: Right lacrimal system

- ***Lacrimal sac*** (*Figures 1*, *3*, *4*, *16*, *17*, *18*): It is located in the lacrimal fossa, which is bound medially by the lacrimal bone and the frontal process of the maxilla (*Figure 1*, *16*). It is related anteriorly, laterally, and posteriorly to the medial palpebral ligament.

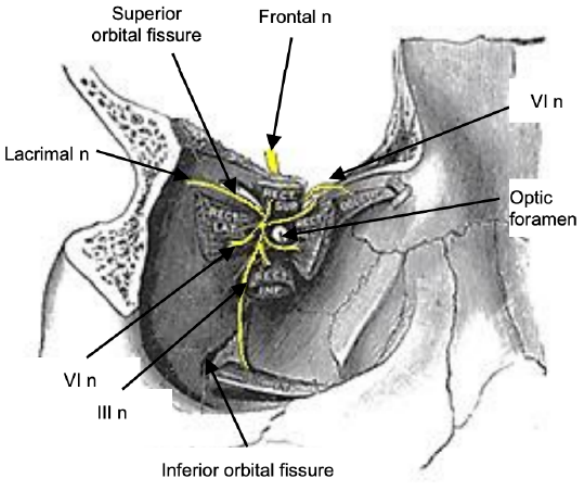


Figure 19: Inferior and superior orbital fissures of (R) orbit

- ***Inferior orbital fissure*** (*Figure 16, 19*): This fissure is situated in the floor of the orbit and separates the sphenoid bone from the maxilla. It transmits the maxillary nerve and a few minor nerves, but no vessels of surgical significance.
- ***Superior orbital fissure*** (*Figure 16, 19*): This fissure lies between the lesser and greater wings of the sphenoid bone. Important anatomical structures that pass through the fissure are cranial nerves III, IV, VI; and the superior and inferior divisions of ophthalmic vein.

Medial Maxillectomy

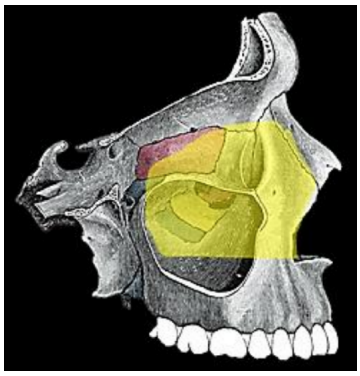


Figure 20: Yellow area indicates extent of bony resection of medial maxillectomy

Medial maxillectomy entails resection of the lateral wall of the nasal cavity (medial wall of antrum and orbit), the ethmoid sinuses and the medial part of the orbital floor (*Figure 20*).

It is employed with tumors (including inverting papilloma) involving the lateral wall of the nose, the lacrimal sac, and ethmoids. CT scan is an important means of anticipating the extent of maxillectomy that is required and to assess the anatomy of the skull base and paranasal sinuses. Once a tumor involves orbital fat, extends inferiorly to invade the palate or nasal floor, extends laterally beyond the infraorbital foramen, or involves the posterior antral wall and beyond, then more extensive resection is required.

Surgical steps

Preoperative consent includes discussing the facial incisions, injury to the optic and infraorbital nerves, diplopia, epiphora, enophthalmos, telecanthus, and CSF leak. The operation is done under *general anesthesia*, with orotracheal intubation. Perioperative broad-spectrum antibiotics are administered for 24 hours. Local anesthetic with vasoconstrictor is injected along the planned skin incisions. The nasal cavity is decongested with a topical vasoconstrictor. The eyelids are sutured together with 6/0 silk taking care not to invert the eyelashes to avoid corneal abrasions.

The operation may be considered in 3 stages: soft tissue dissection/bone exposure; bone resection; and closure/reconstruction.

It is important to complete the soft tissue dissection and bone exposure before doing any bone work to avoid excessive blood loss.



Figure 21: Lateral rhinotomy incision. Very rarely is the lip split extension required for access

- Medial maxillectomy may be done via ***midfacial degloving or lateral rhinotomy approach*** (*Figure 21*). The midfacial degloving approach avoids facial scars and is suited to resections that do not extend above the orbital floor i.e. do not include resection of the lamina papyracea and ethmoids. Once the resection requires removal of the medial wall of the orbit and the ethmoids, lateral rhinotomy provides better access. The skin is incised with a scalpel. The remainder of the soft tissue dissection may be done with electrocautery. The incision is extended onto the nasal bone and the maxilla. The angular vessels are cauterized or ligated adjacent to the medial canthus of the eye (*Figure 12*).
- The ***soft tissues of the face*** are elevated off the face of the maxilla using cautery or an elevator, remaining hard on bone while doing this dissection. Expose the entire face of the maxilla. Stop the dissection laterally at the infraorbital foramen taking care to preserve the infraorbital nerve and to avoid bleeding from the infraorbital artery.
- Sequentially identify the ***medial palpebral ligament, anterior lacrimal crest***, the ***lacrimal sac*** in the ***lacrimal fossa***, and the ***posterior lacrimal crest***. Elevate the ***lacrimal sac*** from its fossa and transect it as distally as possible with a scalpel, to facilitate a dacryocystorhinostomy. Expect some bleeding from the transected sac.
- Next, the ***medial and inferior orbit is exposed***. The periosteum is stripped from the nasal bone and frontal process of the maxilla, taking care to remain in a subperiosteal plane. Strip the orbital contents in an extraperiosteal plane from the lamina papyracea and frontal bone taking care not to fracture or penetrate the thin bone of the lamina papyracea.

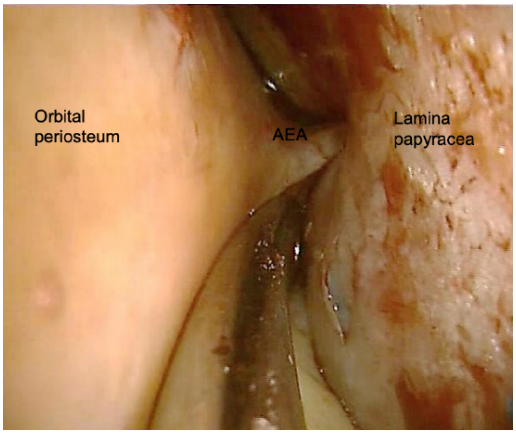


Figure 22: Anterior ethmoidal artery (AEA) exiting foramen at level of frontoethmoidal suture line (right eye)

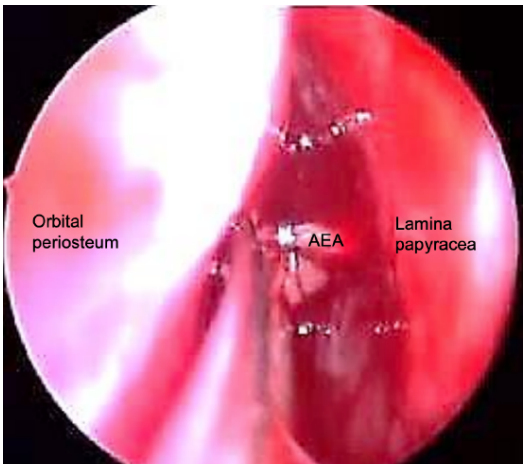


Figure 23: Liga clips being applied to anterior ethmoidal artery (AEA)

- Identify the ***frontoethmoidal suture line***. This is a crucial surgical landmark as it corresponds with the level of the cribriform plate and the anterior and posterior ethmoidal foramina. Retract the orbital contents laterally and identify the ***anterior ethmoidal artery*** as it bridges the divide between the ***anterior ethmoidal foramen*** and the periorbita (*Figure 22, 23*). The anterior ethmoidal artery is ligated, clipped or bipolared and divided, thereby providing access to the ***posterior ethmoidal artery***. It is generally not necessary to divide this vessel.
- Now strip along the ***floor of the orbit*** in an extraperiosteal plane. Take special care not to tear the periosteum at the inferior orbital margin at the attachment of the orbital septum to avoid entering the orbital fat and causing extrusion of the fat.
- Next free the soft tissues from the bone up to the ***anterior free margin of the nasal aperture*** with diathermy. Retract the nasal ala and incise the lateral wall of the nasal vestibule to expose the ipsilateral nasal cavity and inferior turbinate, taking care not to injure the inferior turbinate of septum to avoid troublesome bleeding.

At this point the soft tissue dissection is complete.

Bony resection


Figure 24: Anterior antrostomy, taking care not to injure infraorbital nerve

- ***An antrostomy*** is made in the anterior face of the maxilla with a hammer and gouge or a burr, entering the antrum through the thin bone in the canine fossa. A punch or bone nibbler is used to remove the majority of the bone of the anterior wall of the maxillary sinus up to the orbital rim superiorly, but taking care to leave a margin of bone around the infraorbital foramen so as to protect the nerve and to avoid bleeding from the infraorbital vessels (*Figure 24*). Inspect the antrum to determine the extent of the tumor and to plan the subsequent bony cuts.
- The ***medial maxillectomy*** can now been done. The extent of the bony resection is tailored to the primary tumor.



Figure 25: Coronal CT anteriorly demonstrating resected lateral nasal wall, orbital walls and transected lacrimal sac



Figure 26: Coronal CT demonstrating resected lateral nasal wall including inferior turbinate and uncinate process, orbital floor up to infraorbital nerve, lamina papyracea and anterior ethmoidectomy, with preservation of the middle turbinate



Figure 27: Coronal CT more posteriorly demonstrating resected lateral nasal wall, inferior turbinate and inferomedial orbital wall, and ethmoidectomy with resection remaining below the level of the posterior ethmoidal foramen, and with preservation of middle turbinate

- *Figures 25 – 27* illustrate the extent of the bone resection with a classic medial maxillectomy.

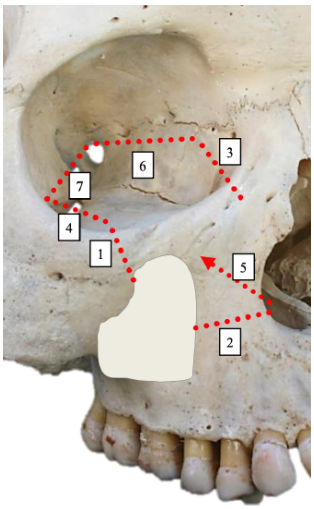


Figure 28: A sequence for osteotomies

- ***The sequence of the osteotomies*** is planned to reserve troublesome bleeding to the end (*Figure 28*). This may have to be adjusted depending on the location and extent of the tumor.
    1. ***Osteotomy through inferior orbital rim***: A sharp osteotome/power saw/ bone nibbler is used to cut through the thick inferior orbital rim just medial to the infraorbital nerve
    2. ***Osteotomy connecting antrostomy with nasal vestibule***: A sharp osteotome is used to connect the anterior antrostomy with the floor of the nasal vestibule.
    3. ***Osteotomy across frontal process of maxilla***: This part of the dissection is often best done with a Kerrison's rongeur or oscillating saw. There is often persistent minor bleeding from the bone that may be controlled with bone wax or cautery. The osteotomy is stopped short of the level of the frontoethmoidal suture.
    4. ***Osteotomy along orbital floor***: While retracting and protecting the orbital contents with a narrow copper retractor an osteotomy is continued posteriorly through the thin bone of the orbital floor/antral roof using either a sharp osteotome or heavy scissors, aiming for the posteromedial corner of the roof of the maxillary sinus.
    5. ***Osteotomy along floor of nose***: A sharp osteotome or heavy scissors is used to divide the lateral wall of the nose/medial wall of the antrum along the floor of the nasal cavity up to the posterior wall of the antrum. When doing this dissection with an osteotome, the dissection is halted when the osteotome hits up against the solid pterygoid bone (signaled by a change in the sound).
    6. ***Osteotomy through lacrimal bone, lamina papyracea and anterior ethmoids***: It is critical that this osteotomy be placed below the level of the frontoethmoidal suture line and the ethmoidal foramina so as to avoid fracturing or penetrating through the cribriform plate. The osteotomy is done be gently tapping on an osteotome to enter the ethmoid air cell systems while carefully retracting the orbital contents laterally. The osteotomy stops short of the posterior ethmoidal artery to safeguard the optic nerve.
    7. ***Vertical posterior osteotomy through posterior ethmoids and along posterior wall of antrum and pterygopalatine fossa***: The final posterior vertical cut is made with a heavy curved (Mayo) scissors as a downward continuation of the osteotomy in (6). It runs though the medial wall of the maxillary sinus, starting superiorly at the posterior end of the previous osteotomy, and ending at the level of the nasal floor.
- The ***medial maxillectomy specimen is then removed*** by gently levering it inferiorly and laterally with the Mayo scissors while completing the posterior osteotomy, in the process fracturing through the apex of the orbital floor and the posterior ethmoids cells and remaining lateral to and preserving the middle turbinate.
- The specimen is inspected to determine the adequacy of the tumor resection.
- An external ethmoidectomy may safely be completed up to the cribriform plate.
- The ***ethmoids*** are carefully inspected to determine whether an external frontoethmoidectomy +/- sphenoidectomy is required, and for evidence of a CSF leak.

Clinical example

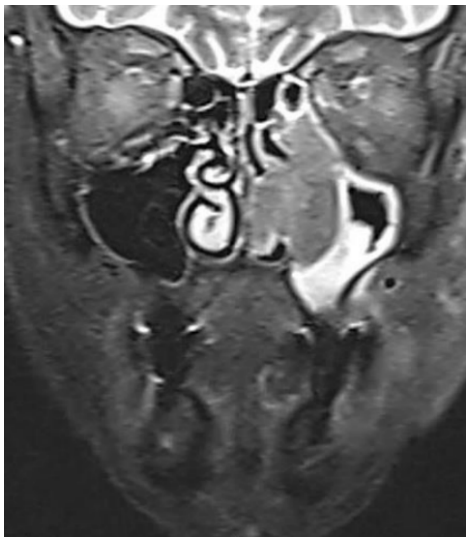


Figure 29: Malignancy of the lacrimal sac resected with a medial maxillectomy

Closure/Reconstruction

Hemostasis is achieved with cautery, bone wax and or topical hemostatics. It is only rarely necessary to pack the nose.

The objectives of closure are to minimize enophthalmos, diplopia, epiphora and an unsightly scar. It is not unusual for patients to complain of some diplopia, but this usually resolves with the passage of time. Suture any tears in the periorbita to avoid herniation of orbital fat. The lacrimal sac is slit open along its longitudinal axis and the edges are sutured to the surrounding tissues to avoid epiphora. If an extensive resection of the orbital floor has been done, then consideration should be given to reconstructing the floor with fascia / bone / titanium mesh. The skin is carefully repaired to optimize the cosmetic results. Patients are instructed about nasal douching and are recalled for nasal toilette.

Author & Editor

Johan Fagan
MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.31: Total Maxillectomy and Orbital Exenteration

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Total maxillectomy refers to surgical resection of the entire maxilla. Resection includes the floor and medial wall of the orbit and the ethmoid sinuses. The surgery may be extended to include orbital exenteration and sphenoidectomy, and resection of the pterygoid plates. It is generally indicated for malignancy involving the maxillary sinus, maxillary bone (sarcomas) and/or orbit and ethmoids, not amenable to lesser or endoscopic resection.

Total maxillectomy is potentially complicated by injury to the orbital contents, lacrimal drainage, optic nerve, ethmoidal arteries, intracranial contents, and may be accompanied by brisk bleeding. A sound understanding of the 3-dimensional anatomy of the maxilla and the surrounding structures is therefore essential. Hence the detailed description of the surgical anatomy that follows.

Surgical Anatomy

Bony anatomy

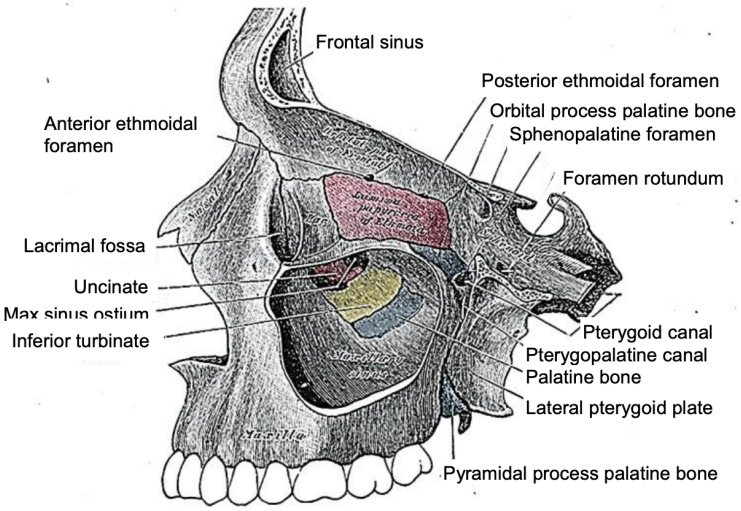


Figure 1: Lateral view of maxilla with windows cut in lateral and medial walls of maxillary sinus

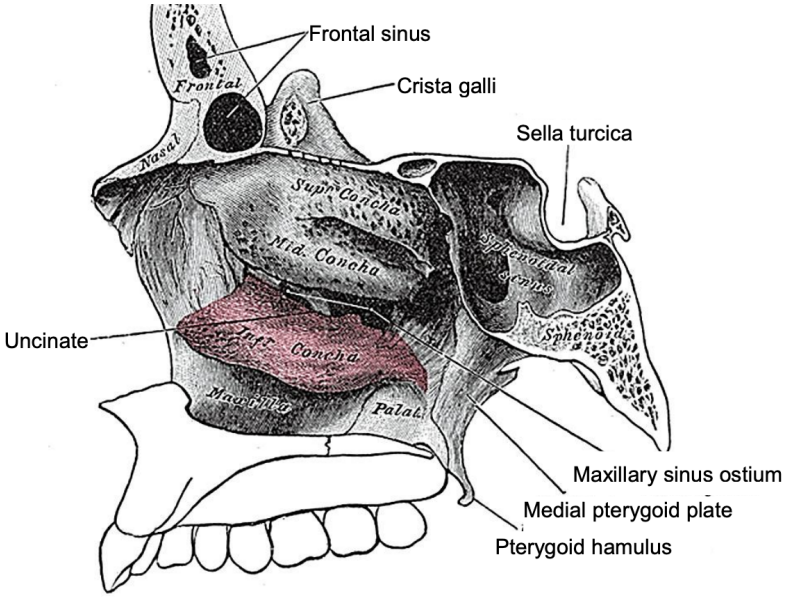


Figure 2: Bony anatomy of the lateral wall of the nose

Figures 1 & 2 illustrate the detailed bony anatomy relevant to total maxillectomy. Critical surgical landmarks to note include:

- The level of the floor of the anterior cranial fossa (fovea ethmoidalis and cribriform plate) corresponds with anterior and posterior ethmoidal foramina located along the frontoethmoidal suture line.
- The proximity (5-11 mm) of posterior ethmoidal foramen and artery to the optic nerve within the optic foramen.

Figure 2 illustrates the bony anatomy of the lateral wall of the nose. The inferior turbinate (concha) is resected with a total maxillectomy, but the middle turbinate is generally preserved, unless involved by pathology.

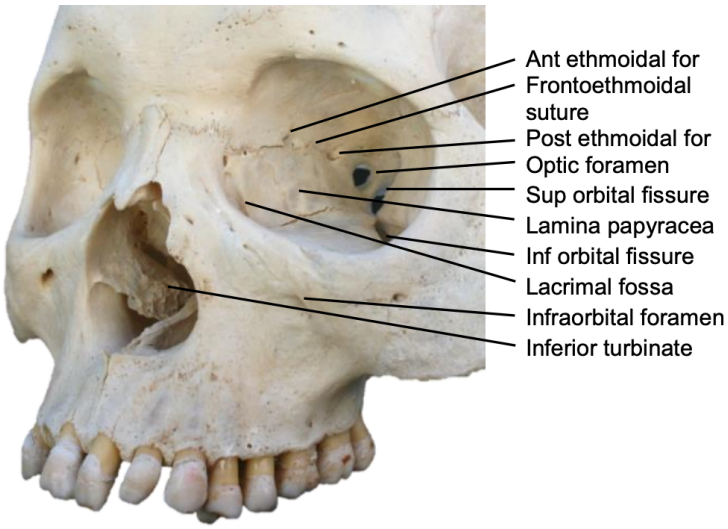


Figure 3: Bony anatomy in cadaver

Figure 3 demonstrates the anatomy of the medial wall of the nose in a cadaveric skull. Note in particular the thin lamina papyracea, the lacrimal fossa, the frontoethmoidal suture line and the anterior and posterior ethmoidal foramina and the infraorbital foramen.

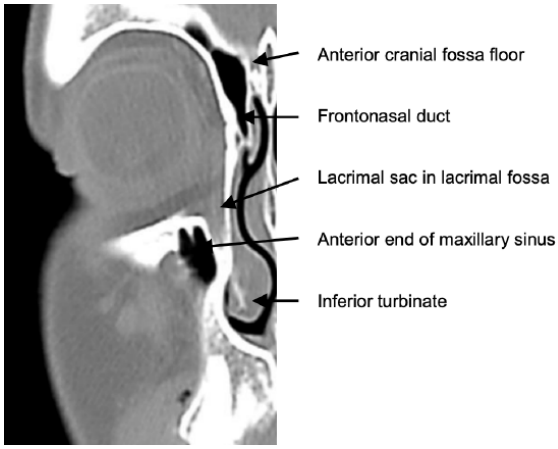


Figure 4: Coronal CT slice through lacrimal fossa

Figure 4 illustrates the coronal anatomy at the level of the anterior extent of a total maxillectomy. Specifically note the lacrimal sac, which is transected at surgery in the lacrimal fossa, and the relative heights of the floors of the antrum and the nasal cavity.

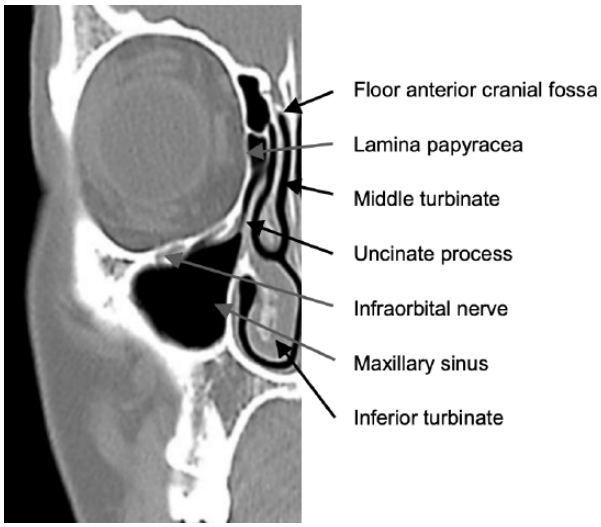


Figure 5: Anatomy in the coronal plane through the anterior ethmoids midway along a maxillectomy

Figure 5 demonstrates the coronal anatomy midway back along a total maxillectomy. Specifically note the infraorbital nerve in the orbital floor, the thin lamina papyracea and the relative heights of the floors of the antrum and the nasal cavity.

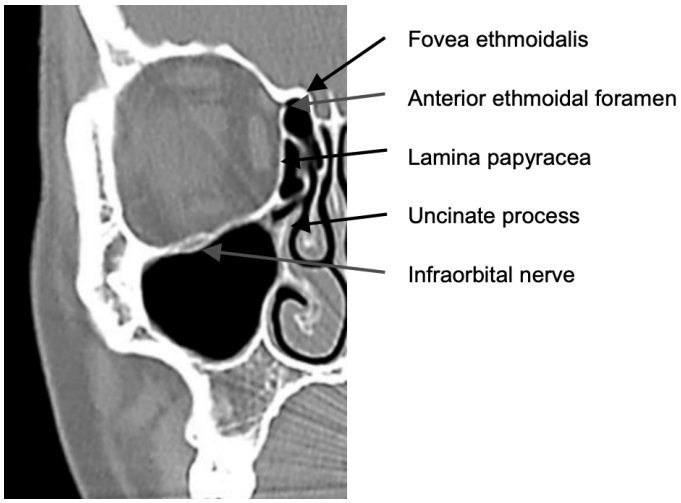


Figure 6: Note the position of the anterior ethmoidal artery where it passes through its foramen which is located in the frontoethmoidal suture line

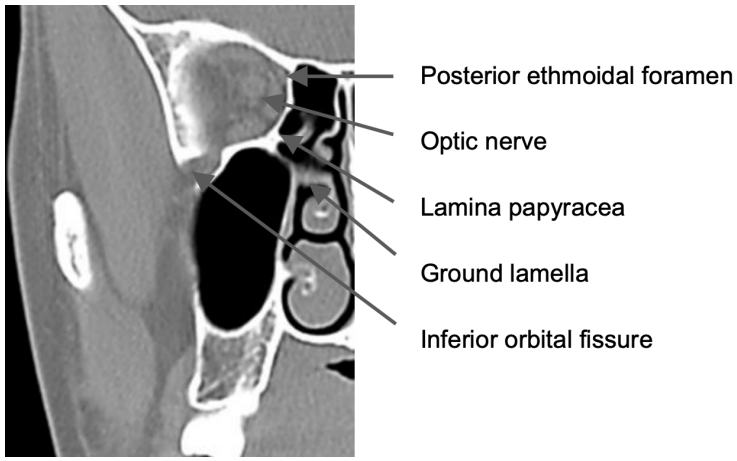


Figure 7: Coronal slice through posterior ethmoids demonstrating the posterior ethmoidal foramen and optic nerve

Figures 6 & 7 illustrate the value of using the anterior and posterior ethmoidal arteries and frontoethmoidal suture line to determine the level of the floor of the anterior cranial fossa when opening the lamina papyracea from the orbital side during total maxillectomy.

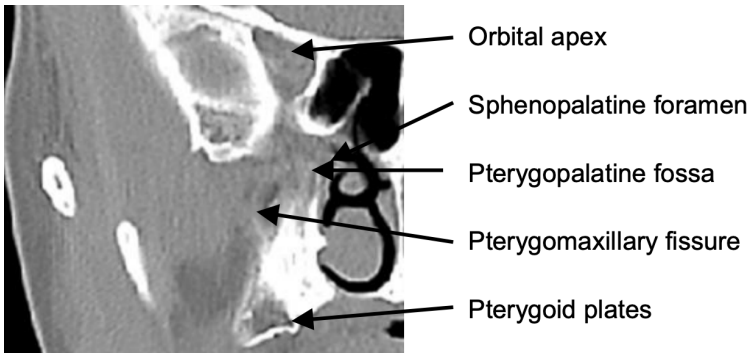


Figure 8: Coronal cut immediately behind the maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa

Figure 8 demonstrates the coronal anatomy immediately posterior to the maxillary sinus, which is in the plane through which a total maxillectomy is done, and in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure, and medially with the nasal cavity via the sphenopalatine foramen.

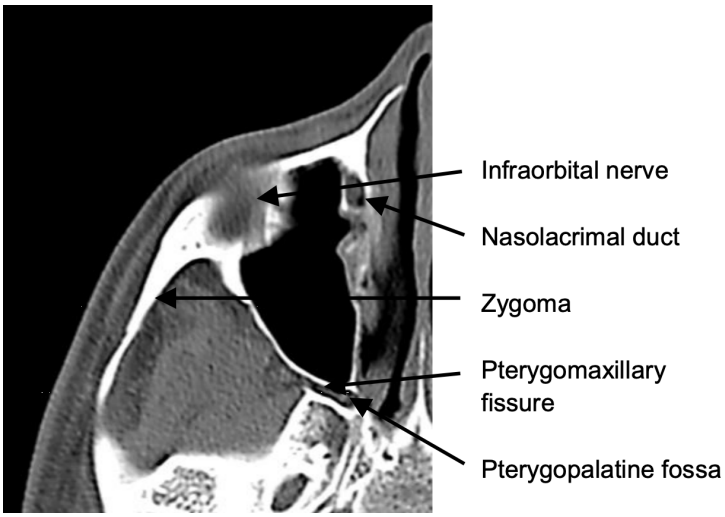


Figure 9: Axial cut at level of infraorbital nerve and orbital floor

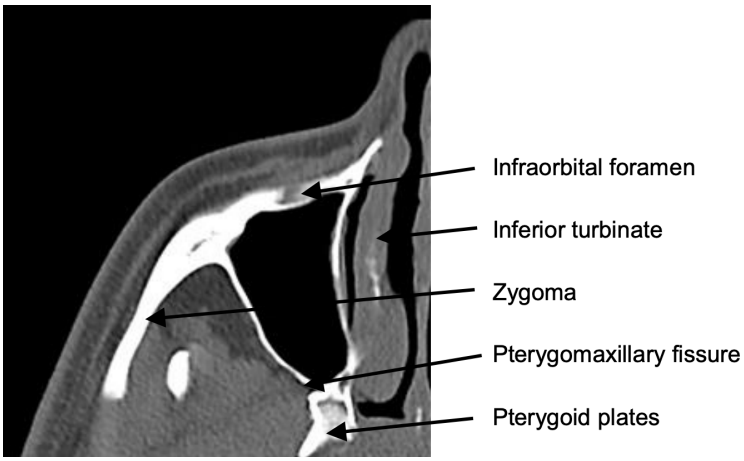


Figure 10: Axial cut at level of infraorbital foramen and pterygoid plates

Figures 9 & 10 illustrate axial views of the anatomy of the maxillary sinus. The posterior resection line of total maxillectomy passes through the pterygopalatine fossa and pterygomaxillary fissure and the anterior aspect of the pterygoid plates.

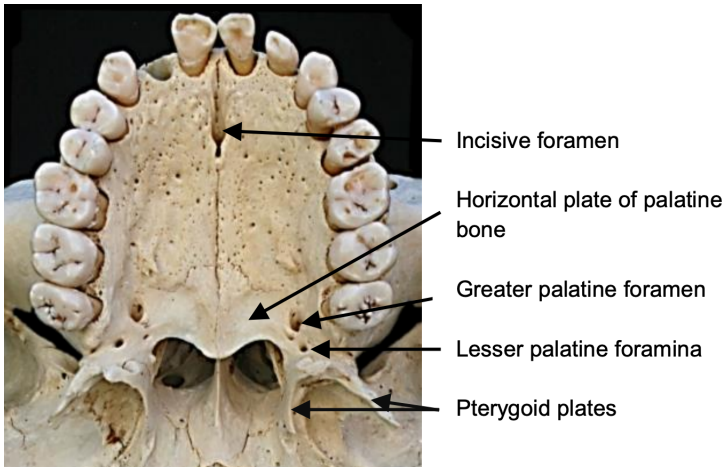


Figure 11: Anatomy of hard palate

The bony anatomy of the hard palate is illustrated in *Figure 11*.

Vasculature

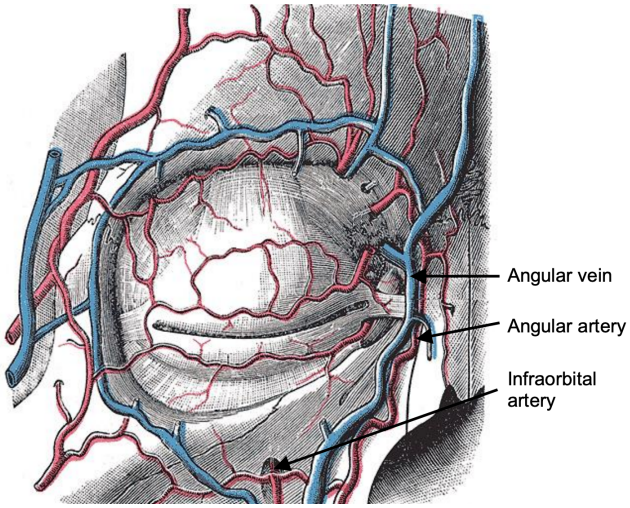


Figure 12: Vasculature around the orbit

An understanding of the blood supply of the maxilla permits the surgeon to anticipate when and where to encounter bleeding, and to plan the sequence of the surgery to reserve the bloodier parts of the surgery until last so as to minimize blood loss and to avoid

blood obscuring the surgical field. The only significant vein encountered during maxillectomy is the ***angular vein*** (*Figure 12*) at the medial canthus.

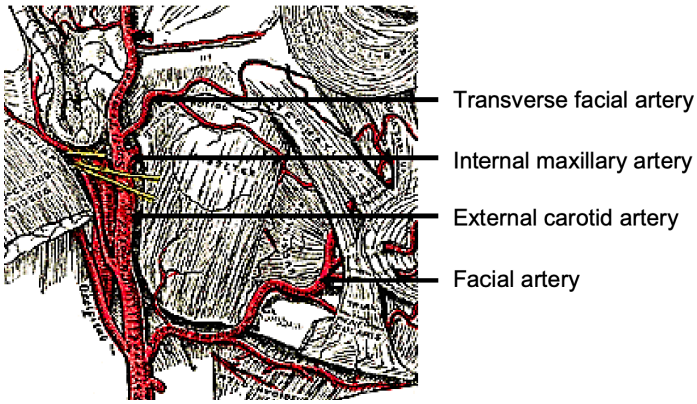


Figure 13: Facial artery and origin of internal maxillary artery, both branches of the external carotid artery

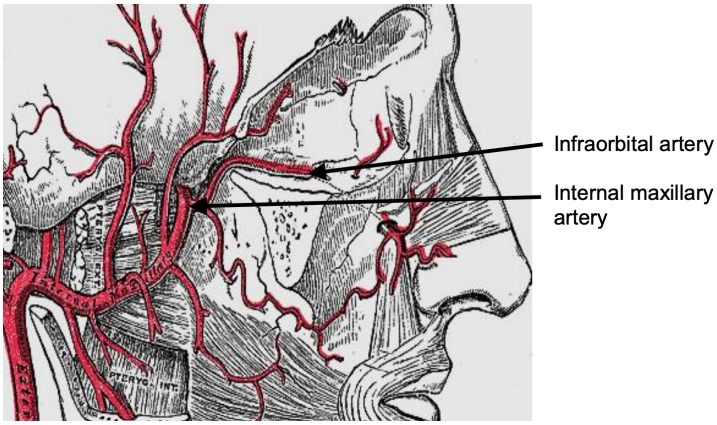


Figure 14: Internal maxillary artery viewed with mandible removed, entering pterygopalatine fossa though the pterygomaxillary fissure

The blood supply to the maxilla and paranasal sinuses originates both from the external (*Figures 13, 14*) and internal carotid artery systems.

The arterial supply relevant to maxillectomy is as follows:

- ***Facial/external maxillary artery***, a branch of the external carotid artery (*Figures 12, 13*).

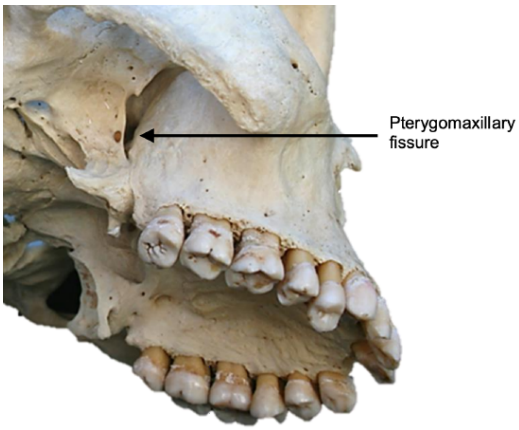


Figure 15: The pterygomaxillary fissure through which internal maxillary artery passes to enter pterygopalatine fossa

- ***Internal maxillary artery***, a branch of the external carotid artery (*Figures 13, 14*), passes through the pterygomaxillary fissure to enter the pterygopalatine fossa (*Figures 14, 15*).

Branches of the internal maxillary artery of surgical significance include:

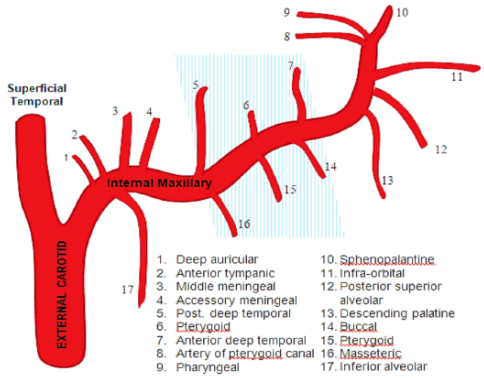


Figure 16: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa

- ***Greater palatine artery*** (descending palatine) (*Figure 16*): It passes inferiorly from the pterygopalatine fossa through the pterygopalatine canal (*Figure 1*) and emerges from the greater palatine foramen of the hard palate (*Figure 11*). It then runs anteriorly medial to the superior alveolus and enters the incisive foramen (*Figure 11*).
- ***Infraorbital artery***: It courses in the infraorbital groove and canal with the infraorbital nerve in the floor of the orbit/roof of antrum and exits anteriorly via the infraorbital foramen to supply the overlying soft tissues of the face (*Figures 12, 14*).
- ***Sphenopalatine artery*** (*Figure 16*): It enters the nasal cavity through the sphenopalatine foramen at the back of the superior meatus.
- ***Posterior lateral nasal arteries***: They are branches of the sphenopalatine artery.
- ***Posterior septal artery***: This is a branch of the sphenopalatine artery and crosses the posterior nasal cavity just above the posterior choana to end on the nasal septum; one branch descends in a groove in the vomer to enter the incisive canal and anastomose with the greater palatine artery.

Branches of the internal carotid artery of surgical significance are:

- ***Anterior ethmoidal artery***: It originates from the ophthalmic artery and enters the orbit through the anterior ethmoidal foramen (*Figure 3*) which is located 25 mm from the anterior lacrimal crest.
- ***Posterior ethmoidal artery***: It originates from the ophthalmic artery and enters the orbit through the posterior ethmoidal foramen (*Figures 1, 3, 7*). It is located approximately 36 mm from the anterior lacrimal crest, and 12 mm (8-19 mm) from the anterior ethmoidal foramen.
- ***Ophthalmic artery***: It emerges with the optic nerve from the optic foramen, 44 mm from the anterior lacrimal crest and approximately 6 mm (5-11 mm) from the posterior ethmoidal foramen.

Nerves

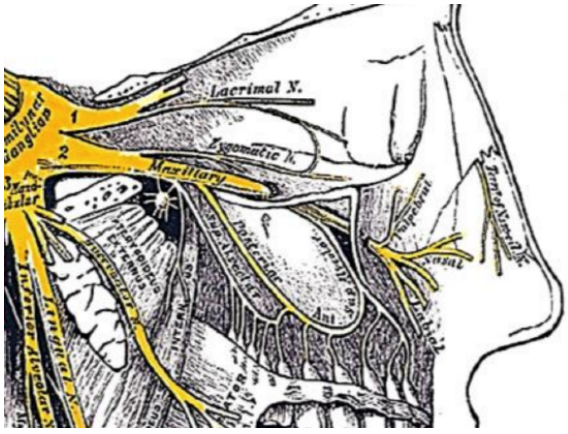


Figure 17: V2, pterygopalatine ganglion and infraorbital nerve

The ***maxillary division of V*** (V2) enters the pterygopalatine fossa via foramen rotundum. The only branch of surgical significance is the ***infraorbital nerve***. It runs in the floor of the orbit/roof of the antrum to exit from the infraorbital foramen (*Figure 3, 17*). The only other major nerve that has to be considered at maxillectomy is the ***optic nerve***.

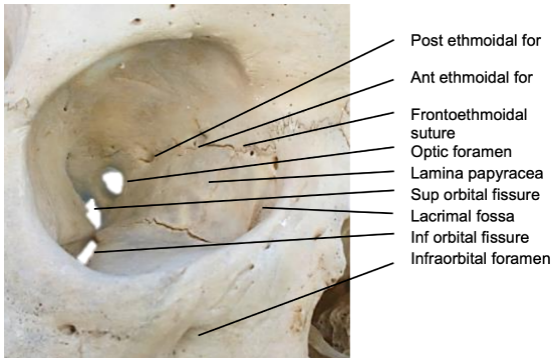


Figure 18: Right medial orbital wall

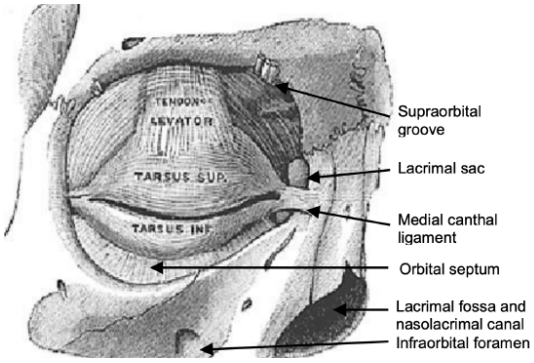


Figure 19: Right orbit showing medial palpebral ligament, orbital septum, lacrimal sac and lacrimal fossa

Figure 18 shows the detailed bony anatomy of the orbit. During dissection of the orbit, the following structures are encountered: medial palpebral ligament, orbital septum, lacrimal sac, periosteum, anterior and posterior ethmoidal arteries and inferior orbital fissure (*Figure 18, 19*). Only when doing orbital exenteration is the superior orbital fissure encountered.

- ***Orbital septum*** (*Figure 19*): This connective tissue structure attaches circumferentially to the periosteum of the orbital margin and acts as a diaphragm that retains the orbital contents. Laterally, it is attached to the orbital margin 1.5 mm anterior to the attachment of the lateral palpebral ligament at the lateral orbital tubercle. Superomedially it crosses the supra-orbital groove, passes inferomedially anterior to the trochlea, and follows the posterior lacrimal crest behind the lacrimal sac. It crosses the lacrimal sac to reach the anterior lacrimal crest, passes inferiorly along the anterior lacrimal crest and then laterally along the inferior orbital rim.
- ***Medial palpebral ligament (medial canthal tendon)*** (*Figure 19*): This fibrous band fixes the tarsal plates to the medial orbital wall. It is intimately related to the lacrimal drainage system. It lies anterior to the canaliculi, but a deep head inserts into the posterior lacrimal crest and onto the fascia of the lacrimal sac.

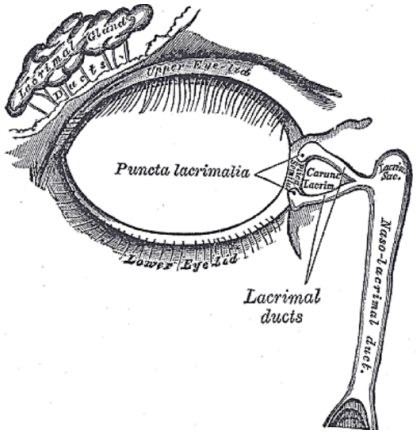


Figure 20: Right lacrimal system

- ***Lacrimal sac*** (*Figures 18, 19, 20*): It is located in the lacrimal fossa, which is bound medially by the lacrimal bone and the frontal process of the maxilla (*Figures 1, 18*). It is related anteriorly, laterally, and posteriorly to the medial palpebral ligament.

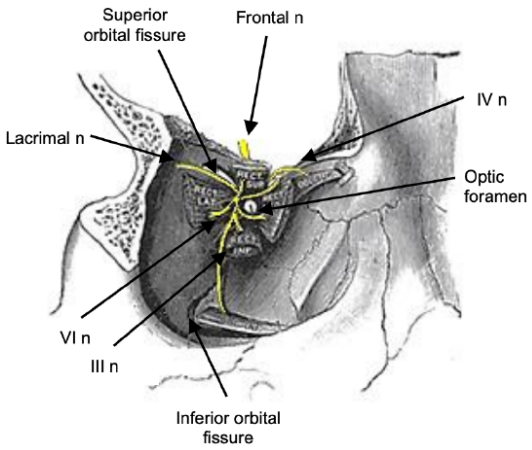


Figure 21: Superior and inferior orbital fissures of (R) orbit

- ***Inferior orbital fissure*** (*Figure 18, 21*): It is situated in the floor of the orbit and separates the sphenoid bone from the maxilla. It transmits the maxillary nerve and a few minor nerves, but no vessels of surgical significance.
- ***Superior orbital fissure*** (*Figure 18, 21*): This fissure lies between the lesser and greater wings of the sphenoid bone. Important anatomical structures that pass through the fissure are cranial nerves III, IV, VI; and the superior and inferior divisions of ophthalmic vein.

Total Maxillectomy Operation

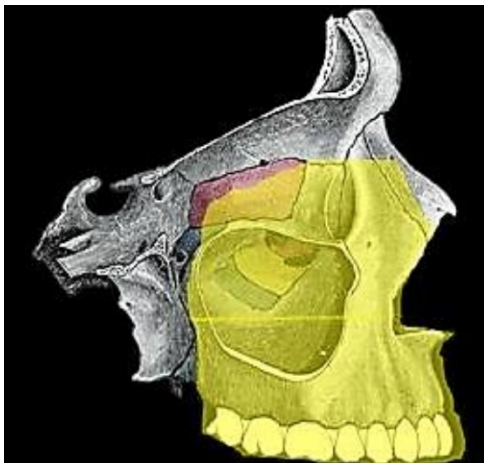


Figure 22: Yellow area indicates extent of bony resection of total maxillectomy

Total maxillectomy entails resection of the entire maxilla, and including the orbital floor and medial wall of the orbit and the ethmoid sinuses (*Figure 22*). The surgery may be extended to include resection of the lateral orbital wall and zygoma, exenteration of the orbit, sphenoidectomy, and resection of the pterygoid plates.

CT scanning is an important means of determining the superior (orbit and roof of ethmoids), posterior (pterygoid plates), lateral (zygoma and infratemporal fossa) and medial extent of the tumor and the resection required.

Once a tumor involves orbital fat and/ muscle, then orbital exenteration is generally recommended. Tumor extension to involve the pterygoid muscles precludes a maxillectomy, as getting clear margins once the pterygoid muscles are invaded by cancer is unlikely.

Surgical steps

Preoperative consent includes discussing the need for a tracheostomy, the facial incisions, loss of sensation in the infraorbital nerve distribution, diplopia, epiphora, enophthalmos, telecanthus, potential injury to the optic nerve, and CSF leak.

The operation is done under *general anesthesia*, with orotracheal intubation. If the eye is to be preserved then eyelids are sutured together with 6/0 silk taking care not to invert the eyelashes so as to avoid corneal abrasions, unless an orbital exenteration is planned. A *tracheostomy* is then done. Perioperative broad spectrum antibiotics are administered for 24 hours. Local anesthetic with vasoconstrictor is injected along the planned skin incisions. The nasal cavity is decongested with a topical vasoconstrictor.

The operation may be considered in 3 stages: soft tissue dissection & bone exposure; bone resection; and closure/reconstruction.

It is important to complete the soft tissue dissection and bone exposure before doing any bone work so as to avoid excessive blood loss.

Soft tissue dissection/bone exposure

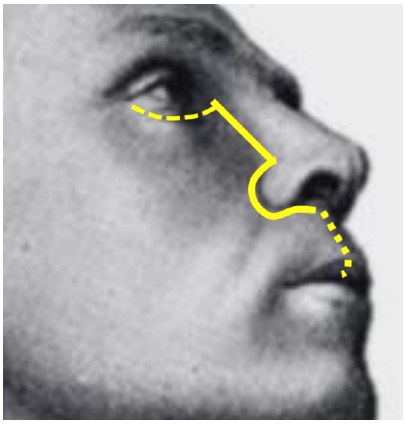


Figure 23: Lateral rhinotomy incision (solid line). A lip split and inferior lid (Weber-Ferguson) incision may be required for access

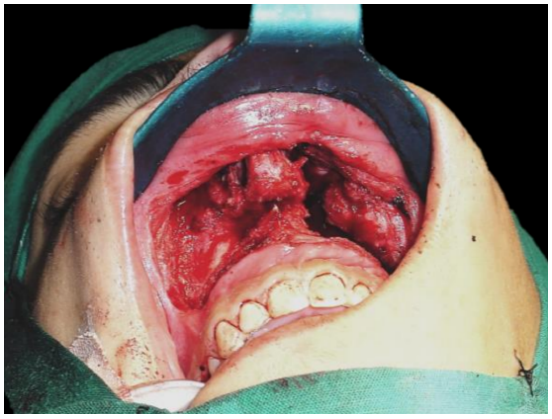


Figure 24: Midfacial degloving approach



Figure 25: Weber-Ferguson approach

- Total maxillectomy may be done via ***lateral rhinotomy*** (*Figure 23*), ***midfacial degloving*** (*Figure 24*) or ***Weber-Ferguson approach*** (*Figure 25*). The midfacial degloving approach avoids facial scars and is suited to resections that do not extend above the orbital floor i.e. do not include resection of the lamina papyracea and ethmoids. Once the resection requires removal of the medial wall of the orbit and the ethmoids, lateral rhinotomy provides better access.
- The ***sublabial mucosa*** is incised with electrocautery along the gingivobuccal sulcus onto the maxilla and extended all the way to the maxillary tuberosity (*Figure 24, 25*).

- The facial skin is incised with a scalpel. The remainder of the soft tissue dissection may be done with electrocautery.
- The incision is extended onto the nasal bone and maxilla.
- The ***angular vessels*** are cauterised or ligated adjacent to the medial canthus of the eye (*Figure 12*).
- With a ***Weber-Ferguson*** approach, the lower lid incision is placed close to the palpebral margin so as to avoid oedema of the lower lid above the scar following surgery. The lower lid skin is elevated down to the inferior orbital rim (*Figure 25*).
- The ***soft tissues of the face*** are elevated off the face of the maxilla using cautery or an elevator, remaining hard on bone while doing this dissection (*Figure 25*). Expose the entire face of the maxilla. Transect the infraorbital nerve and vessels with cautery, and if there is concern about perineural invasion, sample the nerve to ensure clear margins. Strip the tissues all the way around the maxilla up to the pterygomaxillary fissure and the zygoma (*Figure 15*). Do not use sharp dissection beyond the fissure to avoid transecting the internal maxillary artery.
- Sequentially identify the ***medial palpebral ligament, anterior lacrimal crest, lacrimal sac in the lacrimal fossa, and posterior lacrimal crest*** (*Figures 18, 19*).
- Divide the medial palpebral ligament.
- Elevate the ***lacrimal sac*** from its fossa. Transect the sac as distally as possible with a scalpel, so as to facilitate fashioning a dacryocystorhinostomy. Expect some bleeding from the transected sac.
- Next ***the medial and inferior orbit is exposed***. Strip the orbital contents in a subperiosteal plane from the lamina papyracea and frontal bone taking care not to fracture or penetrate the paperthin bone of the lamina papyracea.
- Identify the frontoethmoidal suture (*Figure 18*). This is a crucial surgical landmark as it corresponds with the level of the cribriform plate and the anterior and posterior ethmoidal foramina.

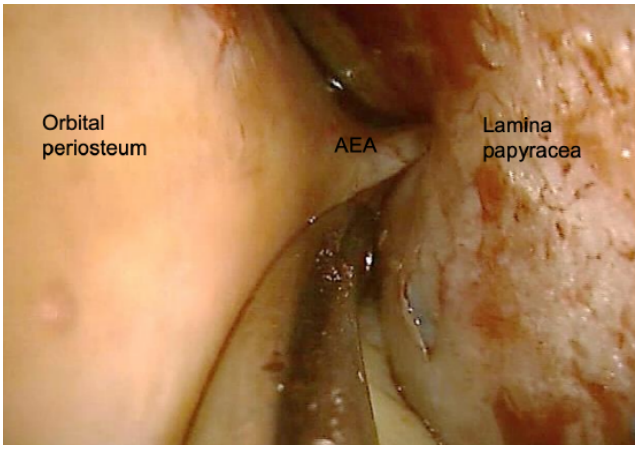


Figure 26: Anterior ethmoidal artery (AEA) exiting anterior ethmoidal foramen at level of frontoethmoidal suture line

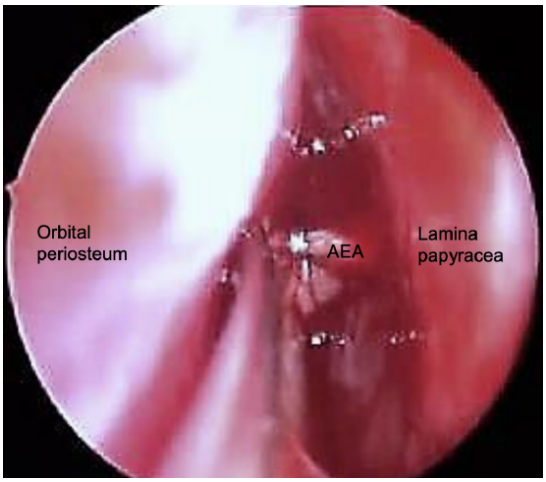


Figure 27: Liga clips being applied to anterior ethmoidal artery (AEA)

- Gently retract the orbital contents laterally and identify the ***anterior ethmoidal artery*** as it bridges the divide between the ***anterior ethmoidal foramen*** and the periorbita (*Figure 26*). The anterior ethmoidal artery is ligated, clipped or bipolared and divided (*Figure 26, 27*), thereby providing access to the ***posterior ethmoidal artery***. It is generally not necessary to divide this vessel.

- Now strip along the ***floor of the orbit*** in a subperiosteal plane. Take special care not to tear the periosteum at the inferior orbital margin at the attachment of the orbital septum to avoid entering the orbit and causing extrusion of orbital fat.
- Next free the soft tissues from the bone up to the ***anterior free margin of the nasal aperture*** with diathermy. Retract the nasal ala and incise the lateral wall of the nasal vestibule to expose the ipsilateral nasal cavity and inferior turbinate, taking care not to injure the inferior turbinate or septum so as to avoid troublesome bleeding.
- Using a tonsil gag in the mouth to retract the tongue, ***visualize the hard and soft palates***. Identify the ***maxillary tuberosity*** and the bony spines of the ***pterygoid plates*** immediately posterior to the tuberosity.
- Using electrocautery, ***incise the mucosa of the hard palate*** along the planned medial resection margin, and extend the sublabial incision laterally around the maxillary tuberosity, and into the groove between the tuberosity and the pterygoid plates.
- Palpate and define the posterior edge of the hard palate and ***divide the attachment of the soft palate to the hard palate*** with electrocautery, thereby entering the nasopharynx. Anticipate and diathermize bleeding from branches of the greater and lesser palatine arteries.

At this point the soft tissue dissection is complete. The bony part of the maxillectomy can now been done.

Bony resection



Figure 28: Coronal CT anteriorly though lacrimal fossa, demonstrating resected maxilla, inferior and medial orbital walls and transected lacrimal sac



Figure 29: Coronal CT demonstrating resected lateral nasal wall including inferior turbinate and uncinate process, orbital floor including the infraorbital nerve, the lamina papyracea and anterior ethmoidectomy, with preservation of the middle turbinate

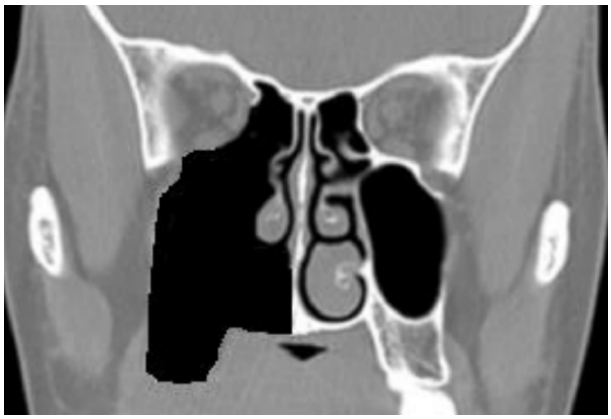


Figure 30: Coronal CT more posteriorly demonstrating resected maxilla, inferior turbinate, medial and inferior orbital walls, and posterior ethmoidectomy with resection remaining below the level of the posterior ethmoidal foramen, and with preservation of middle turbinate

The extent of the bony resection is tailored to the primary tumor and may include the lateral wall of the orbit and zygoma, especially if the antrum is seen to extend into the zygoma on CT imaging. *Figures 28 – 30* illustrate the extent of the bone resection following a classic total maxillectomy.

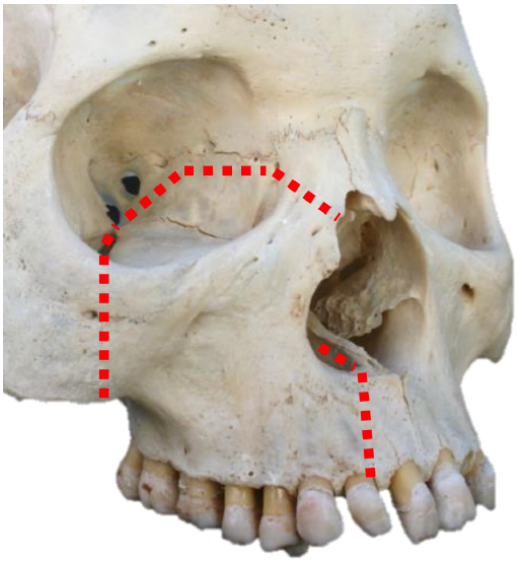


Figure 31: Osteotomies: oblique view

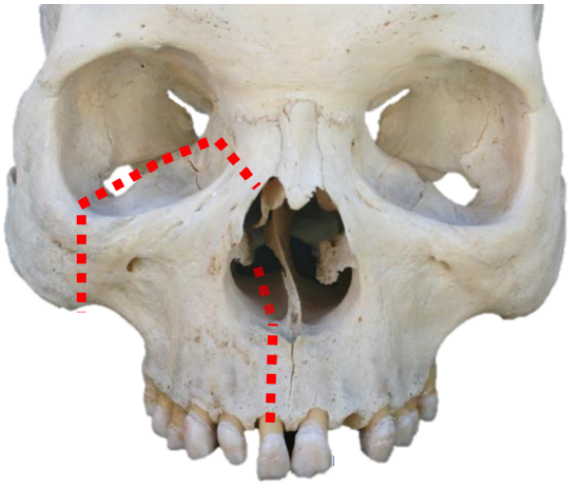


Figure 32: Osteotomies (anterior view)



Figure 33: Osteotomy cuts

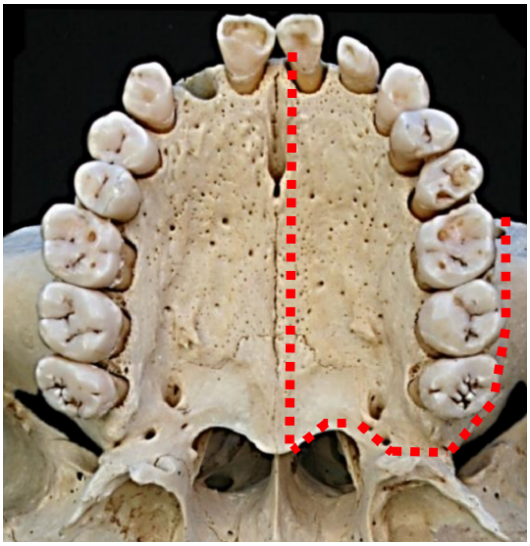


Figure 34: Palatal osteotomies. Note osteotomy passes between palate and pterygoid plates

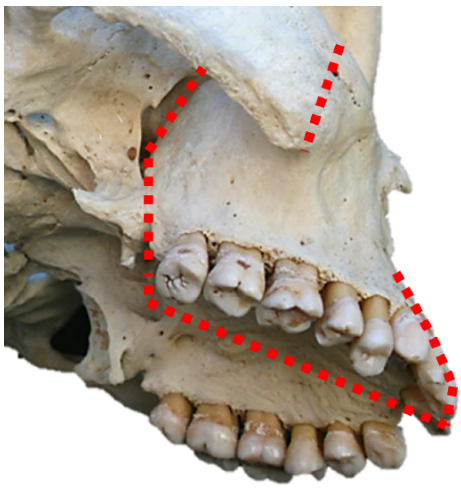


Figure 35: Osteotomy between maxillary tuberosity & pterygoid

The sequence of the osteotomies is planned to reserve troublesome bleeding to the end of the procedure (*Figure 31 - 35*). It may need to be adjusted depending on the location and extent of the tumor.

1. ***Osteotomy through inferior orbital rim and along orbital floor (Figures 29-31)***: A sharp osteotome/power saw/ bone nibbler is used to cut through the malar buttress / inferior orbital rim. This osteotomy is placed lateral to the antrum as seen on the CT scan so as not to enter the antrum. While retracting and protecting the orbital contents with a narrow copper retractor the osteotomy is then continued posteriorly through the thin bone of the orbital floor/antral roof using a sharp osteotome and aiming for the infraorbital fissure.
2. ***Osteotomy through frontal process of maxilla and lacrimal bone (Figures 31-33)***: This thick bone is best transected with a Kerrison's rongeur or oscillating saw. There is often persistent minor bleeding from the bone that may be controlled with bone wax or cautery. The osteotomy is directed towards, but kept a few millimeters below, the level of frontoethmoidal suture line.
3. ***Osteotomy through lamina papyracea and anterior ethmoids (Figures 6, 18, 28-33)***: This osteotomy is done by gently tapping on an osteotome to enter the ethmoid air cell system while carefully retracting the orbital contents laterally. It is critical that this osteotomy be kept a few millimetres below the level of the frontoethmoidal suture line and the ethmoidal foramina to avoid fracturing or penetrating through the cribriform plate (*Figures 5, 6, 29, 39*). The osteotomy stops short of the posterior ethmoidal artery and then is directed inferiorly towards the orbital floor to safeguard the optic nerve.
4. ***Palatal osteotomy (Figures 32-35, 39, 40)***: A sharp osteotome/power saw is used to cut vertically through the superior alveolus and hard palate. The placement of this osteotomy is dependent on the palatal extent of the tumor. It is often preferable to extract a tooth and to place the osteotomy through the dental socket, rather than to place it between two teeth as this might devitalise the adjacent two teeth and it makes soft tissue closure more difficult. The palatal osteotomy is extended to the posterior margin of the hard palate.
5. ***Osteotomy of nasal septum***: This is only required when the palatal osteotomy is placed across the midline. The nasal septum is then divided parallel to the nasal floor with an osteotome or heavy scissors.
6. ***Osteotomy to separate maxillary tuberosity from pterygoid plates (Figures 34-36)***: This is the final osteotomy, and is done by tapping with a (curved) osteotome in the groove between the maxillary tuberosity and the pterygoid bone. Superiorly this cut ends in the pterygomaxillary fissure and the pterygopalatine fossa.



Figure 36: Curved osteotome

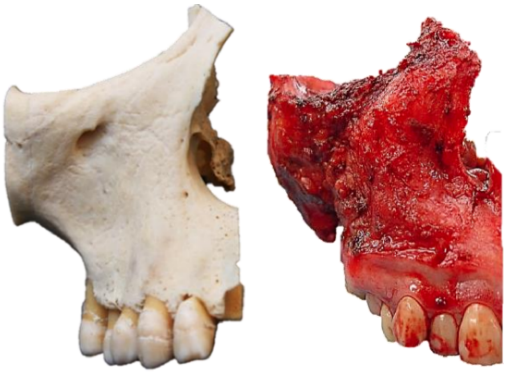


Figure 37: Maxillectomy specimens

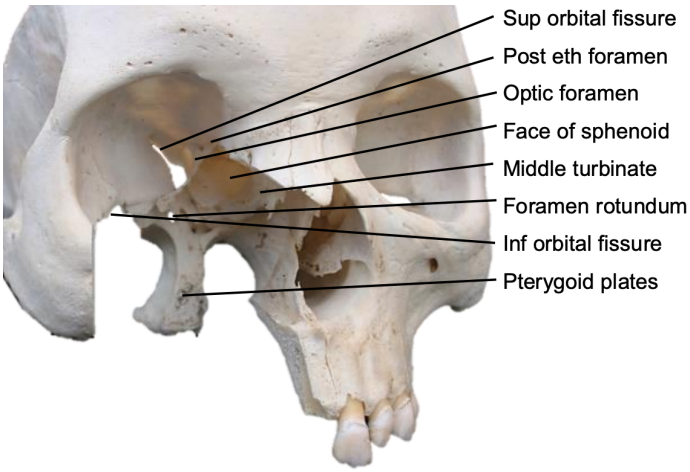


Figure 38: Maxillectomy defect (Anterior view)

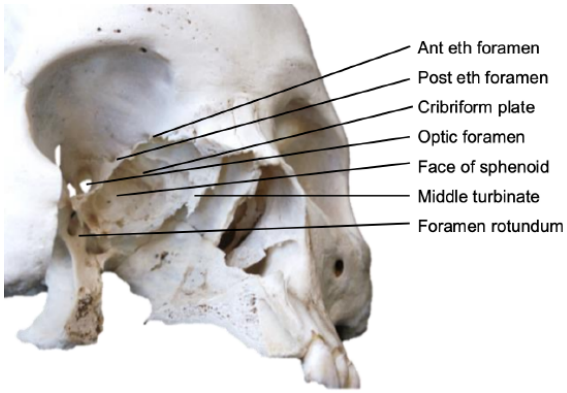


Figure 39: Maxillectomy defect (Anterolateral view)

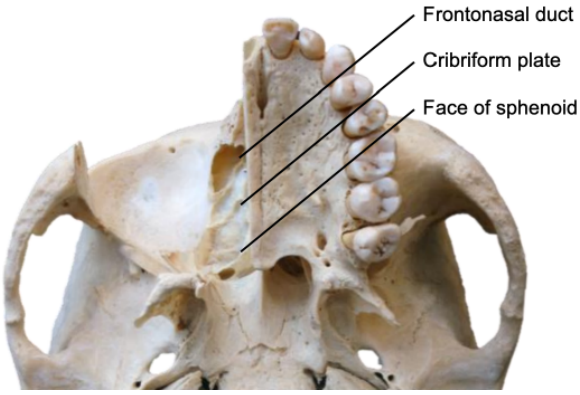


Figure 40: Maxillectomy defect (Inferior view)

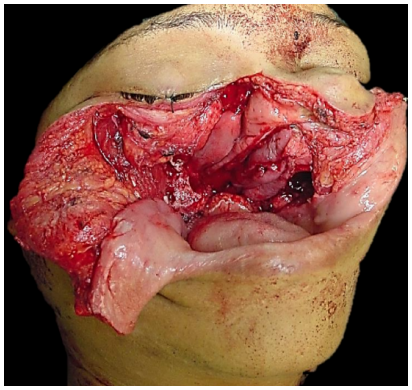


Figure 41: Maxillectomy (bilateral) defect

The maxillectomy specimen can now be gently ***down-fractured***.

The ***internal maxillary artery*** tethers the specimen laterally and is clipped and divided where it enters the pterygomaxillary fissure. If the artery is inadvertently transected, it is clipped and ligated. If the artery is not apparent, then it should be specifically looked for as it may have gone into spasm and may bleed later.

The **specimen is removed** and inspected to determine the ***adequacy of the tumor resection*** (*Figure 37*).

The remnants of the ***ethmoids*** are carefully inspected. An external ethmoidectomy may safely be completed up to the cribriform plate (*Figures 29, 30, 38-40*). The need for external ***frontoethmoidectomy*** +/- ***sphenoidectomy*** is determined, and evidence of a ***CSF leak*** is excluded.

Arterial and venous bleeding occur from the pterygoid venous plexus it may initially be controlled with packing. Meticulous ***hemostasis*** is achieved with bipolar cautery, suture ligatures, clips, bone wax, and topical hemostatics.

Figures 38-41 demonstrate total maxillectomy defects. Note the location of the face of the sphenoid sinus that may be opened and stripped of mucosa for oncological reasons.

Closure/Reconstruction

The objectives of closure and reconstruction are to prevent epiphora, to separate the oral cavity from the nose and orbit, to preserve the facial contours, to minimize enophthalmos and diplopia, to maintain a nasal airway, and to restore dentition.

Epiphora: The lacrimal sac is slit along its length and marsupialized by suturing its edges to the surrounding soft tissue with vicryl sutures.

Oronasal separation may be achieved in several ways:



Figure 42: Example of obturator

- *Dental obturator* (*Figure 42*): This can be fashioned to fill the defect and to restore dentition.

The inner aspect of the maxillectomy cavity is lined with a split-thickness skin graft, which is kept in place with an antiseptic-impregnated gauze pack. The pack is retained with overlying sutures or by screwing a prefashioned plate to the remaining palate with lag screws. A circumferential scar band develops at the interface between the skin graft and the remaining gingivobuccal mucosa and aids to secure the obturator. A temporary obturator may be fitted after the gauze is removed on Day 5. The obturator is remolded as the cavity heals and contracts.

- *Temporalis muscle flap*: Special care has to be exercised not to injure the deep temporal artery supply to the flap.
- *Anterolateral free thigh flap*: This provides good bulk and palatal skin cover but precludes wearing a denture.
- *Scapula tip flap*: Although it provides oronasal separation the bone is suboptimal for dental implants.

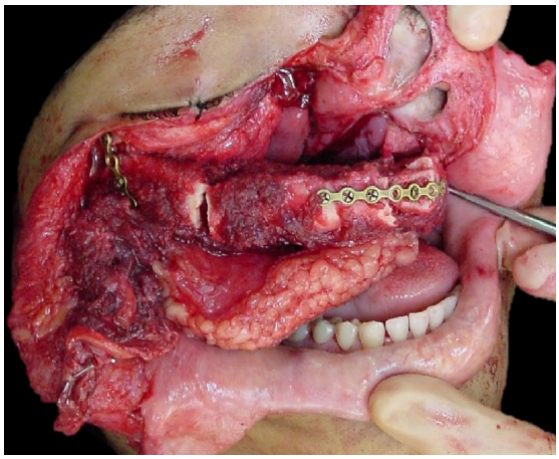


Figure 43: Free fibula flap reconstruction

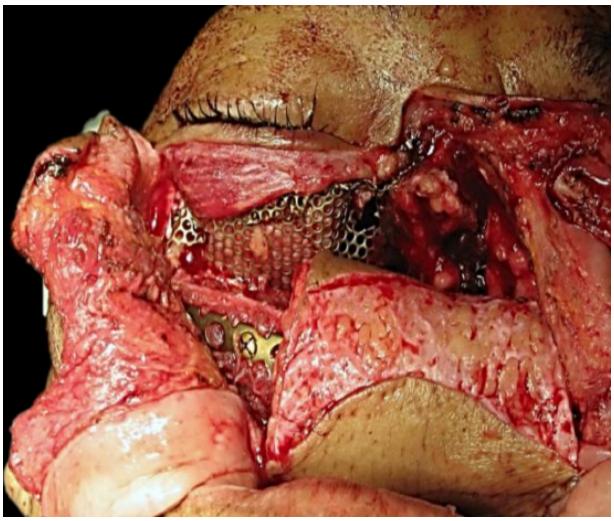


Figure 44: Free fibula flap following bilateral maxillectomy with reconstruction of orbit with titanium mesh

- *Free fibula flap* (*Figure 43, 44*): This is an excellent option as it permits dental implants.
- *Dentition*: This may be achieved with an obturator (*Figure 42*) or with dental implants inserted into a free fibula flap.

Facial contour: Other than the temporalis muscle flap, all the techniques listed above under “oronasal separation” achieve this objective.

Enophthalmos, diplopia: Suture tears in the periorbita to avoid herniation of orbital fat. It is not unusual for patients to complain of some diplopia, but this usually improves with the passage of time. A degree of enophthalmos is to be expected unless the medial and inferior walls of the orbit are carefully reconstructed. If an extended resection of the orbital floor has been done, then consideration should be given to reconstructing the floor with fascia, bone or titanium mesh (*Figure 44*).

Extended total maxillectomy resections

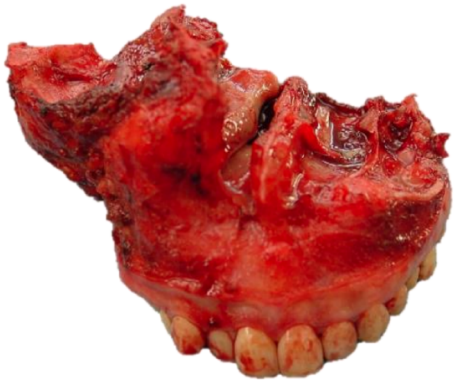


Figure 45: Bilateral (total and inferior) maxillectomies



Figure 46a-c: Total maxillectomy, orbital exenteration, resection facial skin, and parotidectomy

Total maxillectomy may be extended to include the malar complex, sphenoid sinus, cribriform plate (craniofacial resection), contralateral maxilla (*Figure 45*), skin (*Figure 46a-c*), or orbit. When resection extends to the contralateral maxilla (*Figure 45*), then an osseocutaneous free flap reconstruction (*Figures 43, 44*) is imperative.

The patient depicted in *Figures 46a-c* required resection of overlying skin and soft tissues, infratemporal fossa and orbit, as well as nodal metastases to the parotid and neck. The defect was reconstructed with an anterolateral free thigh flap.

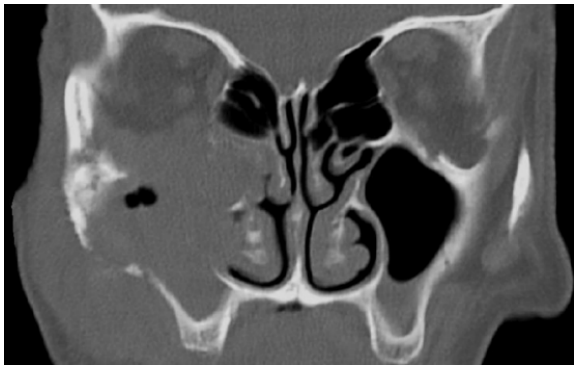


Figure 47: Tumor invading orbital fat

Orbital exenteration is generally indicated when tumor has extended through periosteum to involve fat (*Figure 46*, *47*) and/or muscle and/or the globe; the eyelids; and the lacrimal apparatus. Involvement limited to the bone or periosteum can be managed by resecting the involved periosteum.

Whenever possible the ***eyelids*** are preserved (lid-sparing cf. lid-sacrificing exenteration) so they may be sutured together at completion of the surgery by making palpebral incisions just above and below the eyelashes. The skin is then elevated from the tarsal plates with monopolar cautery up to the orbital rims circumferentially.

The ***periosteum is incised circumferentially*** just medial to the orbital rim, exposing the underlying bone. Take care not to injure the supraorbital nerve so as to preserve sensation to the forehead.

The ***medial and inferior orbital dissections*** are as described above with transection of the lacrimal sac, and ligation and transection of the anterior and posterior ethmoidal arteries.

Next the orbital contents are mobilized in the relatively avascular ***subperiosteal plane inferiorly, laterally and superiorly***. This is achieved by simply stripping the periosteum from the bone with e.g. a Freer's dissector, other than along the ***inferior orbital fissure*** where the tissues are divided with scissors.

All that remains is to ***transect the ocular muscles and optic nerve and ophthalmic vessels at the orbital apex***. Avoid undue traction on the optic nerve as this can injure the contralateral optic nerve. Exposure may be improved by decompressing the globe with a large bore needle. Use curved scissors (curved almost to 900) to transect the orbital apex and to deliver the orbital contents. Pack the orbit for a few minutes, and then use bipolar cautery or a ligature to control the brisk bleeding from the ophthalmic artery.

The ***orbital cavity*** may be managed in a number of ways. Patients may be left with the orbital cavity exposed +/- an (immobile) ocular prosthesis. When wearing a prosthesis is not an option, patients prefer to have the cavity filled with a flap.

- ***Leave to granulate***: This is a lengthy healing process.
- ***Split skin graft*** in the orbital cavity kept in place with gauze packing.



Figure 48: Eyelids sutured together

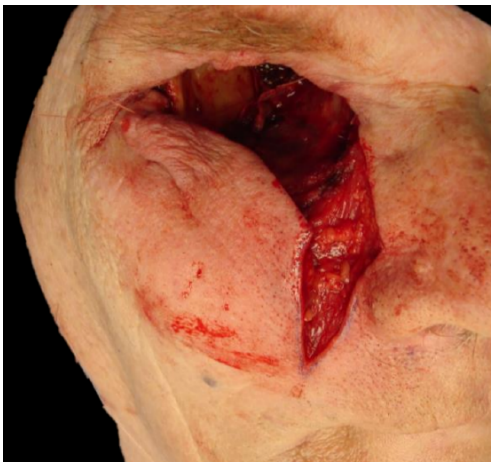


Figure 49a: Cheek advancement flap

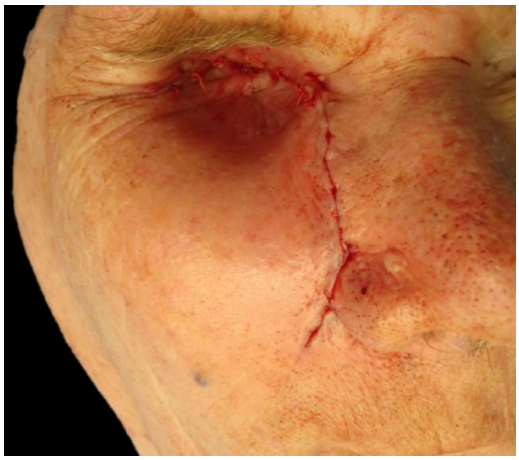


Figure 49b: Cheek advancement flap



Figure 50a: Temporalis muscle filling the orbit prior to suturing spared lower lid to superior orbital margin



Figure 50b: Temporalis muscle flap after suturing spared lower lid to superior orbital margin

- ***Suturing eyelids*** together +/- a cheek advancement flap and inserting gauze packing to ensure that the skin is applied to the bone of the orbit as free floating skin will break down (*Figure 48*, *49a*, *b*).
- ***Radial free forearm flap***, with an additional fascial component folded back on itself to fill the orbit
- ***Anterolateral free thigh flap***
- ***Temporalis muscle flap*** deep to the eyelids or with a split skin graft (*Figure 50*)

Additional clinical examples



Figure 51a: Osteosarcoma of maxilla



Figure 51b: Osteosarcoma of maxilla with expansion of inferior orbital canal indicating invasion of inferior orbital nerve

Osteosarcoma of maxilla (*Figure 51a*) with expansion of inferior orbital canal (*Figure 51b*) indicating invasion of inferior orbital nerve; MRI is indicated to assess proximal perineural spread; resection should include malar complex and frozen section of inferior orbital nerve in pterygopalatine fossa.

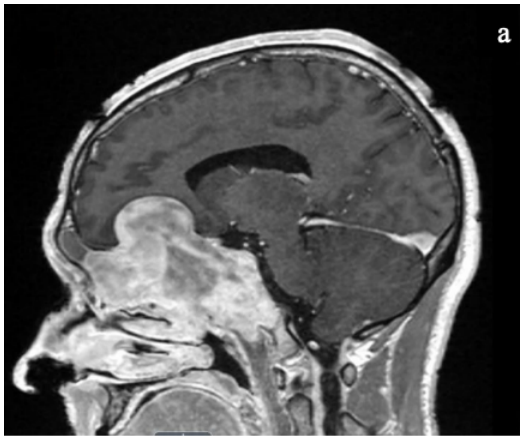
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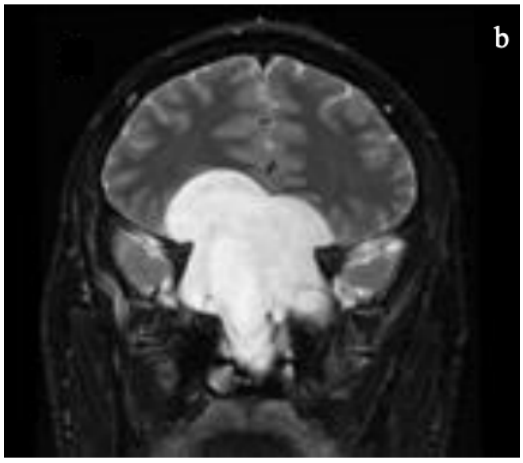
Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Kyle VanKoevering, Daniel Prevedello, Ricardo Carrau







Figures 1a-c: Preoperative images of a large heterogeneously enhancing chondrosarcoma occupying the entire skull base with significant intracranial extension

The sinonasal cavity and anterior cranial fossa can be involved by a wide variety of diverse, rare neoplasms. Surgical extirpation of these lesions is often the mainstay of multimodal treatment for both benign and malignant diseases. However, these tumors pose a variety of challenges for surgical management, including complex anatomic considerations (*Figures 1a-c*).

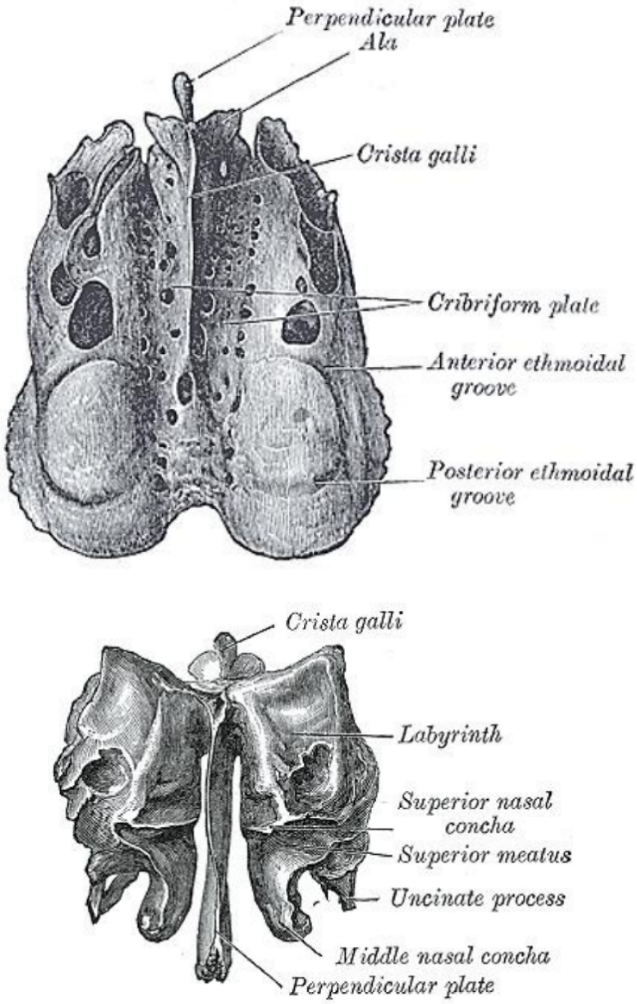
Relevant Anatomy

Also refer to Chapter on FESS for surgical anatomy.

Nasal Cavities and Sinuses

The nasal cavity can be imagined as a quadrangular corridor that is narrower at the top and divided into right and left compartments by a midline septum. It communicates with the exterior through anterior openings, the nares (nostrils). Posteriorly, it opens into the nasopharynx through the posterior choanae. Its external shape reflects its skeletal support, which is composed of the paired nasal bones and the upper and lower lateral nasal cartilages as they surround the pyriform aperture. The walls of each nasal fossa include the nasal septum medially, the horizontal portion of the maxillary bone and palatine bone inferiorly, and the inferior turbinates and ethmoid bones laterally.

Superiorly, the nasal fossae are confined by the cribriform plate and the rostrum of the sphenoid sinus as it slants posteroinferiorly toward the nasopharynx. The inferior turbinate is an independent bone, whereas the middle and superior turbinates are part of the ethmoid bone.



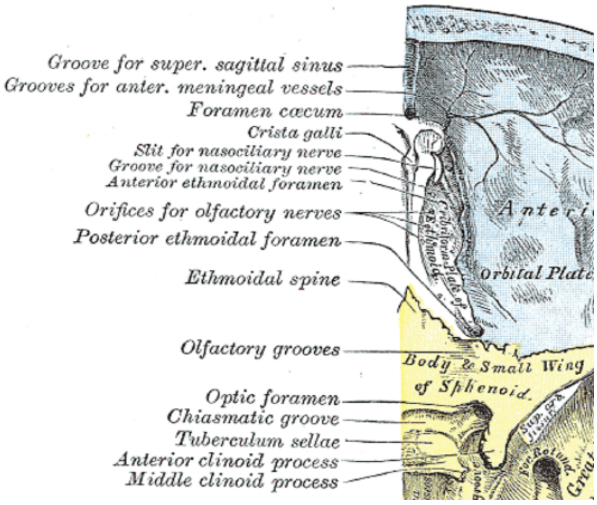


Figure 2a-c: Bony anatomy of anterior skull base

The ethmoid air-cell labyrinth consists of 3-18 cells per side that are connected in the midline by the cribriform plate (*Figure 2*). Each side is divided into an anterior and posterior group of cells based on the attachment of the middle turbinate to the lateral nasal wall i.e. basal lamella. An Onodi cell represents a posterior ethmoid cell which is located superior or lateral to the sphenoid sinus and can occasionally contain the optic nerve or portions of the carotid artery. It may be bigger than the sphenoid sinus.

The roof of the ethmoid labyrinth comprises a portion of the anterior skull base. Laterally, the ethmoid air cells are bound by the orbit (lamina papyracea), and along the roof of the ethmoid sinuses, the anterior and posterior ethmoid arteries can be found exiting the orbit and traversing the skull base toward the vertical lamella of the cribriform plate.

The frontal sinuses are paired cavities within the diploic frontal bone with frondlike pneumatization and asymmetric shapes and sizes. The posterior wall is shared with the anterior cranial fossa. Their floors correspond to the roofs of the orbits and anterior ethmoid cells. The maxillary antrum is the largest of the paranasal sinuses and is situated lateral to the nasal cavity and inferior to the orbit. Its floor, which is formed by the alveolar process of the maxilla, lies 1-1.5 cm inferior to the nasal floor. The posterior and posterolateral walls of the maxillary sinus are contiguous with the pterygopalatine and infratemporal fossae, respectively. The medial wall of the antrum corresponds to the lateral wall of the nasal cavity and contains the drainage ostium. The sphenoid sinus lies in the center of the skull and is situated posterior to the nasal cavity cephalad to the nasopharynx. Its anterior wall bulges into the nasal cavity and contains the drainage ostium, which may be found at the sphenoethmoidal recess above and posterior to the middle turbinate.

There is a wide variety in the degree of pneumatization of the sphenoid sinuses between patients and even from one side to the other. Superiorly, the planum sphenoidale constitutes the posterior portion of the anterior skull base. The sella typically sits within the superior sphenoid sinus.

Orbits

The orbit shares three of its walls with the paranasal sinuses. Its medial wall corresponds to the lateral wall of the ethmoid sinus. It bears, from anterior to posterior, the nasolacrimal sac lying on the lacrimal bone (lacrimal fossa), the anterior and posterior ethmoidal arteries, the trochlea, and the optic nerve with its foramen at the apex of the orbital cavity. Its inferior wall corresponds to the roof of the maxillary sinus. The orbital cavity contains the infraorbital fissure and infraorbital neurovascular bundle. The infraorbital fissure is continuous with the pterygomaxillary fissure. The superior wall is contiguous with the ethmoid or frontal sinuses and with the anterior cranial fossa. As previously stated, the superior orbital fissure serves as a passage for CN V1, III, IV, and VI and represents a potential pathway to the middle cranial fossa. The lateral wall is contiguous with the temporal fossa anteriorly to laterally.

Anterior Cranial Fossa (Figure 2)

The floor of the anterior cranial fossa comprises the frontal, ethmoid, and sphenoid bones. Laterally, the floor of the anterior cranial cavity corresponds to the roof of the orbits, while, centrally, it corresponds to the vault of the nasal cavity and the roof of the ethmoid sinuses. At the central anterior skull base, the most prominent structure is the cribriform plate, which contains multiple foramina, through which the olfactory filaments pass into the nasal cavity. Branches of the anterior ethmoid artery penetrate the

vertical wall of the cribriform plate, the weakest point of the anterior skull base. Anterior to the cribriform, a bony prominence known as the crista galli is seen. The planum sphenoidale denotes the area posterior to the cribriform plate, and its posterior aspect marks the posterior boundary of the anterior cranial fossa.

Preoperative Workup

Workup of patients with any new sinonasal or anterior skull base mass should include a detailed examination, including cranial nerve examination, and nasal endoscopic evaluation. Biopsy of the mass should be performed either in the clinic (if bleeding risk appears low and patient is amenable) or in the operating room. Definitive surgical plans should not be executed without final (permanent) pathologic diagnosis whenever possible.

The extent of disease and hence the required extent of the resection is established endoscopically and by imaging. Cross-sectional imaging is imperative to ascertain the extent of the disease, potential cranial nerve and internal carotid artery involvement, and resectability and potential for cure. Typically, a CT scan is best to evaluate the bony anatomy (bony destruction or remodeling, intracranial extension) and is usually paired with MRI (with and without contrast) to evaluate the soft tissue extent of disease, including orbital, dural, vascular, brain or cranial nerve invasion (*Figure 1*). A proper staging workup for metastatic disease (PET scan, or CT of neck and chest or ultrasound neck and chest x-ray) is critical in treatment planning. In the case of parameningeal sarcomas, MRI of the spine is indicated to ascertain the presence of “drop metastases”.

Surgical Planning

Surgical planning must consider two key components:

- The surgical approach must facilitate a complete, oncologic resection of the tumor, preserving normal tissue and protecting neurovascular structures.
- The operative plan must include a robust reconstructive algorithm to restore the separation of the cranial cavity and upper aerodigestive tract with adequate cosmetic and functional outcomes.

Two distinct surgical techniques should be considered when planning surgery

- ***Traditional open approaches*** involve a transcranial subfrontal approach (most frequently via coronal incisions) combined with a transfacial approach (lateral rhinotomy, midface degloving, Weber-Ferguson incisions) to facilitate en bloc resection of the median anterior cranial base (cribriform plate, roof of ethmoids), superior nasal septum, ethmoid sinuses and lateral wall(s) of the nasal cavity (medial maxilla and lamina papyracea). When needed, it may be combined with orbital exenteration or a subtemporal approach to access the lateral skull base, orbit and infratemporal fossa.
- ***Endonasal endoscopic approaches*** have evolved over the last 30 years and permit comprehensive sinonasal resection and anterior skull base extirpation in lieu of a traditional transfacial approach. The endoscopic approach is equivalent, both oncologically and functionally to a traditional craniofacial resection. Furthermore, the endoscopic approach may be combined with a subfrontal approach to avoid facial incisions. Each of these approaches is detailed below.

Open Craniofacial Approach: Surgical Technique

The open craniofacial approach is described in the following steps:

- Access to the mid- and upper face and cranium
- Sinonasal approaches
  - Lateral rhinotomy
  - Midfacial degloving
  - Expanded endonasal
- Reconstruction
- Closure

Access to mid- and upper face and cranium

- ***Intraoperative navigation***, though generally not critical, can be registered to the preoperative imaging to assist with intraoperative confirmation of surgical landmarks.
- Make a straight ***scalp incision*** in a coronal plane of the skull from one preauricular crease to the contralateral preauricular crease.
- Carry the incision down to the calvarium from temporal line to temporal line.
- At the temporal line, the dissection plane is transitioned to just above the deep layer of the temporalis fascia.

- Elevate the scalp in a subpericranial plane, transecting the attachments of the pericranium at its junction with the deep temporal fascia, around the superior border of the temporalis muscle.

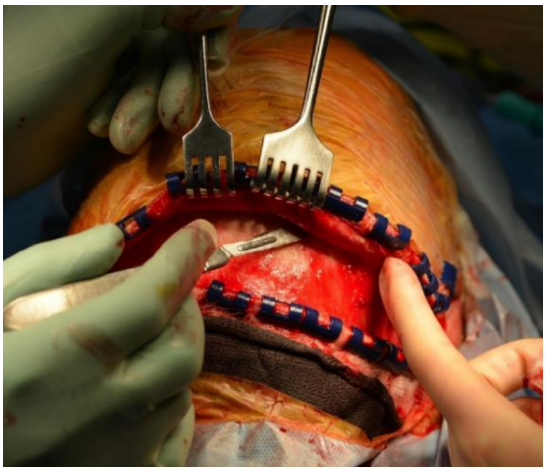


Figure 3: Elevating the scalp flap in a subgaleal plane. The rake is used to lift the scalp while the loose areolar tissues and pericranium are sharply dissected off the galea. Alternatively, the scalp and pericranium can be elevated as one flap initially, and the pericranium back-elevated off the scalp later in the dissection if needed

- ***It is imperative to preserve the pericranium, as this is typically utilized as the reconstructive layer that will separate the intracranial space from the sinonasal cavity*** (*Figure 3*).
- As the scalp is elevated anteriorly, the orbital rims and glabella are exposed
- A 1 cm incision over the periosteum of the zygomaticofrontal area serves as an internal relaxing incision, allowing mobilization of the scalp flap with minimal retraction.

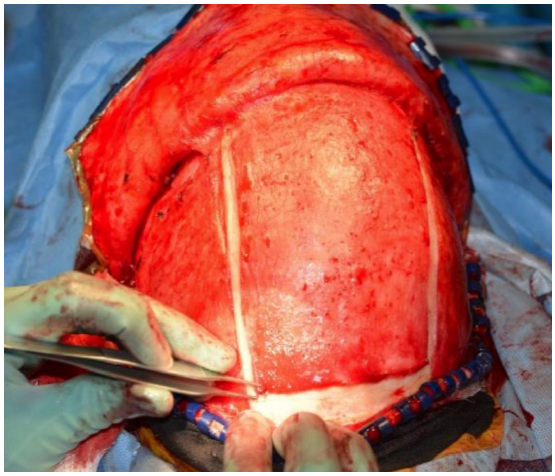


Figure 4: Pericranium is then incised and mobilized off the skull, following the temporal lines laterally and the coronal incision for the posterior cut. If needed, the posterior cut can be extended several centimeters further posteriorly, if additional length will be required for the reconstruction

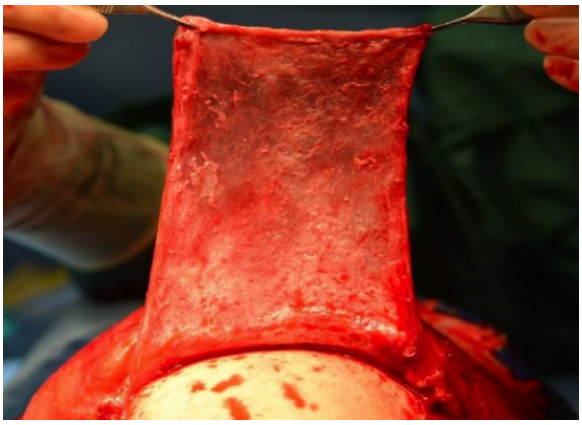


Figure 5: The pericranium is fully mobilized for the reconstruction, either by back-elevating off the scalp flap or elevating separately

- ***Alternatively, the scalp flap and the pericranium can be elevated separately.*** To perform this manoeuvre, the standard coronal incision is performed but the scalp flap is elevated in a subgaleal plane, leaving the loose areolar tissue and pericranium attached to the skull (*Figure 4*). Laterally the deep temporalis fascia is left intact as the scalp is mobilized like the conventional flap elevation noted above. The dissection continues until a point 2 cm above the supraorbital rims. At this point, the pericranium is mobilized separately off the skull by incising along the temporal lines and across the coronal line posteriorly (*Figure 5*).
- The ***frontal branch of the facial nerve*** lies just deep to the superficial temporalis fascia (temporoparietal fascia) inferior to an imaginary line extending from the root of the zygoma to the superior orbital rim. It only comes into play if the resection needs to be extended laterally to expose the middle cranial or infratemporal fossa. In such cases the frontal branch needs to be preserved either by identifying and dissecting the nerve or dissecting in a plane that does not place the branch at risk. The deep temporalis fascia divides into a superficial and deep layer, containing between them a temporal fat pad. The superficial layer is incised superior to that imaginary line extending from the root of the zygoma to the superior orbital rim i.e. prior to encountering the frontal branch, and the scalp flap is elevated in an interfascial plane between the superficial and deep layers of the deep temporalis fasciae. This plane can be followed to the orbital rim and down to the zygoma, depending on the extent of exposure needed at the nasion, and will protect the frontal branch.

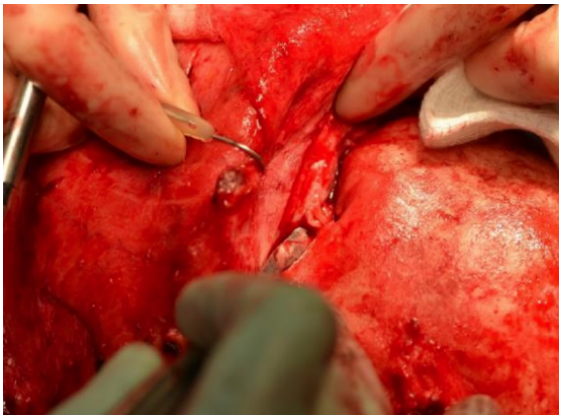


Figure 6: The left supraorbital neurovascular bundle supplies sensation to the left frontal region and serves as one of the key vascular pedicles to the pericranial flap. Here the bundle is mobilized from the supraorbital notch (or foramen as needed) to maintain its integrity as it exits the periorbita and enters the pericranium and scalp. This allows bony osteotomies to be made without compromising the pericranium or sensation in the frontal region

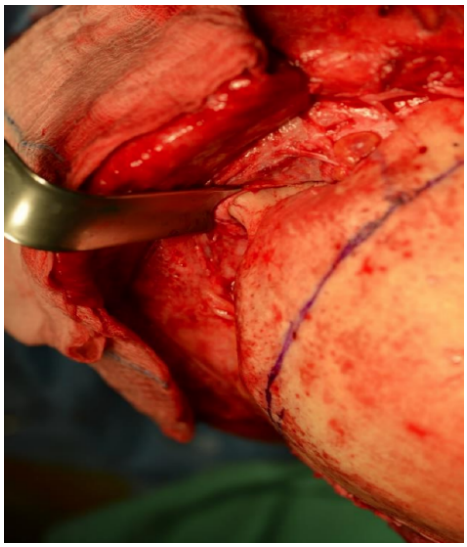


Figure 7: Fully mobilizing the superior periorbita allows the scalp flap to be further retracted as the entire nasal root and superior nasal bones are exposed. The purple line highlights the planned division between the frontal craniotomy and the orbital bar

- As the scalp flap is turned anteriorly and inferiorly, the supraorbital rims are exposed, and the ***supraorbital neurovascular bundles*** are dissected from the supraorbital notches, as depicted in *Figure 6*. When a true supraorbital foramen is present, it may be opened inferiorly using a 3-6 mm osteotome and mallet. This manoeuvre allows inferior mobilization of the supraorbital neurovascular bundle and dissection of the periorbita from the superior and medial orbital walls. Notably, as the periorbita are dissected from the orbital rim, the orbital roof takes a superior trajectory around the orbital rim with an acute angle that must be anticipated or the periorbita will be violated. Although not critical, maintaining the integrity of the periorbita lessens trauma to the orbits and limits fat herniation into the surgical field. Any remaining periosteum is elevated to expose the nasal root and nasal bones (*Figure 7*).
- ***This coronal approach exposes the superior cranium, frontal area, glabella, nasal bones, temporalis muscles and temporal fossae, and the superior two thirds of the orbits.***

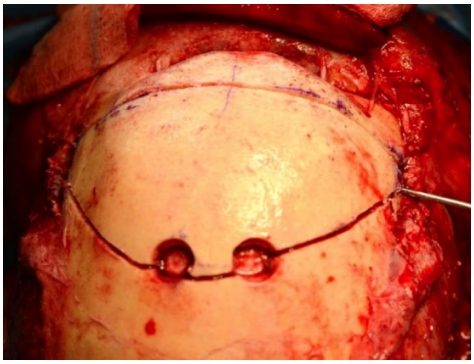


Figure 8: A bifrontal craniotomy, widely exposing the frontal lobes to limit brain retraction

- ***A bifrontal craniotomy is next performed to expose the frontal lobes***. It is typically performed in conjunction with the neurosurgical team (*Figure 8*). The craniotomy typically encompasses the frontal bone bilaterally from the keyhole pterional burr holes and down to approximately 2 cm from the orbital rims (*Figure 8*). Typically, small burr holes are placed on each side of the sagittal sinus; thus, facilitating its dissection and avoiding laceration. The frontal sinus is often transgressed with these cuts, and the posterior table is usually removed from the frontal bone graft, with the remainder of the sinus completely stripped of mucosa to cranialise the sinus. These craniotomy cuts also can be extended laterally for tumors that extend into the orbit or infratemporal fossa.

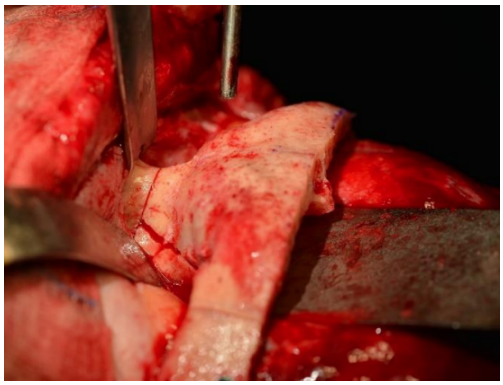


Figure 9: Removal of the orbital bar after the bifrontal craniotomy viewed from the patient's left. It demonstrates the osteotomies required to mobilize the orbital bar, including the lateral osteotomy through the orbital rim, which is then carried down along the roof of the orbit and into the root of the nasal bones

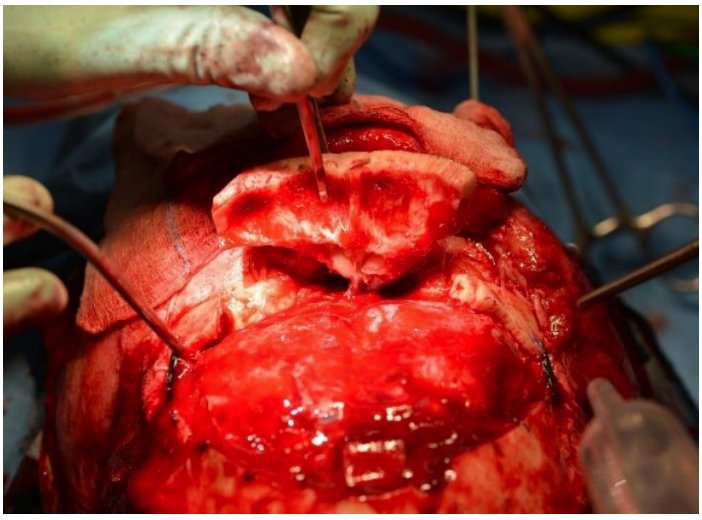


Figure 10: This demonstrates en bloc removal of the orbital bar, exposing the frontoethmoid region and superior orbits

- Following the craniotomy, the ***subfrontal approach is facilitated by removing the orbital bar*** (*Figure 9*). The subfrontal approach maximizes exposure of the anterior skull base while minimizing the retraction of the frontal lobes. It comprises removal of the bone forming the superior orbital rims bilaterally, glabella and nasion, down into the nasal bones (*Figure 9, 10*). The lateral bone cuts are placed at the lateral orbital rims and a posterior cut joins these incisions by traversing the anterior orbital roofs (retracting the periorbita to protect the orbital contents) and across the frontoethmoidal junction just posterior to the frontal outflow tracts. A transverse incision across the nasion, or further inferiorly through the nasal bones, is then performed, often requiring a curved osteotome to free the anterior superior attachment of the nasal septum to the orbital bar to fully mobilize the graft.
- Direct exposure of the anterior skull base has now been achieved.
- ***The subfrontal exposure limits the need for frontal lobe retraction.***
- The ***dura is elevated from the floor of the anterior skull base*** and is sharply divided from the crista galli, which is removed
- Careful elevation of the frontal lobe dura from the roof of the orbits and crista galli exposes the cribriform plate.
- The dural sleeves along the olfactory nerves are individually divided and ligated; however, multiple lacerations of the dura often result around the perforations of the olfactory nerves through the cribriform plate.
- ***Intracranial tumor extension*** with dural involvement requires one to leave a patch of involved dura attached to the specimen and even to resect a portion of one or both frontal lobes to secure adequate tumor margins.
- Gently ***elevate the anterior fossa dura*** in a posterior direction to identify the planum sphenoidale, the anterior clinoid processes and optic canals (*Figure 2c*).
- Drilling with a high-speed drill through the ***planum sphenoidale*** exposes the sphenoid sinus allowing its inspection.
- A high-speed drill or reciprocating saw is then used to ***cut around the cribriform*** plate and through the floor of the anterior cranial fossa.

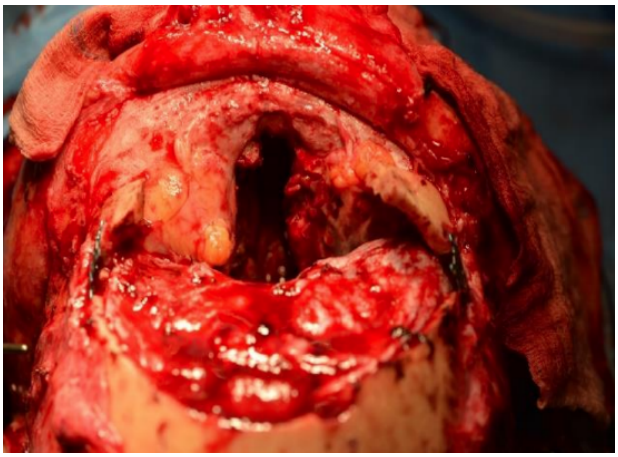


Figure 11: Final exposure of the anterior skull base after removal of the tumor demonstrates how the left orbit is fully skeletonized (note the orbital fat) and the entire nasal cavity has been removed. The frontal lobes have been decompressed after creating a CSF leak allowing wide exposure without significant brain retraction

- The ***anterior skull base can be fully mobilized*** with a high-speed drill utilizing this approach, from the frontal sinus to the planum (*Figure 11*).
- In most instances the ***medial orbital walls*** are included in the resection to provide adequate margins and facilitate the control of the ethmoidal arteries.
- The intracranial exposure allows the complete and often en bloc removal of the anterior cranial base with visualization and protection of the optic nerves and the lateral walls of the sphenoid sinus including the internal carotid arteries.
- ***At this point of the resection, the superior margins and exposure have been achieved, and the tumor has been safely separated and removed from the cranial contents.***

Sinonasal Approaches

A separate inferior (sinonasal) exposure is often required to obtain adequate inferior and lateral margins, as the tumor typically limits visibility into the nasal cavity via a subfrontal approach. This can be performed through a variety of approaches, including ***lateral rhinotomy with medial maxillectomy, midface degloving, or endoscopic endonasal assistance***.

a. *Lateral Rhinotomy Approach* (See Medial maxillectomy chapter)

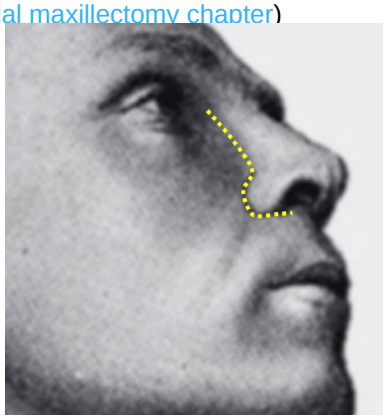


Figure 12: Lateral rhinotomy incision

- A vertical skin incision is made along the lateral nose, from the medial canthus to the nasal ala, then joining a curvilinear incision along the alarfacial groove on the tumor side (*Figure 12*). The incision is carried through the muscular layer to the pyriform aperture. To prevent subsequent alar retraction the incision around the ala is carried vertically toward the maxilla and not under the ala; furthermore, the medial aspect of the nasal ala is not transected.
- The ***nasal mucosa*** is incised along the piriform aperture through the lateral nasal vestibule avoiding the tip of the inferior turbinate.
- Detachment of the ***medial canthal ligament*** facilitates elevation of the periosteum of the medial wall of the orbit, keeping the orbital contents within its periosteal sac.
- The ***nasolacrimal duct*** is transected at its junction with the nasolacrimal sac and the sac is divided and marsupialized.

- The ***anterior and posterior ethmoid vessels*** are identified at the frontoethmoidal suture and controlled with bipolar electrocautery.
- Lateral elevation of the cheek flap exposes the medial maxilla and infraorbital nerve, which is preserved.
- The anterior wall of the maxillary antrum is opened.
- Osteotomies are performed through the nasal process of the maxilla, through the lacrimal fossa and the anterior aspect of the lamina papyracea, connecting to the previous osteotomies.
- The medial wall of the maxilla is cut with an osteotome or drill along the nasal floor.
- The remaining posterior aspect of the lateral nasal wall is cut in a posterior and cephalad direction using curved Mayo scissors from the nasal floor to the sphenoid rostrum.
- A septal incision is created along nasal floor and carried cephalad with curved Mayo scissors. A strut of nasal septum is preserved, if able, to support the external nasal framework.
- Transection of the attachment of the nasal septum to the rostrum of the sphenoid sinus allows the mobilization of the specimen.
- The defect is inspected, and additional bone or soft tissue margins are obtained under direct visualization. Exposure of the contralateral sinonasal cavity is somewhat limited with this approach.

b. Midface Degloving Approach

To avoid facial incisions, the sinonasal tumor component may be resected and mobilized via a sublabial approach. It provides wide exposure to the midface, allowing for mobilization of the periorbita, dividing the ascending process of the maxilla, septal incisions and medial maxillectomy incisions to obtain clear tumor margins.

- Make a wide sublabial incision (1^{st} molar to 1^{st} molar) onto the bone of the maxilla.
- Dissect in a subperiosteal plane along the anterior maxilla up to the orbital rim and infraorbital nerve.
- Expose the nasal cavity by incising the mucoperiosteum around the piriform aperture and elevating the now mobile nose (lower lateral cartilage and nasal skin) and soft tissue envelope off the remaining nasal framework.
- Incise the nasal mucosa along the floor of the pyriform aperture.
- Gently elevate the medial crura of the lower lateral cartilages off the septum with a full transfixion incision and connected to an intercartilaginous incision along the pyriform aperture.
- The soft tissue envelope is then elevated with the lip and lower lateral cartilages.

c. Expanded Endonasal Approach

Endoscopic endonasal approaches (EEA), can be used to supplement traditional subfrontal approaches to avoid facial incisions (combined open-endoscopic resections) or as an oncologically equivalent approach for the resection of the anterior cranial base. EEA evolved following advances in rodlens endoscopy, improved digital camera and video monitor definition, customization of surgical instruments, and refinements in electrophysiological monitoring, jointly with image-guided surgery equipment.

- Examine the nasal cavities with a zero degree rigid endoscope.
- Depending on the bulk and origin of the tumor, dissection may commence either with tumor debulking or with traditional endoscopic sinus surgery.
- Dissection of the paranasal sinuses follows a technique similar to that used for the treatment of inflammatory disease.
- Whenever necessary, ***debulk the tumor*** to provide an adequate working space and visualization, identifying and maintaining the origin of the tumor and assessing its boundaries. The extent of the tumor determines the need for unilateral versus bilateral exposure.
- Following an ***uncinectomy***, create a wide ***medial maxillary antrostomy*** giving access to the posterior maxillary wall and providing orientation with respect to the medial and inferior orbital walls.
- Complete ***anterior and posterior ethmoidectomies, middle turbinectomies, and exposure of the nasofrontal recess*** to define and expose the paramedian anterior skull base, including the roof of the ethmoid sinuses, the vertical and horizontal lamellae of the cribriform plate, and the anterior and posterior ethmoidal artery canals.
- Wide bilateral exposure of the ***sphenoid sinuses*** with complete removal of the rostrum provides unencumbered access to the planum sphenoidale and defines the posterior tumor limit.
- Similarly, a ***Draf III frontal sinusotomy*** (modified endoscopic Lothrop procedure) provides access to the cribriform plate and posterior table of the frontal sinus and defines the anterior limit.
- ***At this point the reconstructive plan should be considered.*** If a ***nasoseptal flap*** is available (it is often not due to oncologic involvement), it should be harvested at this point. Using monopolar cautery, the superior incision is placed along the superior septum beginning at the sphenoid ostium, to be carried anterior and cephalad towards the olfactory groove. Anterior to the

anterior head of the middle turbinate the incision is carried along the superior-most septum to reach the mucocutaneous junction. The inferior incision is typically performed across the inferior choana and along the inferior margin of the septum, at the junction with the nasal floor, and carried anteriorly to meet the anterior incision. The flap is elevated in a submucoperichondrial plane, left pedicled to the posterior septal branch of the sphenopalatine artery. The flap is then tucked in the nasopharynx to complete the resection.

- A wide ***posterior septectomy*** is then performed, ensuring adequate preservation of the anterior septal strut to maintain nasal support. The contralateral septal mucosa can be utilized as a reverse septal flap provided that there is no tumor invasion.
- The ***sphenoidotomies are connected and widened***.

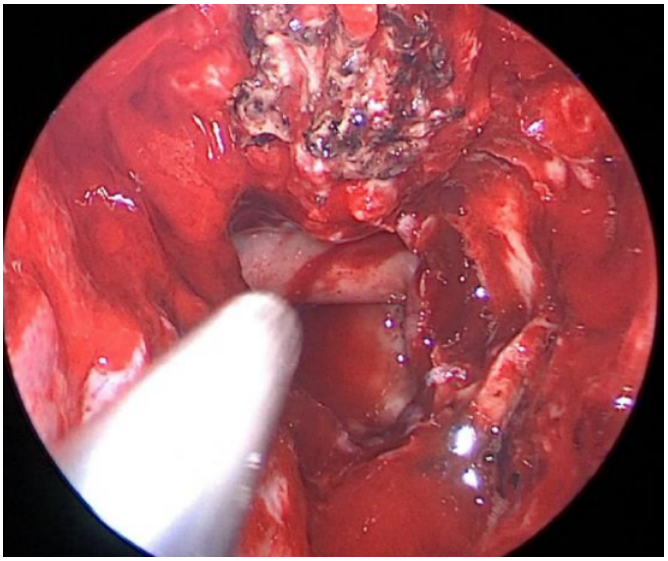


Figure 13: Expanded endonasal approach for exposure of the anterior skull base. After total extirpation of the sinuses, nasoseptal flap harvest (if indicated) and a posterior septectomy, the sphenoid ostia are enlarged into a common sphenoid cavity, widely exposing the skull base from orbit to orbit. A Draf III frontal sinusotomy is helpful in joining and defining the frontal exposure

- This completes a wide exposure of the median anterior skull base, from orbit to orbit and from the sella turcica to the frontal sinus (*Figure 13*).
- The ***lamina papyracea*** may be eggshell fractured and carefully removed as a lateral margin, if necessary, or to better identify and control the ethmoidal arteries. The integrity of the underlying periorbita should be preserved unless tumor invasion mandates its removal.
- Bone over the ***anterior and posterior ethmoidal canals*** may be removed by gentle curettage or drilling, exposing the ethmoidal arteries that then may be cauterized (bipolar electrocautery is strongly recommended).
- Using a high-speed drill with a 3 mm extended-tip coarse diamond or hybrid burr, a horizontal ***osteotomy*** is made through the planum sphenoidale several millimeters anterior to the optic canals.
- Using the Draf III frontal sinusotomy, another horizontal osteotomy is made posterior to the frontal outflow to expose the crista galli.
- These osteotomies are then connected bilaterally with osteotomies along the lateral aspect of the roof of the ethmoid sinuses (junction of the ethmoid sinus roof and orbital roof.
- These rectangular osteotomies incurporate the cribriform plates, septum, and portions of the planum sphenoidale and roof of the ethmoid sinuses and surround the tumor.
- Any remaining bone is thinned and elevated to expose the dura of the ventral skull base and the crista galli, which is resected.
- ***Olfactory filaments*** are cauterized and the bone of the anterior skull base is resected.

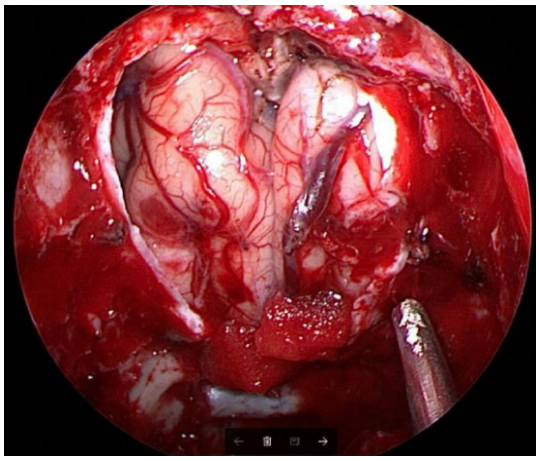


Figure 14: The cribriform plate is drilled and the anterior skull base can be resected to include the underlying dura

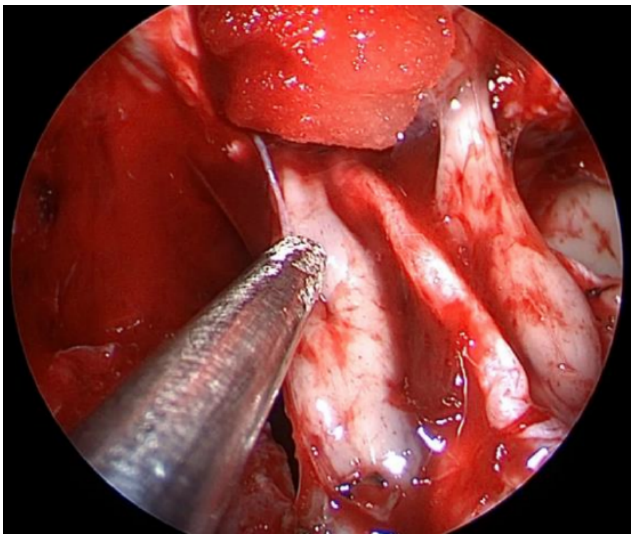


Figure 15: As the cribriform and olfactory bulbs are being gently mobilized from the skull base in an anterior to posterior direction, the olfactory nerves can be identified, transected and sampled for a margin as indicated

- ***Dura*** can be opened or resected along the with ***olfactory bulbs*** (*Figures 14,15*) as needed for tumor clearance.
- ***Margins are sampled*** circumferentially to ensure an adequate oncologic resection.
- ***Alternatively***, the endoscopic drill is used to connect the endoscopic resection to the previously performed osteotomies done via the subfrontal approach, when being used in combination with open approaches. This allows complete mobilization and en bloc removal of the tumor.

Reconstruction

The primary goal of reconstruction is to achieve a watertight dural closure to minimize the risk of a postoperative CSF leak and meningitis.

- Small dural lacerations are closed primarily.
- Large defects require the use of a free tissue graft. Cadaveric dura, pericarpdium, acellular dermis, and fascia lata can be used.

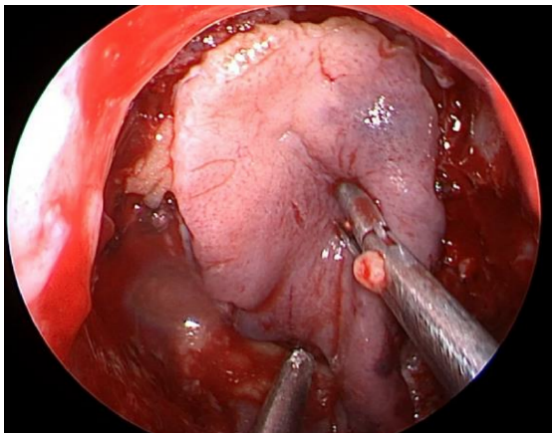


Figure 16: After the resection is complete, an inlay reconstruction is typically performed of the skull base (fat, fascia lata, or a collagen matrix). The nasoseptal flap is then rotated into place, widely covering the defect with bony contact 360 degrees around the skull base defect

- Reconstruction of the skull base infrastructure is ***best achieved with a vascularized flap*** to ensure a durable watertight seal. This is typically completed with a ***pericranial*** or ***galeopericranial*** flap (open approach) or ***nasoseptal*** flap (endoscopic approach) (*Figure 16*).

Pericranial flap

The pericranial flap is pedicled on the supraorbital neurovascular bundles (and sometimes supratrochlear neurovascular bundles and anterior branches of the superficial temporal artery) (*Figures 4, 5, 6*). A unilateral blood supply is sufficient for the survival of the flap.

- The pericranium is elevated off the previously elevated scalp flap or is elevated independently if a subgaleal scalp flap is performed (*Figures 4, 5*).
- The flap is elevated in a subgaleal plane but remains attached to the scalp flap 1-2 cm above the orbital rims to prevent injury to the supraorbital pedicles.

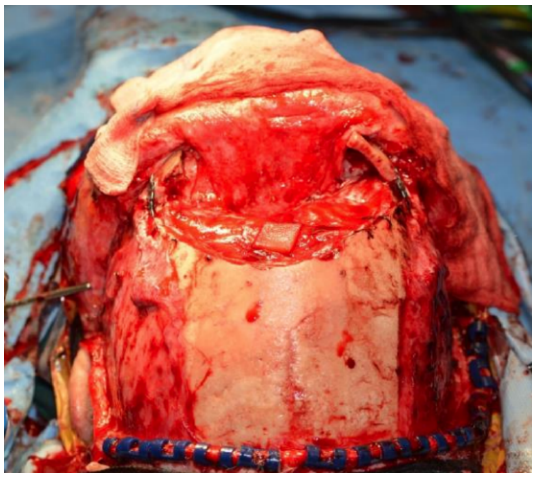


Figure 17: The pericranium is tucked into the epidural plane between the remnant cribriform/orbital roof and the dura. This is typically done prior to replacing the frontal bar or bifrontal bone flaps to create a watertight closure

- The flap is then gently tucked in the epidural space and below the orbital bar and craniotomy bone grafts (*Figure 17*).

Endoscopic reconstruction

- This is best completed with a ***nasoseptal flap***, although ***lateral wall flaps*** are a viable alternative.
- Having elevated the flap earlier with the endoscopic approach, the open skull base defect is cleared and exposed.
- Fat, fascia lata, Duragen or other free grafts can be used as ***inlay grafts for a multilayered reconstruction***.
- The ***nasoseptal flap*** is then rotated extracranially into position to cover the defect (*Figure 15*). The flap should have adequate overlap circumferentially to the remaining bony surface.
- The flap is generally bolstered with sponge-type packing to secure the graft tightly against the skull base.

Closure

- The supraorbital and craniotomy bone grafts are replaced into their anatomic position with adaptation miniplates (wires or even sutures may yield an adequate result).
- The pericranial flap is typically placed between the supraorbital graft and the nasal bones.
- The scalp is then rotated back into position and the facial and scalp incisions are closed in standard fashion

Postoperative Care, Identification and Management of Complications

- The patient is typically extubated immediately postoperatively.
- It is imperative to communicate with the anesthesia team, as with an open skull base defect, the patient cannot be supported with positive pressure mask ventilation, or significant pneumocephalus could result.
- The patient is transferred to a monitored intensive care setting for close neurologic monitoring, and a postoperative CT scan is routinely performed to rule out intracranial hemorrhage, brain contusion or significant pneumocephalus.
- A lumbar spinal drain is not routinely required but may be considered in patients with a tenuous reconstruction. Alternatively, acetazolamide may be administered to decrease the production of CSF, in turn decreasing the pressure and diminishing the potential for a postoperative CSF leak.
- The patient is checked daily for a CSF leak by sitting the patient upright and flexing the neck, monitoring for a steady drip of clear fluid from the nose (“tilt test”).
- IV antibiotics are continued for 48 hours and advanced to oral antibiotics with the patient’s diet. Antibiotics are continued until the nasal packing is removed, approximately 1 week postoperatively.
- The patient usually remains in the hospital for 3-5 days.
- The patient is typically seen in the clinic 1-2 weeks postoperatively. The nasal cavity is gently debrided and packing removed.
- Saline irrigations are then initiated to hydrate the raw mucosal surfaces and gently hydrodebride residual packing and crusting.
- Multiple postoperative debridement visits are typically required while the nose is healing.
- The two most common major complications of anterior skull base resection are CSF leak and tension pneumocephalus. Others include brain contusion, oedema, stroke, meningitis, intracranial abscess, and osteomyelitis.
- Following a viable reconstruction, a CSF leak may be managed conservatively with lumbar spinal drainage, but a low threshold for surgical re-exploration should be maintained.
- Tension pneumocephalus is treated with percutaneous aspiration through a gap between the cranium and the craniotomy bone graft. Recurrent tension pneumocephalus may require diversion of the nasal airway including endotracheal intubation, a nasal airway (nasal trumpet), or a tracheotomy.

Useful References

- Patel SG, Singh B, Polluri A, et al: Craniofacial surgery for malignant skull base tumors: Report of an international collaborative study. Cancer 98:1179- 1187, 2003
- Bhatki AM, Carrau RL, Snyderman CH, Prevedello DM, Gardner PA, Kassam AB. Endonasal Surgery of the Ventral Skull Base- Endoscopic Transcranial Surgery. Oral Maxillofac Surg Clin North Am. 2010 Feb; 22(1): 157-68
- Kassam A, Thomas A, Carrau R, Snyderman C, Vescan A, Prevedello D, Mintz A, Gardner P. Endoscopic reconstruction of the cranial base using a pedicled nasoseptal flap. Neurosurg, 2008 Jul;63(1) Suppl:44-52
- Blacklock JB, Weber RS, Lee YY, Goepfert H. Transcranial resection of tumors of the paranasal sinuses and nasal cavity. J Neurosurg. Jul 1989;71 (1):10-5
- Cheesman AD, Lund VJ, Howard DJ. Craniofacial resection for tumors of the nasal cavity and paranasal sinuses. Head Neck Surg. Jul-Aug 1986;8(6): 429-35

Authors

Kyle K Van Koevering
MD Assistant Professor
Department of Otolaryngology – Head and Neck Surgery
University of Michigan Medical Center
Ann Arbor, MI, USA
kylevk@med.umich.edu

Daniel M Prevedello
MD Professor, Department of Neurological Surgery
Co-Director of Comprehensive Skull Base Surgery Program

The Ohio State University Medical Center
Columbus, Ohio, USA
Daniel.Prevedello@osumc.edu

Ricardo L Carrau
MD, F.A.C.S., MBA Professor and Lynne Shepard Jones Chair in Head and Neck Oncology
Department of Otolaryngology-Head & Neck Surgery
Co-Director of the Comprehensive Skull Base Surgery Program
The Ohio State University Medical Center
Columbus, Ohio, USA
Ricardo.carrau@osumc.edu
carraurl@gmail.com

Editor

Johan Fagan
MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.33: Maxillary Swing Approach to the Nasopharynx

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Lex AC Vlantis

Pathology in the nasopharynx can be addressed endoscopically, or as an open procedure. The advantage of an open procedure is that it affords better surgical access. There are a variety of open approaches to the nasopharynx *inter alia* transnasal, transmaxillary, infratemporal fossa and transpalatal approaches.

The ***maxillary swing approach*** is a variation of the transmaxillary approach and provides wide access to the nasopharynx as well as to the pterygopalatine fossa and pterygomaxillary fissure; it also preserves soft palate function which is so vital for speaking and swallowing.

Indications for maxillary swing include:

- Surgical excision of residual or recurrent nasopharyngeal malignancy, usually carcinoma
- Resection of recurrent juvenile nasopharyngeal angiofibroma
- Covering exposed internal carotid artery following radionecrosis of the nasopharynx after radiotherapy for nasopharyngeal malignancy with pedicled or free flaps

Preoperative consent

Preoperative consent includes but is not limited to facial incisions, loss of sensation in the infraorbital nerve distribution, loss of maxillary bone, wound dehiscence and breakdown, oronasal and oronasopharyngeal fistulae and ectropion.

General preparation

A tracheostomy is routinely performed either under local anesthesia or following administration of a general anesthetic. Perioperative antibiotics are given on induction of anesthesia.

The patient is positioned supine and the head supported with a head ring. The eyes are protected according to the institution's protocol. An ocular lubricant or ointment is inserted into both eyes such as chloromycetin eye ointment if the patient is not allergic to it. The contralateral eye may be covered with a transparent protective adhesive dressing and a tarsorrhaphy performed on the ipsilateral eye taking care not to invert the eyelashes so as to avoid corneal abrasions.

The patient's face and neck are prepped; an alcohol-based solution or other solutions that may irritate the eyes or to which the patient is allergic should not be used. The oral cavity is prepped. The nasal cavity is packed with topical vasoconstrictor-soaked ribbon gauze.

The scalp, lower neck and chest are draped leaving the forehead, face, upper neck and both ears exposed.

Surgical steps

The operation may be considered in 3 stages:

- ***Soft tissue preparation*** - incisions and limited soft tissue dissection to expose bone for osteotomies
- ***Bone work*** - miniplate preparation, osteotomies and maxillary swing
- ***Closure*** (following tumor resection)

It is important to complete the soft tissue dissection and bone exposure before doing any bone work to avoid excessive blood loss.

Marking skin and mucosal incisions



Figure 1: Skin incisions for the maxillary swing approach. The medial canthal structures are avoided. A notch is marked in the vestibule and at the vermillion border

Using a sterile marking pen, draw an incision line 5 mm below and parallel to the lower eyelid lash-line (*Figure 1*). This incision is placed close to the palpebral margin so that oedema of the lower lid above the scar following surgery is avoided.

At the vertical or parasagittal plane of the lateral orbital rim, the incision turns posteroinferiorly towards the 135-degree angle that the inferior border of the maxillary process of the zygoma makes with the zygomatic process of the maxilla. This inferior border can be palpated through the soft tissues of the lateral cheek. The incision is marked to the midpoint of this angled line between the lateral orbital rim and the inferior border of the zygoma. It is roughly parallel but posterior to the zygomaticomaxillary suture line (*Figure 1*).

Unlike the Weber Ferguson incision that follows the concept of facial subunits, the medial end of the lower eyelid incision is not carried onto the nasal bone, but instead avoids the epicanthal fold and so turns inferiorly just before the vertical or parasagittal plane at the medial canthus to follow the junction of the cheek and the lateral nose up to the ala. It then follows the alar groove around and into the nostril.

After a 90-degree notch is made on the nasal sill of the floor of the vestibule, the incision then continues to the midline at the junction of the columella and the lip, at which point it turns inferiorly through 90 degrees and continues in the midline of the philtrum to the midline of the upper vermillion border of the lip. A notch is made along this border too and the incision continues in the midline of the lip and through the superior labial frenulum of the buccal surface of the lip to the midline gingiva between the upper central incisors (*Figure 1*).

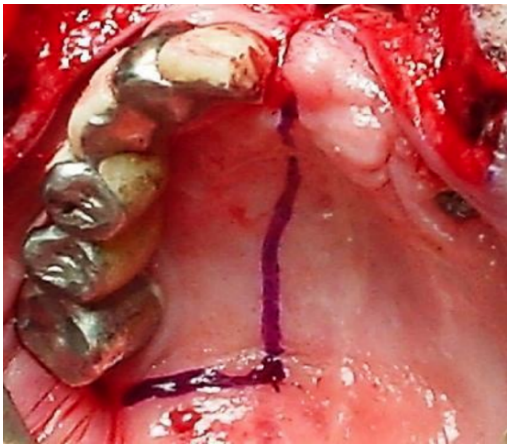


Figure 2: Paramedian hard palate and soft palate incisions

Use a tonsil or Ferguson Auckland mouth gag to open the mouth and retract the tongue to visualize the hard and soft palates. Mark a paramedian or parasagittal incision on the hard palate extending from the junction of the hard and soft palate posteriorly to the premaxillary mucosa anteriorly, 7 mm from the midline on the side of the swing. Here the incision then turns towards the midline and to the gingiva between the two upper central incisors *Figure 2*.

Palpate and identify the maxillary tuberosity and the bony spines of the pterygoid plates and pterygoid hamulus immediately posterior to the tuberosity. The line of the posterior end of the hard palate incision is continued laterally through the mucosa of the soft palate to the posterior aspect of the maxillary tuberosity (*Figure 2*).

Soft tissue dissection to expose bone for osteotomies



Figure 3: Lower eyelid is put under gentle tension while incision is made

All the incision lines are infiltrated with a vasoconstrictor e.g. 1:80,000 adrenaline. Facial skin incisions are made with a scalpel. Facial and palatal incisions are carried through skin or mucosa to periosteum and bone apart from the incisions in the lower eyelid and soft palate. While applying very gentle pressure to the eye and retracting the skin of the cheek, the lower eyelid is put under tension and the skin is incised with a number 15 scalpel blade (*Figure 3*).

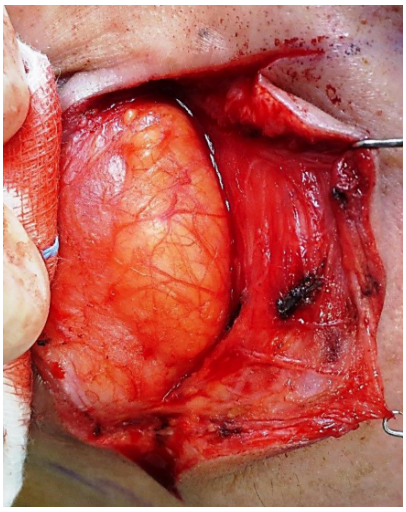


Figure 4: Lower eyelid musculocutaneous flap is elevated off inferior orbital fat pad in preseptal plane

The skin incision is deepened until the stretched *orbicularis oculi* muscle comes into view. This muscle is gently stroked with the blade until all the fibres are divided taking care not to incise the inferior orbital septum or anterior capsule of the inferior orbital fat pad. Using single skin hooks to retract the skin of the lower eyelid, the skin and *orbicularis oculi* muscle are elevated as a unit with sharp dissection from the orbital fat pad in a preseptal plane. Using sharp dissection on the septum of the inferior orbital fat pad preserves the facial nerve branches which innervate the orbicularis muscle on its deep surface (*Figure 4*).

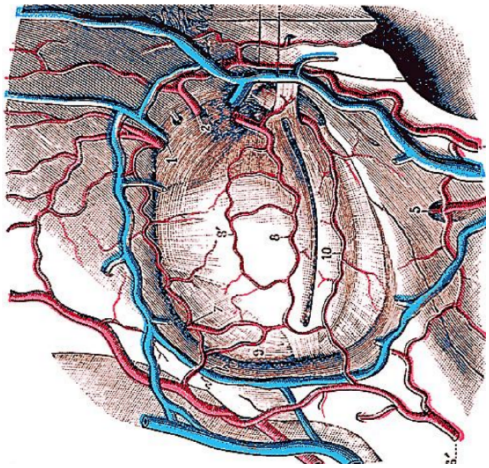


Figure 5: Angular and other vessels

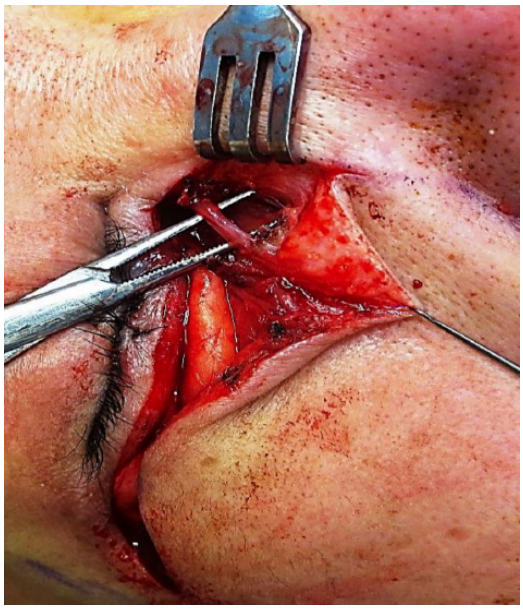


Figure 6: The angular vessels are ligated and divided

Where the medial end of the lower eyelid incision turns inferiorly, the angular vein and artery are encountered; they are ligated and divided to avoid them retracting and causing troublesome bleeding (*Figures 5*, *6*).

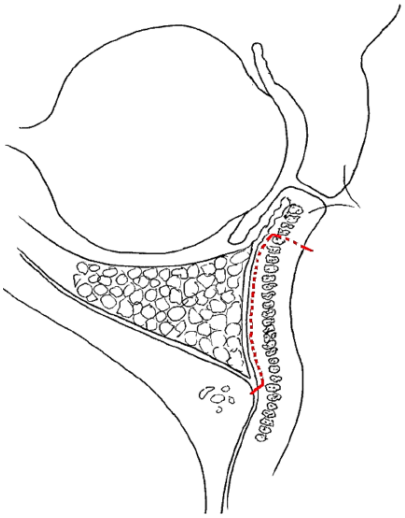


Figure 7: The lower eyelid incision is carried through skin and orbicularis muscle; the lower eyelid musculocutaneous flap is elevated off the inferior orbital fat pad in the preseptal plane and the orbital periosteum incised on the anterior aspect of the inferior orbital rim

The inferior orbital septum fuses with the periosteum at the superior aspect of the inferior orbital rim. The periosteum of the inferior orbital rim is incised anterior to this line of fusion to preserve the integrity of the inferior orbital fat pad (*Figure 7*).

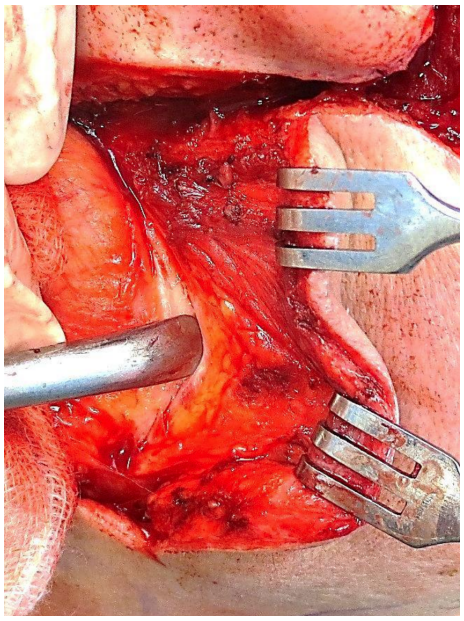


Figure 8: Soft tissues of cheek are elevated off upper maxilla in subperiosteal plane to level of infraorbital foramen

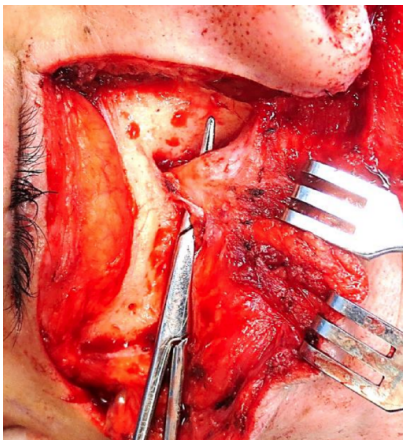


Figure 9: Infraorbital nerve and vessels are ligated and divided

Using a Howarth's periosteal elevator the soft tissues of the cheek are elevated off the upper maxilla in a subperiosteal plane to the level of the infraorbital foramen (*Figure 8*). The infraorbital nerve and vessels are identified and ligated and divided (*Figure 9*).

Do not elevate the soft tissue off the anterior maxilla further inferiorly than the infraorbital foramen as the maxilla depends on the soft tissue of the cheek for its blood supply.

Remain in the subperiosteal plane at the lateral end of the lower eyelid incision while elevating tissue off the zygoma until the inferior margin of the zygoma can be palpated with the angled end of the elevator. It is not necessary to incise the skin over the entire zygoma, but just enough to allow an osteotomy to be made. Usually the skin incision is made up to the midpoint of the zygoma.

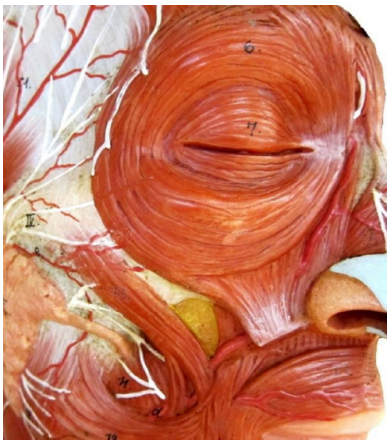


Figure 10: Facial muscles divided with facial incisions

Muscles incised with the facial incisions include the orbicularis oculi, nasalis and orbicularis oris (*Figure 10*).

Next the nasal cavity is entered through the facial wound. Once the rim of the ipsilateral pyriform aperture has been defined, free the soft tissues of the nasal cavity from the free margin of the nasal aperture with diathermy. Retract the nasal ala medially and incise the lateral wall of the nasal vestibule to expose the ipsilateral nasal cavity and inferior turbinate, taking care not to injure the inferior turbinate or septum to avoid troublesome bleeding.

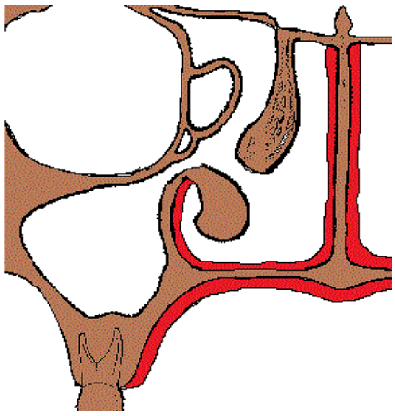


Figure 11: Coronal view of hard palate and nasal floor showing mucosa in red

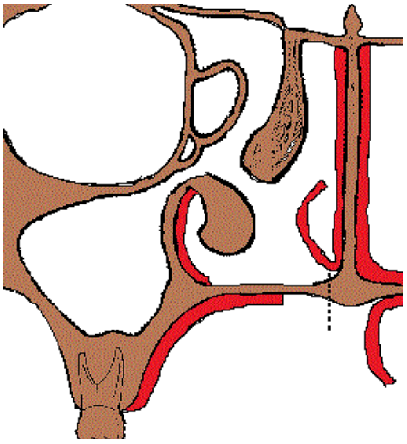


Figure 12: Coronal view of hard palate and nasal floor showing positions of mucosal incisions and elevated mucoperiosteal flaps. The position of the osteotomy is indicated by the dotted line

At the inferior margin of the aperture, use an elevator to elevate the mucoperiosteum off the floor of the nasal cavity. Elevate the entire mucoperiosteum of the floor of the nasal cavity, from the septum medially to the lateral aspect of the inferior meatus, and from the pyriform aperture anteriorly to the posterior margin of the hard palate posteriorly i.e. the horizontal plate of palatine bone. Then incise the elevated mucosa from anterior to posterior as laterally as possible to create a medially based mucoperiosteal flap that will be used to cover the maxillary osteotomy at the end of the procedure (*Figures 11, 12*).

Incise the mucosa of the hard palate along the paramedian incision line onto bone with a scalpel. Extend the incision laterally along the soft palate from the posterior edge of the hard palate incision to the groove between the maxillary tuberosity and pterygoid plates (*Figure 2*). Use a periosteal elevator to elevate the mucoperiosteum of the hard palate off the bone in a subperiosteal plane on the non-swing side of the palatal incision to just across the midline (*Figure 12*).

Bone work - miniplate preparation, osteotomies and maxillary swing

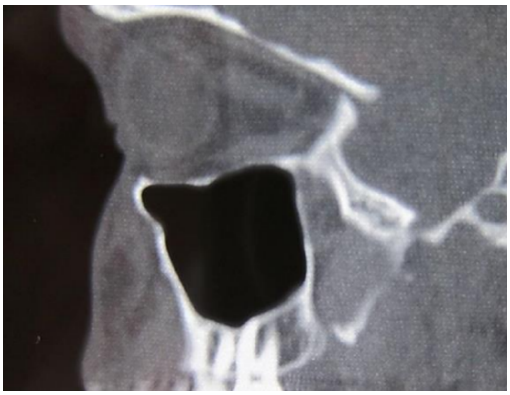


Figure 13: Sagittal plane of orbital floor bulging inferiorly at mid-orbit

Refer to the patient's sagittal imaging to confirm that the orbital floor does not dip below the level of the infraorbital foramen in the plane of the foramen, nor at the midpoint of the orbit (*Figure 13*). If this is the case, then the osteotomy must be placed below the level of the orbital floor.

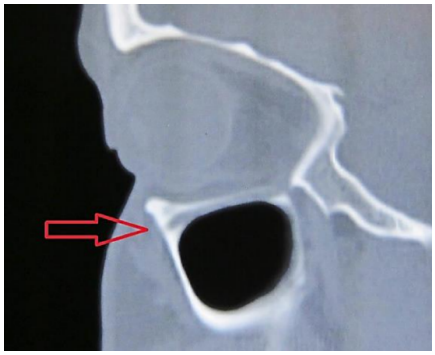


Figure 14: Sagittal plane of orbital floor at the infraorbital foramen (arrow)

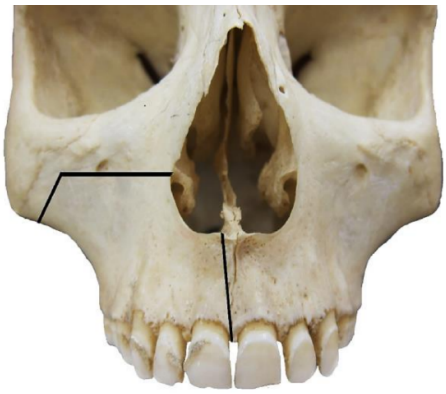


Figure 15: Anterior view of dry skull showing positions of osteotomies

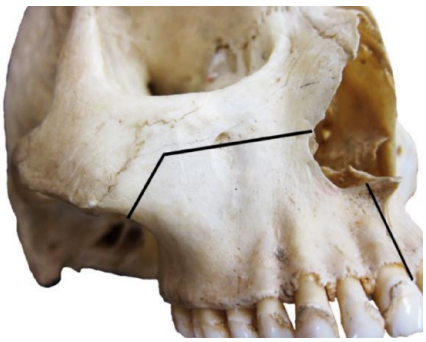


Figure 16: Oblique view of dry skull showing positions of osteotomies

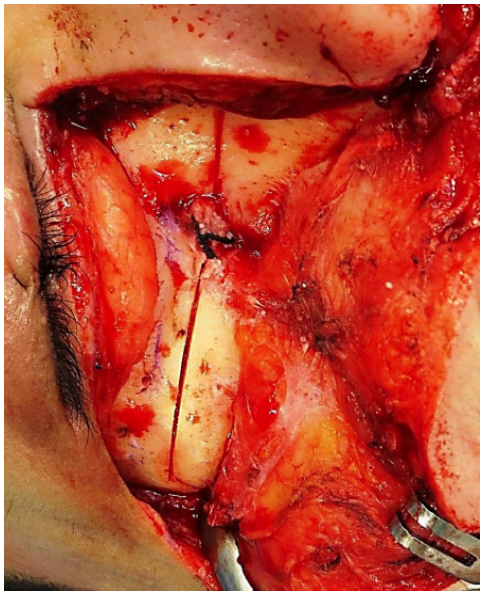


Figure 17: Infraorbital and zygomatic osteotomies; note ligated infraorbital neurovascular bundle

If the orbital floor does not bulge or hang into the antrum (*Figure 14*), then a straight horizontal osteotomy is marked at the level of the inferior margin of the infraorbital foramen, from the rim of the pyriform aperture medially to the malar aspect of the zygoma laterally (*Figures 15, 16, 17*). This osteotomy separates the bony orbit superiorly from the remaining maxilla / zygoma inferiorly.

At the lateral end of this osteotomy, a 2nd osteotomy is marked at 90 degrees to the posteroinferior border of the zygoma. This osteotomy will complete the division of the zygoma (*Figures 15, 16*).

A 3rd osteotomy is marked vertically in the midline of the anterior maxilla and extends between the medial incisors (*Figures 15, 16*).

On the exposed bone of the hard palate (palatine process of maxilla and horizontal plates of palatine bones), the osteotomy is marked just off the midline on the ipsilateral side so that it divides the floor of the nasal cavity from the nasal septum and is not made through or involves the septum. This osteotomy divides the maxilla just off the midline so that the septum remains intact and articulates with the contralateral maxilla (*Figures 12, 15, 24*).

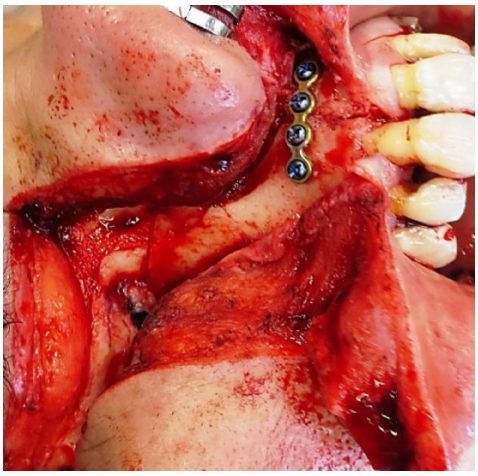


Figure 18: Plating anterior maxillary osteotomy

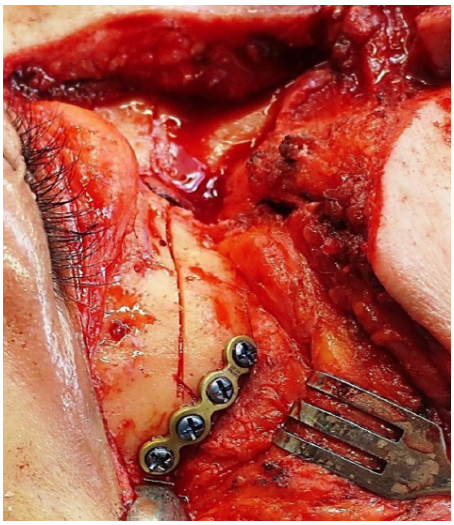


Figure 19: Plating the zygomatic osteotomy

Use a 1x1 cm thin sagittal saw to mark the osteotomies before two 4-hole miniplates are fashioned and screw holes are drilled (*Figures 18, 19*). The miniplates are contoured to the bone. At the osteotomy site in the midline of the anterior maxilla a very prominent bony crest may need to be burred down to accommodate the miniplate (*Figures 15, 16, 18*). It is important that screw holes avoid the dental roots by positioning the miniplates above or between roots if the height of the maxilla is inadequate (*Figure 18*). A 2nd miniplate is positioned over the osteotomy made through inferolateral zygoma (*Figure 19*).

The miniplates should be positioned at 900 to the osteotomy (*Figures 18, 19*). As each hole is drilled, a screw is inserted but not fully tightened, before drilling the next hole, as drilling all the holes before inserting any screws may cause misalignment. Remove all screws and record or mark in some way the orientation of the plates; it is the author's preference to make a drawing on paper and use sterile adhesive strips to attach the orientated plates to the diagram.

We first do the osteotomy that separates the maxilla from the pterygoid plates as the maxilla is still stable. There is no movement of the maxilla at this stage as the other osteotomies have not yet been done; doing it after the other osteotomies causes unpredictable fracturing of the pterygoid process.

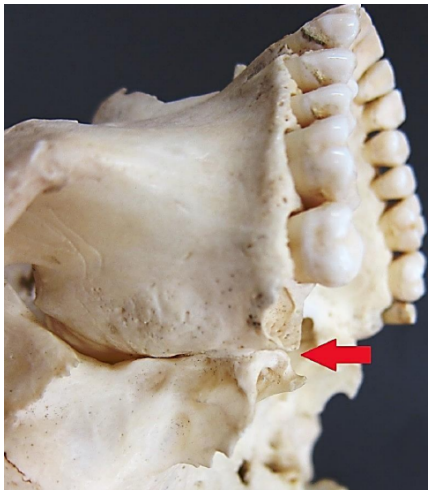


Figure 20: Arrow indicates position of blade of curved osteotome to divide maxilla from pterygoid process

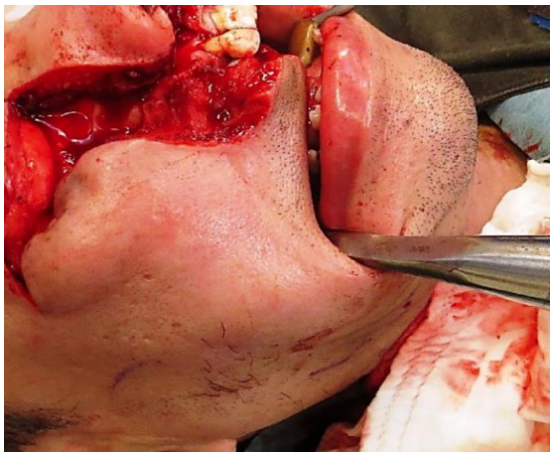


Figure 21: Use blade of curved osteotome to divide maxilla from pterygoid process; use digital palpation to locate the groove posterior to maxillary tuberosity

This osteotomy is done behind the maxillary tuberosity and frees it from the pterygoid plates. A heavy curved osteotome is passed into the oral cavity with its blade placed in the mucosal incision (*Figures 20*, *21*). With the surgeon guiding the osteotome with a finger, an assistant taps the osteotome to complete the osteotomy. The osteotome traverses the pterygomaxillary fissure and ends in the pterygopalatine fossa.

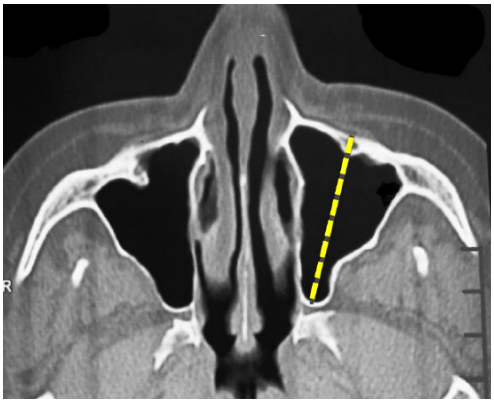


Figure 22: Horizontal distance between the infraorbital foramen and posterior wall of the antrum (yellow line) is estimated prior to the horizontal infraorbital osteotomy to select the appropriate saw blade to avoid lacerating the maxillary artery in the pterygopalatine fossa and pterygomaxillary fissure

Check the axial CT images and measure the anterior-posterior dimensions of the maxillary sinus to determine the distance from the anterior surface of the maxilla to the posterior wall of the maxillary sinus (*Figure 22*). Deepen the maxillary and zygomatic osteotomies to the hilt of the more controllable 1 cm oscillating saw blade, keeping the blade perpendicular to the bone; then the blade is changed for a longer 4 cm blade.

The posterior wall of the maxillary sinus does not need to be cut with a saw as it is thin and fractures easily when the maxilla is mobilized. In fact, sawing through the posterior wall of the antrum should be avoided as it will lacerate the internal maxillary artery and cause significant bleeding before the osteotomies can be completed and the maxilla swung to gain access to the bleeding artery.

When making the infraorbital osteotomy it is important to keep the blade horizontal. It is especially important to be aware (from the preoperative imaging) of the level of the orbital floor and whether it dips below the infraorbital foramen to avoid injuring the contents of the orbit when doing the osteotomy. Medially cut through the lateral nasal wall and laterally, the lateral wall of the antrum.



Figure 23: Position of vertical maxillary osteotomy is just to the ipsilateral side of midline to avoid nasal septum

When making the midline paramedian or parasagittal vertical maxillary osteotomy under direct vision (*Figure 23*), an assistant ensures that the mucoperiosteal flaps of the hard palate and the nasal floor are retracted away from the blade so as not to damage or lacerate them (*Figure 12*). The palatal osteotomy is extended posteriorly up to the posterior edge of the hard palate (*Figure 23*).



Figure 24: Thin sharp osteotome is placed into osteotomy and gently twisted to complete fracture of posterior wall of antrum

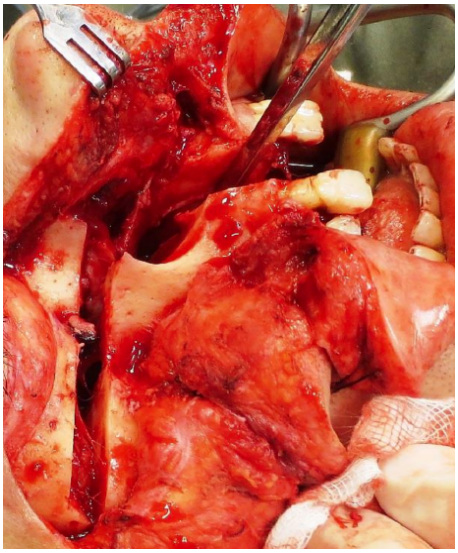


Figure 25: Twisting the osteotome finalizes the bone work; only soft tissue remains to be divided before the maxilla is swung laterally

Next insert a sharp, straight osteotome into the anterior vertical osteotomy and gently twist it to fracture the remaining bony connections, usually the thin posterior wall of the maxillary antrum (*Figures 24, 25*).

If the maxilla remains stable, twisting and tapping of a sharp straight osteotome can be done at multiple sites taking care not to damage the screw holes.

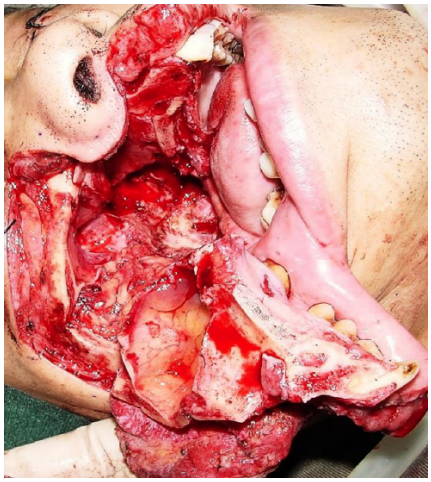


Figure 26: The maxilla has been fully swung laterally exposing the nasopharynx; the maxilla remains based on the soft tissues of the cheek

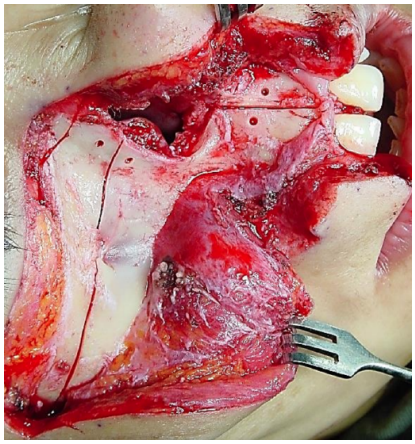


Figure 27: Reduced maxilla at end of procedure before fixing miniplates

Once the maxilla is loose it is gently retracted / swung laterally / out-fractured. Any soft tissue that tethers the maxilla is divided with a pair of curved Mayo scissors (*Figure 27*). The maxilla is wrap-ped in a long length of saline-soaked swab which is used to retract and keep the maxilla out of the surgical field with a *Rochester Pean forceps* or equivalent.

If significant bleeding occurs, it is usually due to laceration of the internal maxillary artery which must quickly be controlled. Using suction and a long curved hemostat the artery is clamped, divided and tied with a silk ligature.

The inferior turbinate is excised, and the posterior nasal septum can be resected for better exposure of the nasopharynx.

Closure

Following resection of the nasopharyngeal tumor one can proceed to closure.

Bleeding might occur from the pterygoid venous plexus and is initially controlled with packing. Meticulous hemostasis is achieved with combinations of bipolar cautery, suture ligatures, clips, bone wax, oxidized cellulose polymer and topical hemostatics.

A fine-bore ***nasogastric feeding tube*** is inserted through the contralateral nasal cavity for postoperative enteral feeding.

Depending on the type of surgery, the ***nasopharyngeal wound*** may be left to mucosalize, or is dressed with a mucosal graft taken from the inferior turbinate, or with a vascularized septal mucosal flap based on the posterior nasal artery.

The ***nasopharynx is packed*** with a dressing via the ipsilateral nasal cavity, e.g. a single length of paraffin gauze, to hold grafts in place and to promote mucosalization.

A ***Foley catheter*** is inserted into the nasopharynx via the contralateral nasal cavity and the balloon is inflated with just enough sterile water to prevent the nasal packing from slipping into the oropharynx.

An ***inferior meatal antrostomy*** is fashioned in the swung maxilla by carefully elevating the mucosa from the medial wall of the antrum and using a bone nibbler to remove bone. Mucosa is laid over the raw bone. In this way the crest between the nasal cavity floor and antral floor is removed which allows for free drainage of antral mucus.

The ***soft and hard palate mucosal incisions*** are preloaded with 3.0 synthetic absorbable polyglycolic acid sutures. This permits accurate suture placement while maximum access is still available. Posteriorly it is best to insert the suture through the mucosa of the soft palate and then through the posterior mucosa of the swung maxilla. Medially it is best to insert sutures through the mucoperiosteum of the swung maxilla and then through the mucoperiosteum of the contralateral hard palate flap. The sutures are kept in order by clamping each with a hemostat and sliding its eye ring or finger grip onto a closed bigger forceps.

The ***maxilla is reduced*** and held firmly in position (*Figure 27*). Ensure that neither the mucosal flap of the nasal floor, nor packing material, is trapped between bony bones.

The two 4-hole ***miniplates are securely screwed*** into place while maintaining bony reduction; each screw is tightened but not to the point of stripping either the bone or the threads of the screws (*Figures 18, 19*).

The ***sutures of the palatal mucosa*** are tied, starting posteriorly. This should be done with care as it is not possible to reinsert a suture should it tear out or snap.

The ***facial and lip wounds*** are closed in two layers i.e. a deeper subcutaneous layer and a skin layer. For the subcutaneous layer and for the lip mucosa the author uses a 3.0 braided absorbable suture, and for the skin a 4.0 non-absorbable monofilament suture, except for the lower eyelid where a 5.0 suture is used.

It is important to ***securely anchor the superomedial corner of the cheek flap*** to avoid the tension on the cheek flap being transmitted to the lower eyelid wound; this is achieved by preloading four braided absorbable sutures deeply with sufficient tissue on both sides of the wound before tying the sutures and closing the rest of the wound of the cheek and eyelid.

A ***prefabricated palatal dental splint*** is securely placed to maintain apposition of the hard palate mucoperiosteal flap against the underlying bone during the healing phase.

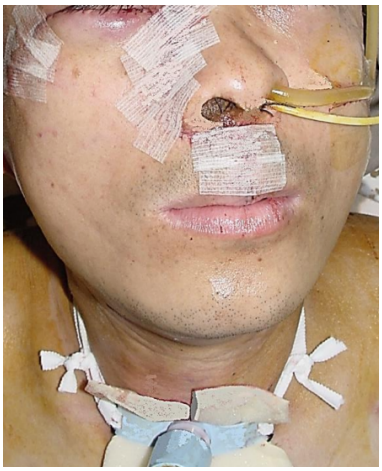


Figure 28: Conclusion of surgery

Figure 28 demonstrates a patient at conclusion of surgery. Note the tracheostomy tube; fine bore feeding tube in the contralateral nostril; and a Foley catheter with cuff inflated to prevent packing falling into the oropharynx.

Postoperative management

Day 0: Perioperative antibiotics are continued for 5 days; chest X-ray is done to confirm the position of the nasogastric tube prior to feeding; chest physiotherapy; tracheostomy care; mouth care; and routine postoperative blood tests

Day 1: Foley catheter in nasopharynx deflated after 24 hours

Day 5: Lower eyelid sutures removed

Day 6: Nasopharyngeal pack loosened and shortened

Day 7: Nasopharyngeal pack removed; start rinsing nasal cavities and nasopharynx three times/day with normal saline; rest of facial sutures removed

Day 8: Tracheostomy tube removed if there has not been significant bleeding

Day 14: Nasogastric tube is removed and oral liquid diet commenced

Day 21: Soft diet commenced if palatal wounds well healed

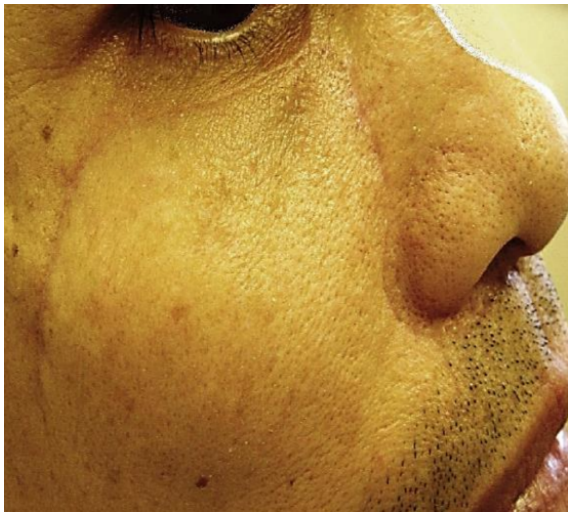


Figure 29: Healed facial scar of patient who underwent maxillary swing procedure

Author

Lex AC Vlantis
MBBCh, FCS(ORL)
Associate Professor Department of Otorhinolaryngology, Head and Neck Surgery
The Chinese University of Hong Kong Prince of Wales Hospital
Hong Kong SAR, China
lexvlantis@cuhk.edu.hk

Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Gerrit Viljoen



Figure 1: Cancer of lateral FOM



Figure 2: Cancer of anterior FOM

Cancers of the floor of the mouth (FOM) are generally treated with primary surgical resection (*Figures 1 & 2*). Adjuvant irradiation is indicated for advanced tumors, tumors with perineural invasion (PNI) or uncertain/close margins.

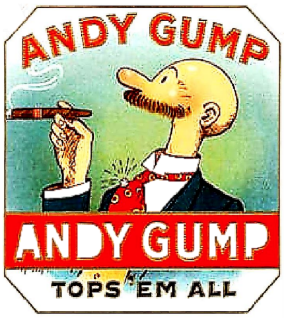


Figure 3: Andy Gump deformity

Resection of cancers of the FOM without taking cognisance of ***oral function*** may severely cripple the patient in terms of speech, mastication, oral transport and swallowing. Resecting the anterior arch of the mandible beyond the midline without reconstructing the bone with loss of the anterior attachments of the suprahyoid muscles (digastric, geniohyoid, mylohyoid, genioglossus) leads to an Andy Gump deformity with loss of oral competence, drooling, and a very poor cosmetic outcome (*Figure 3*).

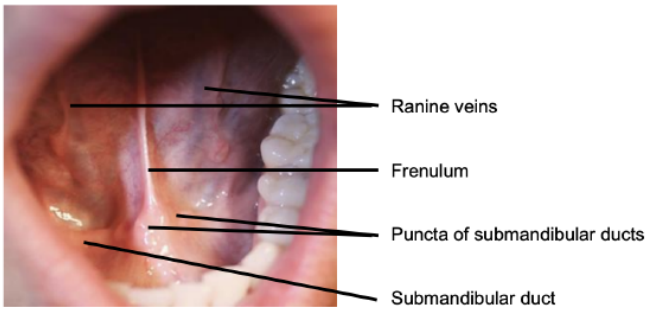


Figure 4: Anterior FOM

The FOM is a horseshoe-shaped area that is confined peripherally by the inner aspect (lingual surface) of the mandible. It extends posteriorly to where the anterior tonsillar pillar meets the tonsillolingual sulcus, and merges medially with under-surface of the oral tongue. It has a covering of delicate oral mucosa through which the thin walled sublingual/ranine veins are visible. The ***frenulum*** is a mucosal fold that extends along the midline between the ***openings of the submandibular ducts*** (*Figure 4*).

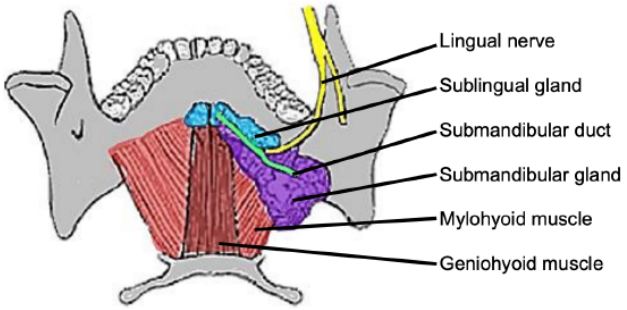


Figure 5: Superior view of FOM and submandibular gland and duct, lingual nerve and mylohyoid and geniohyoid muscles

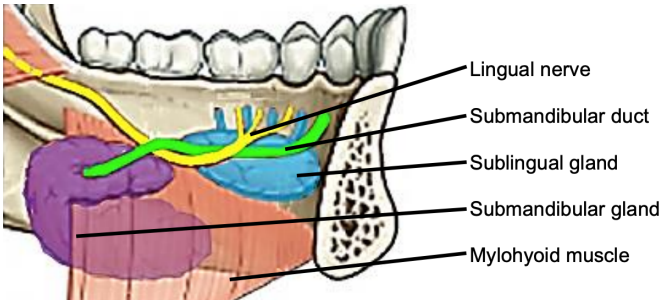


Figure 6: Intraoral view of left sublingual gland with ducts of Rivinus, submandibular gland and duct, lingual nerve and mylohyoid muscles

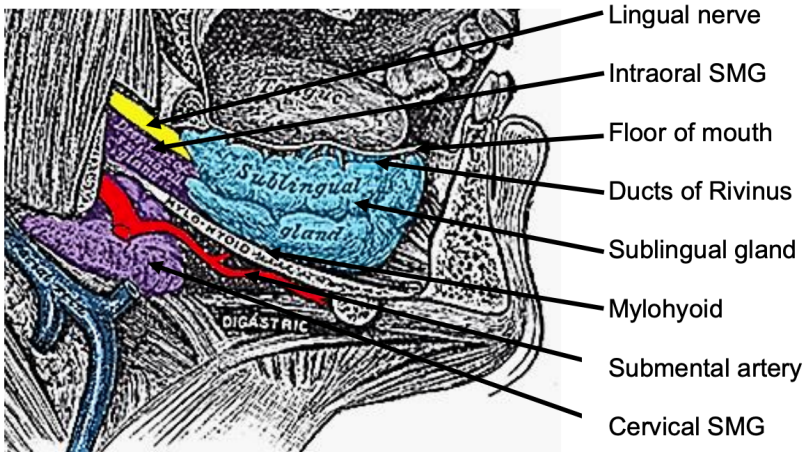


Figure 7: Sagittal view floor of mouth

The ***mylohoid muscle*** forms the diaphragm of the mouth and separates the FOM from the submental and submandibular triangles of the neck (*Figures 5, 6, 7*).

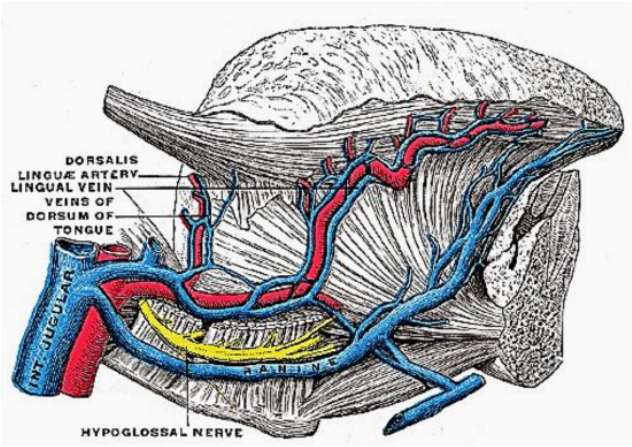


Figure 8: XIIn accompanied by ranine veins

The following structures are located between the mucosa and the mylohyoid muscle: paired ***geniohyoid muscles*** in the midline (*Figure 5*); ***sublingual salivary glands*** (*Figures 5-7*), ***submandibular ducts*** (*Figures 5, 6*), oral component of submandibular salivary glands (*Figures 5-7*), ***genioglossus*** muscle (*Figure 8*), and the ***lingual*** (*Figures 5-7*) and ***hypoglossal nerves*** (*Figure 8*).

The paired ***sublingual salivary glands*** are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles (*Figures 5, 6, 7*). The glands drain via 8-20 excretory ducts of Rivinus into the submandibular duct and also directly into the mouth on an elevated crest of mucous membrane called the plica fimbriata which is formed by the gland and is located to either side of the frenulum of the tongue (*Figures 6, 7*).

The ***submandibular duct*** is located immediately deep to the mucosa of the anterior and lateral FOM and opens into the oral cavity to either side of the frenulum (*Figures 4, 5, 6*).

The ***lingual nerve*** provides sensation to the floor of the mouth. It crosses deep to the submandibular duct in the lateral floor of mouth (*Figures 5, 6, 7*). In the anterior FOM it is located posterior to the duct (*Figure 5*).

Ranine veins are visible on the ventral surface of the tongue, and accompany the hypoglossal nerve (*Figures 4, 8*).

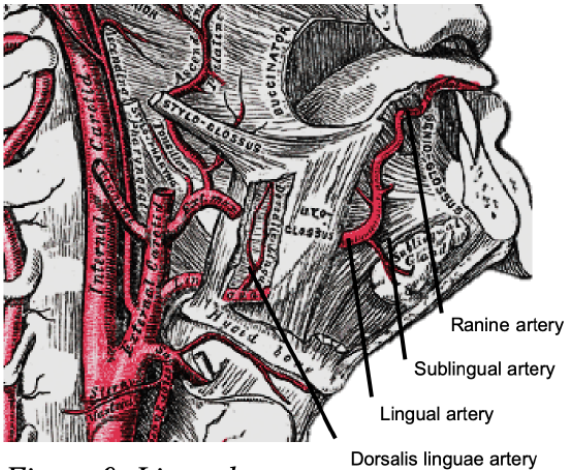


Figure 9: Lingual artery

Arterial supply to the tongue and FOM is derived from the ***lingual artery*** and its branches (***ranine artery, dorsalis linguae, and sublingual arteries***) (*Figures 8, 9*); and the ***mylohyoid*** and ***submental branches*** of the ***facial artery***.

The ***lingual artery*** arises from the external carotid artery between the superior thyroid and facial arteries and courses obliquely forwards and medial to the greater cornu of the hyoid (*Figures 8, 9*).

It then loops downward and anteriorly and crosses medial to XIIn and the stylohyoid muscle. It then courses directly anteriorly below hyoglossus and finally ascends as the ***ranine artery*** (profunda linguae) submucosally on the undersurface of the tongue as

far as its tip; it lies to either side of the genioglossus and is accompanied by the lingual nerve. Two or three small ***dorsales linguae*** arteries arise beneath the hyoglossus and ascend to the posterior part of the dorsum of the tongue and supply the mucous membrane of the posterior FOM, and oropharynx. The ***sublingual artery*** arises from the lingual artery at the anterior edge of the hyoglossus and runs forward between the genioglossus and mylohyoid and supplies the sublingual salivary gland and mucous membrane of the FOM and gingiva (*Figures 8, 9*). A branch of the ***sublingual artery*** pierces the mylohyoid muscle and anastomoses with the ***submental branch*** of the facial artery.

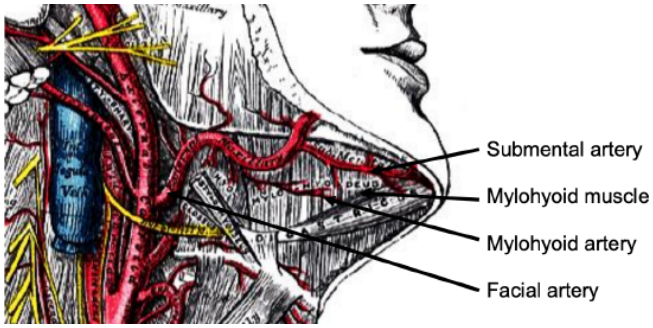


Figure 10: Facial artery emerges from behind posterior belly of digastric (removed), and gives rise to a few branches including submental artery

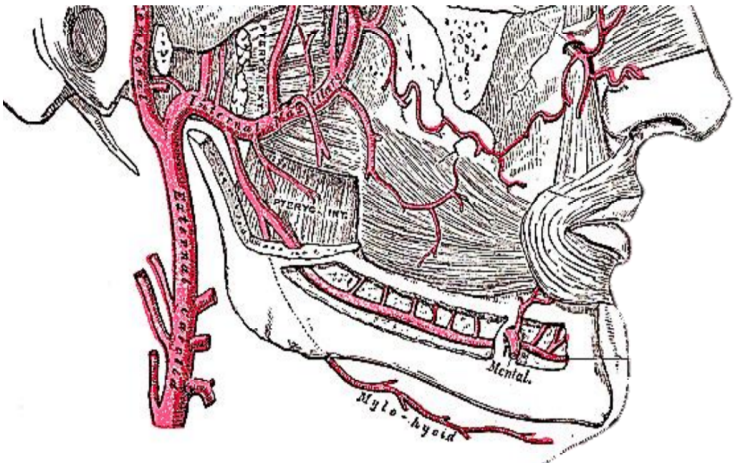


Figure 11: Mylohyoid artery is a branch of the inferior alveolar artery

The ***submental branch*** of the facial artery courses along the inferior, inner margin of the mandible (*Figure 10*). The ***mylohyoid artery*** and vein are encountered when the surgeon elevates the submandibular gland from the lateral surface of the mylohyoid (*Figures 10 & 11*). It branches from the inferior alveolar artery just before it enters the mandibular foramen, crosses the mylohyoid, and disappears anteriorly behind the digastric. It has connections with the submental artery, and via a defect in the mylohyoid with the sublingual artery in the floor of the mouth.

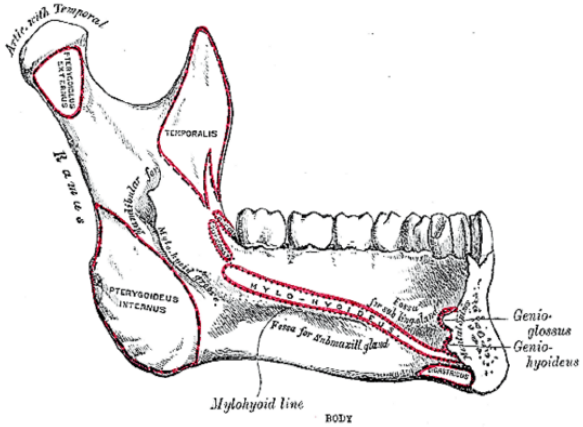


Figure 12a: Attachments of mylohyoid, geniohyoid, genioglossus and digastric muscles to inner aspect of mandible

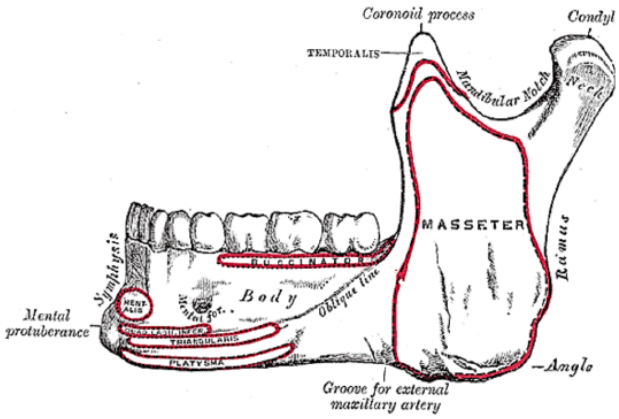


Figure 12b: Attachments of muscles to outer aspect of mandible and location of mental foramen

The ***mandible*** forms the peripheral border of the FOM and may be involved by FOM tumors or may have to be divided (mandibulotomy) or resected (alveolectomy/marginal mandibulectomy/segmental mandibulectomy/hemimandibulectomy). Important surgical features are the position of the mental foramina through which the mental nerves exit to innervate the lower lip, the mylohyoid line to which the mylohyoid muscle attaches, and when planning a marginal mandibulectomy, the height of the body of the mandible and the depth of the dental roots (*Figures 12a, b*).

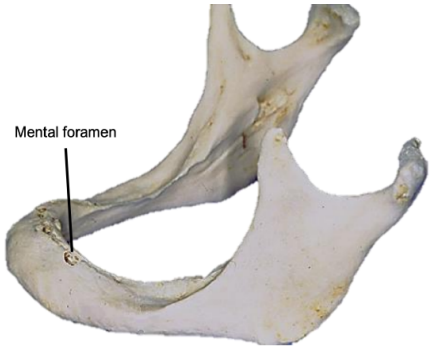


Figure 13: Position of mental foramen in a resorbed mandible

The mental foramen and inferior alveolar nerve may be very close to the superior surface of a resorbed mandible such as is seen in older, edentulous patients (*Figure 13*). A marginal mandibulectomy may also not be possible in such a resorbed mandible due to the lack of residual bone.

Surgical Objectives

- Clear resection margins
- Avoid postoperative orocervical fistulae
- Optimize cosmesis and function
  - Maintain length and mobility of the tongue
  - Avoid pooling of secretions and food in the reconstructed FOM
  - Avoid obstruction of the submandibular ducts
  - Avoid injury to lingual and hypoglossal nerves
  - Maintain mandibular continuity and strength
  - Restore dentition

The author advocates elective neck dissecttion (END) levels I-IV for squamous cell carcinomas that are >4 mm thick and/or >T2 stage. A useful rule of thumb is that a palpable tumor is likely to have a tumor thickness that warrants END. Tumors of the anterior FOM that approach the midline require bilateral END.

The remainder of this chapter will focus on the surgical treatment of the primary tumor.

Preoperative evaluation

1. ***Are there synchronous primaries, or cervical or distant metastases?***
2. ***Is the tumor resectable?*** Other than tumors that extend posteriorly to involve the carotid sheath, very few FOM tumors are irresectable. The key consideration is surgical morbidity; this in turn is dependent on the range and reliability of reconstructive surgery that are available e.g. resection of the mandible beyond the midline can only be done if it is possible to reconstruct the bone with a free fibula flap to avoid an Andy Gump deformity (*Figure 3*).
3. ***Is there clinical evidence of perineural invasion (PNI)?*** Examine the patient for neurological deficits of the hypoglossal, mental, inferior alveolar and lingual nerves. Widening of the alveolar canal on mandibular orthopantomography (Panorex) may be seen. MRI can demonstrate PNI. Should there be evidence of PNI then the affected nerve should be dissected proximally until a clear tumor margin is obtained on frozen section. In the case of the inferior alveolar nerve, this would require a hemi- or segmental mandibulectomy that encompasses the entire inferior alveolar canal.
4. ***Status of dentition?*** Carious teeth may cause osteoradionecrosis. Carious teeth seen on Panorex may be removed at the time of the surgery
5. ***Mandible***: FOM cancers involving mandible require adequate oncological margins, may require osseous flap reconstruction, and have high local recurrence rates. Tumor may involve periosteum, invade only the inner cortex, or involve medullary bone. Tumors involving only the lingual alveolar mucosa adjacent to mandible but not invading bone, or eroding cortex only, require only a marginal mandibulectomy, whereas frank invasion of mandible, and involvement of the medulla require segmental resection.

Risk factors for tumor invasion of the mandible include size, site, and depth of invasion of the soft tissues; larger and deeper tumors are more likely to extend to, and eventually invade the mandible. The pattern of spread within bone is related to tumor extent, rather than anatomic factors providing potential routes and barriers to tumor spread[1]. Tumors enter the mandible at points of abutment (often junction of attached and reflected mucosa in both dentate and edentulous mandibles) rather than preferentially through the occlusal surface, neural foramina, or periodontal membranes. The presence or absence of teeth does not influence patterns of invasion, and the increased height of alveolar bone in dentate jaws does not delay invasive patterns of bone involvement.

There are *two patterns of tumor invasion* of the mandible;[1] with an *invasive pattern*, fingers and islands of tumor advance independently into the cancellous spaces with little osteoclastic activity and no intervening connective tissue; with an *erosive pattern*, tumor advances over a broad front with a connective tissue layer and active osteoclasts separating tumor from bone. An erosive pattern can progress to an invasive pattern, depending on the extent and depth of invasion. An invasive pattern is associated with a significantly higher local recurrence rate and lower 5-year disease specific survival[2].

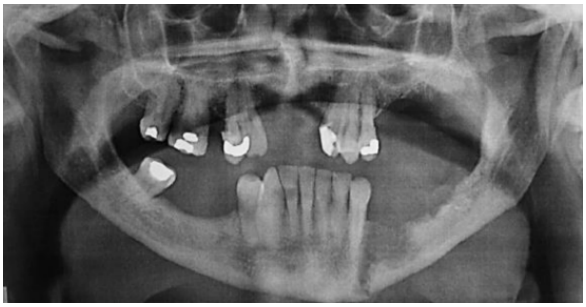


Figure 14: Panorex view of erosion and pathological fracture

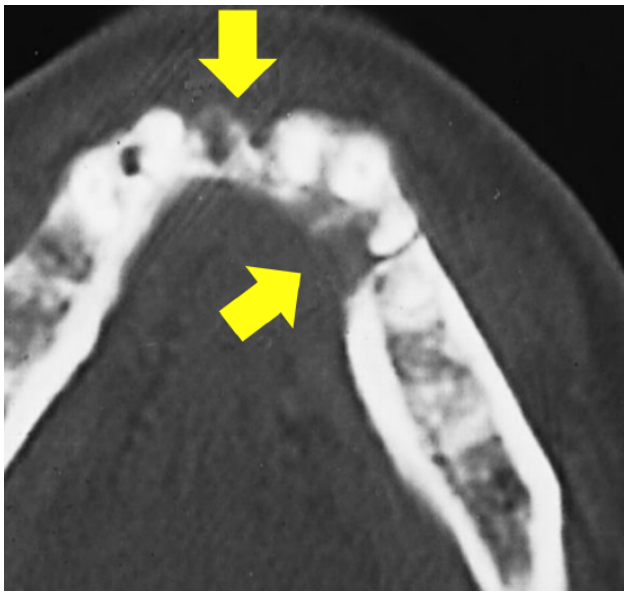
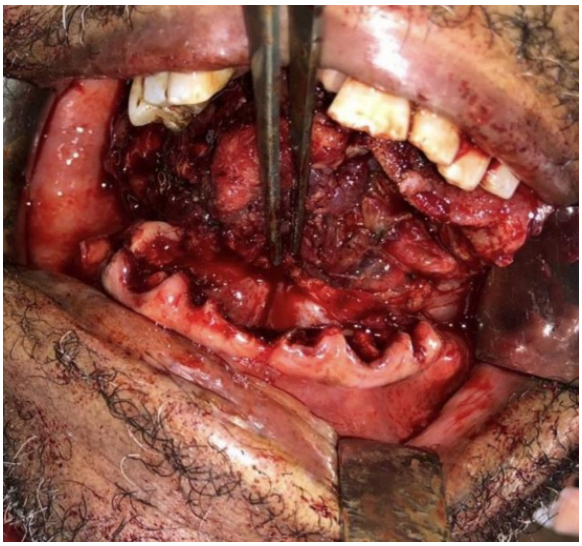


Figure 15: Cortical erosion visible on CT

Panoramic radiography (Panorex) is inexpensive and provides an excellent view of the body, ramus, and inferior alveolar canal (*Figure 14*). It has 80-92% sensitivity and 72-88% specificity for invasion of mandible.[3,4] The overlying spine can obscure the symphyseal region, and it may be difficult to differentiate between periodontal disease and tumor erosion. *CT scans* (*Figure 15*) tend to underestimate the presence and extent of invasion. MRI and single photon emission CT (SPECT) are much more sensitive, but they tend to overestimate the extent of bone involvement.[5]



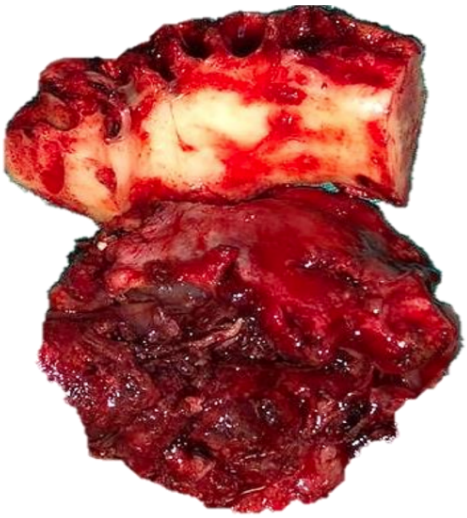


Figure 16a, b: Periosteal stripping reveals normal bone and suitability for marginal mandibulectomy

In the absence of CT scanning, a surgeon may elect to do *periosteal stripping* of tumor off the bone at the time of resection to inspect the bone for evidence of tumor infiltration and to decide how to proceed. Periosteal stripping is easily done using a periosteal elevator and is the most accurate method to determine bone erosion.[6] It has a sensitivity of 96% and specificity of 65%.[3] (*Figures 16a,b*).

Indications for bone resection include preoperative clinical or radiographic findings suggesting mandibular involvement; or if tumor is adherent to mandible and radiographic invasion is absent, intraoperative periosteal stripping can be done to for evidence of bone invasion as the extent of the invasion will dictate whether a marginal or segmental resection is indicated.

Marginal mandibulectomy is indicated in cancers encroaching on, adherent to, or superficially invading mandibular cortex; gingival carcinoma with superficial bone invasion at the level of the dental alveolus; and for cortical invasion, but only if >1 cm height of the lower contour of remaining mandible is retained. Therefore, it is important to determine the vertical height of the mandible clinically or by Panorex to predict whether a free bony composite flap would be required to bolster the remaining mandible.

Segmental mandibulectomy is indicated for medullary invasion; previous radiation therapy; to maintain oncological safety margin of soft tissue in more deeply invading tumors; and if inadequate bone would remain if marginal mandibulectomy is done.

Resection margins of at least 1-2 cm of uninvolved bone as measured from the macroscopic tumor or suspected bone involvement is required. This may require removal of 1 tooth on either side of the tumor in dentate patients. Some surgeons include the entire nerve-bearing segment when bone marrow invasion present.

6. **What type of reconstruction is required?**

7. **Is a tracheostomy required?** Patients with small tumors of the anterior FOM may not require temporary tracheostomy. However, whenever the laryngeal support of the mylohyoid, geniohyoid and genioglossus muscles is lost, and especially when a flap is used to reconstruct a FOM defect, the patient is at risk of airway obstruction and should have a temporary tracheostomy inserted.

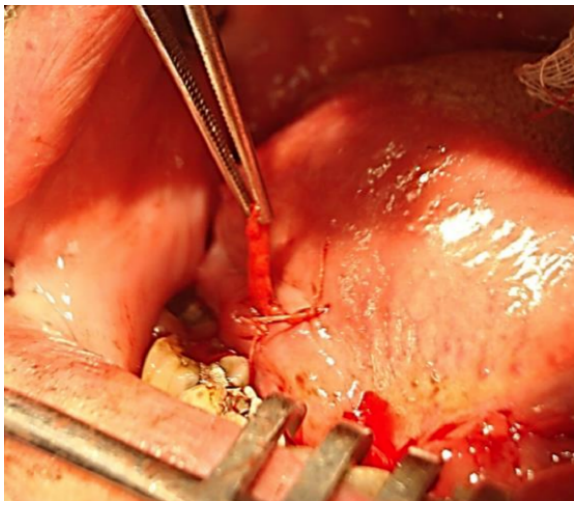


Figure 17: Submandibular duct translocated to right lateral floor of mouth and sutured to mucosa with a vicryl suture

8. **Submandibular salivary glands**: A tumor of the FOM may invade the submandibular duct and cause a hard, fibrotic submandibular salivary gland that can be confused with a lymph node metastasis. In a small T1 anterior FOM tumor that involves the duct in which an END is not planned the remaining duct may have to be translocated so as preserve salivary flow. This is simply done by tunneling over the duct with a hemostat just below the mucosa of the lateral FOM. The end of the transected duct is then grasped with the hemostat and passed posteriorly along the tunnel and delivered through a stab incision. It is secured to the mucosa with an absorbable suture (*Figure 17*).

Anesthesia

Nasal intubation is followed by tracheostomy. Perioperative antibiotics are administered for 24 hours.

Surgical access

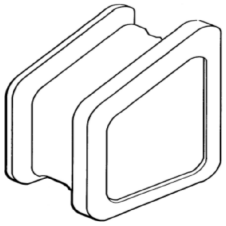


Figure 18: Dental bite block is interposed between lateral teeth to keep mouth open

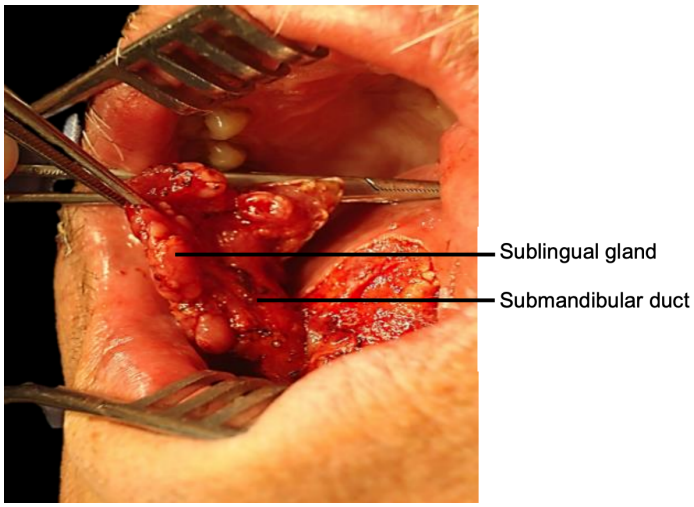


Figure 19: Self-retaining retractor in place; sublingual salivary gland and submandibular duct

Transoral: Smaller tumors (T1-T2) are usually easily excised though the open mouth in an edentulous patient. The mouth is kept widely open either with a dental bite bock (*Figure 18*) or with a selfretaining retractor taking care to protect the teeth (*Figure 19*).

However, resecting an anterior FOM tumor may be quite challenging in a patient with a full set of lower teeth as the teeth may obstruct access to the anterior FOM.



Figure 20: This marginal mandibulectomy defect was covered by advancing gingivolabial mucosa over the bone and suturing it to the edge of the FOM defect

In such cases lower teeth may need to be extracted and a marginal mandibulectomy (*Figure 20*) or a mandibulotomy may be required for access. When a FOM tumor abuts the anterior mandible then doing a marginal mandibulectomy in continuity with the tumor re-section greatly facilitates resection by freeing up the tumor.

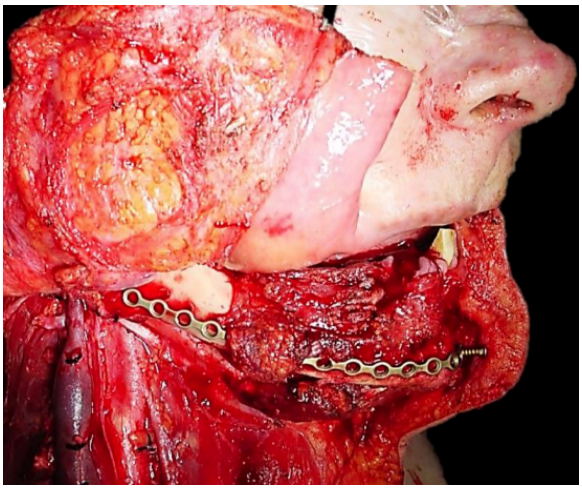


Figure 21: Midline lip-split incision and preplating of mandible before performing segmental mandibulectomy and resecting tumor

Midline lip-split: The lip is split in the midline after scoring/marking the vermillion border to ensure an accurate repair. The soft tissues are stripped off the front of the mandible (*Figure 21*).

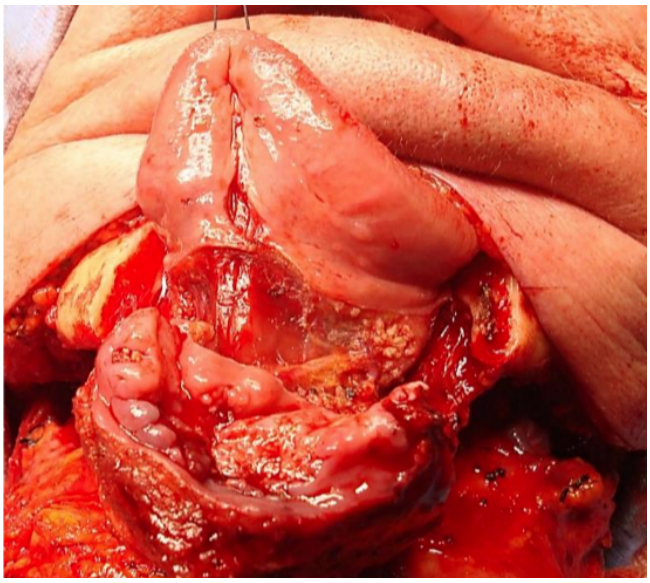


Figure 22: Visor approach with anterior segmental mandibulectomy for cancer of anterior FOM and gingiva

Visor flap: This is achieved by cutting along the gingivolabial and gingivobuccal sulci about 1 cm from the bone to permit placement of sutures when closing the wound, and then stripping the soft tissues from the outer aspect of the mandible. Take care not to transect the mental nerves if they can be saved. The skin flap is then retracted superiorly to expose the mandible (*Figure 22*).

Pull-through: This may be employed when the tumor stops some distance from the inner aspect of the mandible. Following bilateral neck dissections of Levels 1a and 1b, the mandibular attachments of the anterior bellies of digastric, mylohyoid, geniohyoids and genioglossus are divided with electrocautery working from inferiorly (*Figure 12a*). The mucosa of the anterior FOM is then divided 1 cm from the inner aspect of the mandible (to facilitate later repair). This permits the surgeon to deliver the anterior FOM and anterior tongue into the neck and then to proceed with the resection.

Tumor Resection

First complete Levels 1a and b of the neck dissection(s) before proceeding to the resection. This permits the surgeon to cut through the muscles in the FOM and tongue knowing the location of the XIIn, lingual nerve and lingual artery.

Mandibulectomy: If a ***marginal*** or ***segmental mandibulectomy*** is planned then it should be done before resecting the FOM tumor as it improves surgical exposure. If a segmental mandibulectomy is to be done, then ***preplate*** the mandible with a reconstruction plate to ensure alignment of the teeth and a good bony contour (*Figure 20*). Marginal mandibulectomy is done with ***small sharp osteotomes*** to avoid inadvertent fracture of the mandible, or with a powered oscillating or reciprocating saw. With marginal mandibulectomy the cut is made obliquely to preserve the height of the outer cortex for mandibular strength, but to remove the inner cortex that abuts the tumor. With ***segmental mandibulectomy*** the bone is cut at least 2 cm from visible tumor (*Figure 22*).

Tumor: Once the mandibulectomy has been completed, keep the bone attached to the tumor specimen and divide the gingival mucosa on the inside of bone cuts; this will release the tumor from bone and facilitate delivery of the tumor into the surgical field. Identify and preserve the submandibular duct(s), and the lingual and hypoglossal nerve(s) if possible. The sublingual gland may be encountered in anterior FOM cancer resections (*Figure 19*).

Use diathermy to resect the tumor with at least 1 cm margins. Cauterise the ranine vessels during the resection. Larger branches of the lingual artery are ligated as they are encountered. Obtain frozen section confirmation of clear tumor margins if available.

Repair

Following resection, the surgeon carefully assesses the defect to determine how best to ***restore form and function*** i.e. mandibular integrity and contour, and oral competence, mastication, oral transport, swallowing and speech.

Reconstruction pointers

- Mobility of the tongue is key to oral function
- It is imperative that reconstructive surgeons follow patients long-term to learn how best to optimize functional flap design
- Tongue length is more important than width

- Never suture the edge of the tongue to the gingiva; in such cases always maintain tongue mobility with a flap
- Avoid tethering the tip of the tongue
- Some defects are best left open to heal by secondary intention to retain mobility
- Simply shaping a flap to match the resected tissue may well restore form but may have poor functional results
- Too broad a flap in the FOM will cause pooling of saliva and adversely affect oral transport
- A marginal mandibulectomy may be done as part of the reconstructive procedure to enable the surgeon to suture the gingivobuccal or gingivolabial mucosa to the FOM mucosa or flap (*Figure 20*)
- Reduce the risk of orocervical fistula by approximating the mylohyoid to the digastric muscle in the neck, and ensuring that the suction drain is not placed in the upper neck

No repair: Small and/or superficial resections above the mylohyoid that do not communicate with the neck dissection may be left open to heal like a tonsillectomy wound. Resist the temptation to suture such defects as it may alter the shape of the tongue or fix the tongue to the anterior FOM.

Primary closure: Avoid tethering or distorting the tongue. Note the comment about marginal mandibulectomy above (*Figure 20*).



Figure 23: Healed split skin graft over marginal mandibulectomy defect[7]

Split skin graft: This may be used to cover a defect that could otherwise be left open but for concern about a through-and-through communication to the neck, or over a marginal mandibulectomy defect (*Figure 23*). The skin is sutured to the margins of the defect with absorbable sutures, the ends of which are left a few centimeters long. A bolster of antisepticimpregnated gauze is placed over the skin graft and tied down with the long sutures. The bolster is removed after about 5 days.

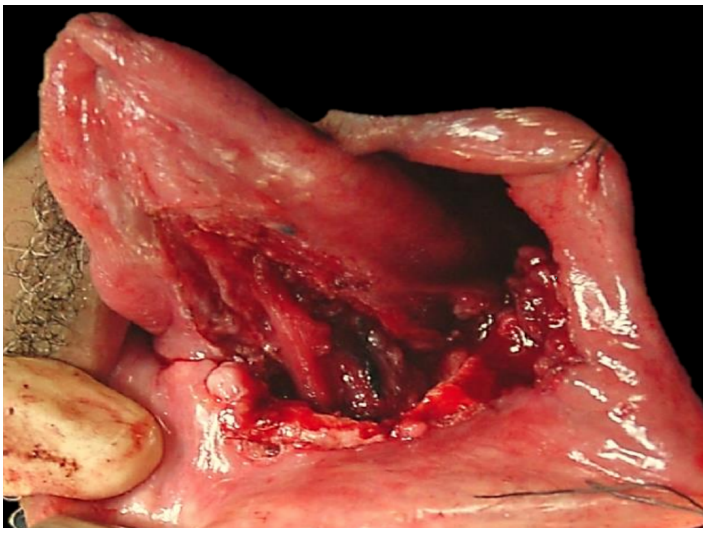


Figure 24a: FOM defect with marginal mandibulectomy

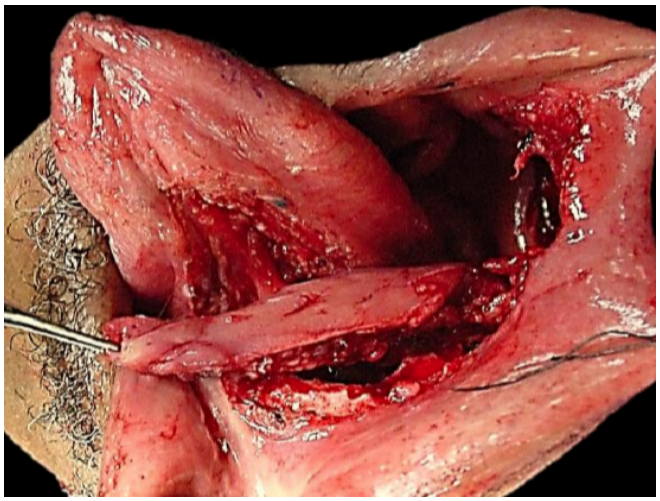


Figure 24b: Buccinator flap based on facial artery

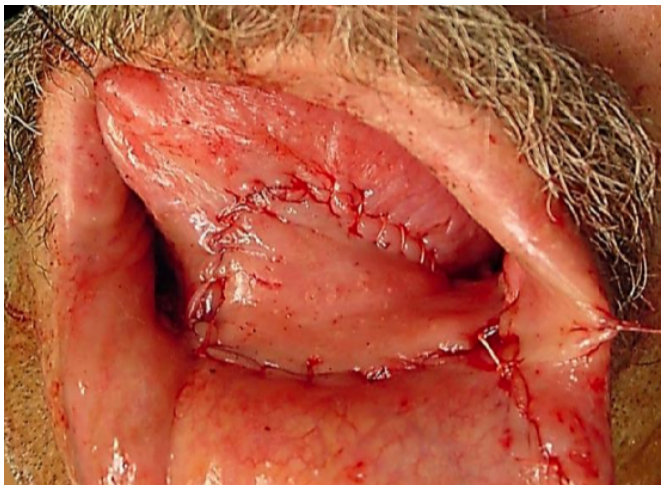


Figure 24c: Buccinator flap for FOM resection with marginal mandibulectomy

Buccinator myomucosal flap: (*Figures 24a-c*) This is an excellent flap for both anterior and lateral FOM defects as it has the same physical qualities as tissues of the FOM. The pedicle however crosses the mandible and is therefore best suited for edentulous patients, patients with missing teeth, or who have undergone marginal mandibulectomy. (See chapter: Buccinator myomucosal flap)



Figure 25: Nasolabial flap inset into lateral FOM



Figure 26: Nasolabial flap reconstruction of anterior FOM defect

Nasolabial flap: The nasolabial flap can be used both for lateral and anterior FOM defects (*Figures 25*, *26*) (See chapter: Nasolabial flap for oral cavity reconstruction)

Submental artery island flap: Though this is an option, concerns exist clearing levels 1a and 1b of the neck (See chapter: Submental artery island flap)

Supraclavicular flap: This has excellent properties for the floor of mouth, being thin and pliable like a radial free forearm flap (See chapter: Supraclavicular flap)

Pectoralis major flap: This flap is only used if other flaps listed are not available. (See chapter: Pectoralis major flap)

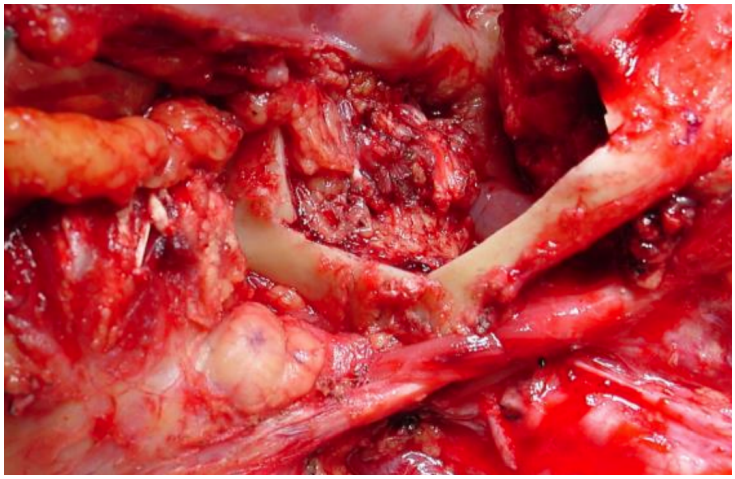


Figure 27a: Marginal mandibulectomy

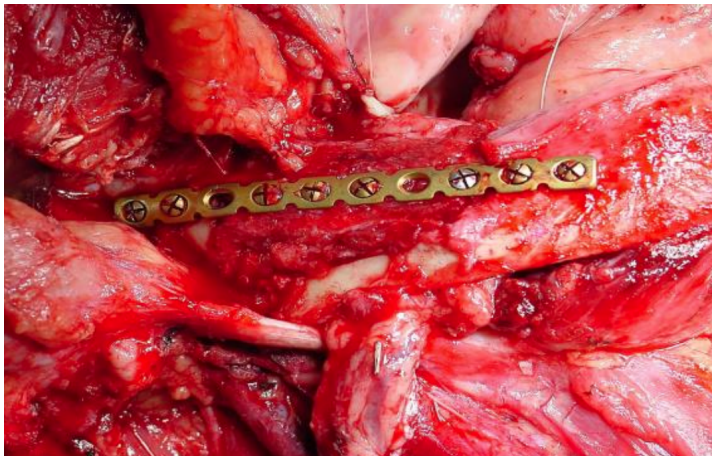


Figure 27b: Onlay radial osseocutaneous flap

Radial free forearm flap: This is a popular choice for FOM repair as the flap is thin and pliable. An osseocutaneous flap can be used as an onlay graft with marginal mandibulectomy defects (*Figures 27a*, *b*) (See chapter: Radial free forearm flap)



Figure 28: Anterolateral free thigh flap used for lateral FOM and tongue defect

Anterolateral free thigh flap: (*Figure 28*) Muscle harvested with the flap can be tailored according to the volume of the defect to be filled. However, it is less pliable than the radial free forearm flap and is only suitable for oral reconstruction in patients with thin thighs. (See chapter: Anterolateral free thigh flap)



Figure 29a: Resected FOM minor salivary gland tumor

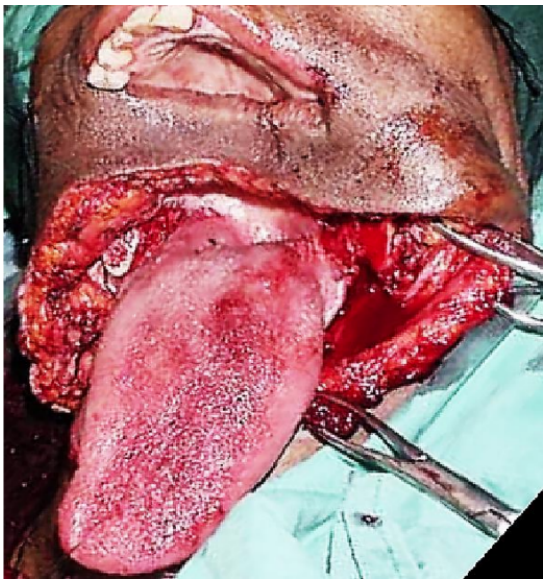


Figure 29b: Note absent mandibular body and FOM



Figure 29c: Mandible reconstructed with free fibula flap

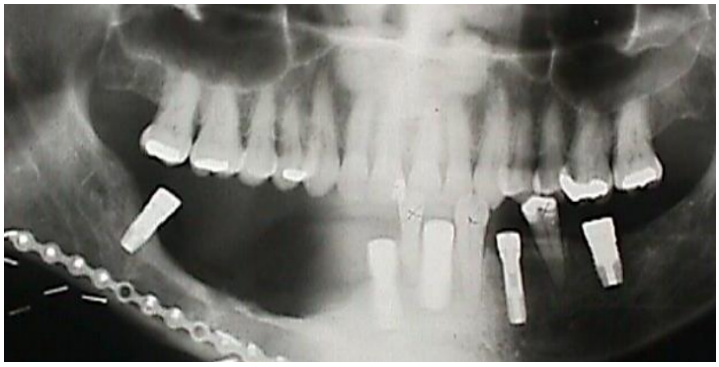


Figure 30a: Dental implants following free fibula flap for segmental mandibulectomy



Figure 30b: Denture being slipped into place over implants

Free fibula flap: This is the workhorse of mandible reconstruction following segmental mandibulectomy (*Figures 29 a-c*). but can also be used as an onlay flap. It is also suitable for dental implants (*Figures 30a, b*). (See chapter: Free fibula flap)

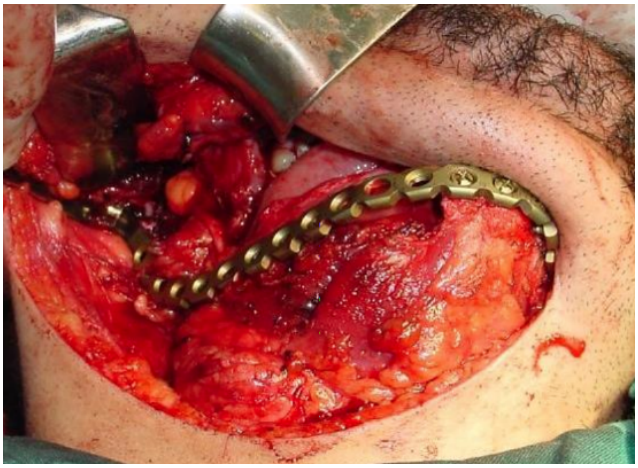


Figure 31: Titanium plate

Titanium reconstruction plate: Although it can be used to replace mandible, it is prone to extrusion both to the inside of the mouth and through skin (*Figure 31*).

Final comments

Resecting tumors of the FOM is challenging particularly in terms of optimizing oral function. The surgical team must master a wide array of reconstructive techniques to secure the best functional and cosmetic outcomes.

References

1. Brown JS, Lowe D, Kalavrezos N, D'Souza J, Magennis P, Woolgar J. Patterns of invasion and routes of tumor entry into the mandible by oral squamous cell carcinoma. Head Neck. 2002;24(4):370-83
2. Shaw RJ, Brown JS, Woolgar JA, Lowe D, Rogers SN, Vaughan ED. The influence of the pattern of mandibular invasion on recurrence and survival in oral squamous cell carcinoma. Head Neck J Sci Spec Head Neck. 2004; 26(10):861-9
3. Rao LP, Das SR, Mathews A, Naik BR, Chacko E, Pandey M. Mandibular invasion in oral squamous cell carcinoma: investigation by clinical examination and orthopantomogram. Int J Oral Maxillofac Surg. 2004;33(5):454-7
4. Acton CHC, Layt C, Gwynne R, Cooke R, Seaton D. Investigative modalities of mandibular invasion by squamous cell carcinoma. Laryngoscope. 2000;110(12):2050-5
5. Brown JS, Browne RM. Factors influencing the patterns of invasion of the mandible by oral squamous cell carcinoma. Int J Oral Maxillofac Surg. 1995;24(6):417-26
6. Genden EM, Rinaldo A, Jacobson A, et al. Management of mandibular invasion: When is a marginal mandibulectomy appropriate? Oral Oncol. 2005; 41(8):776-82
7. Deleyiannis F, Dunklebarger J, Lee E, Gastman B, Lai S, Ferris R, Myers EN, Johnson J. Reconstruction of the marginal mandibulectomy defect: an update. Am J Otolaryngol Head Neck Med Surg. 2007; 28 (6): 363-6

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Author

Gerrit Viljoen MBChB
Resident
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
dr.gerrit.viljoen@gmail.com

Author & Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Devendra Chaukar, Mitali Dandekar

Buccal mucosa cancers are common in the South Asian subcontinent due to the habit of chewing tobacco, betel quid and betel nut while they account for 5-10% of all oral cavity cancers in North America and Western Europe. Oral cavity cancer has a global incidence of 5.5 Age-standardized rate (ASR) and ranks 11th amongst men (GLOBOCAN 2012).

Surgery is the mainstay of treatment with adjuvant therapy reserved for high risk histological features. Surgical management of buccal mucosa is complex in view of its proximity to the infratemporal fossa and the mandible. A detailed understanding of the anatomy, relations and patterns of tumor spread is essential due to implications relating to oral function, cosmesis and local recurrence.

Surgical anatomy

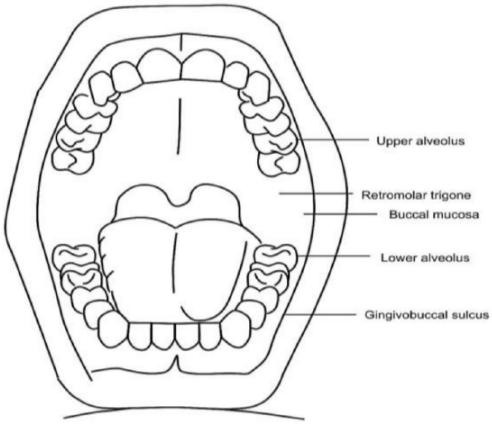


Figure 1: Gingivobuccal complex subsites

The ***gingivobuccal complex*** is a broad term and encompasses the following subsites listed in the International Coding of Diseases (ICD) 10 (*Figure 1*)

- ***Buccal mucosa (C06)***: Buccal mucosa of cheek and vestibule of mouth as well as retromolar area
- ***Gum (C03)***: Superior and inferior alveoli

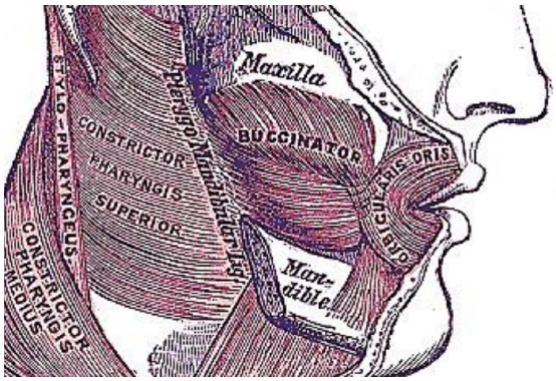


Figure 2: The buccinator attaches to the alveoli. The buccinator and superior constrictor muscles attach to the pterygo-mandibular raphe

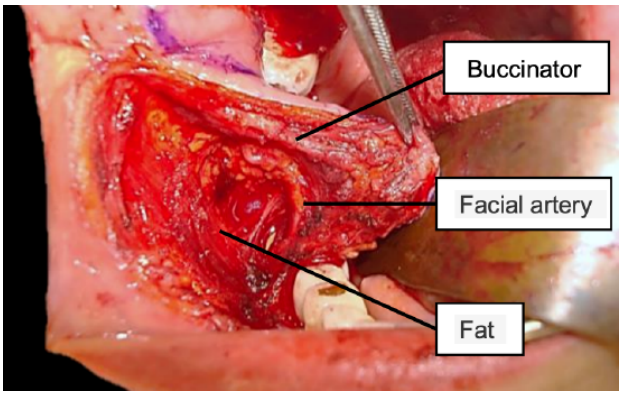


Figure 3: Buccal space exposed after elevation of buccinator flap; Note buccinator muscle, facial artery and fat which contains terminal branches of the facial nerve

The ***buccal mucosa*** lines the inner aspect of the cheek and the lip. It is limited superiorly and inferiorly by its attachments to the alveoli. It extends posteriorly to the retromolar trigone. Deep to the buccal mucosa is the ***buccinator muscle*** (*Figures 2, 3*). Immediately lateral to the buccinator muscle is the ***facial artery and the buccal artery and the vascular plexus*** that the buccinator myomucosal flap is based on. (See chapter: Buccinator myomucosal flap)

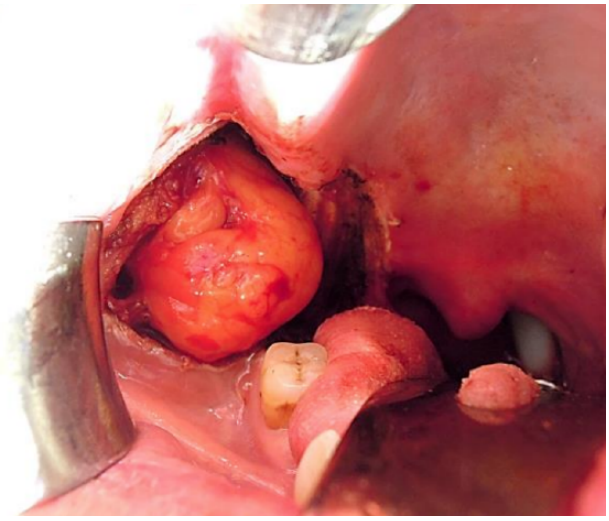


Figure 4: Buccal fat pad adjacent to a posterior buccal defect

Lateral to the buccinator muscle is the buccal space that contains fat which is traversed by the terminal branches of the facial nerve, and further posteriorly, the buccal fat pad, the zygomaticus major, the subcutaneous tissue and the skin (*Figures 3, 4*).

The ***gingival mucosa*** overlies the alveolus from the point of abutment of the gingivobuccal sulcus to the floor of the mouth. The alveolus is the tooth-bearing area of the mandible and maxilla. It has an outer cortex and has inner trabeculae (medullary bone). The cortical lining of the dental socket is the *lamina dura*.

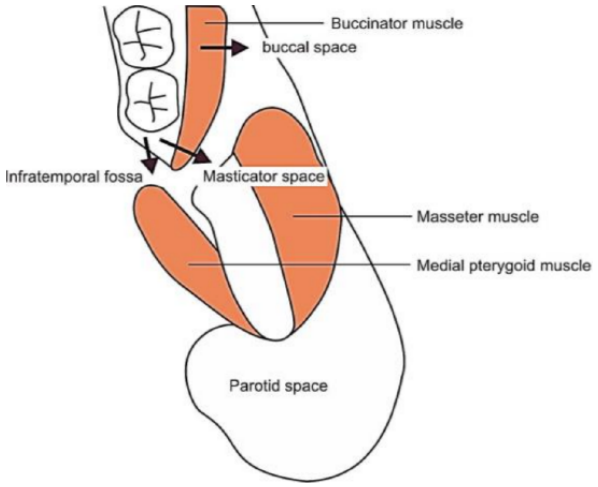


Figure 5: Routes of tumor spread from the retromolar trigone and buccal mucosa

The ***retromolar trigone*** is a triangular area of mucosa overlying the ascending ramus of mandible. It extends from behind the 3rd molar up to the maxillary tuberosity (*Figure 5*).

Posteriorly the buccal mucosa is closely related to the medial pterygoid and masseter muscles i.e. the masticator space and the infratemporal fossa. Tumors, particularly from the ***retromolar trigone***, spread to these spaces (*Figure 5*).

Posterior to the retromolar trigone is the pterygomandibular raphe; it extends between the pterygoid hamulus and the posterior end of the mylohyoid ridge of the mandible (*Figure 2*). The pterygomandibular space is enclosed by this raphe anteriorly and the medial pterygoid and ascending ramus of mandible on either side, and contains the lingual and alveolar nerves. Posteriorly it is related to the parapharyngeal space.

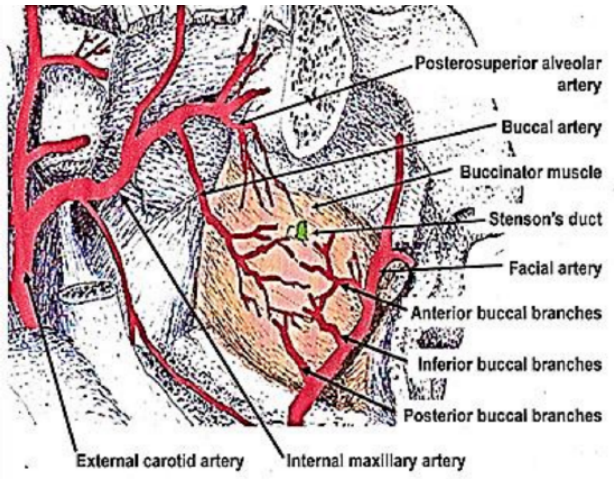


Figure 6: Buccal, inferior alveolar and posterior superior alveolar arteries

Stenson's duct opens in the buccal mucosa adjacent to the 2nd upper molar tooth after crossing the masseter muscle and passing through the buccinator muscle (*Figure 6*).

Arterial supply (*Figure 6*): The buccal mucosa is supplied by the facial and buccal arteries; the buccal artery originates from the pterygoid branch of the maxillary artery. The inferior alveolar artery is a branch of the mandibular branch of the maxillary artery and enters the mandibular canal to supply the inferior alveolus. The superior alveolus is supplied by the posterior superior alveolar artery, a branch of the pterygopalatine segment of the maxillary artery.

Venous drainage: The pterygoid plexus drains into the facial vein which eventually drains into the internal jugular vein.

Lymphatics: The buccal mucosa drains into the deep cervical nodes. Level IB (submandibular nodes) is the first echelon of lymphatic spread of tumor.

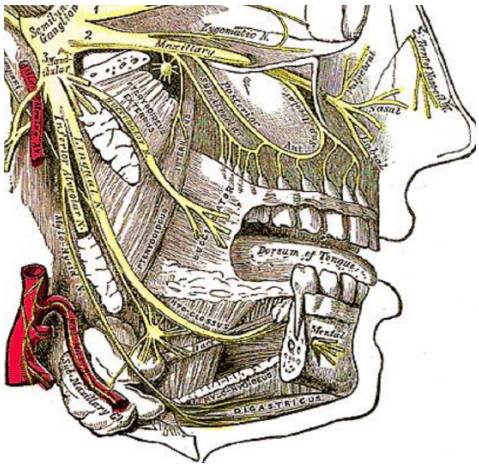


Figure 7: V3, lingual, inferior alveolar and mental nerves

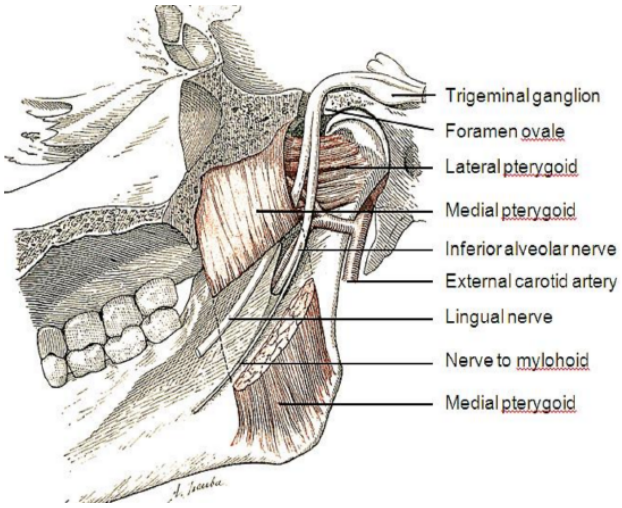


Figure 8: V3, lingual, and inferior alveolar nerves

Innervation: (*Figures 7, 8*) Sensory supply is via the maxillary and mandibular divisions of the trigeminal nerve. Motor supply to the muscles of mastication is by the mandibular nerve; the buccinator muscle is innervated by the buccal branch of the facial nerve.

Salient surgical anatomy

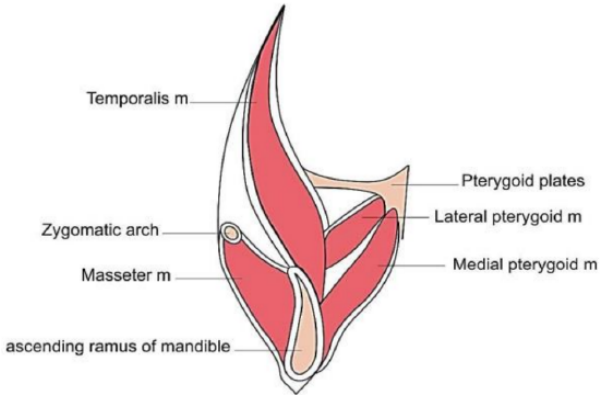


Figure 9: Masticator space

Masticator space (Figure 9)

Enclosed within superficial layer of deep cervical fascia covering muscles of mastication

Inferior boundary: Lower border of mandible

Superior boundary: Parietal calvarium

Medial boundary: Fascia medial to medial pterygoid muscle

Lateral boundary: Fascia overlying masseter and temporalis muscles

Contents: Muscles of mastication, internal maxillary artery, mandibular nerve

Clinical relevance: Involvement of masticator space is considered to be locally very advanced disease i.e. T4b stage (AJCC/TNM)

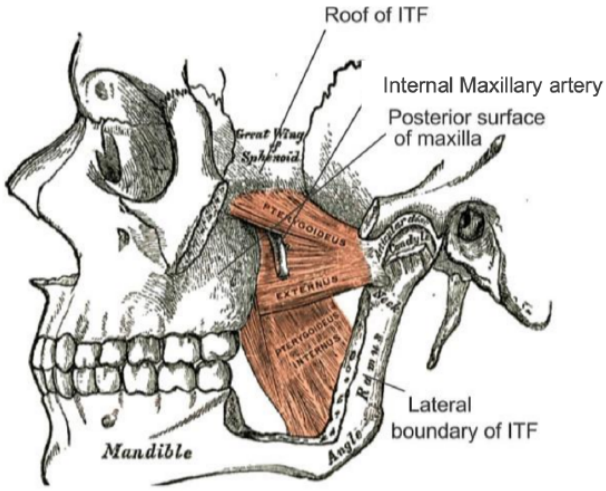


Figure 10A: Boundaries of infratemporal fossa



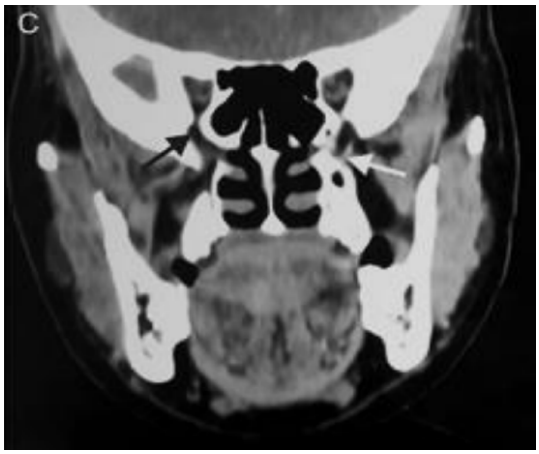


Figure 10B, C: Axial and coronal CT scans demonstrating communication of infratemporal fossa with pterygomaxillary fissure (white arrow) and inferior orbital fissure (black arrow)

Infratemporal fossa/ITF (Figure 10)

Medial boundary: Lateral pterygoid plate of sphenoid bone
Lateral boundary: Mandible
Superior boundary: Greater wing of sphenoid bone and squamous part of temporal bone
Inferior boundary: Medial pterygoid muscle
Anterior boundary: Posterolateral wall of maxilla
Posterior boundary: Tympanic part of temporal bone
Relations: Inferior orbital fissure, pterygomaxillary fissure
Contents: Lower part of temporalis muscle, part of masseter, medial and lateral pterygoid muscles, internal maxillary artery, pterygoid venous plexus, branches of mandibular nerve, facial nerve and otic ganglion
Clinical relevance: ITF involvement can be either “high” or “low”. Tumors involving the high ITF (involving lateral pterygoid and temporalis muscles) are considered irresectable because tumor can escape through the pterygomaxillary and inferior orbital fissures making the possibility of complete (R0) resection unlikely

Buccal Space (Figures 3, 4, 6)

Medial boundary: Buccinator muscle
Lateral boundary: Zygomaticus major muscle
Contents: Mainly buccal fat pad which communicates posteriorly with the retroantral fat pad, Stenson’s duct, minor or occasionally accessory salivary glands, facial and buccal arteries, facial vein, and branches of facial and mandibular nerves
Clinical relevance: Tumor infiltration into the buccal space can potentially lead to spread to the infratemporal fossa via the retroantral fat pad

Preoperative Evaluation

A combination of clinical assessment (under anesthesia if indicated) and imaging is required to evaluate buccal lesions and to assess resectability and to plan the extent of resection.

Irresectable cancers

- Extension into infratemporal fossa up to the lateral pterygoid and temporalis muscles (evaluated on imaging as lesion extending superior to sigmoid notch)
- Significant soft tissue involvement; this manifests clinically as oedema or induration reaching up to the zygoma
- Perineural invasion along V3 to foramen ovale or to trigeminal ganglion
- Significant oropharyngeal involvement with encasement of great vessels
- Irresectable nodal disease

Factors to be considered when planning a resection

- Incisions to approach the tumor
- Management of mandible and maxilla
- Paramandibular disease
- Deep soft tissue infiltration

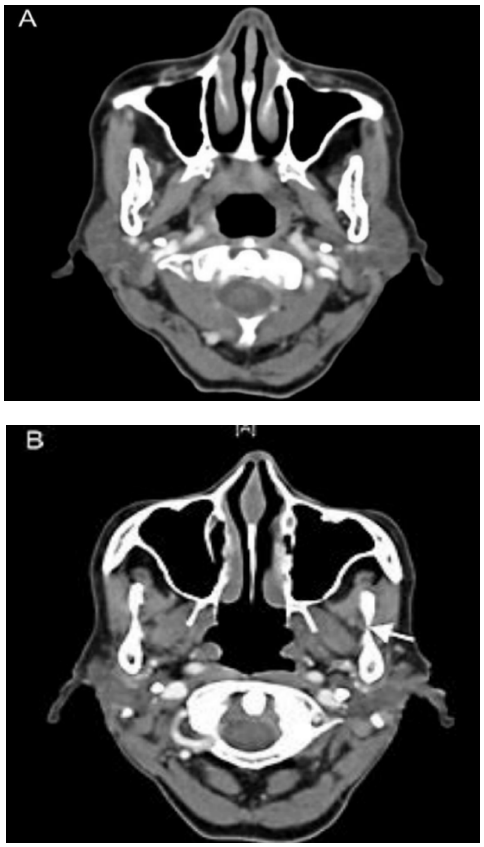
Indications to image buccal mucosal cancers (Not all patients require imaging)

- Tumor abutting mandible to determine presence of bone invasion
- Tumors involving retromolar trigone to assess involvement of infratemporal fossa
- Deep seated buccal mucosal lesion to assess involvement of the masticator space
- Severe trismus that precludes proper clinical assessment



Figure 11: Orthopantogram illustrating tumor eroding mandible

Orthopantomogram/Panorex (OPG) is used primarily to assess dentition for dental prophylaxis prior to radiotherapy. It does not yield soft tissue information; it requires a loss of up to 30% of bony cortex to detect mandibular invasion (poor sensitivity); and is not ideal for midline lesions due to superimposition of the spine (*Figure 11*).



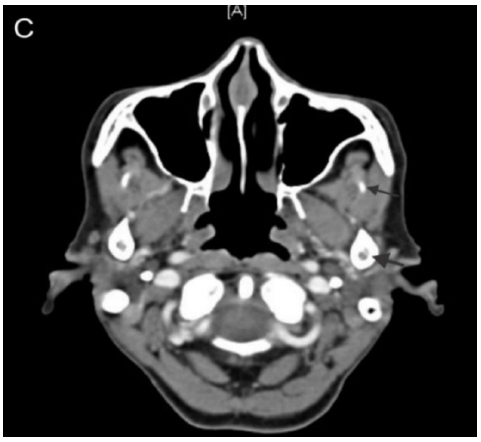


Figure 12A-C: Axial CT: (A) Lower part of infratemporal fossa containing medial pterygoid muscle attached to ascending ramus of mandible; (B) White arrow points to level of sigmoid notch; (C) Higher part of infratemporal fossa; thin black arrow points to coronoid process with bulk of temporalis muscle; thick black arrow points to condyle with attachment of lateral pterygoid muscle

Contrast Enhanced Computed Tomography (CECT) with a "puffed cheek technique" is the preferred imaging modality to assess the primary as well as the neck. A Multidetector CT scan with sagittal reformatting can detect mandibular involvement with an accuracy of up to 90%. Infratemporal fossa involvement is assessed the relationship of tumor to an arbitrary line drawn in an axial plane through the sigmoid notch (between coronoid and condyle) of the mandible (*Figure 12*). Lesions extending superior to the sigmoid notch are considered irresectable due to involvement of the higher part of the infratemporal fossa.

Magnetic Resonance Imaging (MRI) provides superior soft tissue delineation compared to CT. It is indicated for buccal lesions clinically removed from the bone, to assess involvement of the buccal space and infratemporal fossa. MRI may be required in cases of clinical extension into bone to determine involvement of marrow and inferior alveolar nerve. MRI however tends to overestimate bony involvement and is inferior to CT to assess cortical erosion.

Anesthesia considerations

Patients with buccal cancer may have trismus, either longstanding due to oral submucous fibrosis, or of recent onset due to spasm or invasion of the muscles of mastication (mylohyoid, masseter, medial pterygoid, temporalis, and lateral pterygoid). Securing the airway in such patients may require fibreoptic intubation or an awake preoperative tracheostomy. Nasal intubation is preferred to remove the airway from the surgical field. The surgeon may elect to pack the throat during tumor excision to avoid aspiration of blood.

Surgical principles

- Adequately expose all tumor margins before approaching the tumor
- A cheek flap may be required to avoid compromising margins, even for small tumors that are located posteriorly
- Mucosal, soft tissue and bone margins of >5 mm
- Neck dissection indications
  - Nodal metastases
  - Suspicious nodes on imaging
  - T3/T4 cancers
  - T1/T2 cancers with
    - Poor differentiation
    - Tumor thickness >4 mm (rule of thumb: tumor has palpable thickness)
    - Requiring cheek flap for access
    - Bull neck
    - Noncompliance with follow-up
- Consider a temporary tracheostomy
- Preserve function and avoid trismus with selection of appropriate reconstruction technique
- Avoid obstruction of parotid duct; ligate it with major composite resections

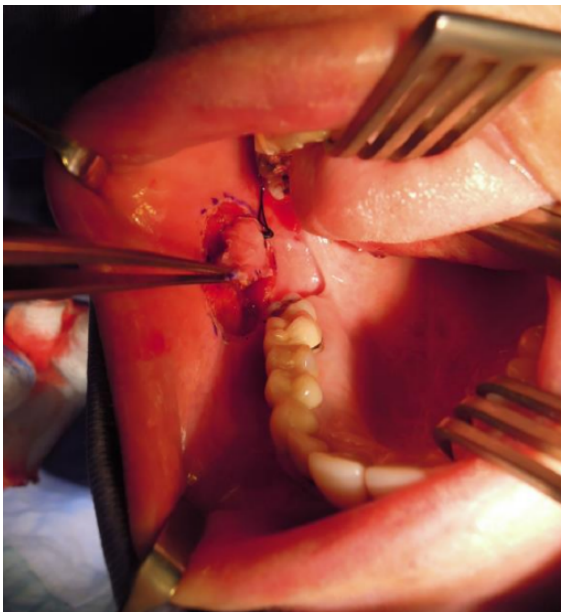


Figure 13: Peroral approach for anteriorly based tumor of buccal mucosa

Peroral: Small anterior lesions are accessible without an external incision (*Figure 13*). However, a peroral approach should be avoided in posterior lesions even if they are small. It is pertinent to resect an adequate base with wide margins as the base is the commonest site of compromised margins with peroral excision. Occasionally an anterior lesion requiring marginal mandibulectomy can be approached perorally.

Cheek flap: Most lesions of the buccal mucosa (with above exceptions) are approached via a cheek flap with one of the two incisions described below.



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Figure 14: Midline lip split incision (a); cancer located away from commissure (b)

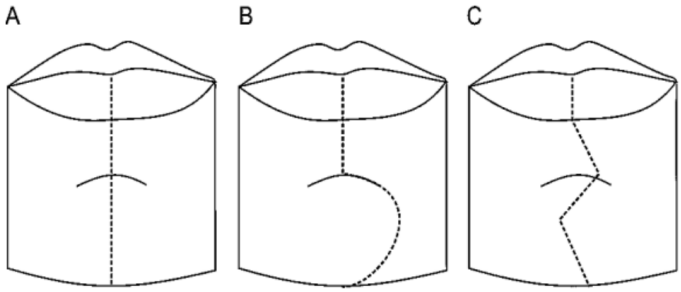


Figure 15: A: Conventional midline lip split incision; B: chin sparing incision; C: V-incision

Midline lip split: When a lesion is located away from the oral commissure, the lip is split in the midline. This incision maintains better oral competence. The incision is continued over the mentum, curving towards the hyoid up to the mastoid process along a suitable skin crease at least 2 finger breadths below the mandible (*Figure 14*). The midline lip split incision can be modified for better cosmesis (*Figure 15*). (Editor favors straight incision as in *Figure 15A*).

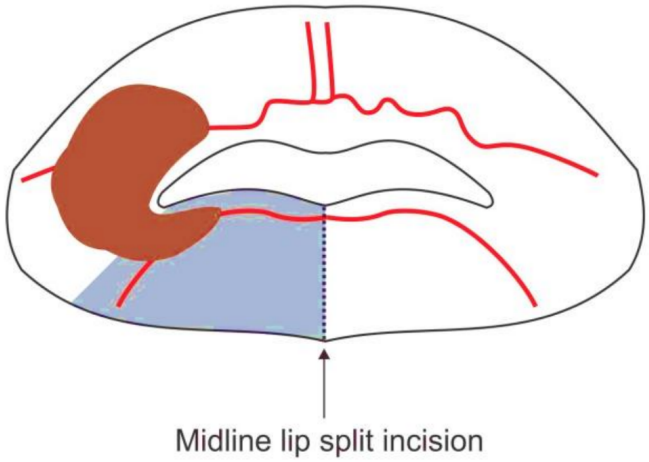


Figure 16: Diagram demonstrating lip vasculature from the superior and inferior labial arteries on either side. A midline lip split in tumors reaching to the commissure results in devascularization of the intervening lip segment

Angle split: The incision is made at the oral commissure when the lesion approaches close to the commissure. This avoids devascularising the lip segment between the commissure and the midline. It is also preferred when adjacent skin excision is required (*Figure 16*).

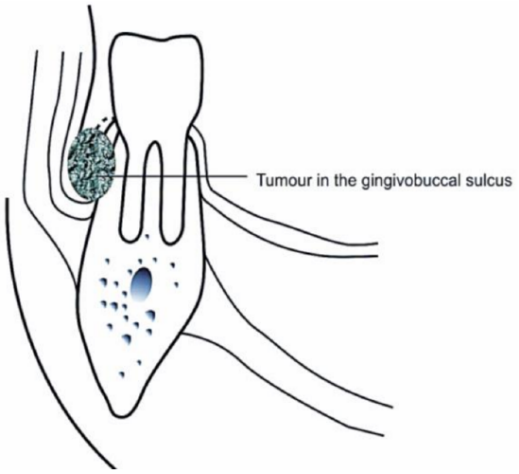


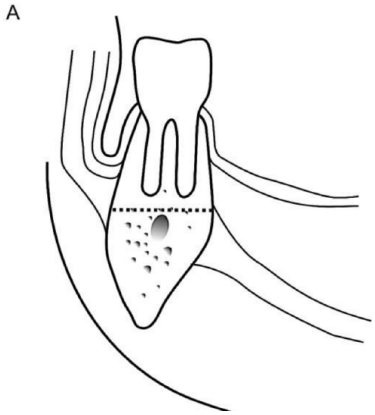
Figure 17: Tumor enters bone through the occlusal surface in a gingivobuccal sulcus tumor

Periosteum is a robust barrier to bone invasion. In alveolar lesions with intact dentition, the mandible is generally invaded via its occlusal surface (*Figures 11, 17*). In the retromolar trigone or in edentulous mandibles, the occlusal surface corresponds to the junction of the attached and reflected mucosa (point of abutment). In irradiated mandibles and in large tumors, the mandible can be invaded at multiple points due to multiple breaks in the periosteum.

With cancers of the floor of the mouth, mandible is infiltrated at the point of abutment. Hence a ***horizontal marginal mandibulectomy*** can be attempted in early gingivobuccal complex cancers lesions to include invasion at the occlusal surface; floor of mouth cancer requires vertical or oblique marginal mandibulectomy to completely excise the lingual plate due to invasion occurring directly at the point of abutment.

Marginal mandibulectomy

Marginal mandibulectomy is indicated when tumor abuts mandible without gross invasion, or when there is only superficial bony invasion.



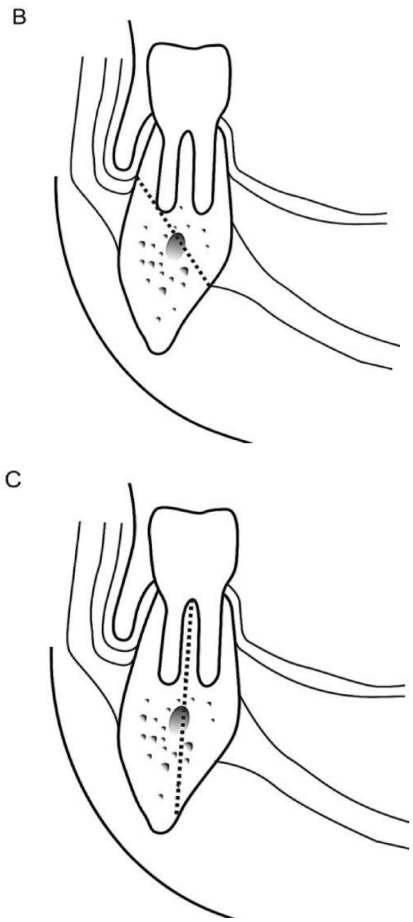


Figure 18: Marginal mandibulectomies: Horizontal (A); Oblique (B); Vertical (C)

Three types of marginal mandibulectomy are described i.e. horizontal, vertical and oblique (*Figure 18*). As the lingual plate is weaker than the buccal plate, an isolated buccal plate excision may not withstand subsequent weight bearing and the bone may fracture. Hence isolated buccal plate excision is risky in buccal mucosa lesions.

The theory of preferential route of tumor entry through the inferior alveolar nerve has been refuted by multiple studies; hence it is no longer advocated to include the inferior alveolar nerve up to the skull base with a rim resection.



Figure 19: Per oral approach for a marginal mandibulectomy

Adequate exposure is achieved with a lower cheek flap. Occasionally, a small anterior lesion can be approached perorally (*Figure 19*).

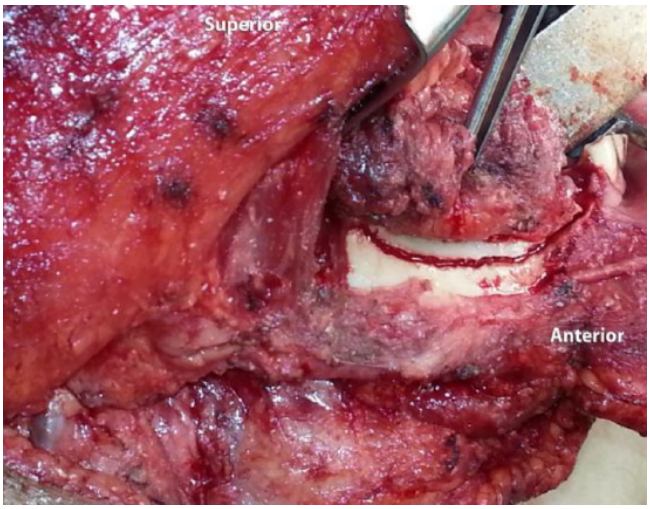


Figure 20: Bone cuts made adjacent to soft tissue cuts

After the mucosal and soft tissue incisions have been made, bone cuts are marked corresponding to the soft tissue incisions (*Figure 20*).


Figure 21: Canoe-shaped marginal mandibulectomy defect

The edges of the bone should be “canoeshaped” to avoid sharp corners (*Figure 21*).

Right-angled cuts predispose to stress fractures and hence are avoided. Inferiorly a bony bridge of >1 cm in height should be retained to avoid a stress fracture. The bone is cut with sharp bone-cutting instruments e.g. a powered saw. Finally, the correspondding gingivolingual sulcus is divided to deliver the specimen.

With marginal mandibulectomy for retromolar trigone cancer, the anterior aspect of the ascending ramus of the mandible is excised in continuity with the coronoid process, as releasing the attachment of the temporalis muscle avoids postoperative trismus.

Segmental and hemimandibulectomy



Figure 22: Pipe stem mandible

This is indicated when there is gross bone erosion, either clinically or radiologically; for significant paramandibular disease; for postradiotherapy recurrence due to the multiple routes of tumor entry; or with a pipe stem mandible (inadequate bony remnant of <1 cm in height) (*Figure 22*).

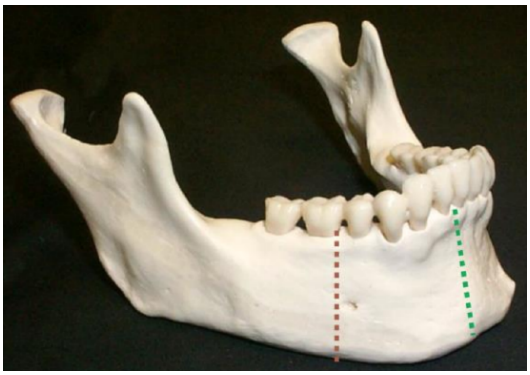


Figure 23: Red cut = Posterior segmental mandibulectomy; Green cut = hemimandibulectomy

Segmental mandibulectomy may encompass the mandibular arch (mid-third segment) or may be arch-preserving (lateral segment). Mandibulectomy that includes the entire ascending ramus, condyle and coronoid can either be a posterior segmental mandibulectomy (posterior to mental foramen) or hemimandibulectomy (*Figure 23*).

Surgical steps

Tracheostomy

Because intubation may be challenging in the presence of trismus, the surgical team must be present during induction of anesthesia. If a difficult intubation is anticipated, then one should infiltrate the skin and trachea with local anesthesia and a vasoconstrictor prior to induction, and the tracheostomy team must be ready to proceed if necessary. The alternative is to perform an awake tracheostomy before induction of anesthesia. In cases where intubation is straightforward, the decision whether to do an elective tracheostomy at the end of the procedure is a judgement call of the surgeon and anesthetist. However, one should have a low threshold for tracheostomy. (See chapter: Tracheostomy)

Neck dissection

If a neck dissection is to be done, then Levels 1 and 2 are dissected ***before*** resecting the primary. This facilitates resection of the primary tumor; it allows the pathologist to do frozen sections of the resected tumor; and for the reconstructive surgeon to examine the surgical defect and raise a flap while the neck dissection is completed. The submandibular gland may be kept in continuity with the main specimen after ligating the facial artery where it exits behind the posterior belly of digastric, should the tumor be involving the lingual surface of the mandible or the floor of the mouth. Supraomohyoid neck dissection (Levels 1-3) is used as an elective neck dissection for buccal cancer. In the presence of nodal metastasis, either Levels 1-4, or Modified Neck Dissection (Levels 1-5) is done. (See chapters: Selective neck dissection technique and Modified and radical neck dissection technique).

Approach to the primary

Once Levels 1 & 2 of the neck dissection have been competed, a decision is made about whether to do a midline lip split or an angle split incision. The lower cheek flap is raised in a subcutaneous plane keeping adequate soft tissue on the tumor. The mucosal cuts are made with adequate margins.

Resecting the primary

After incising the mucosa around and soft tissue using diathermy or a knife, bone cuts are marked adjacent to the soft tissue. The posterior mucosal cut is made according to the extent of tumor. Attention should be paid mainly to ***the 3rd dimension i.e. deep resection margin***. This margin must contain at least one layer of normal tissue beyond the tumor. With this in mind, it should contain the buccinator muscle with superficial lesions and the buccal fat pad or the zygomaticus major muscle with deeper lesions. With lesions deeper than that e.g. adhering to skin or causing peau d'orange, the overlying skin is excised to achieve an adequate margin.

Bone resection depends on whether ***marginal, segmental or hemimandibulectomy*** is required. Marginal mandibulectomy is illustrated in *Figures 18-21*.

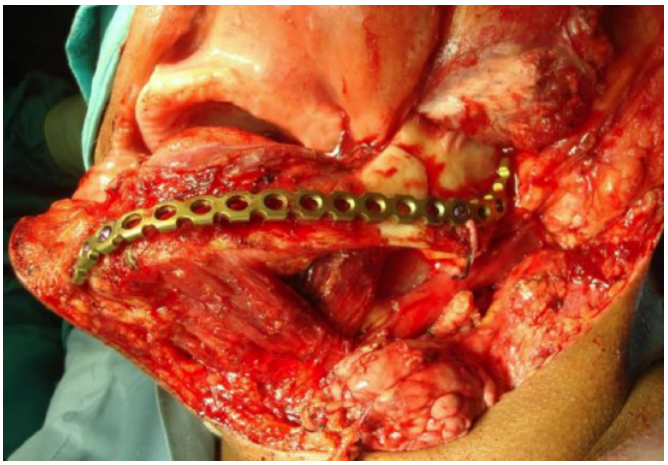


Figure 24: Preplating the mandible

The following description applies to a segmental or hemimandibulectomy. A vertical osteotomy is made about 2 cm anterior to the tumor with a powered saw, drill or Gigli saw. This allows the surgeon to reflect the mandible laterally like opening a book and to expose the tumor. If a bony reconstruction is to be done, then the mandible is preplated to ensure an accurate repair (*Figure 24*). (See chapter: Vascularized free fibula flap reconstruction).

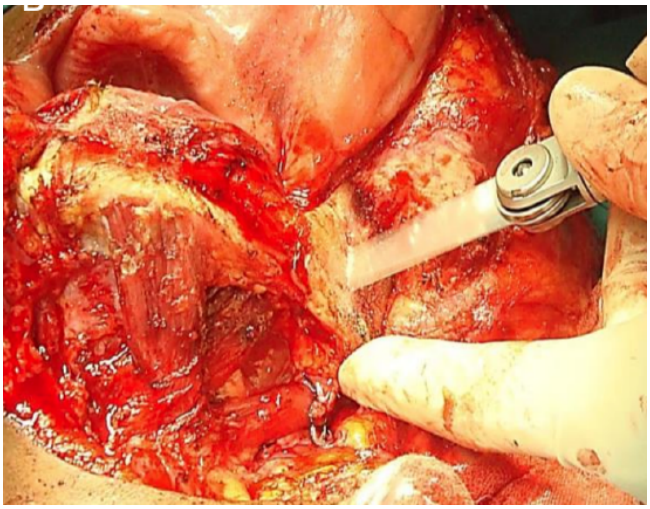


Figure 25: Posterior osteotomy

If the retromolar trigone is not involved, then the posterior osteotomy is made 2 cm behind the posterior edge of the tumor (*Figure 25*).



Figure 26A: Cancer of gingivobuccal sulcus extending to retromolar trigone


Figure 26B: Midline lip-split incision

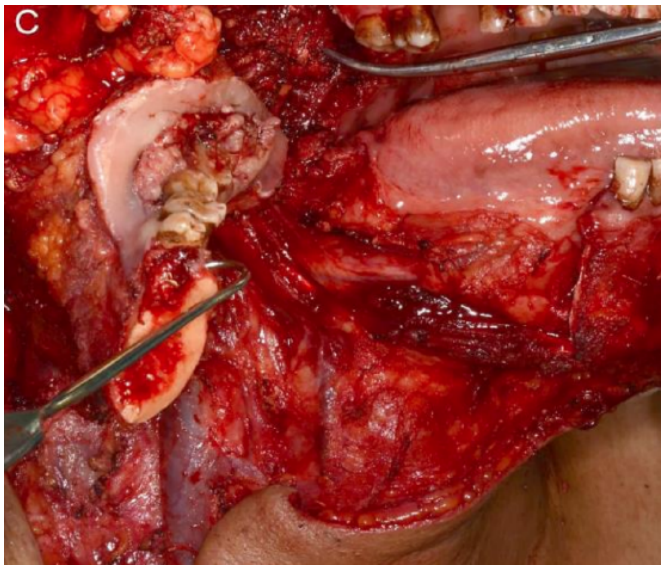


Figure 26C: Anterior mandibulotomy showing improved access

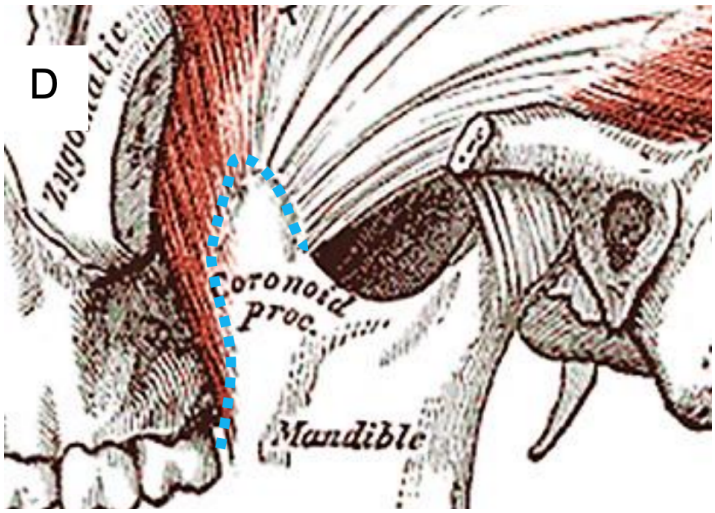


Figure 26D: Broken blue line indicates where insertion of temporalis muscle is freed with cautery

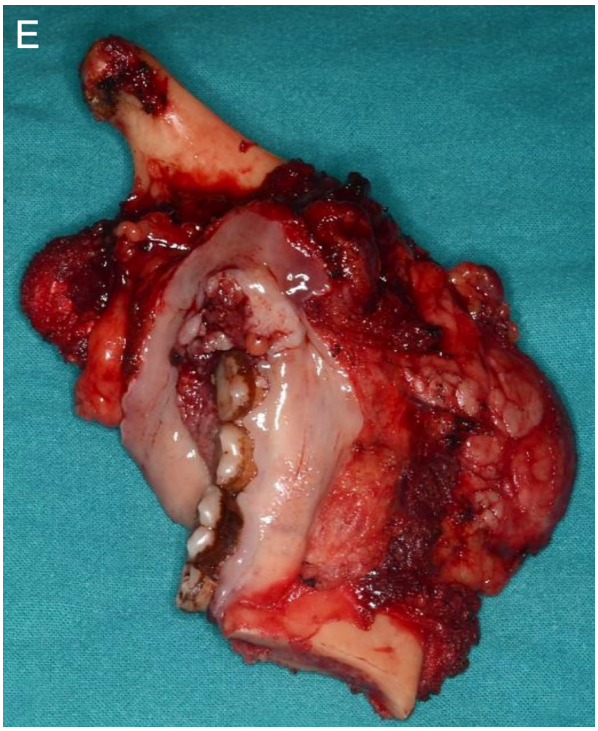


Figure 26E: Hemimandibulectomy

A posterior segmental or a hemimandibulectomy may be required with deep-seated tumors extending posteriorly beyond the retromolar trigone (*Figures 26 A-E*). The masseter muscle is reflected off the bone or is included with the specimen depending on the extent of the tumor. The coronoid process is exposed and released from its attachment to the temporalis muscle, remaining close to the bone to avoid injuring the vessels medial to the coronoid process.

With the mandible now mobile and swung out laterally, the posterior mucosal cuts can be made behind the tumor, cutting through medial pterygoid muscle and its attachments to the lateral pterygoid plate and the maxillary tuberosity, and the inferior alveolar nerve (and lingual nerve) at its entry into the mandibular canal. The maxillary artery may have to be ligated in the sigmoid notch. The mandibular condyle is released from the lateral pterygoid muscle and the hemimandible and tumor are delivered.

Bite excision

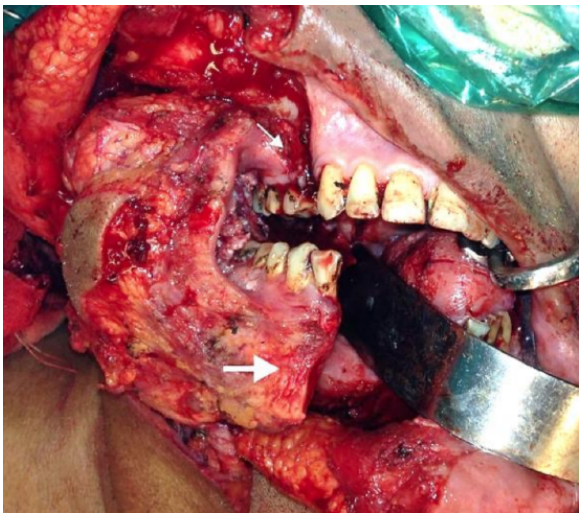


Figure 27: Bite excision; thin white arrow pointing to the upper alveolus; thick white arrow pointing to the lower alveolus

This refers to excision of the superior and inferior alveoli with the intervening interalveolar tissue (like a bite). It is indicated for lesions involving the retromolar trigone extending to the superior alveolus. The specimen consists of the inferior as well as the superior alveolus in continuity with the overlying retromolar trigone mucosa and soft tissue formed by the pterygoid muscles (*Figure 27*). The bony cuts for the mandibulectomy are as described above.

Mucosal incisions are made on the superior alveolus with adequate margins. The mucosal incision of the inferior alveolus is extended to meet the mucosal incision on the superior alveolus at the retromolar trigone. The superior alveolus is cut with a bone cutting instrument to traverse the posterolateral wall of the maxilla up to the maxillary tuberosity. The location of the posterior bony cut depends on the tumor.

Infratemporal fossa

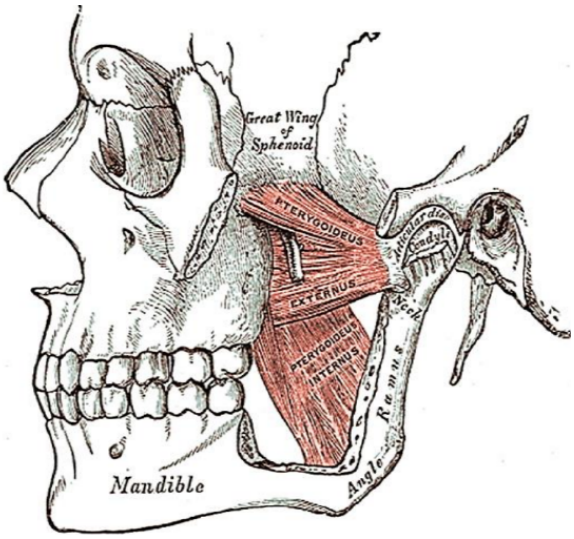


Figure 28: Medial and lateral pterygoids

If the lesion does not involve the ITF, then the bone cut is made anterior to the pterygoid plates. However, if the lesion involves the medial pterygoid muscle, the pterygoid plate is included in the specimen to ensure adequate soft tissue resection that includes the pterygoid muscles. “Bite excision” with resection of the entire medial pterygoid muscle is performed when the lower ITF is involved. If resection of the higher ITF is warranted, then “bite excision” encompassing the pterygoid plates is performed to include the entire medial and lateral pterygoid muscles (*Figure 28*). The temporalis muscle below the temporal fossa is resected in continuity with the coronoid up to the roof of the ITF.

Repair and Reconstruction

The aims are to restore form and function. Whether to repair a defect depends on its size and depth, and whether there is a through-and-through defect into the neck.

Buccal soft tissue defect only: Small defects can be closed primarily or left to granulate and heal by secondary intention like a tonsillectomy defect. Larger defects that include resection of the buccinator muscle that are left to granulate may lead to significant trismus due to scarring and contraction of the scar tissue.

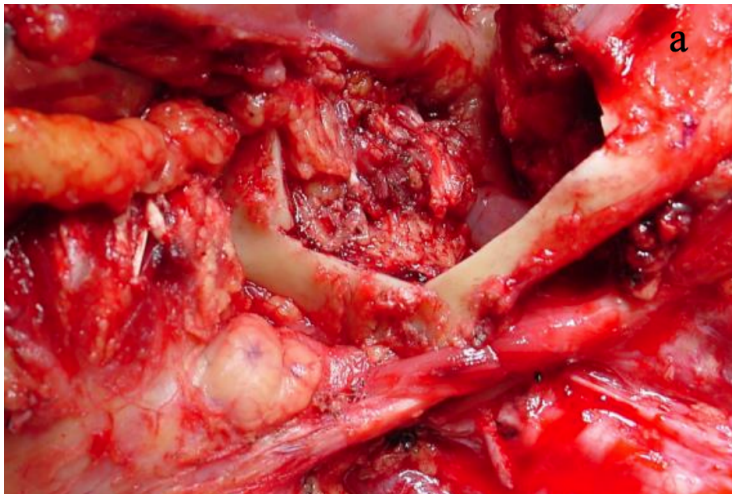


Figure 29a: Marginal mandibulectomy

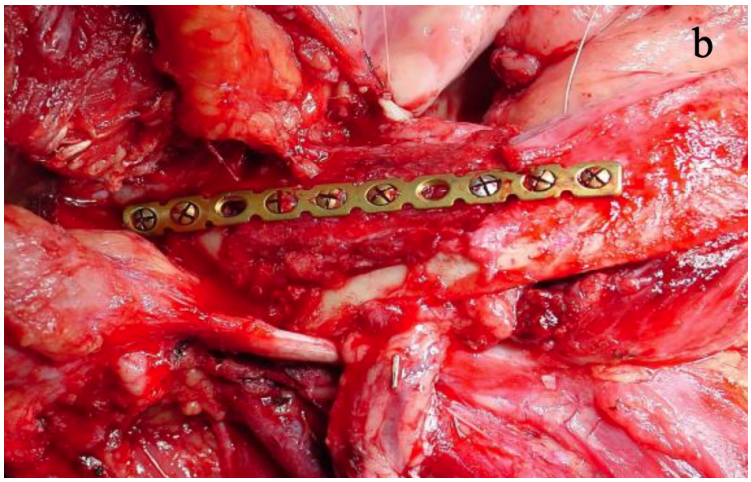


Figure 29b: Onlay radial osteocutaneous flap

Marginal mandibulectomy: A marginal mandibulectomy defect can be strengthened with an onlay fibula or radial forearm osteocutaneous flap (*Figures 29a, b*).

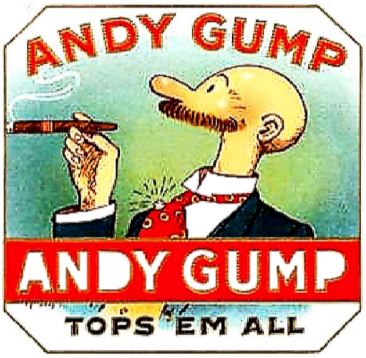


Figure 30: Andy Gump deformity

Segmental mandibulectomy: If the resection crosses the midline and includes the mandibular arch e.g. mid-third mandible segment, reconstruction with an osteocutaneous free flap is mandatory to avoid a debilitating Andy Gump deformity (*Figure 30*).

For lateral and posterior segmental, or hemimandibulectomy defects, reconstruction with a pectoralis major myocutaneous flap is an acceptable alternative if osteocutaneous free flap reconstruction is not possible, or is inadvisable e.g. in the elderly, frail and unfit.

Large soft tissue defect: A large soft tissue defect following e.g. a "bite excision" or infratemporal fossa clearance can be reconstructed with pedicled flaps (forehead, temporalis, pectoralis major, deltopectoral) or free flaps (radial free forearm, anterolateral free thigh).



Figure 31: Bipedicled anterolateral free thigh flap used to repair a through-and-through resection of the buccal mucosa

Facial skin defect: Skin can be reconstructed by bipaddling a radial free forearm, anterolateral thigh (*Figure 31*), or pectoralis major flap to provide both inner and external skin cover. Else a double flap i.e. one flap to cover the inner mucosal and soft tissue defect and the other to cover the skin loss, can be used.

Suitable grafts and flaps

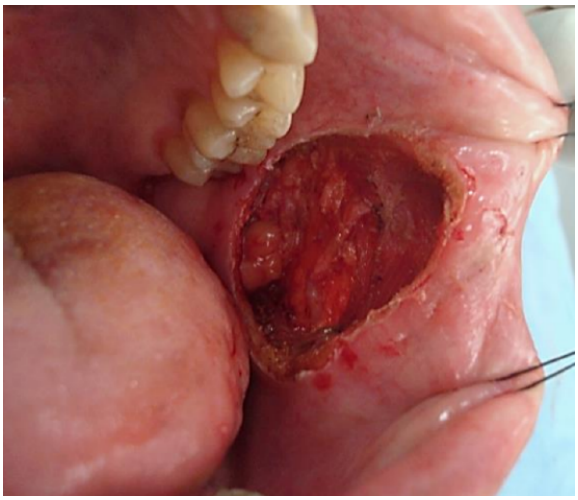


Figure 32: Typical buccal defect that challenges the surgeon how best to close the defect to avoid excessive scarring and trismus

Split skin grafts can be employed for superficial defects. *Figure 32* illustrates a typical soft tissue defect following resection of a buccal tumor; this may be closed with a local, pedicled or a free microvascular transfer flap. Free flaps are generally preferred to local or pedicled flaps as they can be better tailored to the defect.

Split skin graft: The graft is harvested from the thigh and the mucosal defect is quilted with the skin graft with absorbable sutures. Pressure is applied to the graft by using a bolus e.g. BIPP impregnated gauze, which is tied over the graft and kept in situ for 5 days. However, using a split skin graft for deeper and larger defects causes fibrosis that may cause trismus.

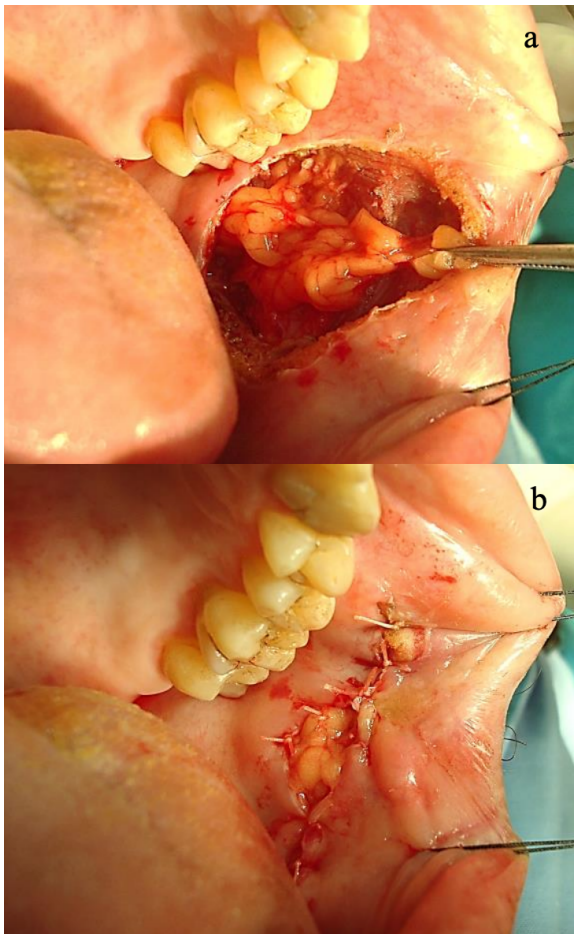


Figure 33a, b: Buccal defect in Figure 39 closed with a buccal fat pad

Buccal fat pad flap (*Figure 33*): The buccal fat is conveniently located in the posterior part of the buccal space and can be gently delivered into the defect and used to fill the defect. It subsequently mucosalizes. In some cases, it may cause a scar band and trismus. (See chapter: Buccal fat pad flap)

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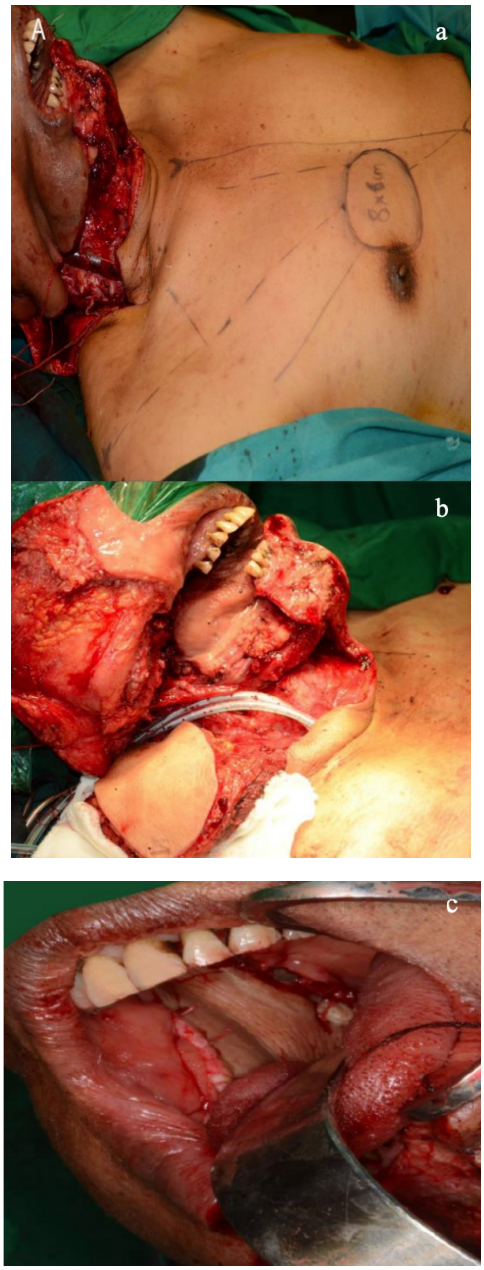


Figure 34a-c: Pectoralis major myocutaneous flap marked on the ipsilateral chest, tunneled into the neck, and reconstructed defect

Pectoralis major flap (*Figure 34*): This was the workhorse of oral cavity reconstruction prior to the advent of free microvascular tissue transfer flaps. The pectoralis major flap has a robust blood supply; has a long pedicle length which makes it amenable to reconstruction of a defect as superior as the lower border of the zygoma; the shape of the flap can be adjusted to the shape of the defect; and a large flap can be harvested. It remains a good choice when free flaps are not available, as a salvage procedure for a failed free flap or when patients cannot tolerate a long procedure e.g. the elderly and infirm. (See chapter: Pectoralis major flap)

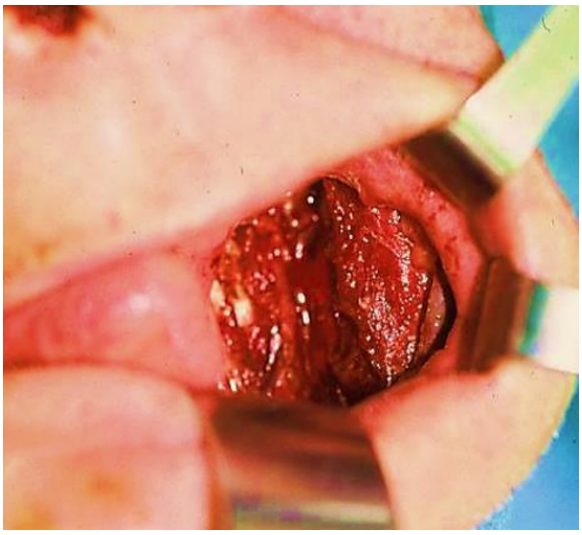


Figure 35a: Initial buccal defect

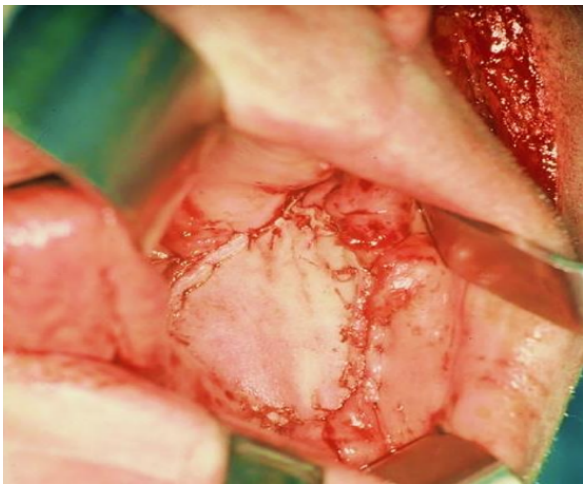


Figure 35b: Nasolabial flap inset into buccal defect with donor site visible

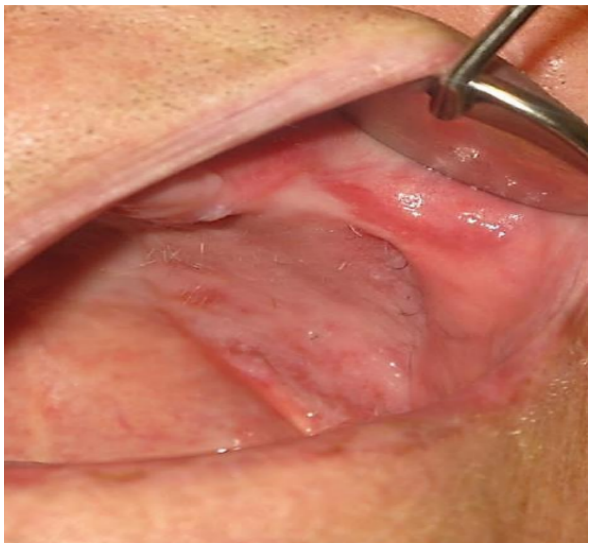


Figure 35c: Healed nasolabial flap in buccal defect



Figure 35d: Final cosmetic result

Nasolabial flap (*Figures 35 a-d*): The nasolabial flap has advantages that the donor site is adjacent to the defect, that the flap is thin and pliable and has a robust blood supply that permits shaping of the flap to precisely fill the defect. A larger defect, particularly when located anteriorly, can be covered with bilateral nasolabial flaps. (See chapter: Nasolabial flap for oral cavity reconstruction)

Tongue flap: Advantages are that the flap is harvested adjacent to the defect and that there is insignificant donor site morbidity. Generally, a posteriorly based flap is used. It is a single stage procedure and the donor site is closed primarily.

Temporalis flap: This is favored by some surgeons. It is based on the deep temporal artery which courses close to the coronoid process of the mandible which this has to be preserved.

Forehead flap: It has a robust blood supply, is pliable and the entire forehead can be utilized. It is however associated with significant cosmetic morbidity and is therefore generally reserved as a 2nd line reconstructive option.

Deltopectoral flap: It is quick and easy to harvest, has consistent anatomy, and is a pliable flap. For oral cavity repair it generally requires a 2nd stage surgery after 3 weeks to disconnect the pedicle.



Figure 36a: Retromolar trigone cancer



Figure 36b: Defect after bite excision

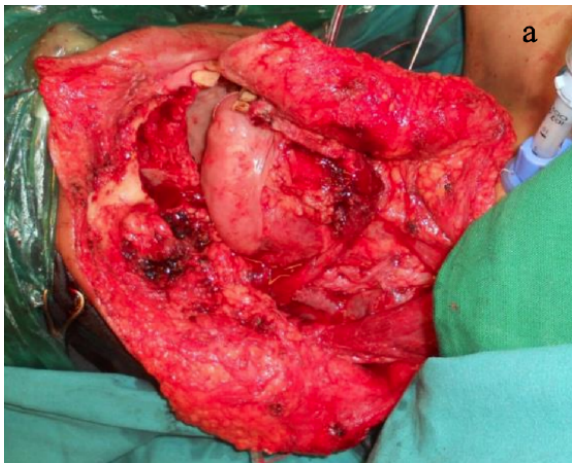


Figure 36c: Harvested flap with donor vessels i.e. radial artery and cephalic vein



Figure 36d: Adequate mouth opening at long term follow-up

Radial free forearm flap (*Figures 36 a-d*): It is a thin, pliable flap with a consistent blood supply and a long vascular pedicle. It is quick and easy to harvest. Donor site morbidity is worse than with anterolateral thigh free flaps. Its pliability makes it amenable to reconstruct a variety of oral defects. It can also be harvested as an osteocutaneous flap (*Figure 29*). *Figures 36 a-d* illustrate the utility of a radial free forearm flap to reconstruct a defect following "bite" excision.



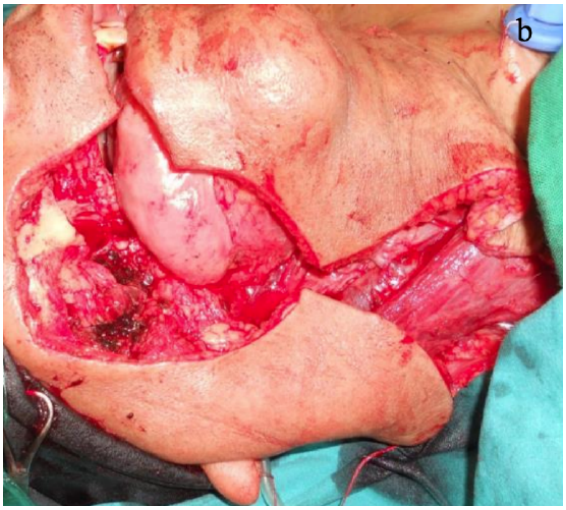




Figure 37a, b, c: Buccal mucosal composite resection with skin loss and repair with anterolateral thigh flap

Anterolateral free thigh flap (*Figure 37*): It can be harvested with muscle and hence used for larger soft tissue defects. Donor site morbidity is insignificant.

Radial osteocutaneous flap (*Figure 29*): This can be complicated by fractures of the remaining radius, and restriction of forearm range of movement. Hence it is the authors' preference to use a free fibula flap.

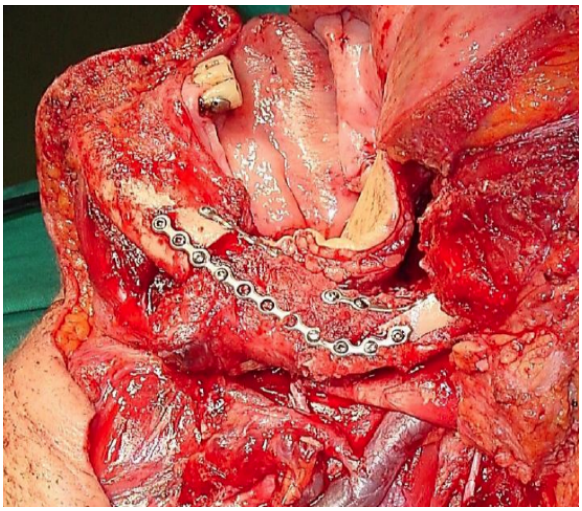


Figure 38: FFF graft following segmental mandibulectomy; skin of leg used to reconstruct oropharynx defect

Free fibula flap (*Figure 38*): Advantages include long bone length, a segmental blood supply making multiple osteotomies feasible, and minimal donor site morbidity.

Scapular tip flap: This is useful in cases requiring skin, bone as well as muscle based on a single vascular pedicle, and is most commonly used for maxillary and orbital defects.

Postoperative care

Airway: Elective tracheostomy is always indicated if mandibular resection crosses the midline with excision of both genial tubercles resulting in the tongue dropping back, extensive composite palatal resection, or buccal mucosal resection requiring reconstruction with a bulky flap.

Position: Maintain the patient at 15 degrees head-high to reduce venous congestion and bleeding. Maintain a head position that avoids twisting of the vascular pedicle of a free flap.

Feeding: Patients are fed by nasogastric feeding tube for at least 5 days, and until that patient can tolerate their own saliva.

Antibiotics: A broad spectrum antibiotic is administered for 24 hours

Rehabilitation

Jaw stretching exercises: Trismus is one of the commonest and most disabling sequelae of surgery for buccal cancer because of scarring and shortening of the muscles of mastication, as well as scarring in the tumor bed and of the flap or skin graft. Jaw stretching exercises should commence after initial wound healing i.e. about 5-7 days after surgery and should be continued for a long period of time.

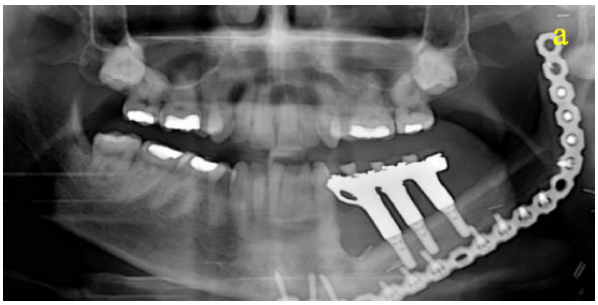


Figure 39: Missing lateral mandibular segment causes mandible to “swing” towards the side of the resection



Figure 40: Bite guide prosthesis used to avoid lateral mandibular swing

Bite guide prosthesis: Unopposed contraction of the opposite muscles of mastication result in deviation of the lower jaw following hemimandibulectomy (*Figure 39*). A bite guide prosthesis prevents this deviation and should be used for at least 6-8 weeks following surgery until complete healing has occurred (*Figure 40*).





Figures 41a, b: Dental implants and rehabilitation after free fibula reconstruction

Dental rehabilitation: Dental implants can be considered in cases of free bone transfer (*Figures 41a, b*) and dentures may have to be adjusted.

Authors

Devendra A Chaukar
M.S, D.N.B.
Associate Professor
Department of Head and Neck Surgery
Tata Memorial Hospital
Mumbai, India
dchaukar@gmail.com

Mitali Dandekar
M.S, D.N.B.
Department of Head and Neck Surgery
Tata Memorial Hospital

Mumbai, India
mitalidandekar@gmail.com

Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.36: Partial Glossectomy for Tongue Cancer

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Cancers of the tongue are generally treated with primary surgical resection. Adjuvant irradiation is indicated inter alia for advanced tumors, tumors with perineural invasion (PNI) or uncertain/close margins.

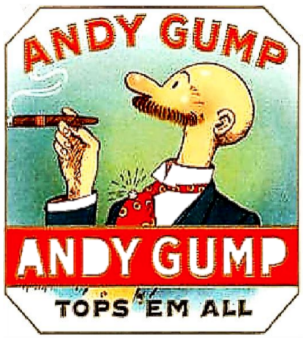


Figure 1: Andy Gump deformity

Resecting tongue cancer without considering subsequent ***oral function*** may severely cripple a patient in terms of speech, mastication, oral transport and swallowing. Resecting the anterior arch of the mandible beyond the midline without reconstructing bone and with loss of the anterior attachments of the suprahyoid muscles (digastric, geniohyoid, mylohyoid, genioglossus) leads to an Andy Gump deformity with loss of oral competence, drooling, and a very poor cosmetic outcome (*Figure 1*).

Surgical Anatomy

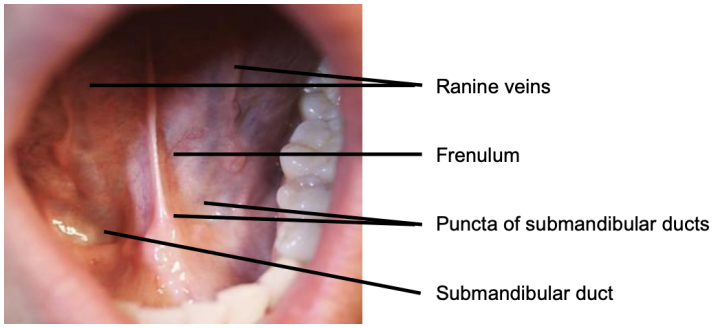


Figure 2: Anterior tongue and FOM

The tongue merges anteriorly and laterally with the ***floor of mouth (FOM)***, a horseshoe-shaped area that is confined peripherally by the inner aspect (lingual surface) of the mandible. Anteriorly the undersurface of the tongue and FOM has a covering of delicate oral mucosa through which the thin walled sublingual/ranine veins are visible. The ***frenulum*** is a mucosal fold that extends along the midline between the ***openings of the submandibular ducts*** towards the tip of the tongue (*Figure 2*).

Posterolaterally the ***tonsillolingual sulcus*** separates the tongue from the tonsil fossa. Posteriorly the ***vallecula*** separates the base of tongue from the lingual surface of the epiglottis.

The ***mucous membrane*** covering the tongue and FOM varies in thickness and quality; this ***has relevance in terms of obtaining surgical margins and retaining tongue mobility***. The undersurface of the tongue has a thin, smooth, pliable mucous membrane. The mucous membrane covering the anterior 2/3^{rds} of the dorsum is thin and quite smooth and adherent to the tongue muscle compared to the mucosa covering the base of tongue (BOT) behind foramen caecum and sulcus terminalis which is rough, thick and fixed to the underlying muscle and contains a number of lymphoid follicles (lingual tonsil). With BOT tumors it is therefore difficult to determine the edge of a tumor making frozen section especially useful to assess resection margins.

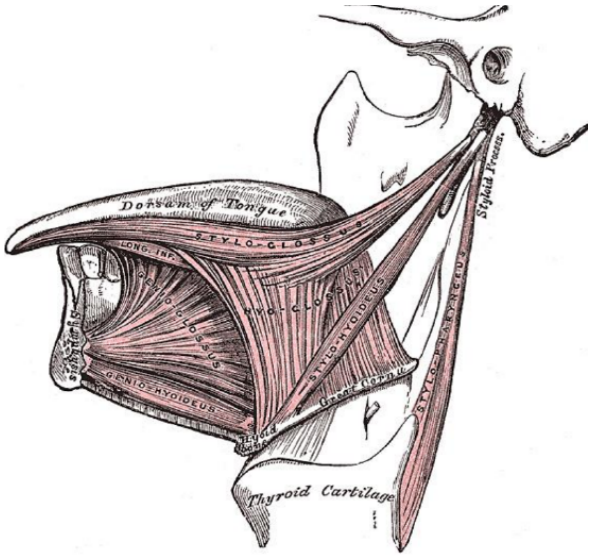


Figure 3: Extrinsic tongue muscles (palatoglossus not shown)

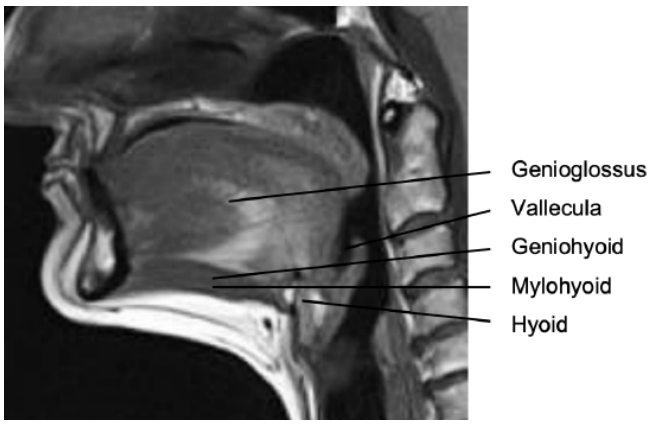


Figure 4: Midline sagittal view of tongue

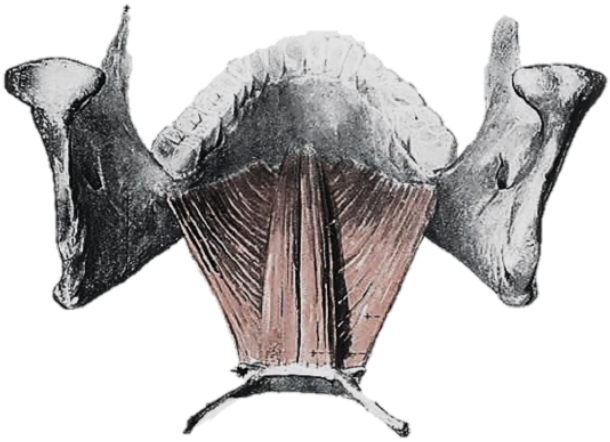


Figure 5: Geniohyoid and mylohyoid

The tongue comprises ***eight muscles***. Four ***extrinsic*** muscles (genioglossus, hyoglossus, styloglossus, palatoglossus) control the position of the tongue and are attached to bone (*Figure 3, 4*); four ***intrinsic*** muscles modulate the shape of the tongue and are not attached to bone. Below the tongue are the ***geniohyoid*** and the ***mylohoid muscles***; the mylohyoid muscle serves as the diaphragm of the mouth and separates the tongue and FOM from the submental and submandibular triangles of the neck (*Figures 3, 4, 5*).

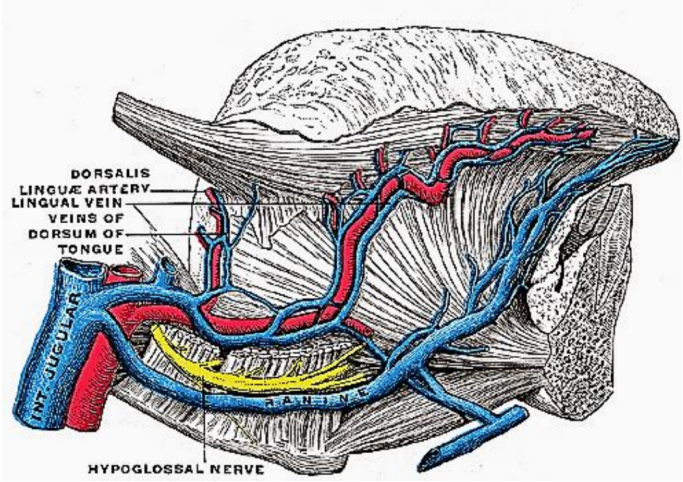


Figure 6: XIIn accompanied by ranine veins

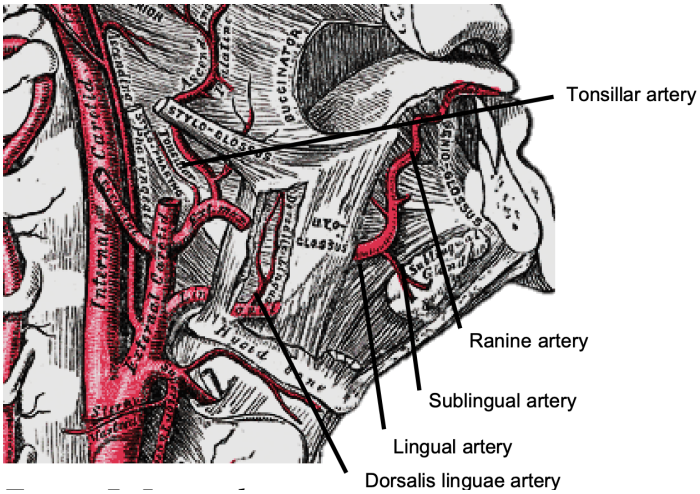


Figure 7: Lingual artery

The tongue is a very vascular organ. The ***arterial supply*** is derived from the paired ***lingual arteries*** and its branches ***(ranine artery, dorsalis linguae, and sublingual arteries)*** (*Figures 6, 7*); and the mylohyoid and submental arteries. Additional blood supply to the tongue emanates from the ***tonsillar branch of the facial artery*** and the ***ascending pharyngeal artery.***

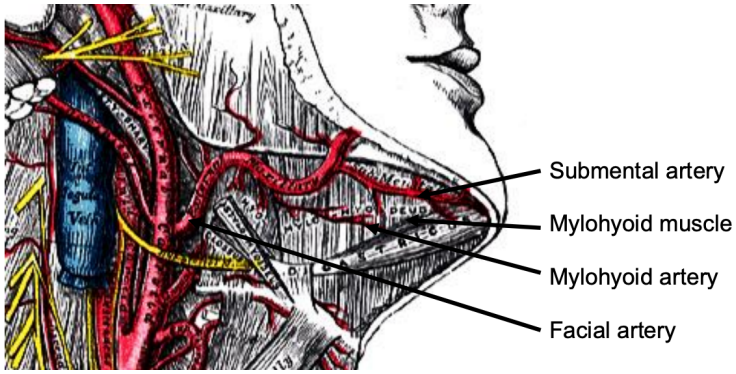


Figure 8: Facial artery emerges from behind posterior belly of digastric (removed), and gives rise to a few branches including submental artery

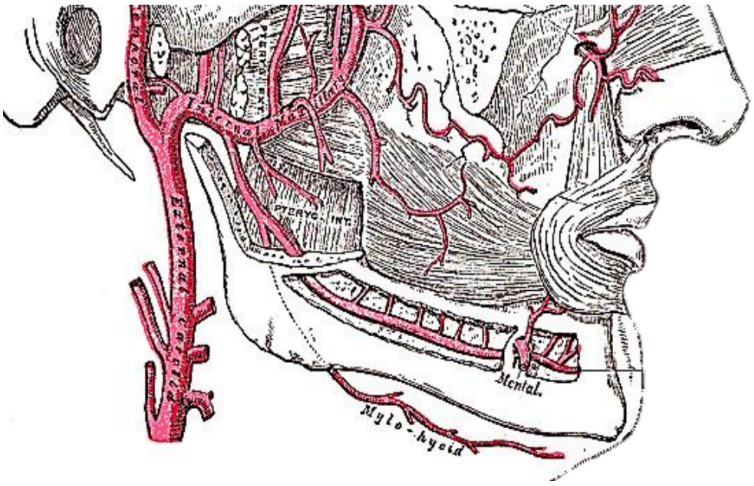


Figure 9: Mylohyoid artery is a branch of the inferior alveolar artery

The ***lingual artery*** originates from the external carotid between the superior thyroid and facial arteries and courses obliquely forwards and medial to the greater cornu of the hyoid (*Figures 6*, *7*). It then loops downward and anteriorly and passes medial to hypoglossal nerve (XIIn) and the stylohyoid muscle. It then courses directly anteriorly and deep to the hyoglossus and finally ascends submucosally on the undersurface of the tongue as far as its tip as the ***ranine artery*** (profunda linguae); it lies to either side of the genioglossus and is accompanied by the lingual nerve. Two or three small ***dorsales linguæ*** arteries arise beneath the hyoglossus and ascend to the posterior part of the dorsum of the tongue and also supply the mucous membrane of the posterior FOM, and oropharynx (*Figure 7*). The ***sublingual artery*** branches from the lingual artery at the anterior edge of the hyoglossus and runs forward between the genioglossus and mylohyoid and supplies the sublingual salivary gland and mucous membrane of the FOM and gingiva (*Figure 7*). A branch of the ***sublingual artery*** pierces the mylohyoid muscle and anastomoses with the submental branch of the facial artery in Level 1b of the neck. The ***submental branch*** of the facial artery courses along the inferior, inner margin of the mandible (*Figure 8*). The ***mylohyoid artery*** and vein are encountered when the surgeon elevates the submandibular gland from the lateral surface of the mylohyoid (*Figures 8*, *9*). It branches off the inferior alveolar artery just before it enters the mandibular foramen, crosses the mylohyoid, and disappears anteriorly behind the digastric. It has connections with the submental artery and via a defect in the mylohyoid with the sublingual artery in the FOM.

Venous drainage is via ***lingual*** and ***ranine veins***. The ***lingual veins*** originate on the dorsum, sides, and undersurface of the tongue and accompany the lingual artery and joins the internal jugular vein. The ***ranine veins*** originate below the tip of the tongue and are visible on its ventral surface; they accompany the XIIn as venae comitantes and either join the lingual vein or pass lateral to hyoglossus to join the common facial vein (*Figures 2*, *6*).

Innervation

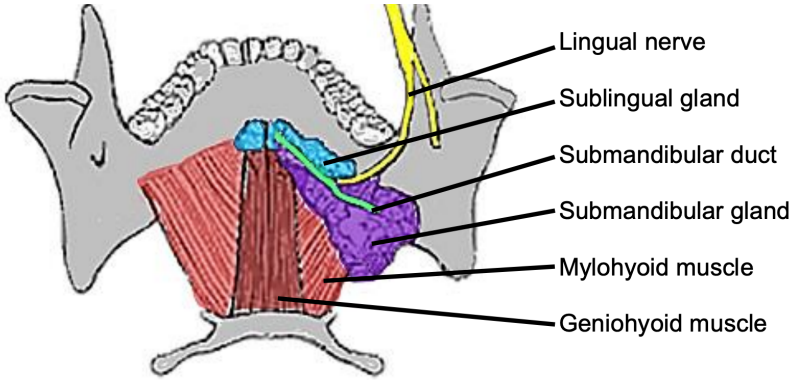


Figure 10: Superior view of FOM, submandibular gland and duct, lingual nerve and mylohyoid and geniohyoid muscles

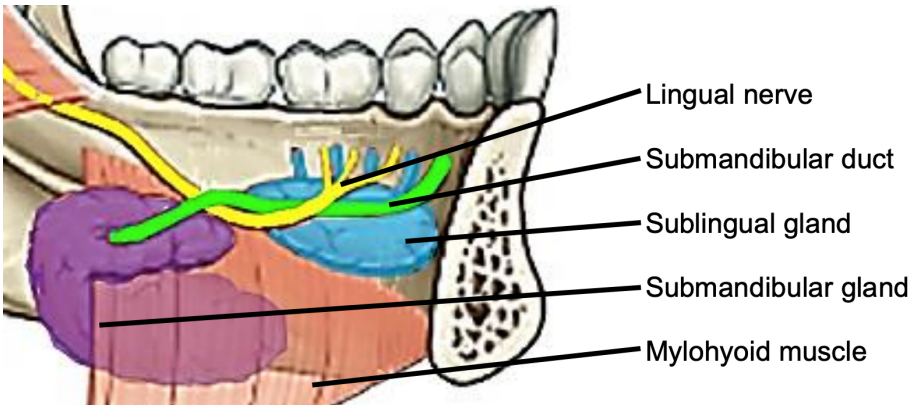


Figure 11: Intraoral view of left sublingual gland with ducts of Rivinus, submandibular gland and duct, lingual nerve and mylohyoid muscles

Other than palatoglossus which is innerveted by the ***Xn***, all intrinsic and extrinsic muscles are innervated by the ***XIIn***. The ***IXn*** provides somatic afferent and taste sensation to the posterior 1/3 of the tongue. The ***lingual nerve*** provides general somatic sensation to the anterior 2/3 of the mouth and FOM; taste is provided by the chorda tympani branch of the ***VIIn*** via the lingual nerve. The ***lingual nerve*** crosses deep to the submandibular duct in the lateral floor of mouth (*Figures 10, 11*). In the anterior FOM it is located posterior to the duct (*Figure 11*).

Structures surrounding the tongue

The following structures are located between the mucosa and the mylohyoid muscles: paired ***geniohyoid muscles*** in the midline (*Figure 4*); ***sublingual salivary glands*** (*Figures 10, 11*), ***submandibular ducts*** (*Figures 10, 11*), oral component of submandibular salivary glands (*Figures 10, 11*), and the ***lingual*** and ***XIIns***. The paired ***sublingual salivary glands*** are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles (*Figures 10, 11*). The ***submandibular duct*** is located immediately deep to the mucosa of the anterior and lateral FOM and opens into the oral cavity to either side of the frenulum (*Figures 2, 10, 11*).

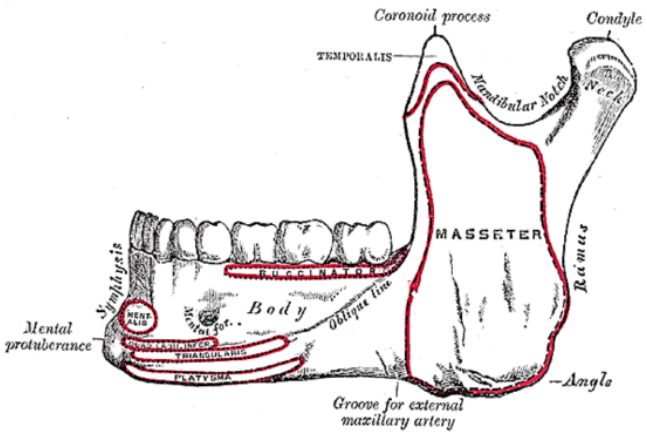


Figure 12a: Attachments of muscles to outer aspect of mandible and location of mental foramen

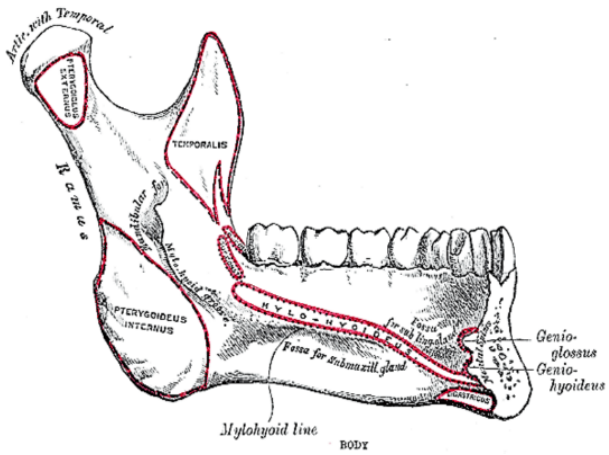


Figure 12b: Attachments of mylohyoid, geniohyoid, genioglossus and digastric muscles to inner aspect of mandible

The ***mandible*** borders the FOM and may have to be divided for access (mandibulotomy), or resected if involved by tumor (alveolectomy / marginal mandibulectomy / segmental mandibulectomy / hemimandibulectomy). Important surgical features are the position of the mental foramina through which the mental nerves exit to innervate the lower lip; the mylohyoid line to which the mylohyoid muscles attach, the attachment of the genioglossus, and when planning marginal mandibulectomy, the height of the body of the mandible and the depths of the dental roots (*Figures 12a, b*).

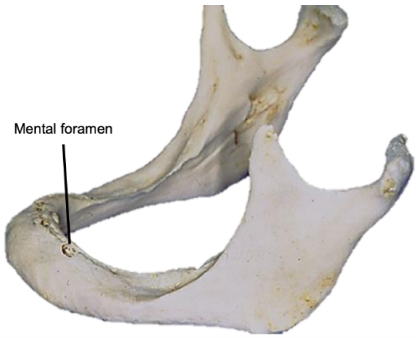


Figure 13: Position of mental foramen in a resorbed mandible

In older, edentulous patients the mandible resorbs and the mental foramen and inferior alveolar nerve may be very close to its superior surface (*Figure 13*). Marginal mandibulectomy may also not be possible in such a resorbed mandible due to the lack of residual bone.

Surgical Objectives

- Adequate resection margins
- Preserve at least one lingual artery to avoid infarction of tongue
- Avoid postoperative orocervical fistula
- Optimize cosmesis and function
  - Maintain length and mobility of tongue
  - Avoid pooling of secretions and food
  - Avoid obstruction of submandibular ducts
  - Attempt to preserve lingual and XII nerves
  - Maintain mandibular continuity and strength
  - Maintain dental occlusion
  - Restore dentition

The author advocates ***elective neck dissection (END)*** Levels I-IV for squamous cell carcinoma of the oral tongue that is >4 mm thick and/or >T2 stage; a useful rule of thumb is that a tumor which is clinically palpable is likely to have a tumor thickness that warrants END. BOT cancers and tumors of the anterior FOM that approach the midline require bilateral END.

The remainder of this chapter will focus on the surgery of cancer of the oral tongue.

Preoperative evaluation

1. ***Are there synchronous primaries, cervical or distant metastases?*** CXR or CT chest and panendoscopy
2. ***Is the tumor resectable?*** It may be difficult to assess the extent of the primary cancer due to pain, tenderness and trismus; if in doubt, a patient requires imaging such as CT/MRI, or examination under anaesthesia. Other than cancers that extend posteriorly to involve the infratemporal fossa or involve the carotid sheath, most tongue cancers are resectable provided suitable reconstructive surgery can be done.
3. ***Is there evidence of perineural invasion (PNI) of major nerves?*** Examine the patient for neurological deficits of the XIIn, mental, inferior alveolar and lingual nerves. Widening of the alveolar canal on mandibular orthopantomography (Panorex) may be seen with involvement of the inferior alveolar nerve. MRI may demonstrate PNI. Should there be evidence of PNI then the affected nerve is dissected proximally until a clear tumor margin is obtained on frozen section.
4. ***Is reconstruction required?*** A key consideration is surgical morbidity relating to cosmesis and function; this in turn is dependent on the available reconstructive options.
5. ***Can the patient tolerate aspiration?*** Major resections and reconstructions, especially if followed by chemoradiation, may be complicated by variable measures of dysphagia and aspiration. Physical fitness, pulmonary reserve, and cognitive function should therefore be considered when selecting patients for such major resections.
6. ***Status of dentition?*** Carious teeth should be removed at the time of the surgery to avoid osteoradionecrosis.
7. ***Mandible***: Tumor may extend onto the FOM, involve periosteum, invade the inner cortex, or involve medullary bone. Panorex shows gross involvement of bone. Invasion of cortical bone is better assessed with CT scan; MRI is superior for assessing invasion of medullary bone. In the absence of CT scans the surgeon may elect to strip tumor off bone at the time of resection to inspect the underlying bone for evidence of periosteal and tumor infiltration and to decide on how to proceed. If only the periosteum is involved, then a marginal mandibulectomy (removal of cortical bone) will suffice. Should marginal mandibulectomy be considered, then the vertical height of the mandible should be assessed clinically or by Panorex so as to predict whether a free bony composite flap would be required to strengthen the remaining mandible. Once cortex is invaded, then either marginal or segmental mandibulectomy is required. Medullary invasion requires segmental or hemimandibulectomy that includes at least a 2 cm length of mandible on either side of the tumor.
8. ***Is a tracheostomy required?*** One should have a low threshold for tracheostomy. Only patients with small tumors may not require a tracheostomy. Whenever the anterior laryngeal support of the mylohyoid, geniohyoid and genioglossus muscles is lost, and especially when a flap is used to reconstruct a defect, the patient is at risk of airway obstruction and should have a temporary tracheostomy.

Anaesthesia

The surgeon should always stand by during induction of anaesthesia as it may be difficult or impossible to intubate the patient, especially with bulky tumors that involve the BOT and preclude elevation of the tongue to visualize the larynx. Should the anesthetist be unable to intubate the larynx, the surgeon may be able to intubate through a laryngoscope or do an emergency tracheostomy or cricothyroidotomy. Nasal intubation facilitates resection of tongue tumors and may be followed by tracheostomy during the course of the operation.

Perioperative antibiotics are prescribed for 24 hours.

Surgical access

Good surgical access is essential to attain adequate resection margins, to control bleeding, and for reconstruction.

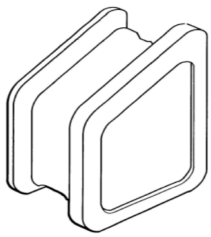


Figure 14: Dental bite block is interposed between lateral teeth to keep mouth open

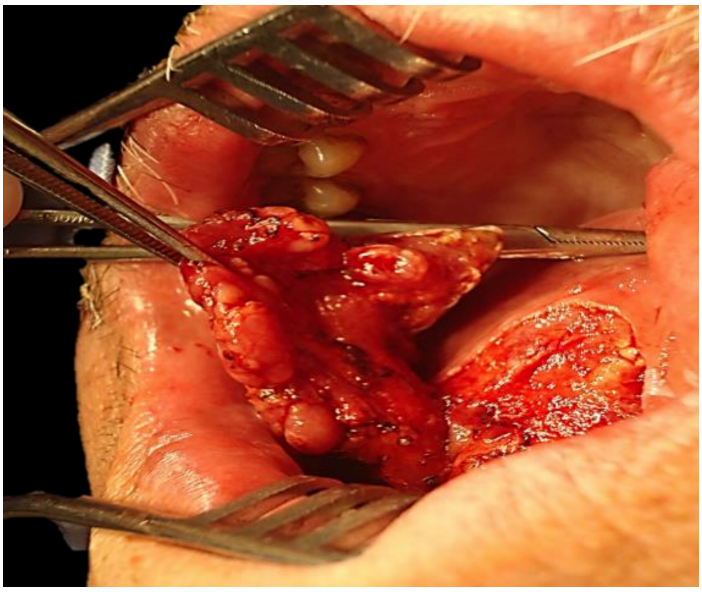


Figure 15: Self-retaining retractor in place

Transoral access: Smaller tumors (T1-T2) are usually easily excised through the open mouth, especially in edentulous patients. The mouth is kept widely open either with a dental bite block (*Figure 14*) or with a self-retaining retractor, taking care to protect the teeth (*Figure 15*).

First doing the marginal mandibulectomy when tumor abuts the mandible greatly facilitates the resection.



Figure 16: Scoring vermillion border for accurate closure

Midline lip-split: The lower lip is vertically divided in the midline after scoring/ marking the vermillion border to ensure an accurate repair of the lip (*Figure 16*).

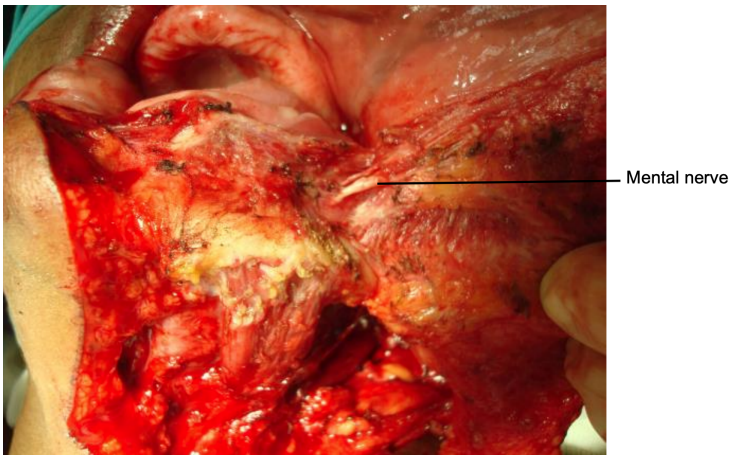
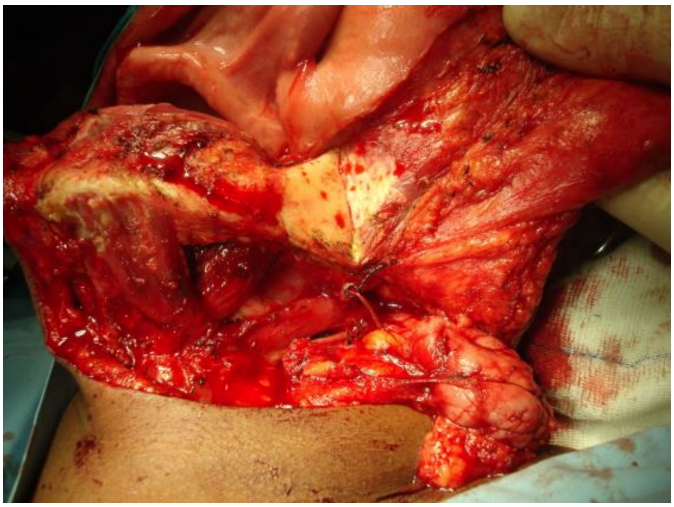


Figure 17: Note preserved mental nerve


Figure 18: Additional bony exposure

Bleeding from the labial artery is controlled with cautery. Incise the gingivolabial and gingivobuccal mucosa >0.5cms from the bone to facilitate subsequent soft tissue closure. Strip soft tissue off the mandible with monopolar cautery taking care (if possible) not to injure the mental nerve where it exits the mental foramen (*Figure 17*). Should the mandible need to be resected beyond the mental foramen, then the nerve is divided, and the tissues stripped from the lateral surface of the bone (*Figure 18*).


Figure 19: Gigli saw

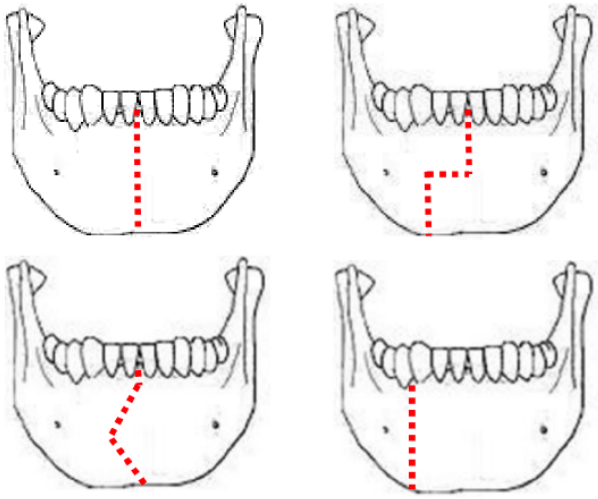


Figure 20: Osteotomy cuts

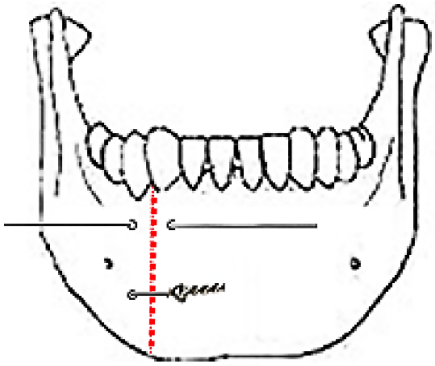


Figure 21: Mandible wired together with stainless steel wire

Mandibulotomy: Dividing the mandible following a midline lip-split affords excellent access to the oral cavity with minimal attendant morbidity. The mandible is divided with a Gigli saw (*Figure 19*) or a powered saw. The osteotomy may be made either vertically or alternatively in a stepor V-shaped fashion so as achieve a more stable repair. The author places the osteotomy just anterior to the mental foramen in lateral tongue cancers (*Figure 20*). Gigli saws make wider cuts than powered saws; hence it is advisable to extract a tooth and make the osteotomy through the dental socket so as avoid devitalizing both adjacent teeth. In dentate patients the mandible is preplated to ensure perfect dental alignment. When plating sets are not available, the mandible is wired together at conclusion of surgery with stainless steel wiring by drilling opposing holes on either side of the osteotomy (*Figure 21*).

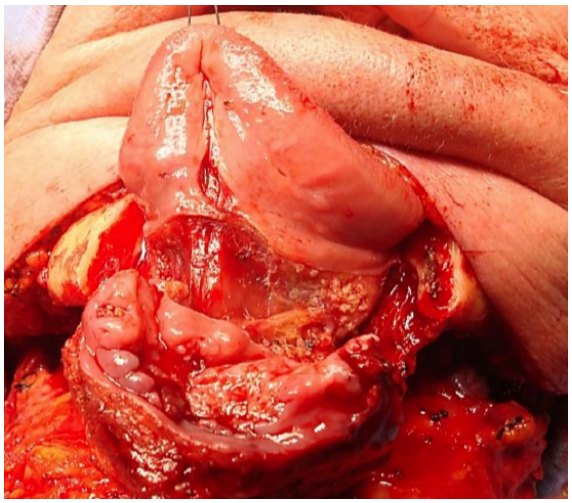


Figure 22: Visor flap and segmental mandibulectomy

Visor flap: This is achieved by cutting along the gingivolabial and gingivobuccal sulci about 0.5 cm from the bone to permit placement of sutures when closing the wound, and then stripping the soft tissues from the outer aspect of the mandible. Take care not to transect the mental nerves if they can be saved. The skin flap is then retracted superiorly to expose the mandible (*Figure 22*).

Pull-through: This may be employed when the tumor stops some distance from the inner aspect of the mandible. Following bilateral neck dissections of Levels 1a and 1b, the mandibular attachments of the anterior bellies of digastric, mylohyoid, geniohyoids and genioglossus are divided with electrocautery working from inferiorly. The mucosa of the FOM adjacent to the tongue tumor is then divided >0.5 cm from the inner aspect of the mandible (to facilitate later repair), taking care not to injure the lingual and XIIns, or the submandibular ducts. This permits the surgeon to deliver the FOM and tongue into the neck and to proceed with the resection.

Partial Glossectomy

Having secured surgical access one can proceed to resect the cancer. Complete Levels 1a and b of the neck dissection(s) before proceeding to the resection; this permits the surgeon to cut through the muscles in the FOM and tongue knowing the location of the XIIn, lingual nerve and lingual artery.

Partial glossectomy only

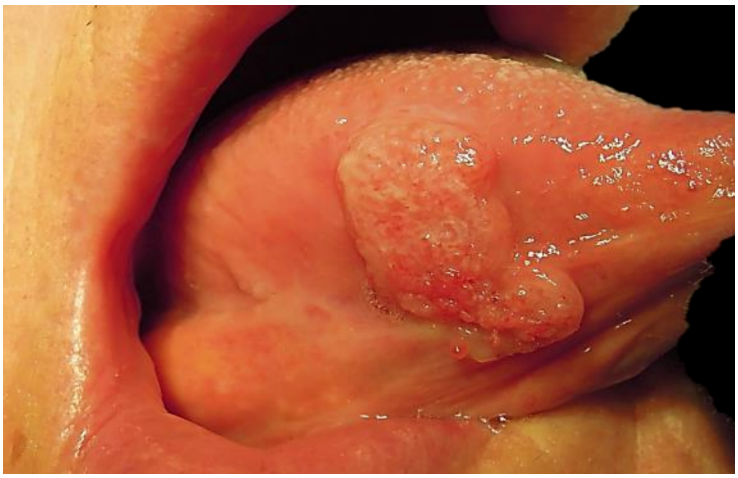


Figure 23: Abundance of uninvolved FOM mucosa permits primary closure without tethering the tongue

A silk stay suture is placed anterior and/or medial to the tumor to retract the normal tongue (*Figure 24b*). Use diathermy to resect the tumor with at least 1 cm margins. Palpate the tumor repeatedly during the resection to ensure that the margins are adequate. Retain as much FOM mucosa as possible to preserve tongue mobility (*Figure 23*).

Maintain haemostasis throughout the resection; cauterise the ranine vessels and ligate the lingual artery with silk when it is encountered. Obtain frozen section confirmation of clear tumor margins if available. Orientate the specimen for the pathologist with a suture before removing the specimen so as to not lose orientation.

Partial glossectomy with mandibulectomy

If a ***marginal*** or ***segmental mandibulectomy*** is required, then it should be done before proceeding to partial glossectomy as it improves surgical exposure. Marginal mandibulectomy is done with a powered oscillating or reciprocating saw; or with ***small sharp*** osteotomes to avoid inadvertently fracturing the mandible. With marginal mandibulectomy the cut is made obliquely to remove the inner cortex ***(including the mylohyoid line)*** that abuts the tumor but to preserve the height of the outer cortex for mandibular strength. If a segmental mandibulectomy is to be done, then ***preplate*** the mandible with a reconstruction plate to ensure alignment of the teeth and a good bony contour. Bone cuts are made at least 2 cm from visible tumor. Once the mandibulectomy has been completed, keep the bone attached to the tumor specimen and divide the gingival mucosa on the inside of the bone cuts; this releases tumor from bone and facilitates delivery of the tumor into the surgical field. Identify and preserve the submandibular duct(s), and the lingual and XIIns if possible. The sublingual gland may be encountered in anterior FOM cancer resections.

Repair / Reconstruction

Obtain ***meticulous hemostasis*** using ties, monopolar and bipolar cautery before closing the tongue defect. Carefully assess the defect to determine how best to ***restore form and function*** i.e. mandibular integrity and contour, oral competence, mastication, oral

transport, swallowing and speech.

Pointers

- Reconstructive surgeons should follow patients long-term to learn how best to optimize functional flap design
- Tongue mobility is key to oral function
- Tongue length is more important than width
- Some defects are best left open to heal by secondary intention to retain mobility
- Avoid tethering the tip of the tongue
- Never suture the edge of the tongue to the gingiva; in such cases maintain tongue mobility with a flap
- Simply shaping a flap to match the resected tissue may well restore form but may have a poor functional result
- Too broad a flap in the FOM causes salivary pooling and adversely affects oral transport
- A marginal mandibulectomy may be done as part of the reconstructive procedure to enable the surgeon to suture the gingivobuccal or gingivolabial mucosa to the FOM mucosa or flap
- Reduce the risk of an orocervical fistula by approximating the mylohyoid to the digastric muscle in the neck, and ensuring that the tip of the suction drain is not placed in the upper neck

No repair: Small and/or superficial resections above the mylohyoid that do not communicate with the neck dissection may be ***left open to heal*** like a tonsillectomy wound. Resist the temptation to suture such defects as it may alter the shape of the tongue or tether the tongue.

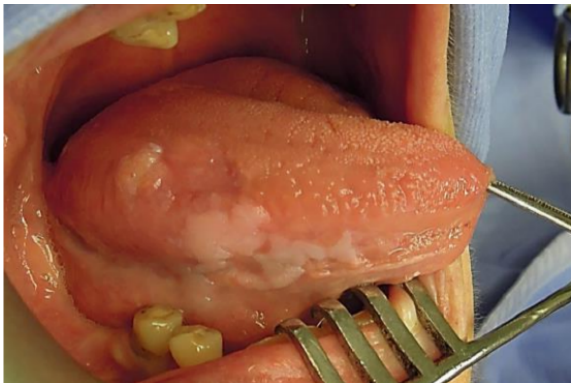


Figure 24a: T2 squamous cell carcinoma of lateral tongue

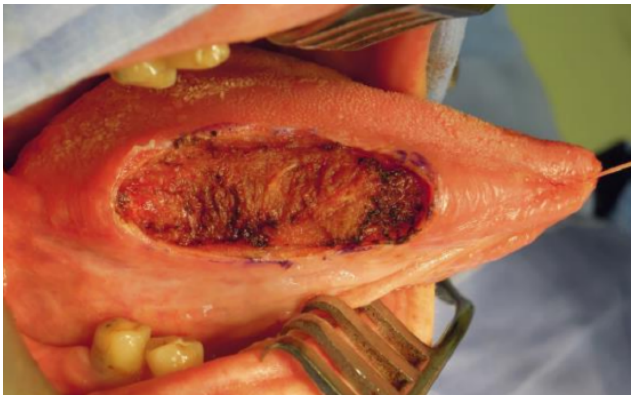


Figure 24b: Defect suitable for no repair or primary closure



Figure 24c: Primary closure with deep absorbable sutures. Abundant FOM mucosa prevents tethering of the tongue



Figure 25a: Defect following primary closure



Figure 25b: Excellent tongue mobility if adequate FOM mucosa preserved

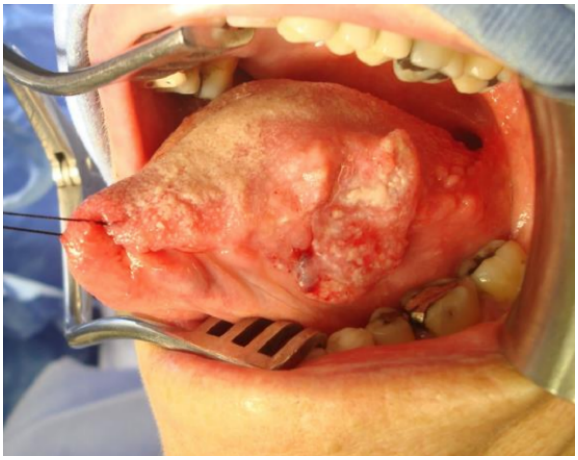


Figure 26a: Larger (T3) cancer of lateral tongue

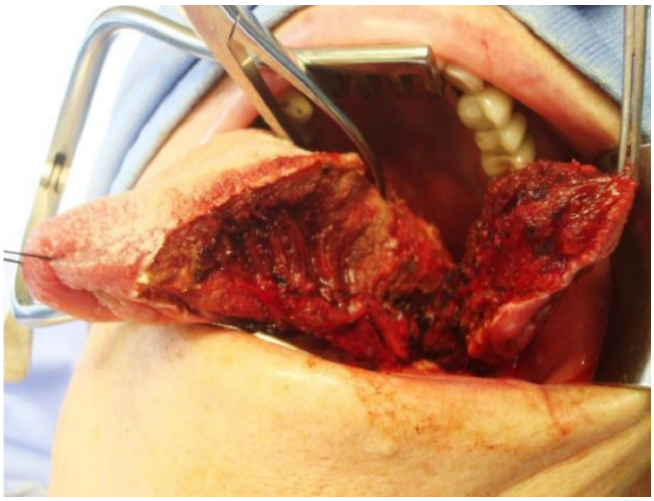


Figure 26b: Hemiglossectomy



Figure 26c: Even though primary closure permitted length and mobility to be retained, this patient may have benefited from additional bulk provided by a buccinator, submental or radial free forearm flap

Primary closure (*Figure 24a-c*): Avoid tethering or distorting the tongue and creating a shortened, stumpy tongue. Preserving FOM mucosa is key to retaining tongue mobility (*Figures 25a,b & 26a-c*).

Split skin graft: There is little point in skin grafting a tongue defect other than when there is concern about sealing a through-and-through communication to the neck, or a marginal mandibulectomy defect. The skin is sutured to the margins of the defect with absorbable sutures, the ends of which are left a few centimeters long. A bolster of antiseptic-impregnated gauze is placed over the skin graft and tied down with the long sutures. The bolster is removed after about 5 days.



Figure 27: Buccinator flap

Buccinator myomucosal flap: (*Figure 27*) This is an excellent flap for partial glossectomy and FOM defects as it has the same physical qualities as tissues of the FOM and oral tongue, has a reasonable amount of bulk, and preserves mobility of the tongue.

Because the pedicle crosses the mandible it is particularly well suited for edentulous patients, patients with missing teeth, or who have undergone marginal mandibulectomy. (See chapter: Buccinator myomucosal flap)

Supraclavicular flap: This has excellent properties for tongue, being thin and pliable like a radial free forearm flap (See chapter: Supraclavicular flap)

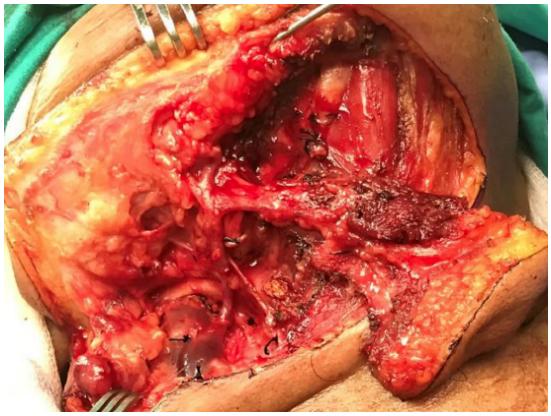


Figure 28a: Submental artery flap on its vascular pedicle



Figure 28b: Flap delivered into mouth

Submental artery island flap: (*Figures 28a, b*) Though this is an option, concerns exist clearing levels 1a and 1b of the neck (See chapter: Submental artery island flap)



Figure 29: Radial free forearm flap

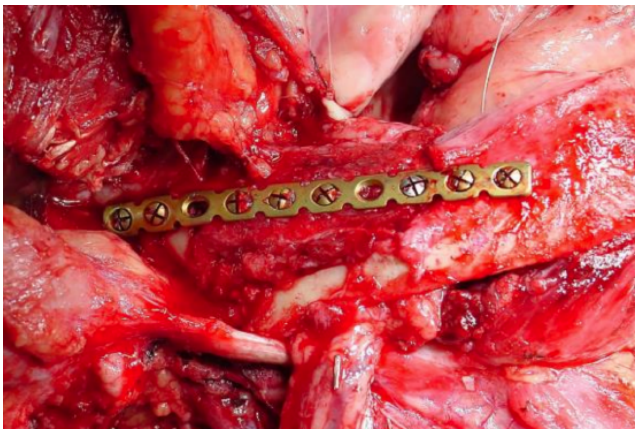


Figure 30: Onlay osseocutaneous flap

Radial free forearm flap: This is a popular choice for the oral tongue as it is thin and pliable and preserves mobility of the tongue (*Figure 29*). An osseocutaneous flap can be used as an onlay graft for marginal mandibulectomy defects (*Figure 30*). (See chapter: Radial free forearm flap)



Figure 31: Anterolateral free thigh flap used for lateral FOM and tongue defect

Anterolateral free thigh flap: (*Figure 31*) Muscle harvested with the flap can be tailored to conform to the volume of the defect to be filled. However, it is less pliable than the radial free forearm flap and is only suitable for oral reconstruction in patients with thin thighs (See chapter: Anterolateral free thigh flap)

Free fibula flap: This is the workhorse of mandible reconstruction following segmental mandibulectomy but can also be used as an onlay flap. It is suitable for dental implants. (See chapter: Free Fibula flap)

Pectoralis major flap: This is only used if other flaps listed are not available as it lacks pliability and provides suboptimal functional results. (See chapter: Pectoralis major flap)

Final comments

Resecting tumors of the tongue is challenging particularly in terms of maintaining oral function. One should not compromise resection margins for function. The surgical team must master an array of reconstructive techniques to secure the best functional outcomes.

Author & Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.37: Base of Tongue Cancer Resection

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Cancers of the base of tongue (BOT) may be treated with primary surgery, and/or irradiation, and/or chemoradiation therapy. Both the oncology team and patient need to carefully weigh up morbidity vs. cure of surgical and nonsurgical options, both of which may cause significant morbidity. Patients need to be carefully assessed relating to their ability to deal with a measure of aspiration, access to speech and swallowing services and to PEG feeding should they not resume oral feeding.

Surgical approaches

Surgeons have to be *au fait* with the full range of surgical approaches and reconstructive options so as to ensure complete resection, minimize morbidity, and optimize speech and swallowing function.

Surgical approaches include the following:

- Transoral
  - Electrocautery (Bovie)
  - CO_2 laser
  - Transoral robotic (TORS)
- External
  - Mandibulotomy with mandibular swing
  - Suprahyoid
  - Lateral pharyngotomy

This chapter focuses on surgical management of BOT cancer other than CO_2 laser and TORS.

Surgical Anatomy

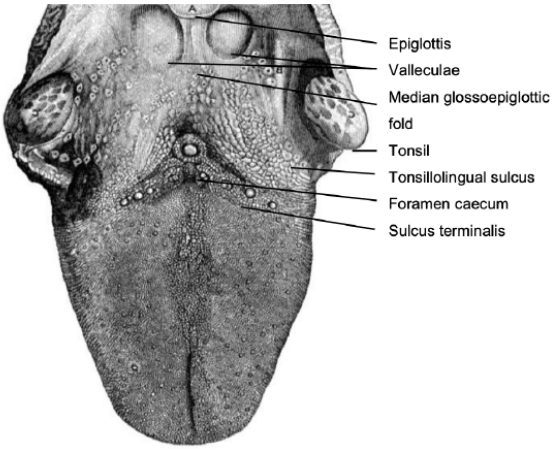


Figure 1: Topography of BOT

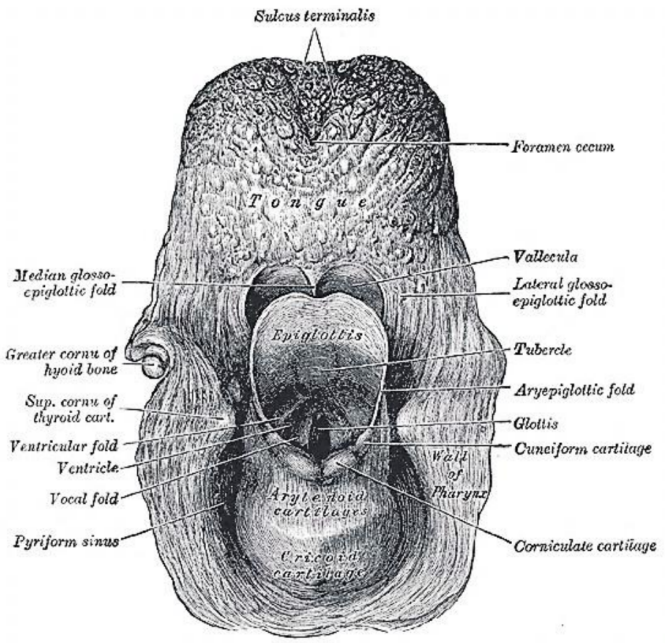


Figure 2: Posterior topographical view of the larynx and BOT

The BOT comprises the posterior 1/3 of the tongue behind the ***foramen caecum*** and ***sulcus terminalis*** (*Figures 1, 2*). The mucosa is rough, thick and fixed to the underlying muscle and contains lymphoid follicles (lingual tonsil); this makes it difficult to identify the edges of a BOT tumor; hence frozen section is especially useful to assess resection margins. Posterolaterally the ***tonsillolingual sulcus*** separates the tongue from the tonsil fossa. The ***valleculae*** separate the base of tongue from the lingual surface of the epiglottis and are divided in the midline by the median glossoepiglottic fold. (*Figures 1, 2*)

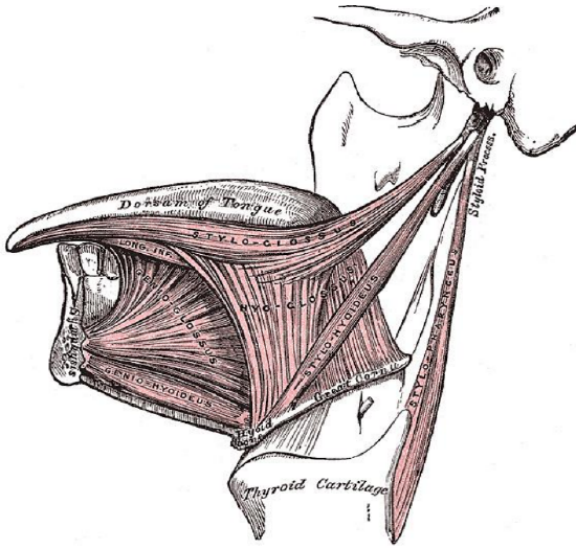


Figure 3: Extrinsic tongue muscles (palatoglossus not shown)

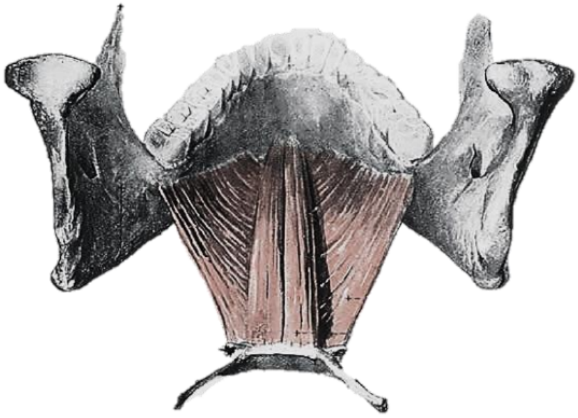


Figure 4: Geniohyoid and mylohyoid muscles

The tongue has ***eight muscles***; four extrinsic muscles (genioglossus, hyoglossus, styloglossus, palatoglossus) control the position of the tongue and are attached to bone (*Figure 3*); four ***intrinsic*** muscles modulate the shape of the tongue and are not attached to bone. Below the tongue are the ***geniohyoid*** and ***mylohoid muscles***; the mylohyoid muscle serves as the diaphragm of the mouth and separates the tongue and FOM from the submental and submandibular triangles of the neck (*Figures 3*, *4*).

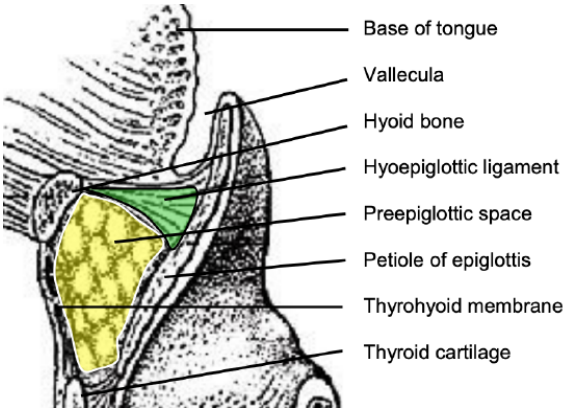


Figure 5: Sagittal view of posterior relations of BOT and preepiglottic space (yellow)

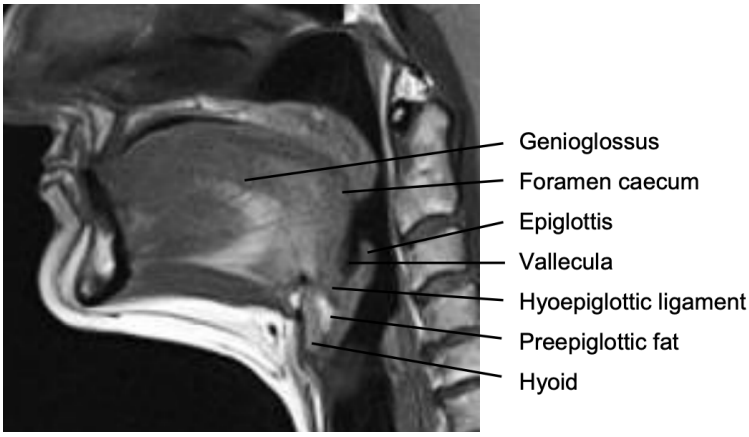


Figure 6: Midline sagittal view of tongue

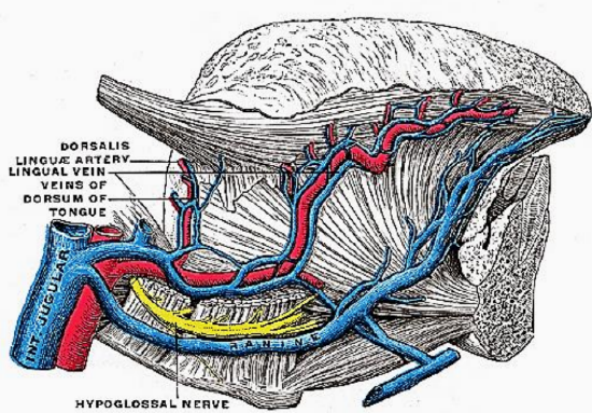


Figure 7: XIIn accompanied by the ranine veins

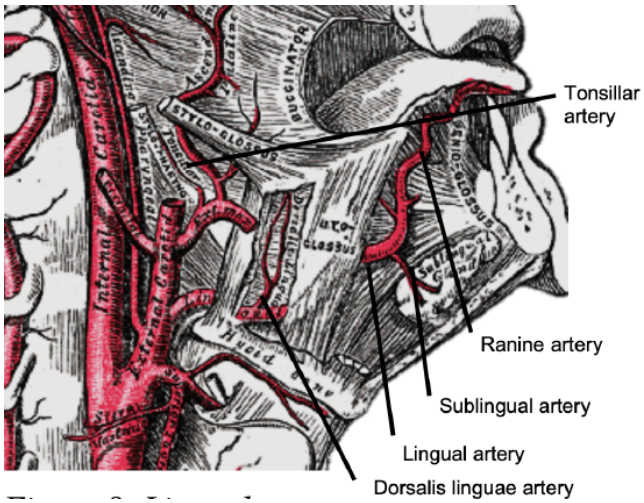


Figure 8: Lingual artery

Posteriorly, the ***hyoid bone*** and ***preepiglottic space*** are important anatomical structures, an understanding of which is key to assessing whether the larynx can be preserved when using a suprahyoid surgical approach (*Figures 5, 6*). Most of the ***tongue muscles attach to the hyoid bone*** (*Figures 3, 4*); the ***lingual artery and hypoglossal nerve (XIIn) pass medial*** to the greater cornu of the hyoid (*Figures 7, 8*). The hyoid bone forms the anterior boundary of the ***preepiglottic space***; the superior boundary is the hyoepiglottic ligament (floor of vallecula), and the posterior border is formed by the petiole of the epiglottis (*Figures 5, 6*).

The ***arterial supply*** of the BOT is derived from the paired ***lingual arteries*** and its posterior (dorsalis linguae) branches (*Figures 7, 8*). Additional supply to the BOT emanates from the ***tonsillar branch of the facial artery*** and the ***ascending pharyngeal artery***. In practice the ***lingual arteries are the only vessels that have to be looked for*** during BOT resection as they are easily injured; it is ***important to preserve at least one lingual artery*** to avoid infarction of the tongue. (The author has had one case where sacrifice of a single lingual artery led to necrosis of half the tongue; this is however unusual as there is usually adequate crossflow).

The ***lingual artery*** originates from the external carotid artery between the superior thyroid and facial arteries and courses obliquely forwards and medial to the greater cornu of the hyoid (*Figures 7, 8*). It then loops downward and anteriorly and passes medial to XIIn and the stylohyoid muscle. It then courses directly anteriorly and deep to the hyoglossus and finally ascends submucosally on the undersurface of the tongue as far as its tip as the ***ranine artery*** (profunda linguae); it lies to either side of the genioglossus and is accompanied by the lingual nerve. Two or three small ***dorsalis linguæ*** arteries arise beneath the hyoglossus and ascend to the posterior part of the dorsum of the tongue and also supply the mucous membrane of the posterior floor of mouth (FOM) and oropharynx (*Figures 7, 8*).

Venous drainage is via ***lingual*** and ***ranine veins*** (*Figure 7*). The ***lingual veins*** originate on the dorsum, sides, and undersurface of the tongue and accompany the lingual artery and join the internal jugular vein. The ranine veins originate below the tip of the tongue and are visible on its ventral surface; they accompany the XIIn as venae comitantes and either join the lingual vein or pass lateral to hyoglossus to join the common facial vein.

An understanding of the ***nerve supply*** is important to preserve oral function. All intrinsic and extrinsic muscles are innerveted by the ***XIIn*** except for palatoglossus which is innervated by ***Xn***. The ***IXn*** provides somatic afferent and taste sensation to the posterior 1/3 of the tongue. The ***lingual nerve*** provides general somatic sensation to the anterior 2/3 of the mouth and FOM; taste is provided by the chorda tympani branch of ***VIIn*** via the lingual nerve.

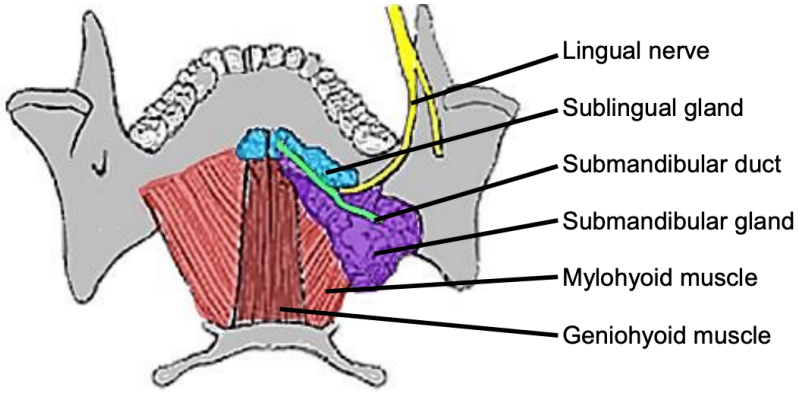


Figure 9: Superior view of FOM, submandibular gland and duct, lingual nerve and mylohyoid and geniohyoid muscles

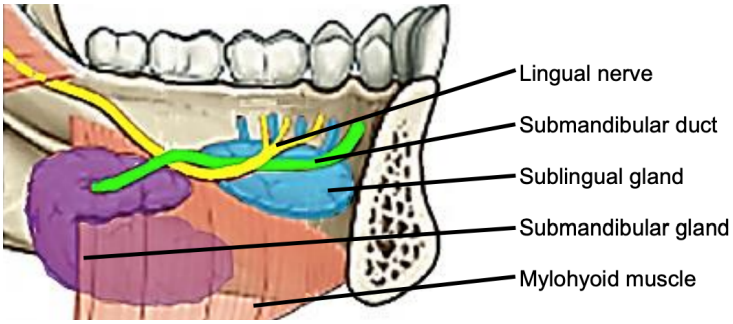


Figure 10: Intraoral view of left sublingual gland with ducts of Rivinus, submandibular gland and duct, lingual nerve and mylohyoid muscles

The lingual nerve is at risk when using a mandibular swing approach to resect tumors of the BOT. The nerve crosses deep to the submandibular duct in the lateral FOM; in the anterior FOM it is located posterior to the duct (*Figures 9, 10*).

The remainder of this chapter focuses on surgical resection of cancers of the BOT.

Surgical Objectives

- Adequate tumor ***resection margins***; this requires a surgical approach that permits good exposure
- ***Surgical morbidity*** should be kept to a minimum relating to swallowing, aspiration, speech, mandibulotomy, lingual nerve function and voice (laryngectomy is required in selected cases to avoid aspiration)
- ***Control occult cervical metastasis; both sides of the neck are electively treated*** because of a significant risk of having bilateral occult cervical metastases; the author generally does bilateral elective neck dissection (END) levels I-IV for squamous cell carcinoma of the BOT

Key surgical points

- ***Oral or transnasal intubation*** may be difficult or impossible
- Select a surgical approach(es) that ensures ***adequate exposure***; transoral access is often inadequate
- The surface of the BOT is firm and irregular making it difficult to determine margins; employ ***frozen section*** to control resection margins
- ***Preserve tongue function***
  - ***Preserve at least one XIIn***; sacrificing both nerves is crippling from speech and swallowing perspectives
  - ***Preserve at least one lingual artery*** to avoid infarction of the tongue
  - Preserve ***sensation*** with the mandibular swing approach by preserving the lingual nerve
- ***Avoid/minimize aspiration***; this may necessitate total laryngectomy in selected cases

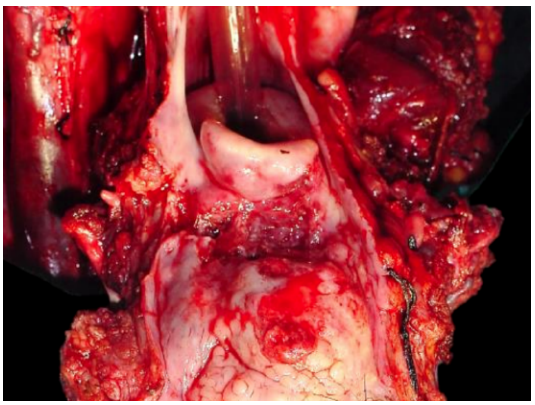


Figure 11: BOT cancer invading vallecula, pre-epiglottic space and epiglottis and requiring total laryngectomy

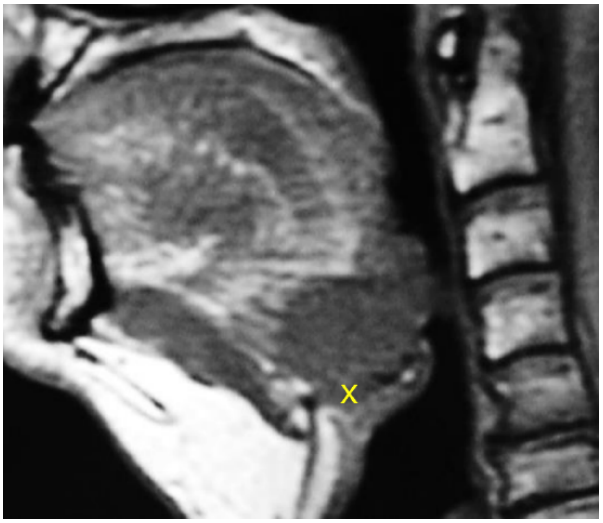


Figure 12: BOT cancer invading and replacing the pre-epiglottic space (x)

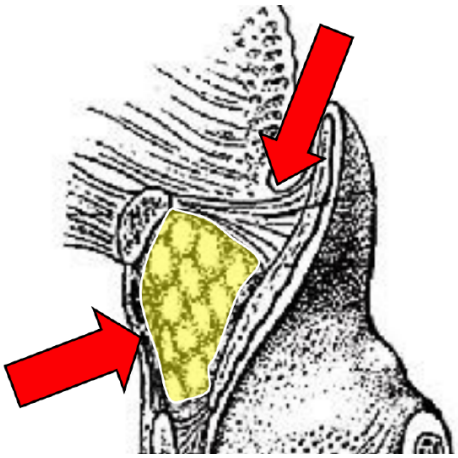


Figure 13: Digital palpation for involvement of pre-epiglottic space

1. ***Are there synchronous primaries, cervical or distant metastases?*** CXR or CT chest, and panendoscopy
2. ***Is the tumor resectable?*** BOT cancer may be irresectable if it invades the parapharyngeal space and carotid sheath or extends anteriorly to necessitate total glossectomy in patients not prepared to undergo such surgery. It may be difficult to assess the extent of the primary due to pain, tenderness or trismus. If in doubt, a patient requires imaging such as CT/MRI, or examination under anesthesia.
3. ***Is laryngectomy required?*** Invasion of the pre-epiglottic space or epiglottis generally indicates a need for laryngectomy to permit swallowing without aspiration (*Figure 11*). Invasion of the pre-epiglottic space is best assessed with MRI / CT scan in a sagittal plane (*Figure 12*). Invasion of the pre-epiglottic space can also be assessed intraoperatively by palpating the pre-

epiglottic space between a finger placed in the vallecula and a finger placed on the skin of the neck just above/below the hyoid bone; fullness is indicative of tumor in the pre-epiglottic space (*Figure 13*).

4. ***Is reconstruction required?*** Restoring BOT bulk with soft tissue flaps may improve speech; however, having an insensate flap ***may impair swallowing***. Therefore, filling the defect with a flap should only be done in selected cases.
5. ***Can the patient tolerate aspiration?*** Physical fitness, pulmonary reserve, and cognitive function should be considered when selecting patients for major resections and reconstructions as such surgery may be complicated by a variable measure dysphagia and aspiration, especially if followed by chemoradiation.
6. ***Status of dentition?*** Carious teeth should be removed at the time of the surgery to avoid osteoradionecrosis.
7. ***Is a tracheostomy required?*** Almost all patients require temporary tracheostomy.

Anesthesia

The ***surgeon always stands by the patient during induction*** of anesthesia as it may be ***difficult or impossible to intubate*** a patient with a bulky BOT tumor that precludes elevation of the tongue to visualize the larynx. Should the anesthetist be unable to intubate the larynx, the surgeon may be able to intubate with a laryngoscope or do an emergency tracheostomy or cricothyroidotomy; it is prudent to inject the tracheostomy or cricothyroidotomy site with local anesthetic with adrenaline prior to induction. Nasal intubation facilitates resection of BOT tumors and is converted to a tracheostomy during the course of the operation.

Perioperative antibiotics are prescribed for 24 hours.

Surgical access

Good surgical access is essential in order to attain adequate resection margins, to control bleeding, and for reconstruction. A combination of open surgical approaches can be used and will now be discussed. ***Level 1 of the neck should first be dissected*** if neck dissection is indicated before proceeding to address the primary tumor.

Transoral access with electrocautery (Bovie) resection



Figure 14: Laterally located BOT cancer suited to transoral resection

The adequacy of transoral access to the BOT varies considerably. A useful way to predict whether transoral resection is likely to be possible is to pull on the anterior tongue with a cotton swab during preoperative clinical evaluation and to then see how accessible the tumor is. Note that ***tumors become more visible and accessible as the resection proceeds***, especially once the thick BOT lining has been incised around the tumor. Laterally placed BOT cancers, especially in edentulous patients, are more amenable to trans-oral access (*Figure 14*).

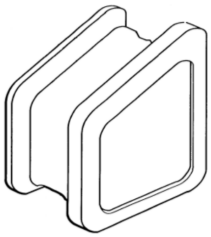


Figure 15: Dental bite block is interposed between lateral teeth to keep mouth open

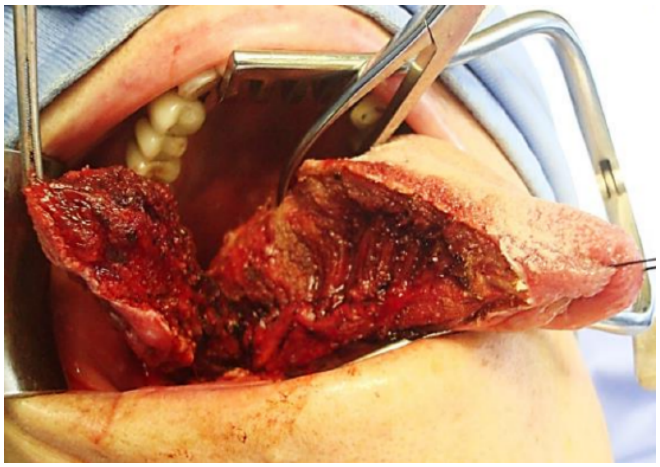


Figure 16: Self-retaining retractor; lateral oral and BOT tumor being resected

The mouth is kept wide open either with a dental bite block (*Figure 15*) or with a selfretaining retractor, taking care to protect the teeth from injury (*Figure 16*). Apply traction to tongue and tumor with silk traction sutures or with tissue forceps (*Figure 16*).

Resect the tumor with at least a 1 cm margin of normal tissue using electrocautery (Bovie). As the resection proceeds posteriorly, insert new silk traction sutures or move the tissue forceps more posteriorly to facilitate delivery of the tumor into the mouth.

Transoral access with median glossotomy

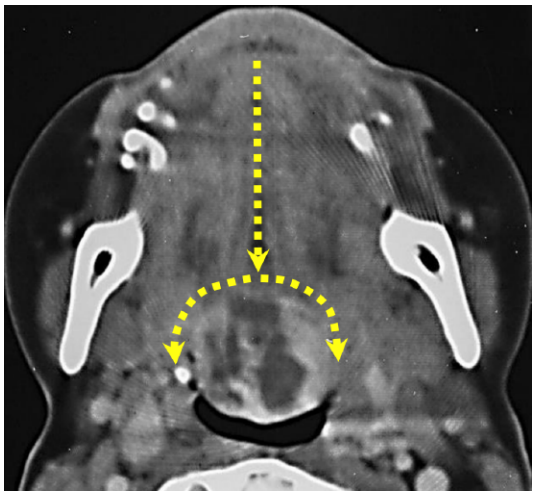


Figure 17: Median glossotomy for lingual thyroid

Midline BOT tumors may be exposed by bisecting the tongue along the median raphe with electrocautery (*Figure 17*); it is a relatively avascular plane as the vessels and nerves all course laterally, and results in little, if any, functional deficits. The incision can be carried posteriorly up to the hyoid bone if needed.

Mandibulotomy with mandibular swing

This affords excellent access to the BOT. It is especially well suited to cancers that extend anteriorly to involve the oral tongue (*Figure 14*), or onto the soft palate. It does however leave a facial scar; it may cause deformity of the lower lip; there is a risk of complications relating to the mandibulotomy and dental malocclusion; and the lingual nerve is at risk of injury.



Figure 18: Scoring vermillion border for accurate closure

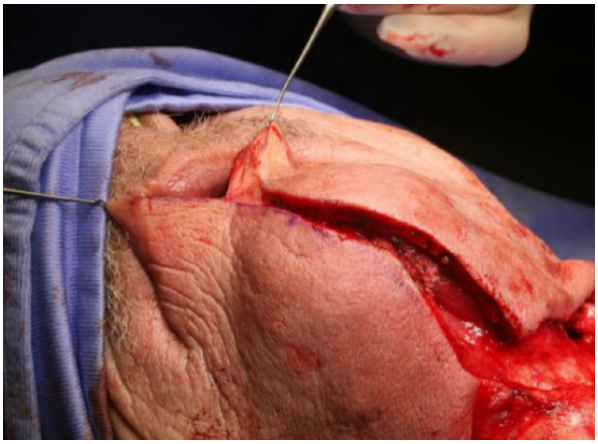


Figure 19: Lip-split incision down to bone

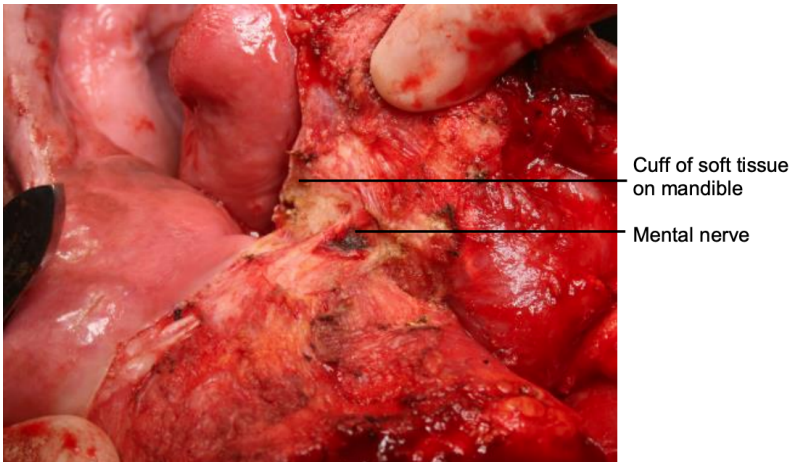


Figure 20: Note preserved mental nerve and cuff of soft tissue

The vermillion border is scored or marked to ensure an accurate repair (*Figure 18*). The lower lip is divided vertically in the midline (*Figure 19*). Bleeding from the labial artery is controlled with cautery. Incise the gingivolabial and gingivobuccal mucosae >0.5 cm from the bone leaving a cuff of soft tissue on the bone to facilitate subsequent soft tissue closure (*Figure 20*). Strip soft tissue off the mandible with monopolar cautery or with a periosteal elevator up to the mental foramen, taking care not to injure the mental nerve where it exits the foramen (*Figure 20*).



Figure 21: Gigli saw

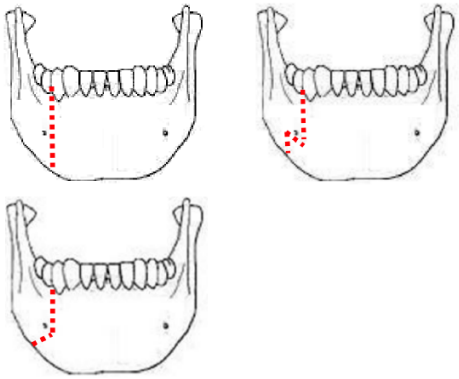


Figure 22: Examples of osteotomies

The mandible is divided just anterior to the mental foramen with a Gigli or a powered saw (*Figure 21*). The osteotomy may be made vertically or alternatively in a stepor V-shaped fashion to achieve a more stable repair (*Figure 22*). It is advisable to extract a tooth and make the osteotomy through the dental socket so as avoid devitalizing adjacent teeth. In dentate patients the mandible is preplated with titanium miniplates contoured to the mandible so as to ensure perfect dental alignment. Two 4- holed, non-compression, 2 mm mandibular plates, one placed along the inferior border of the mandible, and the other placed more superiorly are used. Once the plates have been contoured and the holes drilled, they are removed and the bone cut is made.

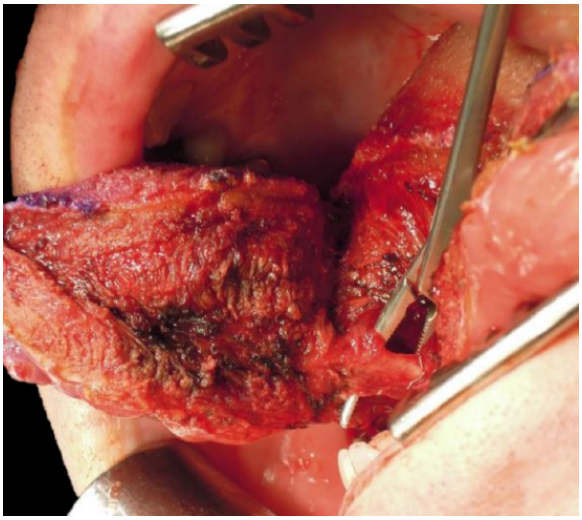


Figure 23: Lingual artery

The surgeon then distracts the cut ends of the mandible to gain access to the oral cavity and proceeds to divide the floor of mouth (FOM) mucosa and mylohyoid muscle about 1 cm from, and parallel to, the mandible, so as to leave soft tissue on the mandible for the subsequent FOM repair at conclusion of surgery. Continue the incision posteriorly along the FOM until the tumor comes into view; the lingual artery (medial to the hyoglossus muscle) and the XIIn course medial to the FOM incision are not at risk of injury at this stage of the dissection. The tumor is resected using electrocautery. The lingual artery may have to be ligated (*Figure 23*).

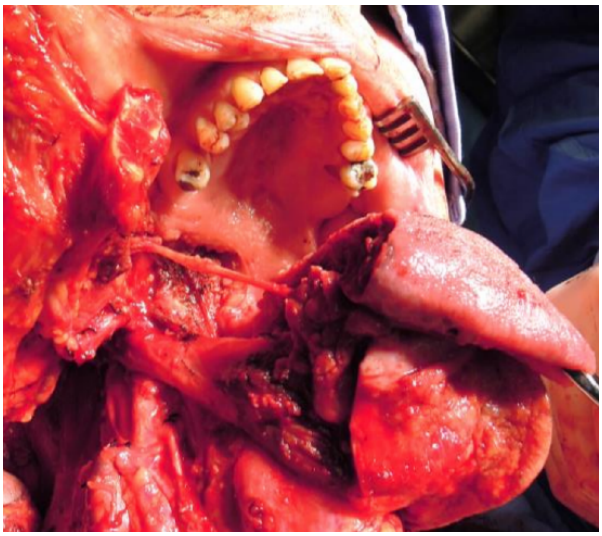


Figure 24: Note wide exposure afforded by mandibulotomy approach to the base of tongue and oropharynx, and the preserved lingual nerve crossing the surgical field

Posteriorly the ***lingual nerve*** extends from the skull base and crosses the line of the incision from lateral to medial to course along the lateral FOM; preserve the nerve if possible (*Figure 24*).

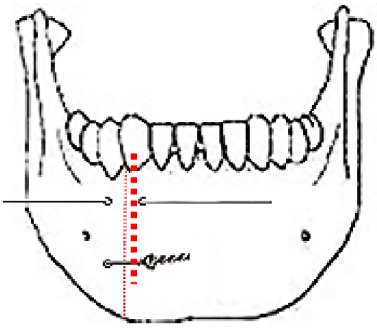


Figure 25: Mandible wired together with stainless steel wire

At conclusion of surgery the FOM is closed with a running vicryl suture, and the osteotomy is plated; when plating sets are not available, opposing holes are drilled on either side of the osteotomy and the mandible is wired together with stainless steel wiring (*Figure 25*). The lip is carefully repaired in layers to approximate the muscles as well as mucosa and skin.

Suprahyoid approach

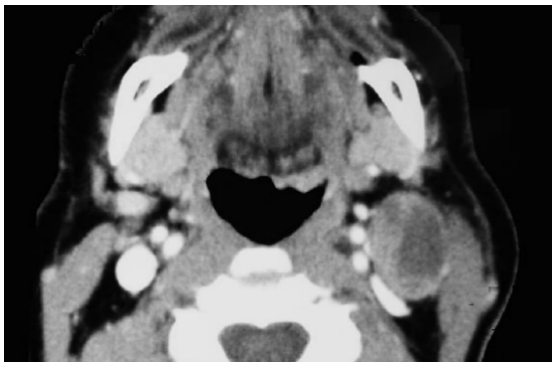


Figure 26: BOT cancer with cystic metastasis suited to suprahyoid approach

This is one of the external approaches favored by the author. It is similar to the suprahyoid dissection step during total laryngectomy. It is well suited to most BOT cancers (*Figure 26*), although access is limited with cancers that extend far anteriorly into the tongue.

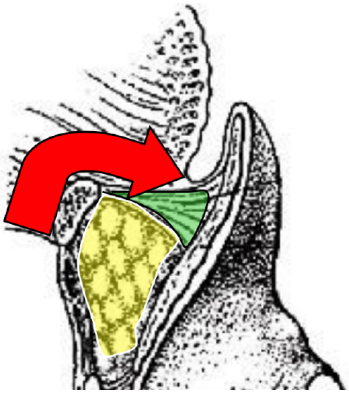


Figure 27: Red arrow indicates suprahyoid access to BOT (hyoepiglottic ligament colored green)

Because the pharynx is entered through the vallecula, it is ***not suited*** to cancers that involve the apex of the vallecula, preepiglottic space or epiglottis (*Figure 11*). ***Following completion of Levels 1a and b of the neck dissection(s)***, the superior aspect of the body of the hyoid bone is skeletonized with electrocautery, keeping the dissection between the lesser cornua of the hyoid bone. The dissection is carried posteriorly above the hyoepiglottic ligament, which forms the roof of the preepiglottic fat (*Figure 27*). The vallecula is entered at its apex (*Figure 27*).

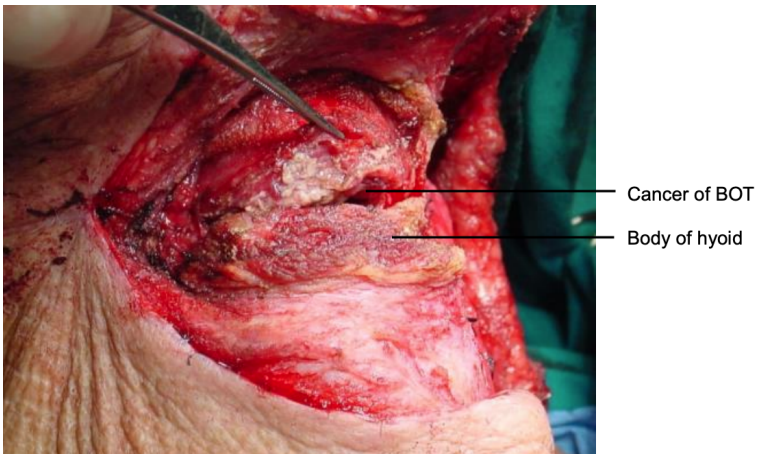


Figure 28: Initial entry into vallecula

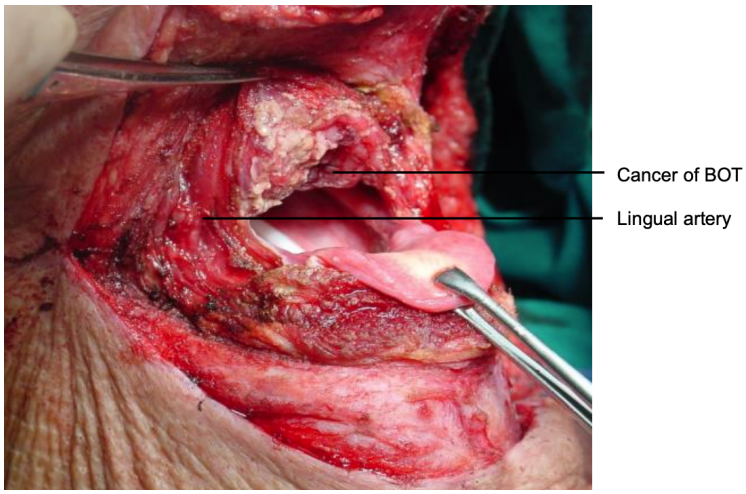


Figure 29: Note wide access to epiglottis, BOT and posterior wall of pharynx

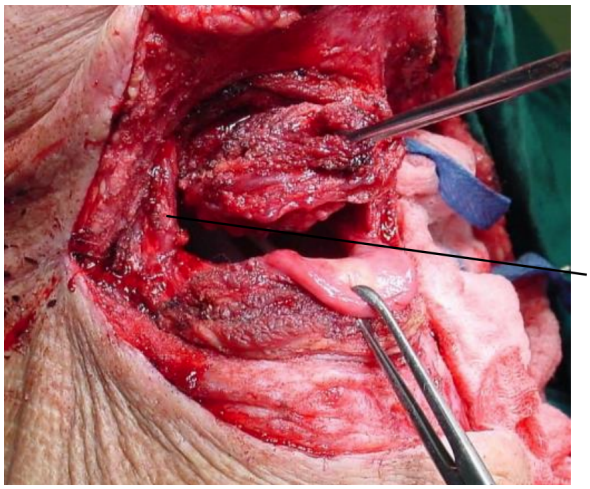


Figure 30: BOT cancer resection

The tumor now comes into view. The cancer is resected with electrocautery (*Figures 28-30*). Take care to identify and preserve the ***lingual arteries*** and, if dissecting even more laterally, the ***XIIn*** (*Figures 29, 30*). Tumor exposure improves as the thick BOT lining is incised to either side of the tumor making the tumor more mobile (*Figure 30*).

Orientate the specimen for the pathologist with a suture before removing the specimen so as not to lose orientation. The adequacy of the resection margins is checked with frozen section if available.

Primary closure can almost always be done by approximating the BOT resection margin to the vallecula with a running vicryl suture. The supra- and infrahyoid muscles are then sutured together and the neck is closed in the usual fashion.

A ***temporary tracheostomy*** is done, and a nasogastric feeding tube is inserted. Once the airway appears adequate the tracheostomy tube is corked for 24 hours before being removed.

Lateral pharyngotomy combined with suprahyoid approach

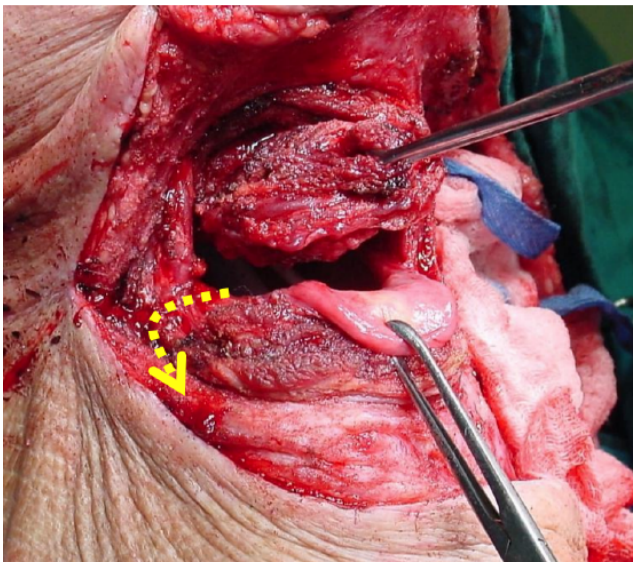


Figure 31: Additional access by lateral pharyngotomy extension (Yellow arrow)

Additional exposure can be obtained by extending the incision along the greater cornu of the hyoid bone and along the posterior margin of the thyroid cartilage; take special care to identify and not to injure the XIIn, the lingual artery or the superior laryngeal nerve (*Figure 31*).

Pull-through approach

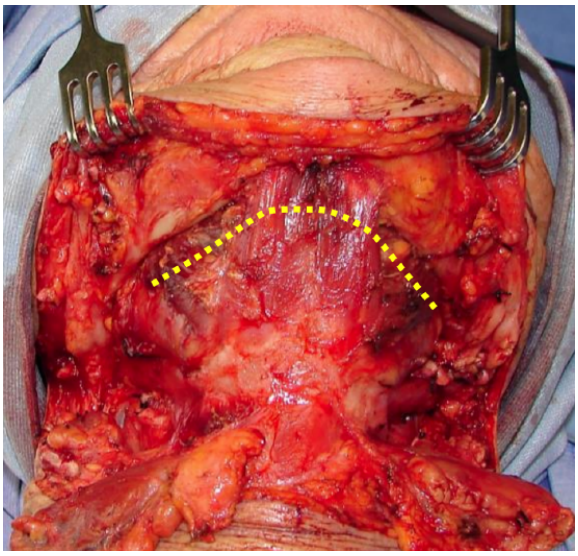


Figure 32: Incision for pull-through approach (Yellow line)

This may be employed when tumor stops some distance from the inner aspect of the mandible. The mucosa of the lateral and anterior FOM is divided >0.5 cm from the inner aspect of the mandible (to facilitate later repair), taking care not to injure the lingual and XIIns, or the submandibular ducts. Following bilateral neck dissections of Levels 1a and 1b, the mandibular attachments of the anterior bellies of digastric, mylohyoid, geniohyoids and genioglossus are divided with electrocautery working from inferiorly (*Figure 32*). This permits the surgeon to drop the FOM and tongue into the neck and to proceed with the resection. At conclusion of surgery the FOM mucosa and muscle are reapproximated with vicryl sutures.

Repair / Reconstruction

Obtain meticulous haemostasis using ties, monopolar and bipolar cautery before closing the defect. Primary closure of BOT defects gives the best swallowing function although inadequate bulk impairs speech if the BOT cannot approximate the soft palate. Simply shaping a flap to match the resected tissue may well restore form but may have a poor functional result. Therefore one must carefully assess the defect to determine how best to optimize swallowing and speech.

Radial free forearm flap: This is a thin and pliable flap and preserves mobility of the tongue but has limited bulk.

Anterolateral free thigh flap: Muscle harvested with the flap can be tailored to conform to the volume of the defect to be filled. However, it is less pliable than the radial free forearm flap and is only suitable for oral reconstruction in patients with thin thighs.

Pectoralis major flap: This is a good option to use

Buccinator myomucosal flap: A posteriorly based buccinator flap can be used to close a small orocervical communication following resection of a lateral BOT cancer.

Submental artery island flap: The bulk of the flap can be increased by including mylohyoid and digastric if needed.

Supraclavicular flap: This is a thin and pliable flap and preserves mobility of the tongue but has limited bulk.

Final comments

Resecting tumors of the BOT is challenging particularly in terms of access and maintaining swallowing function. One should not compromise resection margins for function. The surgical team must master an array of surgical approaches and reconstructive techniques to ensure the best oncological and functional outcomes.

Author & Editor

Johan Fagan
MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.38: Total Glossectomy for Tongue Cancer

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Total glossectomy has significant morbidity in terms of intelligible speech, mastication, swallowing, and in some cases, aspiration. Consequently, many centers treat advanced tongue cancer with chemoradiation therapy and reserve surgery for treatment failures. Total glossectomy is however a very good primary treatment for carefully selected patients, especially in centers that do not offer chemoradiation. Key surgical decisions relate to whether the patient will cope with a measure of aspiration, and whether laryngectomy is required.

Surgical Anatomy

The tongue merges anteriorly and laterally with the ***floor of mouth (FOM)***, a horseshoe-shaped area that is confined peripherally by the inner aspect (lingual surface) of the mandible. Posterolaterally the ***tonsillolingual sulcus*** separates the tongue from the tonsil fossa. Posteriorly the ***vallecula*** separates the base of tongue from the lingual surface of the epiglottis.

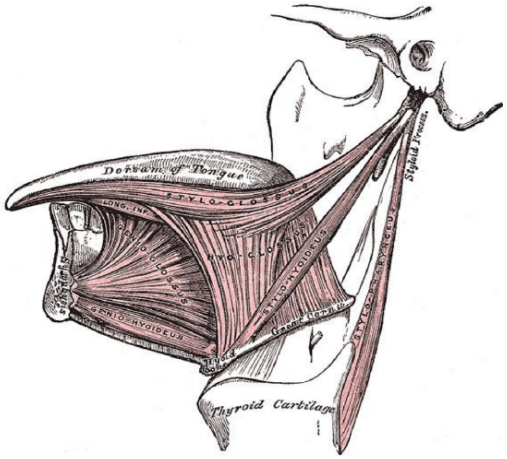


Figure 1: Extrinsic tongue muscles (palatoglossus not shown)

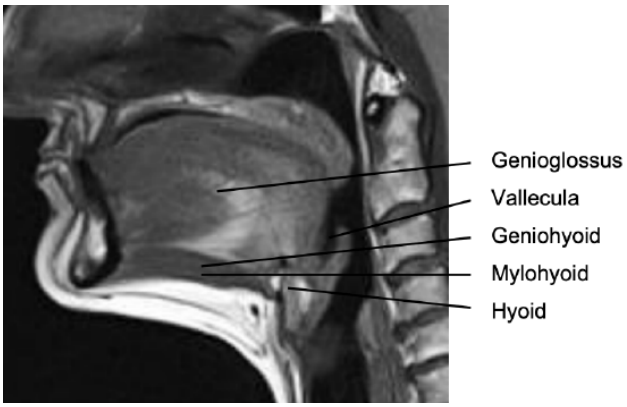


Figure 2: Midline sagittal view of tongue

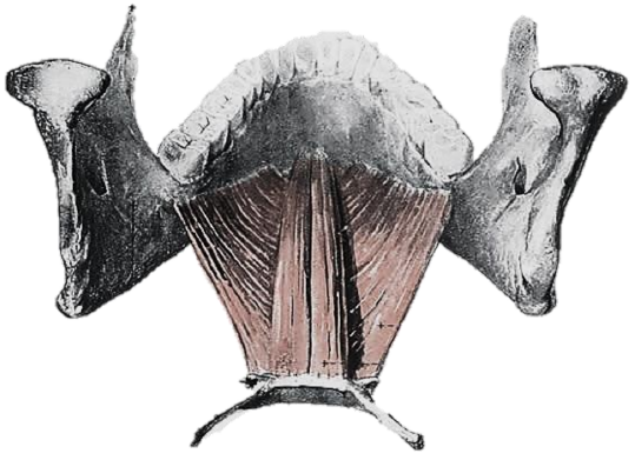


Figure 3: Geniohyoid and mylohyoid

The tongue comprises ***eight muscles***. Four ***extrinsic*** muscles (genioglossus, hyoglossus, styloglossus, palatoglossus) control the position of the tongue and are attached to bone (*Figures 1*, *2*); four ***intrinsic*** muscles modulate the shape of the tongue and are not attached to bone. Below the tongue are the ***geniohyoid*** and the ***mylohoid muscles***; the mylohyoid muscle serves as the diaphragm of the mouth and separates the tongue and FOM from the submental and submandibular triangles of the neck (*Figures 1*, *2*, *3*).

Vasculature

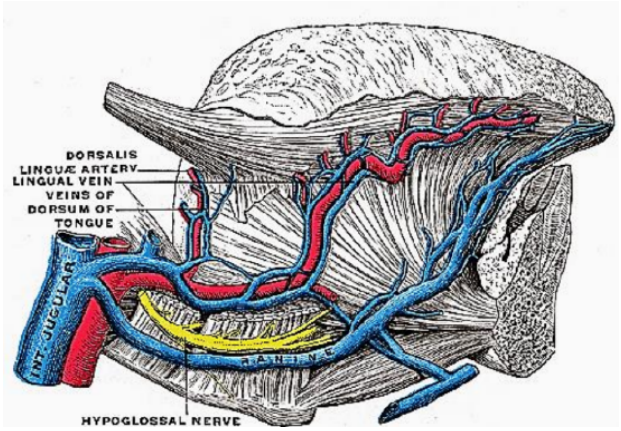


Figure 4: XIIn accompanied by ranine veins

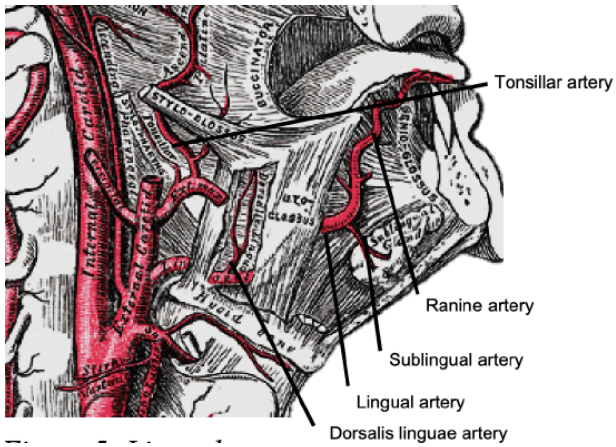


Figure 5: Lingual artery

The tongue is a very vascular organ. The ***arterial supply*** is derived from the paired ***lingual arteries*** and their branches ***(ranine artery, dorsalis linguae, and sublingual arteries)*** (*Figures 4*, *5*); and the ***mylohyoid*** artery and the ***submental*** branch of the ***facial***

artery. Additional blood supply to the tongue emanates from the ***tonsillar branch of the facial artery and the ascending pharyngeal artery***.

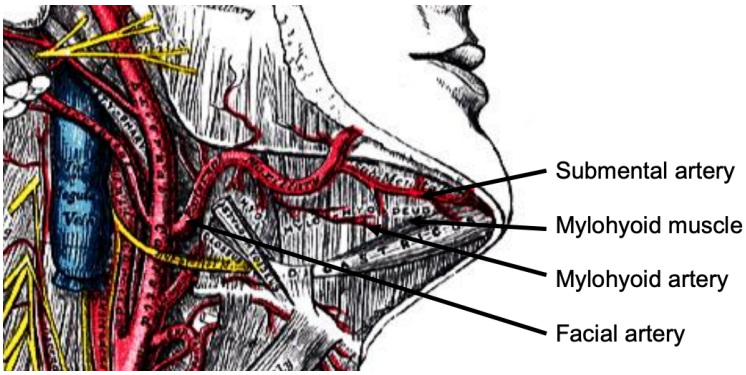


Figure 6: Facial artery emerges from behind posterior belly of digastric (removed), and gives rise to a few branches including submental artery

The ***lingual artery*** originates from the external carotid between the superior thyroid and facial arteries and courses obliquely forwards and medial to the greater cornu of the hyoid (*Figures 4, 5*). It then loops downward and anteriorly and passes medial to hypoglossal nerve (XIIn) and the stylohyoid muscle. It then courses directly anteriorly and deep to the hyoglossus and finally ascends submucosally on the undersurface of the tongue as far as its tip as the ***ranine artery*** (profunda linguae); it lies to either side of the genioglossus and is accompanied by the lingual nerve. Two or three small ***dorsales linguæ*** arteries arise beneath the hyoglossus and ascend to the posterior part of the dorsum of the tongue and also supply the mucous membrane of the posterior FOM, and oropharynx (*Figure 4*). The ***sublingual artery*** branches from the lingual artery at the anterior edge of the hyoglossus and runs forward between the genioglossus and mylohyoid and supplies the sublingual salivary gland and mucous membrane of the FOM and gingiva (*Figure 5*). A branch of the ***sublingual artery*** pierces the mylohyoid muscle and anastomoses with the submental branch of the facial artery in Level 1b of the neck. The ***submental branch*** of the facial artery courses along the inferior, inner margin of the mandible (*Figures 6*).

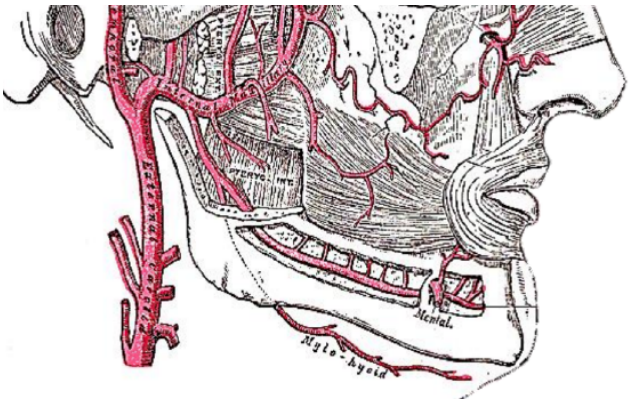


Figure 7: Mylohyoid artery is a branch of the inferior alveolar artery

The ***mylohyoid artery*** and vein are encountered when the surgeon elevates the submandibular gland from the lateral surface of the mylohyoid (*Figure 7*). It branches off the inferior alveolar artery just before it enters the mandibular foramen, crosses the mylohyoid, and disappears anteriorly behind the digastric. It has connections with the submental artery and via a defect in the mylohyoid with the sublingual artery in the FOM.

Venous drainage is via ***lingual*** and ***ranine veins***. The lingual veins originate on the dorsum, sides, and undersurface of the tongue and accompany the lingual artery and joinsthe internal jugular vein. The ***ranine veins*** originate below the tip of the tongue and are visible on its ventral surface; they accompany the XIIn as venae comitantes and either join the lingual vein or pass lateral to hyoglossus to join the common facial vein (*Figure 4*).

Structures surrounding the tongue

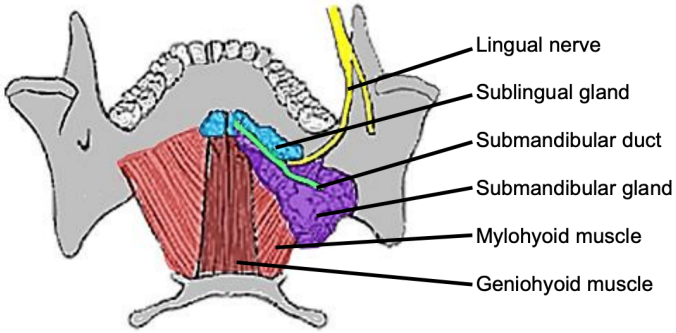


Figure 8: Superior view of FOM, submandibular gland and duct, lingual nerve and mylohyoid and geniohyoid muscles

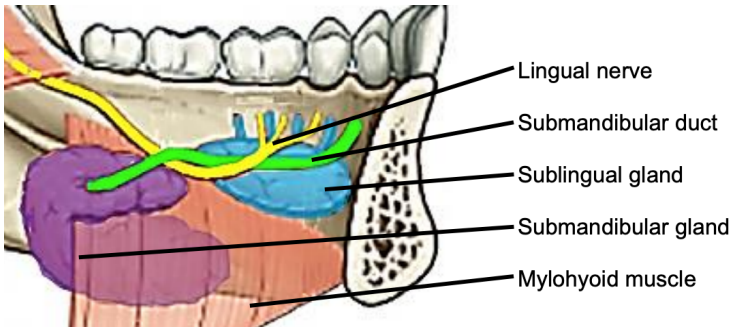


Figure 9: Intraoral view of left sublingual gland with ducts of Rivinus, submandibular gland and duct, lingual nerve and mylohyoid muscles

The following structures are located between the mucosa and the mylohyoid muscle: paired ***geniohyoid muscles*** in the midline (*Figure 3*); ***sublingual salivary glands*** (*Figure 8, 9*), ***submandibular ducts*** (*Figures 8, 9*), oral component of submandibular salivary glands (*Figures 8, 9*), and the ***lingual*** and ***XIIns***. The paired ***sublingual salivary glands*** are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles.

The ***submandibular duct*** is located immediately deep to the mucosa of the anterior and lateral FOM and opens into the oral cavity to either side of the frenulum (*Figures 8, 9*).

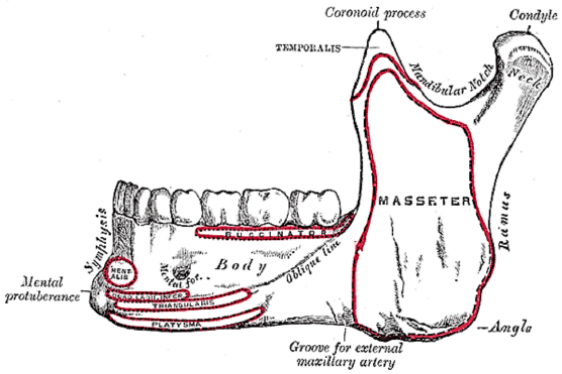


Figure 10a: Attachments of muscles to outer aspect of mandible and location of mental foramen

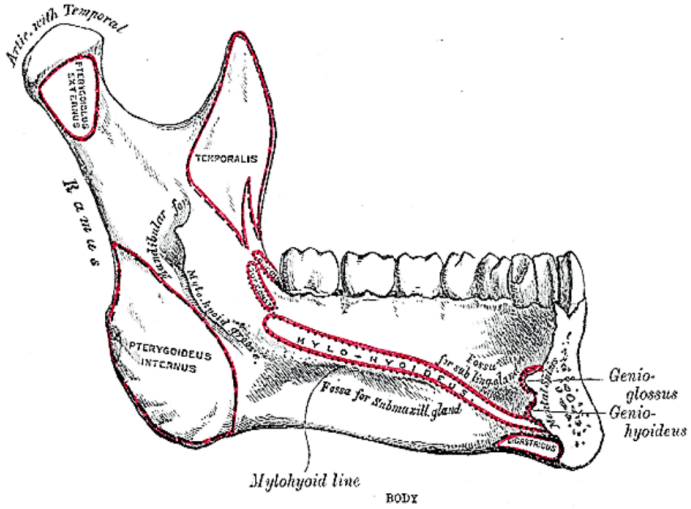


Figure 10b: Attachments of mylohyoid, geniohyoid, genioglossus and digastric muscles to inner aspect of mandible

The ***mandible*** borders the FOM and may be involved by tumor and may have to be divided for access (mandibulotomy) or resected (alveolectomy / marginal mandibulectomy / segmental mandibulectomy / hemimandibulectomy). Important surgical features are the position of the mental foramina through which the mental nerves exit to innervate the lower lip; the mylohyoid line to which the mylohyoid muscle attaches, the attachment of the genioglossus, and when planning a marginal mandibulectomy, the height of the body of the mandible and the depth of the dental roots (*Figures 10a, b*).

In older, edentulous patients the mental foramen and inferior alveolar nerve may be very close to the superior surface of a resorbed mandible. A marginal mandibulectomy may also not be possible in such a resorbed mandible due to the lack of residual bone.

Surgical Objectives

- Adequate resection margins
- Minimize aspiration
  - Preserve some base of tongue (BOT) tissue if possible
  - Suspend hyoid from mandible
  - Total laryngectomy for selected cases
- Avoid pooling of secretions and food in the oral cavity
- Avoid a permanent PEG tube
- Adequate speech and articulation
- Control regional metastases: The author advocates bilateral ***elective neck dissection (END)*** levels I-IV for advanced tongue carcinoma

Preoperative evaluation

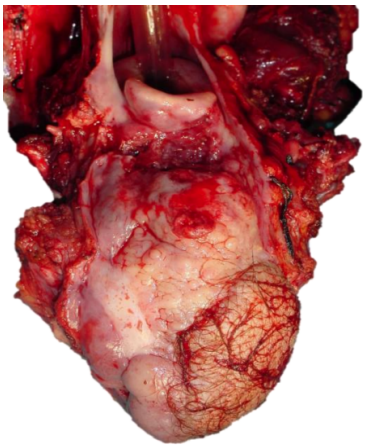


Figure 11: 2nd tongue cancer involving vallecula and epiglottis and requiring total glossectomy with laryngectomy

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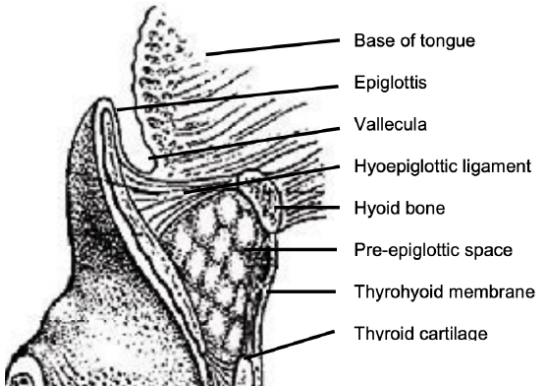


Figure 12: Relationships of hyoid, epiglottis, vallecula, and preepiglottic space

1. ***Are there synchronous primaries, or cervical and distant metastases?*** CXR or CT chest, panendoscopy, CT-PET
2. ***Is the tumor resectable?*** It may be difficult to assess the extent of the primary due to pain, tenderness or trismus; if in doubt, a patient requires imaging such as CT/MRI, or examination under anesthesia.
3. ***Can the patient tolerate aspiration?*** Physical fitness, pulmonary reserve, and cognitive function should be considered when selecting patients for total glossectomy especially if to be followed by chemoradiation as a measure of aspiration is inevitable.
4. ***Is total laryngectomy required?*** Laryngectomy is indicated in patients who are unlikely to tolerate a degree of aspiration, and when tumor extends to the pre-epiglottic space and/or epiglottis (*Figure 11*). Pre-epiglottic space involvement is diagnosed radiologically on CT or MRI (sagittal views); or intraoperatively by palpating for thickening of the pre-epiglottic space between a finger placed in the vallecula and a finger placed on the skin of the neck just below the hyoid bone (*Figure 12*). If in doubt, consent the patient for possible total laryngectomy based on intraoperative surgical and frozen section findings.
5. ***Is there evidence of perineural invasion (PNI) of major nerves?*** Examine the patient for neurological deficits of the XIIn, mental, inferior alveolar and lingual nerves. Widening of the inferior alveolar canal on mandibular orthopantomography (panorex) may be seen with involvement of the inferior alveolar nerve. MRI may demonstrate PNI. Should there be evidence of PNI then the affected nerve is dissected proximally until a clear tumor margin is obtained on frozen section.
6. ***Mandible***: Tumor may extend across the FOM to involve the periosteum, invade the inner cortex, or involve medullary bone. Panorex shows gross involvement of bone. Invasion of cortical bone is better assessed with CT scan; MRI is superior for assessing involvement of medullary bone. If only the periosteum is involved then a marginal mandibulectomy (removal of cortical bone) will suffice. Should marginal mandibulectomy be considered, then the vertical height of the mandible should be assessed clinically or by panorex to predict whether a free bony composite flap would be required to bolster the remaining mandible. Once the cortex is invaded, then either marginal or segmental mandibulectomy is required. Once the medulla is invaded, then segmental or hemimandibulectomy is done that includes at least a 2 cm length of mandible on either side of the tumor.
7. ***Is tracheostomy required?*** Patients routinely require a temporary tracheostomy for possible airway compromise related to bleeding, soft tissue swelling, a bulky flap and loss of anterior laryngeal suspension following division of the mylohyoid, geniohyoid and digastric muscles.
8. ***Type of reconstruction?*** It is essential to have a bulky flap to create a convex floor of mouth so as to avoid pooling of secretions and to facilitate articulation.
9. ***Status of dentition?*** Carious teeth should be removed at the time of surgery to prevent osteoradionecrosis.

Anesthesia

The surgeon should always stand by during induction of anesthesia as bulky tumors may preclude elevation of the tongue to visualize the larynx and it may be difficult or impossible to intubate the patient. Should the anesthetist be unable to intubate the larynx, the surgeon may be able to intubate through a laryngoscope or do an emergency tracheostomy or cricothyroidotomy. Nasal intubation facilitates resection of tongue tumors, and may be followed by tracheostomy during the course of the operation. The author employs nasogastric as opposed to PEG feeding. Perioperative antibiotics are prescribed for 24 hours.

Intraoperative evaluation

Panendoscopy is done to exclude synchronous tumors of the upper aerodigestive tract. Reassess the extent of the primary cancer, especially for posterior and lateral extension, as well as reassess the neck for cervical metastases.

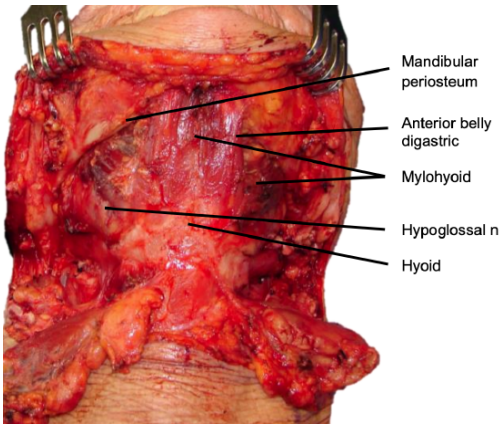


Figure 13: Exposure following bilateral SND

Complete the bilateral neck dissections before resecting the primary tumor (*Figure 13*).

Good surgical access is essential in order to attain adequate resection margins, to control bleeding, and for reconstruction. The author's preference of a combination of transcervical and transoral access will be described. Others prefer a midline lip-spit incision with mandibulotomy (See chapter: Partial glossectomy).

Cervical dissection

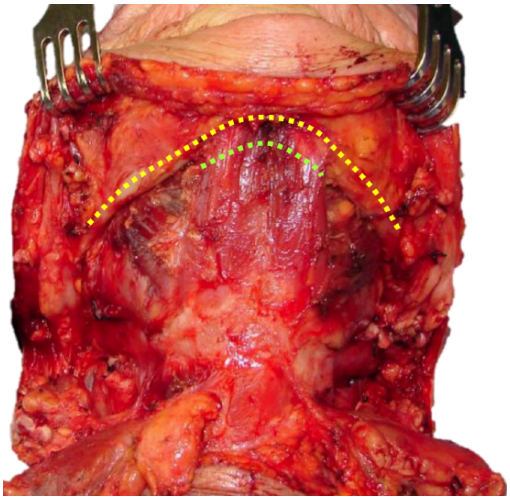


Figure 14: Incise periosteum along lower margin of mandible from angle to angle (yellow line), and divide anterior bellies of digastric (green line)

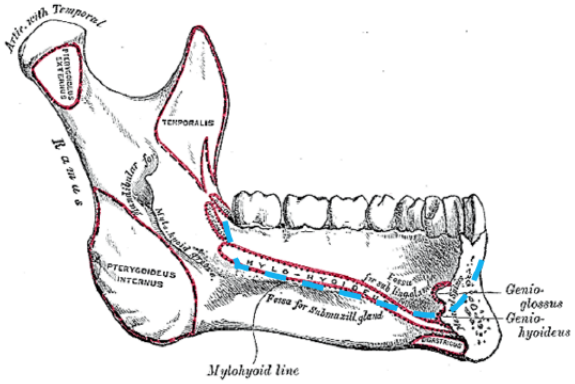


Figure 15: Mylohyoid line and attachments of geniohyoid and genioglossus to inferior and superior mental spines; blue line indicates marginal mandibulectomy

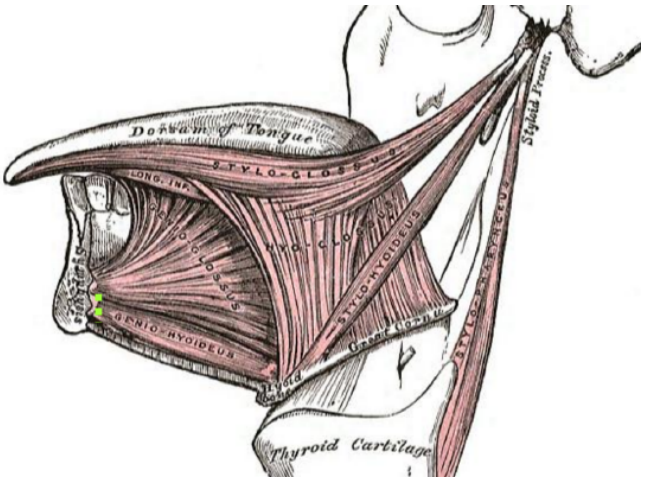


Figure 16: Divide geniohyoid at its attachment to the inferior spine of the mandible

Incise the periosteum along the inferior margin of the mandible from angle-to-angle and divide the anterior bellies of digastric and the mylohyoid with electrocautery (*Figure 14*). Then strip the soft tissues off the medial aspect of mandible in a subperiosteal plane. If tumor does not extend to the lateral FOM, then strip beyond the mylohyoid line to free mylohyoid from bone (*Figure 15*). Free the geniohyoid muscle from the inferior mental spine (*Figures 15, 16*).

Transoral dissection

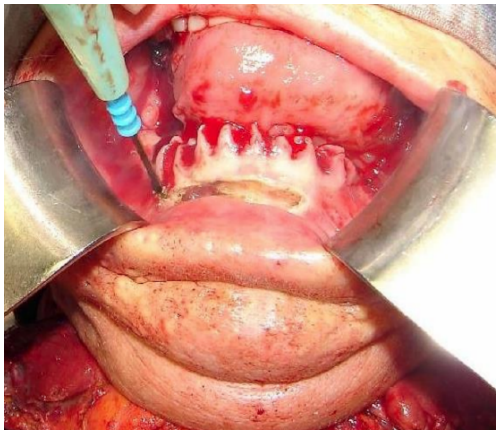


Figure 17: Incise along gingival margin

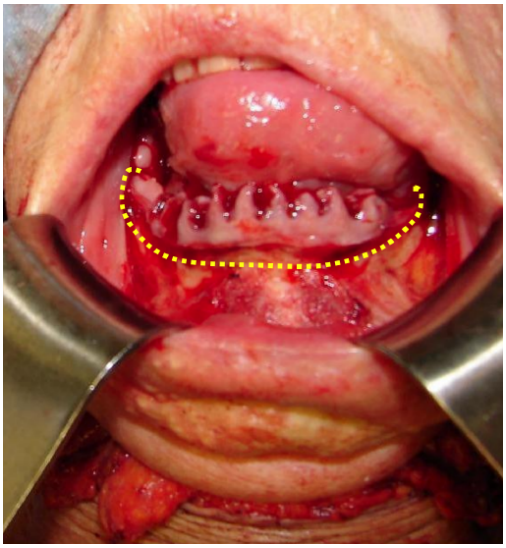


Figure 18: Cut along dotted line with a power saw

First doing a marginal mandibulectomy when tumor abuts the mandible greatly facilitates the tongue resection. Incise the gingival mucosa along the alveolar ridge (*Figure 17*). Strip the soft tissue off the mandible with monopolar cautery; limit exposure of the anterior surface of the mandible in order to maintain its blood supply (*Figure 18*). Take care (if possible) not to injure the mental nerve where it exits the mental foramen.

Perform a marginal mandibulectomy along the superior aspect of the horizontal ramus of the mandible as indicated in *Figure 18*.

Angle the cut to include the mylohyoid line; this is especially important if tumor extends to the lateral FOM and abuts bone (*Figures 15, 19*). Not only does the marginal mandibulectomy have oncological relevance in terms of resection margins, but it avoids the sump effect of having a concavity along the medial border of the mandible as will become apparent later in the chapter.

Glossectomy

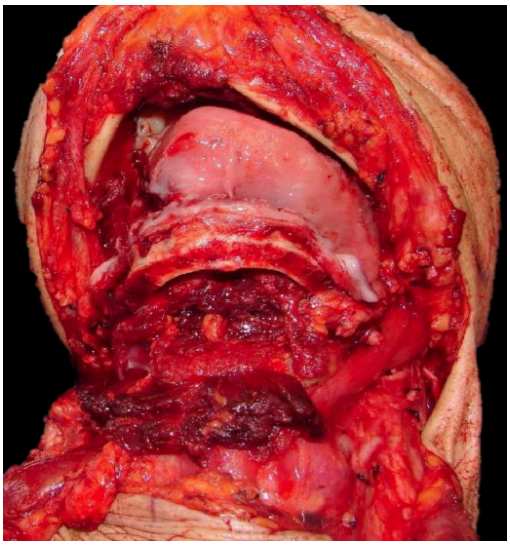


Figure 19: Marginal mandibulectomy, FOM and tongue dropped into neck

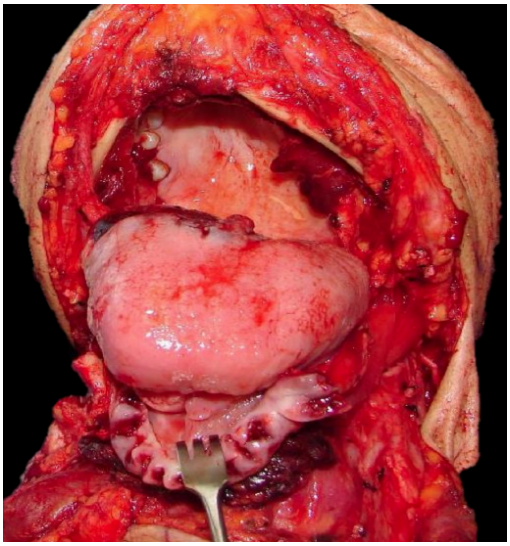


Figure 20: Transcervical resection under excellent vision

The marginal mandibulectomy, FOM and tongue are delivered into the neck (*Figure 19*). This permits the surgeon to resect the tongue with excellent exposure of the cancer and the vallecula (*Figure 20*).



Figure 21: Resected cancer with marginal mandibulectomy

Preserve as much BOT mucosa as possible to facilitate swallowing. The specimen is examined for adequacy of resection margins, and sent for frozen section if available (*Figure 21*).

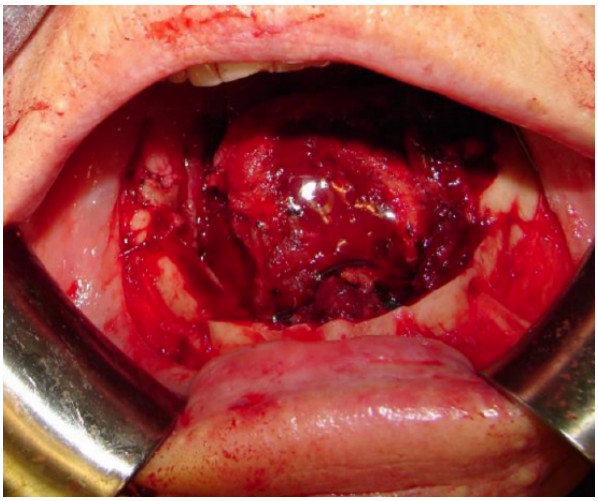


Figure 22: Small amount of residual base of tongue

An assessment is then made about the need for total laryngectomy based on the location of the posterior margin; should the epiglottis and pre-epiglottic fat be uninvolved and the patient is mentally and physically fit enough to tolerate some aspiration, then one can proceed to reconstructing the defect (*Figure 22*).

Reconstruction

The ***key functional elements*** of reconstruction are that the flap have enough bulk to create a convex floor of mouth so as to avoid pooling of secretions and to facilitate articulation, and that the hyoid be suspended from the mandibular arch to facilitate breathing and swallowing.

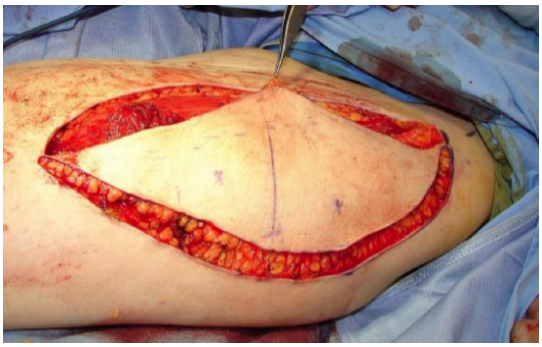


Figure 23: Large anterolateral thigh flap

A ***range of flaps*** will provide adequate tissue volume i.e. pectoralis major, latissimus dorsi, anterolateral free thigh or rectus abdominis free flaps (*Figure 23*). Radial free forearm flaps should not be used as they have inadequate bulk and result in a concave floor of mouth and a sump that interferes with deglutition and causes pooling and spillage of saliva and food. Mandibulectomy may necessitate free fibula flap reconstruction.

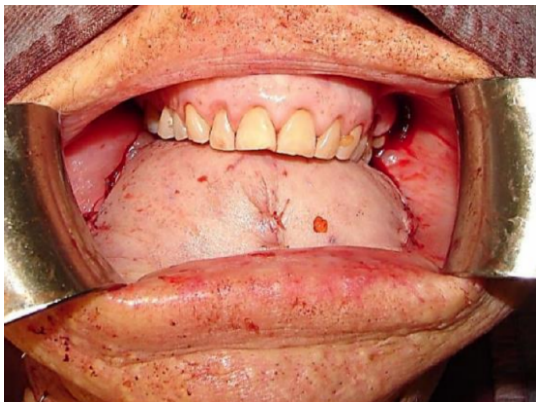


Figure 24: Large flap creates convex FOM



Figure 25: Long-term result of pectoralis major flap used to create a convex FOM



Figure 26: Reconstructed tongue with preserved dentition

The flap should be ***large enough so that it bulges up to the hard palate*** with the knowledge that it will flatten out with time (*Figures 23, 24, 25*). The edges of the flap are sutured to the gingivobuccal and gingivolabial mucosae with continuous vicryl sutures (*Figure 24*). The aesthetic benefit of preserving the lower teeth needs to be weighed up against the fact that the teeth have limited functional value in the absence of a functioning tongue and that the lateral FOM will serve as a sump for saliva and food (*Figure 26*).

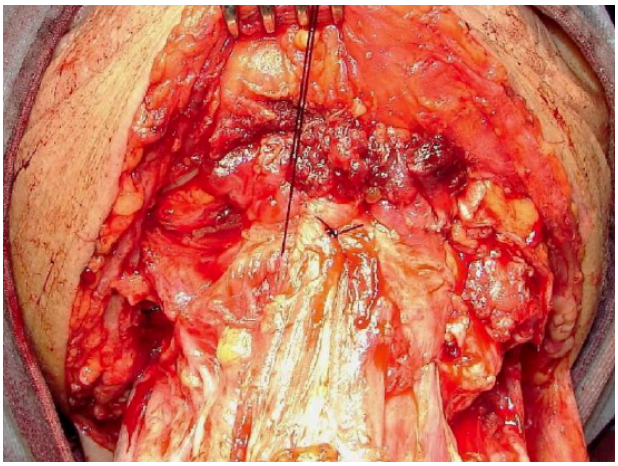


Figure 27: Laryngeal suspension

Laryngeal suspension is required to facilitate swallowing and to avoid obstructive sleep apnoea as all attachments of the larynx to the mandible have been severed (anterior bellies of digastric, mylohyoid, geniohyoids and genioglossus). This is achieved by suspending the hyoid bone from the anterior arch of the mandible with thick non-absorbable sutures (*Figure 27*).

Closure

The neck is closed over suction drains. A tracheostomy is done.

Postoperative management

Once the patient is thought to have an adequate airway, the tracheostomy is initially corked overnight before being removed. The speech and swallowing therapist subsequently assists the patient with swallowing. Because of the absence of oral transport, this involves taking thickened liquids and pureed food initially being placed in the back of the mouth with a syringe or spoon until the patient learns to throw the head back and use gravity to assist with the oral transport phase of swallowing.

Total glossectomy with total laryngectomy

The operation is done in exactly the same manner other than the laryngectomy which is added to the procedure.

Author & Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.39: Oropharyngeal Cancer Resection

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Eugene Myers

Management of cancer of the oropharynx has undergone a paradigm shift in recent years following the realization that HPV infection is both an etiologic and prognostic factor for a subset of oropharyngeal squamous cell carcinoma; the introduction of transoral robotic surgery (TORS) to resect oropharyngeal tumors; as well as attempts to reduce the morbidity of chemoradiation by accepting smaller resection margins when combined with postoperative irradiation.

This chapter describes transoral and transmandibular resection of cancer of the oropharynx; it does not address the debate of the relative merits of chemoradiation vs. transoral excision using electrocautery, CO2 laser or robotics vs. open resection. Readers are referred to other chapters in the Open Access Atlas of Otolaryngology, Head & Neck Operative Surgery for detailed descriptions of Transoral laser microsurgery (TLM), Transoral lateral oropharyngectomy/radical tonsillectomy, and Resection of cancers of the base of tongue.

Surgical anatomy

The oropharynx is comprised of the base of the tongue, tonsils, soft palate, and the lateral and posterior walls of the pharynx between the levels of the hard palate and hyoid bone.

Base of the tongue (BOT)

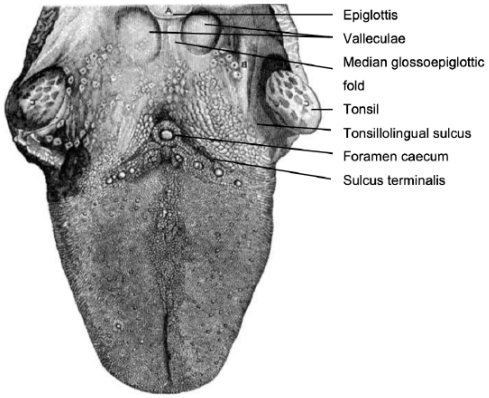


Figure 1: Topography of BOT

This comprises the posterior 1/3 of the tongue behind the ***foramen caecum*** and ***sulcus terminalis*** (*Figure 1*). The mucosa is rough, thick and fixed to the underlying muscle and contains lymphoid follicles (lingual tonsil); this makes it difficult to identify the edges of a BOT tumor; hence frozen section is especially useful to assess resection margins. Posterolaterally the ***tonsillolingual sulci*** separate the tongue from the tonsillar fossae. The ***valleculae*** separate the BOT from the lingual surface of the epiglottis and are separated in the midline by the median glossoepiglottic fold (*Figure 1*).

Soft palate

The soft palate has a complex muscular structure and innervation. It has key functions relating to speech and swallowing.

Resection and inadequate reconstruction of the palate results in loss of nasal separation which manifests clinically as nasal regurgitation of fluids and food, and hypernasal speech which can be quite disabling. The complex muscular anatomy of the soft palate and lateral pharyngeal wall is illustrated in *Figure 4*.

Soft palate	Tensor veli palatini	V_3
	Levator veli palatini	X
	Palatoglossus	X
	Palatopharyngeus	X
	Musculus uvulae	X
Lateral pharyngeal wall	Salpingopharyngeus	X
	Superior constrictor	X
	Middle constrictor	X
	Stylopharyngeus	IX

Table 1: Muscles of the soft palate and oropharynx and cranial nerves which innervate them

Muscles that contribute to the soft palate and lateral pharyngeal wall are summarized in *Table 1*.

Lateral and posterior pharyngeal walls

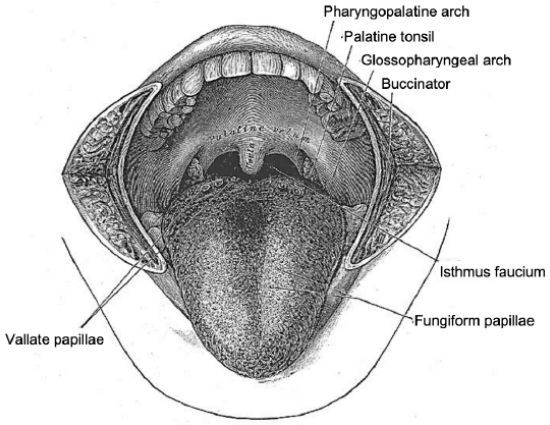


Figure 2: Anterior view of soft palate

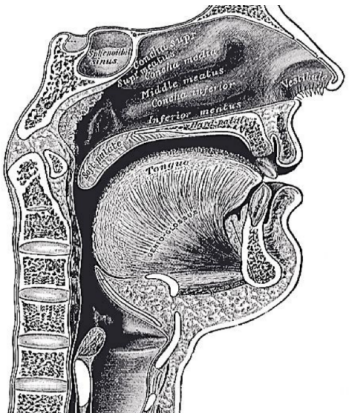


Figure 3: Lateral view of soft palate and its attachment to the hard palate

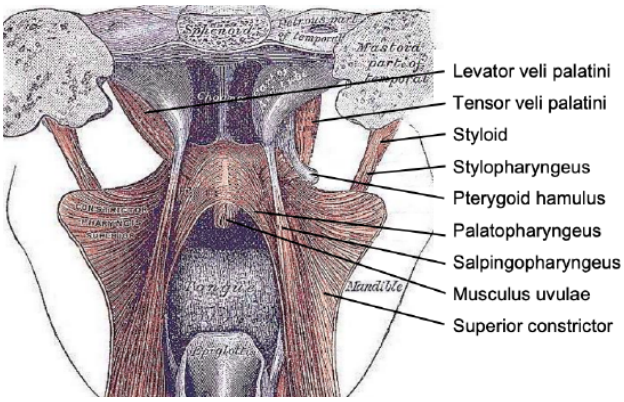


Figure 4: Posterior view of the soft palate and pharynx with the superior constrictor splayed open

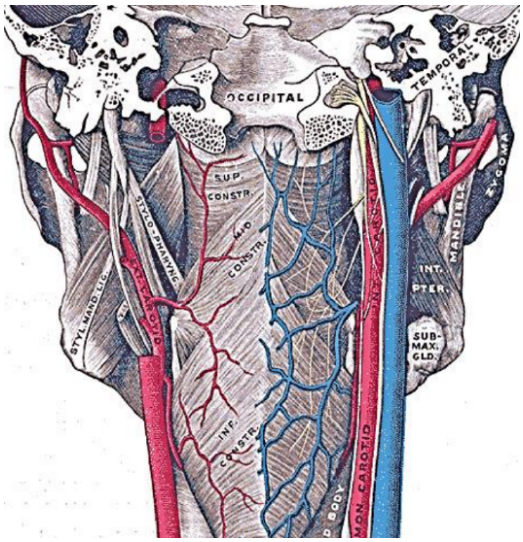


Figure 5: Posterior view of the pharynx illustrates the attachment of the superior constrictor to the pharyngobasilar fascia above and the median raphe to which the pharyngeal constrictors attach; note the close anatomical relationships of the internal and external carotid artery systems to the pharynx

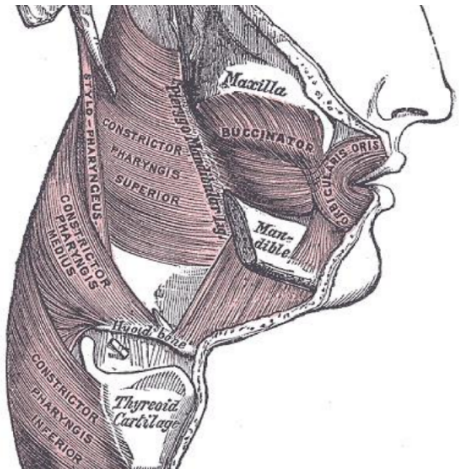


Figure 6: Note how buccinator and superior constrictor muscles attach to the pterygomandibular raphe

The pharynx has a number of layers i.e. mucosa, submucosa, muscle and serosa. The ***submucosa*** is represented by the ***pharyngobasilar fascia***; it thins as it extends inferiorly from its attachment to the skull base and lines the inner aspect of the constrictor muscles. It fills the gaps between the skull base and the superior constrictor, the superior and middle constrictors, and the middle and inferior constrictors (*Figure 5*). Posteriorly it forms a median raphe to which the pharyngeal constrictors attach (*Figure 5*). The ***anterior faucial/tonsillar pillars*** are formed by the ***palatoglossus muscles*** with a thin mucosal covering and constitute the anterior limit of the oropharynx, behind which it is encircled by the ***superior and middle constrictor muscles***

(*Figures 2, 4, 5, 6*). The ***palatopharyngeus muscles*** constitute the posterior faucial/tonsillar pillars. The tonsils are situated between the anterior and posterior pillars, with the pharyngeal constrictor muscle lateral to the tonsil. The ***buccopharyngeal fascia*** constitutes the ***serosal layer***; it is the outermost coat of the pharynx and is a thin layer of connective tissue that forms the anterior wall of the prevertebral space.

Nerves

The only notable nerves encountered at surgery are the ***lingual, inferior alveolar and mental nerves***, and possibly the ***XIIn*** if resection includes the lateral tongue.

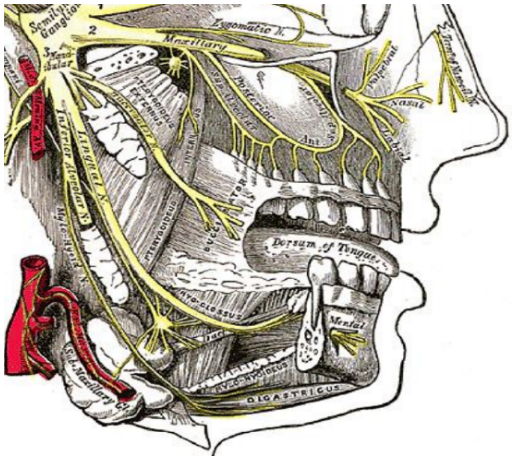


Figure 7: V_3, lingual, inferior alveolar and mental nerves

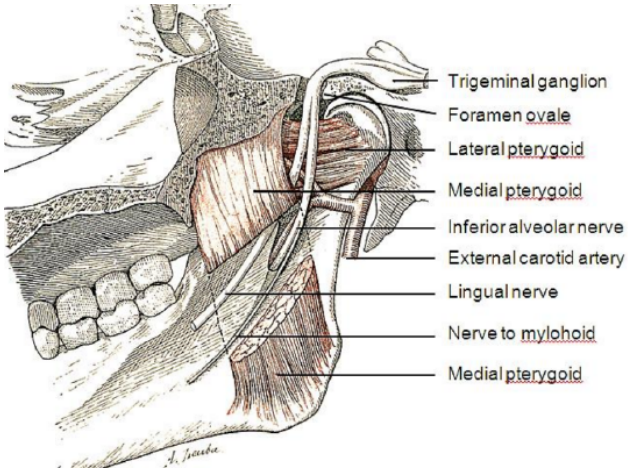


Figure 8: V_3, lingual, inferior alveolar and mental nerves

The ***lingual nerve*** is a branch of V_3 and provides sensory innervation to the floor of the mouth (FOM). The nerve crosses deep to the submandibular duct in the lateral FOM; in the anterior FOM it is located posterior to the duct (*Figures 7, 8*). It is worthwhile attempting to preserve the nerve when resecting smaller tumors in the tonsillar region.

The ***inferior alveolar nerve*** and its accompanying vessels enter the mandibular canal at the lingula and innervate the inferior alveolus and teeth (*Figures 7, 8*). The nerve is transected whenever a segmental mandibulectomy is done. The ***mental branch*** of the nerve exits the mandibular canal at the mental foramen to innervate the skin of the lower lip and should be preserved when doing a mandibulotomy by placing the osteotomy anterior to the mental foramen (*Figure 7*).

Arteries

Knowledge of vascular anatomy enables the surgeon to anticipate where arteries will be encountered and helps to minimize blood loss. Depending on the surgical procedure, vessels that may be encountered include the ***inferior labial, facial, lingual, inferior alveolar, mental, palatal*** and ***tonsillar*** arteries and the ***pterygoid venous plexus***.

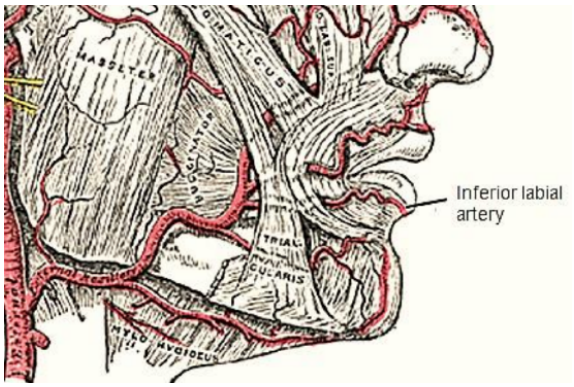


Figure 9: Inferior labial artery

The ***inferior labial artery*** is transected when the lower lip is divided in the midline. A branch of the facial artery, it is located superficially, just deep to the surface of the lip, and is controlled with bipolar cautery (*Figure 9*).

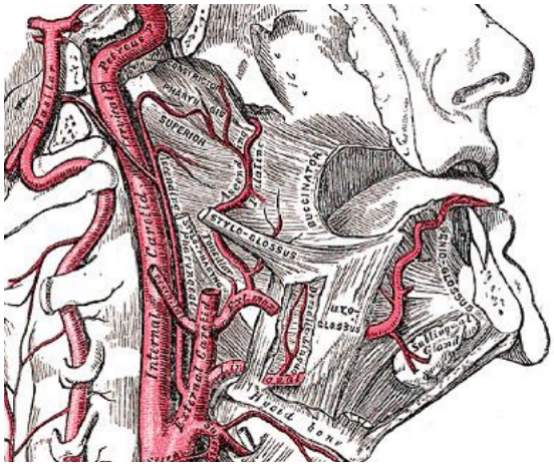


Figure 10: The ascending pharyngeal and ascending palatine and tonsillar branches of the facial (external maxillary) artery lie on the pharyngeal constrictor deep to the medial and lateral pterygoid muscles

The ***facial artery*** is generally not a problem as it is reflected laterally in the cervicofacial flap that is raised when exposing the lateral surface of the mandible (*Figure 9*). It is commonly used as a donor vessel for free microvascular transfer flap reconstruction. The ***tonsillar and ascending palatine arteries*** are branches of the facial artery (*Figure 10*). The ***lingual artery*** is only encountered when resection includes the posterolateral tongue (*Figure 10*).

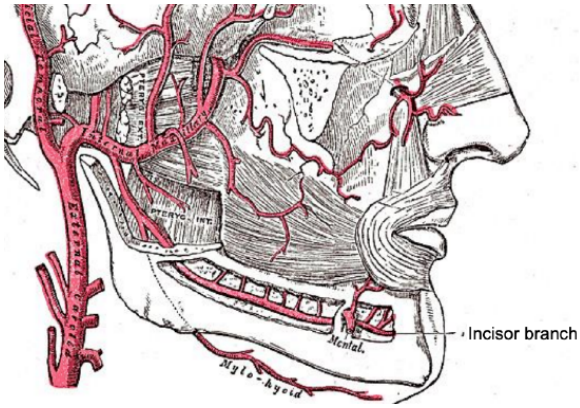


Figure 11: Buccinator, inferior alveolar and mylohyoid arteries

The ***inferior alveolar artery*** is a branch of the internal maxillary artery, and courses between the medial pterygoid muscle and mandible where it enters the mandibular canal at the lingula accompanied by the inferior alveolar nerve and vein (*Figures 5, 8, 11*).

The ***mental artery*** accompanies the mental nerve and exits the mandible at the mental foramen (*Figure 11*). If a mandibulotomy is to be done for access just anterior to the mental foramen, avoid dissecting right up to the foramen so as not to cause bleeding

requiring cautery, as this might injure the nerve. The ***arterial supply to the soft palate*** is derived mainly from the ***ascending pharyngeal artery***, which anastomoses with the ***greater palatine artery*** at the junction of the hard and soft palate; additional supply is derived from the ***ascending palatine and tonsillar arteries*** (*Figure 10*). Despite transecting the soft palate with diathermy, one may encounter troublesome bleeding which is controlled with diathermy.

Muscles

The muscles of the soft palate, the pharyngeal constrictors and the palatopharyngeus and palatoglossus are generally not individually dissected and identified but are simply resected with the primary tumor using electrocautery and scissors. Muscles that are encountered depending on the surgical approach and that are individually identified include ***orbicularis oris, masseter, temporalis, mylohyoid, and the medial and lateral pterygoids***.

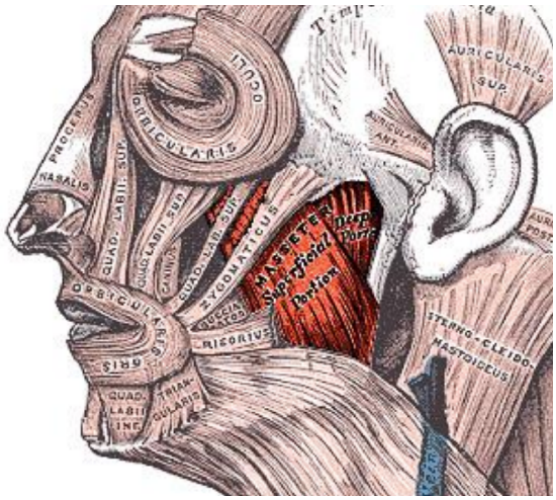


Figure 12: Orbicularis oris and masseter

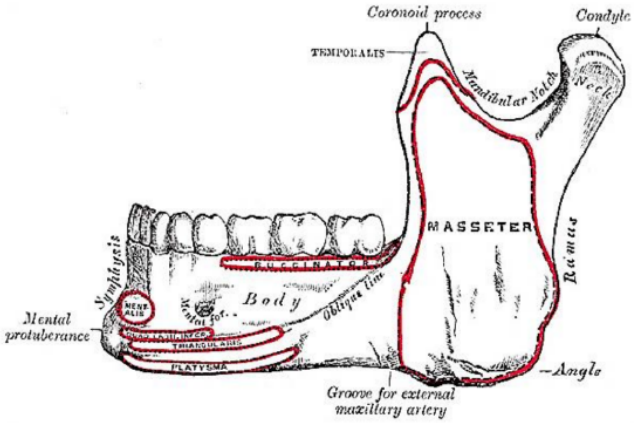


Figure 13: Muscle attachments to outer aspect of mandible and location of mental foramen

The ***orbicularis oris*** is transected with a lip-split incision and has to be carefully reapproximated at conclusion of surgery (*Figure 12*). Dissecting along the lateral surface of the mandible, one next encounters the ***masseter muscle*** (*Figure 12*). It is a thick quadrilateral muscle with superficial and deep portions, the fibers of which converge at the insertion to the lateral aspect of the vertical ramus of the mandible (*Figure 13*). Both the superficial and deep portions arise from the zygoma. Laterally the muscle is covered by the parotid gland. It is innervated by V_3.

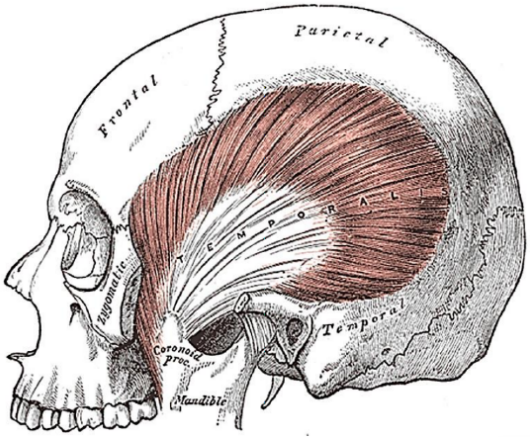


Figure 14: Temporalis muscle inserts into coronoid and anteromedial surface of vertical ramus of mandible

The next muscle one encounters as one dissects along the lateral surface towards the coronoid process of the mandible is the ***temporalis muscle*** (*Figures 13, 14*).

The temporalis muscle arises from the temporal fossa and temporalis fascia and passes behind the zygomatic arch to insert onto the coronoid process and anteromedial surface of the vertical ramus (*Figures 13, 14*). It is innervated by V_3. It receives its blood supply from the deep temporal arteries; preserving these arteries is crucial if a temporalis muscle flap is to be used to reconstruct a surgical defect.

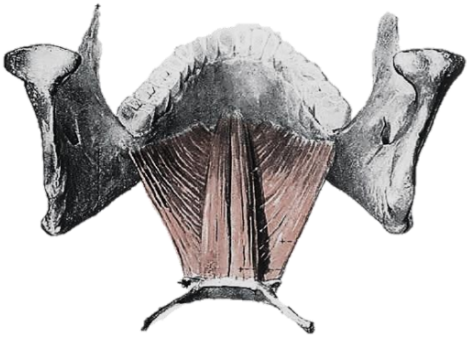


Figure 15: Geniohyoid and mylohyoid

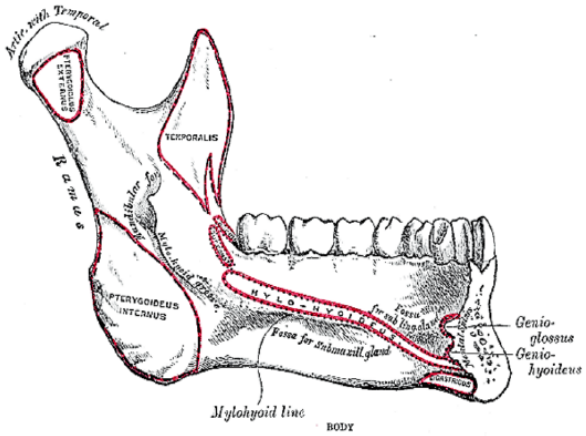


Figure 16: Attachments of mylohyoid, geniohyoid, genioglossus and digastric muscles to inner aspect of mandible

The ***mylohyoid muscle*** is the “diaphragm” of the mouth, and is transected along the medial margin of the mandible when doing a mandibular swing approach to the oropharynx (*Figures 15, 16*).

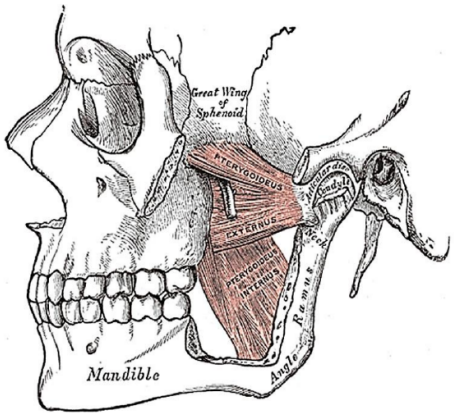


Figure 17: Medial and lateral pterygoids

The next muscle encountered along the medial aspect of the mandible is the ***medial pterygoid*** (*Figures 8, 17*). It has two heads (*Figure 17*): the larger deep head arises from just above the medial surface of the lateral pterygoid plate; the smaller superficial head arises from the maxillary tuberosity and the pyramidal process of the palatine bone (*Figure 17*). The muscle passes inferolaterally to insert onto the inferomedial surface of the ramus and angle of the mandible (*Figures 16, 17*). It is innervated by V_3.

The final muscle that may be encountered is the ***lateral pterygoid***; its superior head originates from the infratemporal surface and crest of the greater wing of the sphenoid, and the inferior head from the lateral surface of the lateral pterygoid plate (*Figure 17*). It inserts onto the neck of mandibular condyle and the articular disc and capsule of the temporomandibular joint (*Figures 16, 17*). It is innervated by V_3.

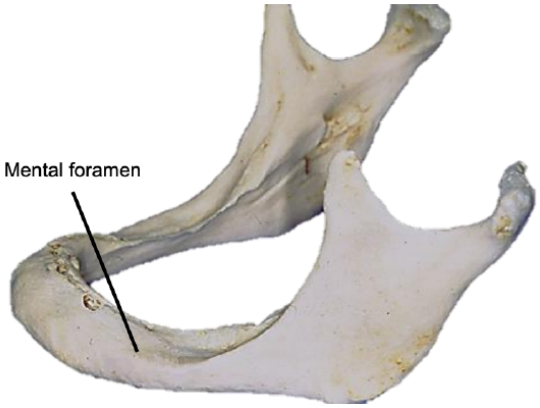


Figure 18: Position of mental foramen in a resorbed mandible

The ***mandible*** may need to be divided (mandibulotomy) to gain access to the oropharynx, or the angle and vertical ramus of the ***mandible*** may be included in the tumor resection (marginal, segmental or hemimandibulectomy). Important surgical features are the position of the mental foramen through which the mental nerve exits to innervate the lower lip, the mylohyoid line to which the mylohyoid muscle attaches, and when planning a marginal mandibulectomy, the height of the body of the mandible and the depth of the dental roots (*Figures 13, 16*). The mental foramen and inferior alveolar nerve may be very close to the superior surface of a resorbed mandible such as is seen in older, edentulous patients (*Figure 18*). A marginal mandibulectomy may not be possible in such a resorbed mandible due to the lack of residual bone.

Surgical Objectives

- Adequate tumor ***resection margins***; this requires a surgical approach that permits good exposure
- ***Surgical morbidity*** relating to palatal function (nasal regurgitation and speech), swallowing, mandible, lingual nerve function and cosmesis should be kept to a minimum; prevent pharyngocutaneous fistulae
- ***Control occult cervical metastasis; the neck is electively treated*** when there is significant risk of occult cervical metastases; the author generally does elective neck dissection (END) levels I-III for squamous cell carcinoma; and bilateral END with cancers of the soft palate and/or base of tongue

The remainder of this chapter focuses on surgical treatment of the primary tumor.

Preoperative evaluation

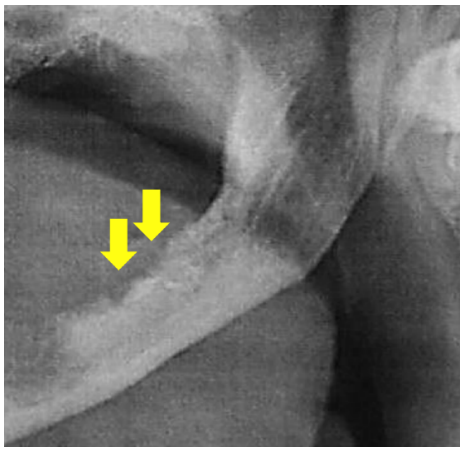


Figure 19: Panorex shows mandibular destruction by tumor

1. ***Are there synchronous primaries, cervical or distant metastases?*** CXR or CT chest, and panendoscopy
2. ***Is the tumor resectable?*** Since local control and ultimately cure depend upon complete resection of cancer with clear margins, there is little point in doing an incomplete tumor resection. It may be difficult to assess the extent of the primary due to pain, tenderness or trismus. If in doubt, a patient requires imaging such as CT/MRI, or examination under anesthesia. Examples of irresectable tumors include posterior extension to involve the carotid sheath and parapharyngeal space, superior extension to the infratemporal fossa and skull base, perineural extension to the trigeminal ganglion, and irresectable node metastases. A key consideration is surgical morbidity; this in turn is dependent on the range and reliability of reconstructive surgery and prosthodontic support services
3. ***Is there clinical evidence of perineural invasion (PNI) of major nerves?*** Examine the patient for neurological deficits of the hypoglossal, mental, inferior alveolar, lingual, and trigeminal nerves and of the sympathetic trunk (Horner's syndrome). Widening of the mandibular canal on mandibular orthopantomography (Panorex) may be seen. MRI may demonstrate PNI. Should there be evidence of PNI then the affected nerve should be dissected proximally until a clear tumor margin is obtained on frozen section. In the case of the inferior alveolar nerve, this would require a hemi- or segmental mandibulectomy that encompasses the entire inferior alveolar canal
4. ***Is a tracheostomy required?*** Most patients with resections requiring any form of reconstruction with a flap are at risk of airway obstruction and should have a temporary tracheostomy. Oral or transnasal intubation may be difficult or impossible due to tumor and/or trismus; a tracheostomy is then done under local anesthesia and the patient is intubated through the stoma
5. ***What type of surgical approach is required?*** Select surgical approaches that ensure adequate exposure; transoral access is often inadequate
6. ***Does the mandible have to be resected?*** Tumor may involve the medial pterygoid muscle at its insertion onto the mandible (clinically manifested by trismus), extend onto periosteum, invade only the inner cortex, involve medullary bone, or manifest PNI of the inferior alveolar nerve. Panorex only shows gross involvement of bone (*Figure 19*). Invasion of cortical bone is better assessed with CT; MRI is superior for assessing medullary invasion. In the absence of CT scans the surgeon may elect to strip tumor off bone at the time of resection taking care not to seed tumor, inspect the bone for evidence of periosteal and bony infiltration, and then decide how to proceed. If only the periosteum is involved, then a marginal mandibulectomy (removal of cortical bone) may suffice. Should marginal mandibulectomy be considered, then the vertical height of the mandible should be assessed clinically or by Panorex so as to predict whether a free bony composite flap would be required to strengthen the remaining mandible. Once the cortex is invaded, then either marginal or segmental mandibulectomy is required. Medullary invasion requires segmental or hemimandibulectomy that includes at least a 2 cm length of mandible on either side of the tumor.
7. ***Status of dentition?*** Carious teeth are removed at the time of the surgery to reduce the risk of osteoradionecrosis
8. ***What type of reconstruction is required?*** This can often only determined once the resection has been done and the defect can be assessed

Key surgical points

- ***Preserve function***
  - Attempt to preserve the lingual and hypoglossal nerves

- Reconstruct soft palate defects
- Reconstruct mandibular defects

- ***Do not compromise margins to preserve function***
- Employ ***frozen section*** (if available) to ensure clear resection margins
- Have a low threshold for performing a ***tracheostomy***

Anesthesia

The ***surgeon always stands by the patient's side during induction*** of anesthesia as it may be ***difficult or impossible to intubate*** a patient who has a bulky tumor, or who has trismus. Should the anesthetist be unable to intubate the larynx, the surgeon may be able to intubate through a laryngoscope or do an emergency tracheostomy or cricothyroidotomy; it is prudent to inject the tracheostomy or cricothyroidotomy site with local anesthetic (with adrenaline) prior to induction. Nasal intobation facilitates resection of pharyngeal tumors and is converted to a tracheostomy during the course of the operation.

Perioperative antibiotics are prescribed for 24 hours.

Surgical access

Good surgical access is essential in order to attain adequate resection margins, to control bleeding, and for reconstruction. A combination of surgical approaches can be used and will now be discussed. ***Level 1 of the neck should first be dissected*** before proceeding to address the primary tumor if neck dissection is indicated.

Transoral resection with electrocautery (Bovie)

Transoral access varies considerably. Edentulous patients are generally better suited to transoral resection. A useful way to predict whether transoral resection is likely to be possible is to pull on the anterior tongue with a cotton swab during preoperative clinical evaluation and to then see how accessible the tumor is. Note that ***tumors become more visible and accessible as the resection proceeds***, especially once the thick BOT lining has been incised around tumor.



Figure 20: Dental bite block is interposed between lateral teeth to keep mouth open

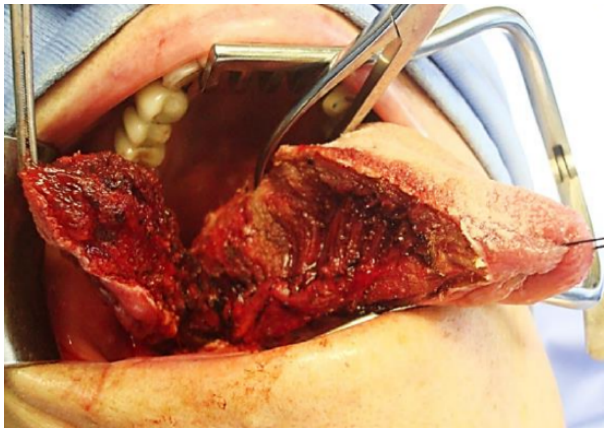


Figure 21: Self-retaining retractor; lateral oral and BOT tumor being resected



Figure 22: Dingman retractor

The mouth is kept wide open either with a dental bite block (*Figure 20*), or with a self-retaining retractor, taking care to protect the teeth from injury (*Figure 21*), or with a tonsil gag or Dingman retractor (*Figure 22*).

Apply traction to the tongue and the tumor with silk traction sutures or with tissue forceps (*Figure 21*). Resect the tumor with at least a 1 cm margin of normal tissue using electrocautery (Bovie). As the resection proceeds, insert new silk traction sutures or reapply the tissue forceps to facilitate delivery of the tumor.

Mandibulotomy with mandibular swing

This affords ***excellent access*** to the oropharynx. It does however leave a facial scar; it may cause deformity of the lower lip; there is a risk of complications relating to the mandibulotomy and dental malocclusion; and the lingual nerve is at risk of injury.



Figure 23: Skin incisions for Level 1 neck dissection and mandibulotomy approach



Figure 24: Scoring the vermillion border

Having completed the Level 1 neck dissection, the vermillion border is scored or marked so as to ensure an accurate repair (*Figures 23*, *24*).

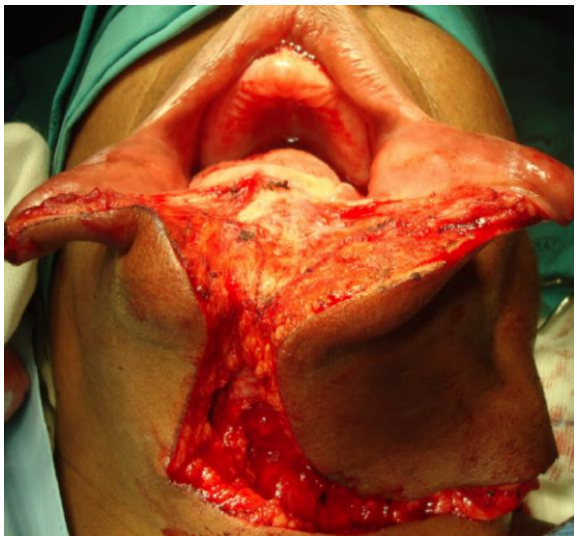


Figure 25: The lower lip is divided vertically in the midline onto bone after Level 1 neck dissection has been completed

The lower lip is vertically divided in the midline (*Figure 25*). Bleeding from the inferior labial artery is controlled with bipolar cautery. At this point, some surgeons prefer to do a ***median mandibulotomy***; it is however the authors' preference to do a ***paramedian mandibulotomy***.

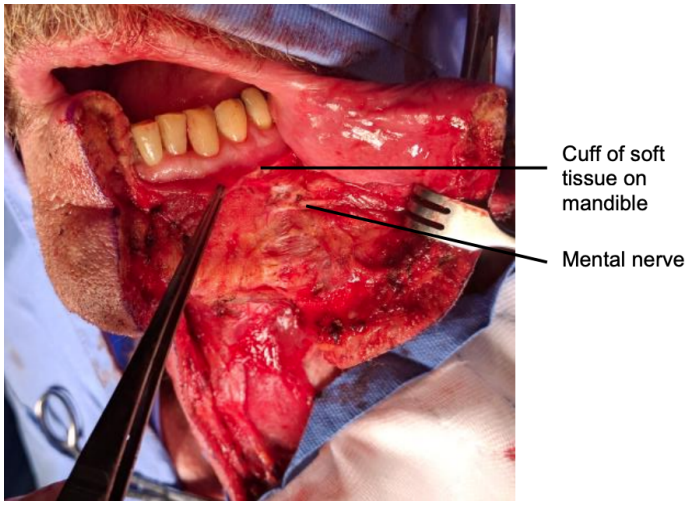


Figure 26: Mental nerve and cuff of soft tissue

Incise the gingivolabial and gingivobuccal mucosae >0.5 cm from the bone to leave a cuff of soft tissue on the bone to facilitate subsequent soft tissue closure (*Figure 26*).

Strip soft tissue off the mandible with monopolar cautery or with a periosteal elevator stopping just short of the mental foramen so as not to injure the mental nerve or mental artery where it exits the foramen (*Figure 26*).



Figure 27: Gigli saw

A ***paramedian mandibulotomy*** is done just anterior to the mental foramen. Compared to median mandibulotomy, the advantages are that it is closer to tumor, it does not disturb the genioglossus, geniohyoid, and digastric muscles, there is less disruption of the FOM, and should segmental mandibulectomy be required, then only the lateral mandible is sacrificed. The mandible is divided just anterior to the mental foramen with a Gigli or a powered saw (*Figure 27*).

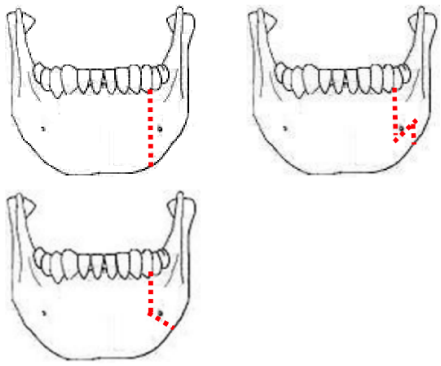


Figure 28: Examples of osteotomies

The osteotomy may be made vertically or alternatively in a step- or V-shaped fashion to achieve a more stable repair (*Figure 28*). It is advisable to extract a tooth and make the osteotomy through the dental socket to avoid devitalizing adjacent teeth.

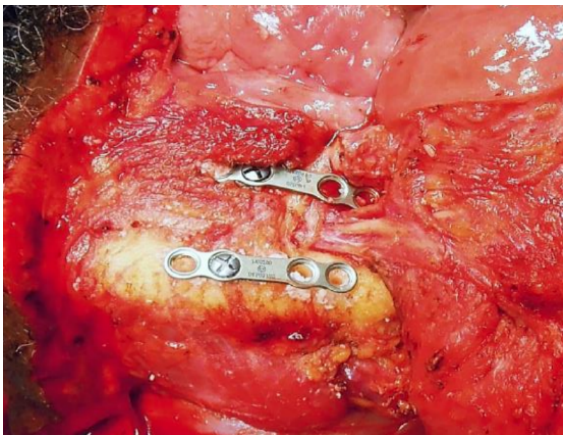


Figure 29: Preplating with 4-holed miniplates above and below mental nerve

In dentate patients the mandible is preplated with titanium miniplates contoured to the mandible to ensure perfect dental alignment. Two 4-holed, non-compression, 2 mm mandibular plates, one placed along the inferior border of the mandible and the other placed more superiorly, are used (*Figure 29*). Once the plates have been contoured and the holes drilled, they are removed, and the bone cut is made.

The surgeon then distracts the cut ends of the mandible to gain access to the oral cavity and proceeds to divide the FOM mucosa and mylohyoid muscle about 1 cm from, and parallel to, the mandible, so as to leave soft tissue on the mandible for FOM repair at conclusion of the surgery. Continue the incision posteriorly along the FOM until the tumor comes into view; the lingual artery (medial to the hyoglossus muscle) and the XIIn course medial to the FOM incision and are not at risk of injury at this stage of the dissection.

The ***tumor is resected using electrocautery***. Posteriorly the ***lingual nerve*** extends from the skull base, passes behind medial pterygoid and crosses the incision line from lateral to medial to course along the lateral FOM; preserve the nerve if possible.

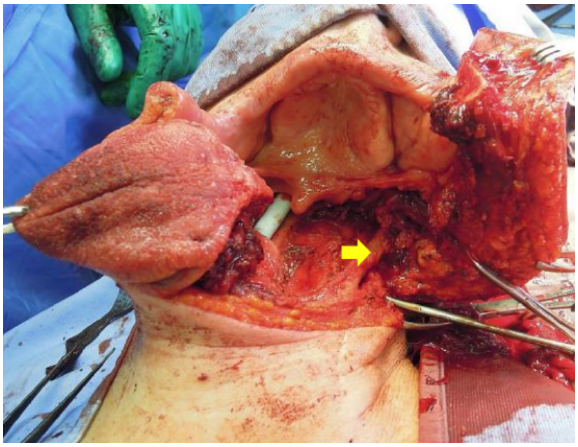


Figure 30: Note the excellent access afforded by mandibulotomy approach (Arrow points to internal carotid artery)

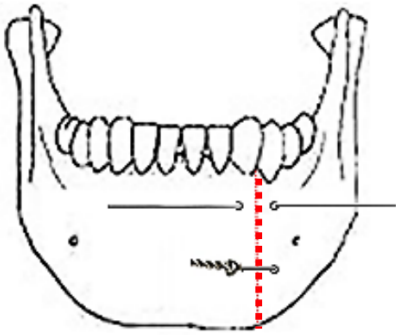


Figure 31: Mandible wired together with stainless steel wire

At the ***conclusion of surgery***, the FOM is closed with a running vicryl suture, and the osteotomy is plated; when plating sets are not available, opposing holes are drilled on either side of the osteotomy and the mandible is wired together with stainless steel wires (*Figure 31*).

Marginal and segmental mandibulectomy

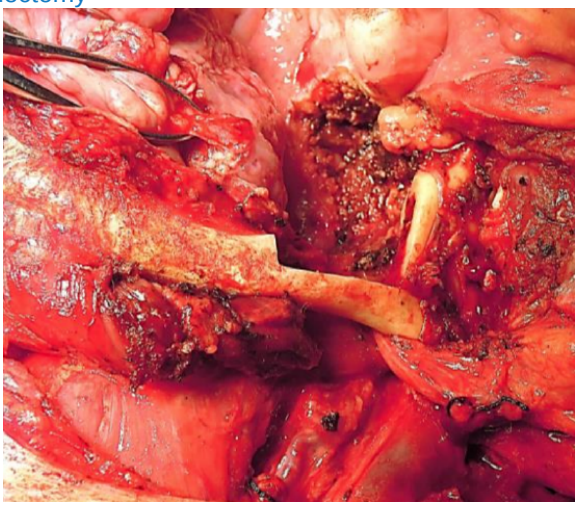


Figure 32: Marginal mandibulectomy

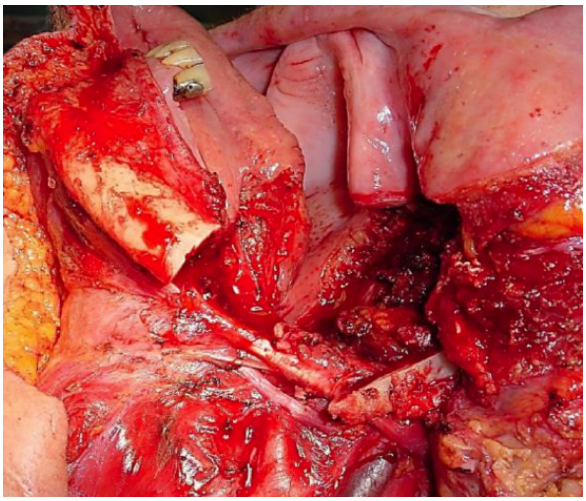


Figure 33: Segmental mandibulectomy preserving only posterior rim of vertical ramus (note preplating holes)

Marginal mandibulectomy is done for access, for securing adequate oncologic resection margins, or to facilitate mucosal repair by suturing gingivolabial to gingivobuccal mucosa (*Figure 32*). Segmental mandibulectomy is done to secure adequate oncologic margins (*Figure 33*).

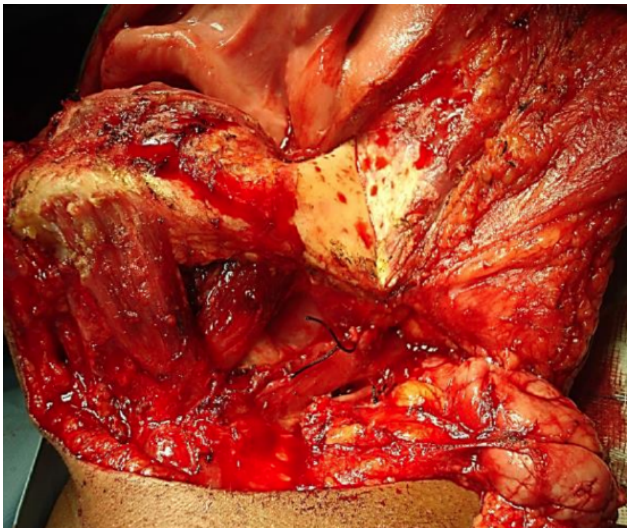


Figure 34: Stripping masseter off bone

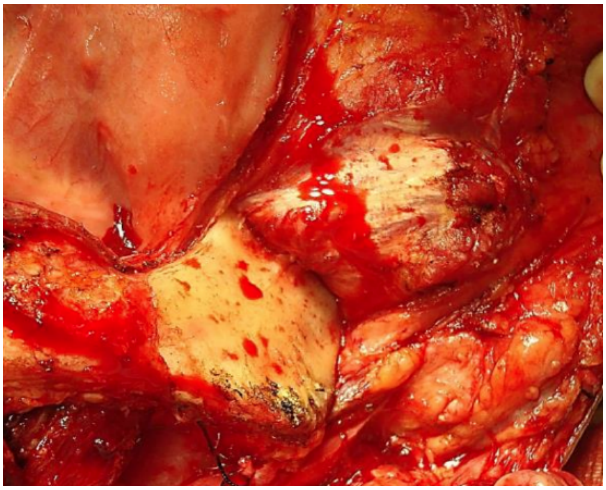


Figure 35: Exposing vertical ramus of mandible up to coronoid process, mandibular notch and neck of condyle

The initial surgical steps are as described for paramedian mandibulotomy (up to *Figure 26*). Transect the mental nerve and artery with cautery and continue to strip soft tissue off the lateral aspect of the mandible up to the masseter muscle; then strip the masseter off its mandibular insertion using electrocautery (*Figures 34*, *35*).

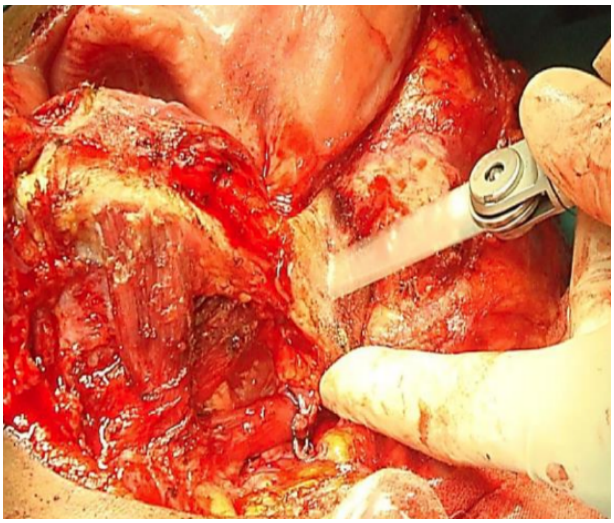


Figure 36: Osteotomy with oscillating saw

Inspect the tumor, and decide as to whether marginal, segmental or hemimandibulectomy is required to obtain clear margins and then plan the osteotomies. Use an oscillating/reciprocating saw or a Gigli saw for the osteotomies (*Figure 36*). Beware of the close proximity of the external carotid artery and its branches to the vertical ramus when making the osteotomies (*Figures 5*, *11*).

With segmental mandibulectomy in dentate patients one should preplate the mandible with a reconstruction plate to ensure accurate repair and perfect dental occlusion.

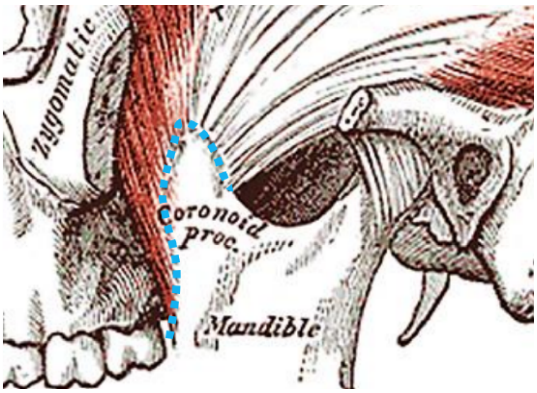


Figure 37: Broken blue line indicates where insertion of temporalis muscle is freed with cautery

To resect the ***coronoid process***, strip the masseter off the entire length of the vertical ramus, identify the mandibular notch, and while pulling caudad on the mandible, free the insertion of the temporalis muscle from the coronoid with cautery, keeping close to bone throughout to avoid blood vessels situated medially; this step is simpler if the distal osteotomy has already been done (*Figure 37*).

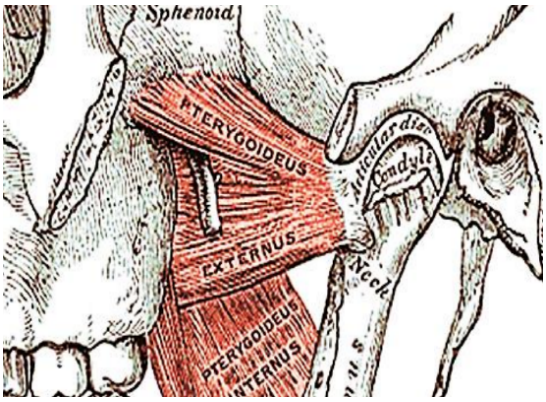


Figure 38: To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule

It is generally not necessary to resect the ***condyle***; rather carefully transect the condylar neck bearing in mind the proximity of the internal carotid artery. To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule (*Figure 38*).

Tumor resection

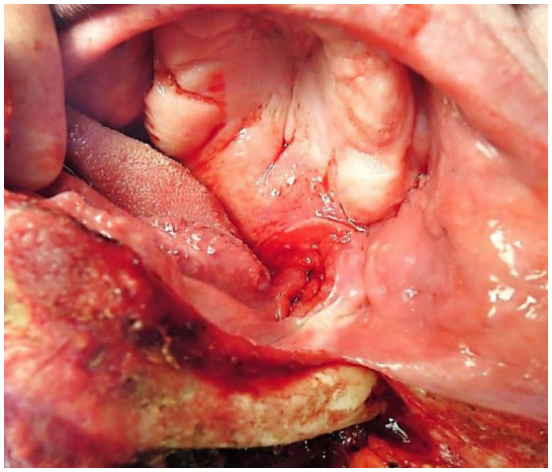


Figure 39a: Cancer of the tonsil fossa, soft palate & BOT fully exposed

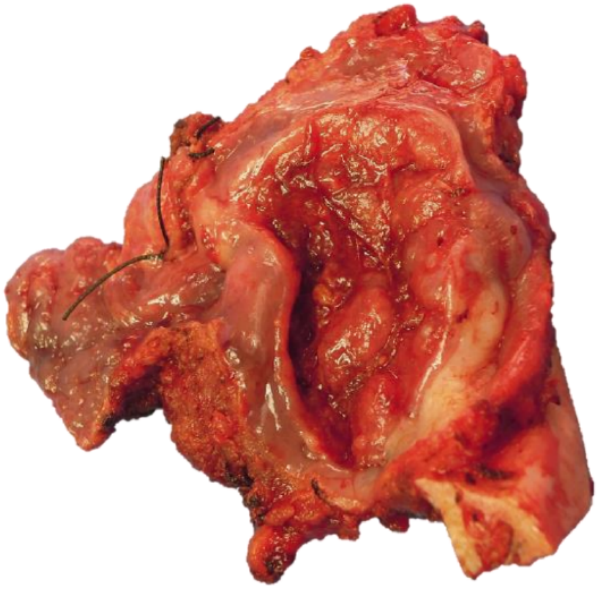


Figure 39b: Marginal mandibulectomy with cancer attached

With adequate exposure, resecting the tumor is generally quite straightforward using electrocautery (*Figures 39 a, b*). The surgeon must remain aware of the locations of the internal and external carotid arteries; palpating the styloid process is useful as the internal carotid artery lies medial to the bone.

Orientate the tumor for the pathologist with a silk suture (*Figure 39b*); obtain frozen section of the margins if available.

Repair / Reconstruction

Obtain meticulous hemostasis using ties, monopolar and bipolar cautery before closing the defect.

The ***lip*** is carefully repaired in layers to approximate the muscles as well as mucosa and skin.

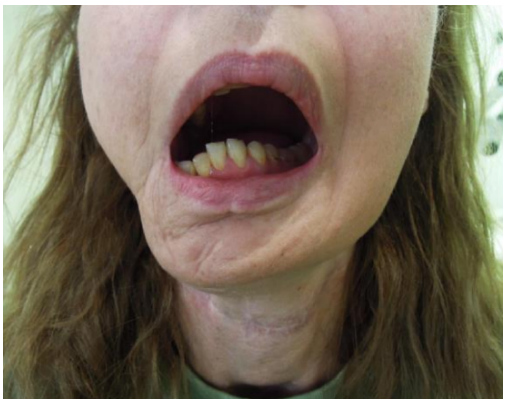


Figure 40: Missing lateral mandibular segment causes mandible to “swing” towards the side of the resection

The ***pharynx*** is a complex functional unit. Whether and how to repair or reconstruct oropharyngeal defects requires that a surgeon critically follows his/her patients and learns from successes and failures. Poor repairs and reconstructions cause hypernasal speech and nasal regurgitation. Failure to reconstruct a lateral mandibular segmental defect (allowing mandible to “swing”) may have significant cosmetic and functional consequences (*Figure 40*).

Healing by secondary intention is not utilized frequently enough with BOT resections, but is of course commonly employed with tonsillectomy, TLM and TORS.

Primary closure of BOT defects yields the best swallowing results, although inadequate bulk impairs speech if the BOT cannot approximate the soft palate. Primary closure of palatal defects may cause hypernasal speech and nasal regurgitation.

Pedicled and free tissue transfer flaps may be used to reconstruct oropharyngeal defects. Simply shaping a flap to match the resected tissue may well restore form yet have a poor functional result. Therefore, one must carefully assess the defect to determine how best to optimize function.

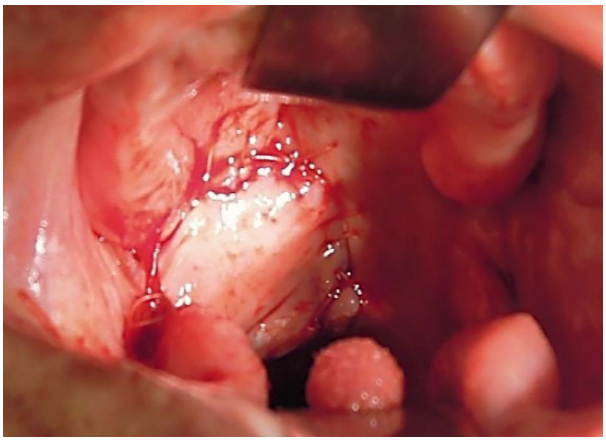


Figure 41: Buccinator myomucosal flap used to restore soft palate and tonsil fossa defects

Buccinator myomucosal flap: (See chapter: Buccinator myomucosal flap) A posteriorly-based buccinator flap can be used to repair defects of the soft palate, lateral pharyngeal wall and BOT. It is an excellent choice as it has the same physical qualities as tissues of the oropharynx, has a reasonable amount of bulk, and preserves mobility (*Figure 41*).

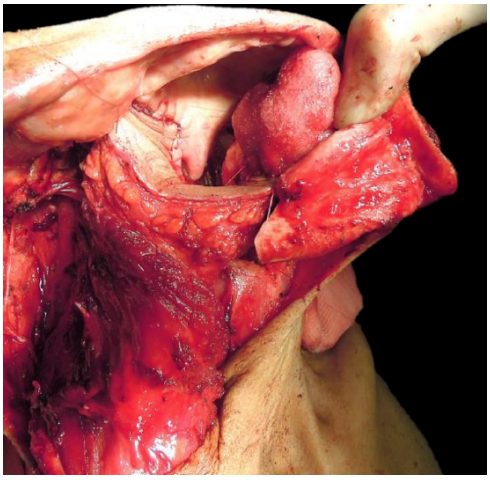


Figure 42: Pectoralis major flap used to reconstruct an oropharyngeal defect and to fill in the bony defect of a segmental mandibulectomy

Pectoralis major flap: (See chapter: Pectoralis major flap) Although this is a reasonable option to use, it may drag down on the soft palate causing palatal incompetence. It is a useful soft tissue filler of a lateral segmental mandibular defect (*Figure 42*).

Buccal fat pad flap: (See chapter: Buccal fat pad flap) This is a useful flap to cover exposed mandible or maxillary bone, or to augment a thinned out soft palate, or to close a small soft palate defect

Temporalis muscle flap: (See chapter: Temporalis muscle flap) This is commonly used in some centers for oropharyngeal defects. The muscle is pedicled on the coronoid process which is immediately adjacent to the oropharynx. It requires that the deep temporal arteries be preserved.

Other pedicled flaps to consider are the Submental artery island flap and Supraclavicular flap



Figure 43: Soft palate and lateral pharyngeal wall reconstruction with RFFF

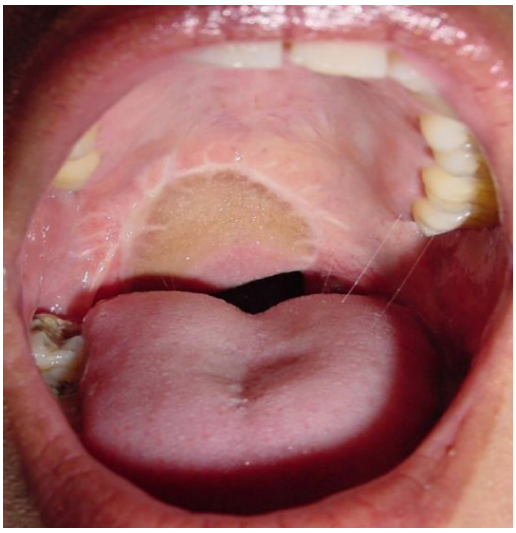


Figure 44: Soft palate reconstruction with RFFF

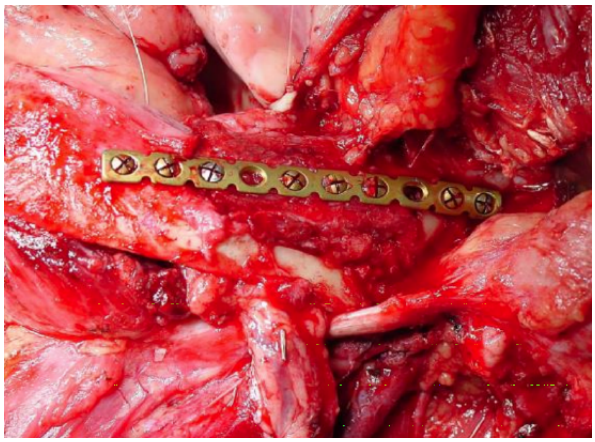


Figure 45: Marginal mandibulectomy with onlay radial osseocutaneous flap

Radial free forearm flap (RFFF): (See chapter: Radial free forearm flap) This is a thin, pliable flap and is therefore an excellent option for oropharyngeal repair (*Figures 43-45*). It can also be used as an onlay osseocutaneous flap following marginal mandibulectomy.

Anterolateral free thigh flap: (See chapter: Anterolateral free thigh flap) Muscle harvested with the flap can be tailored to conform to the volume of the defect to be filled. However, it is less pliable than the radial free forearm flap and is therefore less suited to soft palate reconstruction.

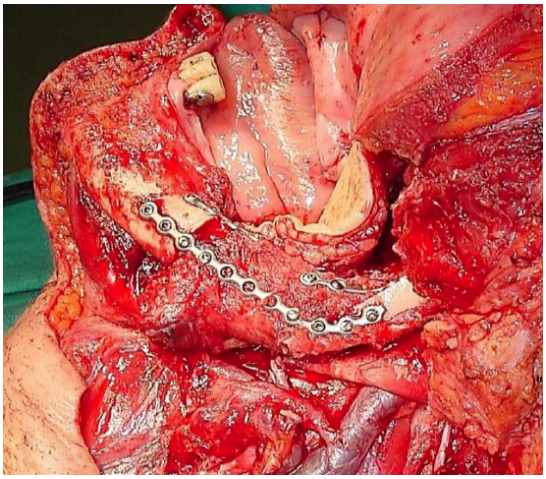


Figure 46: FFF graft following segmental mandibulectomy; skin of leg used to reconstruct oropharynx defect

Free fibula flap (FFF): (See chapter: Vascularized free fibula flap). This is the workhorse flap for patients requiring reconstruction of mandible (*Figure 46*).

Postoperative management

- ***Antibiotics*** are administered for 24 hours
- A ***temporary tracheostomy*** is done; once the airway appears adequate, an uncuffed tracheostomy tube is inserted, the tracheostomy tube is corked for 24 hours and if tolerated, is removed
- A ***nasogastric feeding*** tube is inserted; oral feeding is commenced on Day 5
- ***Suction drains*** are removed when drainage is <50 mL/24 hours



Figure 47: Palatal prosthesis

- ***Prosthetic devices*** can be used to correct palatal incompetence (*Figure 47*)

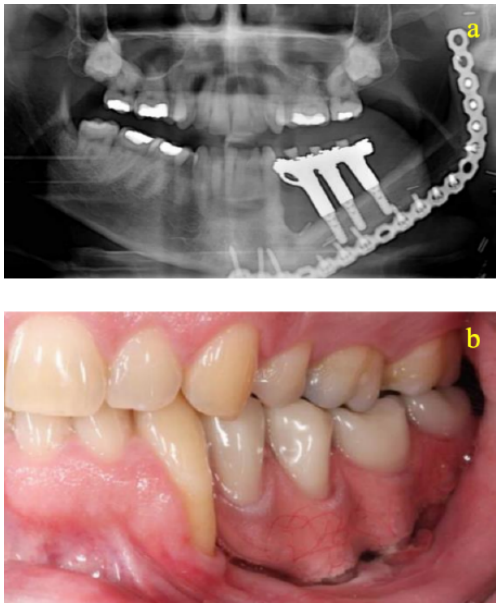


Figure 48a, b: Dental implants and rehabilitation following FFF reconstruction

- ***Dental rehabilitation*** may involve new dentures or implants (*Figures 48a*, *b*)

Final comments

Resecting tumors of the oropharynx is challenging particularly in terms of access and optimizing swallowing and speech. One should not compromise resection margins for function. The surgical team must master an array of surgical approaches and reconstructive techniques to ensure the best oncological and functional outcomes.

Author and Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology

University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Eugene N Myers
MD, FACS, FRCS Edin (Hon)
Distinguished Professor & Emeritus
Chair Department of Otolaryngology Eye and Ear Institute, Suite 519
200 Lothrop Street
Pittsburgh, PA 15213, USA
myersen@upmc.edu

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1.40: Transoral Lateral Oropharyngectomy (Radical Tonsillectomy) for Cancer of the Tonsil

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan & Wayne Koch

In developed countries, early (T1/2) tonsil cancers are commonly resected by lateral oropharyngectomy (radical tonsillectomy) employing transoral CO_2 laser microsurgery or transoral robotic surgery (TORS) techniques. Yet most surgeons in the world do not have access to CO_2 laser or TORS. In such centers early tonsil cancers are often resected by simple tonsillectomy. However, dissecting along the tonsillar capsule and not including the pharyngeal constrictors as the deep margin often results in close or involved deep margins necessitating adjuvant (chemo)radiation.

Because cancers of the tonsil are in a direct line-of-sight for the surgeon when using a simple tonsillectomy gag, there is little reason why the surgical principles that apply to lateral oropharyngectomy by transoral CO_2 laser or TORS techniques should not be employed to lateral oropharyngectomy performed with headlight/diathermy, or microscope/diathermy, or loupes/headlight/diathermy techniques to secure adequate resection margins.

Regardless of the surgical tools being used, lateral oropharyngectomy requires a detailed understanding of the “inside-out” 3D anatomy of the oropharynx, and of the parapharyngeal (PPS) and retropharyngeal spaces. Without such an understanding one is less likely to achieve adequate resection margins and more likely to encounter bleeding, nerve damage and injury to the internal carotid artery.

This chapter details the surgical anatomy of the oropharynx, PPS and retropharyngeal spaces, and discusses principles and techniques relating to transoral resection of tonsil cancers regardless of the surgical tools being used.

Surgical anatomy

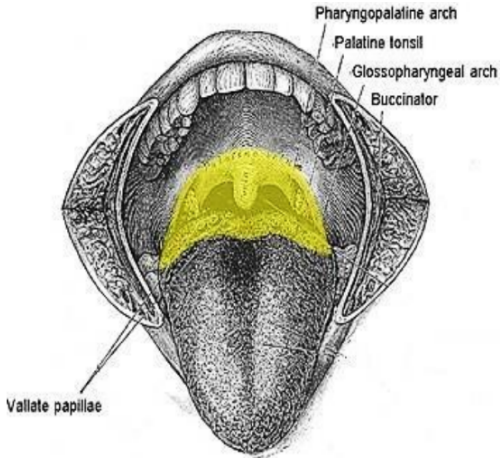


Figure 1: Oropharynx

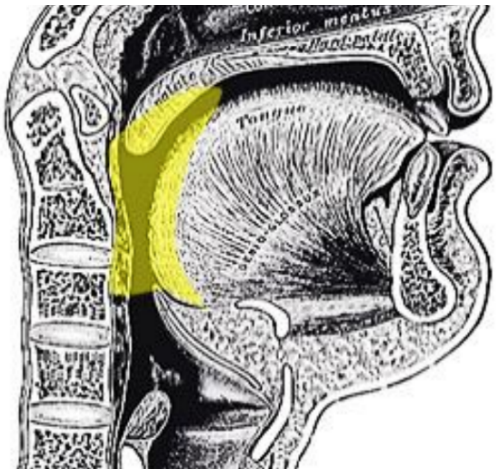


Figure 2: Oropharynx

The oropharynx encompasses the base of tongue, tonsils, soft palate, and lateral and posterior walls of the pharynx between the levels of the hard palate and hyoid bone (*Figures 1a, b*).

Ligaments and fasciae	Pterygomandibular raphe Buccopharyngeal fascia
Muscles	Buccinator Superior constrictor Middle constrictor Medial pterygoid Stylopharyngeus Muscles of soft palate
Nerves	Lingual Glossopharyngeal (IX)
Arteries	Internal carotid Dorsalis linguae Ascending pharyngeal Tonsillar and ascending palatine branches of facial artery Descending palatine
Spaces	Prestyloid PPS Poststyloid PPS Retropharyngeal space

Table 1: Key anatomy for lateral oropharyngectomy

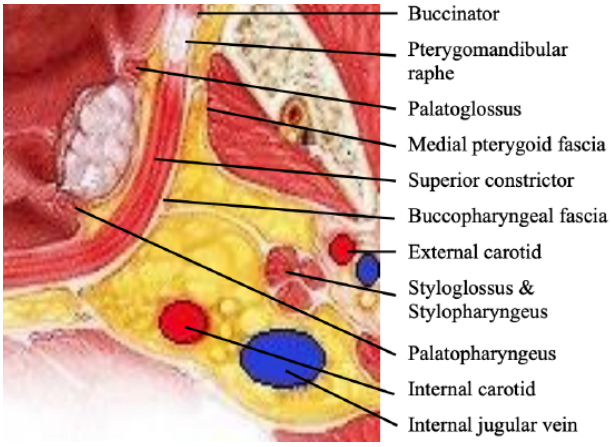


Figure 2: Key anatomical structures for lateral oropharyngectomy at level of tonsil; yellow tissue is parapharyngeal fat (Adapted from Ento Key)

Key anatomical structures relevant to lateral oropharyngectomy are listed in *Table 1* and illustrated in *Figure 2*.

Base of tongue (BOT)

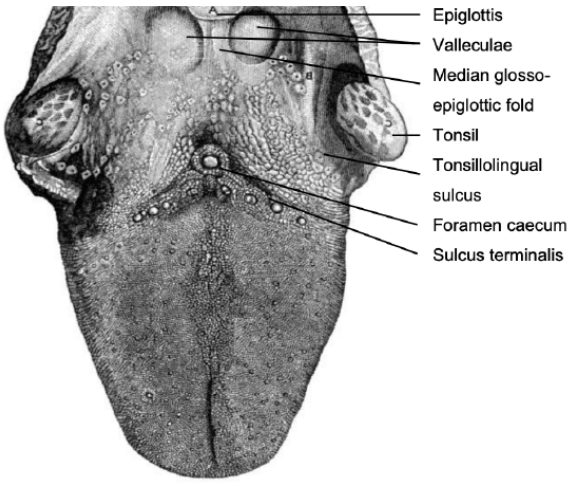


Figure 3: Topography of BOT

This comprises the posterior 1/3 of the tongue behind the ***foramen caecum*** and ***sulcus terminalis*** (*Figure 3*). The mucosa is rough, thick and fixed to the underlying muscle and contains lymphoid follicles (lingual tonsil); this makes it difficult to identify the edges of a BOT tumor; hence frozen section is especially useful to assess resection margins. Posterolaterally the ***tonsillolingual sulci*** separate the tongue from the tonsillar fossae. The ***valleculae*** separate the BOT from the lingual surface of the epiglottis and are separated in the midline by the median glossoepiglottic fold (*Figure 3*).

Soft palate

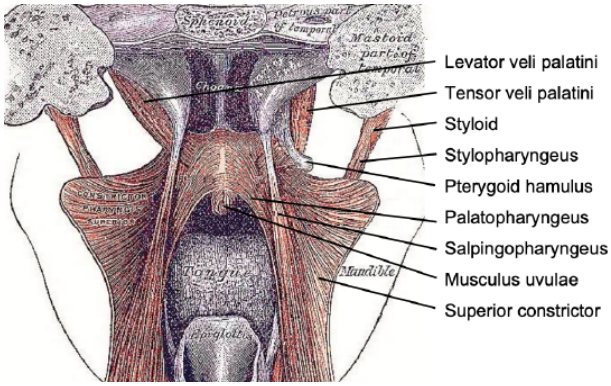


Figure 4: Posterior view of soft palate and pharynx with superior constrictor splayed open

Soft palate	Tensor veli palatini	V_3
	Levator veli palatini	X
	Palatoglossus	X
	Palatopharyngeus	X
	Musculus uvulae	X
Lateral pharyngeal wall	Salpingopharyngeus	X
	Superior constrictor	X
	Middle constrictor	X
	Stylopharyngeus	IX

Table 2: Muscles of soft palate and oropharynx and cranial nerves which innervate them

The soft palate has a complex muscular structure and innervation. It has key functions relating to speech and swallowing. Resection and inadequate reconstruction of the palate results in loss of nasal separation which manifests clinically as nasal regurgitation of fluids and food, and hypernasal speech which can be quite disabling. The complex muscular anatomy of the soft palate and lateral

pharyngeal wall is illustrated in *Figure 4*. Muscles that contribute to the soft palate and lateral pharyngeal wall are summarized in *Table 2*.

Lateral and posterior pharyngeal walls

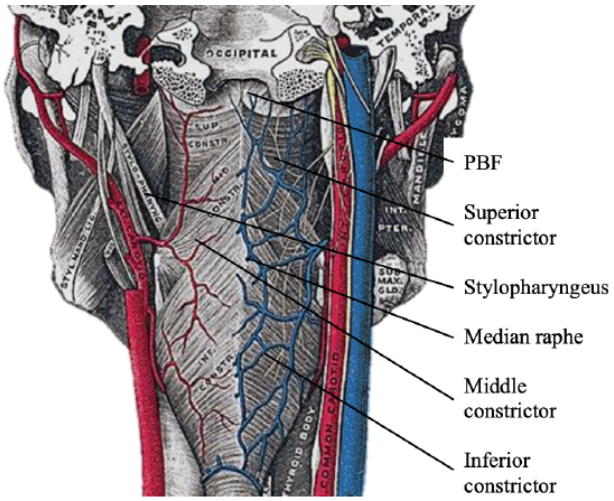


Figure 5: Posterior view of pharynx illustrates attachment of the superior constrictor to pharyngobasilar fascia (PBF) above and the median raphe to which pharyngeal constrictors attach; note close anatomical relationships of internal and external carotid artery systems to pharynx

Lateral oropharyngectomy involves dissecting along the outer aspect of the pharyngeal constrictors. The oropharynx has several layers i.e. mucosa, submucosa, muscle and ***buccopharyngeal fascia***. The submucosa is represented by the ***pharyngobasilar fascia*** that lines the inner aspect of the constrictor muscles. It thins as it extends inferiorly from its attachment to the skull base and bridges the gaps between the skull base and the superior constrictor, the superior and middle constrictors, and the middle and inferior constrictors (*Figure 5*). Posteriorly it forms a ***median raphe*** to which the pharyngeal constrictors attach (*Figure 5*).

The ***buccopharyngeal fascia*** invests the pharyngeal constrictor muscles and is continued forward from the superior constrictor over the buccinator (*Figure 2*). It is loosely attached to the prevertebral layer by connective tissue, with the retropharyngeal space between them.

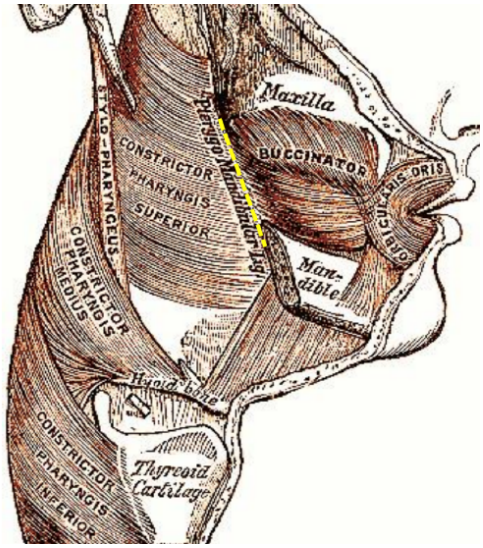


Figure 6: Note how buccinator and superior constrictor muscles attach to the pterygomandibular raphe (yellow line)

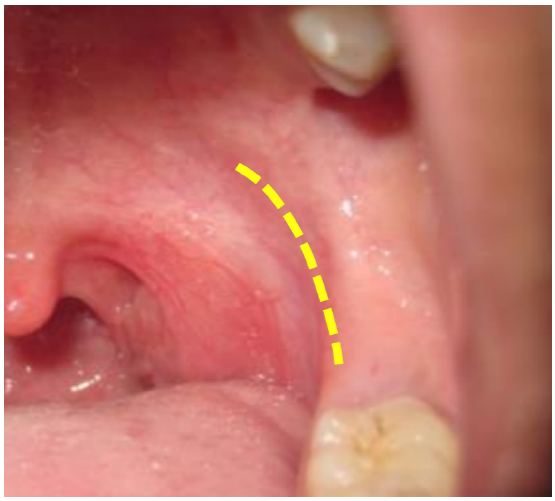


Figure 7: Pterygomandibular fold represents the surface marking of pterygomandibular raphe

The ***pterygomandibular raphé/ligament*** is a ***tendinous band of buccopharyngeal fascia*** and is a key structure to identify initially in lateral oropharyngectomy to gain access to the correct lateral dissection plane. It is attached at one end to the hamulus of the medial pterygoid plate, and at the other end to the posterior end of the mylohyoid line of the mandible (*Figures 6, 7*).

It is interposed between the buccinator muscle which is attached to its anterior edge, and the superior constrictor muscle which is attached to its posterior edge (*Figures 2, 6*). Medially it is covered only by buccal mucosa. Laterally it is separated from the ramus of the mandible and medial pterygoid muscle and fascia by adipose tissue (*Figure 2*). The pterygomandibular fold represents the surface marking of the pterygomandibular raphe (*Figure 7*).

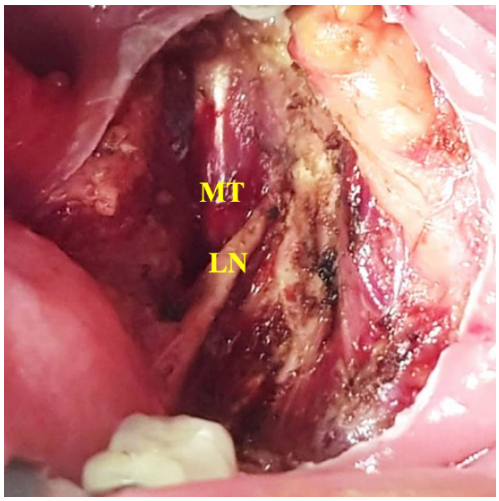


Figure 8: The lingual nerve (LN) courses lateral to the medial pterygoid muscle (MT)

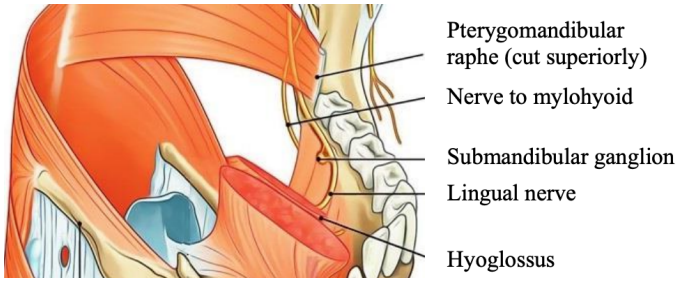


Figure 9: Lingual nerve emerging between lower attachment of raphe to the mandible and the mylohyoid muscle (adapted from Earthslab.com)

The ***lingual nerve*** emerges anteriorly between the medial pterygoid and the vertical ramus of the mandible (*Figure 8*). It is therefore protected by the medial pterygoid muscle during lateral oropharyngectomy. However, it is vulnerable to injury when dissecting inferiorly where it courses above the mylohyoid muscle (*Figure 9*).

The ***buccinator muscle*** is transected during lateral oropharyngectomy just anterior to the pterygomandibular raphe. It is a thin, quadrilateral muscle in the cheek, and originates from the outer surfaces of the alveolar processes of the maxilla and mandible. Posteriorly it attaches along the length of the pterygomandibular raphe (*Figures 2, 6*).

Medially, it is covered by submucosa and mucosa of the cheek. Laterally it is related to the ramus of the mandible, the masseter and medial pterygoid muscles, the buccal fat pad and the buccopharyngeal fascia.

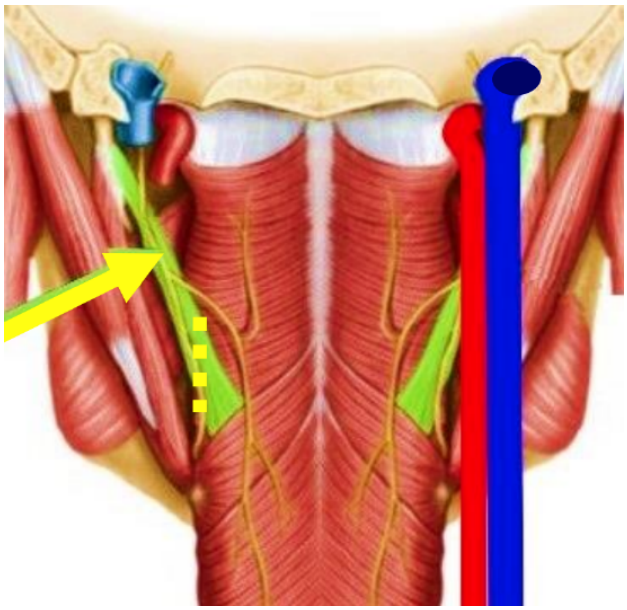


Figure 10: Relationships of stylopharyngeus muscle (green) and internal carotid artery and internal jugular vein. Yellow arrow points to IX nerve. Yellow broken line indicates division of stylopharyngeus muscle during lateral oropharyngectomy (adapted from Netter's Anatomy)

The ***superior*** and ***middle constrictor muscles*** form the lateral and posterior walls of the oropharynx (*Figures 4, 5, 6, 9, 10*), with lesser contributions from the ***salpingopharyngeus*** (*Figure 4*), ***stylopharyngeus*** (*Figures 4, 5, 6, 10*) and ***palatopharyngeus*** (*Figure 4*) muscles.

The ***stylopharyngeus*** arises from the medial side of the base of the styloid process, passes downward through the fat of the PPS along the side of the pharynx, then between the superior and middle constrictors, and fans out beneath the mucosa (*Figures 2, 5, 6, 10*). The glossopharyngeal (IX) nerve innervates the stylopharyngeus. It runs on the lateral side of the muscle and crosses over it to reach the base of the tongue (*Figure 10*).

The deep dissection plane during lateral oropharyngectomy is between the buccopharyngeal fascia/fat of the prestyloid, retrostyloid and retropharyngeal spaces, and the constrictors. Because the stylopharyngeus crosses the PPS to join the pharynx, it must be transected to enable the surgeon to follow the plane along the constrictors towards the retropharynx (*Figures 2, 10*).

The muscles of the ***soft palate*** are not individually dissected and identified but are simply transected with the primary tumor.

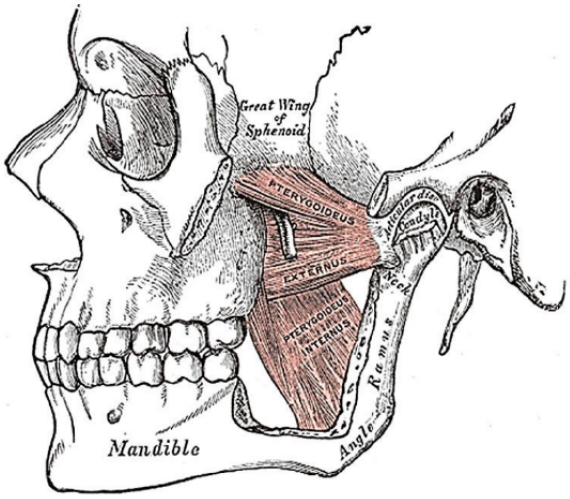


Figure 11: Medial and lateral pterygoids

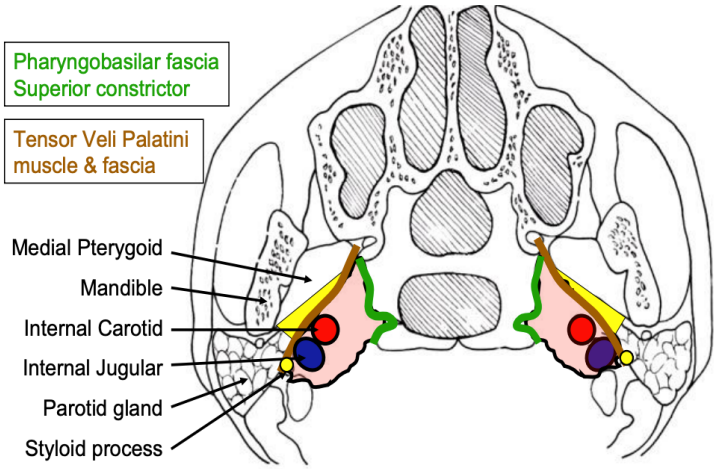


Figure 12: Axial view of prestyloid (yellow) and poststyloid (pink) PPS

The ***medial pterygoid*** (*Figures 2, 8, 11, 12*) constitutes the anterolateral border of the prestyloid PPS and is exposed early in the dissection. It has two heads: the larger deep head arises from just above the medial surface of the lateral pterygoid plate; the smaller superficial head arises from the maxillary tuberosity and the pyramidal process of the palatine bone (*Figure 11*). The muscle passes inferolaterally to insert onto the inferomedial surface of the ramus and angle of the mandible.

Parapharyngeal space (PPS)

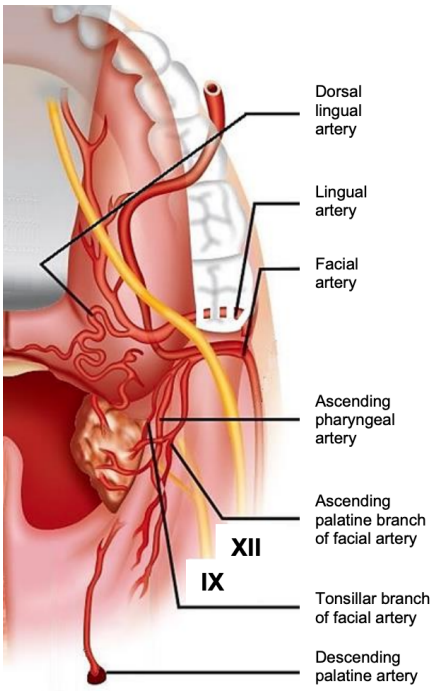


Figure 13: Arterial supply of tonsil and lateral oropharyngeal wall

The pharyngeal constrictor muscles form the medial border of the PPS, and the dissection therefore proceeds alongside, or within the fat of the PPS (*Figures 12, 13*). Therefore, the surgeon must be familiar with the anatomy of the PPS to anticipate the location of blood vessels, the stylopharyngeus muscle and the ICA.

The PPS extends as an inverted pyramid from the base of the skull superiorly, to the hyoid bone inferiorly. *Figures 2* and *12* illustrate axial views of the prestyloid and poststyloid components of the PPS, separated by the styloid process, tensor veli palatini muscle and its fascia (brown). The prestyloid PPS is bordered anterolaterally by the medial pterygoid muscle, and posterolaterally by the deep lobe of the parotid gland (*Figures 2, 12*) and contains mainly fat. It is traversed by the arteries and veins supplying the pharynx and tonsil. The poststyloid PPS is confined medially by the pharyngobasilar fascia above, and the superior and middle constrictor muscles of the pharynx and contains the internal carotid artery and the internal jugular vein, as well as lower cranial nerves IX -XII, and the sympathetic trunk.

Arteries and veins (Figures 13, 14)

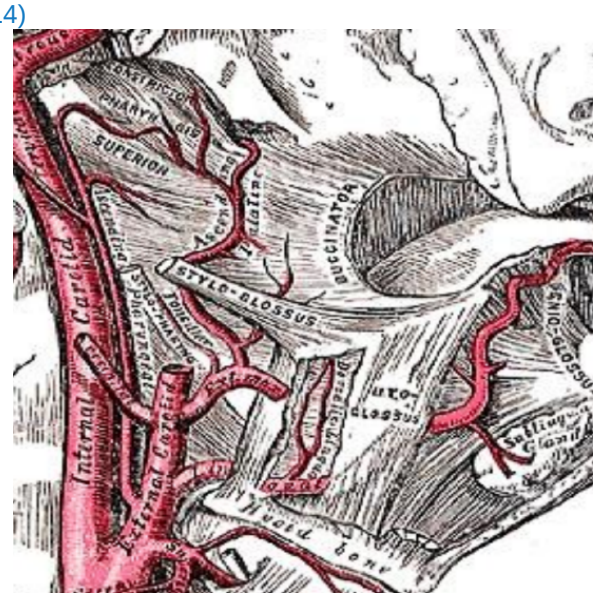


Figure 14: The ascending pharyngeal and ascending palatine and tonsillar branches of the facial (external maxillary) artery lie on the pharyngeal constrictor in the PPS

Knowledge of the vascular anatomy enables the surgeon to anticipate where arteries will be encountered and to minimize blood loss. Depending on the surgical procedure, vessels that may be encountered include the ***tonsillar and ascending palatine branches of the facial artery*** that arise in Level 1 of the neck, and the ***ascending pharyngeal artery***, a branch of the external carotid artery (*Figure 13*). If the dissection includes BOT, the ***dorsalis linguae branches of the lingual artery*** may be encountered (*Figures 13, 14*). If the dissection is extended superiorly, the ***descending palatine artery*** may be encountered at the junction of the soft and hard palates (*Figure 13*).

Venous drainage is via the ***pharyngeal venous plexus*** to the ***internal jugular vein*** (*Figure 5*). The internal jugular vein is located posterolateral to the carotid and is hence not a concern (*Figures 2, 5, 10*).

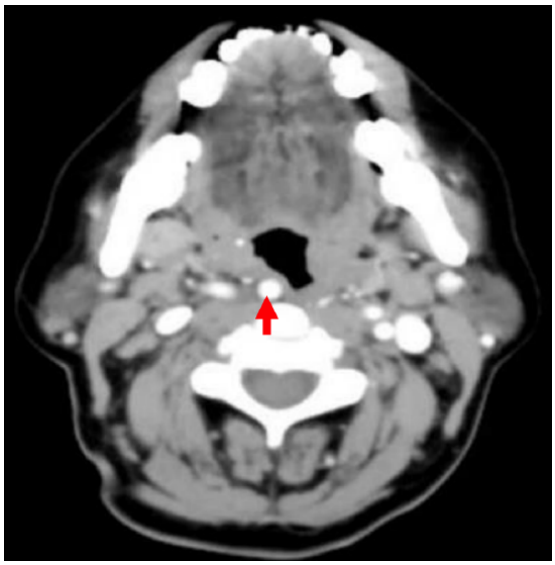


Figure 15: Retropharyngeal internal carotid artery

The ***internal carotid artery*** is generally not exposed, although pulsations of the vessel through the surrounding fat should be looked out for. Dividing the stylopharyngeus muscle gives direct access to the poststyloid PPS and artery (*Figures 2, 5, 10, 14*). The artery is normally located about 20-30 mm posterolateral to the outer aspect of the constrictors but may be ectatic (*Figure 15*) in up to 40% of the cases. A retropharyngeal ICA must be recognized preoperatively and protected and may be a relative contraindication to transoral resection.

Glossopharyngeal nerve (IXn)

Somatic sensory	Tonsils, base of tongue, pharynx, middle ear
Visceral sensory	Carotid bodies Carotid sinus
Parasympathetic fibres	Parotid gland via otic ganglion
Motor fibres	Stylopharyngeus muscle

Table 3: IXn functions

Figures 10 and *13* show the course of the XIn in the PPS. The main trunk of the nerve curves anteromedially around the lateral border of stylopharyngeus and courses between the superior and medial pharyngeal constrictors. Of the functions of the IXn listed in *Table 3*, injury to the nerve during lateral oropharyngectomy would only affect taste and sensation to the base of tongue.

Lateral Oropharyngectomy

Lateral oropharyngectomy for cancer of the tonsil and lateral pharyngeal wall may be performed with a headlight and monopolar electrocautery, operating microscope and electrocautery, transoral CO_2 laser microsurgery or TORS. The latter two techniques provide superior visual detail of tissue planes, tumor margins, vasculature and nerves. The description of the surgical steps that follow apply equally to all these techniques.

Indications

- Tumors of the lateral pharyngeal wall and tonsil that can be resected transorally with clear margins
- The ideal tumor is a T1/2 tonsil cancer in which the constrictor muscles have not been invaded

Contraindications[1]

General

- Poor transoral surgical access
- Coagulopathy
- Cervical spine pathology
- Poor fitness for surgery

Oncologic

- Cancer invading beyond pharyngeal constrictors to involve tissues and structures in PPS, medial pterygoid muscle, mandible or maxilla (requires combined transoral and transcervical approaches)
- Clinical evidence of perineural extension along major nerves e.g. lingual / V3
- Posterolateral fixation of cancer to prevertebral fascia
- Substantial extension into tongue base beyond unaided transoral exposed view

Vascular

- Retropharyngeal carotid artery
- Cancer adjacent to ICA or carotid bulb which will result in exposure of vessel
- Tumor encasement of carotid artery

Functional

- Resection of >50% deep tongue base
- Resection of >50% of posterior pharyngeal wall
- Resection of up to 50% of tongue base as well as entire epiglottis
- Resection of soft palate causing debilitating velopharyngeal insufficiency

Clinical evaluation

- Location and extent of primary tumor determined by visual inspection, palpation (and ultrasound[2] evaluation)
- Mobility of tumor with swallowing and on palpation: if mobile it suggests that the PPS is not involved
- Fixation to prevertebral fascia: assessed by gently rocking soft tissue of tonsil fossa medially and laterally using bimanual palpation with one finger intraorally and opposite hand extraorally
- Function of lingual, inferior alveolar, mental, and hypoglossal nerves
- Position of ICA (inspection and palpation)
- Cervical and distant metastasis
- Synchronous primaries
- Access
  - Mouth opening
  - Trismus (possible medial pterygoid and infratemporal involvement)
  - Dentition
  - Cervical spine extension

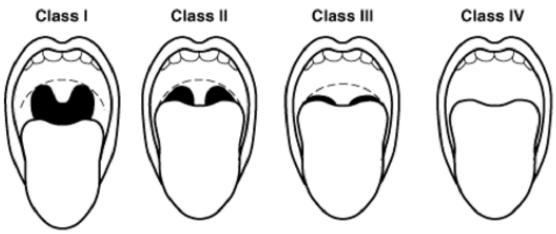


Figure 16: Mallampati scoring system

- Mallampati score (*Figure 16*)

Radiological evaluation

- Primary tumor

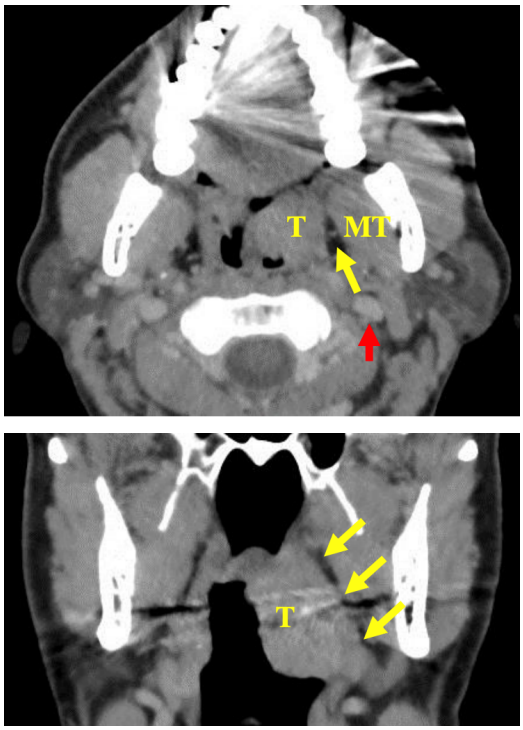


Figure 17ab: Axial and coronal CTs illustrate PPS fat (yellow arrows) separating tumor (T) from medial pterygoid muscle (MT), and the position of internal carotid artery (red arrow)

- CT / MRI / US2 (*Figures 17ab*)
- Not always required
- Mainly for advanced tumors if concern about extension to PPS and adjacent structures
- To determine position of internal carotid artery with larger resections
- Neck
- Chest

Informed consent

- Trauma
  - Dental
  - Lips, soft tissue
  - Traction injury of lingual and hypoglossal nerves due to prolonged tongue depression
- Failure to complete transoral resection
- Possible conversion to combined transcervical approach
- Flaps o Oropharynx defect
  - Cervical communication
- Neck dissection
- Tracheostomy
- Postoperative
  - Feeding
  - Analgesia
  - Primary or secondary haemorrhage
  - Healing time
- Anticipated functional outcomes

Anesthesia

- General anesthesia
- Orotracheal or nasotracheal intubation
- Nasogastric feeding tube contralateral to tumor (not always)
- Perioperative antibiotics if combined neck dissection

Surgical instrumentation (minimum)

The minimum instruments required for transoral lateral oropharyngectomy using a headlight +/- loupes include the following:

- Tonsillectomy instrument set



Figure 18: Dingman retractor

- Tonsil / Dingman retractor (*Figure 18*)
- Lindholm or other broad laryngoscope for reaching inferior extension, lateral wall or tongue base



Figure 19: Long-tipped insulated blade extension for monopolar cautery

- Standard or extended length monopolar electrocautery with insulated blade (for blunt dissection in PPS) (*Figure 19*)
- Bipolar long-tipped insulated electrocautery

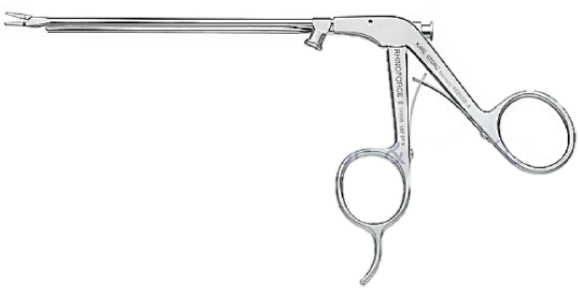


Figure 20: Liga clip applicator

- Liga clip applicator and clips, as used for transoral laryngeal microsurgery (*Figure 20*)

Surgical steps

- Perform panendoscopy to exclude synchronous tumors
- Inspect and palpate the tumor to determine mobility and extent
- Palpate tumor to ascertain extension to tongue base, fullness to superolateral aspect of pterygomandibular fold, soft palate, mobility with respect to pterygomandibular ligament
- Insert Dingman or tonsil retractor and place in suspension

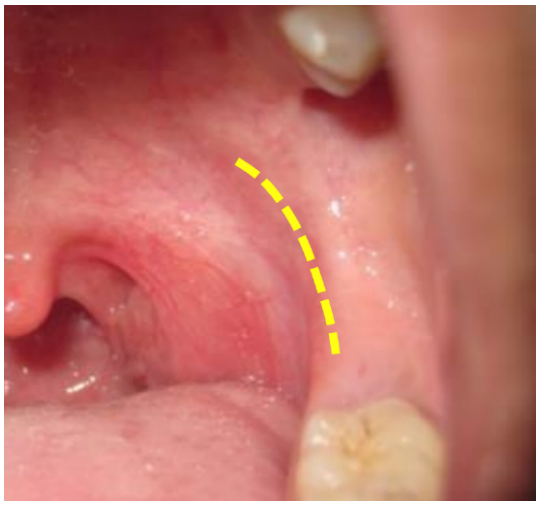


Figure 21: Pterygomandibular fold represents the surf

- Identify the pterygomandibular fold; it can be located by palpation (*Figure 21*)

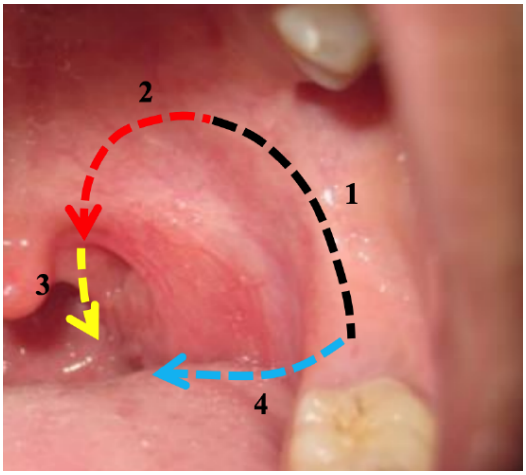


Figure 22: Typical sequence of incisions

- Incise the oral mucosa over the pterygomandibular fold to expose the pterygomandibular raphe; it is a key anatomical landmark to establish the correct lateral dissection plane (*Figure 22*)

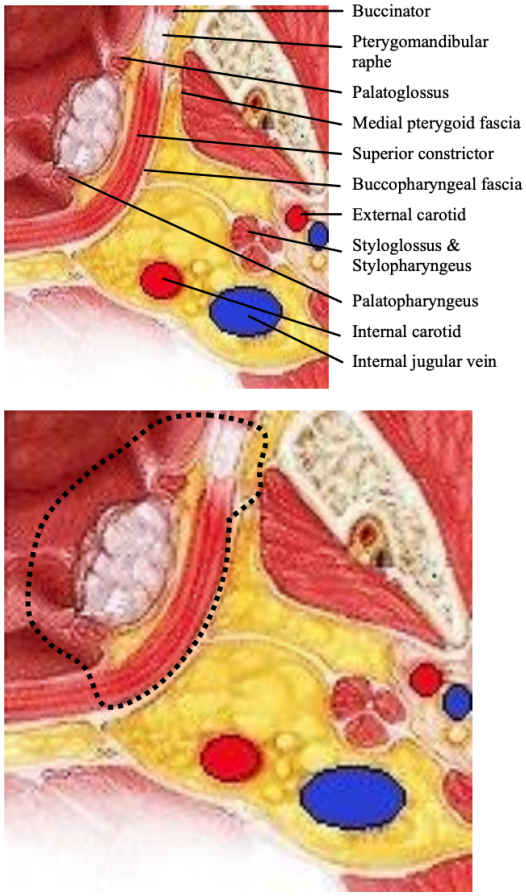


Figure 23: Key anatomical structures for lateral oropharyngectomy and typical dissection lines and planes for lateral oropharyngectomy (Adapted from Ento Key)

- Transect the buccinator muscle along its attachment to the pterygomandibular raphe (*Figures 22, 23*)
- Identify the fascia overlying medial pterygoid muscle (*Figure 23*)
- Dissect posteriorly along the medial pterygoid fascia while retracting the tumor and tonsil medially
- If possible, preserve the buccopharyngeal fascia to seal the oropharynx from structures in the PPS
- Free the superior pole of the specimen by incising through the pterygomandibular raphe, and soft palate mucosa and muscles (*Figure 22*)
- Free the tumor posteriorly by extending this incision inferiorly through the palatopharyngeus muscle (posterior tonsillar pillar) and pharyngeal mucosa and superior pharyngeal constrictor; this prevents the surgeon excising the posterolateral pharyngeal wall too far medially during the final steps of resection (*Figures 20, 21*)
- Free the tumor inferiorly by cutting below the tumor, including the tonsillolingual sulcus and lingual tonsil if required (*Figures 22, 23*)
- Continue the lateral dissection, taking care to remain medially in the dissecttion plane on the superior pharyngeal constrictor, palatoglossus, and palatopharyngeus muscles, using blunt dissection with the blade of the cautery
- Multiple branches of the facial, lingual and ascending pharyngeal arteries are seen to enter the specimen and are clipped, cauterized or tied and divided
- The facial or lingual arteries may have to be clipped or tied
- Identify the oblique-running styloglossus and vertically running stylopharyngeus muscles inferiorly in the surgical field
- The IX nerve may be seen coursing anterolaterally between these muscles (*Figures 10, 13*)
- The styloglossus and stylopharyngeus muscles obscure the internal carotid artery from the surgeon superiorly in the field (*Figure 10*). Transmitted pulsations, also from the external carotid artery, can be observed through the muscles, parapharyngeal fat and buccopharyngeal fascia
- Dissect bluntly when freeing the styloglossus and stylopharyngeus muscles inferiorly to avoid injury to the lingual artery
- Transect the styloglossus and stylopharyngeus muscles inferiorly as they course between the superior and middle pharyngeal constrictors

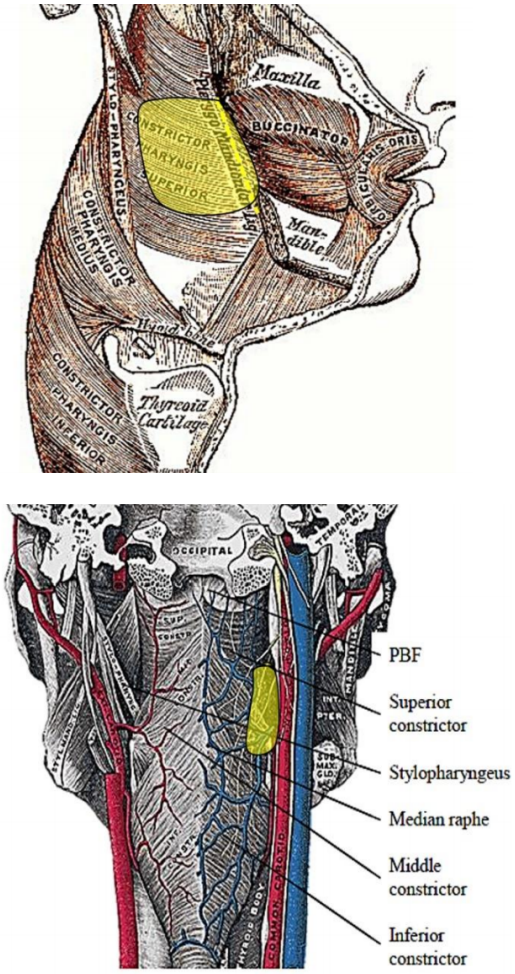


Figure 24ab: Typical resection (yellow)

- Release the specimen with final inferior cuts at the tonsillolingual sulcus and medial cuts through the superior pharyngeal constrictor (*Figures 24 a,b*)
- Carefully orientate and mark the specimen for the pathologist before removing it from the mouth
- If concern remains about inferior extension to lateral wall or tongue base, remove mouth retractor and examine with wide laryngoscope. Limited resection of residual disease may be undertaken with cup forceps and extended monopolar cautery using telescope for improved visualization and evacuating suction for smoke
- Obtain hemostasis
- If there has been a concurrent neck dissection, check for a direct communication with the neck

Postoperative care

- Analgesia
- Feeding: Commence when comfortable
- Airway
- Bleeding
- Antibiotics only if concomitant neck dissection

Complications

- Postoperative hemorrhage (1.5 - 13% of TORS)
  - Up to a month postoperatively
  - Potentially life-threatening
  - Multiple large vessels are ligated and are left exposed to the pharynx to scar over by secondary intention
  - With large resections one may elect to ligate the facial and lingual arteries or the ECA during the neck dissection to reduce the severity of postoperative bleeding

- Management depends on severity
  - Minor: Observe in hospital
  - Major
    - Intubate/ tracheostomy
    - Ligate/clip bleeders
    - Ligate ECA
    - Embolisation
- Airway obstruction
  - Bleeding
  - Oedema
  - Flaps
  - Secretions
  - If in doubt, do a tracheostomy or keep intubated
- Dental trauma
- Lip or tongue lacerations
- Taste disturbance due to prolonged traction or surgical injury to the lingual nerve…recovers with time
- Hypoglossal nerve traction injury… recovers with time

Other issues

Can the specimen be removed piecemeal?

- It is a well-established, safe practice with transoral CO_2 laser microsurgery to transect tumor to determine depth of invasion and to remove a tumor piecemeal, or to debulk the tumor to facilitate resection
- When a large oropharyngeal tumor prevents adequate exposure of the margins, it is therefore acceptable to transect the tumor and remove it piecemeal, taking care to accurately orientate the specimens for the pathologist

What constitutes a clear margin?

- It is not possible to achieve wide deep margins with cancers of the lateral pharyngeal wall without having to resect the contents of the PPS
- However, a 99% 5-year estimated local control was reported by Hinni (2013) following transoral resection of 128 tonsil cancers with average deep resection margins of only 1.98mm [3]
- Therefore, favourable outcomes can be achieved provided microscopically clear margins are achieved

When is reconstruction required?

- An exposed carotid artery must be covered with a flap (note: full thickness removal of the pharyngeal constrictor muscle with extension into PPS fat is an indication for a combined open and transoral approach. This approach also provides access for flap inset, and is a natural extension of neck dissection, management of ECA)
- Significant resection of soft palate can cause palatal incompetence that manifests as nasopharyngeal reflux and impaired speech
- Function does improve as the tumor bed scars and contracts with time
- It remains a judgement call when reconstruction of the palate is required to prevent these sequelae
- Options include
  - Local palatal flaps e.g. rotating uvula into the defect

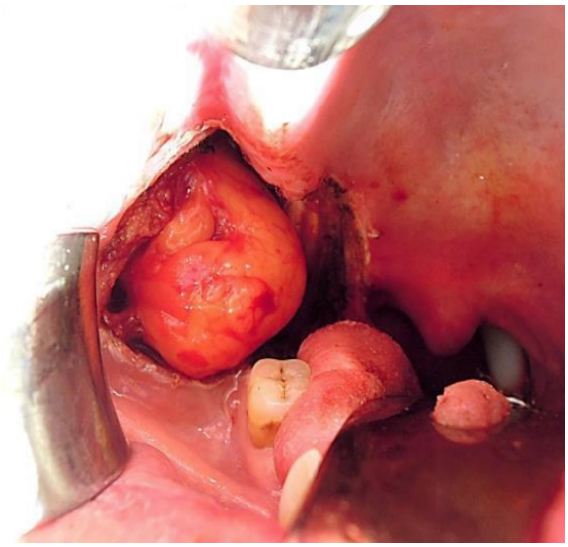


Figure 25: Buccal fat pad flap used to augment the palate or to close a pharyngocervical communication

- Buccal fat pad flap (*Figure 25*)

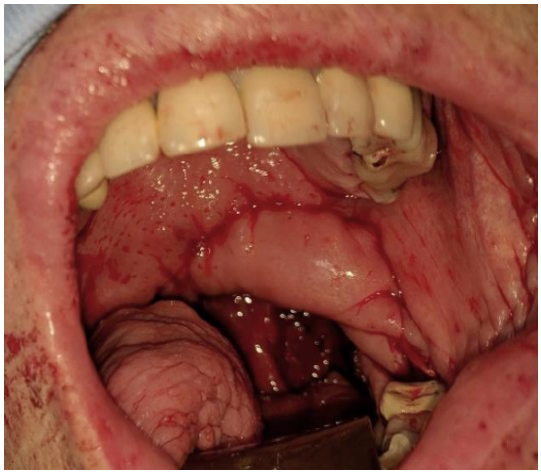


Figure 26: Soft palate and tonsil fossa defect reconstructed with buccinator flap

- Buccinator myomucosal flap (*Figure 26*)

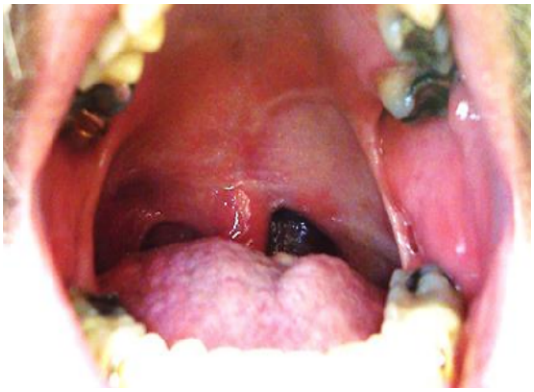


Figure 27: Radial free forearm flap reconstruction of oropharynx and soft palate defect

- Radial free forearm flap (*Figure 27*)

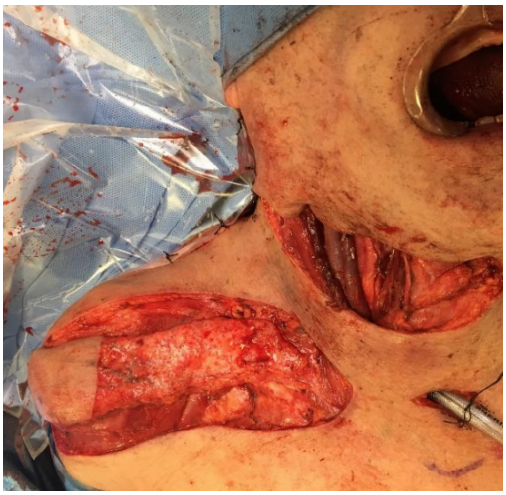


Figure 28: Supraclavicular flap

- Supraclavicular flap (*Figure 28*)



Figure 29: Submental artery island flap

- Submental artery island flap (*Figure 29*)
- Pectoralis major flap
- Anterolateral free thigh flap

Neck dissection

- Oropharyngeal squamous carcinomas generally need to have the N0 neck treated either surgically or with (chemo) radiation
- Neck dissection is ideally done at the same operation, but may be staged
- There is a risk of causing a communication between the pharynx and submandibular triangle at the tonsillolingual sulcus
- A communication can be avoided by
  - Cutting through the submandibular gland with cautery, leaving the deep portion of the gland in situ
  - Leaving the whole submandibular gland in situ, taking care to clear the facial nodes (there are no intraglandular lymph nodes)
- Should a communication occur, then it can be dealt with by
  - Suturing the free margin of the mylohyoid to the posterior belly of digastric and avoiding placing the tip of the suction drain close to Level 1
  - Repairing the defect with a flap
    - Buccal fat pad flap (*Figure 25*)
    - Buccinator myomucosal flap (*Figure 26*)
    - Radial free forearm flap (*Figure 27*)
    - Supraclavicular flap (*Figure 28*)

- Submental artery island flap (*Figure 29*)
- Pectoralis major flap
- Anterolateral free thigh flap

Feeding tube

It is simpler to remove a nasogastric feeding tube the day following surgery, than to have to insert it should the patient struggle to swallow.

Tracheostomy

Tracheostomy may be considered for two reasons i.e. concerns about the airway (edema, soft tissue reconstruction, patient factors) or when there are concerns about postoperative bleeding. It remains a judgement call by the surgeon in consultation with the anesthetist.

Salvage surgery

Salvage surgery may be considered following previous transoral resection and/or chemoradiation. It requires a higher level of surgical skill and experience, and a very detailed radiological assessment of resectability via a transoral approach. When concerns exist about injuring the ICA, the ICA may first be exposed via Level 2 of the neck and gauze packed anterior to the ICA in the PPS to protect it during the transoral phase of the dissection.

References

1. Weinstein GS, O'Malley BW, Rinaldo A et al. Eur Arch Otorhinolaryngol 2015; 272 (7): 1551-2 https://doi.org/10.1007/s00405-014-3331-9
2. Faraji F, Coquia SF, Wenderoth MB, Padilla ES, Blitz D, DeJong MR, Aygun N, Hamper UM, Fakhry C. Evaluating oropharyngeal carcinoma with transcervical ultrasound, CT, and MRI. Oral Oncology. 2018: 78:177-85
3. Hinni ML, Zarka MA, Hoxworth JM. Margin mapping in transoral surgery for head and neck cancer. Laryngoscope. 2013 May;123(5):1190-8

Additional reading

- Chapter in Open Access Atlas of Otolaryngology Head and Neck Operative Surgery: Oropharyngeal cancer resection
- Gun R, Durmus K, Kucur C, et al. Transoral Surgical Anatomy and Clinical Considerations of Lateral Oropharyngeal Wall, Parapharyngeal Space, and Tongue Base. Otolaryngol Head Neck Surg. 2016 Mar;154(3):480-5

Author

Wayne M. Koch, MD
Professor of Otolaryngology-Head & Neck Surgery
Johns Hopkins University
Baltimore, MD 21287 USA
wkoch@jhmi.edu

Author & Editor

Johan Fagan
MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan

Failure of a branchial cleft to involute may manifest as an epithelial-lined cyst, sinus or fistula. Sinuses open either onto the skin, or into the oro- or hypopharynx.

Branchial anomalies may be diagnosed at any age but present most commonly in infancy and childhood as a cutaneous sinus, a cyst or an abscess. The differential diagnosis of a cystic lateral neck mass includes thymic, parathyroid and thyroid cysts, cystic metastases (papillary thyroid carcinoma, oropharyngeal squamous cell carcinoma, skin cancer), tuberculous cold abscess, lymphatic malformation, plunging ranula, and laryngocoele. The existence of branchiogenic carcinoma is controversial. Cystic metastases to cervical lymph nodes originating from oropharyngeal squamous cell carcinoma occur far more commonly and should be suspected particularly in adult patients presenting with cystic masses in Levels 2 or 3 of the neck.

Surgical excision is the standard of care. An understanding of the embryology of the branchial apparatus is required to diagnose and operate on such patients.

Embryology

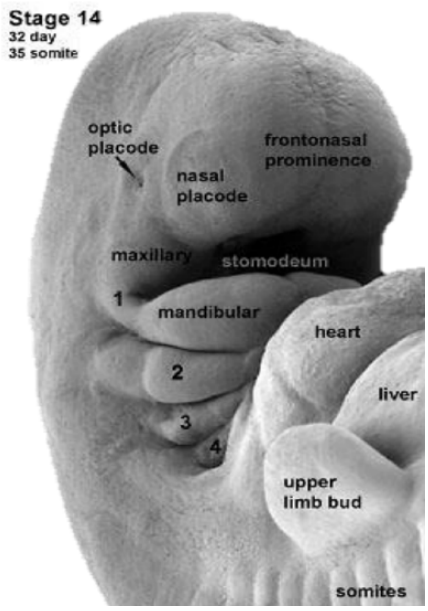


Figure 1: Branchial arches 1 - 4 with intervening branchial clefts

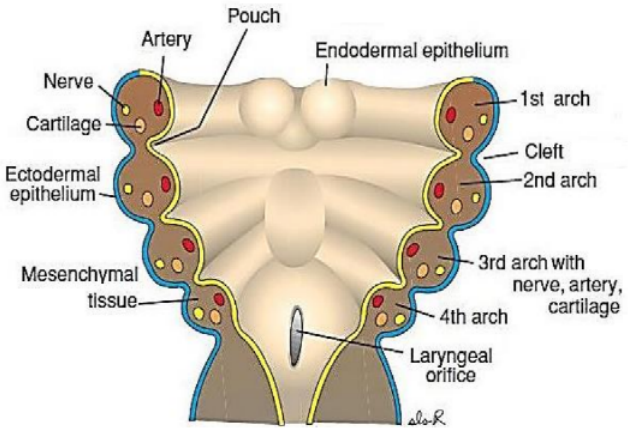


Figure 2: Pharynx opened from behind illustrates anatomy of branchial apparatus

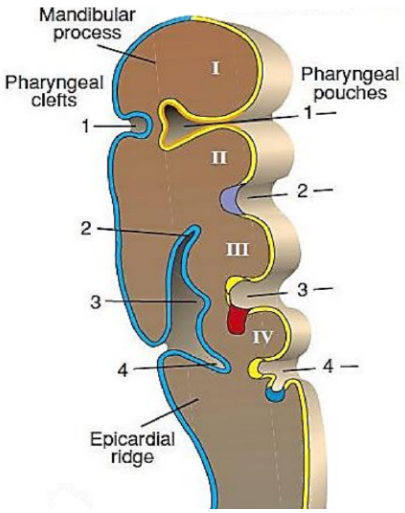


Figure 3: Branchial arches, clefts and pouches; clefts 2-4 form the Sinus of His

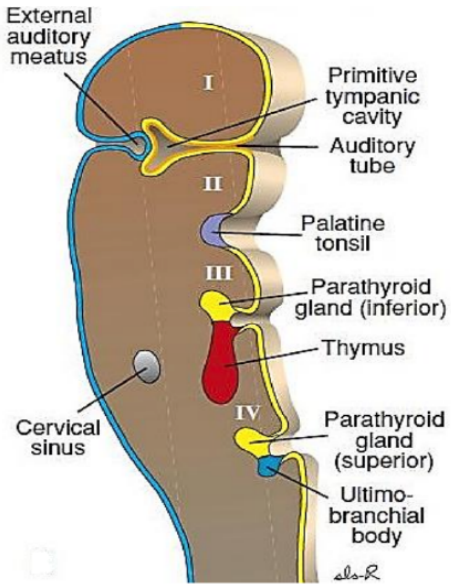


Figure 4: Structures that evolve from branchial clefts and pouches; clefts 2-4 form cervical sinus that is subsequently obliterated

The branchial apparatus develops during the 2nd - 6th weeks of life. At this stage the neck of the foetus is shaped like a hollow tube with circumferential ridges called branchial arches which are separated internally by branchial pouches and externally by clefts

(*Figure 1*). It is lined by ectoderm externally and endoderm internally; mesoderm and neural crest cells migrate into the branchial arches to evolve into musculoskeletal, vascular and cranial nerves that serve the structures of that arch (*Figure 2*). The endoderm that lines the branchial pouches evolves into the middle ear, tonsil, thymus and parathyroid (*Figures 3, 4*). The 1st branchial cleft evolves into the external auditory meatus (*Figure 3*).

The 2nd - 4th clefts form a common cavity called the Sinus of His with a single external opening (*Figure 3*). The 2nd arch subsequently grows inferiorly and covers the *Sinus of His* to give rise to a single branchial cleft cyst called the cervical sinus which subsequently involutes (*Figure 4*). Should a branchial cleft or the *Sinus of His* persist, it results in an epithelium-lined branchial cyst or sinus. Because clefts 2 - 4 embryologically have a common external opening, one cannot determine the cleft of origin by the position of the external sinus. A sinus may also result from spontaneous drainage of a cyst onto the skin or pharyngeal mucosa or following incision and drainage. A fistula results from a communication between a branchial cleft and pouch.

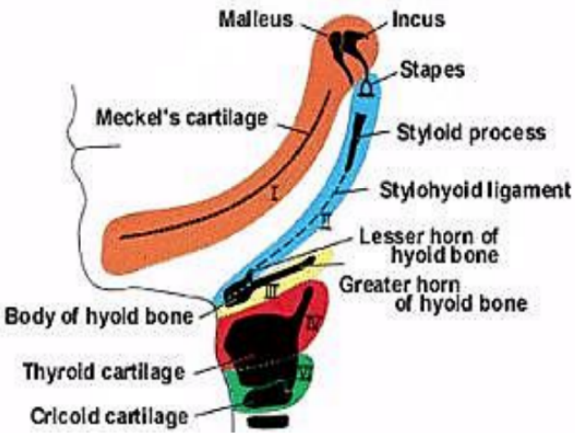


Figure 5: Derivatives of branchial arches

	Bone/Cartilage	Nerve	Artery
I	Incus, malleus, mandible	V2, V3	Maxillary Ext carotid
II	Stapes, styloid, hyoid (lesser cornu/upper body)	VII	Stapedial Hyoid
III	Hyoid (greater cornu/ inferior body	IX	Common carotid Internal carotid
IV	Thyroid & epiglottic cartilages	Vagus Superior laryngeal	Right: aortic arch, subclavian Left: aortic arch
VI	Cricoid cartilage, Arytenoid cartilages, Corniculate cartilage	Vagus Recurrent laryngeal	Right: Pulmonary Left: Pulmonary, ductus arteriosus

Table 1: Derivatives of arches

Branchial anomalies lie caudad to the embryologic derivatives of the associated arch and cephalad to the derivatives of next arch (*Figures 4, 5, Table 1*).

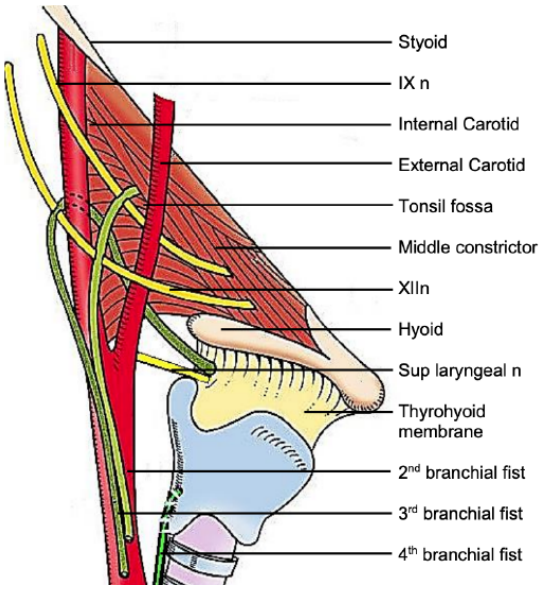


Figure 6: 2nd, 3rd & 4th branchial fistulae: Tracts lie inferior to embryologic derivative of associated arch and superior to derivative of next arch (Adapted from O'Rahily, Muller: Human Embryology & Teratology, 2nded. New York: Wiley-Liss, 1996)

General clinical presentation



Figure 7: 3rd Branchial cleft cyst presenting as a deep neck abscess

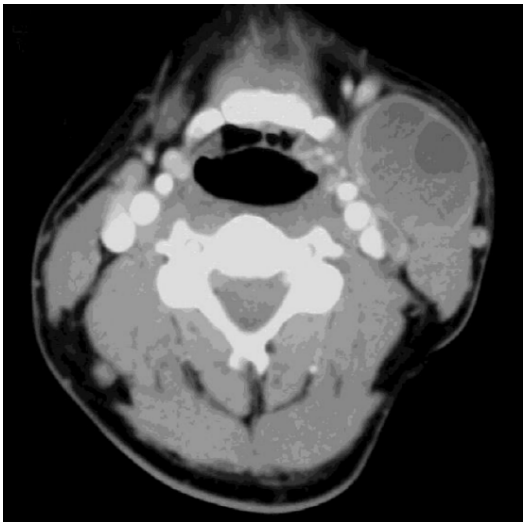


Figure 8: Infected 2nd branchial cleft cyst

A cyst may present as an external swelling, or cause dysphagia or airway obstruction due to its mass effect, or become infected and present as an abscess (*Figures 7, 8*).

1st Branchial cleft cysts/sinuses/fistulae

1st branchial cleft anomalies are uncommon and result from incomplete closure of the ventral part of the 1st branchial cleft. The 1st branchial cleft evolves into the external auditory canal; the pouch into the middle ear cavity, mastoid air cells and eustachian tube (*Figures 4*, *5*); Work divided 1st branchial cleft anomalies into Types 1 & 2 (Laryngoscope 1972;82:1581- 93).

First branchial cleft anomaly Type I

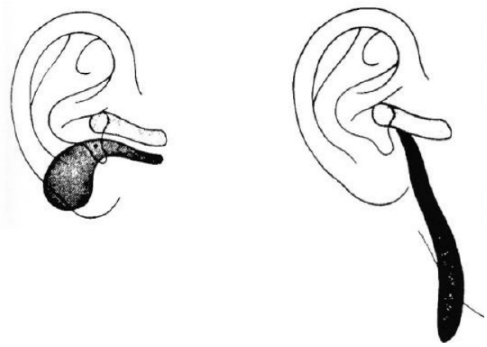


Figure 9: 1st Branchial cleft anomalies Types 1 & 2 (From: Work. Laryngoscope 1972;82:1581-93)

This is a duplication of the external auditory canal and is lined by squamous epithelium (*Figure 9*). It runs parallel to the ear canal and may have a fistula terminating in the postauricular or pretragal regions. It generally does not involve the VIIn. Treatment is by surgical excision of the cyst or fistula and of involved skin and cartilage of the external auditory canal.

First branchial cleft anomaly Type II



Figure 10: Typical swelling associated with 1st branchial cyst

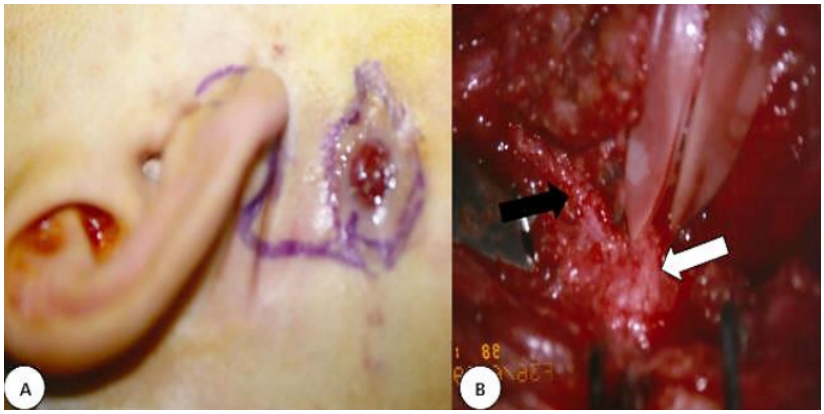


Figure 11: A: Fistula at anterior border of sternomastoid; B: fistula tract (black arrow) deep to VIIn (white arrow) displacing the nerve laterally (Choi JH, Woo HY. J Current Surg. 2012; 2(1): 29-31)

This typically presents as a cyst / sinus / fistula, or combinations thereof. It is of both ectodermal and mesodermal origin and hence may contain skin, adnexia and cartilage. It extends between the angle of the mandible and the external auditory canal. The cyst or the external opening is typically located in the neck superior to the hyoid bone i.e. the next branchial arch (*Figures 10, 11*).

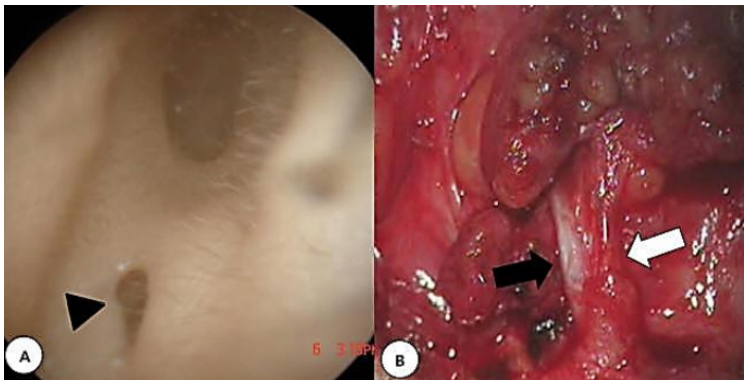


Figure 12: Sinus opening in external auditory canal; B: Tract (black arrow) parallels external auditory canal and terminates deep to VIIn (white arrow) (Choi JH, Woo HY. J Current Surg. 2012;2(1): 29-31)

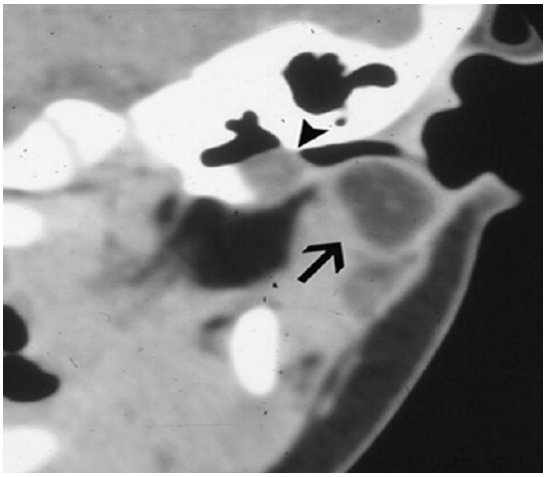


Figure 13: Coronal CT of 1st branchial cleft cyst Type 2 in parotid (arrow) that is connected via smaller cyst in external ear canal at osseocartilaginous junction (arrowhead) (Khanna G. Radiographics 2006;26: 157-71)

It crosses the angle of the mandible, courses through parotid and terminates near the bony-cartilaginous junction of the external auditory canal (*Figures 9, 11-13*).

A surgeon should not embark on such surgery without being comfortable with operating on the VIIn, as the VIIn is associated with the 1st branchial arch, and is intimately associated with 1st branchial cleft anomalies; the tract may pass deep, lateral or between branches of the nerve, or a cyst may displace the nerve caudally.

Carefully examine the external ear canal with a diagnostic microscope for the presence of a sinus opening in the floor of the ear canal (*Figure 12*). Request CT +/ MRI to determine the anatomical relationships with the ear canal, parotid and VIIn; the position of the nerve can be estimated according to the position of the retromandibular vein relative to the anomaly.

Treatment is by surgical excision; this requires identification and preservation of the VIIn, partial parotidectomy, and excision of skin and cartilage of the external auditory canal around the tract:

- General anesthesia: avoid muscle relaxants so that VIIn can be stimulated
- Consider using a nerve monitor especially if there is likely to be scarring from previous sepsis
- Make a parotidectomy (lazy-S) incision (see Parotidectomy); incorporate a skin ellipse made around surgical scars, sinuses or fistulae
- Locate the VIIn
- In younger children, locate the VIIn by using anterior border of sternocleidomastoid, posterior belly of digastric, and cartilage of external auditory meatus as landmarks because:
    - VIIn is just deep to parotid fascia

- Cartilaginous pointer and styloid process landmarks are often not present or poorly developed





Figure 14ab: Resection of cyst by superficial parotidectomy, exposing VIIn and its branches

- Perform a limited superficial parotidectomy and dissect the divisions and branches of the VIIn beyond the branchial anomaly (*Figures 14a,b*)
- Dissect the sinus/fistula/cyst, and preserve VIIn and its branches
- Remove the anomaly up-to-and-including cartilage and skin of the external auditory canal (if involved)
- Should the anomaly (rarely) involve the tympanic membrane, repair it with a myringoplasty

2nd Branchial cysts/sinuses/fistulae

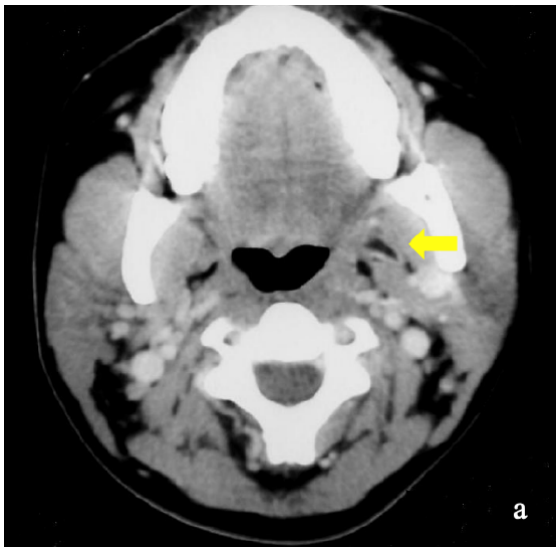


Figure 15a: 2nd Branchial cleft fistula terminating in supratonsillar fossa



Figure 15b: 2nd Branchial cleft fistula terminating in supratonsillar fossa

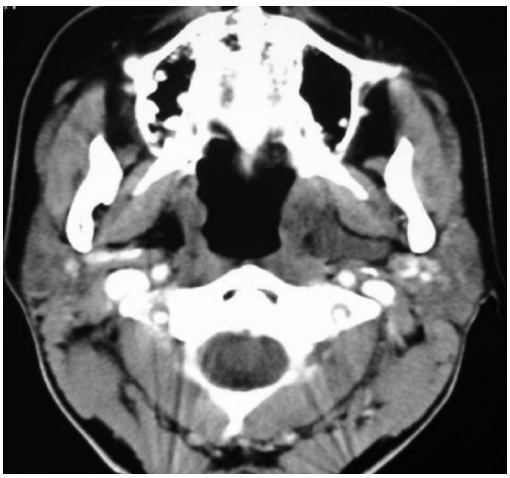


Figure 16: Extension of 2nd branchial fistula towards tonsil

https://med.libretexts.org/@go/page/17679



Figure 17: Deep extension of cyst along medial pterygoid muscle toward tonsil

More than 90% of branchial anomalies arise from 2nd branchial clefts. The 2nd branchial arch contributes to the development of the hyoid; the cleft forms the Sinus of His jointly with clefts 3 and 4, and subsequently involutes; and the pouch becomes the palatine tonsil and supratonsillar fossa. Consequently 2nd arch anomalies communicate with the oropharynx via the supratonsillar fossa (*Figures 15 - 17*).

Like 3rd and 4th branchial anomalies, ***2nd branchial cleft fistulae/sinuses*** are found along the anterior border of sternocleidomastoid. A fistula tracks deep to platysma (embryologically covers external opening of Sinus of His) and courses superiorly between the internal and external carotid arteries and passes over the XIIn and IXn to enter the supratonsillar fossa (*Figure 6*). A cyst may occur anywhere along its course.



Figure 18: Typical 2nd branchial cleft cyst



Figure 19: Typical 2nd branchial cleft cyst

A ***2nd branchial cleft cyst*** typically presents as a mass along the anterior border of sternocleidomastoid (*Figures 8, 18, 19*). It contains a clear fluid and transilluminates with light.



Figure 20: Cystic metastasis from oropharyngeal cancer that may be mistaken for a branchial cyst

It is ***clinically indistinguishable from other conditions such as a Level 2 cystic metastasis*** from carcinoma of the oropharynx, skin or thyroid (*Figure 20*) and from salivary and hydatid cysts in the parapharyngeal space. Therefore it is important in the adult to examine the upper aerodigestive tract for a primary cancer and to send a fine needle aspirate for cytologic examination.

Surgery

The branchial cyst +/ tract is surgically excised under general anesthesia. CT or MRI may help to delineate a tract (*Figures 15-17*). Tonsillectomy may be required if the tract terminates in the supratonsillar fossa. Avoid operating on an inflamed cyst; aspirate the contents, commence antibiotics and adjust the choice of antibiotics in accordance with the microbiology results of the aspirate.

- Place a transverse cervical incision in a natural skin crease about at the level of the hyoid bone incorporating any skin sinuses in an ellipse of skin
- For wider exposure, extend the incision posteriorly over the sternocleidomastoid muscle; avoid vertical skin incisions as they are cosmetically unacceptable; rather use transverse stepladder incisions if necessary
- Divide the platysma muscle (cyst is embryologically deep to the muscle)



Figure 21: Skin incision over mass

- Identify, ligate and divide the external jugular vein as it crosses sternocleidomastoid muscle
- Take care not to injure the greater auricular nerve which lies just behind and parallel to the vein
- Elevate subplatysmal flaps superiorly and inferiorly and expose the cyst
- Expose the posterior wall of the cyst by dissecting along the anterior border of sternocleidomastoid with a scalpel or electrocautery while retracting the muscle posteriorly
- Mobilize the cyst using sharp and blunt dissection inferiorly and anteriorly

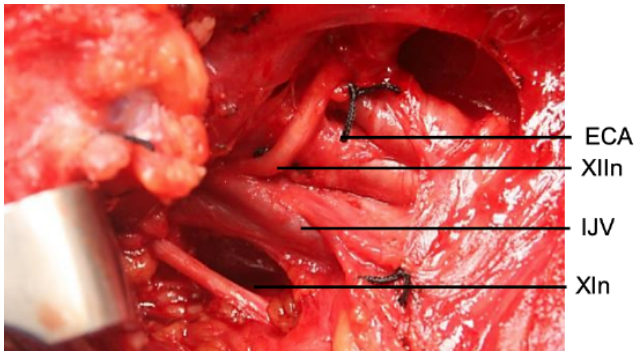


Figure 22: Structures deep to branchial cyst

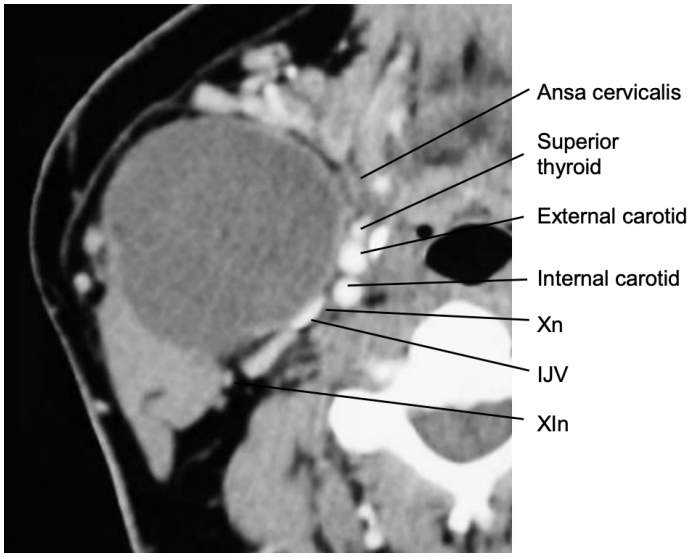


Figure 23: Structures deep to branchial cyst (approx positions of Xn, XIn)

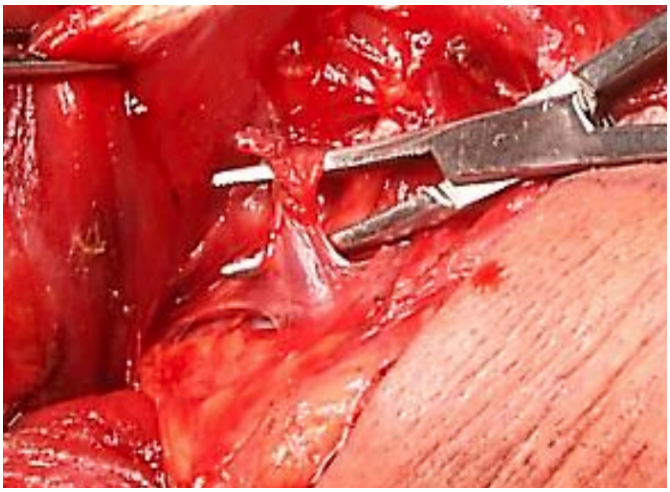


Figure 24: Ranine veins that cross XIIn



Figure 25: Mobilized branchial cyst

- Elevate the cyst off the deep structures i.e. Xn, XIn, XIIn, descendens hypoglossi, internal jugular vein and carotid vessels (*Figures 22*, *23*); take care not to traumatize the ranine/lingual veins where the tract crosses the XIIn (*Figure 24*)

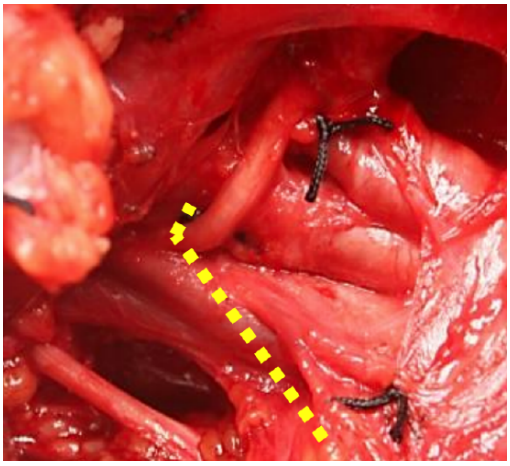


Figure 26: Course of tract over XIIn and between internal and external carotid arteries

- Look for a tract above the cyst (not always present), and follow the tract superiorly between the internal and external carotid arteries (*Figure 26*) to where it enters the oropharynx
- It may be necessary to extend the cervical incision or to use step-ladder incisions for additional exposure
- Take care not to injure X, XI, and XIIn
- If an internal opening is not found, ligate the tract at the level of the posterior belly of digastric

- If an internal opening is present, then place a finger in the supratonsillar fossa to identify the end of the tract; dissect the tract up to the pharyngeal constrictor and ligate and divide the tract; to completely excise a tract that terminates in the supratonsillar fossa a tonsillectomy may be required
- Drain the neck with a 5 mm suction drain
- Suture platysma and skin

3rd & 4th Branchial cysts/sinuses/fistulae



Figure 27: External opening of 3rd branchial fistula that presented with recurrent neck abscesses

Third and 4th branchial cleft cysts are rare. Because of their common origin from the *Sinus of His*, 3rd and 4th branchial cleft cysts share certain features. They typically present as recurrent cervical abscesses or are misdiagnosed as acute suppurative thyroiditis (*Figure 27*). An external sinus or fistula is located along the anterior border of sternocleidomastoid (*Figure 27*). Because the 2nd - 4th clefts jointly form the *Sinus of His* with a single external opening, it is impossible to distinguish branchial clefts 2 - 4 from one another based on the location of a skin sinus or fistula.

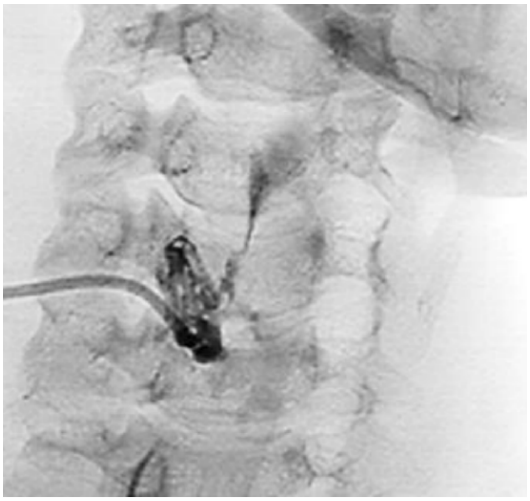


Figure 28: Fluoroscopic sinogram with pigtail catheter in cervical abscess cavity of branchial cyst with contrast entering pyriform fossa (Cain et al. Right-sided pyriform sinus fistula: a case report and review of the literature. Case Rep Otolaryngol. 2012;2012:934968)

The cleft or pouch of origin is defined by the location of the internal (pharyngeal) opening. Unlike 2nd branchial anomalies, 3rd and 4th anomalies enter the pyriform fossa below the level of the hyoid bone (2nd arch). Gas in the region of the upper pole of the thyroid gland abutting the pyriform fossa on ultrasound or CT is pathognomonic of 3rd or 4th branchial anomalies. Barium esophagogram has a high sensitivity for demonstrating the internal opening of a fistula in the pyriform fossa. Fluoroscopic or CT sinogram/ fistulogram may delineate the course of a tract (*Figure 28*).

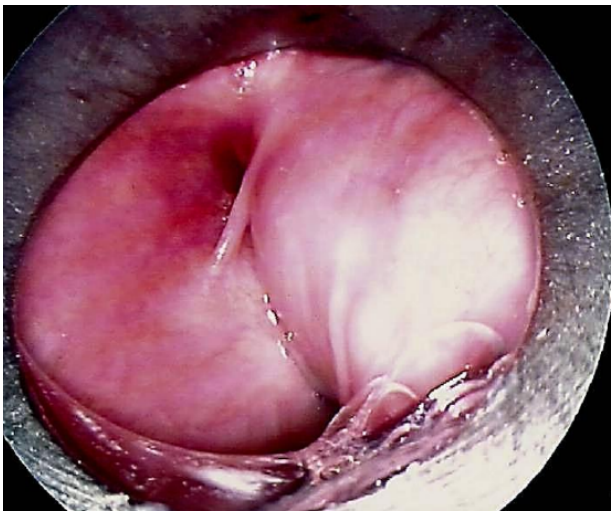


Figure 29: Internal opening of branchial sinus/fistula in pyriform fossa

Direct laryngoscopy will reveal the internal opening of a sinus or fistula in the pyriform fossa (*Figure 29*).

3rd Branchial cysts/sinuses/fistulae



Figure 30: 3rd branchial cyst; note proximity to thyrohyoid membrane

A fistula tracks deep to platysma, passes behind the internal carotid artery, loops over XIIn, courses just superior to the superior laryngeal nerve to pierce the thyrohyoid membrane and enters the upper part of the pyriform fossa. Branchial cysts may occur anywhere along the course of this tract (*Figure 30*).

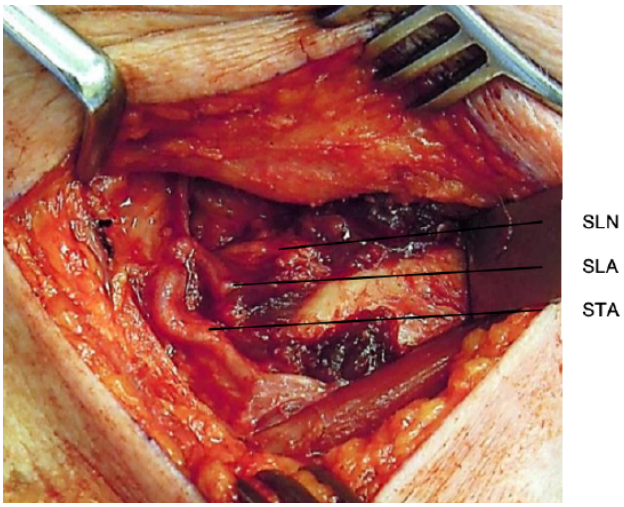


Figure 31: Final view of superior thyroid artery (STA), superior laryngeal artery (SLA) and superior laryngeal nerve (SLN)

Resection is via a transverse skin crease incision or via thyroidectomy approach. Be prepared to have to identify the recurrent laryngeal nerve and to do partial thyroid lobectomy. Superiorly preserve the superior laryngeal nerve where it traverses the thyrohyoid membrane (*Figure 31*).

4th Branchial cysts/sinuses/fistulae



Figure 32: Infected 4th branchial cyst displacing thyroid gland anterolaterally



Figure 33: Infected 4th branchial cyst in paratracheal region extending to pyriform fossa

These are extremely rare. They almost always occur on the (L) side and typically are misdiagnosed as “acute suppurative thyroiditis”, or cervical abscesses that have been repeatedly drained (*Figures 32, 33*).

The external opening of a fistula or sinus is found along the anterior border of the sternocleidomastoid and is generally a consequence of incision and drainage of a branchial cyst that has been mistaken as a “cervical abscess”. The diagnosis is clinched by finding an ***internal opening near the apex of the pyriform fossa on direct laryngoscopy*** (*Figure 29*).

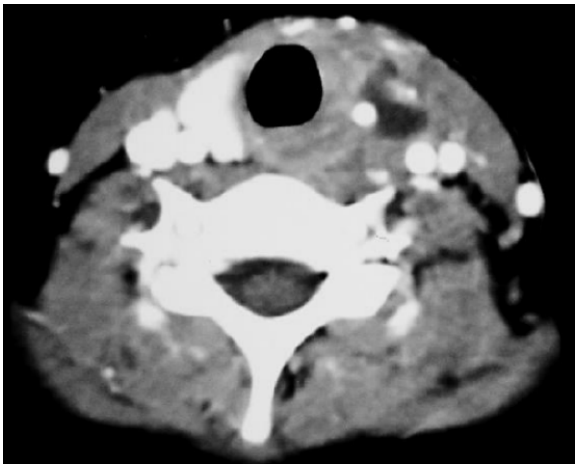


Figure 34: Cyst abutting thyroid gland

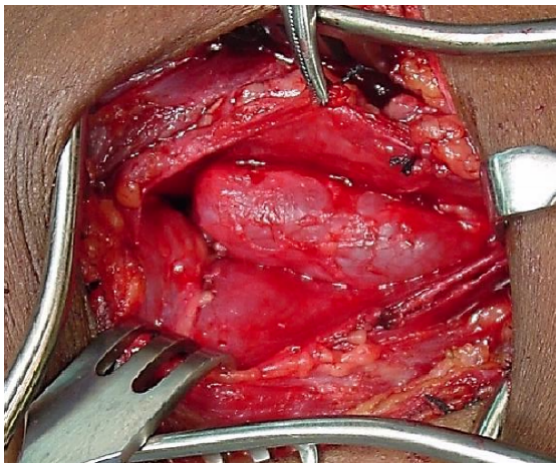


Figure 35: Exposure of cyst

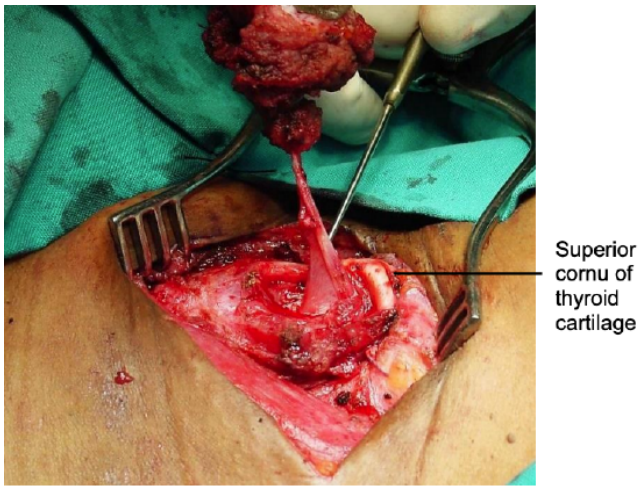


Figure 36: Following tract behind thyroid lamina towards pyriform fossa

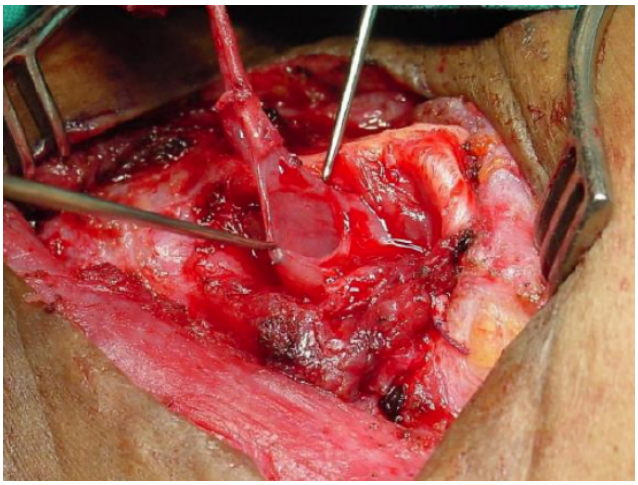


Figure 37: Opening into pyriform fossa

A true fistula would follow the course of the recurrent laryngeal nerve around the aorta (left) or subclavian artery (right), to then ascend superficial to the recurrent laryngeal nerve in the paratracheal region; this has never been reported in practice. It then passes behind the thyroid ala and opens into the apex of the pyriform fossa; 4th branchial cleft cysts may occur anywhere along this course including abutting thyroid gland and within the mediastinum (*Figures 6, 29, 32-37*).

CT scan is an important investigation as it is both diagnostic and serves as a surgical roadmap. CT-fistulography may delineate the fistula tract.

Treatment is to excise the cyst and/or fistula, and is often combined with partial thyroidectomy (*Figures 35-37*).

Partial resection of the thyroid lamina may be required to gain exposure to where the tract enters the pyriform fossa (Note: an entire thyroid lamina may be resected without causing functional problems). Although the fistula tract theoretically extends into the mediastinum, this is rarely the case in clinical practice.

Endoscopic cauterization of the sinus opening and tract in the pyriform fossa has been described (Verret et al). At direct laryngoscopy an intravenous balloon catheter or angiocath is advanced into the sinus tract at the apex of the pyriform fossa; the balloon is inflated to dilate the opening of the sinus and an electrocautery ball coagulator is inserted into the sinus opening and the tract is coagulated.

Chemocauterization with 40% trichloroacetic acid (TCA) is less invasive and has been proposed as 1st line treatment, although patients may be prone to recurrence (Cain et al). The purported advantages of TCA over electrocautery are that a longer segment of tract can be obliterated without risk of thermal injury to adjacent structures. It can be repeated several times, where after surgery is recommended for recurrence.

Useful references

- Devaney KO, Rinaldo A, Ferlito A, Silver CE, Fagan JJ, Bradley PJ, Suá - rez C. Squamous Carcinoma Arising in a Branchial Cleft Cyst - Have You Ever Treated One? Will You? J Laryngol Otol. 2008; 122(6): 547 -50
- Verret DJ et al. Endoscopic cauterization of fourth branchial cleft sinus tracts. Arch Otolaryngol Head Neck Surg. 2004 Apr; 130(4):465 - 8
- Cain RB, Kasznica P, Brundage WJ. Right -sided pyriform sinus fistula: a case report and review of the literature. Case Rep Otolaryngol. 2012;2012: 934968
- http://php.med.unsw.edu.au/embryolog...010_Lecture_11
- https://missinglink.ucsf.edu/restric...CleftCyst.html

Author and Editor

Johan Fagan
MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.42: Surgical Drainage of Neck Abscesses

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Jean Morkel

Neck abscesses can be difficult to drain and have fatal consequences if not timeously diagnosed, accurately localized and promptly incised and drained. Yet the management is commonly left in the hands of surgical trainees.

This chapter presents the relevant surgical anatomy and surgical approaches to the different fascial spaces of the head and neck. Because fascial planes both direct and confine spread of sepsis, it is important to have an understanding of the fascial planes and fascial spaces of the head and neck.

Classification of Cervical Fasciae

- Superficial cervical fascia (*Figures 1, 2*)
- Deep cervical fascia (*Figures 2-4*)
  - Superficial (investing) layer
  - Middle layer
    - Muscular layer
    - Visceral layer
  - Deep layer
    - Alar fascia
    - (Pre)vertebral fascia

Superficial Cervical Fascia



Figure 1: Delicate superficial cervical fascia overlying external jugular vein and fat following division of platysma over the lateral neck

This very thin, delicate fascia is found just deep to the skin and envelopes the muscles of the head and neck including platysma and the muscles of facial expression. It is so thin that it may be difficult to identify when incising the neck. It extends from the epicranium above to the axillae and upper chest below and includes the superficial musculoaponeurotic system/SMAS. The space deep to the superficial cervical fascia contains fat, vessels (e.g. anterior and external jugular veins), nerves and lymphatics and is by definition not a deep neck space (*Figure 1*). Abscesses located either superficial to or within the tissue space immediately deep to the superficial cervical fascia are treated by simple incision and drainage.

Deep Cervical Fascia (Figures 2-4)

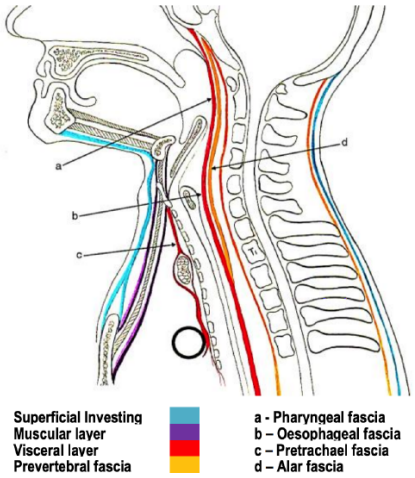


Figure 2: Sagittal view of 3 layers of deep cervical fascia

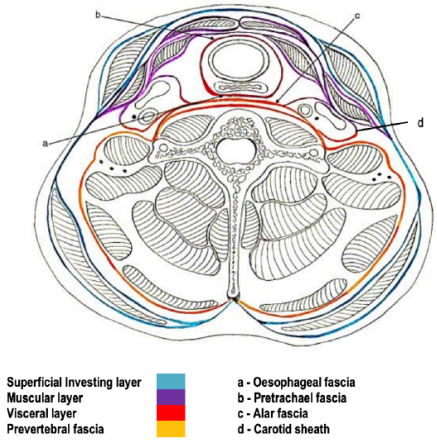


Figure 3: Infrahyoid cross-section of deep cervical fasciae

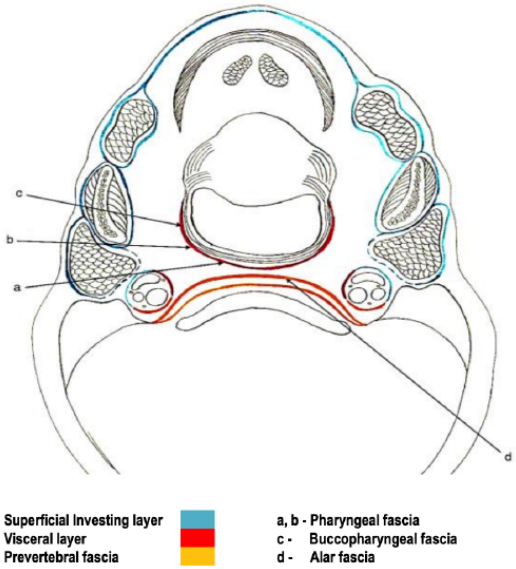


Figure 4: Suprahyoid cross-section of deep cervical fasciae

This ***envelopes the deep neck spaces***; hence an understanding of its anatomy is ***key to managing deep neck sepsis***. It comprises 3 layers i.e. ***superficial***, ***middle***, and ***deep***.

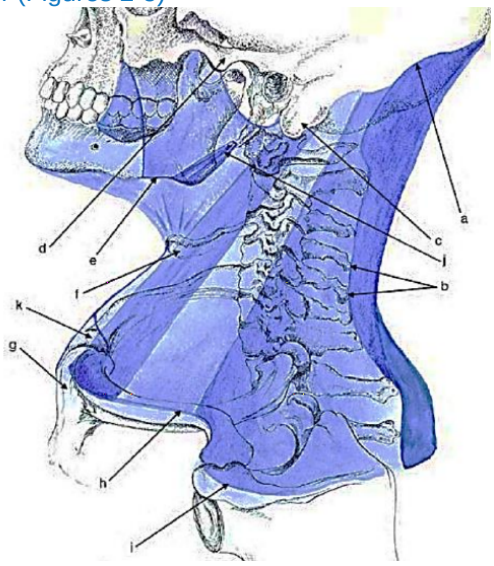


Figure 5: Attachments of superficial layer of deep cervical fascia

The superficial layer, also known as the ***investing layer***, surrounds the neck and envelopes the muscles of mastication i.e. masseter, buccinator, digastric and mylohyoid (*Figures 4, 5*).

The attachments of the superficial layer of deep cervical fascia are as follows (*Figure 5*):

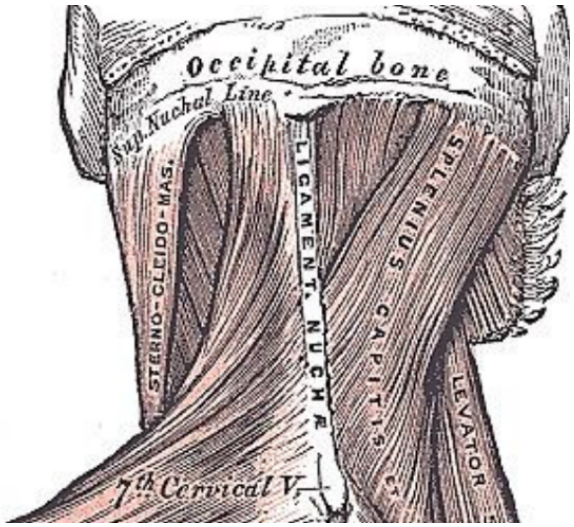


Figure 6: The superficial/investing layer of deep cervical fascia attaches to superior nuchal line and ligamentum nuchae

a) Superior nuchal line of occipital bone (*Figures 2, 6*)

b) Posteriorly merges with ligamentum nuchae, a midline intermuscular extension of the supraspinous ligament (*Figures 2, 3, 6*).

c) Mastoid processes of temporal bones

d) Zygomatic arches

e) Inferior border of mandible

f) Hyoid bone

g) Manubrium sterni

h) Clavicles

i) Acromion

j) Forms stylomandibular ligament

k) Fascia parts just above manubrium sterni to contain anterior jugular veins, and attaches to anterior and posterior surfaces of the manubrium (*Figure 2*)

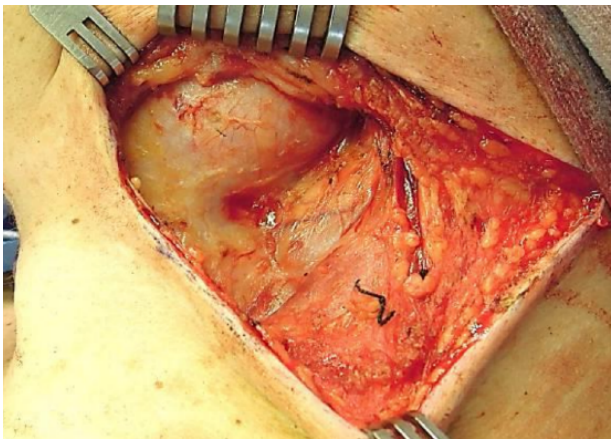


Figure 7: The superficial/investing layer of deep cervical fascia covers the submandibular gland and the lateral aspect of the major vessels as part of the outer surface of carotid sheath, and the sternocleidomastoid muscle

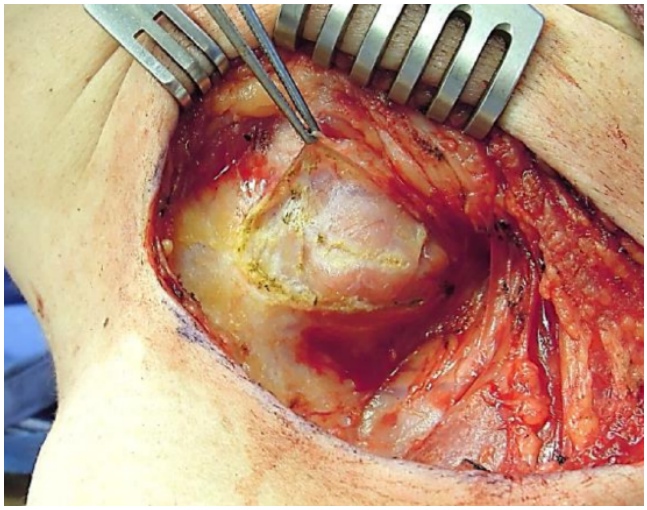


Figure 8: Submandibular capsule incised to demonstrate its thin capsule

The fascia splits into superficial and deep layers to enclose trapezius and sternocleidomastoid (*Figure 3*). It also encapsulates the submandibular and parotid glands (*Figures 4*, *7*, *8*), and contributes to the carotid sheath (*Figure 3*).

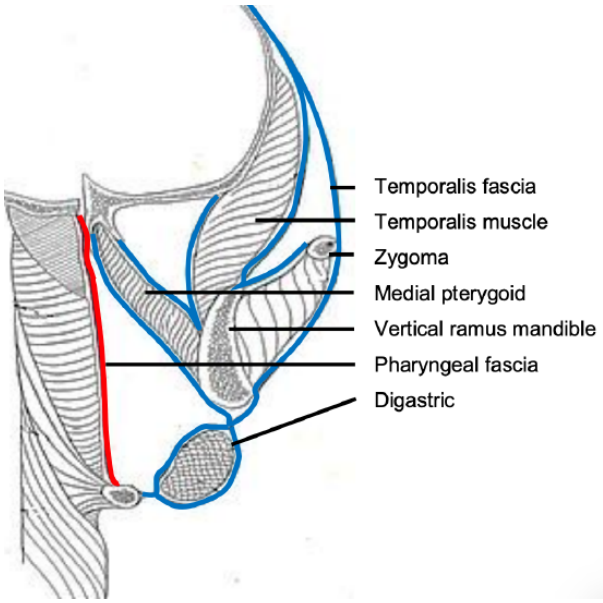


Figure 9: Coronal view of superficial (investing) layer (blue) surrounding masticator muscles (visceral fascia: red)

Between the ramus of the mandible and the hyoid bone it envelopes the anterior belly of the digastric muscle (*Figure 9*). ***The superficial layer of deep cervical fascia therefore defines the parotid, submandibular and masticator spaces and contributes to the wall of the carotid space*** (*Figures 4, 7*).

Deep Cervical Fascia: Middle layer

The middle layer of deep cervical fascia extends superiorly from the skull base along the carotid sheath to the pericardium (*Figures 2, 3, 10*). It has ***muscular*** and ***visceral*** layers:

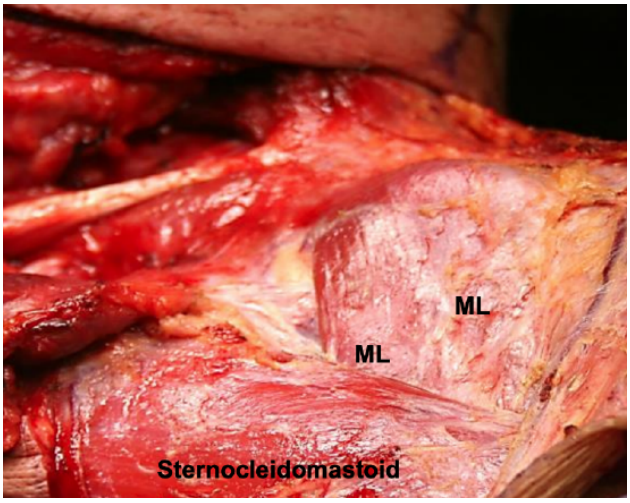


Figure 10: Muscular layer (ML) of middle layer of deep cervical fascia overlying the infrahyoid strap muscles

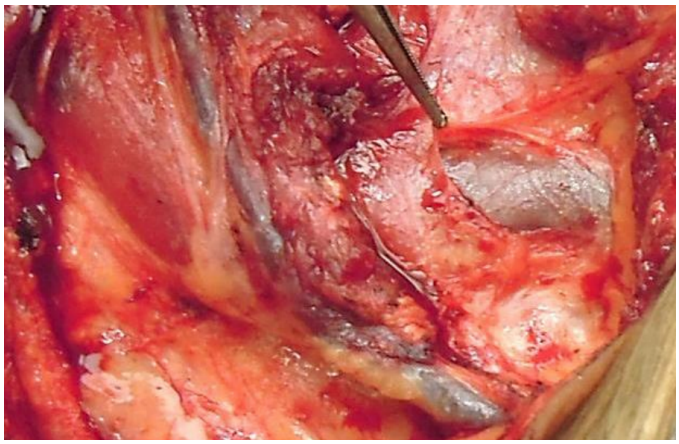


Figure 11: Thin carotid sheath being elevated off the internal jugular vein

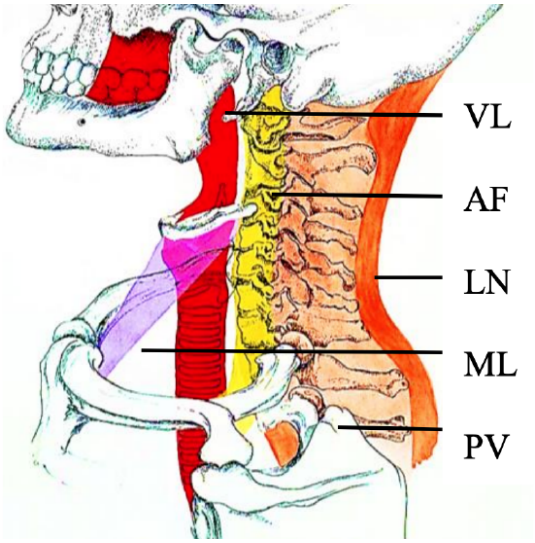


Figure 12: Middle and deep layers of deep cervical fascia: Visceral layer (VL), Alar Fascia (AF), Ligamentum Nuchae (LN), Muscular layer (ML), and Prevertebral Fascia (PV)

- ***Muscular layer*** (*Figures 2, 3, 10, 11, 12*): It envelopes the infrahyoid strap muscles (sternohyoid, sternothyroid, omohyoid, thyrohyoid), the carotid artery and internal jugular vein (***carotid sheath and carotid space***)
- ***Visceral layer*** (*Figures 2, 3, 4, 9, 12*): It lies deep to the infrahyoid muscles, and splits to enclose thyroid, trachea, pharynx and esophagus

Deep Cervical Fascia: Deep Layer

This encircles the prevertebral and paraspinal muscles, and also contributes to the carotid sheath. It is divided into ***prevertebral*** and ***alar fasciae***.

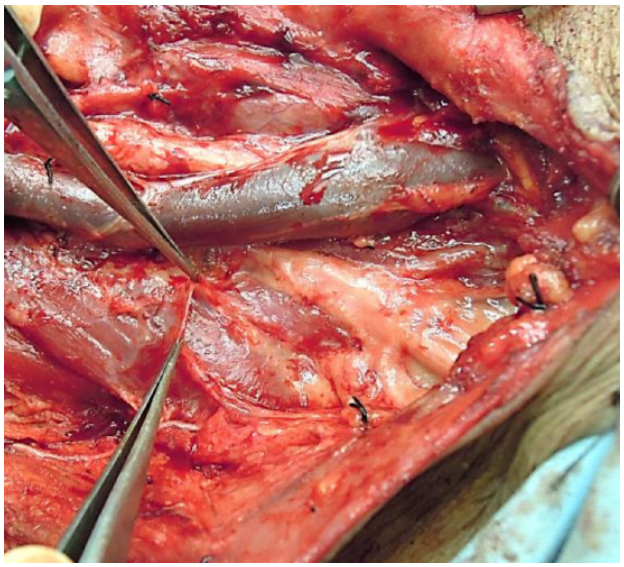


Figure 13: The thin prevertebral fascia that covers the prevertebral muscles and brachial plexus

- ***Prevertebral fascia (a.k.a. vertebral fascia)*** (*Figures 2, 3, 4, 12, 13*): This attaches to the vertebral bodies in the midline, and extends laterally over the prevertebral muscles to attach to the transverse processes of the vertebrae, and then envelops the paraspinal muscles to meet with the superficial layer of deep cervical fascia at the ligamenttum nuchae in the midline posteriorly (*Figures 3, 12*). It extends from the base of the skull to T3 (*Figure 12*). It covers the floor of the posterior traingle of the neck; inferiorly it constitutes the fascial covering over the brachial plexus from where it extends laterally as the axillary sheath to encase the axillary vessels and brachial plexus (*Figure 13*).
- ***Alar fascia*** (*Figures 1, 2, 3, 12*): This fascia is interposed between the *prevertebral* and *visceral* fasciae and forms the *posterior wall of the retropharyngeal/retrovisceral space*. It extends between the transverse processes from the skull base to the superior mediastinum where it merges with the visceral layer of deep fascia on the posterior surface of the esophagus at the level of T2, thereby terminating the *retropharyngeal space* inferiorly (*Figure 2*).

Classification of Deep Neck Spaces

The deep fasciae create clinically relevant deep neck spaces, some of which interconnect with one another. Some are potential spaces and become apparent only when distended by pus or air (surgical emphysema). The terminology and classifications of deep neck spaces used in the literature are not entirely consistent.

Working from cephalad-to-caudad the deep neck spaces may be grouped as follows:

I. Facial region

a. Buccal space

b. Canine space

c. Masticator space

i. Masseter space

ii. Pterygoid space

iii. Temporal space

d. Parotid space

II. Suprahyoid region

a. Sublingual space

b. Submental space

c. Submandibular space

d. Ludwig’s Angina (IIa + IIb +IIc)

e. Parapharyngeal space

f. Peritonsillar space

III. Infrahyoid region: Pretracheal space

IV. Entire Neck

a. Retropharyngeal space

b. Danger Space

c. Carotid Space

d. Prevertebral Space

Dental numbering systems

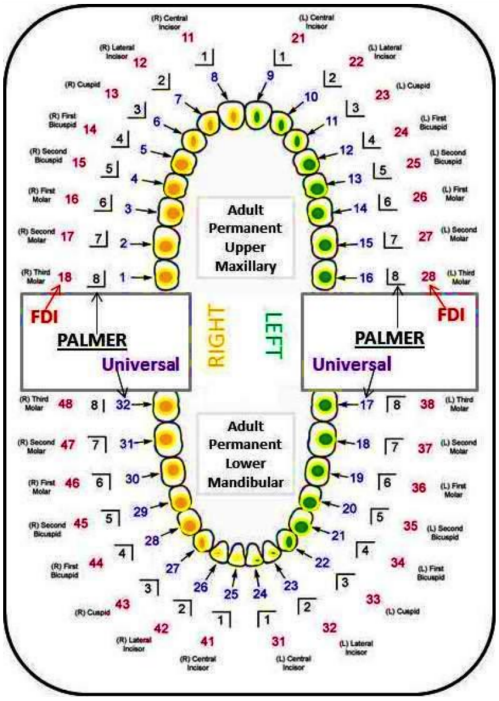


Figure 14: Three dental numbering systems

Fascial space infections are often of odontogenic origin. Hence it is important to know how to number the teeth, especially when interpreting radiology reports. **Three different numbering systems** are used in dentistry (*Figure 14*).

Surgical drainage deep neck spaces

I.a. Buccal Space Abscess

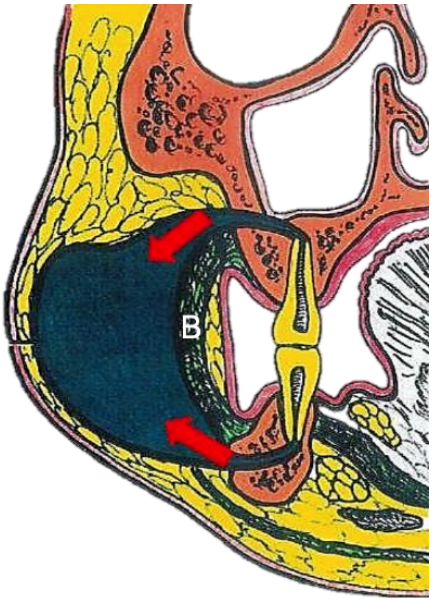


Figure 15: Buccal space abscess; note how dental sepsis drains above and below the buccinator muscle (B)

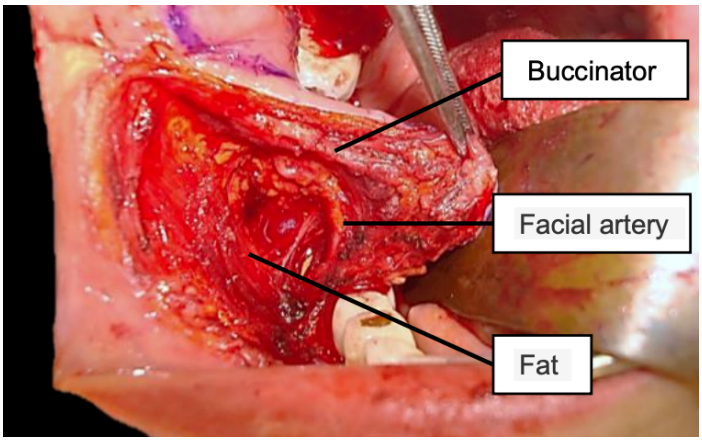


Figure 16: Right buccal space exposed during elevation of buccinator flap; Note buccinator muscle, facial artery and the fat which contains the terminal branches of the facial nerve

The buccal space is confined laterally by the superficial cervical fascia just deep to the skin, medially by the investing layer of cervical fascia that overlies the buccinator muscle, anteriorly by the labial musculature, posteriorly by the pterygomandibular raphe, superiorly by the zygomatic arch and inferiorly by the lower border of the mandible (*Figure 15*). It contains buccal fat, Stenson's duct, terminal branches of the facial nerve, and the facial artery and veins (*Figure 16*).



Figure 17: Buccal space abscess with marked swelling of the cheek and minimal trismus

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Buccal space sepsis is principally of odontogenic origin in adults (*Figure 15*); this includes the maxillary bicuspid and molar teeth and even the mandibular equivalents. However buccal space sepsis in children may have non-odontogenic causes as well. The infection is easily diagnosed as there is often marked cheek swelling, trismus is not severe (*Figure 17*) and there are often carious bicuspid or molar teeth. More specifically the abscess manifests as loss of the nasolabial skin fold, a rounded, tender cheek swelling, and swelling of the lower eyelid (*Figure 17*). Diagnostic needle aspiration is easily performed.

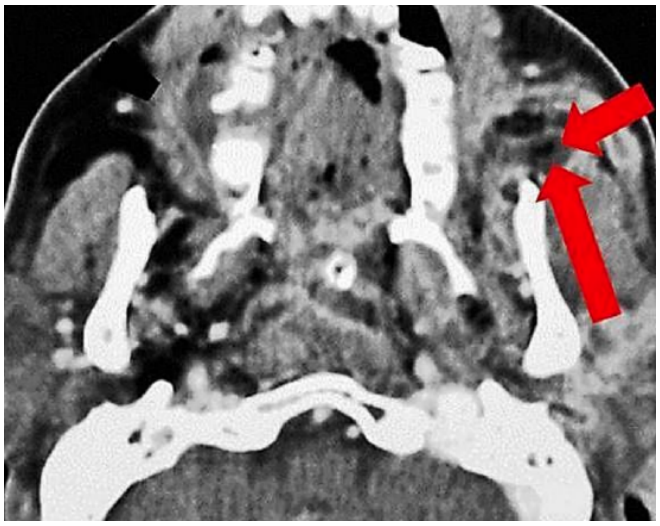


Figure 18: CT of buccal space abscess

Initial radiology should include an orthopantomograph (OPG) or Cone Beam CT (CBCT) to exclude an odontogenic causes. More advanced imaging such as contrast enhanced CT (*Figure 18*) or MRI may be useful in more complex cases.

Surgical approaches to the buccal space

Treat the cause, e.g. carious teeth. Transoral drainage is done just inferior to the point of fluctuance. Generally an incision is made intraorally just inferior to the opening of the parotid duct; with necessary care and using blunt dissection only into the periphery of the space, injury to branches the facial nerve is avoided. The intraoral approach does not allow for dependent drainage.

If one elects to make a more inferiorly placed external incision parallel to the inferior border of the mandible, blunt dissection should be directed superiorly and anteriorly remaining superficial to the masseter. Take care not to injure the marginal mandibular nerve, facial artery or vein.

Alternately one can place incisions in the mandibular and/or maxillary vestibules, and dissect bluntly either inferiorly (mandible) or superiorly (maxilla) through the buccinator muscle into the abscess.

I.b. Canine Space Abscess

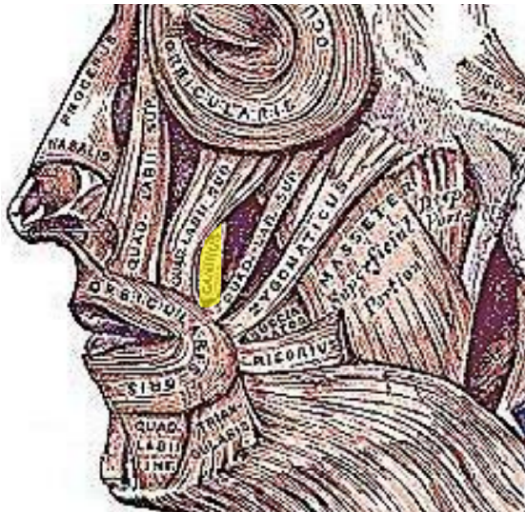


Figure 19: Levator anguli oris muscle (yellow)



Figure 20: Canine space abscess with swelling lateral to the nares and of the upper lip.



Figure 21: Canine space infection causing marked cellulitis of the eyelids



Figure 22: Sinus formation and ectroprion following canine space abscess

Whether the canine space is a true fascial space or simply a muscular apartment is a matter for debate. A canine space infection is usually caused by maxillary cuspid infection that perforates the lateral cortex of the maxilla above the insertion of the levator anguli oris muscle of the upper lip (*Figure 19*). The muscle's origin is the maxillary wall high up in the canine fossa; it inserts into the angle of the mouth with the orbicularis and zygomatic muscles. If infection extends below the insertion of the levator muscle, as is more commonly found, it presents as a swelling of the labial sulcus or, less commonly, as a palatal swelling. However infection of the canine space generally presents as swelling lateral to the nares and of the upper lip (*Figure 20*). It may cause marked cellulitis of the eyelids (*Figure 21*) or drain spontaneously, creating a sinus and cause subsequent scarring (*Figure 22*).

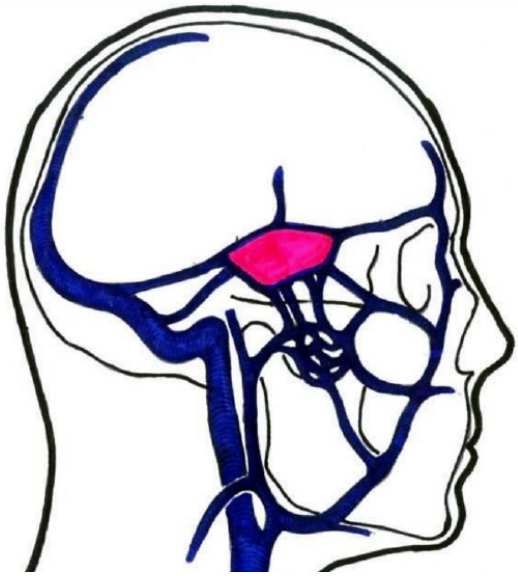


Figure 23: Septic thrombi of the angular vein may travel via the superior and inferior ophthalmic veins and cause cavernous sinus thrombosis

Septic thrombi of the angular vein may extend via the superior and inferior ophthalmic veins to the cavernous sinus and cause cavernous sinus thrombosis with the classical signs of ptosis, proptosis, chemosis and ophthalmoplegia/paresis (Cranial nerves III, IV, VI) (*Figure 23*).

Surgical approaches to the canine space

Drainage is normally achieved via an intraoral approach, with access high in the maxillary labial vestibule. Dissect superiorly through the levator anguli oris muscle using blunt dissection to avoid injury to the infraorbital nerve.

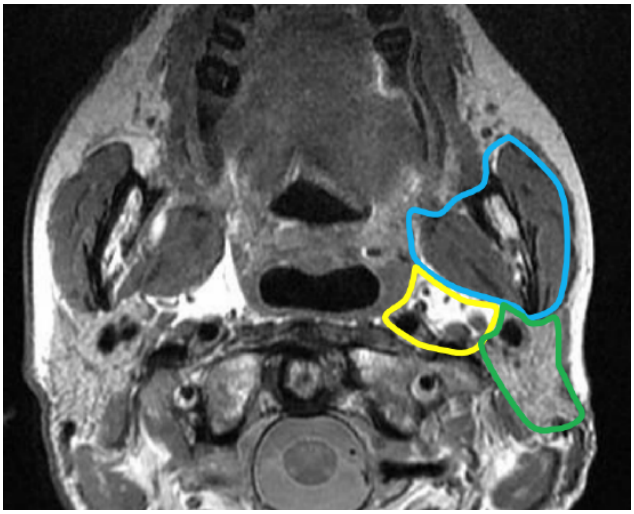


Figure 24: Masticator space (blue outline), parapharyngeal space (yellow outline) and parotid space (green outline)

The masticator space(s) is defined by the superficial (investing) layer of deep cervical fascia (*Figure 9*). It contains the masseter, medial and lateral pterygoids, ramus and body of the mandible, temporalis tendon, and inferior alveolar vessels and nerve. It is related superiorly to the temporal space; posteromedially to the parapharyngeal space; and posteriorly to the parotid space (*Figure 24*).

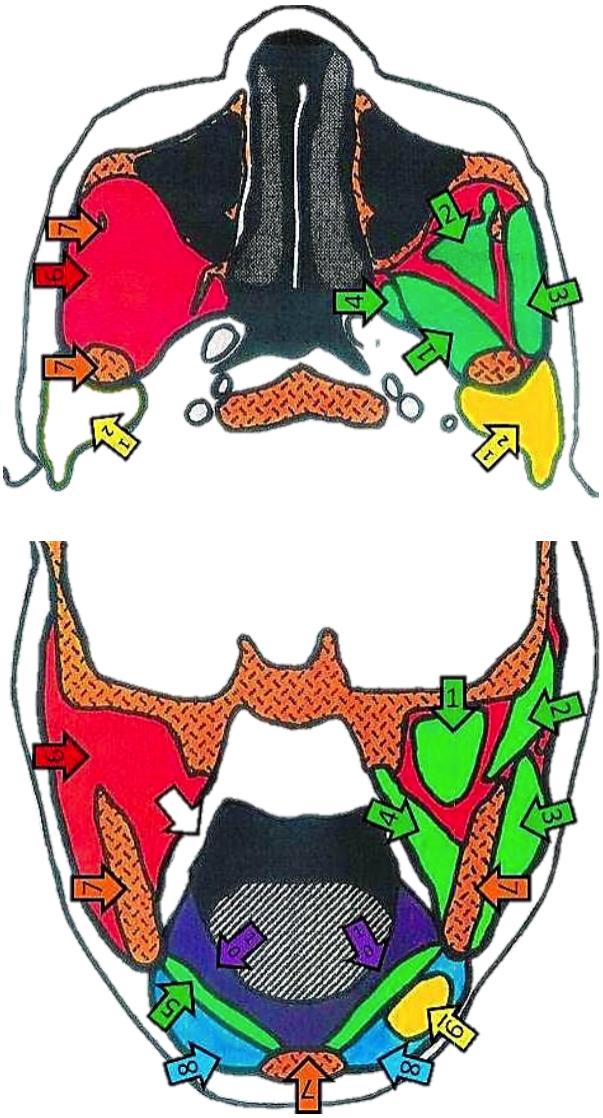


Figure 25ab: Axial and coronal views of the masticator space and relevant anatomy and other spaces: 1-Lateral Pterygoid m, 2-Temporalis m, 3-Masseter m, 4-Medial Pterygoid m, 5-Mylohyoid m, 6-Masticator space, 7-Mandible, 8-Submandibular space, 9-Submandibular gland, 10- Sublingual space, 11-Parapharyngeal space, 12-Parotid/Parotid space

The literature is not consistent about how to define the masticator space and often speaks about “masticator spaces” or a “masticator space with compartments”. ***The masticator space(s) has masseteric, pterygoid and temporal spaces/compartments*** which communicate with each other as well as with the buccal, submandibular and parapharyngeal spaces (*Figures 25 a*, *b*).



Figure 26: Needle aspiration is a valuable diagnostic tool

Sepsis is primarily of dental origin, especially from the 3rd inferior molar tooth. Infection may be confined to only one the masticator compartments or may spread to any or all the above mentioned compartments/spaces. Patients generally present with local pain and marked trismus. Needle aspiration is a valuable diagnostic tool (*Figure 26*).

Drainage of abscesses of the masticator spaces will next be discussed according to the individual masseteric, pterygoid and temporal spaces /compartments.

I.c.i. Masseteric Space

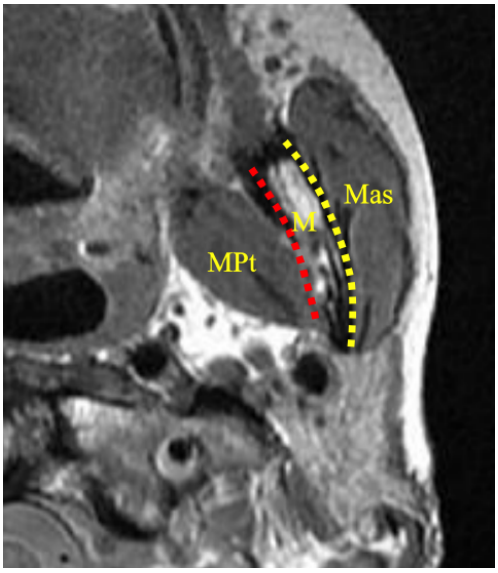


Figure 27: (Sub)masseteric space (Yellow line); pterygoid space (red line); Medial pterygoid (MPt); mandible (M); and masseter (Mas)

The masseteric (submasseteric) space is located between the masseter muscle laterally and the mandibular ascending ramus medially (*Figure 27*). Anteriorly, the space is bound by the inner surface of the masseteric fascia and posteriorly by the parotidomasseteric fascia as it splits to envelop the parotid gland. The superior and inferior borders are, respectively, the zygomatic arch and angle and the inferior border of the ramus where the masseter muscle is attached.



Figure 28: Masseteric space abscess with bulging of the masseter and severe trismus

Clinically patients present with bulging of the masseter muscle, severe trismus and pain (*Figure 28*). Due to its submasseteric location, palpation often reveals a nonfluctuant, very firm swelling.

Surgical approaches to masseteric space



Figure 29: Tongue depressors used to overcome trismus

Tongue depressors are a useful aid to overcome the severe trismus and to gain access to the mouth for intraoral local anesthetic blocks, incision and drainage procedures and even for intubation (*Figure 29*).

An ***external approach*** is generally employed. An incision is made at the angle of the mandible, parallel to the inferior border of the mandible. After cutting through the skin and subcutaneous tissue, blunt dissection is directed superiorly through the platysma and the submandibular space. Care should be taken to avoid injury to the mandibular branch of the facial nerve. An ***intraoral approach*** can be used via a vertical incision made along the pterygomandibular raphe; use blunt dissection lateral to the mandibular ramus and medial/deep to the masseter muscle to reach the abscess. ***Combined approaches*** can also be used. ***Ultrasound-guided drainage*** can be considered in patients with unilocular submasseteric space infection and severe trismus causing a significant anesthetic risk.

I.c.ii. Pterygoid Space



Figure 30: Left Pterygoid space abscess

The pterygoid (pterygomandibular) space consists mostly of loose areolar tissue. It is located between the pterygoid muscles and the ramus of the mandible (*Figures 27, 30*). Other nomenclature includes “internal pterygoid space” or “superficial pterygoid space”.

It is bound medially and inferiorly by the medial pterygoid muscle and the pterygomasseteric sling respectively. The lateral pterygoid muscle is located superomedially. The medial ramus of the mandible is located laterally. The parotid gland curves medially around the back of the mandibular ramus to form its posterior border, while anteriorly the buccinator and superior constrictor muscles join to form a fibrous junction, the pterygomandibular raphe. The pterygoid space contains the inferior alveolar nerve, artery and vein, the lingual nerve and the nerve to the mylohyoid muscle.

Sepsis of the pterygoid space is commonly due to infection of the 3rd molar tooth, or results from infection following 3rd molar surgery or mandibular orthognathic surgery; it may also follow mandibular local anesthetic blocks. Trismus and pain are often the presenting sign and symptom.

Surgical approaches to the pterygoid space

An ***extraoral submandibular approach*** is normally employed. Dissect bluntly through the pterygomasseteric sling up to the pterygoid space, remaining medial to the ramus and lateral to the medial pterygoid muscle. An ***intraoral approach*** is done via a vertical incision, lateral and parallel to the pterygomandibular raphe. Blunt dissection is then used to reach the pterygoid space by dissecting along the medial surface of the ramus. A ***combined approach*** with through-and-through drains can also be employed.

I.c.iii. Temporal Space (Figures 31, 32)

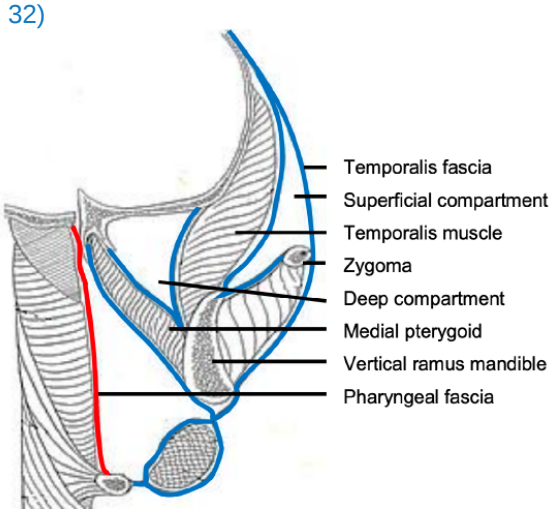


Figure 31: Deep and superficial compartments of temporal space

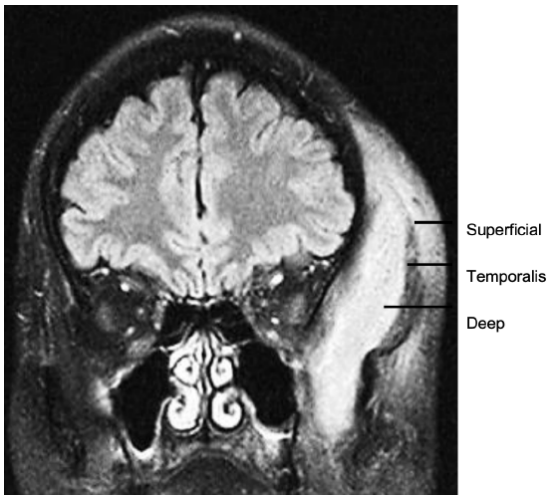


Figure 32: MRI of deep and superficial temporal space abscesses (BMJ Case Reports 2010; doi:10.1136/bcr.01.2010.2656)

The temporalis muscle partitions this space into deep and superficial compartments. The superficial compartment is contained laterally by the temporalis fascia (superficial/investing layer of deep fascia), and medially by the temporalis muscle; the deep compartment is limited laterally by the deep surface of the temporalis muscle, and medially by the periosteum overlying the temporal bone.

It contains the internal maxillary artery and its branches, the inferior alveolar artery and nerve, and is bisected by the temporalis muscle. It is related inferiorly to the masticator space. Sources of sepsis include maxillary molar infection or post-extraction sepsis; maxillary sinusitis, maxillary sinus fractures; temporomandibular arthroscopy and sepsis following injections into the temporomandibular joint.

Temporal space sepsis typically presents as swelling of the temporal fossa, pain and trismus. Contrast enhanced CT or MRI scans indicate the relations of the abscess to the temporalis muscle and extension to other spaces e.g. masticator space (*Figure 32*).

Surgical approaches to temporal space

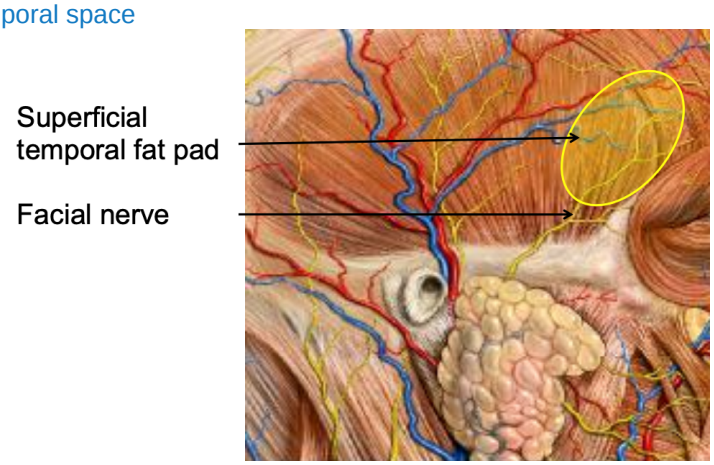


Figure 33: Facial nerve crossing zygoma



Figure 34: External approach to the superficial and deep compartments of the temporal space

External approach to superficial and deep compartments: An incision is made 3 cm lateral to the lateral canthus of the eye taking care not in injure the frontal/temporal branches of the facial nerve which run across the superficial temporal fat pad, deep to the orbicularis oculi muscle, just lateral to the orbital rim (*Figure 33, 34*); or by a horizontal brow incision. The deep compartment is drained by advancing a hemostat through the temporalis muscle into the space between the temporalis muscle and temporal and sphenoid bone.

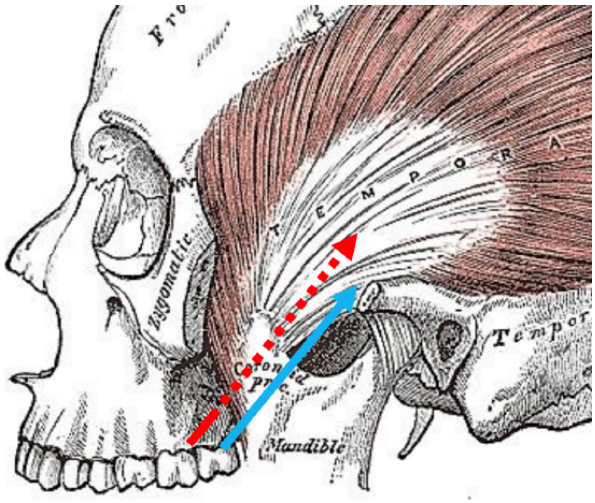


Figure 36: Intraoral drainage: Red arrow: medial to coronoid process to reach deep compartment; Blue arrow: lateral to coronoid process to reach superficial compartment

Intra-oral drainage: The temporalis muscle attaches to the coronoid process of the mandible (*Figure 35*). The key anatomical landmark for intraoral drainage therefore is the vertical ramus of the mandible where it ascends from the retromolar trigone. To drain the ***superficial compartment***, make a stab incision in the mucosa lateral to vertical ramus of the mandible and advance a hemostat lateral to the coronoid process into the abscess. To drain the ***deep compartment***, make a stab incision in the mucosa medial to the vertical ramus and advance a hemostat medial to the coronoid process into the abscess. A ***combined approach*** can also be used.

I.d. Parotid Space



Figure 36: (R) parotid space (yellow outline) and (L) parotid abscess

The parotid space is bound by the superficial (investing) layer of deep cervical fascia (*Figures 24, 36*). The investing fascia splits at the level of the stylomandibular ligament to enclose the gland by superficial and deep parotid capsules. The space extends from the external auditory canal to the angle of the mandible. It is located lateral to the carotid and parapharyngeal spaces and posterior to the masticator space (*Figure 24*). It contains the parotid gland, proximal part of the parotid duct, facial nerve, posterior facial / retromandibular vein, intraparotid lymph nodes and terminal branches of external carotid artery. The superficial capsule is strong, but the deep capsule is thin, allowing for infection to spread easily into the parapharyngeal space.



Figure 37: Parotid space abscess

Sources of sepsis include parotitis, sialadenitis and adjacent sepsis. Parotid space sepsis typically presents with tenderness, swelling, and trismus (*Figure 37*). Fluctuation is often absent and it may be difficult to distinguish clinically between parotitis and a parotid abscess. Ultrasound or a contrast enhanced CT scan is useful to diagnose a parotid abscess (*Figure 36*).

Surgical approaches to the parotid space

Injury to the facial nerve is the principle concern. Incision and drainage is done under general anesthesia by elevating a parotidectomy skin flap to expose the parotid capsule. Incisions are made in the parotid capsule along the axis of the facial nerve, a hemostat is passed bluntly into the abscess(es), and drains are inserted. Resolution of the parotid swelling is generally quite delayed.

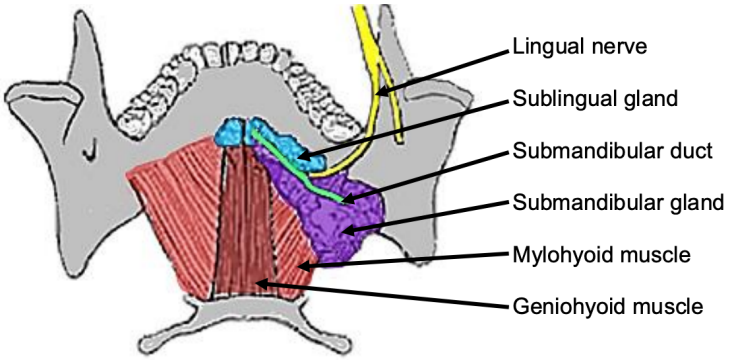


Figure 38: Superior intraoral view of SMG, duct, lingual nerve and mylohyoid and geniohyoid muscles

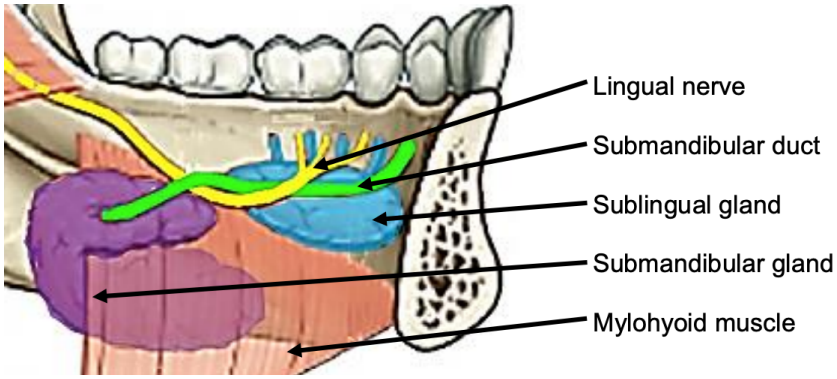


Figure 39: Intraoral view of left sublingual gland with ducts of Rivinus, SMG and duct, lingual nerve and mylohyoid muscles

The sublingual space is contained by the mucosa of the floor of the mouth above, the mylohyoid muscle below (*Figures 38, 39*), and is continuous with the opposite side across the midline. Anteriorly and laterally it is bound by the mandible. The posterior border is the hyoid bone. The space contains the sublingual salivary glands, intraoral components of the submandibular salivary glands and the submandibular ducts, and the hypoglossal and lingual nerves (*Figures 35, 36*).

The space is connected with the submandibular space at the posterior edge of the mylohyoid muscle around which pus can track; as well as with the submental space inferiorly with mylohyoid muscle interposed; and the parapharyngeal space posteriorly.



Figure 40: Swelling of the floor of the mouth with elevation of the tongue

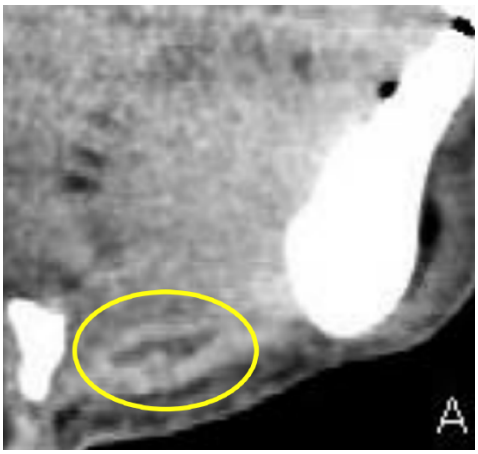


Figure 41: Sublingual space abscess situated above mylohyoid



Figure 42: Coronal CT scan of sublingual space abscess situated above mylohyoid

Sources of infection include dental sepsis, especially of the 3rd lower molar tooth, sialolithiasis, and an infected ranula. Patients present with pain, swelling, induration in the floor of the mouth and elevation of the tongue (*Figure 40-42*).

Surgical approaches to the sublingual space

Drain the sublingual space ***transorally*** by incising the mucosa in the anterior floor of the mouth, preferably parallel to the submandibular duct, and proceed with blunt dissection taking care not to injure the lingual nerve or the submandibular ducts. If the submandibular space is also affected, both spaces can be reached via a ***submandibular approach***.

II.b. Submental Space

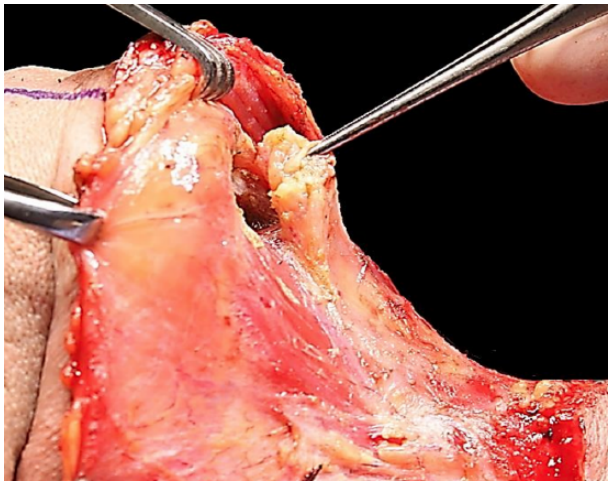


Figure 43: Elevating the contents of submental space from between the anterior bellies of digastric during a neck dissection

The submental space is located below the chin, crosses the midline and is bound superficially by the superficial layer of cervical fascia and skin, laterally by the anterior bellies of the digastric muscles, and deeply by the investing layer of cervical fascia

overlying the mylohyoid muscle. The anatomical relations are the sublingual space (above mylohyoid) and the submandibular spaces laterally. It contains fat, lymph nodes and the anterior jugular vein (*Figure 43*).



Figure 44: Clinical presentation of infection of the submental space secondary to a carious mandibular incisor

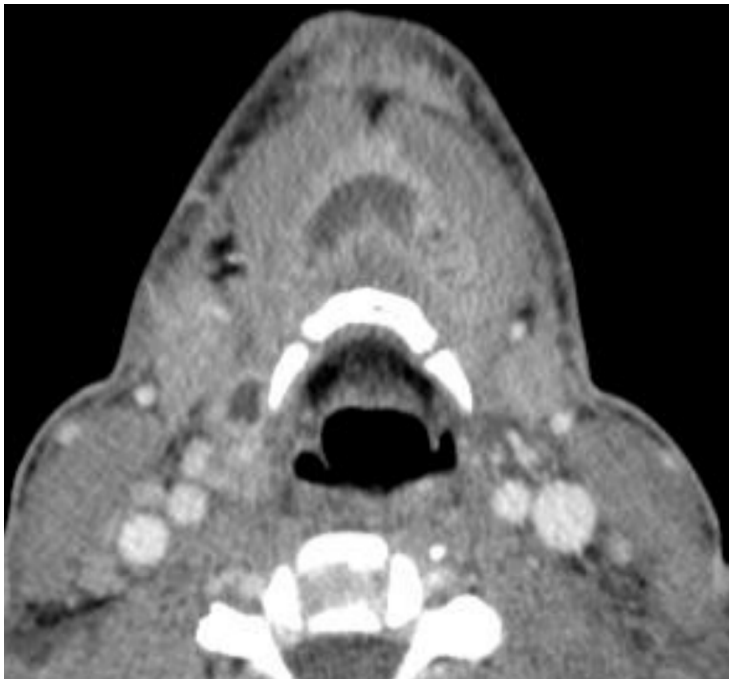


Figure 45: Submental space abscess anterior to the hyoid bone

Sources of sepsis are typically dental (mandibular incisor), an infected ranula, lymphadenitis or extension of infections of the submandibular space. Patients present with a tender submental swelling (*Figures 44, 45*).

Surgical approaches to the submental space

Drainage is achieved via an external transverse skin incision made between the hyoid bone and the mentum.

II.c. Submandibular Space

A lack of conformity exists in the literature about what is meant by “submandibular space”. Some subdivide the “submandibular space” into submaxillary, sublingual and submental spaces, while others consider the submaxillary and submandibular spaces to be synonymous. To best conform to conventional head and neck surgery terminology, the latter use of the word is adopted in this chapter.

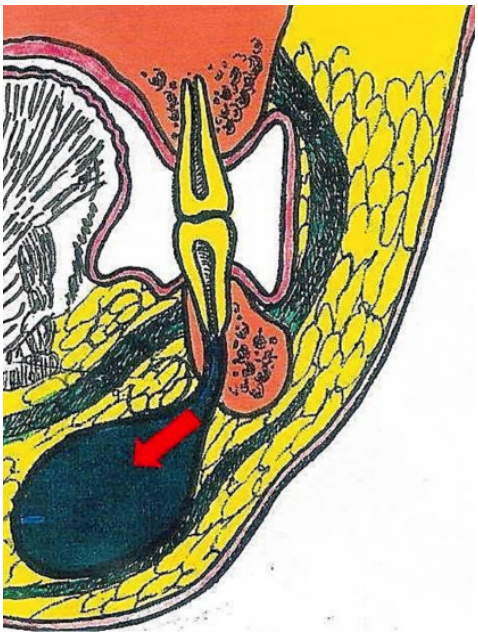


Figure 46: Coronal view depicting an odontogenic submandibular space abscess

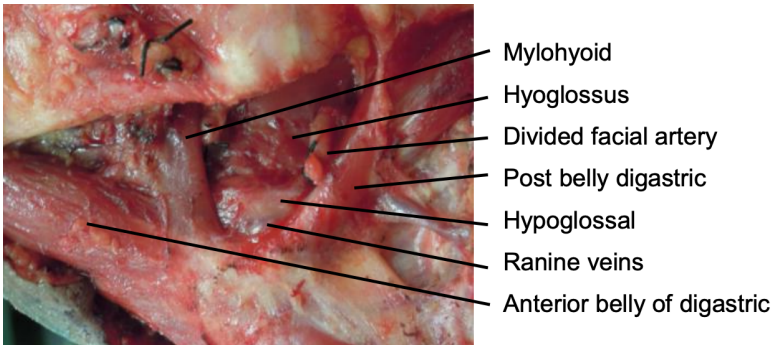


Figure 47: Medial wall of (L) submandibular space comprising thin investing fascia covering the mylohyoid muscle, hypoglossal nerve, ranine veins and hyoglossus muscle

As the most inferior space of the suprahyoid neck, the submandibular space extends upwards from the hyoid and is contained laterally between the hyoid and mandible by the superficial (investing) layer of deep cervical fascia and by the medial surface of the mandible up to its mylohyoid line (*Figures 7, 8, 9, 46*). Medially it is limited by the investing fascia that covers the mylohyoid muscle, the hypoglossal nerve, ranine veins and hyoglossus muscle (*Figure 47*). It contains the superficial portion of the submandibular gland, submandibular and submental lymph nodes, facial artery and vein, fat and the inferior loop of the hypoglossal nerve. The anterior belly of digastric separates it from the submental space (*Figure 47*). The submandibular gland and its duct pass around the posterior margin of the mylohyoid to enter the sublingual space in the floor of the mouth (*Figures 38, 39*). Behind the posterior margin of the mylohyoid muscle is a direct communication between the submandibular and sublingual spaces. Infection may spread anteriorly to the submental space and posteriorly to the parapharyngeal and/or retropharyngeal spaces.

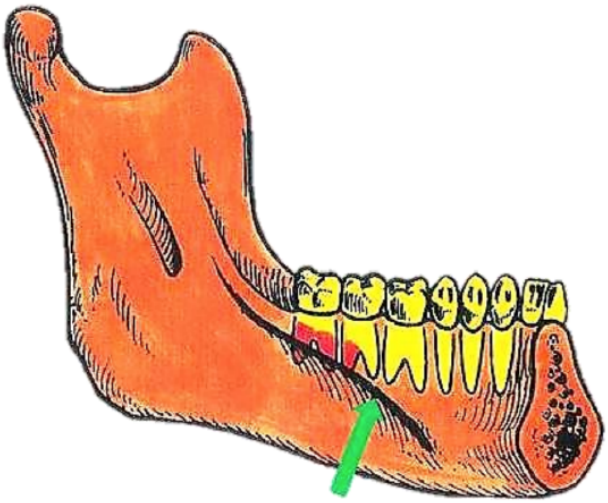


Figure 48: Odontogenic infections are commonly caused by the 2nd and 3rd mandibular molars as the apices of the dental roots extend below the mylohyoid line (green arrow)



Figure 49: OPG depicting a periradicular radiolucency of the 3rd molar



Figure 50: Submandibular space abscess

Sources of sepsis include sialadenitis, sialolithiasis, and dental sepsis (*Figures 46*, *48*, *49*). Patients typically present with swelling and tenderness over the submandibular triangle of the neck and only very minor trismus (*Figures 50*).



Figure 51: Horizontal skin crease incision made at level of hyoid extended through platysma muscle with blunt dissection



Figure 52: Corrugated extraoral drain in place

Make a horizontal skin crease incision at the level of the hyoid to avoid transecting the marginal mandibular nerve. Extend the incision through the platysma muscle using blunt dissection (*Figures 51, 52*).

II.d. Ludwig's Angina



Figure 53: Typical appearance of Ludwig's angina with sublingual, submental and submandibular swelling

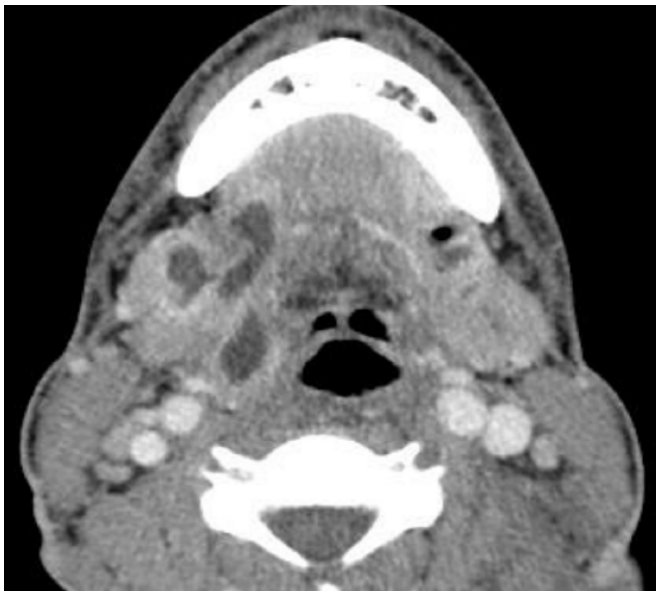


Figure 54: Bilateral submandibular space abscesses

Ludwig's Angina, named after Wilhelm Friedrich Von Ludwig (1790-1865) refers to inflammation, cellulitis or an abscess, generally of dental origin, that ***involves the sublingual, submental and submandibular spaces***. "Angina" is derived from the Latin term "angere", which means "to strangle". Patients present with pain, drooling, dysphagia, submandibular swelling, and trismus. Upward and posterior displacement of the tongue may cause severe airway compromise (*Figure 53*) which is the primary morbidity and mortality. In the pre-antibiotic era the mortality rate for was 50%; today the mortality rate is <5%. Sepsis is typically bilateral (*Figure 54*).

An orthopantomogram (OPG) or a CT scan should be requested to identify the source of dental sepsis; special attention should be paid to the status of the 2nd and 3rd lower molars. A contrast-enhanced CT scan or even MRI provides a roadmap for the surgeon to drain all septic foci in the neck (*Figure 54*).

Surgical approaches to Ludwig's Angina



Figure 55: Fibreoptic flexible endoscope for nasotracheal intubation

Securing an airway is the initial objective. One should have a low threshold for doing an awake tracheostomy under local anesthesia to secure the airway before inducing anesthesia. Transoral intubation may be hazardous and is often unsuccessful. Fibreoptic intubation requires skill and experience and may cause nasal/nasopharyngeal bleeding (*Figure 55*).



Figure 56: Day 1 post-surgery depicting a severely compromised airway with marked elevation of the tongue

Nebulized adrenaline (1 mL 1:1000 adrenaline diluted to 5 mL with 0.9% saline) and intravenous dexamethasone (controversial) has been suggested to create more controlled conditions for flexible nasotracheal intubation. It is important to note that after incision and drainage, there is often ***even more swelling which may compromise the airway on day 1-2 after the surgery*** (*Figure 56*).

Early aggressive empiric intravenous antibiotic therapy targeting gram-positive and anaerobic organisms should be employed.

Incision and drainage: Ludwig's angina starts as a rapidly spreading cellulitis without lymphatic involvement and generally without abscess formation. There is absolute consensus that drainage is indicated when there is a suppurative infection and/ or radiological evidence of a fluid collection or air in the soft tissues.

However one of the main controversies in management of Ludwig's angina is whether surgical drainage is always indicated in the earlier stages of the infection. In the authors' experience, a more aggressive surgical approach should be followed in all cases i.e.

early tracheostomy and empiric placement of drains in the affected spaces after removal of the underlying cause. It must however be noted that this combined medical and surgical protocol is dictated by surgical/anesthesia/intensive care logistical problems often experienced in developing world practice.

Drainage may be intraoral and/or external, depending on the spaces involved. The submandibular spaces are drained externally. If sepsis extends both above and below the mylohyoid muscle, through-and-through drains extending between the oral cavity and the skin of the neck may be inserted.

II.e. Parapharyngeal Space (PPS)

The PPS extends from the base of the skull to the hyoid bone as an inverted pyramid in the center the head and neck, and consists mostly of fat. It is also known as the lateral pharyngeal space, pterygomaxillary space or pharyngomaxillary space.

Medially it is defined by the visceral layer of the deep cervical fascia (pharyngobasilar fascia above and buccopharyngeal fascia covering the superior pharyngeal constrictor muscle). The posterior border is formed by the prevertebral fascia of the deep layer and by the posterior aspect of the carotid sheath. Laterally the space is limited by the superficial/investing layer of deep cervical fascia that overlies mandible, medial pterygoids and parotid. The anterior boundary is the interpterygoid fascia and the pterygomandibular raphe.

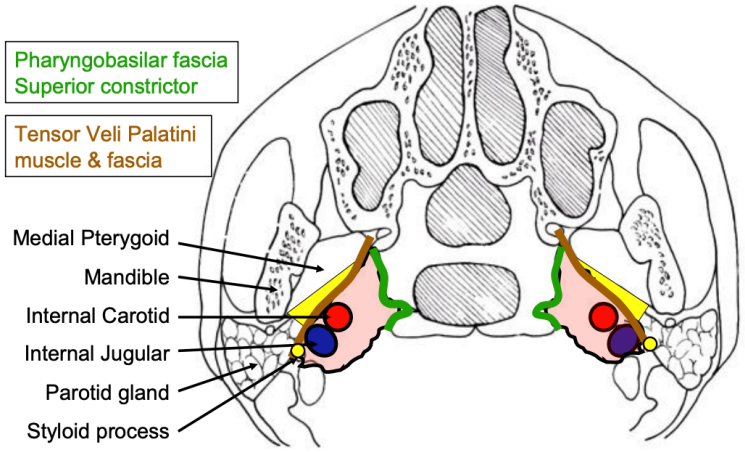


Figure 57: Schematic axial view of prestyloid (yellow) and poststyloid (pink) parapharyngeal spaces

The space is often divided into a prestyloid and a poststyloid compartment/space as the styloid process and styloid fascia divides this space. Some authors elect to use the terms prestyloid parapharyngeal space and parapharyngeal space synonymously as the poststyloid parapharyngeal space is regarded as a separate space namely the carotid sheath or space. *Figure 57* illustrates the prestyloid and poststyloid components of the PPS, separated by the styloid process, tensor veli palatini and its fascia. The prestyloid PPS contains the internal maxillary artery, inferior alveolar nerve, lingual nerve, and auriculotemporal nerve, the deep lobe of the parotid gland, fat and occasionally ectopic salivary gland tissue. The poststyloid space encompasses the carotid space and contains the internal carotid artery, internal jugular vein, cranial nerves IX - XII, and the sympathetic trunk (*Figure 57*).

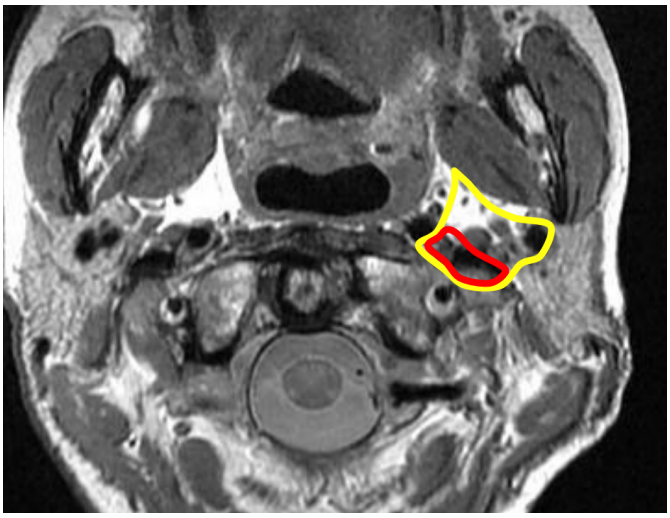


Figure 58: Parapharyngeal space (yellow outline) and carotid space/poststyloid space (red outline)

The PPS (*Figure 58*) is a central connection for all other deep neck spaces and was the most commonly affected space before the modern antibiotic era. It interfaces posterolaterally with the parotid space, posteromedially with the retropharyngeal space and inferiorly with the submandibular space. Anterolaterally it abuts the masticator space. The carotid space courses through the PPS. Infections can arise from tonsils, pharynx, teeth, salivary glands, nose, or may extend from a Bezold's abscess (mastoid abscess).

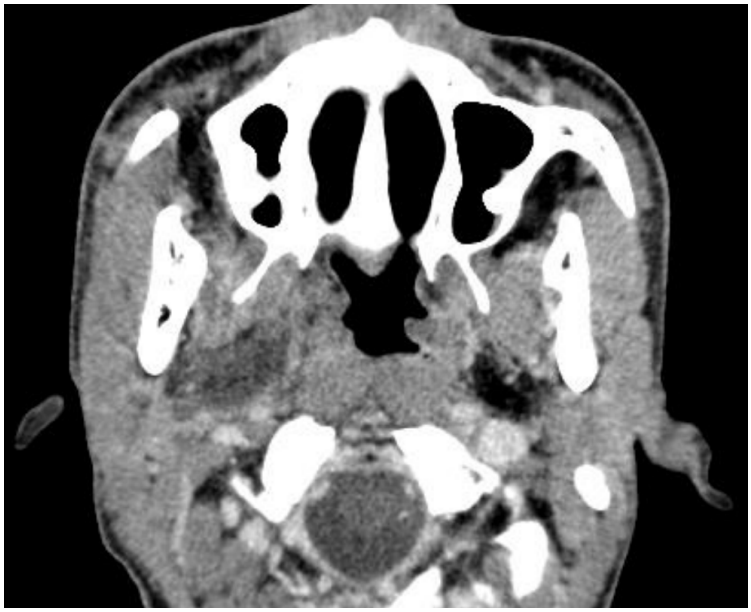


Figure 59: Parapharyngeal space abscess (axial view)

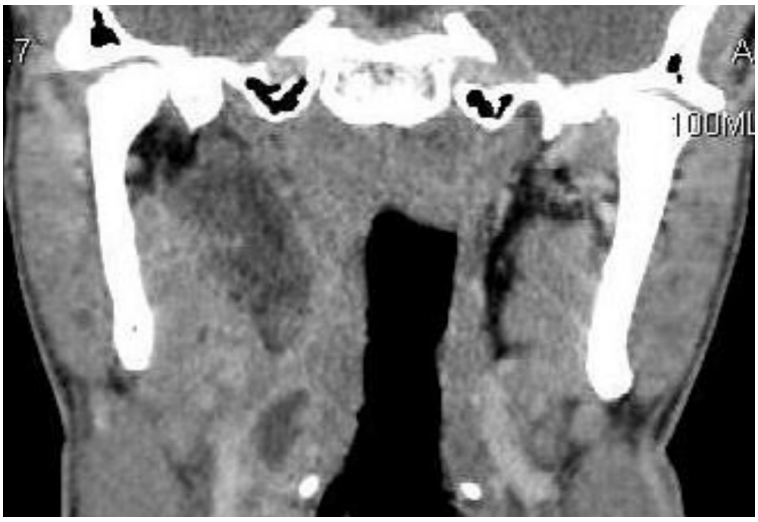


Figure 60: Parapharyngeal space abscess extending from hyoid to skull base

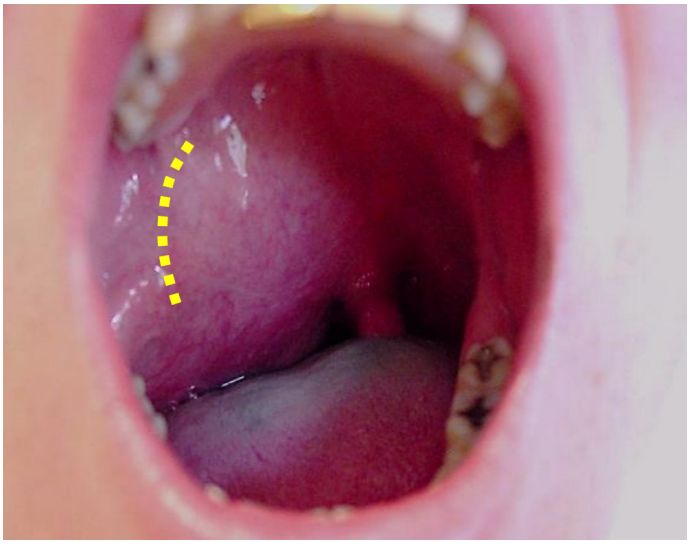


Figure 61: Typical clinical picture of a prestyloid PPS abscess and incision

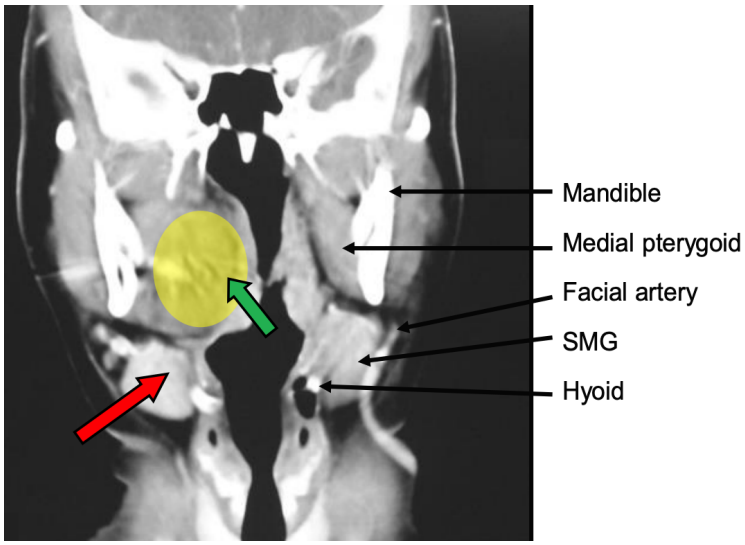


Figure 62: Anatomical relations of PPS abscess and drainage approaches either via oral cavity (green arrow) by incising the anterior tonsillar pillar lateral to the tonsil or via submandibular triangle above hyoid by dissecting bluntly with a finger posterior to the submandibular gland (red arrow)

Medial displacement of the lateral pharyngeal wall and tonsil is a hallmark of PPS infection (*Figures 59-62*). Trismus, drooling, dysphagia, odynophagia, neck stiffness, a “hot potato” voice and swelling below the angle of the mandible may be present when the anterior compartment is involved. The ipsilateral neck pain can be intensified by lateral flexion of the neck to the contralateral side which compresses the lateral pharyngeal space. Trismus suggests inflammation of the pterygoid muscle which lies close to the anterior compartment. Infection of the posterior compartment often has no trismus or visible swelling.

Surgical approaches to the PPS

Three approaches may be employed depending on the location of the abscess. Additional approaches may be considered to drain adjacent sepsis.

The prestyloid PPS may be drained ***transorally*** (*Figure 61*) by incising the lateral pharyngeal wall, or via a ***suprahyoid*** approach (*Figure 62*).

The retrostyloid PPS is best approached ***transcervically*** from Level 2a of the neck. A transverse cervical skin incision is made, and subplatysmal flaps elevated to expose the anterior border of sternomastoid. The investing layer of deep cervical fascia is divided along the anterior border of the sternocleidomastoid, and a finger is passed deep to the posterior belly of digastric, dissecting bluntly along the carotid sheath up to the tip of the styloid.

II.f. Peritonsillar Space

The peritonsillar space is bound medially by the capsule of the palatine tonsil, laterally by the superior constrictor, while the anterior and posterior borders are defined by the anterior and posterior tonsillar pillars. It is a potential space and has no important contents, mostly loose connective tissue. Laterally it abuts the masticator space; this accounts for the typical occurrence of trismus with inflammatory processes. Posteriorly it borders the parapharyngeal space.



Figure 63: Peritonsillar abscess displacing tonsil medially

Peritonsillar abscesses (*Figure 63*) are the most common deep neck space abscesses and occur as a consequence of tonsil infection. It has also been proposed that it is a consequence of inflammation of Weber’s glands which are minor salivary glands found in the peritonsillar space.

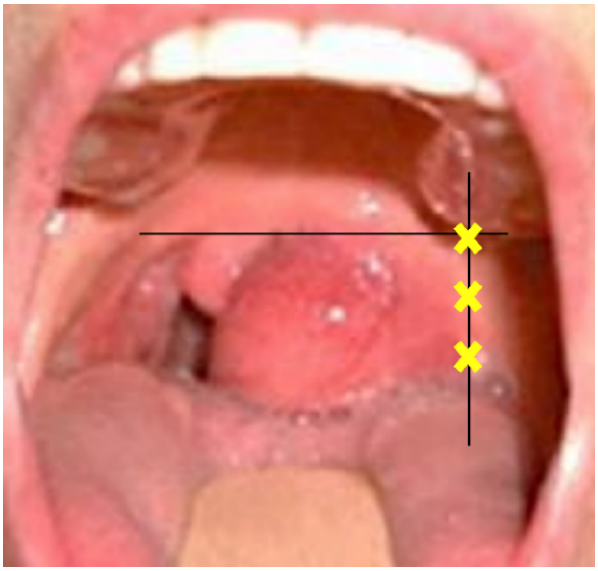


Figure 64: Avoid entering the tonsil by commencing aspiration where horizontal line at the base of uvula intersects with a vertical line through molar teeth; if unsuccessful, then aspirate along the vertical line

Patients typically present with pain, odynophagia, drooling, dehydration, trismus, medial displacement of the tonsil, palatal asymmetry, edema and contralateral displacement of the uvula (*Figure 64*). The diagnosis is clinical and special radiological investigations are usually unnecessary.

Surgical approaches to peritonsillar space

Peritonsillar abscesses may be treated by *needle aspiration, incision and drainage, or quinsy tonsillectomy*.

Needle aspiration/Incision and drainage: Local anesthetic is injected along the anterior tonsillar pillar followed by transoral needle aspiration and/or incision and drainage with a scalpel superomedially. The incision is then opened widely with a hemostat. The classical needle aspiration sites are demonstrated in *Figure 64*. A needle inserted too medially will enter the tonsil tissue and miss the abscess cavity.

Quinsy tonsillectomy: This is advocated by some surgeons for patients with recurrent tonsillitis or in children who would not tolerate a procedure under local anesthesia. The patient, however, should first be rehydrated and optimized for surgery. As trismus is generally due to muscle spasm, it resolves on induction of anesthesia. Hence intubation is generally not a problem. The tonsillectomy on the side of the quinsy is usually quite straight-forward once the abscess cavity has been entered as the abscess wall defines the lateral dissection plane. Bipolar cautery is required for hemostasis as ligating vessels in inflamed tissues may prove difficult.

III.a. Pretracheal Space

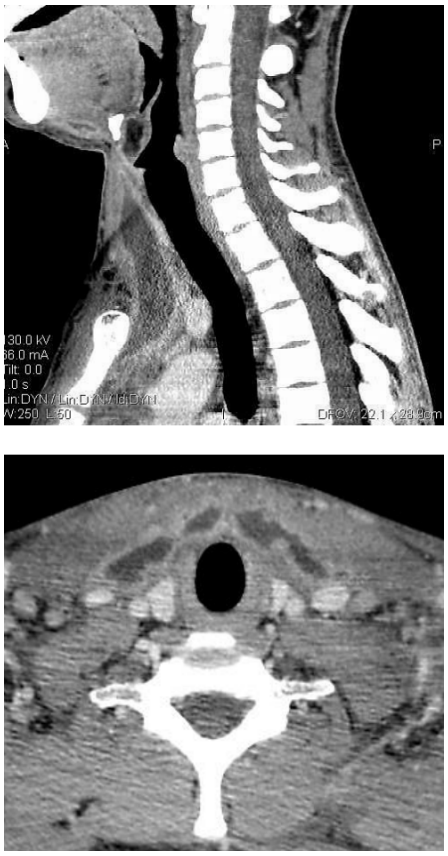


Figure 65ab: Pretracheal abscesses

The pretracheal (anterior visceral or previsceral space) is enclosed by the visceral layer of the middle layer of deep cervical fascia. It lies immediately anterior to the trachea, abuts the ventral wall of the esophagus posteriorly and extends from the superior border of the thyroid cartilage to the superior mediastinum at level T4 (*Figures 65 a, b*). Etiology includes perforation of the anterior esophageal wall by endoscopic instrumentation, foreign bodies, trauma and thyroiditis. Patients present with dysphagia, odynophagia, pain, fever, voice change and stridor.

Surgical approaches to pretracheal space

Drainage is achieved by a transverse anterior skin crease cervical incision.

IV.a. Retropharyngeal Space

The retropharyngeal space is located immediately behind the nasopharynx, oropharynx, hypopharynx, larynx, and trachea. It is bound anteriorly by the visceral layer of the middle layer of the deep cervical fascia where it surrounds the pharyngeal constrictors, and posteriorly by the alar layer of the deep layer of deep cervical fascia. It extends from the skull base to T2/tracheal bifurcation where the visceral and alar layers fuse (*Figures 2, 3, 4*). It contains retropharyngeal lymphatics and lymph nodes, and communicates laterally with the parapharyngeal spaces where it abuts the carotid sheaths.

Because retropharyngeal lymph nodes generally regress by age 5 years, retropharyngeal space infection occurs more commonly in young children. Most retropharyngeal abscesses in children are related to upper respiratory tract infections. In adults they are generally caused by direct trauma and foreign bodies, and may also be caused by traumatic perforations of the posterior pharyngeal wall or esophagus. Sepsis may also extend from the parapharyngeal space, or from infections originating in the nose, adenoids, nasopharynx, and sinuses. The differential diagnosis includes an abscess secondary to spinal tuberculosis.



Figure 66: Lateral X-ray demonstrating flattening of the spine and soft tissue swelling of >½ of the vertebral bodies (arrow) (Wikipedia)

Patients present with malaise, neck stiffness, odynophagia, bulging of the posterior pharyngeal wall, trismus, stertor or stridor. Sepsis may extend posteriorly to the prevertebral space, into the chest causing mediastinitis and empyema, or laterally to the parapharyngeal space. It can cause carotid artery rupture and jugular vein thrombosis. CT is the imaging investigation of choice. Lateral cervical X-rays show loss of cervical lordosis and widening of the prevertebral soft tissues which should normally be less than ½ the width of the corresponding vertebral body (*Figure 66*). CXR or CT is done to exclude intrathoracic extension of sepsis.

Surgical approaches to retropharyngeal space

Sedation and muscle relaxants should be avoided to prevent loss of control of the airway.

Small abscesses may be aspirated transorally with a needle in a compliant patient. Larger abscesses require incision and drainage using transoral and/or transcervical approaches.

With ***transoral drainage*** it may be helpful to localize the abscess by first aspirating it before incision and drainage. Make an incision through the posterior pharyngeal wall mucosa, and open the abscess with blunt dissection.

Transcervical drainage is achieved by a transverse cervical skin incision, raising subplatysmal flaps to expose the neck and dissecting along the anterior border of the sternomastoid. The sternocleidomastoid muscle and carotid sheath are then retracted laterally and blunt dissection is done up to the hypopharynx to open the retropharyngeal space abscess.

IV.b. Danger Space

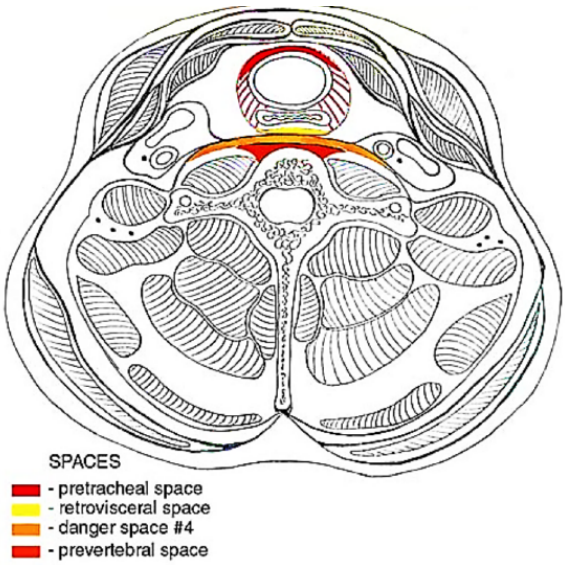


Figure 67: Danger space (orange); prevertebral space (red), retropharyngeal space (yellow), and pretracheal space

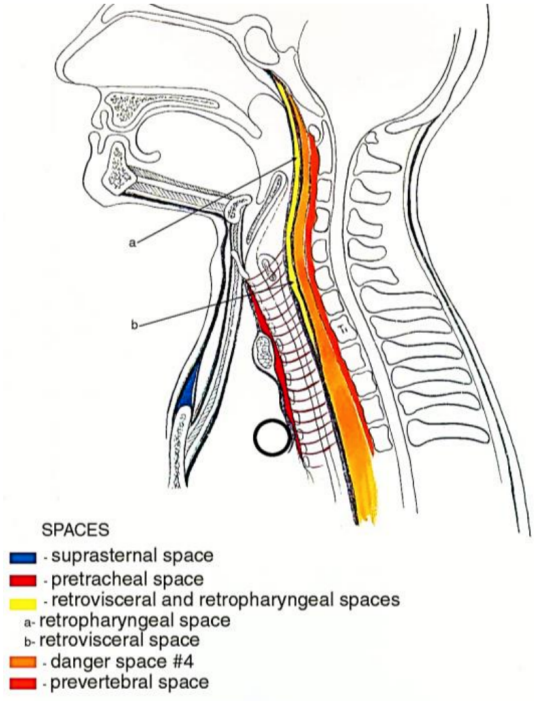


Figure 68: Danger space (orange); prevertebral space (red), retropharyngeal space (yellow), and pretracheal space

The term “danger space” is derived from the potential for rapid spread of infection along this space to the posterior mediastinum. It is a potential space that contains mostly fat. It is located between the alar and prevertebral layers of the deep layer of deep cervical fascia and laterally is bordered by the transverse processes (*Figure 67*, *68*). It is immediately posterior to the retropharyngeal space, anterior to the prevertebral space, and extends from the skull base above to the posterior mediastinum and diaphragm below.

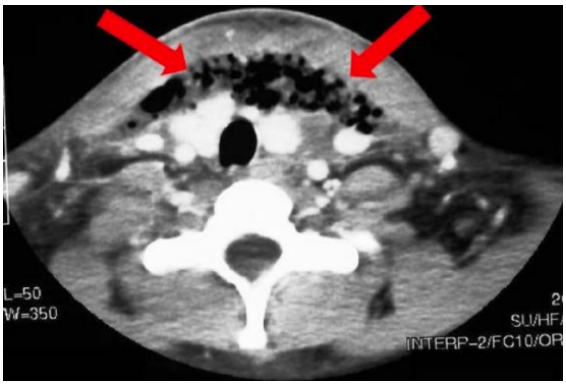


Figure 69: CT depicting soft tissue air in a patient with mediastinitis caused by spread from a fascial space infection

Infection usually originates from adjacent retropharyngeal, parapharyngeal, or prevertebral sepsis and may spread rapidly because of the loose areolar tissue that occupies this space to cause mediastinitis (*Figure 69*), empyema, and septicaemia.

Clinically the infection is difficult to distinguish from infection of the retropharyngeal space. Even contrast-enhanced CT may not adequately differentiate between infection of the retropharyngeal and danger spaces, but extension below T4 suggests involvement of the danger space. The differential diagnosis includes tuberculosis.

Surgical approaches to the Danger Space

Surgical drainage is achieved by an external transcervical approach along the anterior border of the sternocleidomastoid, dissecting between the larynx and the carotid sheath. One may need to divide the superior thyroid artery for access.

IV.c. Carotid Space

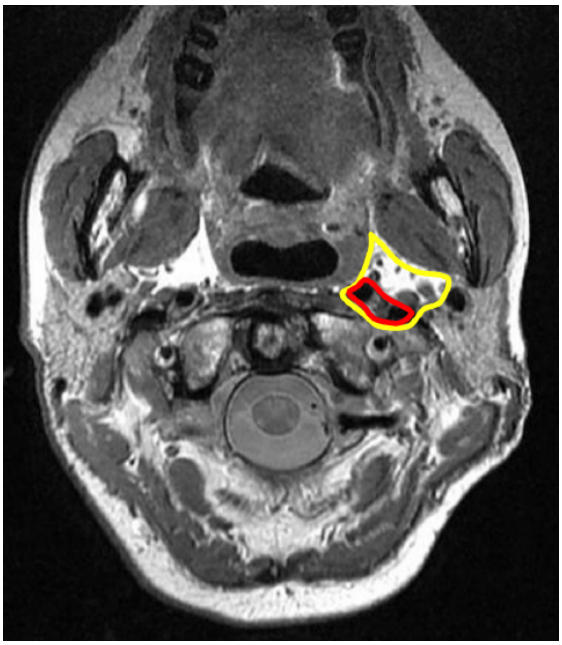


Figure 70: Parapharyngeal space (yellow outline) and carotid/poststyloid space (red outline)

The carotid space is a potential space contained within the carotid sheath (*Figure 70*). The nomenclature is confusing and terms such as carotid sheath and post-styloid parapharyngeal space (PPS) are used synonymously. The carotid sheath is formed by the muscular layer of the middle layer of deep cervical fascia. The investing layer of deep cervical fascia contributes to the anterior wall (*Figures 3, 4*).

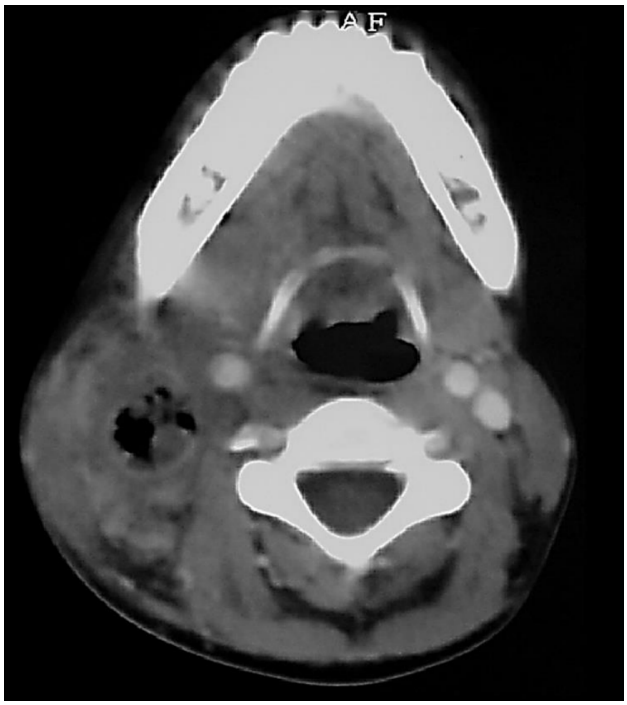


Figure 71: Carotid space abscess within lumen of internal jugular vein as a consequence of mastoiditis

The space contains the internal carotid artery, internal jugular vein, cranial nerves IX-XII, lymph nodes and the sympathetic trunk. Above the level of the hyoid bone it is contained within the retrostyloid component of the PPS (*Figure 71*). In the suprahyoid neck the space is bordered anteriorly by the styloid process and the PPS, laterally by the anterior belly of digastric and the parotid space and medially by the lateral margin of the retropharyngeal space.

Sepsis may originate from infection within the PPS, from intravenous drug abuse, central venous (CVP) line sepsis, or from lateral sinus thrombosis related to mastoiditis (*Figure 71*). Patients may initially not have localising signs as the infection is deep-seated.

Often clinical signs may only become evident after onset of neurological or vascular complications. Patients may present with torticollis to the side opposite to the sepsis, and tenderness along the course of the carotid. They lack trismus. Vascular complications include suppurative jugular vein thrombophlebitis (Lemierre syndrome), septic pulmonary emboli, carotid artery thrombosis, carotid aneurysm, stroke, or carotid or jugular vein blowouts. Involvement of the sympathetic trunk can cause Horner's syndrome. Contrast enhanced CT is recommended. Duplex ultrasonography can identify vascular complications.

Surgical approaches to the carotid space

Treatment is directed at drainage of the sepsis via a transverse cervical skin crease incision with elevation of subplatysmal flaps superiorly and inferiorly for exposure. Clot propagation and pulmonary emboli are limited by anticoagulation.

IV.d. Prevertebral Space

This is a potential space and extends from the skull base to the coccyx. Due to the anatomy of the potential space, it has also been named the perivertebral space. It is divided into two divisions, namely the prevertebral and paraspinal spaces. It is immediately posterior to the Danger Space and is bound anterolaterally by the carotid space. It is located anterior to the vertebral bodies, behind the prevertebral fascial layer of the deep layer of deep cervical fascia that separates it from the Danger Space (*Figures 67, 68*). Laterally it is limited by the fusion of the prevertebral fascia with the transverse processes of the vertebral bodies.

Infection may be caused by trauma, especially surgery, or may originate from the cervical or thoracic spine. The diagnosis is difficult to make. Patients may present with neck and/or back pain, just fever and/or neurologic dysfunction ranging from nerve root pain to paralysis. MRI is the imaging modality of choice to assess epidural or spinal cord involvement.

Surgical approaches to prevertebral space

Incision and drainage may be done using transoral or transcervical approaches. The latter approach is made along the anterior border of sternocleidomastoid, dissecting between the larynx and the carotid sheath. One may have to divide the superior thyroid artery for access.

Antibiotics for odontogenic infections

Antibiotics should initially be administered empirically, parenterally, at high doses, and should cover a broad spectrum of oral flora i.e. gram-positive, gram-negative, and anaerobic organisms. The literature advises empiric treatment with combinations of penicillin, clindamycin, and metronidazole. The authors favor a combination of penicillin G and metronidazole. Alternatively, amoxicillin-clavulanate with metronidazole can be used, or clindamycin for patients who are allergic to penicillin. Antibiotic cover needs to be extended to cover Methicillin-resistant Staphylococcus aureus (MRSA) and gram-negative rods in immune compromised patients. Antibiotics should be modified based on the results of microscopy, culture and sensitivity reports.

Recommended reading

http://cosmos.phy.tufts.edu/~rwillso...neck/Index.htm

Author

Jean Morkel BChD, MBChB, MChD, FCMFOS
Professor and Academic Head
Department of Maxillo-Facial and Oral
Surgery and Anesthesiology & Sedation
Faculty of Dentistry
University of the Western Cape
Cape Town, South Africa
jamorkel@uwc.ac.za

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Klaus Stelter and Goetz Lehnerdt

Acute tonsillitis is treated with steroids e.g. dexamethasone, NSAIDs e.g. ibuprofen and beta-lactam antibiotics e.g. penicillin or cefuroxime. Only 10 days of antibiotic therapy has proven to be effective to prevent rheumatic fever and glomerulonephritis.

Tonsillectomy is only done for recurrent acute bacterial tonsillitis, or for noninfectious reasons such as suspected neoplasia.

Partial tonsillectomy (tonsillotomy) is the 1st line treatment for snoring due to tonsillar hyperplasia. It is low-risk, and postoperative pain and risk of hemorrhage are much less than with tonsillectomy. It is immaterial whether the tonsillotomy is done with laser, radiofrequency, shaver, coblation, bipolar scissors or monopolar electrocautery, as long as the crypts remain open and some tonsil tissue remains.

Pain and hemorrhage are the main morbidity of tonsillectomy. Bleeding may occur anytime until the wound is completely healed, which is normally at 2-3 weeks. Patients have to be informed about what to do in case of hemorrhage. Life threatening hemorrhage often is preceded by smaller bleeds, which can spontaneously cease. That is why every hemorrhage, even the smallest, has to be treated as an inpatient. Massive hemorrhage is an extreme challenge for every paramedic or emergency doctor because of difficult airway management.

Function and anatomical structure of tonsils in childhood and adolescence

Tonsils allow one to acquire immunity and provide immune defense by antigen presentation. This is why they contain T-lymphocytes, germinal centers of B-lymphocytes 1 and macrophages. They are the first and easiest-to-reach station of the mucosa associated lymphoid tissue system (MALT)[2-4]. As the main phase of the immune acquisition continues until the age of 6 years, the palatine tonsils are physiologically hyperplastic at this time[5, 6]. This is followed by involution, which is reflected by regression of tonsil size until age 12 years[7].

The lymphoid tissue is separated by a capsule from the surrounding muscle (superior pharyngeal constrictor)[8]. The blood supply originates from four different vessels, the lingual artery, the ascending pharyngeal artery and the ascending and descending palatine arteries. These vessels radiate mainly to the upper and lower tonsillar poles, as well as to the center of the tonsil from laterally[9]. The tonsils have deep crypts that create a large surface area to provide a docking surface for potential antigens[10].

Tonsil diseases

Sore throat episodes (R07.0)

Synonyms include “acute sore throat”, and “throat infection”. "Sore throat" is an imprecise term and does not clinically distinguish between acute tonsillitis and pharyngitis. Neither the cause nor the exact location is determined[11]. In “sore throat” it remains unclear whether one is dealing with acute (bacterial) tonsillitis which, if recurrent, is an indication for tonsillectomy[12].

Acute tonsillitis (J03.0 - J03.9)

Also known as “severe tonsillitis” [13], “true tonsillitis”, or “acute sore throat” [11], this refers to viral or bacterial tonsillitis with odynophagia, swelling and redness of the tonsils, possibly with a tonsillar exudate, cervical lymphadenopathy and fever >38.3°C (rectal)[14, 15]. Odynophagia for 24-48 hours, as part of prodromal symptoms of a common cold (viral infection of upper respiratory tract), is excluded from the term "acute tonsillitis" [11]. Depending on the stage and appearance of the tonsillar deposits or exudate, one can distinguish catarrhal angina with redness and swelling of the tonsils (early stage), from follicular angina with stipple-like fibrin deposits, from lacunar angina with confluent deposits (late stage)[16, 17]. "Acute tonsillitis" can be diagnosed by a specialist purely on clinical grounds[18]. Smears, blood tests or viral evidence are unnecessary in most cases[19-23]. Penicillin or another beta-lactam antibiotic is the first line of treatment.

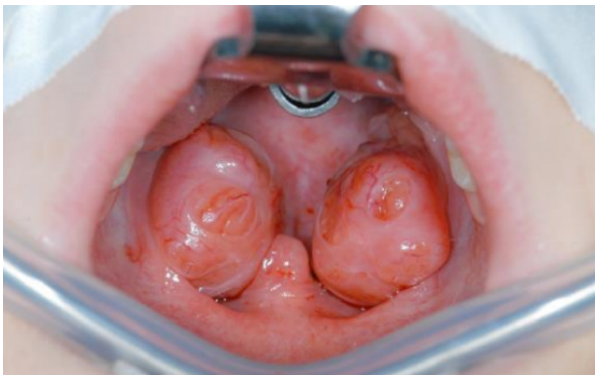


Figure 1: Hyperplastic tonsils in a child

Chronic tonsillitis (J35.0 and J35.9)

Also called “chronic (hyperplastic) tonsillitis”, it is not well-defined and thus should not be used[24]. It is better to speak of (chronic) recurrent tonsillitis[25, 26], because true chronic tonsillitis with persistentsymptoms lasting >4 weeks with adequate treatment and recovery of the mucosa (as in rhinosinusitis) does not exist.

Recurrent acute tonsillitis (J35.0)

Also called “recurrent tonsillitis” or “recurrent throat infections” [27], this refers to recurrent bouts of acute tonsillitis. In contrast to a single attack of acute tonsillitis, it is usually caused by many different bacterial pathogens[28, 29] and flare up again a few weeks after cessation of antibiotic therapy[30]. Depending on the frequency and severity of such episodes, ***this is an indication for tonsillectomy***.

Peritonsillar abscess (J36)

This is also called “peritonsillitis”, or “quinsy” [31, 32], and is acute tonsillitis complicated by an abscess, typically unilateral[33]. The abscess may form in the intratonsillar, para/ peritonsillar or retrotonsillar spaces. The pathogens are typically staphylococci[34], streptococci and fusobacterium necrophorum[35]. In contrast to acute tonsillitis, viruses play no role in abscesses[36]. A peritonsillar abscess is drained by aspiration or drainage or by unilateral tonsillectomy.

Tonsil hyperplasia (J35.1 and J35.3)

Tonsil hyperplasia[37], also known as (idiopathic) tonsillar hypertrophy[38], refers to abnormal enlargement of the palatine tonsil. It has to be distinguished from physiological pediatric palatine tonsil hyperplasia[39, 40] which is not a sign or consequence of recurrent inflammation[41, 42]. Also, children with tonsil hyperplasia do not suffer from acute tonsillitis[43, 44] or middle ear infections[45]. A pediatric tonsil is only "pathologically" hyperplastic if snoring (with or without obstructive sleep apnoea) or rarely dysphagia[46] or even more rarely dysphonia[47] occur.

Surgical procedures

Tonsillectomy

(Extracapsular) tonsillectomy means that the entire tonsil, including its capsule, is removed from the tonsil fossa; no lymphatic tissue remains between the anterior and posterior palatal arches[48]. Since the late 1960s, with the realization that the tonsil is a focus of infection[49-52], this form of tonsil operation has been the gold standard and is still the most common surgery done in the world[53].

Video 1: Extracapsular tonsillectomy

Tonsillotomy (partial tonsillectomy)

Only the medial part of the tonsil is removed. It requires that the (well-perfused) lymphatic tissue is resected, and that the remaining crypts remain open to the oropharynx[54, 55]. Active lymphatic tissue, with secondary follicles and crypts, is left in the tonsil fossae[56]. Tonsillotomy can be done with most dissecting and coagulating methods. The most common are laser tonsillotomy and radiofrequency tonsillotomy and are described in detail in this chapter.

Video 2: Laser tonsillectomy

Video 3: Radiofrequency tonsillectomy

Intracapsular tonsillectomy

Intracapsular, subcapsular or subtotal tonsillectomy describes a method in which the lymphatic tissue of the tonsil, including all crypts and follicles, is removed[57, 58], but the capsule of the tonsil is preserved; thus the underlying muscles are not exposed[59]. At the end of the operation there is an empty tonsil fossa without typical subsequent scarring[59]. Indications for intracapsular tonsillectomy are foetor ex ore (halitosis) and recurrent detritus (debris) in the tonsillar crypts. It differs from tonsillotomy in which a lot more tonsillar tissue is left behind.

Video 4: Intrascapular tonsillectomy with radiofrequency

Thermal- or cryotherapy of palatine tonsil

The tonsil tissue is heated (or cooled) interstitially; subsequent scarring causes shrinkage of the lymphoid tissue. No tissue is removed and a large part of the lymphoid tissue allegedly remains functional. The indication is mild tonsillar hyperplasia. Synonyms and different techniques include interstitial (electro)coagulation, laser coagulation, thermal coagulation, and cryocoagulation of the palatine tonsil[60, 61], photodynamic therapy, ultrasound therapy[62], radiofrequency-induced thermotherapy[63], temperature-controlled tonsil treatment[64, 65], and tonsil thermotherapy.

Preoperative evaluation, swabs & diagnosis

Pathogens, biofilms, and normal findings

With the discovery of rheumatic fever, group A streptococci (GAS) were primarily blamed for all ills in the upper respiretory tract in the 70's [66-73]. However more recently, anaerobes, e.g. Fusobacterium necrophorum, Streptococcus Intermedius and Prevotella Melaninogenica and Histicola have also been incriminated[28, 74, 75].

Children up to 8 years of age have a tendency towards diffuse intracellular pathogen enrichment with interstitial abscesses, while in adults or adolescents a more superficial bacterial accumulation at the edge of the crypts occurs. Particularly in the case of recurrent tonsillitis, several pathogens and microorganisms play a joint role. These can jointly form biofilms and bacterial clusters and thus evade antibiotics[76]. The oral cavity and especially the furrowed tonsil is a reservoir for multiple pathogens (viruses and bacteria), parasites[77] and fungi[78]. However, all these microbes belong to resident flora with which we have lived symbiotically for aeons[28, 79]. Streptococci still play the largest role in acute tonsillitis (30%)[80], followed by Haemophilus Influenzae and Neisseria[28]. Mostly, however, mixed infections (viral and bacterial initially) are responsible[81].

Diagnosis

"Acute tonsillitis" in children and adults is a clinical diagnosis[82]. In viral tonsillitis, in addition to pain and fever, primarily cough, hoarseness, and rhinorrhoea occur, while in bacterial tonsillitis, in addition to pain with lymph node swelling, there is mainly a tonsillar exudate and fever >38.3°C [83]. A streptococcal antigen test can confirm the diagnosis and is 98% specific for streptococci, although not particularly sensitive. A problem with these tests is the high number of asymptomatic chronic carriers of staphylococci and streptococci (10% of healthy children), who are definitely not in need of therapy[84-89]. In the early stages, a distinction between viral and bacterial tonsillitis is often difficult to make, especially when one considers that in 97.5% of cases, at least one virus, even in bacterial tonsillitis, is found (adenovirus and parainfluenza virus respectively in 47.5% [90, 91])[81].

Conservative Treatment

Antibiotic therapy: In clinically apparent or proven bacterial tonsillitis associated with distress, antibiotics (beta-lactam) are justified. Beta-lactam antibiotic therapy also provides relatively reliable protection against the dreaded rheumatic fever and glomerulonephritis which often cause, especially in developing countries, arthritis, myocarditis and death. Studies have shown that antibiotic therapy can prevent sequelae such as peritonsillar abscesses, acute otitis and sinusitis. The penicillins, particularly in children and adolescents, have the greatest benefit at the lowest cost. There is no difference to cephalosporins. Macrolides and clindamycin have more side-effects with the same efficacy and should be reserved for patients with proven penicillin allergy[92, 93].

Postoperative antibiotic therapy is not indicated as it neither reduces pain nor postoperative bleeding[94, 95].

Steroids: In acute tonsillitis or after tonsillectomy, oral or intramuscular steroids (dexamethasone 10 mg), as well as betamethasone (8 mg) and prednisolone (60 mg), significantly improve symptoms with minimal side effects and no adverse effects relating to disease progression[96-98].

Analgesics: Nonsteroidal anti-inflammatory drugs have been used successfully for pain relief for >40 years [99]. For acute tonsillitis, ibuprofen has the best efficacy with minimal side-effects compared to paracetamol and acetylsalicylic acid (ASA)[100]. Another

advantage of ibuprofen is its longer duration of action (6-8 hours) compared to paracetamol. Both substances have a large therapeutic range and at the correct dosage, the safety is comparable [101, 102]. Diclofenac and ketorolac are very effective, but in children have fewer docking sites and are metabolised more quickly, which is why the dose should be adjusted to a higher level than in adults)[103]. In postoperative management these substances play a role in opioid reduction, but as first-line therapy in paediatrics are not suitable for a sore throat [104, 105]. Metamizol is not recommended as first or second choice analgesic in children due to a small but real risk of agranulocytosis[106].

Complications of tonsillitis

In general, acute tonsillitis runs its course without complications and heals within 3-4 days. Rare but serious complications after streptococcal tonsillitis are glomerulonephritis and rheumatic fever, which triggers cardiomyopathies and rheumatic-like joint pain[107]. Early and a long course (10 days) of antibiotics (penicillin or cephalosporin) reduces the frequency of both these complications by 70% [108]. In parts of the developing world where rheumatic fever is more common, preventing this complication is the main argument in favor of penicillin therapy[108].

Peritonsillar abscess is a second, more frequent complication. It is typically unilateral, although bilateral abscesses occur in up to 4% [109]. It is preceded by acute tonsillitis in only 1/3 of cases[110]. Even correctly administered antibiotic treatment of acute tonsillitis cannot really prevent peritonsillar abscesses (in contrast to rheumatic fever)[111]. Since peritonsillar abscesses can rapidly spread to the soft tissues of the neck and are potentially life-threatening, the primary therapy is urgent and surgical[112-114]. It does not matter whether the abscess is needle aspirated, incised or treated by tonsillectomy[115]. But the surgeon has to keep in mind that a stab incision can fail to drain inferiorlylocated abscesses[109, 116]. Before the operation, high-dose steroid therapy, as well as penicillin should be administered, as is often done for mixed infections[117].

Indications for tonsil surgery

Surgery is done for infections, to relieve airway obstruction, for halitosis and for diagnosis when a tumor is suspected. Surgery for recurrent tonsillitis depends on its frequency and severity, and the presence of additional diseases (antibiotic allergies, immunosuppression and PFAPA syndrome).

Paradise criteria for tonsillectomy[118]

Paradise (1984) reported that tonsillectomy significantly lowers the frequency of severe recurrent sore throats in children aged 3-15 years. Most published guidelines incorporate the so-called Paradise criteria for tonsillectomy:

- 7 episodes of tonsillitis per year in one year or,
- 5 episodes of tonsillitis per year in 2 consecutive years or,
- 3 episodes of tonsillitis per year in 3 consecutive years

A diagnosis of "purulent tonsillitis" must however be documented and confirmed by an elevated temperature (>38.3°C), tonsillar exudate, enlarged lymph nodes at the angle of the jaw, and antibiotic treatment[119, 120]. The authors also reported that on average only a few (not all) throat infections can be prevented by tonsillectomy in the following 2 years; 47 of 187 patients withdrew from the planned three-year follow-up[121]. For less severe sore throat inflammation or less frequent throat inflammation, the risk of tonsillectomy does not outweigh the benefits[122].

While tonsils contribute to immune competence until 12 years, a negative long-term effect on the immune system cannot be proven[123]. Nevertheless, in children under 8 years, the indications for complete removal must be strictly adhered to, as the risks of serious or fatal bleeding are higher[124].

With tonsillotomy (unlike tonsillectomy), some active lymphatic tissue is retained; it continues to grow in about 15% of cases, but rarely causes problems such as renewed snoring or recurrent tonsillitis[125]. The fear that frequent tonsillitis or peritonsillar abscesses will occur after tonsillotomy is unfounded[126-128]. All crypts remain open during laser, ultrasound, shaver, high- and radiofrequency technique[129, 130].

Surgical technique

Extracapsular tonsillectomy

Cold steel dissection is the most commonly performed surgical technique in children and adults, and is described in detail in the chapter on Pediatric Tonsillectomy. The technique is similar in adults.

The tonsils are dissected from the tonsil bed partly sharply and partly bluntly with a raspartorium and scissors. The feeding vessels, especially at the upper and lower tonsil pole, are pinched off and then selectively ligated. After removal of the tonsil, a dry swab is pressed for about 1 minute into the tonsil bed to stop bleeding from small vessels. Some surgeons perform additional suturing of the lower pole (so-called “pole suturing”, a controversial method[131]).

This method of tonsillectomy has been known for decades and has been very commonly used, especially in the 70s and 80s with the discovery of that tonsils are a source of infection[132]. Optical magnification (microscope or loupes), makes it possible to specifically identify the smaller vessels and perform bipolar coagulation before dissection[133].

Due to its good long-term results and low morbidity and mortality, cold steel dissection is still the most common method of tonsillectomy[134].

Tonsillotomy (partial tonsillectomy)

The tonsil is not completely removed, but only the portion that bulges into the throat, which due to its size causes functional problems. By preserving some tonsil tissue a lymphatic and immunologically active rudiment is retained.

The tonsil has a rich blood supply and has to be sufficiently cut and coagulated (not crushed) during surgery so that there is no postoperative bleeding, infection or pain. To this end, several dissection procedures have been developed (in principle, a tonsillectomy can also be performed with all these methods):

- CO^2 laser [135] [136]
- Monopolar high frequency current [137]
- Ultrasound scalpel [138]
- Bipolar radiofrequency coblation [139]
- Bipolar scissors [140]
- Argon gas-assisted monopolar needle [141]
- Microdebrider [142]

Advantages of tonsillotomy (regardless of what method is used to reduce the tonsils) are significantly less pain [143] and a lower postoperative bleeding rate [144] compared with tonsillectomy.



Figure 2: Instruments to perform radiofrequency dissected tonsillotomy / partial tonsillectomy

The quickest and easiest way to perform tonsillotomy is with monopolar high frequency dissection (Video 3). Instrumentation is shown in *Figure 2*.

- Following induction of general anesthesia the patient is positioned supine with neck slightly extended
- Select an appropriate length Boyle Davis blade and insert the gag to retract the tongue and expose the tonsils (*Figure 1*)
- Grasp a tonsil with a broad tonsil holding forceps and gently pull it toward the midline. Avoid pulling too hard to avoid doing a complete tonsillectomy
- Insert a Colorado needle into the tonsil at the edge of the anterior faucal pillar
- Spare the mucosa of the velopalatinal arch to avoid bleeding and pain in the incision line
- Amputate the protruding part of the tonsil by dissecting with continuous movements of the needle. Do not remain too long in the same place with the cutting needle as it may burn holes in the tonsil

- Pack the wound with a gauze swab for at least 1 minute
- Minor bleeding stops spontaneously. Larger bleeding vessels can be coagulated with bipolar forceps. A suture or ligature is not required
- Repeat the process on the contralateral side

Intracapsular (subtotal) tonsillectomy

The tonsil capsule covering the underlying muscle remains in the tonsil fossa[145]. Slightly less postoperative pain and earlier food intake have been reported[146]. The instrumentation and technique is similar to tonsillotomy. All the methods of tonsillotomy previously listed may also be used. The microdebrider has been reported to be a useful tool[147-152].

- The surgeon has to pull harder on the tonsil to subluxate the capsule, but the capsule itself has to remain in place and not be breached
- It may be very difficult to determine the exact proportion of residual tonsil that remains in the fossa
- After tonsillitis with subsequent scarring it is difficult even with loupes or a microscope to identify the exact plane of the tonsil capsule and only to remove only the active lymphatic tissue
- Because the vessels are bigger in the abyss of the crypts and near the capsule, bleeding has to be controlled with bipolar forceps more often than with (more superficial) tonsillotomy

Postoperative pain

Tonsillectomy is very painful, especially if the capsule is breached and the muscle is exposed. Severe pain and superinfection of the wound bed can cause delayed healing and prolong hospital stay. Especially adolescent and adult patients report pain, exhaustion and fatigue weeks after surgery. In tonsillectomy the wound remains open and heals in 2-3 weeks secondarily by granulation. Sealing the wound beds postoperatively e.g. with fibrin glue[153] or sucralfate[154] has no advantage in terms of postoperative bleeding or pain.

With tonsillotomy, however, pain was reported as only around 2-3 on the numerical analogue scale.

Intracapsular tonsillectomy is allegedly less painful than tonsillectomy[155]. However, it is unlikely that intracapsular tonsillectomy produces as little pain as tonsillotomy. Pain is perceived very differently by individuals. In children and adults, the differences, regardless of surgeon and method, can be enormous[156-158]. Children of African descent have more postoperative pain than Europeans and respond better to opiates[159]. This complicates both objective pain measurement (which does not exist), as well as a standard therapy. Pain therapy must therefore be individualized and adjusted, especially in children. Questionnaires (e.g. Ramsay Sedation Scale[160]) for analgesic use, food intake, otalgia, and downtime use popular surrogate parameters.

Because pain is perceived and processed multimodally, the treatment must be multimodal. Firstly, a local long-lasting pain reliever (e.g. Bupivacaine or Ropivacaine[161]) should be injected into the wound postoperatively or perioperatively to pre-vent activation of the early pain pathway[162-164]. Then already perioperatively it should be cooled locally by a cold compress[165] and later a lot of ice should be eaten (local cooling and calorie intake)[166]. Mouth-washes with gingicaine, benzocaine or tetracaine also provide pain relief, but also numb the taste buds and respiratory flow receptors, which is often perceived as very unpleasant.

The perioperative and postoperative administration of high-dose steroids (dexamethasone or prednisolone) is clearly recommended in all guidelines. This reduces postoperative nausea and analgesic consumption significantly[167-169].

A fixed analgesic regimen with ibuprofen or diclofenac makes sense in adults and adolescents, but for children and infants rescue medication is often enough[170, 171]. An increased risk of bleeding due to nonsteroidal anti-inflammatory drugs, (except for aspirin) should not be feared[172, 173]. One should therefore adhere to the WHO staging system[174] (http://www.who.int/cancer/palliative/painladder/en/). After tonsillectomy, it may well be that in the first days WHO stage III drugs (strong opioid, e.g. piritramide iv) or even a pain pump must be administered to ensure pain under 4 on the visual analogue scale and adequate food intake[175]. Pain and nausea (with and without vomiting) after tonsillectomy are often trivialized by both nurses as well as physicians and therefore it is more likely that few analgesics will be administered postoperatively[176-178].

Post-tonsillectomy bleeding

Early and late postoperative bleeding

Postoperative bleeding can occur anytime until the wound is completely healed, despite careful intraoperative hemostasis and dissection; usually after 2-3 weeks.

Postoperative bleeding occurs either as socalled early bleeding within the first 24 hours, or in the form of late bleeding with a peak incidence between the 5th and 8th day after surgery. From the 3rd postoperative week bleeding occurs only very rarely. Therefore late postoperative bleeding presents a special problem because it often occurs only at home and therefore the time factor to get a professional play a major role.

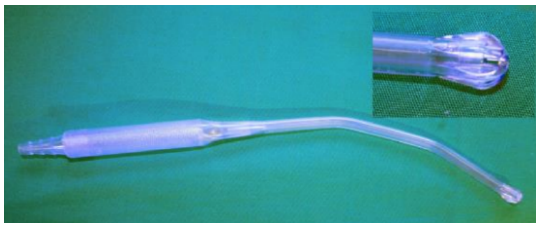


Figure 3: Rigid tonsil or thoracic suction device manufactured by Cardinal Health, IL, USA (Medi-Vac ® Yankauer Suction Handle, REF KEX80)

The most common cause of late bleeding is the physiological detachment of the fibrin layer from the open wound bed and usually results in harmless bleeding. This bleeding almost always ends spontaneously, or due to local icing (sucking ice cubes, applying an ice cravat) or by tranexamic acid intravenously or locally (rinsing)[179]. If bleeding does not spontaneously subside because a larger vessel is bleeding, vessel ligation or suturing under anesthesia is required. Massive hemorrhage is an extreme challenge for every paramedic or emergency doctor because of the difficult airway management. Intubation is only possible with suctioning the airway with suction tubes (*Figure 3*).

During induction and intubation, the ENT doctor should be present and prepared to perform emergency Cricothyroidotomy. Aspirated blood or incorrect intubation is the most common clinical complication of postoperative bleeding. Intraoperatively the surgeon must decide whether targeted bipolar coagulation and swab pressure are sufficient or whether suturing or ligation are necessary. If that fails, either the lingual artery, ascending pharyngeal artery, facial artery or even the external carotid artery must be ligated from externally or embolisation the feeding vessels by interventional radiology should be done. Such massive bleeding is signalled in most cases by a minor "warning bleeding"[180, 181], so any bleeding must be taken seriously and the patient must be hospitalized.

Postoperative bleeding depending on method of surgery

In principle, intraoperative and postoperative bleeding can occur with all intervenetions involving the tonsils. However, for the tonsillotomy the postoperative bleeding rate is, by a factor of 5-10, lower than that for tonsillectomy[182]. In cryptolysis and thermotherapy of the tonsils postoperative bleeding is a rarity[183, 184]. Only extracapsular tonsillectomy remains problematic. "Cold dissection" with ligature or suturing has the lowest postoperative bleeding rates. Significantly more severe late bleeding has been reported after laser, coblation, monopolar or bipolar techniques[185-187].

Videos

Video 1: Extracapsular Tonsillectomy

Video 2: Laser Tonsillotomy

Video 3: Radiofrequency Tonsillotomy

Video 4: Intracapsular Tonsillectomy

References

1. Westermann J. Organe des Abwehrsystems. Springer; 2010. 361-2
2. Brandtzaeg P. The B-cell development in tonsillar lymphoid follicles. Acta Otolaryngol Suppl. 1996;523:55-9
3. Nave H, Gebert A, Pabst R. Morphology and immunology of the human palatine tonsil. Anat Embryol (Berl). 2001 Nov;204(5):367-73
4. Brandtzaeg P. Immune functions of nasopharyngeal lymphoid tissue. Adv Otorhinolaryngol. 2011;72:20-4
5. Perry M, Whyte A. Immunology of the tonsils. Immunol Today. 1998 Sep;19(9):414-21
6. Kaygusuz I, Godekmerdan A, Karlidag T, et al. Early stage impacts of tonsillectomy on immune functions of children. Int J Pediatr Otorhinolaryngol. 2003 Dec;67(12):1311-5
7. Kaygusuz I, Alpay HC, Godekmerdan A, et al. Evaluation of long-term impacts of tonsillectomy on immune functions of children: a follow-up study. Int J Pediatr Otorhinolaryngol. 2009 Mar;73(3):445-9
8. Perry ME, Slipka J. Formation of the tonsillar corpuscle. Funct Dev Morphol. 1993;3(3):165-8

9. Westermann J. Organe des Abwehrsystems. Springer; 2010. 361-362.
10. Drucker M, Drucker I, Neter E, Bernstein J, Ogra PL. Cell mediated immune responses to bacterial antigens on human mucosal surfaces. Adv Exp Med Biol. 1978;107:479-88
11. Georgalas CC, Tolley NS, Narula A. Tonsillitis. Clin Evid (Online). 2009
12. Paradise JL. Etiology and management of pharyngitis and pharyngotonsillitis in children: a current review. Ann Otol Rhinol Laryngol Suppl. 1992 Jan;155:51-7
13. Lange G. [Angina and chronic tonsillitis--indications for tonsillectomy]. Z Allgemeinmed. 1973 Mar 20;49(8):366-70
14. Österreichische Gesellschaften für HalsNasen-Ohren-Heilkunde KuH, Kinderund Jugendheilkunde. Gemeinsame Empfehlung zur Entfernung der Gaumenmandeln (Tonsillektomie). Monatsschr Kinderheilkd. 2008 Mar 7;3(156):268-71
15. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
16. Berghaus A. [Chronic inflammation of the upper airways. Operation instead of antibiotic]. MMW Fortschr Med. 2005 Sep 29;147(39):27
17. Berghaus A, Pirsig W. Mundhöhle und Pharynx. In: Berghaus A, Rettinger G, Böhme G., eds. Hals-Nasen-Ohren-Heilkunde. 1 ed. Stuttgart: Hippokrates Verlag; 1996. 386-453
18. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
19. Stuck BA, Genzwurker HV. [Tonsillectomy in children: preoperative evaluation of risk factors]. Anesthesist. 2008 May;57(5):499-504
20. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
21. Kurien M, Stanis A, Job A, Brahmadathan, Thomas K. Throat swab in the chronic tonsillitis: how reliable and valid is it? Singapore Med J. 2000 Jul;41(7):324-6
22. Fujikawa S, Hanawa Y, Ito H, Ohkuni M, Todome Y, Ohkuni H. Streptococcal antibody: as an indicator of tonsillectomy. Acta Otolaryngol Suppl. 1988;454:286-91
23. Borschmann ME, Berkowitz RG. Oneoff streptococcal serologic testing in young children with recurrent tonsillitis. Ann Otol Rhinol Laryngol. 2006 May;115(5):357-60
24. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
25. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
26. Burton MJ, Towler B, Glasziou P. Tonsillectomy versus non-surgical treatment for chronic / recurrent acute tonsillitis. Cochrane Database Syst Rev. 2000;(2):CD001802
27. Georgalas CC, Tolley NS, Narula A. Recurrent throat infections (tonsillitis). Clin Evid (Online). 2007
28. Jensen A, Fago-Olsen H, Sorensen CH, Kilian M. Molecular mapping to species level of the tonsillar crypt microbiota associated with health and recurrent tonsillitis. PLoS One. 2013;8(2):e56418
29. Swidsinski A, Goktas O, Bessler C, et al. Spatial organisation of microbiota in quiescent adenoiditis and tonsillitis. J Clin Pathol. 2007 Mar;60(3):253-60
30. Jensen JH, Larsen SB. Treatment of recurrent acute tonsillitis with clindamycin. An alternative to tonsillectomy? Clin Otolaryngol Allied Sci. 1991 Oct;16(5):498-500
31. Raut VV. Management of peritonsillitis/peritonsillar. Rev Laryngol Otol Rhinol (Bord). 2000;121(2):107-10
32. Fried MP, Forrest JL. Peritonsillitis. Evaluation of current therapy. Arch Otolaryngol. 1981 May;107(5):283-6
33. Dalton RE, Abedi E, Sismanis A. Bilateral peritonsillar abscesses and quinsy tonsillectomy. J Natl Med Assoc. 1985 Oct;77(10):807-12
34. Klug TE, Henriksen JJ, Rusan M, Fuursted K, Ovesen T. Bacteremia during quinsy and elective tonsillectomy: an evaluation of antibiotic prophylaxis recommendations for patients undergoing tonsillectomy. J Cardiovasc Pharmacol Ther. 2012 Sep;17(3):298-302
35. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Significant pathogens in peritonsillar abscesses. Eur J Clin Microbiol Infect Dis. 2011 May;30(5):619-27
36. Rusan M, Klug TE, Henriksen JJ, Ellermann-Eriksen S, Fuursted K, Ovesen T. The role of viruses in the pathogenesis of peritonsillar abscess. Eur J Clin Microbiol Infect Dis. 2012 Sep;31(9):2335-43

37. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
38. Semberova J, Rychly B, Hanzelova J, Jakubikova J. The immune status in situ of recurrent tonsillitis and idiopathic tonsillar hypertrophy. Bratisl Lek Listy. 2013;114(3):140-4
39. Perry M, Whyte A. Immunology of the tonsils. Immunol Today. 1998 Sep;19(9):414-21
40. Goldberg S, Shatz A, Picard E, et al. Endoscopic findings in children with obstructive sleep apnea: effects of age and hypotonia. Pediatr Pulmonol. 2005 Sep;40(3):205-10
41. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
42. Ericsson E, Lundeborg I, Hultcrantz E. Child behavior and quality of life before and after tonsillotomy versus tonsillectomy. Int J Pediatr Otorhinolaryngol. 2009 Sep;73(9):1254-62
43. Stelter K, Ihrler S, Siedek V, Patscheider M, Braun T, Ledderose G. 1-year follow-up after radiofrequency tonsillotomy and laser tonsillotomy in children: a prospective, double-blind, clinical study. Eur Arch Otorhinolaryngol. 2012 Feb;269(2):679-84
44. Sarny S, Ossimitz G, Habermann W, Stammberger H. [The Austrian tonsil study 2010--part 1: statistical overview]. Laryngorhinootologie. 2012 Jan;91(1):16-21
45. Braun T, Dreher A, Dirr F, Reichel O, Patscheider M. [Pediatric OSAS and otitis media with effusion]. HNO. 2012 Mar;60(3):216-9
46. Gronau S, Fischer Y. [Tonsillotomy]. Laryngorhinootologie. 2005 Sep;84(9):685-90
47. Fischer Y, Gronau S. [Identification and evaluation of obstructive sleep apnea in children before adenotonsillectomy using evaluative surveys]. Laryngorhinootologie. 2005 Feb;84(2):121-35
48. Alavoine J, Graber A. [Extracapsular tonsillectomy under general anesthesia]. Rev Laryngol Otol Rhinol (Bord). 1968 Sep;89(9):568-79
49. Feinstein AR, Levitt M. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
50. Rapkin RH. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
51. Wannamaker LW. Tonsils, rheumatic fever and health delivery. N Engl J Med. 1970 Feb 5;282(6):336-7
52. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
53. van den Akker EH, Hoes AW, Burton MJ, Schilder AG. Large international differences in (adeno)tonsillectomy rates. Clin Otolaryngol Allied Sci. 2004 Apr;29(2):161-4
54. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
55. Koltai PJ, Solares CA, Mascha EJ, Xu M. Intracapsular partial tonsillectomy for tonsillar hypertrophy in children. Laryngoscope. 2002 Aug;112(8 Pt 2 Suppl 100):17-9
56. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
57. CHAMPEAU D. [Intracapsular tonsillectomy.]. Ann Otolaryngol Chir Cervicofac. 1961 Dec;78:866-9
58. FALCAO P. [Total intracapsular palatine tonsillectomy; systematization of technic.]. Rev Bras Otorrinolaringol. 1954 Jul;22(4-5):309-32
59. Anand A, Vilela RJ, Guarisco JL. Intracapsular versus standard tonsillectomy: review of literature. J La State Med Soc. 2005 Sep;157(5):259-61
60. Almqvist U. Cryosurgical treatment of tonsillar hypertrophy in children. J Laryngol Otol. 1986 Mar;100(3):311-4
61. Principato JJ. Cryosurgical treatment of the lymphoid tissue of Waldeyer's ring. Otolaryngol Clin North Am. 1987 May;20(2):365-70
62. Chatziavramidis A, Constantinidis J, Gennadiou D, Derwisis D, Sidiras T. [Volume reduction of tonsil hyperplasia in childhood with a surgical ultrasound device]. Laryngorhinootologie. 2007 Mar;86(3):177-83
63. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT.). Acta Otolaryngol. 2007 Nov;127(11):1176-81
64. Zhu X, Yang H, Chen X, Jin Y, Fan Y. [Temperature-controlled radiofrequency-assisted endoscopic tonsillectomy and adenoidectomy in children]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2011 Jun;25(12):551-3

65. Coticchia JM, Yun RD, Nelson L, Koempel J. Temperature-controlled radiofrequency treatment of tonsillar hypertrophy for reduction of upper airway obstruction in pediatric patients. Arch Otolaryngol Head Neck Surg. 2006 Apr;132(4):425-30
66. Feinstein AR, Levitt M. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
67. Rapkin RH. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
68. Wannamaker LW. Tonsils, rheumatic fever and health delivery. N Engl J Med. 1970 Feb 5;282(6):336-7
69. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
70. el Barbary Ae, Mohieddin O, Fouad HA, Khalifa MC. The tonsils and rheumatic fever. Ann Otol Rhinol Laryngol. 1969 Jun;78(3):648-56
71. Stryjecki J. [Tonsillectomy in the course of rheumatic fever in children]. Pediatr Pol. 1968 Dec;43(12):1531-4
72. Matanoski GM, Price WH, Ferencz C. Epidemiology of streptococcal infections in rheumatic and nonrheumatic families. II. The interrelationship of streptococcal infections to age, family transmission and type of group A. Am J Epidemiol. 1968 Jan;87(1):190-206
73. Alpert JJ, Peterson OL, Colton T. Tonsillectomy and adenoidectomy. Lancet. 1968 Jun 15;1(7555):1319
74. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Similar recovery rates of Fusobacterium necrophorum from recurrently infected and non-infected tonsils. Dan Med Bull. 2011 Jul;58(7):A4295
75. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Significant pathogens in peritonsillar abscesses. Eur J Clin Microbiol Infect Dis. 2011 May;30(5):619-27
76. Ramirez-Camacho R, Gonzalez-Tallon AI, Gomez D, et al. [Environmental scanning electron microscopy for biofilm detection in tonsils]. Acta Otorrinolaringol Esp. 2008 Jan;59(1):16-20
77. Mucke W, Huber HC, Ritter U. [The microbe colonization of the palatine tonsils of healthy school age children]. Zentralbl Hyg Umweltmed. 1994 Aug;196(1):70-4
78. Mitchelmore IJ, Reilly PG, Hay AJ, Tabaqchali S. Tonsil surface and core cultures in recurrent tonsillitis: prevalence of anaerobes and betalactamase producing organisms. Eur J Clin Microbiol Infect Dis. 1994 Jul;13(7):542-8
79. Schwaab M, Gurr A, Hansen S, et al. Human beta-Defensins in different states of diseases of the tonsilla palatina. Eur Arch Otorhinolaryngol. 2010 May;267(5):821-30
80. Brook I, Foote PA, Jr. Comparison of the microbiology of recurrent tonsillitis between children and adults. Laryngoscope. 1986 Dec;96(12):1385-8
81. Proenca-Modena JL, Pereira Valera FC, Jacob MG, et al. High rates of detection of respiratory viruses in tonsillar tissues from children with chronic adenotonsillar disease. PLoS One. 2012;7(8):e42136
82. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
83. Österreichische Gesellschaften für HalsNasen-Ohren-Heilkunde KuH, Kinderund Jugendheilkunde. Gemeinsame Empfehlung zur Entfernung der Gaumenmandeln (Tonsillektomie). Monatsschr Kinderheilkd. 2008 Mar 7;3(156):268-71
84. Kaplan EL. The group A streptococcal upper respiratory tract carrier state: an enigma. J Pediatr. 1980 Sep;97(3):337- 45
85. Kaplan EL, Top FH, Jr., Dudding BA, Wannamaker LW. Diagnosis of streptococcal pharyngitis: differentiation of active infection from the carrier state in the symptomatic child. J Infect Dis. 1971 May;123(5):490-501
86. Tanz RR, Shulman ST. Chronic pharyngeal carriage of group A streptococci. Pediatr Infect Dis J. 2007 Feb;26(2):175-6
87. Tanz RR, Shulman ST. Streptococcal pharyngitis: the carrier state, definition, and management. Pediatr Ann. 1998 May;27(5):281-5
88. Wessels MR. Clinical practice. Streptococcal pharyngitis. N Engl J Med. 2011 Feb 17;364(7):648-55
89. Roberts AL, Connolly KL, Kirse DJ, et al. Detection of group A Streptococcus in tonsils from pediatric patients reveals high rate of asymptomatic streptococcal carriage. BMC Pediatr. 2012;12:3
90. Drago L, Esposito S, De VE, et al. Detection of respiratory viruses and atypical bacteria in children's tonsils and adenoids. J Clin Microbiol. 2008 Jan;46(1):369-70
91. Piacentini GL, Peroni DG, Blasi F, et al. Atypical bacteria in adenoids and tonsils of children requiring adenotonsillectomy. Acta Otolaryngol. 2010 May;130(5):620-5
92. Chiappini E, Regoli M, Bonsignori F, et al. Analysis of different recommendations from international guidelines for the management of acute pharyngitis in adults and children. Clin Ther. 2011 Jan;33(1):48-58
93. Chiappini E, Principi N, Mansi N, et al. Management of acute pharyngitis in children: summary of the Italian National Institute of Health guidelines. Clin Ther. 2012 Jun;34(6):1442-58

94. Al-Layla A, Mahafza TM. Antibiotics do not reduce post-tonsillectomy morbidity in children. Eur Arch Otorhinolaryngol. 2013 Jan;270(1):367-70
95. Dhiwakar M, Clement WA, Supriya M, McKerrow W. Antibiotics to reduce post-tonsillectomy morbidity. Cochrane Database Syst Rev. 2012;12:CD005607
96. Hayward G, Thompson MJ, Perera R, Glasziou PP, Del Mar CB, Heneghan CJ. Corticosteroids as standalone or addon treatment for sore throat. Cochrane Database Syst Rev. 2012;10:CD008268
97. Hayward G, Thompson MJ, Perera R, Del Mar CB, Glasziou PP, Heneghan CJ. Corticosteroids for the common cold. Cochrane Database Syst Rev. 2012;8:CD008116
98. Hayward G, Thompson M, Heneghan C, Perera R, Del MC, Glasziou P. Corticosteroids for pain relief in sore throat: systematic review and metaanalysis. BMJ. 2009;339:b2976
99. Moore N. Forty years of ibuprofen use. Int J Clin Pract Suppl. 2003 Apr;(135):28-31
100. van den Anker JN. Optimizing the management of fever and pain in children. Int J Clin Pract Suppl. 2013 Jan;(178):26-32
101. Hay AD, Redmond NM, Costelloe C, et al. Paracetamol and ibuprofen for the treatment of fever in children: the PITCH randomised controlled trial. Health Technol Assess. 2009 May;13(27):iii-x,1
102. Hay AD, Costelloe C, Redmond NM, et al. Paracetamol plus ibuprofen for the treatment of fever in children (PITCH): randomised controlled trial. BMJ. 2008;337:a1302
103. Forrest JB, Heitlinger EL, Revell S. Ketorolac for postoperative pain management in children. Drug Saf. 1997 May;16(5):309-29
104. Romsing J, Ostergaard D, Drozdziewicz D, Schultz P, Ravn G. Diclofenac or acetaminophen for analgesia in paediatric tonsillectomy outpatients. Acta Anaesthesiol Scand. 2000 Mar;44(3):291-5
105. Romsing J, Ostergaard D, WaltherLarsen S, Valentin N. Analgesic efficacy and safety of preoperative versus postoperative ketorolac in pediatric tonsillectomy. Acta Anaesthesiol Scand. 1998 Aug;42(7):770-5
106. Barzaga AZ, Choonara I. Balancing the risks and benefits of the use of over-thecounter pain medications in children. Drug Saf. 2012 Dec 1;35(12):1119-25
107. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
108. Del Mar CB, Glasziou PP, Spinks AB. Antibiotics for sore throat. Cochrane Database Syst Rev. 2006;(4):CD000023
109. Lehnerdt G, Senska K, Fischer M, Jahnke K. Bilateral peritonsillar abscesses. Eur Arch Otorhinolaryngol. 2005 Jul;262(7):573-5
110. Segal N, El-Saied S, Puterman M. Peritonsillar abscess in children in the southern district of Israel. Int J Pediatr Otorhinolaryngol. 2009 Aug;73(8):1148-50
111. Powell EL, Powell J, Samuel JR, Wilson JA. A review of the pathogenesis of adult peritonsillar abscess: time for a reevaluation. J Antimicrob Chemother. 2013 Apr 23.
112. Segal N, El-Saied S, Puterman M. Peritonsillar abscess in children in the southern district of Israel. Int J Pediatr Otorhinolaryngol. 2009 Aug;73(8):1148-50
113. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
114. Herzon FS, Martin AD. Medical and surgical treatment of peritonsillar, retropharyngeal, and parapharyngeal abscesses. Curr Infect Dis Rep. 2006 May;8(3):196-202
115. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
116. Lehnerdt G, Senska K, Jahnke K, Fischer M. Post-tonsillectomy haemorrhage: a retrospective comparison of abscess- and elective tonsillectomy. Acta Otolaryngol. 2005 Dec;125(12):1312-7
117. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
118. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
119. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
120. Paradise JL, Bluestone CD, Bachman RZ, et al. History of recurrent sore throat as an indication for tonsillectomy. Predictive limitations of histories that are undocumented. N Engl J Med. 1978 Feb 23;298(8):409-13
121. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
122. Paradise JL, Bluestone CD, Colborn DK, Bernard BS, Rockette HE, KursLasky M. Tonsillectomy and adenotonsillectomy for recurrent throat infection in moderately affected children. Pediatrics. 2002 Jul;110(1 Pt 1):7-15

123. Kaygusuz I, Alpay HC, Godekmerdan A, et al. Evaluation of long-term impacts of tonsillectomy on immune functions of children: a follow-up study. Int J Pediatr Otorhinolaryngol. 2009 Mar;73(3):445-9
124. Windfuhr JP, Schloendorff G, Baburi D, Kremer B. Serious post-tonsillectomy hemorrhage with and without lethal outcome in children and adolescents. Int J Pediatr Otorhinolaryngol. 2008 Jul;72(7):1029-40
125. Stelter K, Ihrler S, Siedek V, Patscheider M, Braun T, Ledderose G. 1-year follow-up after radiofrequency tonsillotomy and laser tonsillotomy in children: a prospective, double-blind, clinical study. Eur Arch Otorhinolaryngol. 2012 Feb;269(2):679-84
126. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
127. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
128. Ericsson E, Graf J, Hultcrantz E. Pediatric tonsillotomy with radiofrequency technique: long-term follow-up. Laryngoscope. 2006 Oct;116(10):1851-7
129. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
130. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
131. Watson MG, Dawes PJ, Samuel PR, et al. A study of haemostasis following tonsillectomy comparing ligatures with diathermy. J Laryngol Otol. 1993 Aug;107(8):711-5
132. Kristensen S, Tveteras K. Posttonsillectomy haemorrhage. A retrospective study of 1150 operations. Clin Otolaryngol Allied Sci. 1984 Dec;9(6):347-50
133. Andrea M. Microsurgical bipolar cautery tonsillectomy. Laryngoscope. 1993 Oct;103(10):1177-8
134. Ewah B. An evaluation of pain, postoperative nausea and vomiting following the introduction of guidelines for tonsillectomy. Paediatr Anaesth. 2006 Oct;16(10):1100-1
135. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
136. Unkel C, Lehnerdt G, Schmitz KJ, Jahnke K. Laser-tonsillotomy for treatment of obstructive tonsillar hyperplasia in early childhood: a retrospective review. Int J Pediatr Otorhinolaryngol. 2005 Dec;69(12):1615-20
137. Davies J, Coatesworth AP. Double-blind randomized controlled study of coblation tonsillotomy versus coblation tonsillectomy on post-operative pain. Clin Otolaryngol. 2005 Dec;30(6):572-3
138. Haegner U, Handrock M, Schade H. ["Ultrasound tonsillectomy" in comparison with conventional tonsillectomy]. HNO. 2002 Sep;50(9):836-43
139. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT). Acta Otolaryngol. 2007 Apr 23;1-6
140. Isaacson G. Pediatric intracapsular tonsillectomy with bipolar electrosurgical scissors. Ear Nose Throat J. 2004 Oct;83(10):702, 704-702, 706
141. Huber K, Sadick H, Maurer JT, Hormann K, Hammerschmitt N. [Tonsillotomy with the argon-supported monopolar needle--first clinical results]. Laryngorhinootologie. 2005 Sep;84(9):671-5
142. Lister MT, Cunningham MJ, Benjamin B, et al. Microdebrider tonsillotomy vs electrosurgical tonsillectomy: a randomized, double-blind, paired control study of postoperative pain. Arch Otolaryngol Head Neck Surg. 2006 Jun;132(6):599-604
143. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
144. Scherer H. [Tonsillotomy versus tonsillectomy]. Laryngorhinootologie. 2003 Nov;82(11):754-5
145. Windfuhr JP, Werner JA. Tonsillotomy: it's time to clarify the facts. Eur Arch Otorhinolaryngol. 2013 Aug 22
146. Sobol SE, Wetmore RF, Marsh RR, Stow J, Jacobs IN. Postoperative recovery after microdebrider intracapsular or monopolar electrocautery tonsillectomy: a prospective, randomized, single-blinded study. Arch Otolaryngol Head Neck Surg. 2006 Mar;132(3):270-4
147. Cantarella G, Viglione S, Forti S, Minetti A, Pignataro L. Comparing postoperative quality of life in children after microdebrider intracapsular tonsillotomy and tonsillectomy. Auris Nasus Larynx. 2012 Aug;39(4):407-10
148. Nguyen CV, Parikh SR, Bent JP. Comparison of intraoperative bleeding between microdebrider intracapsular tonsillectomy and electrocautery tonsillectomy. Ann Otol Rhinol Laryngol. 2009 Oct;118(10):698-702
149. Reilly BK, Levin J, Sheldon S, Harsanyi K, Gerber ME. Efficacy of microdebrider intracapsular adenotonsillectomy as validated by polysomnography. Laryngoscope. 2009 Jul;119(7):1391-3

150. Vaughan AH, Derkay CS. Microdebrider intracapsular tonsillectomy. ORL J Otorhinolaryngol Relat Spec. 2007;69(6):358-63
151. Sobol SE, Wetmore RF, Marsh RR, Stow J, Jacobs IN. Postoperative recovery after microdebrider intracapsular or monopolar electrocautery tonsillectomy: a prospective, randomized, single-blinded study. Arch Otolaryngol Head Neck Surg. 2006 Mar;132(3):270-4
152. Sorin A, Bent JP, April MM, Ward RF. Complications of microdebrider-assisted powered intracapsular tonsillectomy and adenoidectomy. Laryngoscope. 2004 Feb;114(2):297-300
153. Segal N, Puterman M, Rotem E, et al. A prospective randomized double-blind trial of fibrin glue for reducing pain and bleeding after tonsillectomy. Int J Pediatr Otorhinolaryngol. 2008 Apr;72(4):469-73
154. Sampaio AL, Pinheiro TG, Furtado PL, Araujo MF, Olivieira CA. Evaluation of early postoperative morbidity in pediatric tonsillectomy with the use of sucralfate. Int J Pediatr Otorhinolaryngol. 2007 Apr;71(4):645-51
155. Cantarella G, Viglione S, Forti S, Minetti A, Pignataro L. Comparing postoperative quality of life in children after microdebrider intracapsular tonsillotomy and tonsillectomy. Auris Nasus Larynx. 2012 Aug;39(4):407-10
156. Lavy JA. Post-tonsillectomy pain: the difference between younger and older patients. Int J Pediatr Otorhinolaryngol. 1997 Oct 18;42(1):11-5
157. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
158. Stelter K, Hiller J, Hempel JM, et al. Comparison of two different local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomized, double blind, clinical trial. Eur Arch Otorhinolaryngol. 2010 Jul;267(7):1129-34
159. Sadhasivam S, Chidambaran V, Ngamprasertwong P, et al. Race and unequal burden of perioperative pain and opioid related adverse effects in children. Pediatrics. 2012 May;129(5):832-8
160. Tekelioglu UY, Apuhan T, Akkaya A, et al. Comparison of topical tramadol and ketamine in pain treatment after tonsillectomy. Paediatr Anaesth. 2013 Jun;23(6):496-501
161. Ozkiris M, Kapusuz Z, Saydam L. Comparison of ropivacaine, bupivacaine and lidocaine in the management of post-tonsillectomy pain. Int J Pediatr Otorhinolaryngol. 2012 Dec;76(12):1831-4
162. Stelter K, Hiller J, Hempel JM, et al. Comparison of two different local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double blind, clinical trial. Eur Arch Otorhinolaryngol. 2010 Jul;267(7):1129-34
163. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
164. Arikan OK, Ozcan S, Kazkayasi M, Akpinar S, Koc C. Preincisional infiltration of tonsils with ropivacaine in post-tonsillectomy pain relief: doubleblind, randomized, placebo-controlled intraindividual study. J Otolaryngol. 2006 Jun;35(3):167-72
165. Rotenberg BW, Wickens B, Parnes J. Intraoperative ice pack application for uvulopalatoplasty pain reduction: a randomized controlled trial. Laryngoscope. 2013 Feb;123(2):533-6
166. Sylvester DC, Rafferty A, Bew S, Knight LC. The use of ice-lollies for pain relief post-paediatric tonsillectomy. A single-blinded, randomised, controlled trial. Clin Otolaryngol. 2011 Dec;36(6):566-70
167. Steward DL, Grisel J, Meinzen-Derr J. Steroids for improving recovery following tonsillectomy in children. Cochrane Database Syst Rev. 2011;(8):CD003997
168. Windfuhr JP, Chen YS, Propst EJ, Guldner C. The effect of dexamethasone on post-tonsillectomy nausea, vomiting and bleeding. Braz J Otorhinolaryngol. 2011 Jun;77(3):373-9
169. Randel A. AAO-HNS Guidelines for Tonsillectomy in Children and Adolescents. Am Fam Physician. 2011 Sep 1;84(5):566-73
170. Baugh RF, Archer SM, Mitchell RB, et al. Clinical practice guideline: tonsillectomy in children. Otolaryngol Head Neck Surg. 2011 Jan;144(1 Suppl):S1- 30
171. Sutters KA, Miaskowski C, HoldridgeZeuner D, et al. A randomized clinical trial of the effectiveness of a scheduled oral analgesic dosing regimen for the management of postoperative pain in children following tonsillectomy. Pain. 2004 Jul;110(1-2):49-55
172. Lewis SR, Nicholson A, Cardwell ME, Siviter G, Smith AF. Nonsteroidal antiinflammatory drugs and perioperative bleeding in paediatric tonsillectomy. Cochrane Database Syst Rev. 2013 Jul 18;7:CD003591
173. Riggin L, Ramakrishna J, Sommer DD, Koren G. A 2013 updated systematic review & meta-analysis of 36 randomized controlled trials; no apparent effects of non steroidal antiinflammatory agents on the risk of bleeding after tonsillectomy. Clin Otolaryngol. 2013 Apr;38(2):115-29

174. Zernikow B, Smale H, Michel E, Hasan C, Jorch N, Andler W. Paediatric cancer pain management using the WHO analgesic ladder--results of a prospective analysis from 2265 treatment days during a quality improvement study. Eur J Pain. 2006 Oct;10(7):587-95
175. Hadden SM, Burke CN, Skotcher S, Voepel-Lewis T. Early postoperative outcomes in children after adenotonsillectomy. J Perianesth Nurs. 2011 Apr;26(2):89-95
176. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
177. Kamarauskas A, Dahl MR, Hlidarsdottir T, Mainz J, Ovesen T. Need for better analgesic treatment after tonsillectomy in ear, nose and throat practices. Dan Med J. 2013 May;60(5):A4639
178. Stanko D, Bergesio R, Davies K, Hegarty M, von Ungern-Sternberg BS. Postoperative pain, nausea and vomiting following adeno-tonsillectomy - a longterm follow-up. Paediatr Anaesth. 2013 May 13
179. Chan CC, Chan YY, Tanweer F. Systematic review and meta-analysis of the use of tranexamic acid in tonsillectomy. Eur Arch Otorhinolaryngol. 2013 Feb;270(2):735-48
180. Sarny S, Habermann W, Ossimitz G, Stammberger H. Significant posttonsillectomy pain is associated with increased risk of hemorrhage. Ann Otol Rhinol Laryngol. 2012 Dec;121(12):776-81
181. Windfuhr JP, Schloendorff G, Baburi D, Kremer B. Serious post-tonsillectomy hemorrhage with and without lethal outcome in children and adolescents. Int J Pediatr Otorhinolaryngol. 2008 Jul;72(7):1029-40
182. Hessen Soderman AC, Ericsson E, Hemlin C, et al. Reduced risk of primary postoperative hemorrhage after tonsil surgery in Sweden: results from the National Tonsil Surgery Register in Sweden covering more than 10 years and 54,696 operations. Laryngoscope. 2011 Nov;121(11):2322-6
183. Krespi YP, Kizhner V. Laser tonsil cryptolysis: In-office 500 cases review. Am J Otolaryngol. 2013 Apr 10
184. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT.). Acta Otolaryngol. 2007 Nov;127(11):1176-81
185. Sarny S, Ossimitz G, Habermann W, Stammberger H. Hemorrhage following tonsil surgery: a multicenter prospective study. Laryngoscope. 2011 Dec;121(12):2553-60
186. Sarny S, Ossimitz G, Habermann W, Stammberger H. [Austrian tonsil study part 3: surgical technique and postoperative haemorrhage after tonsillectomy]. Laryngorhinootologie. 2013 Feb;92(2):92-6
187. Windfuhr JP, Wienke A, Chen YS. Electrosurgery as a risk factor for secondary post-tonsillectomy hemorrhage. Eur Arch Otorhinolaryngol. 2009 Jan;266(1):111-6

Authors

PD Dr. med. Klaus Stelter
Dep. of Otorhinolaryngology, Head and Neck Surgery
RoMed Clinic Bad Aibling
Harthauser Str. 16
83043 Bad Aibling
info@alpenpraxisklinik.de

Prof. Dr. med. Götz Lehnerdt
Dep. of Otorhinolaryngology, Head and Neck Surgery
St. Anna Clinic Wuppertal
Vogelsangstr. 106
42109 Wuppertal
Hno.kh-anna@cellitinnen.de

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Daniel Schuster, James Netterville, Johan Fagan

This chapter provides an overview of management of *Zenker's divertula* (ZD), including detailed surgical technique, with an emphasis on effective therapy and management.

Zenker, a German pathologist, first reported 27 hypopharyngeal pulsion diverticula in 1878.[1] In 1907, *Killian*, described the triangular dehiscence between the cricopharyngeus and inferior constrictor muscles that is the anatomic site of formation of *Zenker's Diverticula*.[2] (*Figure 1*)

Although there is a role for open surgery, management has evolved to effective, safe endoscopic techniques with proven low morbidity.

Etiology

The etiology has been debated for more than a century. Historically, authors have theorized that trauma, congenital upper esophageal strictures, thyroid goiter, or foreign bodies may play role.[3] Gastroesophageal reflux, cricopharyngeal achalasia, persistently elevated resting tone of the cricopharyngeus, structural abnormality of the cricopharyngeus muscle, and central or peripheral neurologic disease have also been proposed as contributing or causal factors, though convincing evidence is lacking.[3]

However, it was Zenker who correctly described it as a ***pulsion diverticulum*** and put earlier theories to rest.[1] Since that time most authors agree that ***anatomic predisposition*** plays a central role in the pathogenesis, though the exact aetiology is still a subject of debate.

It is now widely accepted that ***dysfunction of the cricopharyngeus muscle*** plays a central aetiological role. High intraluminal pressures at the level of Killian's triangle result in herniation of esophageal mucosa and submucosa through this area of inherent muscular weakness. Some advocate that high intraluminal pressures produced by incoordination of the inferior constricttor muscle against a closed cricopharyngeus is responsible, while others state that high pressures are a result of the anatomic relationship between the relatively wide hypopharynx and a narrower esophageal inlet through which food boluses pass.[5] Killian's triangle itself is of variable size, and patients with larger areas of inherent muscular weakness are likely more predisposed to a ZD.

Pathophysiology

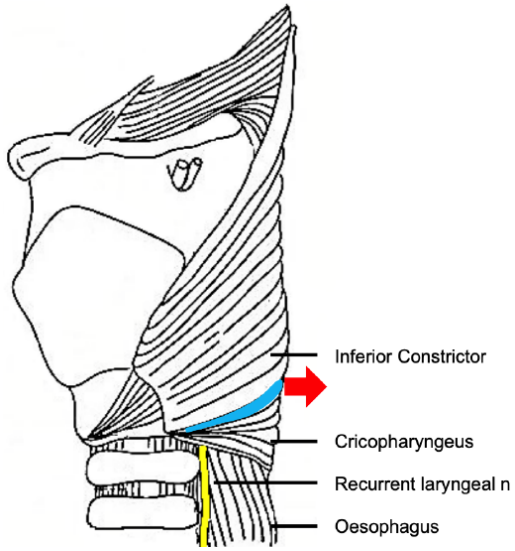


Figure 1: Red arrow shows where ZD extrudes through Killian's dehiscence (blue) between the inferior constrictor and the cricopharyngeus muscles

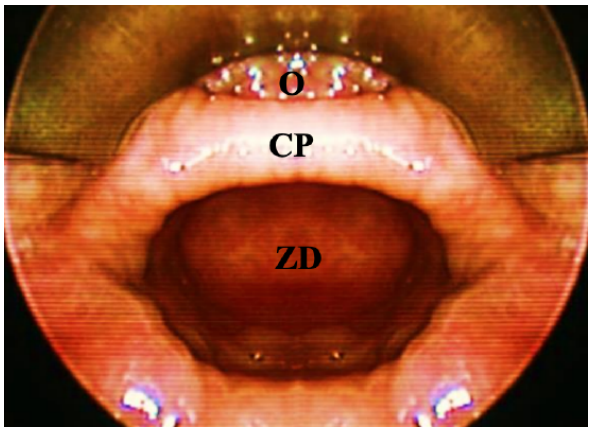
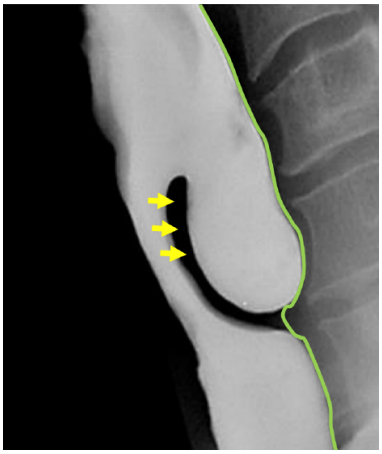


Figure 2: Cricopharyngeal bar (CP) containing the cricopharyngeus muscle, which separates esophagus (O) from ZD


Figure 3: Barium swallow of ZD. Note location of cricopharyngeus muscle (arrows) in upper part of party wall between esophagus and ZD; and how buccopharyngeal fascia contains the diverticulum (green line)

ZD is a pulsion diverticulum or herniation of esophageal mucosa and submucosa through Killian's triangle, which is immediately proximal to the cricopharyngeus muscle (*Figures 1*, *2*, *3*).

Of surgical importance is that the entire diverticulum is contained within the buccopharyngeal fascia, which itself is not involved in the formation of the diverticulum (*Figure 3*). The buccopharyngeal fascia is in effect displaced posteriorly by the posterior wall of the diverticulum, creating a safer plane to divide the "party wall" (that contains the cricopharyngeus) without penetrating the fascia and entering the prevertebral space (*Figure 3*). This anatomic relationship between the ZD and the surrounding buccopharyngeal fascial layer is the key to understanding how the upper digestive tract remains separated from the retropharyngeal space when incising the anterior wall of the diverticulum, or in the case of an isolated endoscopic cricopharyngeal myotomy. Disrupting this fascial layer could theoretically increase the likelihood of developing mediastinitus.

However, when endoscopically dividing a hypertrophic cricopharyngeus muscle in the absence of a ZD, the buccopharyngeal fascia is situated immediately behind the cricopharyngeus muscle, and great care has to be taken to preserve this fascial layer when completely dividing the cricopharyngeus muscle. Despite initial fears that this fascia could not be preserved during endoscopic cricopharyngeal myotomy, Chang et al demonstrated in a cadaveric study that the buccopharyngeal fascial layer remained histologically intact with carbon dioxide (CO_2) laser cricopharyngeal myotomy.[4]

Clinical Presentation

ZD occurs predominantly in the elderly; it is rarely seen in patients <40 years of age. A thorough history may raise suspicion of a ZD. Hallmark symptoms are progressive dysphagia coupled with postprandial regurgitation of undigested food. When associated with halitosis, weight loss, noisy deglutition, coughing, globus sensation, and recurrent unprovoked aspiration, the history alone is pathognomonic.[5] Symptoms may exist for weeks to years, and the severity of the symptoms generally correlates with the size of the ZD. Physical examination is often normal, although occasionally pooling of saliva in the hypopharynx may be noted on laryngoscopy that may or may not clear with swallowing. A neck mass is rarely palpable. Rarely, Boyce's sign, or a swelling in the neck that gurgles with palpation, is present.[6]

Clinicians must mindful that, although rare (incidence <0.5%), carcinoma can occur in a ZD[7]. Blood-tinged regurgitated food should raise suspicion for this, and is an indication that observation is not a reasonable option. Barium swallow frequently shows filling defects within the sac which usually represent undigested food. However, a constant filling defect on serial studies should raise concern of a tumor.[5]

Special Investigations

Diagnosis is confirmed with a contrast swallow and videofluoroscopy (*Figure 3*). Laryngoscopy is done to rule out other causes of dysphagia, as well as to document vocal cord dysfunction. Preoperative evaluation must include assessment of the function of the lower esophageal sphincter, as cricopharyngeal myotomy in patients with an incompetent lower esophageal sphincter places them at risk of developing severe gastroesophageal and laryngopharyngeal reflux.

Surgical Anatomy

A ZD is a thin-walled sac lined by stratified squamous epithelium with a thin layer of fibrous submucosa. ***The muscular layer of the hypopharynx is absent from its wall.*** The posterior mucosal herniation passes through Killian's dehiscence/ triangle and is located between the inferior fibers of the inferior pharyngeal constrictor and the superior edge of cricopharyngeus muscle (*Figures 1, 3*). The common (party) wall contains the cricopharyngeus at its upper edge and separates the esophagus from diverticulum (*Figures 2, 3*).

It is important to understand that after the ZD herniates through Killian's dehiscence, it expands posterior to the cricopharyngeus and the superior esophageal muscles layers but is still contained within the perioesophageal fascia. This protective layer of investing facia surrounding both the esophagus and ZD is the key to endoscopic division of the cricopharyngeus muscle and the entire party wall between the ZD and the esophagus. Without this fascial layer, saliva would be likely to track into the mediastinum causing mediastinitis.

Treatment

Observation with dietary manipulation is a reasonable option for a relatively small ZD, or in patients with minimal symptoms, or who pose a significant anesthetic risk.

Surgical approaches include the following:

- ***Endoscopic***
  - Cricopharyngeal myotomy
  - Diverticulotomy
    - Stapling
    - Laser
    - Electrocoagulation
- ***External transcervical***
  - Cricopharyngeal myotomy
  - Inversion
  - Diverticulopexy (suspension)
  - Diverticulectomy
    - Suturing
    - Stapling

Most authors currently advocate endoscopic surgery as the preferred treatment, and many studies have reported endoscopic techniques to be both safe and effective.[8-12] Advantages compared to external procedures are brief anesthetic time, early oral intake, short hospitalization, minimal pain and that revision surgery, either endoscopic or external, is not compromised by scarring.

As with any surgery, the risks and benefits of surgery must be carefully weighed, particularly because ZD patients are generally elderly and often infirm.

Endoscopic procedures

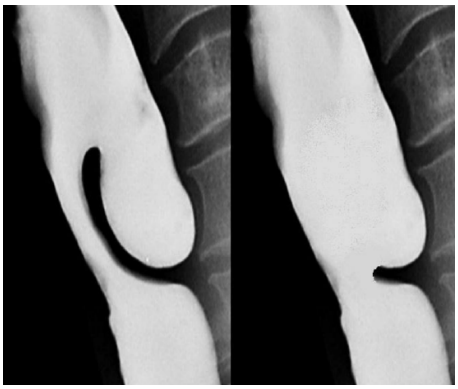


Figure 4: Before and after endoscopic diverticolotomy with a stapler: Cricopharyngeus and the party wall between the ZD and the esophagus have been divided, incorporating the pouch in the esophagus. Note how the stapler is unable to divide the distal party wall resulting in a residual bar

Endoscopic surgery completely divides the common wall between the esophagus and the diverticulum (diverticulotomy), thereby incorporating the diverticulum into the esophageal lumen; and in the process also performs a cricopharyngeal myotomy (*Figure 4*).

Much debate exists regarding the most effective technique. The authors are in agreement with a study that found ***endoscopic CO_2 laser*** to be more effective and to result in significantly less recurrence than ***endoscopic stapling***.[10] This may be because the endoscopic stapler does not divide the most distal part of the common wall between the esophagus and the diverticulum (*Figure 4*). In parts of the world where neither a stapler nor CO_2 laser is available, a ***long suction cautery*** will work in the place of the laser.

Consideration must be given to ***flexibility and disease of the cervical spine***. ***Communication with the anesthesia care team*** should include a discussion regarding the need for ***paralysis*** as a component of the general anesthetic, as muscular tone may limit visualization and complicate placement of the scope.

The ***choice of operating diverticuloscope*** depends on the procedure to be performed.



Figure 5a: Benjamin diverticuloscope

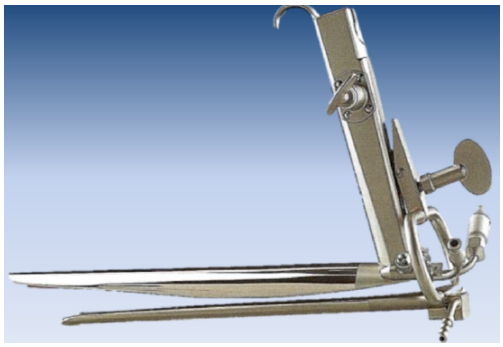


Figure 5b: Weerda bivalve diverticuloscope

Benjamin diverticuloscope: (*Figure 5a*) For CO_2 laser diverticulotomy, the authors have found the Benjamin diverticuloscope (Storz) to provide the optimum combination of visualisation and ease of placement. Because it has straightened tips, rather than outward-curved tips of the Dohlman scope that was first used for endoscopic surgery, it is often able to be placed in patients in whom placement of the original Dohlman scope would have been difficult.

Weerda diverticuloscope: The long bivalved Weerda diverticuloscope (Storz) provides additional anterior-to-posterior volume by opening the blades of the scope; this is essential for using the ***stapler technique***. However, the width of the proximal end of the scope makes it more difficult to insert in patients with narrow interdental width.



Figure 6: Perforated pouch

Passing a diverticuloscope can be difficult or impossible in some patients. It is therefore important to caution patients that an endoscopic approach may have to be abandoned due to poor access. In less experienced hands the scope is a particularly dangerous instrument as it may be difficult to insert and may penetrate the posterior pharyngeal wall or the pouch causing cervical sepsis and mediastinitis (*Figure 6*). ***It is therefore crucial that the surgeon exercises sound judgement and abandons the procedure before causing an iatrogenic perforation***.

Surgical steps for endoscopic diverticulotomy

- Administer broad spectrum antibiotics perioperatively
- General anesthesia is done with orotracheal intubation (nasotracheal intobation hampers access)
- Protect the upper teeth with a gum guard
- Study the barium swallow to determine the dimensions of the ZD and the locations of the neck of the ZD and of the esophageal inlet
- Commence endoscopy with an anterior commissure or Dedo laryngoscope
- Pass via the right pyriform sinus into the postcricoid region
- Examine the diverticulum
- Identify the esophageal lumen
- Suction retained food and secretions from the ZD
- Use 0-degree Hopkins rod to closely examine the area (including the hypopharynx) – note any abnormalities that could contribute to dysphagia

- Pass a blunt probe into the esophageal lumen and press it downwards to stretch the cricopharyngeus muscle; relaxation of the cricopharyngeus muscle permits easier passage of the anterior lip of the Benjamim or Weerda scopes into the esophagus
- If the lumen of the esophagus is difficult to cannulate with the laryngoscope
  - Insert a rubber catheter, a suction catheter, or a long 4 mm round anesthesia lumen finder into the lumen of the esophagus
  - Then pass the diverticuloscope over the catheter or lumen finder which will pull down on the esophageal lumen and direct the anterior lip of the scope into the esophagus
- Inspect the ZD for malignancy
- Carefully remove the laryngoscope
- Perform rigid esophagoscopy
  - Inspect the esophagus
  - Dilating the esophageal opening with the scope facilitates passage of diverticuloscope
- ***Use of Benjamin diverticuloscope*** to engage the ZD (*Figure 5a*)
  - It is not always possible to insert the scope due to anatomical limitations
  - Lubricate the scope with surgical jelly
  - Extend the neck posteriorly as far as the cervical spine allows
  - Pass the scope into the right pyriform sinus gently lifting the tip of the scope as it is directed medially under the postcricoid region
  - Advance the scope with the anterior limb passing into the esophageal lumen
  - The scope is often stable with no need for suspension
- ***Use of Weerda diverticuloscope*** to engage the ZD (*Figure 5b*)
  - Pass the closed end of the scope into the pouch taking care not to perforate the thin wall of the pouch
  - Open the blades, and retract the scope until the esophageal opening appears anteriorly
  - Pass the anterior blade of the scope into the esophagus and keep the posterior blade in the pouch
  - Distract the blades further to bring the party wall into view (*Figure 1*)
  - Suspend the scope with a scope holder
- Clear the pouch of food debris
- Proceed to cricopharyngeal myotomy +/- diverticulotomy

Endoscopic CO_2 laser cricopharyngeal myotomy +/- diverticulotomy

CO_2 laser has the advantage of dividing the party wall up to the inferior aspect of the pouch. When a stapler is used there is always a residual inferior lip of the pouch that cannot be divided by the device due to its design; the laser is often used to divide this residual bar. In the era of critical cost containment, the laser therefore has the advantage of being able to complete the entire task, whereas the stapler may need assistance of further division of the inferior party wall. Asymptomatic postsurgical subcutaneous emphysema occurs slightly more frequently following CO_2 laser than with the endoscopic stapler.

- Set the CO_2 laser at 5-10 W, CW mode and with a slightly defocused spot size to improve hemostasis
- Visualize the common party wall using an operating microscope with an integrated CO_2 laser microsled
- Diverticulotomy
  - Use the laser to transect the mucosa and cricopharyngeus muscle in the in the midline of the common wall



Figure 7: Party wall has been divided. Careful inspection demonstrates that all layers of the cricopharyngeous muscle and mucosa have been divided to inferior aspect of sac

- Continue to transect the party wall in the midline with the laser down to its most inferior edge (*Figure 7*)

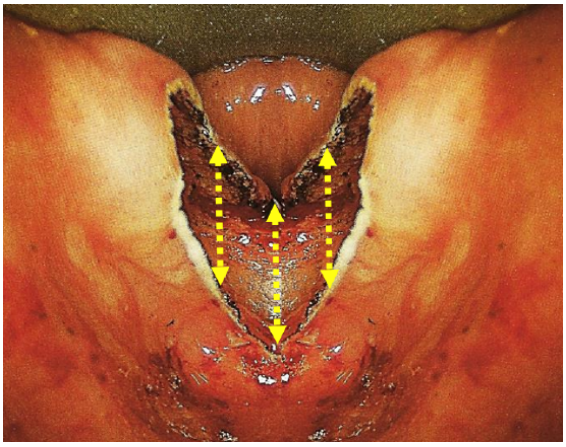


Figure 8: Position of 3 mucosal sutures

- Though not required (because of the intact perioesophageal fascia as previously discussed (*Figure 3*), we place three sutures to close the mucosal defect (*Figure 8*)
- The first suture closes the superior esophageal mucosal margin to the inferior edge of the posterior wall of the diverticulum in the midline
- Then two additional sutures are placed one on each side of the midline to approximate the mucosal edges
- The added length of the 4-0 RB1 taper needle, 27-inch Vicryl suture facilitates endoscopic tying technique needed to tie the sutures down through the scope
- Inspect the area for hemostasis
- Remove the diverticuloscope



Figure 9: ZD on right side would be very difficult to treat with the Stapler and is best done with CO_2 laser, as it is too shallow for the stapling technique

CO_2 laser is particularly useful for pouches of <4 cm because the stapler does not divide the distal 1-2 cm of the party wall (*Figure 9*).

Cricopharyngeal myotomy

Cricopharyngeal myotomy forms part of the diverticulotomy procedure as described above, but may also be done in isolation for very small ZDs or for cricopharyngeal spasm

- Insert a diverticuloscope with its two tips anterior and posterior to the cricopharyngeus muscle
- Identify the prominence of the cricopharyngeus muscle

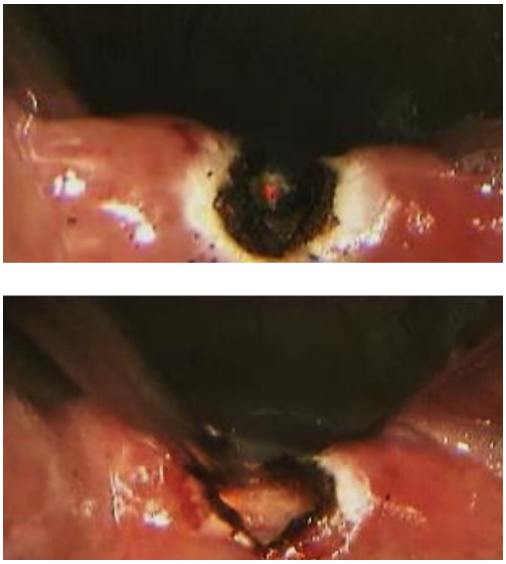


Figure 10: Transmucosal laser cricopharyngeal myotomy: incising muscle (top); and completed myotomy (below)

- Use the laser to transect the mucosa overlying the muscle in the midline (*Figure 10*)
- Proceed to meticulously completely transect the cricopharyngeus muscle without disrupting the posterior layer of perioesophageal fascia (*Figure 10*)

Staple-assisted endoscopic diverticulotomy

Endoscopic stapling, though not our preferred method, is a valuable method to use if CO_2 laser is not available.

Compared to laser or diathermy, it is quicker (few minutes), has a lesser risk of perforation and mediastinitis, provides good hemostasis, and avoids thermal injury to the recurrent laryngeal nerve. The principal disadvantage is that it does not divide the distal 1-2 cm of the wall of the diverticulum and is therefore not suited to small pouches (*Figure 9*).

The first few procedural steps are identical to the CO_2 laser approach described above. The procedures only differ following inspection and stretching of the cricopharyngeus muscle.

- Insert a bivalve (Storz) diverticuloscope; this scope is required to provide a wide enough exposure to introduce a stapler



Figure 11: Example of disposable linear stapler/cutter with ends open and closed

- Introduce the endoscopic stapler (*Figure 11*)
- A long 0-degree Hopkins rod can be used to assist visualization
- Place the two ends of the stapler astride the party wall in the midline, with one end in the esophagus, and the other in the pouch
- The 3rd author places the anvil (not the cartridge) of the stapler into the pouch, because it allows one to divide a greater length of the party wall; others prefer to place the anvil in the esophagus due to its smaller diameter[9]
- Advance the stapler to the fundus of the diverticulum or as far as it will go
- Fire the stapler
  - Firmly squeeze the handle that approximates the anvil and cartridge
  - Activate the cutting blade with the handle or slide
  - Release the stapler and remove the instrument

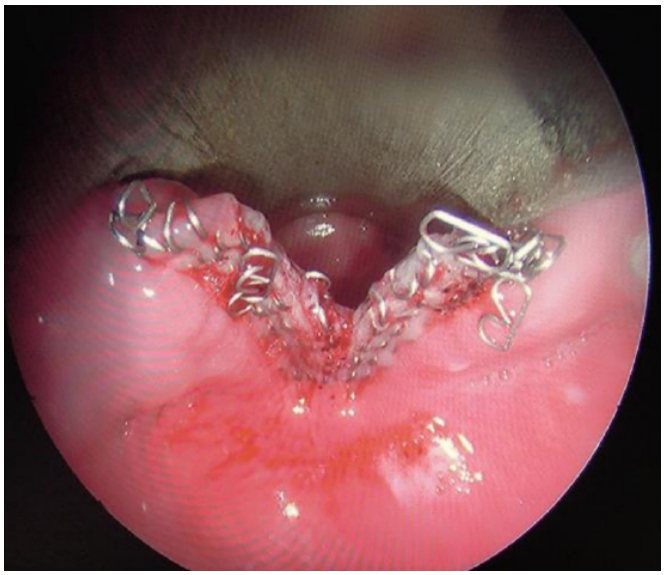


Figure 12: Diverticulotomy with stapler

- Examine the field using the Hopkins rod to determine whether an additional cartridge should be used to divide any remaining party wall (*Figure 12*)
- Inspect the diverticulum to ensure it has not been perforated
- Remove the instrumentation



Figure 13: Note distance between tip of cartridge, and staples and cutting groove

It is important to note that the tip of the stapler cartridge extends beyond the end of the staples, and that the staples extend beyond the razor incision (*Figure 13*). The result is that this method will always leave some residual sac, which we believe contributes to its higher recurrence rate.

One option to minimize this problem is to place traction sutures on either side of the planned myotomy prior to firing the stapler. Pulling on these sutures during stapler activation maximizes the length of the razor cut. Some evidence exists that this may increase the long-term success of this technique.[13]

Endoscopic diverticulotomy with electrocautery

In resource-limited settings, access to endoscopic staplers and CO_2 laser may not be possible due to the significant associated costs. Consequently, we believe that another option for endoscopic treatment of ZD without the expense of this equipment is to use electrocautery to perform diverticulotomy, as was originally described by Dohlman.[14] With this technique one exposes the common wall using a diverticuloscope in the same way as with the previous two procedures. A pair of insulated surgical forceps is then used to grasp the common party wall in the midline, and monopolar electrocautery is applied to the forceps. This is repeated as many times as is necessary to carry the myotomy down to the most inferior aspect of the common wall. Again, sutures may be placed on either side of the myotomy to help close the mucosa, though this is not necessary because the buccopharyngeal fascia, the key layer to maintaining separation between the digestive tract and the mediastinum, remains intact.

Postoperative care following endoscopic diverticulotomy

- Observe patients overnight (regardless of surgical technique)
- Monitor for signs and symptoms that signal mediastinitis, as early intervenetion to treat this rare but potentially fatal complication is mandatory; radiating back or chest pain, fever, and tachycardia despite adequate pain control should raise suspicion of mediastinitis
- Following CO_2 laser or cautery diverticulotomy a small number of patients develop some subcutaneous emphysema; in our experience this almost never results in mediastinitis
- Start a clear liquid diet the morning following surgery
- Discharge the patient if he/she tolerates a clear liquid diet without concerning signs or symptoms
- The patient should remain on liquids and soft foods for several weeks to prevent esophageal rupture being caused by large solid food boluses
- Progress to a regular diet over a few weeks

Open Transcervical Diverticulectomy

The primary indication to treat ZD in an open fashion is inability to gain adequate exposure using transoral endoscopic techniques, or with an extensive, large ZD. Although rare, the anatomy of some patients will prevent adequate endoscopic exposure. As a result, all surgeons who treat ZD endoscopically should be familiar with open transcervical techniques and should be prepared to perform it if needed. Historically, different open procedures were performed including diverticulopexy and inversion if the pouch. In our experience, success rates are significantly higher with open diverticulectomy.

Surgical steps of Open Diverticulectomy

- Review the position of the diverticulum on the preoperative barium swallow
- Perform direct laryngoscopy with an anterior commissure laryngoscope
- Suction all food debris from the diverticulum
- Pack the diverticulum with vaseline gauze to assist with its identification

- Transorally insert a Maloney dilator into the esophagus; this helps identify relevant structures in the neck during the open dissection
- Make a 5-8 cm transverse cervical skin incision to the left of the midline at the level of the cricoid (Although rarely a large diverticulum will extend to the right of midline, it can still be delivered to the left side with the larynx rotated)
- Incise the platysma muscle
- Elevate subplatysmal flaps
- Dissect between the strap muscles, trachea, and thyroid gland medially, and the sternocleidomastoid, and the carotid/internal jugular vein vascular bundle laterally
- The superior laryngeal nerve defines the superior boundary of the dissection
- Palpate and identify the fullness of the cricothyroid joint
- It is now safe to place a double pronged skin hook under the posterior edge of the thyroid cartilage superior to this joint to rotate the entire laryngo-tracheal complex to present the ZD into the operative field
- Replace the skin hook with a Weitlaner self-retaining retractor to hold the operative field open
- With this laryngotracheal rotation the RLN is safe as long as one dissects in the posterior midline of the cricopharyngeus muscle
- At this point the ZD is not well defined, but rather a fullness that can be palpated deep to the peripharyngeal fascia
- Below this identify the firm dilator within the esophagus
- Dissect through the perioesophageal fascia until the ZD is isolated
- Bluntly dissect and elevate the ZD off the cricopharyngeus muscle
- The cricopharyngeus muscle can easily be palpated and visualized, stretched over the esophageal dilator
- Dissect with a blunt right angle dissector between the cricopharyngeus muscle and the underlying esophageal mucosa
- Divide the muscle layer from below the cricopharyngeus muscle up to the inferior border of the neck of the ZD
- One can also (with loupe magnification) use a 15 knife blade to divide the muscle layer down to the esophageal mucosa
- Use a suture to loosely tack the cricopharyngeus muscle end up to the region of the posterior border of the thyroid cartilage
- (One can at this point use a stapler to seal and divide the neck of the diverticulum; however, this adds significant expense to the procedure)

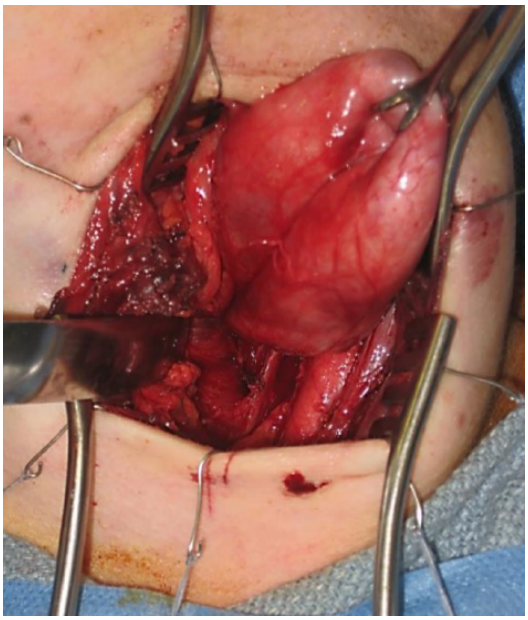


Figure 14: Left neck: The diverticular sac has been exposed and the overlying fascia is dissected off; note carotid artery lateral to the sac

- Open the diverticulum and inspect the mucosal surfaces (*Figure 14*)

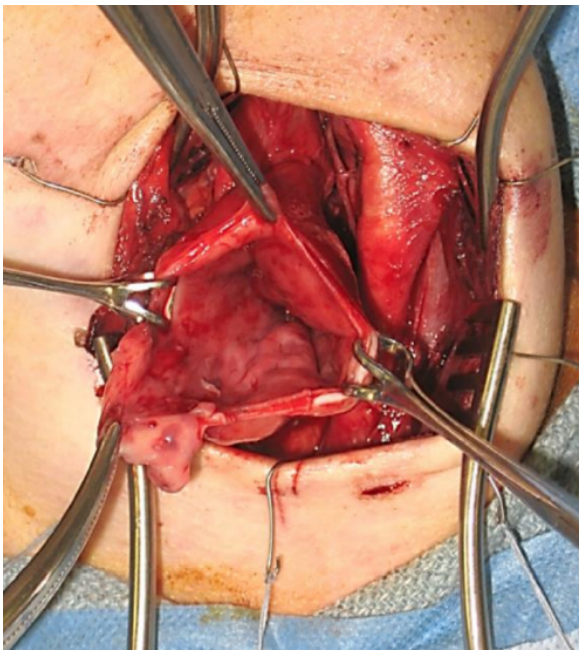


Figure 15: Left neck: The diverticular sac has been opened. Inspect the mucosal surfaces prior to doing a conservative resection

- Perform a conservative resection of the diverticulum, leaving about 1-2 cm of mucosa (*Figure 15*)
- Close the diverticulectomy defect using absorbable inverting mattress sutures transversely from superior-to-inferior (Do not close the defect vertically from side-to-side as this effectively narrows the esophageal lumen and predisposes to stricture formation)
- Irrigate the neck copiously
- Ensure hemostasis
- Insert a drain
- Close the neck in a layered fashion
- Insert a nasogastric feeding tube
- Continue with antibiotics for 24 hours
- Continue nasogastric tube feeding for about a week
- Introduce oral feeding if the patient is swallowing their saliva well with no symptoms at the end of the week
- If the patient's neck is sore or they are having a hard time to swallow, confirm there is no leak on barium swallow before commencing oral feeding

Complications of surgery

Like all surgical procedures, operations performed for ZD are not without complications. When performing endoscopic procedures, care should be taken to avoid causing ***damage to the lips, teeth, tongue, and gums*** especially in cases of difficult exposure. ***Bleeding*** is a potentially dangerous complication, as a ***hematoma*** in the neck can result in airway compression. As a result, particular attention should be paid to achieving hemostasis during open procedures.

Perhaps the most feared complication of ZD surgery, which can occur in both endoscopic and open procedures, is ***esophageal perforation*** and a subsequent leak. Because the fascial planes in the neck are continuous with the mediastinum, leakage of esophageal contents into the neck can cause ***mediastinitis***, which can be lethal if not quickly recognized and managed appropriately. In endoscopic procedures, perforation can occur in two main ways. The pouch itself can be perforated by advancing equipment too aggressively. This can also be caused by a stapling device, or an aggressively inserted suction or blunt probe. Alternatively, division of the common wall between the diverticulum and the esophagus can result in perforation if the dissection is carried too deeply behind the divided muscle layer. For a leak to occur, the perioesophageal fascia must be violated. Perforation and mediastinitis should be diagnosed promptly. Early signs include tachycardia, fever, and chest and neck pain. Crepitus may also occur. Any concern about this complication should prompt an immediate workup and empiric therapy. The patient should take nothing by mouth, and broad-spectrum antibiotics should be started empirically. Serial chest X-rays may demonstrate expanding subcutaneous air. A contrast swallow should be performed to establish if a clinical fluid leak is present through the perioesophageal

fascia. If diagnosed early, this can usually be managed conservatively. A nasogastric tube for feeding may be necessary until the perforation heals.

Open procedures can result in additional complications. ***Injury to critical structures*** in the neck are the primary concern. The ***recurrent laryngeal nerve*** is of particular interest and can be identified if needed if the neck of the diverticulum is more inferior than is usual. If the dissection and ligation of the ZD is performed in the midline posteriorly the nerve is naturally avoided during this dissection.

Postoperative ***wound infection*** can occur as well, particularly if diverticular contents are spilled into the neck. This underscores the need to suction the sac endoscopically prior to opening the neck.

Excising too much of the sac wall with an open diverticulectomy procedure may cause a ***stricture***.

Recurrence

Regardless of the technique used to treat ZD, perhaps the most common problem is recurrence. In our experience, this is more likely to occur after endoscopic stapling; we feel this is due to the inability to extend the diverticulotomy to the most inferior edge of the sac. In some cases, symptommatic recurrence can progress to the point that a revision procedure is indicated. When recurrence does occur, the diverticulum is often wider. In order to successfully address recurrence, the surgeon must extend the diverticulotomy all the way to the bottom of the sac and eliminate the shelf.

References

1. Zenker, FA, von Ziemssen H. Dilatations of the esophagus. Cyclopedia Pract Med 1878; 3:46-8
2. Killian G. La boudre de l'oesophage. Ann Mal Orelle Larynx 1907; 34:1
3. Scher RL. Zenker's Diverticulum. Cummings Otolaryngology-Head & Neck Surgery, 5th ed. 2010;74:986-97
4. Chang CWD, Liou SS, Netterville JL. Anatomic Study of Laser-Assisted Endoscopic Cricopharyngeus Myotomy. Ann Otol Rhinol Laryngol 2005;114(12):897- 901
5. van Overbeek JJM. Pathogenesis and methods of treatment of Zenker's Diverticulum. Ann Otol Rhinol Laryngol 2003;112(7):583-93
6. Siddiq M, Sood S, Strachan DR. Pharyngeal Pouch (Zenker's diverticulum) Postgrad Med J 2001; 77:506-11
7. Payne WS. The treatment of pharyngoesophageal diverticulum: the simple and complex. Hepatogastroenterology 1992; 39:109-14
8. Smith SR, Genden EM, and Urken ML. Endoscopic stapling technique for the treatment of Zenker diverticulum vs standard open-neck technique: A direct comparison and charge analysis. Arch Otolaryngol Head Neck Surg 2002;128: 141-4
9. Richtsmeier WJ. Endoscopic management of Zenker diverticulum: the staple-assisted approach. Am J Med 2003; 115(3A):175S178S
10. Adam SI, Paskhover B, Sasaki CT. Laser versus stapler: outcomes in endoscopic repair of Zenker diverticulum. Laryngoscope 2012; 122:1961-6
11. Maune S. Carbon dioxide laser diverticulostomy: a new treatment for Zenker diverticulum. Am J Med 2003;115-(3A): 172S174S
12. Miller FR, Bartley J, Otto RA. The endoscopic management of Zenker diverticulum: CO_2 laser versus endoscopic stapling. Laryngoscope 2006; 116:1608-11
13. Bonavina L, Rottoli M, Bona D, Siboni S, Russo IS, Bernardi D. Transoral stapling for Zenker diverticulum: effect of the traction suture-assisted technique on long term outcomes. Surg Endosc; published online 27 April 2012
14. Dohlman G. Endoscopic operations for hypopharyngeal diverticula. Proceedings of the Fourth International Congress of Otolaryngology, London, 1949:715-7

Suggested reading in Open Access Atlas

Cricopharyngeal myotomy: surgical technique

Authors

Daniel Schuster, M.D.
Dept. of Otolaryngology - Head and Neck Surgery
Vanderbilt University Medical Center
Nashville, TN, USA
daniel.schuster@vanderbilt.edu

James L. Netterville, MD
Mark C. Smith Professor and Director of Head and Neck Oncologic Surgery
Dept. of Otolaryngology – Head and Neck Surgery
Vanderbilt Bill Wilkerson Center
Nashville, TN, USA
james.netterville@vanderbilt.edu

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.45: Cricopharyngeal Myotomy Surgical Technique

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

John Fagan

Cricopharyngeal myotomy may be indicated for cricopharyngeal spasm causing dysphagia or aspiration and is done in patients undergoing external resection of a pharyngeal pouch / Zenker's diverticulum (ZD).

Cricopharyngeal dysfunction / achalasia may be ***primary or secondary***. ***Primary achalasia*** refers to persistent spasm or failure of the cricopharyngeus to relax, where the pathology is confined to the muscle and there is no underlying neurologic or systemic cause. It may be idiopathic or be associated with intrinsic disorders of the muscle e.g. polymyositis, muscular dystrophy, and hypothyroidism. Cricopharyngeal spasm may be ***secondary*** to neurologic disorders e.g. poliomyelitis, oculopharyngeal dysphagia, stroke, and amyotrophic lateral sclerosis (ALS), or diabetic neuropathy, myasthenia gravis, and peripheral neuropathies.

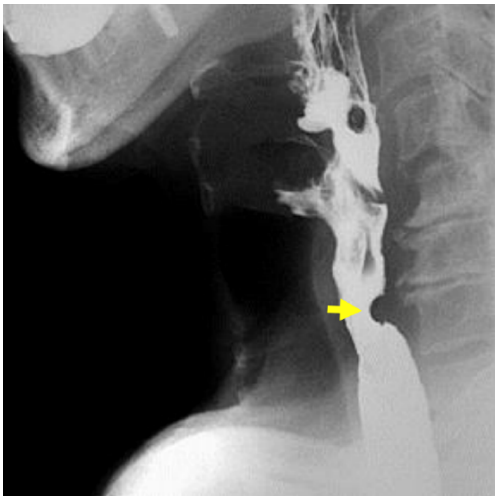


Figure 1: Note cricopharyngeal bar

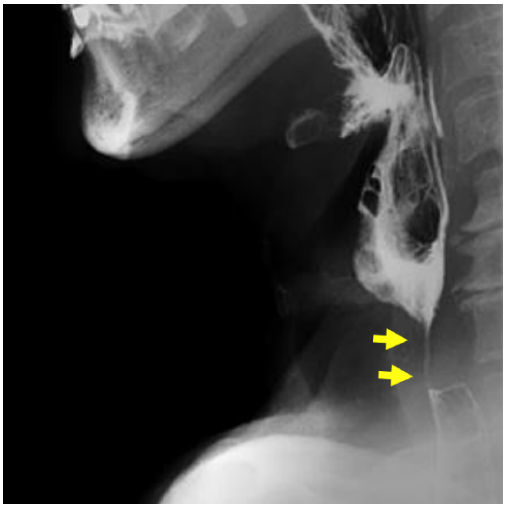


Figure 2: Spasm of cricopharyngeus muscle causing dysphagia

The diagnosis is made on history and contrast swallow (videofluoroscopy). The contrast swallow typically shows a prominent bulge in the posterior wall of the proximal esophagus due to contraction of the cricopharyngeus muscle (*Figure 1*). *Figure 2* shows spasm of the cricopharyngeus muscle causing dysphagia and regurgitation.

The myotomy is commonly done via an external approach, although an endoscopic approach using CO_2 laser can also be employed. Alternative treatments include dilatations and Botulinum toxin injections.

Cricopharyngeal myotomy is also done in patients undergoing external resection of a ***pharyngeal pouch***, as elevated cricopharyngeus muscle tone is considered a cause of a ZD.

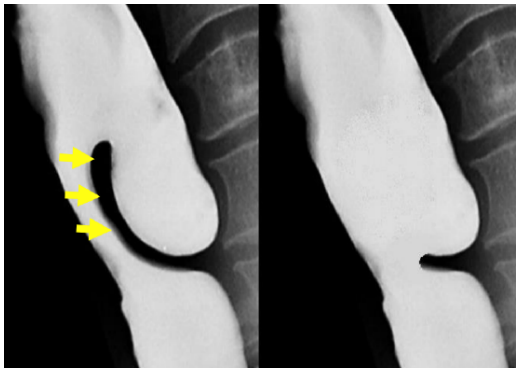


Figure 3: Contrast swallow before and after endoscopic diverticolotomy: Cricopharyngeus (yellow arrows) and the party wall between the ZD and the esophagus are divided

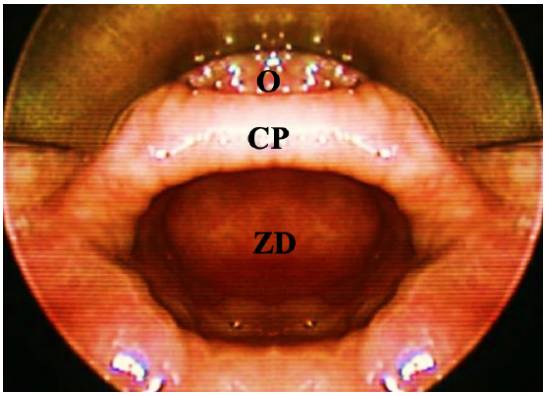


Figure 4: Cricopharyngeal bar (CP) containing the cricopharyngeus muscle, which separates esophagus (O) from ZD

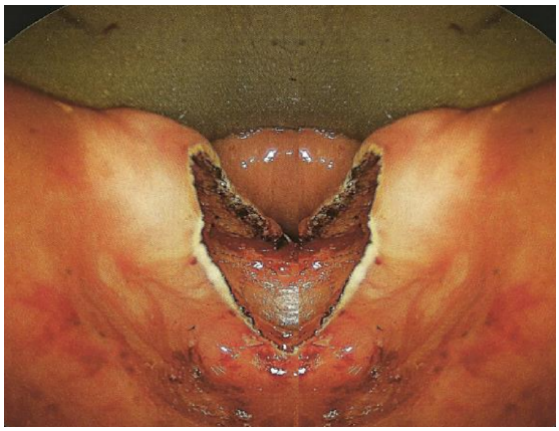


Figure 5: Party wall has been divided. Note that both the cricopharyngeus muscle and mucosa have been divided to the inferior aspect of the sac



Figure 6: ZD would be very difficult to treat with a stapler and is best done with CO2 laser cricopharyngeal myotomy, as it is too shallow for the stapling technique

With endoscopic diverticulotomy, the cricopharyngeus muscle is divided when cutting through the wall between the ZD and the esophagus (*Figure 3-5*). See chapter on Zenker's Diverticulum. Cricopharyngeal myotomy may also be done in isolation for very small ZDs (*Figure 6*).

Surgical anatomy

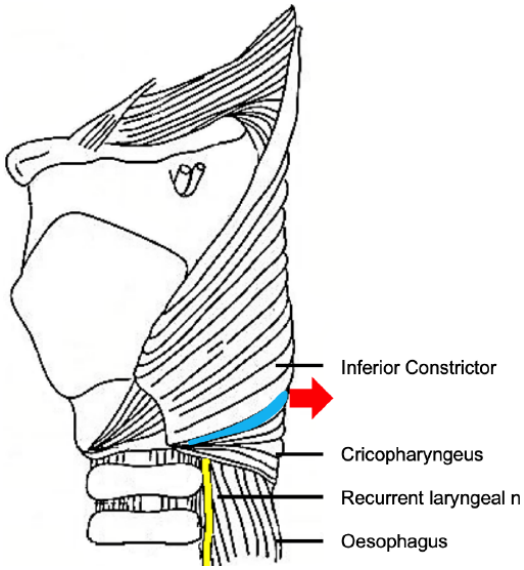


Figure 7: Red arrow shows where ZD extrudes through Killian's dehiscence (blue) between the inferior constrictor and the cricopharyngeus muscles

Figure 7 illustrates how the cricopharyngeus muscle fans out from its origin from the cricoid cartilage to surround the proximal end of the esophagus. Note Killian's dehiscence through which a ZD typically herniates between the cricopharyngeus and inferior constrictor muscles. Note also the proximity of the recurrent laryngeal nerve, which should be protected from injury with external surgical approaches.

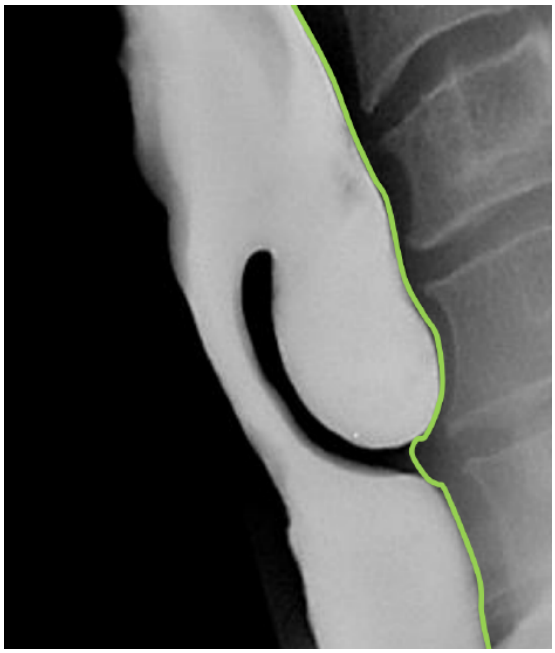


Figure 8: Barium swallow of ZD. Note how the buccopharyngeal fascia contains the pharynx, esophagus and diverticulum (green line)

Figure 8 illustrates the ***buccopharyngeal fascial layer*** that contains the pharynx and esophagus, and a ZD.

The anatomic relationship between the ZD and the surrounding buccopharyngeal fascial layer is key to understanding how the upper digestive tract remains separated from the retropharyngeal space when incising the anterior wall of the diverticulum, or with isolated endoscopic cricopharyngeal myotomy. Disrupting this fascial layer can theoretically increase the likelihood of developing mediastinitis. When endoscopically dividing a hypertrophic cricopharyngeus muscle in the absence of a ZD, the buccopharyngeal fascia is situated immediately behind the cricopharyngeus muscle; hence ***great care must be taken to preserve this fascial layer when endoscopically dividing the cricopharyngeus muscle***. Despite initial fears that this fascia could not be preserved during endoscopic cricopharyngeal myotomy, Chang et al demonstrated in a cadaveric study that the buccopharyngeal fascial layer remained histologically intact with CO_2 laser cricopharyngeal myotomy. [1]

Special investigations

Diagnosis of cricopharyngeal spasm and a ZD is confirmed with a contrast swallow or videofluoroscopy (*Figures 1-2*). Laryngoscopy is done to rule out other causes of dysphagia. Preoperative evaluation must include assessment of the function of the lower esophageal sphincter, as cricopharyngeal myotomy in patients with an incompetent lower sphincter places them at risk of developing severe gastroesophageal and laryngopharyngeal reflux.

External cricopharyngeal myotomy

External cricopharyngeal myotomy is a quick and relatively simple procedure.

- Perform direct laryngoscopy and rigid esophagoscopy to exclude other pathology causing dysphagia such as tumors and strictures

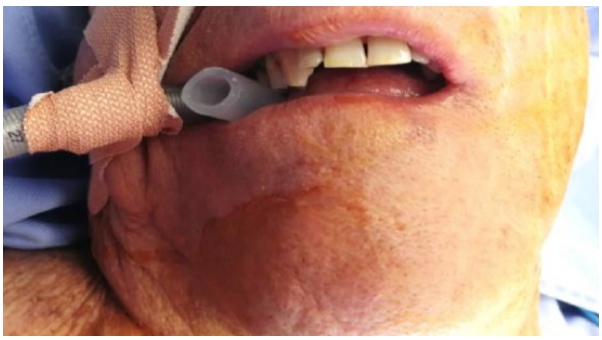


Figure 9: Suction tubing used to stent esophagus

- Stent the esophagus with a piece of suction tubing (*Figure 9*) / endotracheal tube / Maloney dilator; this helps the surgeon to palpate and identify the esophagus during dissection
- Extend the neck and turn the head to the right side
- Palpate and identify the cricoid cartilage; this denotes the level of cricopharyngeus



Figure 10: Transverse skin incision

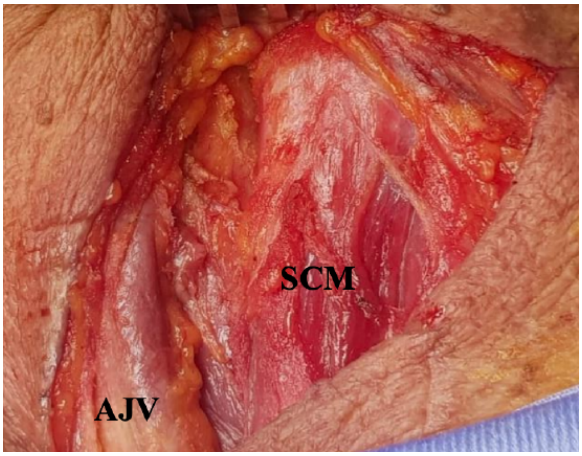


Figure 11: Liberal exposure achieved with transverse incision and subplatysmal flaps; AJV: Anterior jugular vein; SCM: Sternocleidomastoid

- Make a liberal transverse cervical skin incision to the left of the midline at the level of the cricoid (*Figure 10*). A transverse incision is cosmetically preferable to a vertical incision
- Incise platysma muscle
- Elevate subplatysmal flaps (*Figure 11*)
- Dissect along the anterior border of the sternocleidomastoid muscle
- Identify and divide the omohyoid muscle as it crosses the internal jugular vein
- Dissect along the medial aspect of the internal jugular vein and common carotid artery, and the lateral aspect of the thyroid gland, larynx and trachea
- Identify, ligate and divide the middle thyroid vein

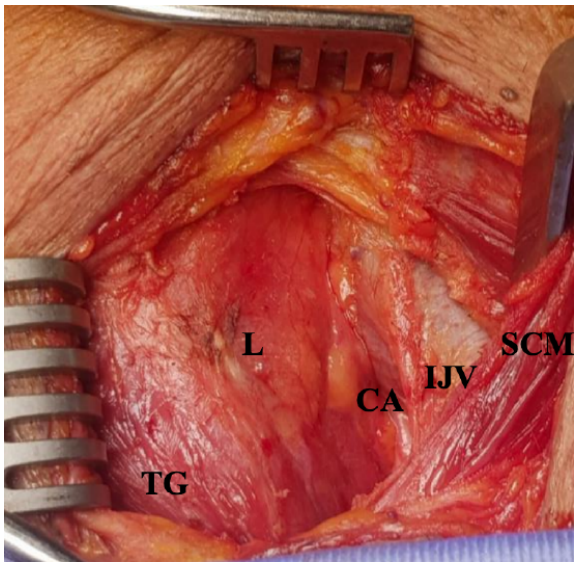


Figure 12: Retracting the sternocleidomastoid (SCM) exposes the thyroid gland (TG), larynx (L), internal jugular vein (IJV) and common carotid artery (CA)

- Continue the dissection until the prevertebral fascia is reached, and strip superiorly and inferiorly with a finger to expose the larynx, esophagus, thyroid gland (medially) and contents of the carotid sheath (laterally) (*Figure 12*)
- The superior laryngeal nerve defines the superior boundary of the dissection
- Palpate the cricothyroid joint

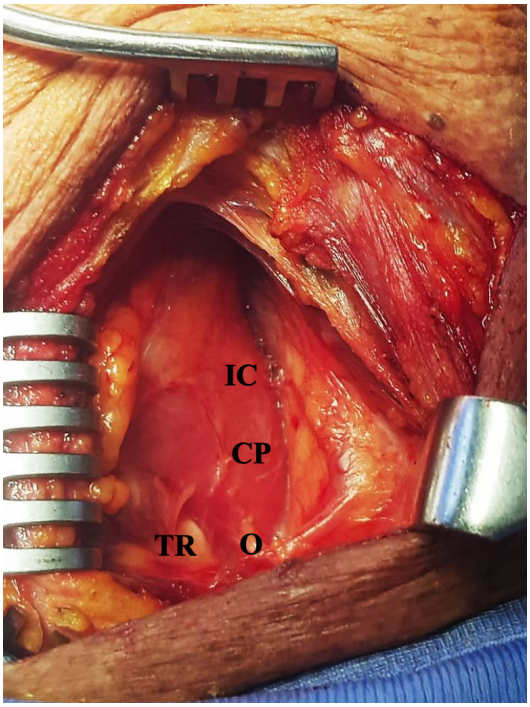


Figure 13: The rake is retracting the thyroid gland to expose the 1st tracheal ring (TR), esophagus (O), cricopharyngeus (CP), and inferior constrictor (IC)

- Place a double pronged hook or sharp rake under the posterior edge of the thyroid cartilage or the thyroid gland and rotate the laryngotracheal complex to bring the esophagus, cricopharyngeus and inferior pharyngeal constrictor muscles into view (*Figure 13*)
- With this laryngotracheal rotation the RLN is safe, provided one dissects close to the posterior midline of the cricopharyngeus muscle
- Palpate and identify the cricoid cartilage
- Palpate and identify the firm tubing / dilator within the esophagus

- The cricopharyngeus muscle is easily palpated and visualized, stretched over the esophageal stent

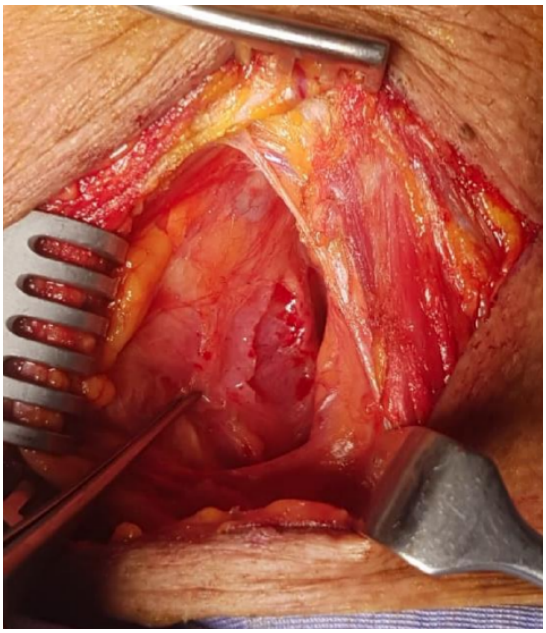


Figure 14: Cricopharyngeal myotomy, with esophageal mucosa stretched over suction tubing coming into view

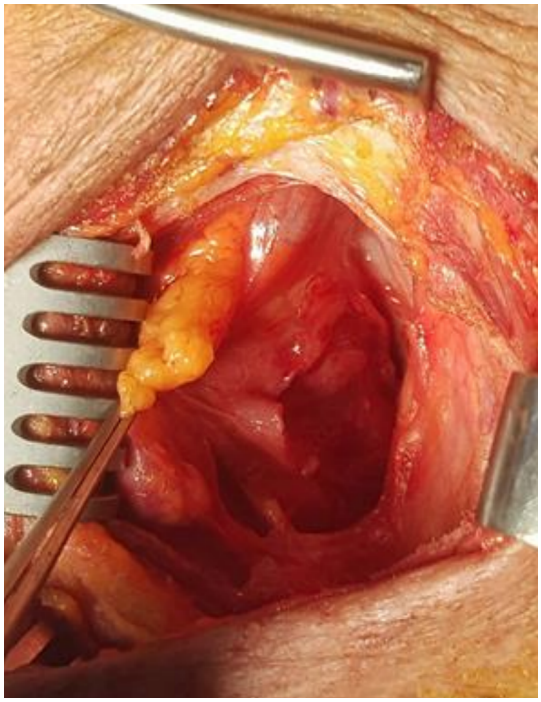


Figure 15: Completion of cricopharyngeal myotomy with muscle elevated from mucosa



Figure 16: Closed wound and suction drain

- Cut vertically with a 15# scalpel blade through the cricopharyngeus muscle until the underlying esophageal mucosa comes into view (*Figures 14*, *15*)
- Ensure hemostasis
- Insert a suction drain, and close the neck in a layered fashion (*Figure 16*)
- Introduce oral fluids the same day if the mucosa has not been breached

Endoscopic cricopharyngeal myotomy

- Administer broad spectrum antibiotics perioperatively
- General anesthesia is done with orotracheal intubation (nasotracheal intubation hampers access)
- Protect the upper teeth with a gum guard
- Perform laryngoscopy
- Perform rigid esophagoscopy
    - Inspect the esophagus to rule out other pathology that may be causing symptoms such as tumors or strictures
    - Dilating the esophageal opening with the scope facilitates subsequent passage of the diverticuloscope

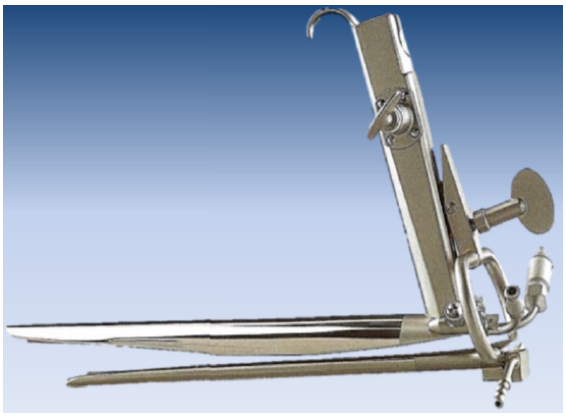


Figure 17: Weerda bivalve diverticuloscope



Figure 18: Benjamin diverticuloscope

- Insert a Weerda or Benjamin diverticuloscope (*Figures 17, 10*)
  - Extend the neck posteriorly as far as the cervical spine allows
  - Lubricate the scope
  - Advance the scope with blades slightly apart until the esophageal opening appears
  - It is not always possible to insert the scope due to anatomical limitations
  - Pass the anterior blade of the scope into the esophagus and keep the posterior blade against the posterior wall of the hypopharynx
  - Identify the transverse bar denoting the upper edge of cricopharyngeus
  - Distract the blades further to better visualize the cricopharyngeus bar
  - Suspend the scope with a scope holder
- Visualize the cricopharyngeus bar using an operating microscope with an integrated CO_2 laser microsled
- Set the CO_2 laser at 5-10W, CW mode and with a slightly defocused spot size to improve hemostasis



Figure 19: Transmucosal laser cricopharyngeal myotomy: incising mucosa and muscle



Figure 20: Transmucosal laser cricopharyngeal myotomy: completed myotomy

- Use CO_2 laser to transect the mucosa overlying the muscle in the midline (*Figure 19*)
- Meticulously completely transect the cricopharyngeus muscle without disrupting the posterior layer of perioesophageal fascia (*Figure 20*)
- Instruct the anesthetist to ***avoid ventilating the patient with a face mask*** when reversing the anesthesia, as it may cause air to track through the defect into the tissues of the neck, causing surgical emphysema and potentially increasing the risk of a

postoperative leak and sepsis
- Observe the patient overnight
- Following CO_2 laser, a small number of patients develop some subcutaneous emphysema; this almost never results in mediastinitis
- Monitor for signs and symptoms that signal mediastinitis e.g. radiating back or chest pain, fever, and tachycardia despite adequate pain control, as early intervention for this rare but potentially fatal complication is mandatory
- Commence a clear liquid diet the morning following surgery
- Discharge the patient if he/she tolerates a clear liquid diet without concerning signs or symptoms
- The patient should remain on liquids and soft foods for at least a week

Reference

1. Chang CWD, Liou SS, Netterville JL. Anatomic Study of Laser-Assisted Endoscopic Cricopharyngeus Myotomy. Ann Otol Rhinol Laryngol 2005; 114(12):897-901

Suggested chapters in Open Access Atlas

- CO_2 laser transoral microsurgery
- Surgery for pharyngeal pouch / Zenker's diverticulum

Author & Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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1.46: Surgical Management of Facial Fractures

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Prabhat Bhama, Mack Cheney

Maxillofacial trauma is typically caused by blunt trauma due to interpersonal violence, moving vehicle accidents (MVA), falls, or sporting activities[1]. Because these activities transcend cultural and geographic borders, maxillofacial trauma remains a global health issue. Technological advances have resulted in faster methods of transportation and with these developments maxillofacial trauma has become a major public health issue also in the developing world. Although management of the airway and cardiopulmonary system take precedence, facial injuries demand attention because of their potential for long-term impact on quality of life (QOL) and the patient's psychological wellbeing[2] as the face houses many vital structures necessary for sight, hearing, speech, olfaction, and mastication.

Pathophysiology

When energy transferred to a bone exceeds its stress tolerance, a fracture may result. Several factors determine if and how a bone fractures: the amount of energy transferred to the bone e.g. mechanism of injury, speed of collision, airbag deployment etc; vectors of forces; and the characteristics of the tissue involved e.g. anatomic location of impact and quality/health of the bone.

A ***simple fracture*** occurs when a single site of discontinuity exists between two bony segments. With a ***comminuted fracture*** there are multiple segments of bone. Bone segments protruding through skin are considered ***open fractures***, as are fractures of the alveolar bone and sinuses. They are more susceptible to infection compared to their closed counterparts. ***Closed fractures*** are uncommon in the face.

The bony fragments may remain anatomically reduced or can become displaced depending on the mechanism of injury and muscular forces acting on the fragments. The degree of anatomic disruption of fractured segments is referred to as ***displacement***. Blood flow to the fracture site results in ***callus formation*** over time followed by mineralization of the callus if the fracture site is immobilized.

Malunion occurs when fracture segments are not reduced and the bone heals in an anatomically incorrect position[3]. In the face, this can cause significant disfigurement and disability.

Disfigurement occurs because the skin soft tissue envelope (SSTE) of the face is dependent upon the underlying maxillofacial skeletal framework. Anatomic perturbations of the bony framework from maxillofacial trauma manifest as abnormal appearances of the SSTE. Depending on the location of the fracture(s), the aesthetic deformity may be inconspicuous e.g. minimally displaced anterior maxillary sinus wall fractures, or obvious e.g. displaced nasal bone fractures.

Disability occurs when malunion interferes with function. This is most evident with dentoalveolar or mandibular fractures, as malunion can result in dental malocclusion, making mastication difficult or impossible.

The surgeon must ensure that bony fragments are ***anatomically reduced and stabilized*** so that when healing is complete, callus formation is minimized to minimize disfigurement and disability. Even when reduction is achieved, the result may not be ideal. Poor blood supply or wound infection may cause ***delayed union*** when bone fails to mineralize[3] months after reduction and immobilization. ***Fibrous union*** may occur (usually within 10 days in adults) if bones are reduced but inadequately immobilized. ***Non-union*** may result if bone is lost or the wound is contaminated with foreign material. Therefore, the surgeon must ensure that a fracture site is clean, free of foreign material (insomuch as possible), and well vascularized prior to reduction and immobilization. Antibiotics are sometimes warranted to counter bacterial contamination.

Basic Management Principles

Not all maxillofacial fractures require intervention. The primary goals of repair of craniomaxillofacial (CMF) fractures are ***restoration of premorbid anatomy and function***:

- ***Craniofacial structure***
  - Facial height

- Facial width
- Facial projection

- ***Craniofacial function***
  - Dental occlusion

Fracture reduction and fixation are best performed in the 1st two weeks following injury[5]. Strict attention to the following principles optimize bone healing and surgical outcomes

- Anatomic reduction (realignment) of fracture segments
- Fixation (immobilization) of bones across fracture sites in the operating room
- Postoperative immobilization of bones across fracture sites (prevention of reinjury or stress to fracture sites)
- Preventing infection

Anatomic reduction of fractured segments requires a 3-dimensional understanding of maxillofacial anatomy. Nonetheless, substantial individual variation is common, and premorbid photographs or examination of the unaffected side of the face can be beneficial. Intraoperative imaging is also used by some to achieve adequate reduction[5], although such technology is costly and time consuming. Bilateral fractures may preclude using the contralateral face as a template. In many cases, the surgeon must reference normal anatomic landmarks. However, ***when there are no anatomically normal bony landmarks to use as reference, one should first restore dental occlusion, followed by the buttresses of the face*** (see section on maxillomandibular fixation and anatomy).

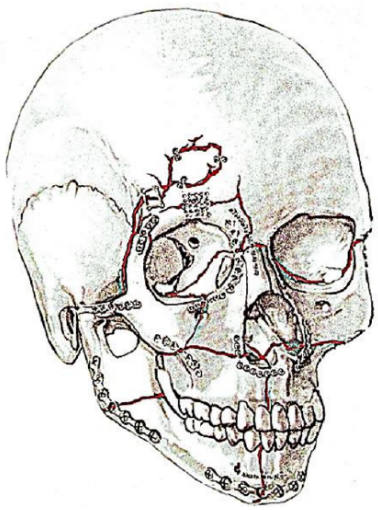


Figure 1: Plating of pan-facial fractures



Figure 2: Plain film following ORIF of multiple fractures



Figure 3: Reconstruction (blue) vs. minilates (grey)

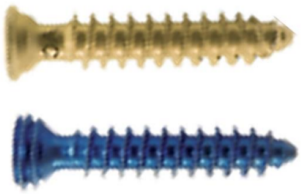


Figure 4: Locking (below) vs. non-locking (above) screws

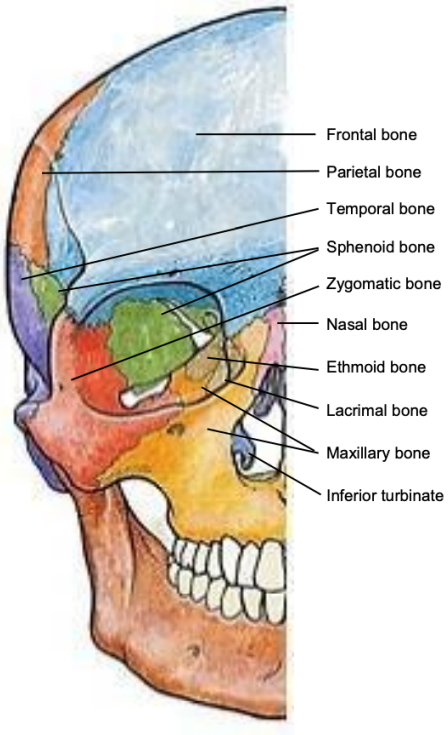


Figure 5: Frontal view of bones of skull

Fixation of bone across fracture sites is done to immobilize the bone against musculoskeletal forces and to permit mineralization to occur. Fixation is generally accomplished using titanium plates secured with screws (*Figures 1*, *2*, *3*, *4*).

Screws are either self-tapping or self-drilling. Self-tapping screws require predrilling prior to inserting the screws, but also require less force which is advantageous when fixing fragile bony segments. Larger plates and screws provide greater stability and immobilization. Nonlocking plates are typically used for the midface. These plates must be shaped to fit the bone precisely or they will distract the bony segment towards the plate when the screw is engaged.

Locking plates can be helpful when immobilizing mandibular fractures. When used with locking head screws, locking plates do not require exact coaptation of the plate to the bone as the bone is not compressed against the plate (*Figures 3*, *4*). This avoids impairing cortical bone perfusion and provides a more stable fixation when compared to a non-locking system.

Because titanium plates and screws are too expensive for many developing world centers, reliance is placed on ***stainless steel wire*** to reduce and fix fractures.

Preventing infection begins with initial management in the emergency unit. Open wounds are copiously irrigated with sterile isotonic fluid. Badly contaminated wounds are thoroughly cleaned and irrigated. Pressurized pulsatile irrigation methods have been demonstrated to be useful in wound debridement[6] and are particularly useful to cleanse wounds with particulate matter e.g. sand and road debris. ***Prophylactic antibiotics*** to prevent infection when treating non-mandibular maxillofacial fractures ***have been discouraged*** [7], although a recent review highlighted the lack of large high quality randomized controlled trials to evaluate antibiotic use in non-mandibular facial fractures. When treating ***fractures of the mandible, prophylactic antibiotics are likely beneficial when used in the immediate perioperative period*** [8]. In any case, adherence to sterile technique in the operating room and good quality postoperative wound care should not be compromised.

Surgical Anatomy

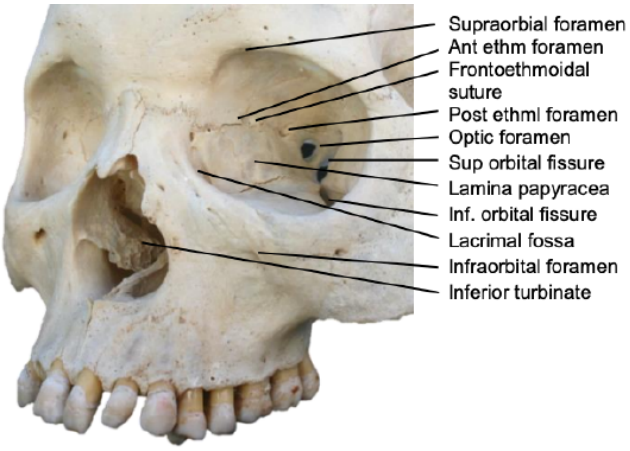


Figure 6: View of orbit

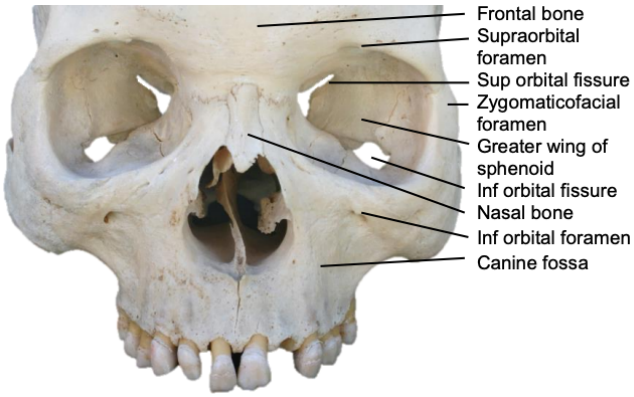


Figure 7: Frontal view of the skull

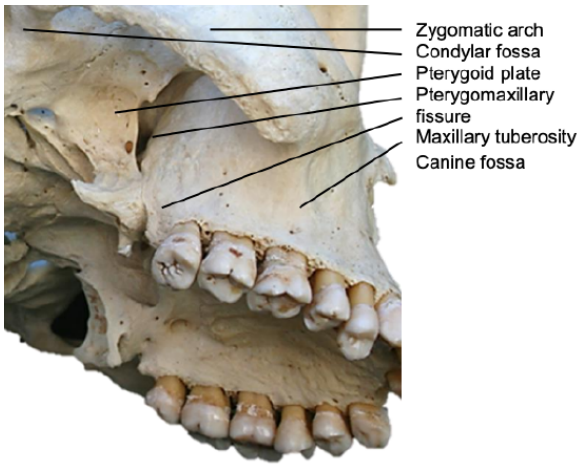


Figure 8: The internal maxillary artery passes through the pterygomaxillary fissure to enter the pterygopalatine fossa

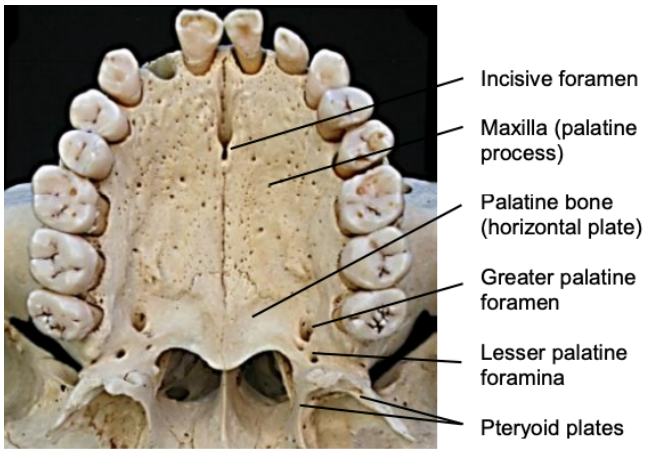


Figure 9: Palatal anatomy

Knowing which fractures require treatment requires a thorough understanding of the anatomy of the craniomaxillofacial (CMF) skeleton and how forces are transmitted (*Figures 5-9*). This anatomical knowledge, coupled with a detailed history, physical examination, and imaging permit the surgeon to establish a treatment plan for various fracture patterns.

Because of the complexity of the CMF skeleton, it is helpful to divide injuries into the following anatomic regions: frontal sinus, nasoethmoid complex (NEC), zygomaticomaxillary complex (ZMC), midface, palatoalveolar, and mandible.

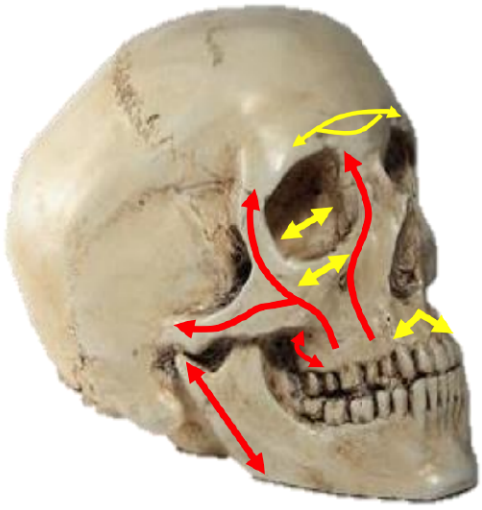


Figure 10: Vertical (red) and transverse (yellow) buttresses

Four paired, vertically-oriented bony pillars (buttresses) i.e. the nasomaxillary (NM), zygomaticomaxillary (ZM), and pterygomaxillary (PM) buttresses[10], and the vertical rami of the mandible support the sinus cavities and give structure to the craniofacial skeleton (*Figure 10*). They resist deformation by the powerful forces of mastication and other vertical forces[9].

The ***NM buttress*** extends from the nasion inferiorly along the pyriform aperture. The ***ZM buttress*** extends from the frontozygomatic suture line inferiorly through zygomaticomaxillary suture line to the maxillary alveolus. The ***PM buttress*** extends from the cranial base superiorly to the inferior border of the pterygoid plates. ***Transversely oriented buttresses*** include the ***frontal bar, infraorbital rim*** and ***nasal bones***, and the ***hard palate*** and ***maxillary alveolus*** (*Figure 10*).

It is helpful to think of the face as skin and soft tissue draped over the sinus cavities which are enclosed by thin bone; hence the appearance and structure of the skin depends on the structure of the underlying craniofacial skeleton and the integrity of the buttresses. Repair of maxillofacial injuries is therefore directed at re-establishing relationships between the buttresses and surrounding bone and soft tissue, as well as reduction and stabilization of the integrity of the buttress(es).

Assessment of fractures

History

The craniofacial trauma surgeon generally remains uninvolved with patient care in the emergency department until stabilization of the airway and cardiopulmonary systems is complete. Nonetheless, it is certainly possible that craniofacial trauma may compromise the airway or vascular system in which case the experience of a head and neck surgeon can be particularly helpful. In such scenarios, an abbreviated history can be obtained while surgical intervention is taking place in the emergency department. For instance, a patient with bilateral mandibular fractures may present in airway distress because of posterior displacement of the oropharyngeal tongue. In such a case, anterior traction on the tongue using a penetrating towel clamp or by digitally grasping the tongue with a gauze swab can facilitate endotracheal intubation. In some cases, endotracheal intubation may be difficult or precluded (because of suspected laryngeal injury), necessitating tracheostomy or cricothyroidotomy. In cases of vascular compromise, exsanguination is a risk. Typically, tamponade is crucial for hemostasis in emergency situations until formal wound exploration and repair can be completed. Once the airway, breathing, and circulatory systems have been stabilized, a more thorough history can be obtained.

The surgeon should determine the mechanism of injury i.e. fall, assault, moving vehicle collision, and the speed of the injury. While treatment of the patient can continue without knowing the exact mechanism of injury, information regarding mechanism can help the clinician understand the injury pattern and possibly reveal more inconspicuous injuries. For instance, a patient involved in a high-speed motor vehicle collision will typically be at higher risk for more severe injuries to the craniofacial skeleton. Knowing this information may encourage a clinician to order more comprehensive imaging studies.

In addition to the mechanism of injury, the time and location of the injury can be important. These factors can provide clues regarding the status of the patient's wounds i.e. presence of debris, risk of infection, etc. It is also crucial to ascertain the condition of the patient when the first respondents arrived e.g. was the patient unconscious, cooperative, or combative? This information can provide clues regarding the neurologic status of the patient. The Glasgow Coma Scale (GCS) on arrival of the first responders is information typically presented to the trauma surgeon.

It is not uncommon that patients with craniofacial injuries were under the influence of alcohol or drugs when they sustained an injury. This information should also be obtained.

In an awake and appropriately responsive patient, it is helpful to obtain a complete history directly from the patient as well. Important questions to ask include:

1. Neurologic status relating to the head and neck (pain, paraesthesia, etc.)
2. Visual changes
3. Changes in dental occlusion
4. Changes in hearing
5. Changes in smell and/or taste

Once the patient's complaints have been documented, a complete past medical and surgical history should be obtained. The surgeon should be aware of the status of the cervical spine which may preclude positioning changes in the operating room. Additionally, a list of current medications, allergies, family history and review of systems should be obtained. The patient's tobacco, alcohol, and illicit drug use history should be noted.

Clinical examination

A complete head and neck examination is performed. This includes a ***neurological examination*** which begins with assessment of the patient's sense of person, place, and time. Cranial nerves II-XII are examined. Visual acuity, pupillary light reflexes, and extraocular movements are assessed. Facial sensation should be noted in all three divisions of the Vn. The motor division of the Vn is examined by asking the patient to bite down while palpating the masseter muscle. Facial nerve function should be carefully examined by asking the patient to raise the eyebrows, close the eyes tightly, smile, purse lips, puff cheeks, and depress the lower lip. The cochlear division of the VIIn can be grossly assessed using a conversational voice, and more detailed information regarding audiologic status can be obtained with a tuning fork exam. The IXn and Xn can be tested with the gag reflex and the voice quality. XIn function can be examined via shoulder shrug and head turn. The XIIn can be examined by assessment of tongue movement.

The ***scalp*** should be carefully examined for lacerations, foreign debris, or hematomas.



Figure 11: Battle's sign that appeared four days after the temporal bone fracture

Otoscopy is essential to rule out external auditory canal lacerations which can result in canal stenosis if left untreated. The tympanic membrane should be visualized to rule out hemotympanum, which may be an indicator of a temporal bone fracture. Clear or thin bloody otorrhoea may be due to cerebrospinal fluid (CSF) leakage. In such cases, fluid should be collected and sent for beta-2 transferrin analysis. The mastoid bone should then be examined for ***Battle's sign*** (*Figure 11*) along with the auricle.



Figure 12: Halo sign of CSF mixed with blood

Nasal examination is important to rule out obvious fractures. Anterior rhinoscopy is performed to rule out septal hematoma or epistaxis. Septal hematoma requires drainage to prevent abscess formation and/ or cartilage destruction, which can result in severe nasal disfigurement. Open fractures of the nasal septum can sometimes be found on anterior rhinoscopy. The surgeon should also assess for watery rhinorrhoea which may be indicative of CSF leakage. Beta-2 transferrin testing can confirm the identity of the fluid. When unavailable, the ***halo test*** can sometimes be helpful: a drop of the fluid is placed on a gauze swab; blood coalesces in the center leaving a ring of CSF around the blood (*Figure 12*). If deemed necessary, nasendoscopy can also be performed to further examine for CSF leakage.

Examination of the oral cavity begins with assessment of occlusion. While all patients will not have Angle Class I ***occlusion***, it is imperative to assess if the patient's occlusion has changed since the accident. A gross ***dental exam*** is also helpful to determine if oral-maxillofacial surgery consultation is required. The maxilla should be grasped and assessed to determine stability. The ***oral cavity*** is then examined with attention to the buccal mucosa, Stensen's duct, floor of mouth, tongue, palate, and maxillary/mandibular alveolar ridges. The ***oropharynx*** is then examined. If indicated, nasolaryngoscopy can be performed to examine the ***larynx***. This is required if the patient presents with otherwise unexplained respiratory distress, voice changes, or crepitus.

The ***facial soft tissues*** are then carefully examined to rule out lacerations and abrasions. The underlying ***bony skeleton*** can be palpated to assess for step-offs.

The ***neck*** should then be examined. Palpation can reveal hematoma, crepitus, or displacement of the airway. Cervical spine status is essential to know prior to manipulating the patient's head and/or neck.

Imaging

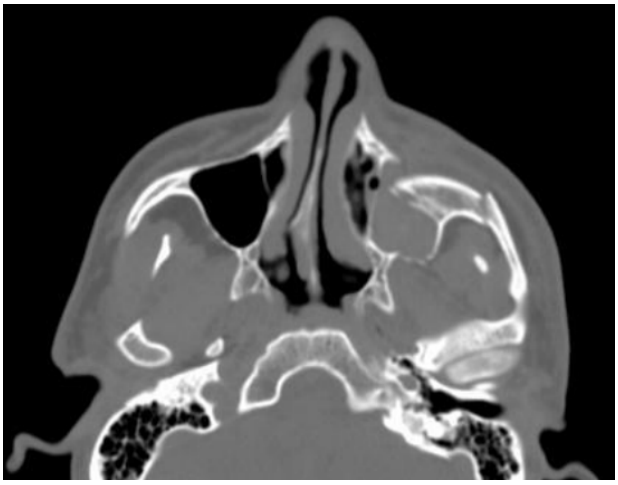


Figure 13: CT scan demonstrating zygomaticomaxillary fractures



Figure 14: 3-D reconstruction demonstrates a fractured mandible

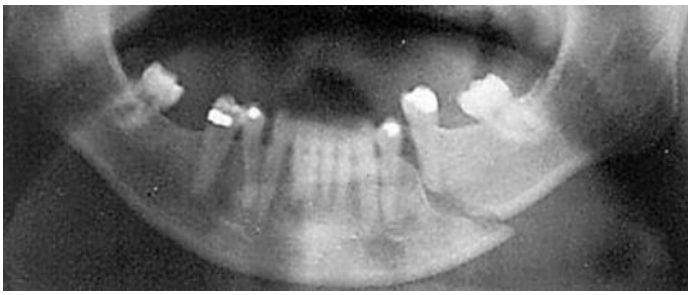


Figure 15: Panorex of fractured mandible

Imaging may be required to exclude injury to the brain, vasculature, and cervical spine and other associated injuries. Standard modern-day imaging for CMF skeleton includes fine cut, uncontrasted computed tomography (CT) of the CMF skeleton (*Figure 13*). It is often helpful to obtain coronal reformats and three-dimensional reconstructions (*Figure 14*). In the absence of CT imaging, reliance is placed on plain X-rays; panorex images are helpful with mandibular fractures (*Figure 15*). When available, the ideal imaging study of choice for maxillofacial trauma is noncontrast CT scan of the face with fine cuts, coronal and sagittal reformats, and 3D reconstructions.

Dental Occlusion

The most important consideration when reducing facial fractures involving or altering the occlusal surface is to ensure that premorbid dental occlusion is restored.

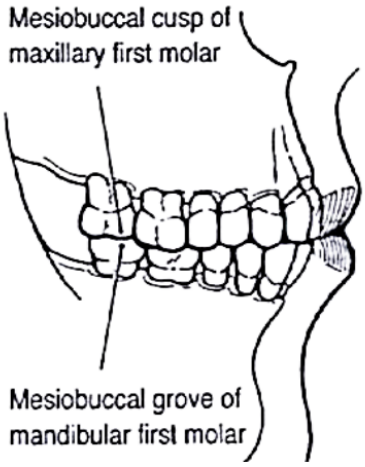


Figure 16: Class I Angles' occlusion (Angle E. Treatment of malocclusion of the teeth. 7th ed. Philadelphia: SS White, 1907)

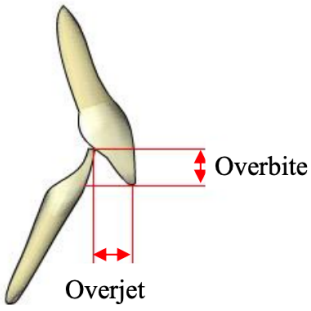


Figure 17: Incisal relationships - overbite and overjet

Angle class I occlusion is considered normal. It is defined as intercuspation of the mesial buccal cusp of the 1st maxillary molar with the buccal groove of the 1st mandibular molar (*Figure 16*). The maxillary incisors should extend slightly anteriorly past the mandibular incisors, known as ***overjet***. The amount of overlap between the labial surface of the mandibular incisor and the lingual surface of the maxillary incisor is termed ***overbite*** (*Figure 17*).

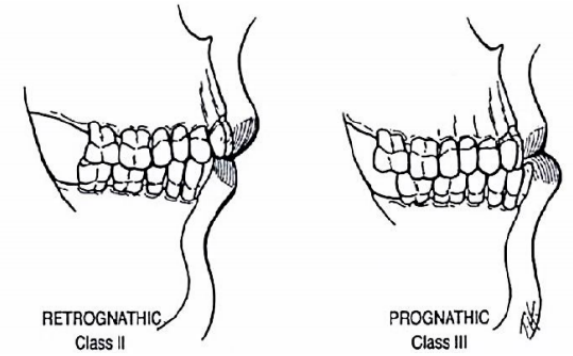


Figure 18: Angles' classification of occlusion (Angle E. Treatment of malocclusion of the teeth. 7th ed. Philadelphia: SS White, 1907)

Angle class II (retrognathic) and ***Angle class III (prognathic) occlusions describe*** alternative relationships. Angle's occlusal classification does not address anterior or transverse dental relationships (*Figure 18*).

One to 3 mm of overjet and overbite is considered normal; if excessive, it is considered to be a form of malocclusion. Transversely, the buccal cusps of the mandibular molars should lie between the buccal and lingual cusps of the maxillary molars (*Figure 16*).

Stepwise treatment of fractures

Treatment of facial fractures should not necessarily be tailored to achieve Class I occlusion; rather, the goal should be to restore premorbid occlusion. Premorbid occlusion is determined by assessing the positions of wear facets on the dentition intraoperatively.

Reduction and MMF



Figure 19: Wiring archbars together

Prior to fixation of fracture sites, appropriate reduction is achieved and the patient is placed into mandibulomaxillary fixation (MMF) using arch bars, bone supported devices or with direct interdental wiring techniques[11] (*Figure 19*). For a detailed description of arch bar placement, readers are referred to the cited URL[4].

Arch bars can often be removed if adequate fixation has been achieved with plating. However, if arch bars have been used as a tension band, they should remain in place for 6 weeks.

Exposing fractures

Once the patient has been placed into MMF (if required), the fracture sites are exposed. Several approaches are available to access the facial skeleton depending on the site and extent of the fractures. Lacerations overlying the fractures are utilized to access the underlying bone if possible.

Fractures of frontal bone and nasal root



Figure 20: Coronal incision

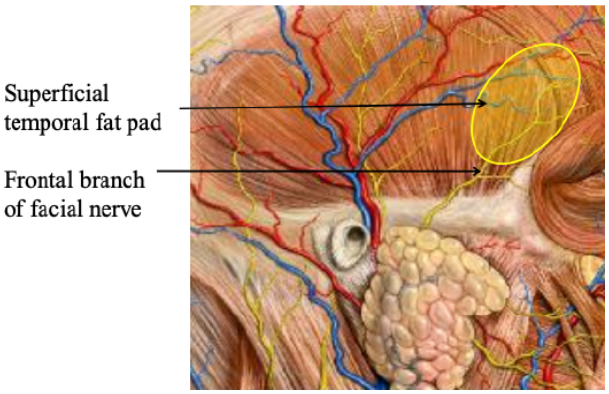


Figure 21: Anatomy of frontal branch of facial nerve

These can be addressed using a coronal incision (*Figure 20*). The incision extends from just superior to the root of the helix and is carried across the parietal bone keeping behind the hairline of the scalp, ending just superior to the contralateral helical root. Medially the incision may be extended to the pericranium if a pericranial flap is planned, or onto the cranium; laterally the dissection is typically kept in a plane just deep to the temporoparietal fascia with special care taken when approaching the zygoma to avoid the frontal branch of the facial nerve which resides in this plane (*Figure 21*).

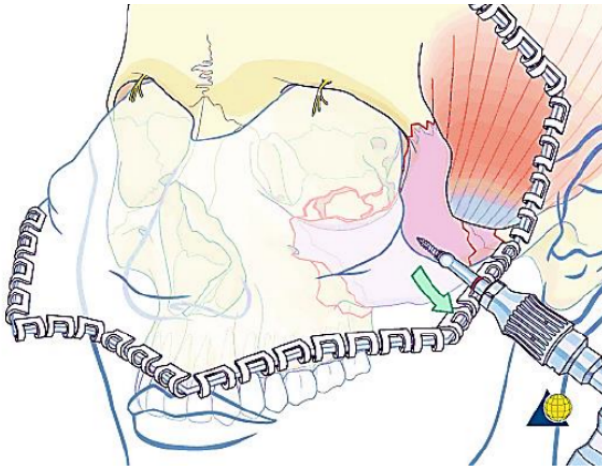


Figure 22: Coronal flap has been raised anteriorly to expose the frontal bone, root of the nose and lateral orbital rim (AO Foundation)

Figure 22 illustrates the coronal flap reflected anteriorly, taking care to preserve the supraorbital nerves if possible.

Fractures of lateral orbital rim and frontozygomatic suture

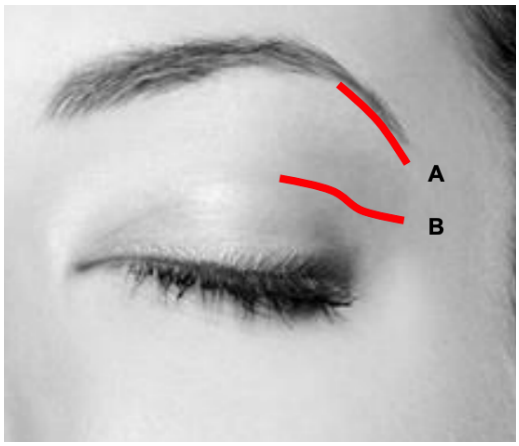


Figure 23: Lateral brow (A) and lateral lid crease incisions (B)

Access to the lateral orbital rim and frontozygomatic suture can be achieved by ***lateral brow*** or ***lateral lid crease incisions*** (*Figure 23*). Oftentimes isolated fractures of this region can be fixed using a miniplate with at least 2 screws on each side of the fracture line.

The ***lateral brow approach*** provides direct access to the superolateral orbital rim. No neurovascular structures are at risk. Scarring is generally concealed if the incision is placed within the hairs of the brow although it can cause alopecia if not carefully placed. It is used for fractures high up on the lateral orbital rim.

- Protect the cornea with a temporary tarsorrhaphy or a corneal cover shield
- Inject local anasthetic/vasoconstrictor into the skin and subcutaneous tissue
- Moisten and part the hair of the lateral eyebrow to open a linear gap for the incision

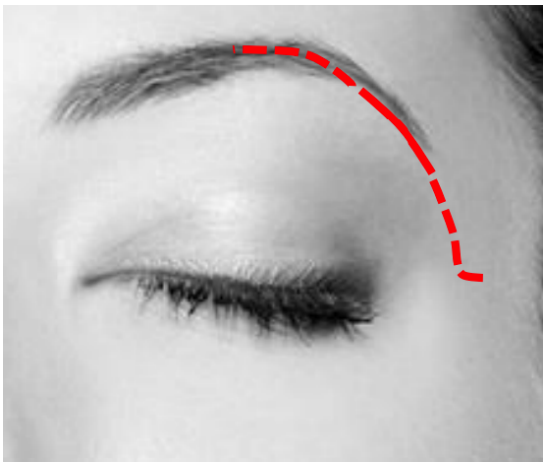


Figure 24: Lateral brow incision with medial and lateral extension for additional exposure

- Make a 2 cm incision within the confines of the lateral eyebrow through skin, subcutaneous fat and muscle (*Figure 24*)
- Cut parallel to the hair follicles to avoid injuring the hair follicles
- For additional exposure extend the incision medially within the eyebrow towards the supraorbital foramen and nerve; or inferiorly along the orbital rim by way of a small angled skin-only extension into a skin crease laterally, at least 6-7 mm above the lateral canthus (*Figure 24*)
- Undermine the orbicularis oculi muscle to expose the periosteum
- Dissect in an extraperiosteal dissection plane to expose the frontozygomatic suture line and fracture area
- Incise the periosteum with a scalpel along the superolateral orbital rim
- First expose the medial aspect of the superolateral orbital rim to gain access to the fossa containing the lacrimal gland
- Carry the subperiosteal dissection from this bony concavity inside the anterolateral portion of the orbital roof over the superolateral orbital rim. Widely undermining skin and periosteum facilitates exposure of the inferior lateral orbital rim
- Close the wound in three layers i.e. periosteum, muscle, and skin.

The ***lateral lid crease approach*** provides direct access to the lateral orbital rim (*Figure 23*).

- Protect the cornea with a temporary tarsorrhaphy or a corneal cover shield
- Inject local anesthetic/vasoconstrictor into the skin and subcutaneous tissue
- Incise the skin in the lateral half of the upper eyelid in a natural supratarsal skin crease. It is a curvilinear incision with the medial portion curved convexly superiorly and the lateral portion kept in line with the lateral canthus
- If a lid fold is not apparent, then place the incision 10 mm above the lash line in the centre of the lid and 6-7 mm above the lateral canthus
- The incision may be extended laterally onto the lateral orbital rim, and then curved superiorly for improved access
- Make a small slit at the lateral end of the wound and introduce scissors into the preseptal plane and dissect medially underneath the orbicularis oculi muscle
- Divide the orbicularis oculi leaving the orbital septum intact
- Elevate the skin/muscle flap with scissors from medial-to-lateral until the periosteum is exposed at the superolateral orbital rim
- Use an elevator to reflect the periosteum from the inside of the anterolateral orbital roof, and then from the lateral and posterior surface of the superolateral orbital rim
- The lacrimal gland may herniate if the periosteum is breached
- Incise the periosteum along the superolateral orbital rim
- Close the wound in three layers i.e. periosteum, muscle, and skin

Fractures of the inferior orbital rim and orbital floor

The inferior orbital rim and orbital floor can be accessed via a ***preseptal transconjunctival approach***[12]; visualization can be augmented with endoscopy[13]. Alternatively, a ***transcutaneous approach*** can also be made via ***subciliary, subtarsal, or infraorbital incisions***.

The preseptal transconjunctival approach provides access to the orbital floor and rim. This approach may be combined with lateral canthotomy and cantholysis for extended access to the lateral orbit.

- Protect the cornea with a temporary tarsorrhaphy or a corneal cover shield
- Make an incision through the palpebral conjunctiva and lower lid retractors immediately inferior to the lower border of the tarsal plate
- Dissect the posterior lamella away from the anterior lamella in the plane between the preseptal orbicularis oculi and the orbital septum
- This provides excellent access to the orbital rim
- Once the orbital rim is reached, the periosteum is sharply incised, revealing the underlying rim and providing access to the orbital floor

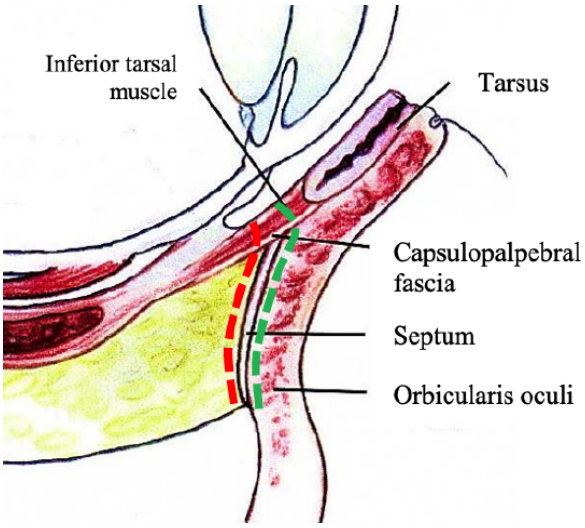


Figure 25: Preseptal (green) & retroseptal (red) routes

- Both the preseptal and retroseptal routes are shown in *Figure 25*; the authors prefer the preseptal route

Transcutaneous subciliary, subtarsal, or infraorbital incisions (*Figure 26*)

- Use existing lacerations in the lower eyelid if present to access the orbit
- Otherwise, incisions can often be made in existing relaxed-skin tension lines (RSTL)
- Even if not made in an RSTL, incisions in the lower eyelid are generally quite well hidden. In the diagram below, the following incisions are marked: A-subciliary, B-subtarsal, C-infraorbital, Dextended subciliary. These approaches differ only in the position of the skin incisions
- The plane of the approach to the orbital rim is otherwise similar

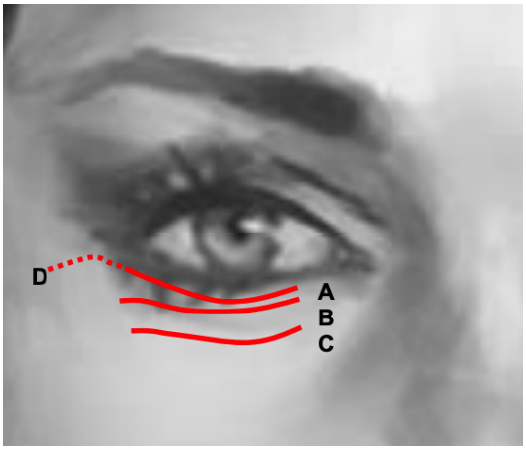


Figure 26: Transcutaneous subciliary (A), subtarsal (B), infraorbital (C), extended subciliary (D) incisions

- ***Subciliary incision*** (*Figure 26*)
  - Carry the incision through skin to the pretarsal orbicularis oculi
  - Develop the plane between the orbicularis oculi and subcutaneous tissue until the inferior border of the tarsal plate is reached
  - Penetrate the orbicularis oculi
  - Develop the plane between the orbicularis oculi and septum to reach the orbital rim
- ***Subtarsal incision*** (*Figure 26*)
  - Make the skin incision inferior to the edge of the tarsal plate
  - Carry the incision through the orbicularis oculi muscle
  - Develop the plane between orbicularis oculi and orbital septum
- ***Infraorbital incision*** (*Figure 26*)
  - The infraorbital incision is located directly superficial to the orbital rim
  - Carry the incision through skin, orbicularis oculi, and periosteum of the orbital rim to gain direct access to the rim

Fractures of the medial orbital wall

The medial orbit can be accessed using a ***preseptal precaruncular transconjunctival approach*** [14]. Dissection deep to periorbita may be facilitated by using a Freer's suction elevator. Recent developments in multiportal endoscopic approaches to the skull base have also been reported[15, 16].

Fractures of maxilla and lower midface

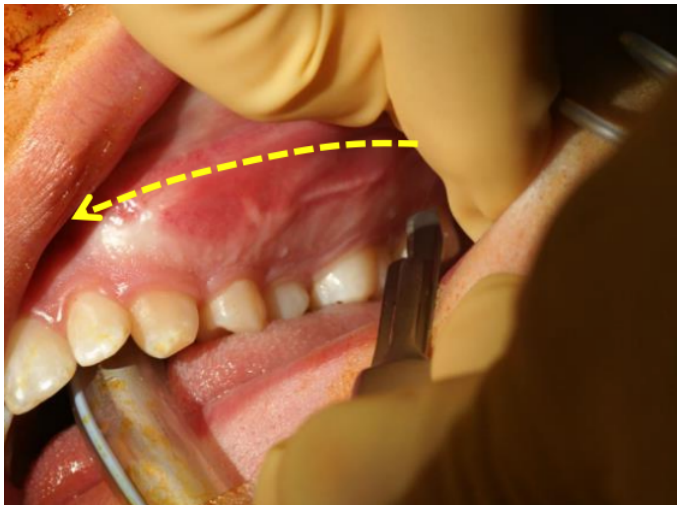


Figure 27: Sublabial approach to face of maxilla

The maxilla and lower midface can be exposed via a sublabial incision positioned approximately 1 cm from the labial sulcus to facilitate closure (*Figure 27*).

- Incise the sublabial mucosa with a #15 scalpel blade or monopolar electrocautery
- Use electrocautery to incise the soft tissue overlying the maxilla until the bone is reached
- Use a periosteal elevator to dissect over the face of the maxilla in a subperiosteal plane to identify the fractures
- Take care to avoid applying excessive pressure to the fragile anterior maxillary sinus wall, particularly if there is a fracture in this location



Figure 28: Maxilla with infraorbital foramen

- The infraorbital nerve is at risk during this dissection and should be preserved if possible (*Figure 28*)

Nasoethmoid/Orbital Fractures

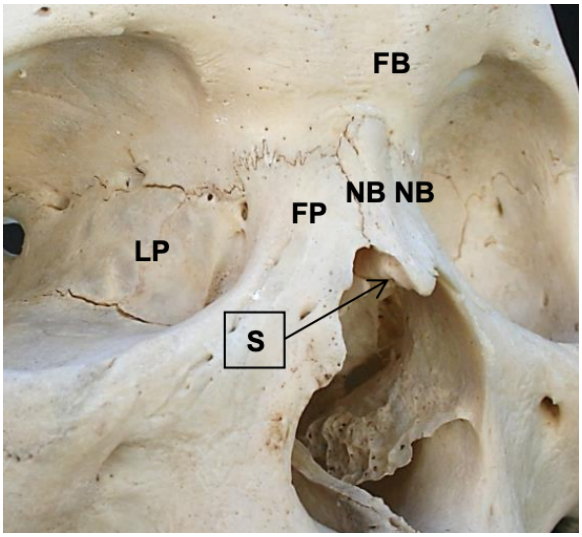


Figure 29: View of external nose: lamina papyracea (LP); nasal bones (NB); frontal bone (FB); frontal process of maxilla, bony septum (S)

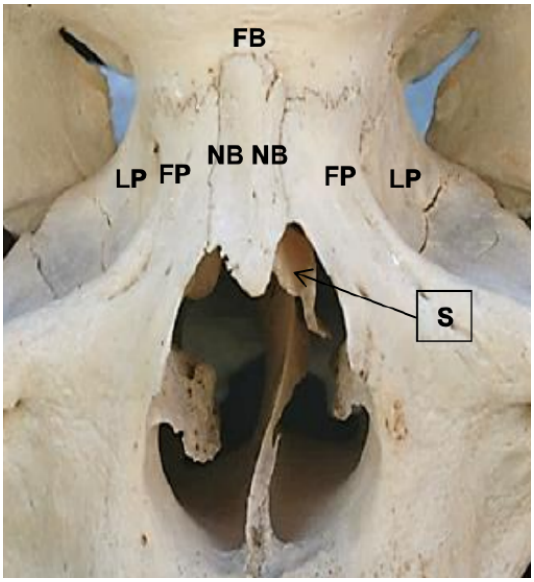


Figure 30: Anterior view of external nose: lamina papyraceae (LP); nasal bones (NB); frontal bone (FB); frontal process of maxilla (FP), bony septum (S)

Naso-orbital-ethmoid (NOE) complex fractures generally result from high-energy impact to the glabella or nasal root. Because the lamina papyraceae of the medial orbital walls are extremely thin (*Figures 29, 30*), these often fracture, resulting in posterior displacement of the nasal root. This presents a challenge because the fractures can involve the frontal sinus outflow pathways causing sinonasal dysfunction, or cerebrospinal fluid leaks.

NOE fractures are often best visualized with axial CT scans; both bony and soft tissue windows should be reviewed, particularly in the orbital region. Coronal images are helpful to delineate the floor of the anterior cranial fossa.

Surgical access may be technically challenging; accurate reduction and fixation are even more demanding. Fixation of these fractures can be achieved using microplate systems (1.0-1.3 mm with 2-3 mm screws). Fractures of the orbital floor are can be repaired using bone grafts, titanium mesh, porous polyethylene (PPE) sheets, composite PPE and titanium mesh, or resorbable materials.

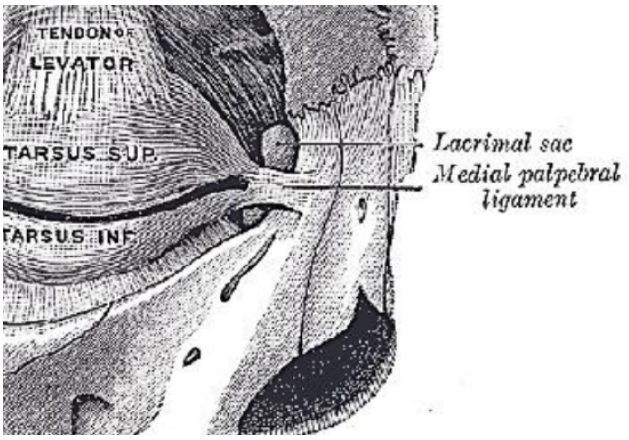


Figure 31: Medial canthal ligament

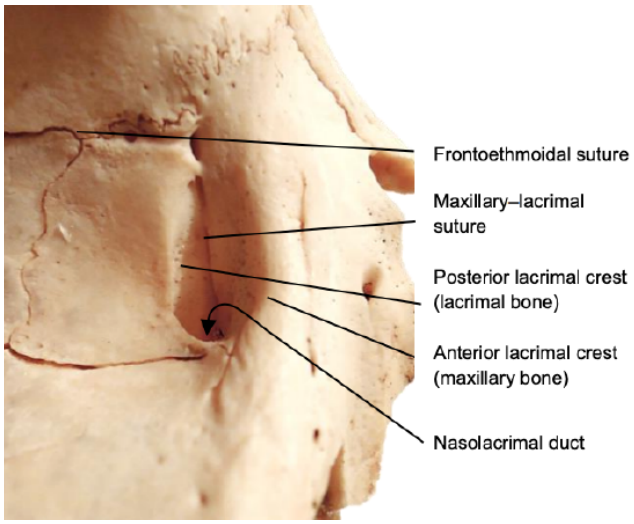


Figure 32: Anterior and posterior lacrimal crests are formed by the maxillary and lacrimal bones

The ***medial canthal ligaments*** represent the medial extensions of the orbicularis oculi muscles and are of importance in the management of NOE fractures (*Figure 31*).

The ligaments split into two primary components prior to their attachments to the anterior and posterior lacrimal crests, with some superior extensions as well (*Figure 32*). Fractures can displace the medial canthal ligaments resulting in malposition of the globe e.g. telecanthus.

The initial examination of the patient with an ***orbital wall fracture*** should include a thorough ophthalmologic examination with particular attention to extraocular muscle function and visual acuity. If either of these is compromised one should consult an ophthalmologist.

Orbital blowout fractures with herniation of orbital soft tissue into the maxillary or ethmoid sinuses and result in decreased orbital volume (enophthalmos) or diplopia due to entrapment of extraocular muscles causing limitation of ocular movements. Diplopia is a common consequence of orbital blowout fractures.

Entrapment of extraocular muscles requires immediate surgical intervention. Delay in reconstituting the periorbita and the entrapped muscle can result in fibrosis of the tissues and permanent diplopia. If a blowout defect is large enough to permit substantial herniation of tissue, hypoglobus and/or enophthalmos can result. In such defects, it is uncommon to have entrapment of extraocular muscles.

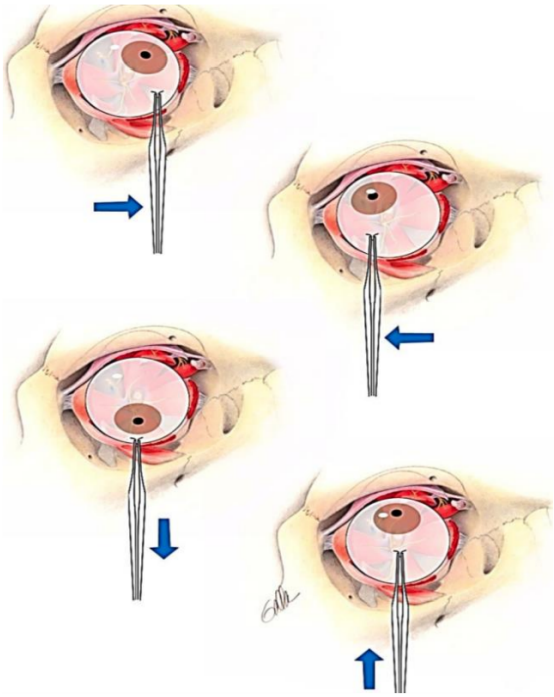


Figure 33: Forced duction testing

In a patient unable to cooperate with the physical examination, ***forced duction or traction testing*** (*Figure 33*) can be used to determine the presence of mechanical restriction of ocular motility.

The bulbar conjunctiva is anesthetized topically, and the conjunctiva is grasped near the limbus with toothed forceps. The globe is then moved into the direction in which the mechanical restriction is suspected.

Fractures of the orbital apex or optic canal are not common. In cases of traumatic optic neuropathy, magnetic resonance imaging (MRI) should be employed prior to decompression. (See chapter: Endoscopic transnasal optic nerve decompression)

Isolated Nasal Fractures

More than 1/3 of facial fractures affect the nasal complex[17]. Examine the external nose and nasal cavity thoroughly. Nasal fractures can be present without causing nasal deformity or airway obstruction.

Epistaxis can be controlled in several ways. Initial management may involve pinching the cartilaginous nasal walls against the nasal septum for 15 minutes. If this fails, then the nose is suctioned and oxymetazoline is sprayed into the nose for vasoconstriction and the cartilaginous nose is again pinched for 15 minutes. If this fails, one may elect to insert absorbable or non-absorbable packing in the nasal cavities. Absorbable nasal packing is preferred because it avoids traumatizing the fragile nasal mucosa.

It is important to perform an ***endonasal examination*** to rule out a ***septal hematoma*** as it must be evacuated to prevent a septal abscess or septal necrosis[18]. Drainage is performed by incising the septal mucoperichondrium. Silastic splints are placed endonasally to oppose the mucoperichondrial flaps against the septal cartilage.



Figure 34: Undisplaced nasal fracture that can simply be observed

Nasal fractures are reduced only if the patient has aesthetic or functional complaints. It is the authors' opinion that ***radiographic examination is unnecessary in clinically undisplaced nasal fractures*** (*Figure 34*). Such patients are simply reminded to avoid contact sports while the nasal bones heal.

Because ***initial soft tissue swelling*** may mask a displaced bony fracture, it is prudent to re-examine such a patient once the soft tissue swelling has subsided. Timely reduction of fractures is important as delays make manipulation of fractured bone fragments very challenging and may lead to malunion. Although it may be possible to achieve a closed reduction up to 3 weeks after injury, it is preferable to perform the reduction within 10-14 days.



Figure 35: Asch septum-straightening forceps and Boies nasal fracture elevator

Reduction of nasal fractures can often be accomplished via a closed approach. This is typically be performed under local anasthesia and insertion of nasal pledgets soaked in vasoconstrictor e.g. oxymetazoline or cocaine. An Asch septum-straightening forceps or Boies nasal fracture elevator is used to reduce the fracture (*Figure 35*). The Boies elevator is inserted endonasally on the depressed side first with the dominant hand and the surgeon's nondominant hand is placed on the nose for stability. The fracture is then reduced into place. The same process is performed on the contralateral side to reduce the fractured fragment. Adhesive strips and a splint are placed over the nasal dorsum and are removed after 5-10 days. In patients with extensive fractures, open septal fractures, or persistent deformities following closed reduction, open reduction can be considered.

Le Fort Fractures (*Figure 36*)

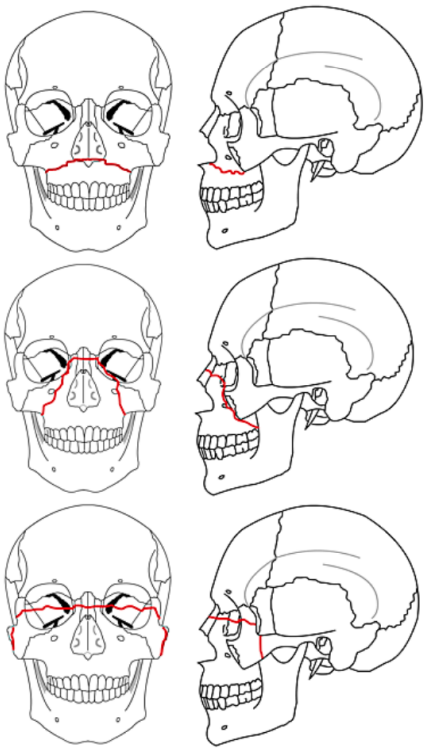


Figure 36: Le Fort I (Top); Le Fort II (Center); Le Fort III (Bottom) (Wikipedia)

Le Fort fractures typically occur in conjunction with other midface fractures. If only one side of the face is involved, it is termed a "hemi" Le Fort fracture. Le Fort I fractures traverse the maxillary alveolus through the pyriform sinus and may involve the pterygoid plates. Le Fort II fractures extend from the maxilla into the orbit in a pyramidal configuration. Le Fort III fractures are complete craniofacial dissociation.

Although these fracture patterns are useful descriptors to communicate between providers, craniomaxillofacial surgeons should describe each fracture in detail on each side of the face, also including fractures of the frontal bone and mandible. Miniplate systems (1.5-2.0 mm with 4-6 mm screws) are ideal for fixation of lower midface fractures.

Zygomaticomaxillary complex fractures



Figure 37: Fracture of zygomaticomaxillary complex with impingement of coronoid process of mandible

Zygomaticomaxillary complex fractures involve the zygomatic arch, in addition to disruption of its articulations with the frontal, sphenoid, maxillary and temporal bones. Axial CT scans readily identify such fractures (*Figure 37*).

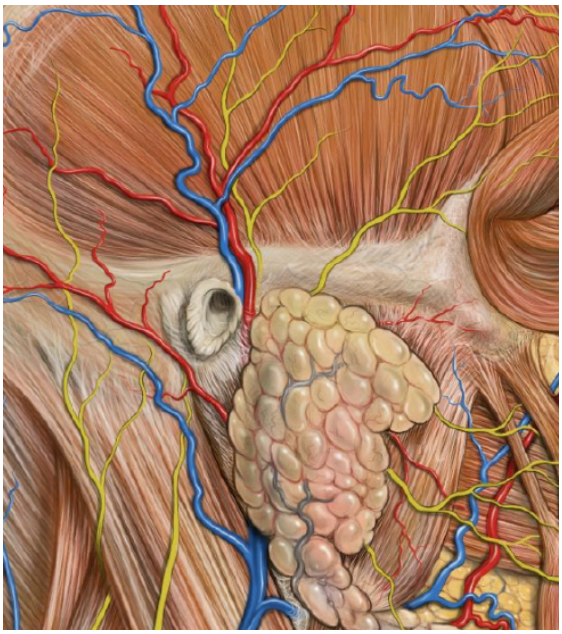


Figure 38: Frontal branch of facial nerve

These fractures are reduced using approaches highlighted earlier. Plating can be challenging in this region because of the proximity of the frontal branch of the facial nerve to the zygoma (*Figure 38*).

Mandible fractures

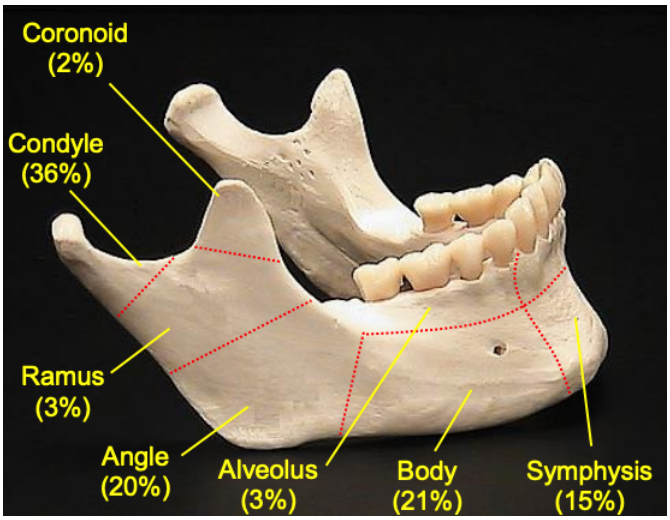


Figure 39: Mandible fracture frequencies. (From Cheney ML. Facial Surgery 1st Ed)

Mandibular fractures are the second most prevalent type of facial fracture[19] and most commonly involve the condylar region, followed by the body and angle (*Figure 39*).

Fractures can be described ***as greenstick, simple, or compound***. Greenstick fractures entail injury to only one surface of the bone and are common in the pediatric population because of the flexibility of the young skeleton. A simple fracture is a fracture not involving the intraoral mucosa. Compound fractures, also known as open fractures, involve exposure of bone by violations of soft tissue. Comminuted fractures have multiple fragments of bone disassociated from one another.

Open reduction and internal fixation of mandible fractures can be straightforward as with parasymphyseal fractures, or very challenging as in subcondylar fractures. Consequently, complication rates following mandible fracture repair are significant. A recent series of >500 mandible fractures revealed an overall complication rate of 26% with hardware failure being the most common[20]. The authors found that ***antibiotic use did not decrease infection rates***, but that patients with systemic medical conditions and smokers had higher risks of postoperative complications.

Substantial variations exist in treatment of mandibular fractures around the globe. Otolaryngologists, plastic surgeons, and oromaxillofacial surgeons all operate on the mandible and come from different training backgrounds, which likely accounts for some of the variations in treatment. Nonetheless there are several aspects of treatment that ought to be practiced universally.

The 1st step is to determine if the patient's dentition is adequate for placement of maxillo-mandibular fixation (MMF). In the edentulous patient, open reduction and internal fixation (ORIF) is necessary for repair of displaced mandible fractures, whereas in the dentate mandible, if teeth are present on both the mesial and distal aspects of the fracture line, ORIF or closed reduction are both reasonable options.

Closed reduction is an option for non- or minimally-displaced simple fractures that can undergo MMF. A comorbid condition that may preclude ORIF e.g. a medically unstable patient, is also an indication for closed reduction. Closed reduction is accomplished with placement of ***arch bars and the application of dental wiring to achieve MMF***. The MMF is released 6 weeks later and fracture stability is assessed. If the patient remains in occlusion, then he/she should be placed on a soft diet and arch bars should be removed 2 weeks later. Postoperative panorex examination can be helpful to assess bony alignment and occlusion.

Mandibular symphysis, parasymphysis, and body

- Expose the fractures via a transoral incisions.
- Typically, an incision is made in the sublabial mucosa of the lower lip approximately 1 cm from the labial sulcus
- Sharp dissection is continued through periosteum
- A periosteal elevator is used to expose the fracture sites

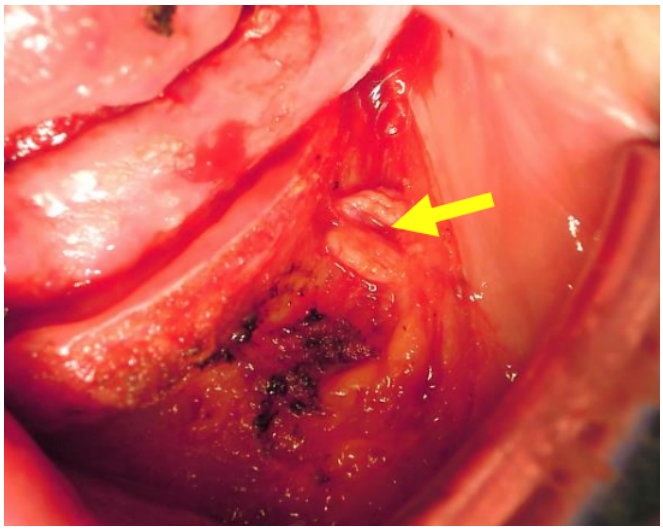


Figure 40: Mandible exposed via intraoral approach; note mental nerve exiting the left mental foramen

- The mental nerve is at risk during this dissection as it exits the mandible between the 1st and 2nd premolar teeth (*Figure 40*)
- Blunt dissection can be used to free the nerve from surrounding soft tissue; this permits greater exposure of the labial surface of the mandible
- ***Open reduction and internal fixation of symphyseal and parasymphyseal fractures*** can be accomplished using lag screws, a lag screw and plate, plate and arch bar, or two plates
  - Fractures medial to the mental foramina can be treated using placement of two lag screws
  - A lag screw with plate should be used when placement of only one lag screw is possible
  - These fractures can also be stabilized using two miniplates - one at the superior border of the mandible inferior to the tooth roots, and one at the inferior border of the mandible. Two screws should be present on either side of the fracture
  - Complex anterior fractures often require placement of a load-bearing reconstruction plate
- ***Simple fractures of the mandibular body*** in patients who are not candidates for ORIF can sometimes be treated with closed reduction, although ORIF is preferred, and can be achieved using lag screws, one Champy plate (in certain circumstances), two plates, or one large reconstruction plate (in special circumstances).

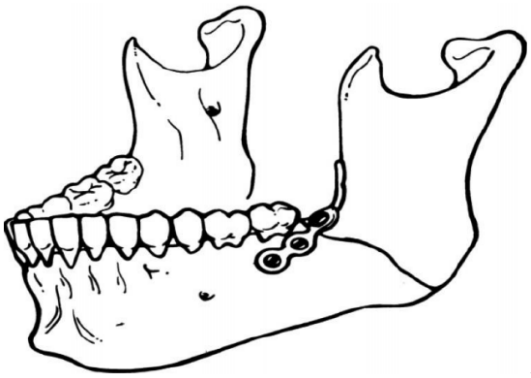


Figure 41: Champy plate[21]

Complex body fractures often require two plates or a reconstruction plate with at least three or four screws on each side of comminution. Wire fixation is possible in some cases of simple angle and ramus fractures when augmented with 6 weeks of postoperative MMF if plates are unavailable.

Severely comminuted mandible fractures

This requires reduction of multiple small fragments and is often best managed via a transcutaneous approach.

- Typically make a skin incision in a skin crease approximately 2 cm below the inferior margin of the mandible.
- Dissect through the platysma.

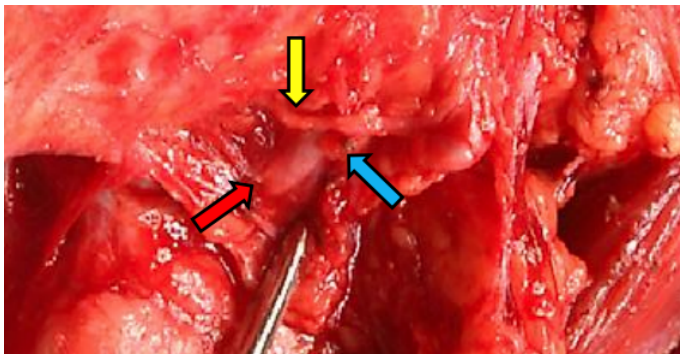


Figure 42: Transcutaneous exposure of left mandible with marginal mandibular nerve (yellow arrow) crossing facial artery (red arrow) and ligated vein (blue arrow)

- Incise and reflect the fascia overlying the submandibular gland superiorly to protect the marginal mandibular branch of the facial nerve (*Figure 42*)
- Identify and ligate and divide the facial artery and vein if necessary (*Figure 42*)
- Incise the mandibular periosteum to expose the fracture site

Mandibular ramus or subcondylar fractures

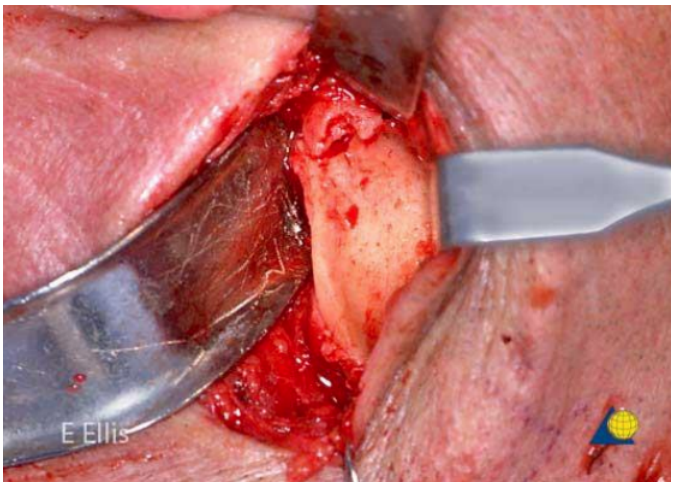


Figure 43: Retromandibular approach (left)

These can be accessed via retromandibular (rhytidectomy) approaches (*Figure 43*). While it permits excellent access to the posterior mandible, it does ***carry a great risk of damage to the facial nerve***. Even slight traction on the facial nerve can cause postoperative dysfunction which can be disturbing for patients. For this reason, endoscopic approaches to the subcondylar region, although technically challenging, are also be used.

Condylar process and condylar head fractures Treatment can be complex, and can entail observation, closed reduction, or ORIF based on the extent of injury[5].

Useful Resource

AO Surgery: Guide to Maxillofacial Trauma: (Highly recommended)

References

1. Lee K. Global Trends in Maxillofacial Fractures. Craniomaxillofacial trauma & reconstruction 2012;5:213-22
2. Bisson JI, Shepherd JP, Dhutia M. Psychological sequelae of facial trauma. J Trauma 1997;43:496-500
3. Manson PN. Facial bone healing and bone grafts. A review of clinical physiology. Clin Plast Surg 1994;21:331-48
4. CMF. (Accessed December 17, 2013, at https://www2.aofoundation.org/wps/po...soloState=true
5. Wilde F, Lorenz K, Ebner AK, et al. Intraoperative imaging with a 3D C-arm system after zygomatico-orbital complex fracture reduction. J Oral Maxillofac Surg 2013;71:894-910
6. Hughes MS, Moghadamian ES, Yin LY, et al. Comparison of bulb syringe, pressurized pulsatile, and hydrosurgery debridement methods for removing bacteria from fracture implants. Orthopedics 2012;35: e1046-50
7. Adalarasan S, Mohan A, Pasupathy S. Prophylactic antibiotics in maxillofacial fractures: a requisite? J Craniofac Surg 2010;21:1009-11
8. Morris LM, Kellman RM. Are prophylactic antibiotics useful in the management of facial fractures? Laryn-goscope 2013
9. Manson PN, Hoopes JE, Su CT. Structural pillars of the facial skeleton: an approach to the management of Le Fort fractures. Plast Reconstr Surg 1980;66:54- 62
10. Cheney ML. Facial surgery: plastic and reconstructive. Baltimore: Williams & Wilkins; 1997
11. Rai A, Datarkar A, Borle R, Rai M. Comparative assessment between eyelet wiring and direct interdental wiring for achieving intermaxillary fixation: a prospective randomized clinical study. J Oral Maxillofac Surg 2012;70:1914-7
12. Santosh BS, Giraddi G. Transconjunc-tival preseptal approach for orbital floor and infraorbital rim fracture. J Maxillofac Oral Surg 2011;10:301-5
13. Polligkeit J, Grimm M, Peters JP, et al. Assessment of indications and clinical outcome for the endoscopy-assisted combined subciliary/transantral approach in treatment of complex orbital floor fractures. J Craniomaxillofac Surg 2013;41:797-802
14. Moe K. The precaruncular approach to the medial orbit. Arch Facial Plast Surg 2003;5:483-7
15. Bly RA, Su D, Hannaford B, et al. Computer modeled multiportal approaches to the skull base. J Neurol Surg Part B, Skull base 2012; 73:415-23
16. Lim JH, Sardesai MG, Ferreira M, Jr., Moe KS. Transorbital neuroendoscopic management of sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa. J Neurol Surg Part B, Skull base 2012;73:394-400

17. Illum P, Kristensen S, Jorgensen K, et al. Role of fixation in the treatment of nasal fractures. Clin Otolaryngol Allied Sci 1983;8:191-5
18. Landis BN, Borner U. Septal hematoma: always think about it! J Pediatrics 2013;163:1223
19. Hwang K, You SH. Analysis of facial bone fractures: An 11-year study of 2,094 patients. Indian J Plast Surg: official publication of the Association of Plastic Surgeons of India 2010; 43:42-8
20. Gutta R, Tracy K, Johnson C, et al. Out - comes of Mandible Fracture Treatment at an Academic Tertiary Hospital: A 5-Year Analysis. J Oral Maxillofac Surg 2014
21. Singh RK, Pal US, Agrawal A, Singh G. Single miniplate osteosynthesis in angle fracture. Natl J Maxillofac Surg 2011;2: 47-50

Authors

Prabhat K. Bhama, M.D., M.P.H.
Staff Surgeon
Department of Otolaryngology
Alaska Native Tribal Health Consortium
Anchorage, Alaska, USA
pbhama@gmail.com

Mack L. Cheney, M.D.
Chair, Office of Global Surgery
Professor, Division of Facial Plastic and Reconstructive Surgery
Department of Otolaryngology
Harvard Medical School/Massachusetts Eye and Ear Infirmary
Boston, Massachusetts, USA
mack_cheney@meei.harvard.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

André Bandiera de Oliveira Santos, Claudio Roberto Cernea

Skin cancer is the most common cancer among Caucasians. The most common histological types are basal cell carcinoma (BCC), squamous cell carcinoma (SCC) and melanoma. Head and Neck Surgery (HNS) has its role in the treatment of advanced cases of the most frequent types and in the treatment of rare tumors.[1]

BCC

The incidence of BCC is the highest of all malignant tumors. However, it is difficult to quantify, as notification is not mandatory in most countries. It is estimated to have an incidence between 500 and 1000 cases / 100,000 inhabitants, i.e. at least 100 times higher than the incidence of oral cancer in the United States.[2]

There are several treatment modalities with cure rates of the order of 95%. Eighty percent of BCCs are of the head and neck. Curettage, cryotherapy, electrocoagulation, photodynamic therapy and topical chemotherapy can be performed with high success rates, especially in early cases. The most commonly used treatment is conventional surgical excision.[3]

The small number of cases referred for surgery are advanced, sometimes due to the patient's neglect of the tumor, difficulty in accessing specialised care, and failure of previous treatments. The most common site is the nose, and there are reports of younger mean age for patients treated by head and neck surgery specialists, when compared to those treated by dermatologists.[1,4]

There are at least 8 histological subtypes of BCC: nodular, superficial, morpheaform (sclerodermiform), metatypical, micronodular, sclerosing, pigmented, and adenoid.

The occurrence of more than one subtype in a single tumor is common. The nodular and superficial subtypes are the most prevalent and the least aggressive, with a lower probability of relapse. The subtypes micronodular, metatypical and morpheaform present more aggressive characteristics and are more likely to relapse.[5]

Clinically, nodular BCC presents as an elevated, nodular lesion, with well-defined borders, a reddish-brown, pearly, shiny color and with teleangiectases on the borders, sometimes ulcerated. The superficial BCC has the same characteristics without the appearance of a nodule. Much less characteristic, the morpheaform sub-type presents as a reddish, brown or even whitish plaque, resembling sclerodermia, with a poorly defined border. This characteristic is due to the presence of collagenase at the extremities of the tumors which may present with finger-like extensions, sometimes called pseudopods.[4] In these cases, the margins of surgical resection are uncertain and should be confirmed by frozen section examination until complete resection of the lesion. Most of the time the diagnosis is made only after biopsy and the professional can only then plan the surgery.[6]

In cases of locally advanced tumors, there is a need for histopathological confirmation with incisional biopsy by an experienced pathologist, to determine a diagnosis and permit the correct therapeutic planning. The clinical characteristics described above do not always apply to large lesions, since there is often significant tissue destruction and loss of tissue differentiation.[7]

For surgical planning, computed tomography with contrast should be performed in 2 cases where there is suspicion of invasion of deep planes, especially bony, cartilaginous and parotid. In cases of suspected invasion of the skull base, MRI should be requested.[8]

The location of a BCC is important because of the likelihood of recurrence. High risk areas are nose, eyelids, periorbita, periorally, chin, mandibular, preauricular, postauricular, ear and temporal. Factors such as immunosuppression and previous radiotherapy also increase the chance of relapse, as well as the occurrence of scleroderma, metatypic or micronodular subtypes at any point of the tumor.[9]

Almost all of the tumors treated by head and surgeons can be classified into the high-risk group. For these lesions, excision with circumferential and deep free margins confirmed by frozen section is recommended. A 1cm margin is desirable, but is not always possible, especially on the face. Elective neck dissection is not indicated. We observed an incidence of less than 1% of cervical metastases, which is therefore a rare occurrence.[10]

Radiotherapy may be indicated in surgical cases with compromised margins where reoperation is not an option, major bone resections and invasion of the skull base. There is a good response of BCC to radiotherapy in the rare cases where surgery is not the treatment of choice.[11]

Inhibitors of the Hedgehog pathway (HH), such as Vismodegib, are oral chemotherapy options for advanced and irresectable cases. Well-tolerated, the medication presents objective results in selected cases, at a high cost.[12]

SCC

SCC is derived from the spinous layer of the epidermis and accounts for 20% of malignant skin tumors. It has a metastatic potential of around 10%. The precusor lesion is actinic keratosis. One of the lesions that presents a difficult differential diagnosis is the keratoacanthoma, a benign lesion with fast growth.[2]

Clinically, cutaneous squamous cell carcinoma may appear as a plaque or a papule. Bowen's disease and Queyrat's erythroplasia are different forms of SCC in situ. The invasive form is firm and often ulcerated. Although most cases referred to the head and neck surgeon already has been diagnosed by biopsy, it is preferable that the biopsy be reviewed or repeated in doubtful cases.

Risk factors for recurrence in SCC are:

- Location in zone "H"
- Immunosuppression
- Previous radiotherapy
- Recurrence in an operated site
- Poorly defined borders
- Rapid growth
- Neurological symptoms
- Little or moderately differentiated
- Acantholytic, adenosquamous, metaplastic or desmoplastic subtypes
- Invasion level corresponding to Clark IV or V or Breslow> 4 mm
- Vascular or perineural invasion

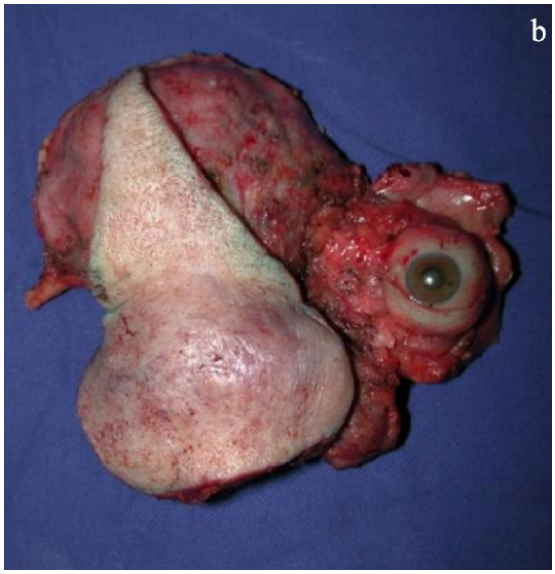
Classically, elective neck dissection is not indicated for cutaneous SCC. The search for sentinel lymph nodes in high-risk SCC is not routine and its benefit is questionable. With cervical metastases, neck dissection should be comprehensive; and with parotid metastasis, at least a supraomohyoid neck dissection should be done, in addition to parotidectomy.[13]

Radiotherapy can be used as primary treatment in nonsurgical cases. As adjuvant treatment, it is beneficial in cases of cervical metastasis revealed by neck dissection or parotidectomy, especially if there is extracapsular extension. Other indications are involved margins and perineural invasion.[11]

TNM Staging for Nonmelanoma Skin Cancer (2017)

T1 T2 T3 T4	< 2 cm > 2 cm e <4 cm ≥4 cm, deep invasion (> 6mm or beyond subcutaneous), bone erosion or perineural invasion T4a: Gross invasion of cortical bone or marrow T4b: Invasion of the base of the skull or foramina of the base of the skull
N1 N2a N2b N2c N3	ipsilateral lymph node <3 cm, without extracapsular extension ipsilateral lymph node between 3 and 6 cm, without extracapsular extension more than 1 lymph node, ipsilateral, <6 cm, without extracapsular extension Contralateral or bilateral lymph node(s) <6cm, without extracapsular extension N3a: lymph node ≥ 6 cm, without extracapsular extension N3b: lymph node (s) with extracapsular extension





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Figure 1 a-e: Recurrent BCC of glabella with invasion of glabella, orbit and skull base

Resection of high-risk head and neck tumors should be planned with 10 mm circumferential and deep free margins. Often the planning of this type of resection involves exenteration of the orbit, resection of bone, by a multimultidisciplinary team to permit large surgical approaches (*Figure 1*).

Resulting deformity requires a commonsense approach by the surgeon and a frank discussion with the patient.[14] Curative treatment is not always the best option and palliative alternatives should be considered.



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Figure 2 a-c: Patient with SCC of eyelid with orbital and skull base invasion, reconstructed with anterolateral thigh flap

With surgical planning, involvement of the surgical teams from other specialties such as plastic surgery, neurosurgery and otorhinolaryngology is required to optimize surgical outcome and functional rehabilitation (*Figure 2*).



Figure 3 a-c: Retroauricular SCC reconstructed with a trapezius flap

With the patient anesthetised, the borders of the tumor including the peripheral rim of erythema should be carefully marked. The margin should be drawn with a surgical pen or other marker before infiltration of local anesthetic. Drawing the specimen and the defect for the pathologist is desirable and assists in describing the margins (*Figure 3*). Infiltration with vasoconstricttor-containing solution can be employed as it reduces the need for electrocoagulation of the margins, contributing to better histopathological analysis. To remove the tumor, a double-bladed scalpel (1 mm distance between the blades)[15] may be used, which can be made by attaching a second blade with sterile adhesive tape.

This technique allows the removal of margins of skin that can be immediately taken to the pathologist, even prior to removal of the tumor. After removal of the lesion, the deep margin should be assessed, if possible, also with frozen section.

Melanoma

Melanocytes are cells originating from the neural crest that occupy the epidermis in its basal layer. In part because of their distinct embryological origin, melanomas have very pronounced metastatic potential.

Although it accounts for 4% of skin tumors, melanoma is the most lethal skin tumor. Its prognosis is related to tumor thickness from the granulosa layer to the deepest part of the primary lesion (Breslow index). The higher the Breslow index in millimeters, the greater the chance of lymphatic and distant metastases, especially above 1 mm.[16]

Clinically, any melanocytic lesion that changes its growth characteristics, changes color or has pruritus should be suspected.

The ABCDE rule exemplifies such characteristics - Asymmetry, irregular Borders, multiple Colors, Diameter >6 mm and Evolution. The diagnosis of melanoma is made with a biopsy, preferably excisional, or incisional in cases where the resulting defect is unacceptable.

Most of the time the head and neck surgeon receives the diagnosis of melanoma following a prior biopsy. The treatment to be followed depends fundamentally on the Breslow index.[17] It is necessary to resect a margin of macroscopic normal skin around the biopsy scar, according to Breslow index below:

Wide excision is the main treatment in patients without metastases. Treatment of the lymphatics depends on sentinel lymph node screening.

Sentinel lymph node biopsy is indicated in all patients with melanoma with a Breslow index above 1 mm without detectable metastases. Cases with Breslow between 0.75 mm and 1 mm should indicate if there is ulceration or a mitotic index other than zero.

On the day prior to surgery, the patient should have lymphoscintigraphy with technetium. The technetium is injected around the scar and the image obtained locates the first lymph node that drains the region. The nuclear physician then marks the patient's skin overlying the lymph node confirmed by the probe (probe attached to the measuring device). After anesthesia, the patent blue dye is injected (patent blue dye is permeable to lymphatic vessels, unlike methylene blue and other dyes). The recommended volume is 1mL, preferably in insulin syringe, but it is not always possible to inject all the contents, and there is the risk of permanently "tattooing" the skin in regions such as the face. For best results, the injection should be performed intradermally - below this level the drainage is impaired. Leaks from the syringe should be carefully avoided to avoid compromising the procedure.

Close proximity of the lymph node and the primary lesion (rarely with lesions outside the head and neck) may impair the investigation when using the probe. In some cases, margin resection may be necessary prior to sentinel lymph node biopsy. Intraoperative frozen section examination of sentinel lymph nodes is not currently recommended, since it may impair the study of the whole lymph node with hematoxylin-eosin and immunohistochemical study (HMB 45, melan A and protein S100), which is best performed in a block of paraffin.

Classically, the finding of a positive cervical sentinel lymph node is an indication for neck dissection of all 5 levels of the neck. Recently, in a prospective, randomised study, survival proved to be equal between serial ultrasound observation and elective neck dissection in cases with positive sentinel nodes,[18] and continues to be a subject of debate today.[17]

With parotid lymph nodes, parotidectomy and supraomohyoid neck dissection should be performed. Much controversy exists about what to do in relation to the facial nerve with intraparotid sentinel lymph nodes - due to the need for reoperation if the node is positive. We perform superficial parotidectomy if nerve dissection is required, which has been shown to be rare - in most cases the lymph nodes are close to the parotid capsule and can be safely biopsied without nerve dissection.

In cases of cervical macrometastases, neck dissection is performed according to the standard procedure for squamous cell carcinoma of mucosa of the head and neck. Preservation of structures not affected by metastases (modified radical cervical

dissection) may be performed. Locoregional control is important in melanoma and the presence of distant metastases does not contraindicate neck dissection by itself. Selected cases also benefit from metastasectomy in extra-cervical sites. The behaviour of distant metastases may be aggressive but is not infrequently slow and indolent.[17]

After neck dissection for macrometastases, complementary cervical radiotherapy is indicated. This approach is well accepted for extracapsular extension, but some studies have shown better control also for macrometastases.[17]

Staging

T	**Breslow (mm)**	
T1	≤ 1.0	A: 0- 0.8mm without ulceration B: 0.8-1mm or <0.8 with ulceration
T2 T3 T4	1.01-2.0 2.01-4.0 > 4.0	A – With ulceration B – Without ulceration

Number of metastatic lymph nodes

	Number of metastatic lymph nodes	**Metastatic lymph node mass**
N1	1 lymph node 0 lymph node	A: micrometastasis * B: macrometastasis† C: metastasis or in transit without metastatic lymph nodes
N2	2-3 lymph nodes 1 lymph node	A: micrometastasis* B: macrometastasis† C: metastasis or in transit without metastatic lymph nodes
N3	4 or more 2 or more	A: positive sentinel lymph nodes B: 4 or more, at least 1 clinically detectable or any number of coalescing lymph nodes C: two or more, with satellite metastasis or associated in transit

	Local	**DHL sérica**
M1a	Skin distant, subcutaneous, or lymph node metastasis	
M1b	Pulmonary metastasis	(0) DHL normal
M1c	All other visceral metastases	(1) DHL elevated
M1d	Metastasis to Central Nervous System	

* diagnosed after sentinel lymph node or elective lymphadenectomy

† defined as metastatic lymph node clinically confirmed by therapeutic lymphadenectomy or when lymph node metastasis exhibits gross extracapsular extravasation

Levels of histological invasion (Clark)

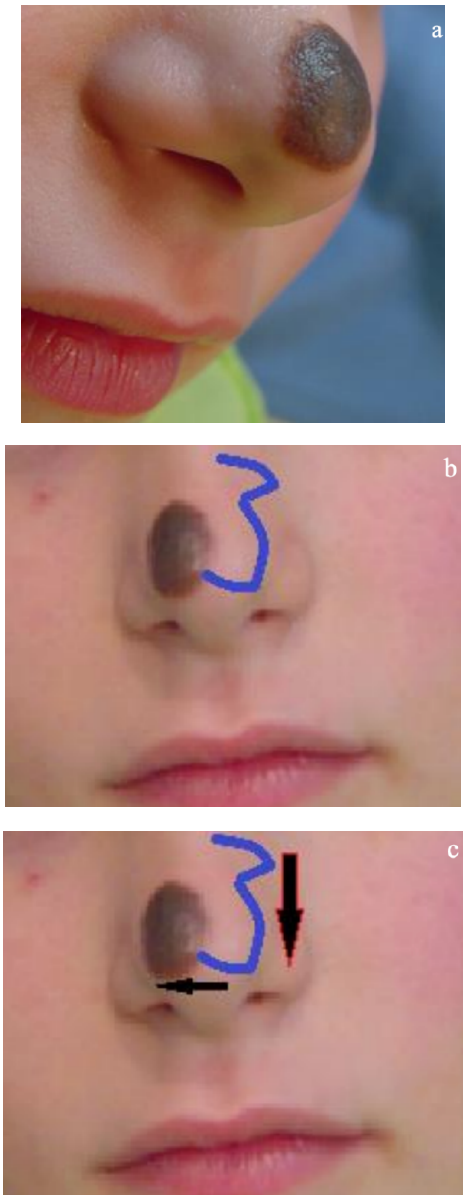
I	in situ. Entire lesion is intraepidermal
II	Beyond basement membrane. Occupies papillary dermis, does not reach the border between papillary and reticular

III	Occupies papillary dermis; reaches border between papillary dermis and reticular, without invading the reticular
IV	Includes reticular dermis
V	invades hypodermis

Clinical stages of melanoma: UICC 2017

Melanomas with Breslow > 4 mm present a >40% chance of distant metastasis. They are sometimes mistakenly thought to have such a bad outcome that it would not be worthy resecting an additional margin and treating the cervical nodes. Such a practice is unfortunately common and worsens the prognosis. Even in advanced cases, surgical treatment should always be considered, since local control is very important for treatment.

Surgery according to tumor location





Figures 4 a-d: Patient of 4 years with congenital nevus reconstructed with bilobed flap

The nose is the site of highest incidence of skin tumors on the face. Simple suturing is usually preferred when possible. Nasal tip defects smaller than 1 cm without cartilage invasion can be reconstructed with a bilobed flap from the nose itself (*Figure 4*).





Figure 5 a-b: Patient with melanoma of nasal tip, Breslow 1,3 mm, reconstructed with nasal flap

One option is the nasal sliding flap, using part of the glabella (*Figure 5*). Small nasal wing defects can be reconstructed with a superior or inferior pedicled nasogenial flap.

Small nasal dorsal defects can be reconstructed with a glabellar flap. With large resections of nasal skin without removal of cartilage, the frontal (or Indian) flap is a good option, requiring two surgical visits, the second time being scheduled three to four weeks later with transection of the pedicle. Removing nasal cartilage implies a greater complexity of reconstruction, which should include the nasal lining and possibly using auricular cartilage to replace a nasal wing.

With total or near total rhinectomy, nasal reconstruction should be an exception, as keeping the defect open may be the best option, being careful not to keep the bone exposed (often it is necessary to remove part of the nasal bone) and posterior reconstruction with a prosthesis.

With the scalp, the thickness of the primary lesion and its extension into the pericranium is important. If the pericranium can be preserved, skin grafting is a good option for most cases. However, when there is invasion and hence resection of pericranium, a scalp flap is needed to cover the exposed bone and a skin graft for the donor area.



Figures 6 a-c: Patient with eyelid melanoma, Breslow 1 mm, reconstruction with Mustardé flap

In the malar region several reconstruction options may be considered. The Mustardé flap is a good option, especially for defects near the lower eyelid (*Figure 6*). Large bilobed or rhomboid flaps can also be used, always taking care to avoid ectropion due to tension on the lower eyelid.



Figures 7 a,b: Resection of SCC of the upper lip, reconstructed with bilateral V-Y flaps

Figure 7 is an example of lip reconstruction with V-Y flaps bilaterally. The frontal and temporal regions are regions where skin grafting lends itself well, with aesthetic and functional results superior to grafting on other parts of the face and neck. Still, flap coverage should be preferred whenever possible.

A defect arising from orbital exenteration may be skin grafted directly or onto a temporalis muscle flap in order to better adapt the prosthesis.

References

1. Andrade N, Santos A, Lourenco S, esta Neto C, Cernea C, Brandao L. Epidemiological and histopathological profile of 642 cases of basal cell carcinoma of head and neck surgery in a tertiary institution Sao Paulo: Rev. Bras. Cir. Cab. Pesc.; 2011:148-53
2. Madan V, Lear JT, Szeimies RM. Nonmelanoma skin cancer. Lancet 2010;375:673-85
3. Zou Y, Zhao Y, Yu J, et al. Photodynamic therapy versus surgical excision to basal cell carcinoma: meta-analysis. J Cosmet Dermatol 2016;15:374-82
4. Rubin AI, Chen EH, Ratner D. Current concepts - Basal-cell carcinoma. N Engl J Med 2005;353:2262-9
5. Sexton M, Jones DB, Maloney ME. Histologic pattern analysis of basal cell carcinoma. Study of a series of 1039 consecutive neoplasms. J Am Acad Dermatol 1990;23:1118-26

6. Cernea CR, Dias FL, Lima RA, et al. Atypical facial access: an unusually high prevalence of use among patients with skull base tumors treated at 2 centers. Arch Otolaryngol Head Neck Surg 2007;133:816-9
7. Costantino D, Lowe L, Brown DL. Basosquamous carcinoma - an underrecognized, high-risk cutaneous neoplasm: case study and review of the literature. J Plast Reconstr Aesthet Surg 2006;59:424-8
8. Williams LS, Mancuso AA, Mendenhall WM. Perineural spread of cutaneous squamous and basal cell carcinoma: CT and MR detection and its impact on patient management and prognosis. Int J Radiat Oncol Biol Phys 2001;49:1061-9
9. Bastiaens MT, Hoefnagel JJ, Bruijn JA, Westendorp RG, Vermeer BJ, Bouwes Bavinck JN. Differences in age, site distribution, and sex between nodular and superficial basal cell carcinoma indicate different types of tumors. J Invest Dermatol 1998;110: 880-4
10. Santos AB, Andrade NM, Brandão LG, Cernea CR. Which features of advanced head and neck basal cell carcinoma are associated with perineural invasion? Braz J Otorhinolaryngol 2017; 83:94-7
11. Mendenhall WM, Ferlito A, Takes RP, et al. Cutaneous head and neck basal and squamous cell carcinomas with perineural invasion. Oral Oncol 2012;48:918-22
12. Sekulic A, Migden MR, Basset-Seguin N, et al. Long-term safety and efficacy of vismodegib in patients with advanced basal cell carcinoma: final update of the pivotal ERIVANCE BCC study. BMC Cancer 2017;17:332
13. O'Hara J, Ferlito A, Takes RP, et al. Cutaneous squamous cell carcinoma of the head and neck metastasizing to the parotid gland - a review of current recommendations. Head Neck 2011;33: 1789-95
14. Cernea CR, Ferraz AR, de Castro IV, et al. Perineural Invasion in Aggressive Skin Carcinomas of the Head and Neck. Orl-J Oto-Rhino-Laryngology and Its Related Specialties 2009;71:21- 6
15. Cernea CR, Velasco O, Gomes MQ, et al. Double-bladed scalpel: a new option for harvesting margins in head and neck cancers. ORL J Otorhinolaryngol Relat Spec 2006;68:83-7
16. Balch CM, Gershenwald JE, Soong SJ, et al. Final version of 2009 AJCC melanoma staging and classification. J Clin Oncol 2009;27:6199-206
17. Coit DG, Thompson JA, Algazi A, et al. Melanoma, Version 2.2016, NCCN Clinical Practice Guidelines in Oncology. J Natl Compr Canc Netw 2016;14: 450-73
18. Faries MB, Thompson JF, Cochran AJ, et al. Completion Dissection or Observation for Sentinel-Node Metastasis in Melanoma. N Engl J Med 2017;376: 2211-22

Readers are also referred to the Open Access Atlas chapters:

- Local flaps for facial reconstruction
- Sentinel lymph node biopsy (SLNB) techniques for cutaneous and mucosal malignancy of the head and neck

Authors

André Bandiera de Oliveira Santos
Head and Neck Surgeon,
Faculty of Medicine
University of São Paulo, Brazil
andre_bandiera@yahoo.com.br

Claudio Roberto Cernea
Professor
Faculty of Medicine
University of São Paulo, Brazil
cerneamd@uol.com.br

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CHAPTER OVERVIEW

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2.1: Local and Regional Anesthesia Techniques for Otologic Ear Surgery

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Alexander Bien, Richard Wagner, Eric Wilkinson

The logistics of performing otologic (ear) surgery in developing countries and in humanitarian settings are challenging. Implementing the use of local anesthesia to perform middle ear and mastoid surgery in such situations has many advantages.

This article will outline the rationale for local anesthesia in otologic surgery as well as educate the reader about local anesthetic agents and the anatomy of the ear that allows local anesthesia to be an effective means under which to perform otologic procedures.

Rationale for Local Anesthesia

Performing otologic procedures under local anesthesia - as opposed to general anesthesia - has many advantages in a humanitarian setting. Depending on the specific setting, the main impetus for performing a procedure under local anesthesia may be the lack of trained anesthesia support. In the absence of trained anesthesia staff in the form of anesthetists or nurse anesthetists, local anesthesia is the safest option. Thus, ***safety is a primary advantage***.

Another reason is the potential for the lack of adequate and/or functional anesthesia machines and monitoring equipment. Not only must there be a functioning anesthesia machine that can deliver inhaled anesthetic agents and assume ventilatory functions, but there must also be other equipment to ensure adequate and monitored delivery of these functions. This includes a reliable pulse-oximeter, EKG machine, blood pressure monitor, and end-tidal CO_2 monitor. Even if inhaled agents were not used and adequate anesthesia was attained with injectable agents alone, such a propofol, most of these “ancillary” monitoring devices would still be needed. Again, this returns to the issue of safety.

Another reason is that of ***recovery time and turnover; the ability to perform more cases in a shorter amount of time***. Time is of the essence in the humanitarian setting, even more so than in a Western medical setting. A humanitarian mission may be limited to a certain number of days or even daylight hours. The capacity to perform even one additional case in any given day may translate into the benefit of many - depending on the duration of the outreach - more patients. No time needs to be allotted for the reversal of anesthesia and the monitoring needs during recovery are minimal - limited primarily to observation. Most, if not all, of these concerns are eliminated with the use of purely local anesthetic.

Neurovascular Anatomy of the Ear

The ear is complex in terms of its neurovascular composition, but an understanding of these elements is crucial in the successful application of local anesthesia in otologic surgery. With that in mind, it bears mention that the goal of local anesthesia (with vasoconstrictive agents), especially in ear surgery, is not simply anesthesia so that the patient feels no pain, but also hemostasis so the surgeon feels no pain! For this reason, a discussion of the relevant anatomy for the practice of local anesthesia in otologic surgery must include not only the neural innervation of the ear but also its vascular supply.

Vascular supply

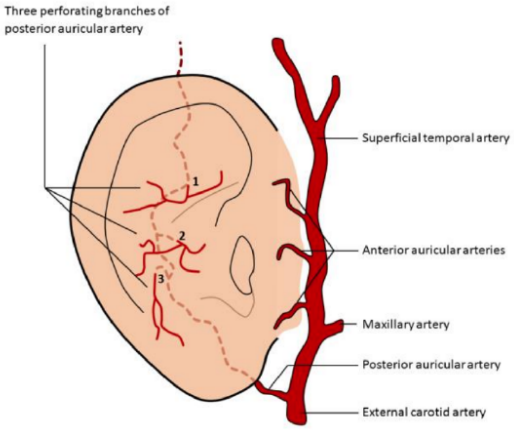


Figure 1: Arterial supply to external ear

As evidenced by its brisk bleeding if lacerated and its ability to heal after injury, the auricle has a robust blood supply.[2] The ***external ear*** receives its blood supply from the two terminal branches of the external carotid: the ***posterior auricular artery and small auricular rami of the superficial temporal artery*** (*Figure 1*).

These same two arteries supply the external ear canal with the addition of the ***deep auricular artery***. The deep auricular artery branches from the first part of the internal maxillary artery, passes through the substance of the parotid gland and behind the temporomandibular joint to penetrate and ***supply the medial portion of the external ear canal***.



Figure 2: Representation of the arterial supply of the tympanic membrane from both the small peripheral arterioles and the larger manubrial artery, both branches of the deep auricular artery (Adapted from Hollinshead, 1982)

The ***tympanic membrane*** receives its blood supply from several sources. Owing to its position anatomically, its vasculature is derived from those vessels supplying the middle ear and external auditory canal. Working from lateral to medial, the outer surface has the same supply as does the medial portion of the external ear canal: the ***deep auricular artery***. The deep auricular artery gives off branches that form a ***vascular ring*** around the tympanic membrane but also gives off a more prominent twig, the ***descending or manubrial artery***, that descends along the manubrium of the malleus (*Figure 2*).

The ***medial, or mucosal, surface of the tympanic membrane*** is supplied by branches from the ***anterior tympanic branch of the internal maxillary artery*** and from the ***stylomastoid branch of the posterior auricular artery*** [1].

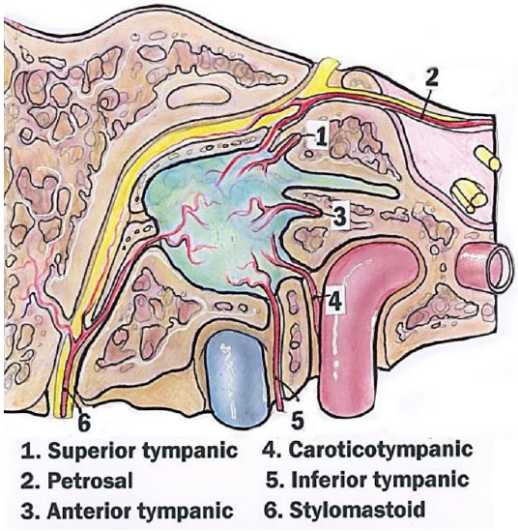


Figure 3: Contributions to the arterial supply of the middle ear (Adapted from Hollinshead, 1982)

The blood supply of the ***middle ear and mastoid*** arises primarily from the external carotid system. Four arterial contributions arise from the external carotid artery. Two of these contributors are the ***anterior tympanic artery*** that arises from the internal maxillary artery and the ***inferior tympanic artery*** that arises from the ascending pharyngeal artery. The other two are the stylomastoid artery that arises either from the posterior auricular or occipital arteries, and the middle meningeal artery that arises from the internal maxillary artery (*Figure 3*). After entering through the stylomastoid foramen, the ***stylomastoid artery*** gives off the posterior tympanic artery that enters the middle ear, as well as giving off branches to the mastoid air cells. The ***middle meningeal artery*** supplies two arteries to the middle ear: the petrosal and superior tympanic arteries. Finally, there can be several branches off of the internal carotid artery that enter through the caroticotympanic canal to supply the middle ear.

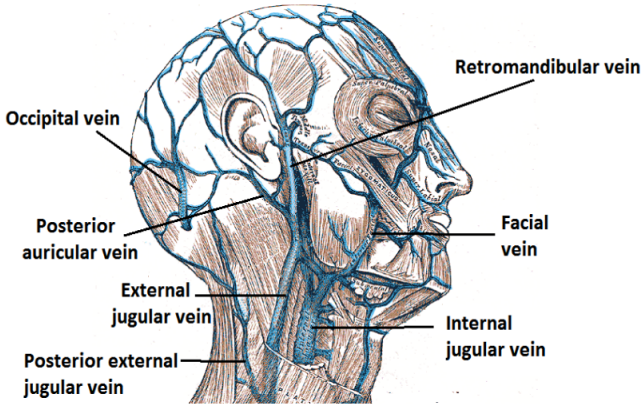
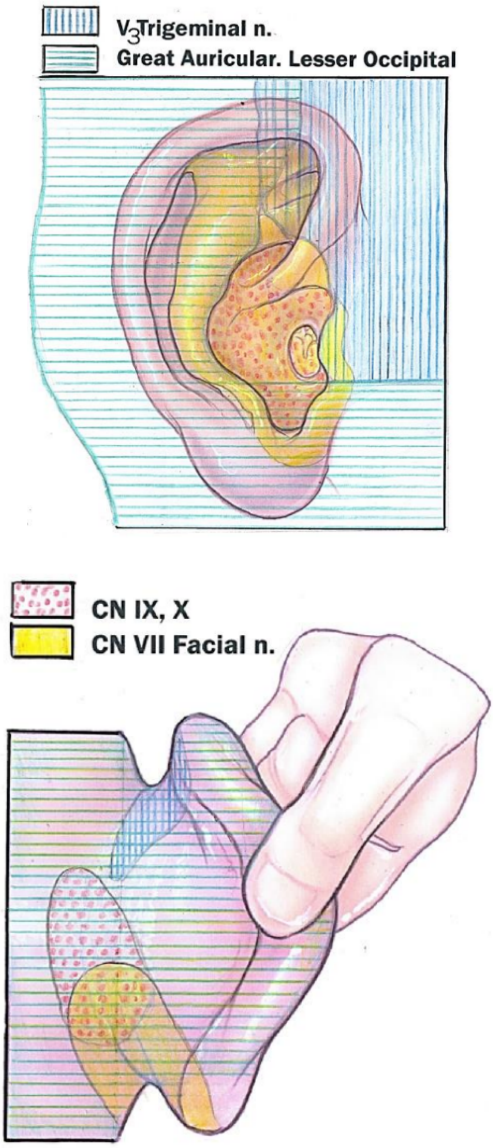


Figure 4: Venous drainage of external ear

Venous drainage of the external ear is via the ***superficial temporal*** and ***posterior auricular veins*** into the retromandibular and the external jugular veins respectively (*Figure 4*). Ultimately, the retromandibular vein splits to drain into the internal and external jugular veins; on occasion, the posterior auricular vein will drain directly to the sigmoid sinus via the mastoid emissary vein[1].

Nerve supply



Figures 5a, b: Cutaneous innervation of the lateral and posterior aspects of the auricle by the trigeminal nerve, the cervical plexus, the 7th cranial nerve, and the 9th and 10th cranial nerves (Adapted from Hollinshead, 1982)

Innervation of the auricle has been explained in exquisite detail elsewhere[2], but an overview of the main contributing nerves will be undertaken here. Sensation to the external ear is provided by several cutaneous branches of cranial nerves as well as by cutaneous branches of the cervical plexus. This is reflective of the origin of auricular skin that originates from both brachial and post-brachial components[1]. There is invariably some overlap in the innervation from person-to-person, but the contributions are relatively constant (*Figures 5a, b*).

A branch of the mandibular division of the trigeminal nerve (V3), the auriculotemporal nerve, supplies the anterior portion of the external ear, the crus of the helix, and the tragus. This same nerve supplies the anterior and superior walls of the external auditory canal[1, 3]. A majority of the remaining lateral, posterior, and medial portions of the ear - excluding the concha are supplied by cutaneous branches of C2 and C3 via the great auricular nerve. The C2 and C3 roots of the cervical plexus also supply the skin overlying the mastoid via the lesser occipital nerve[1].

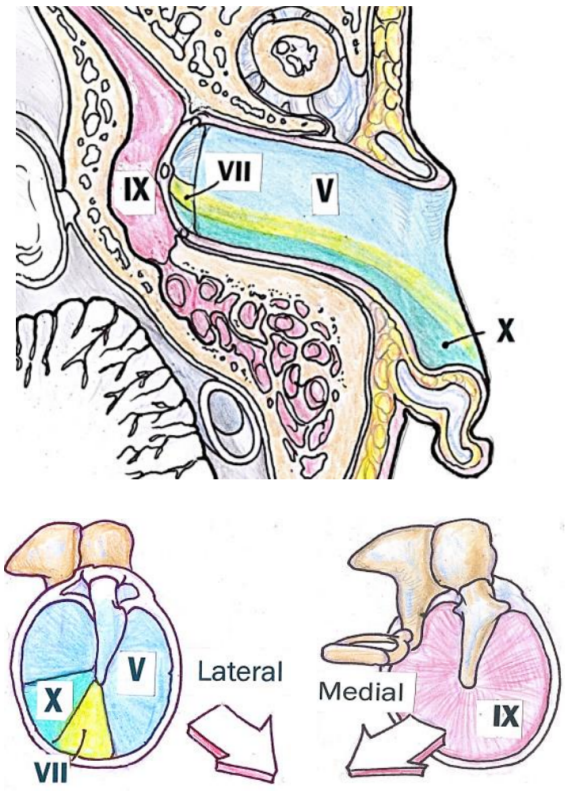


Figure 6: Innervation of external auditory canal, tympanic membrane, and middle ear (Adapted from Hollinshead, 1982)



Figure 7: Pattern of neural innervation of the external tympanic membrane. Notice its similarity to the vascular topography of the external tympanic membrane (Figure 3) (Adapted from Hollinshead, 1982)

The concha of the external ear has similarly complex and overlapping sensory innervations. Branches of the 7th (facial), 9th (glossopharyngeal), and 10th (vagus) cranial nerves supply this area. At least two of these cranial nerves (7th and 10th), and possibly the 9th, also supply the posterior external auditory canal. All three of these nerves reach their ultimate points of innervation via the auricular branch (Arnold's nerve) of the vagus nerve. Arnold's nerve arises from the superior jugular ganglion and eventually emerges through the tympanomastoid fissure. Along its course, it picks up the auricular branch (not the tympanic branch) from the 9th along with a branch from the posterior auricular branch of the facial nerve[1, 3]. In a similar fashion to the external ear, the ***tympanic membrane*** is innervated by several different nerves (*Figures 6, 7*). Just as the auriculotemporal branch of V3 supplies the anterior and superior aspects of the external ear canal, so too does it supply the anterior and superior aspects of the external tympanic membrane. Along those lines, the 7th, 9th, and 10th cranial nerves innervate the posterior portion of the external auditory

canal as well as the posterior portion of the tympanic membrane via the auricular branch of the vagus nerve[1]. The medial portion of the tympanic membrane and middle ear are similarly innervated primarily by the tympanic plexus of the glossopharyngeal nerve (*Figure 6*).

The topography of nerves on the external surface of the tympanic membrane closely follows that of its vascularity (*Figures 4 & 7*).

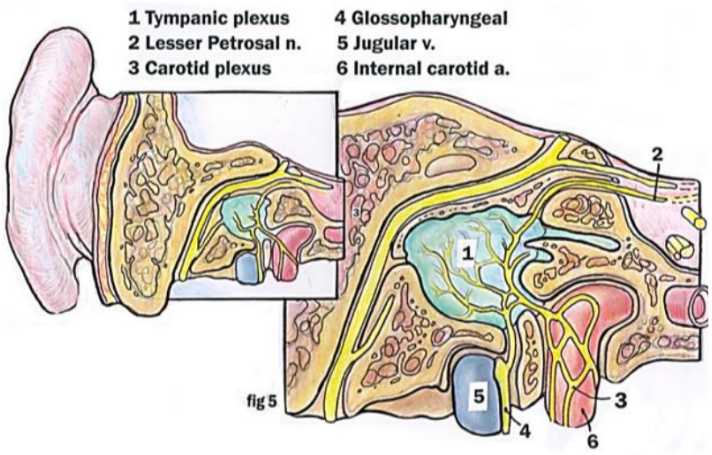


Figure 8: Contributions to tympanic plexus (Adapted from Hollinshead, 1982)

As just mentioned, the middle ear is innervated primarily by the tympanic branch (Jacobson's nerve) of the glossopharyngeal nerve. Upon entering the middle ear during surgery, this nerve can often be clearly seen coursing over the promontory. Jacobson's nerve combines with caroticotympanic nerves from the carotid plexus to form the tympanic plexus (*Figure 8*).

In addition to providing sensory fibers to the mucosa of the middle ear, the tympanic plexus also gives off branches to the entire tympanic cavity, mastoid air cells, and Eustachian tube.

Local Anesthetic Agents

Having reviewed the neurovascular anatomy of the ear, obtaining some general knowledge of the properties, varieties, and mechanisms of the various local anesthetics is useful prior to exploring some specific applications of these agents.

The primary action of local anesthetics is well-known. The ultimate effect of local anesthetics is the inhibition of nerve impulse propagation. This blockage occurs because of the inhibition by the local anesthetic of influx of Na+ ions, thus preventing an action potential and nerve depolarization. The precise mechanism that prevents sodium influx is thought to involve specific binding sites within sodium channels located in the cell membrane of the nerve, but the exact mechanism by which this occurs is less clear[4, 5].

Two Main Classes

There are ***two main classes*** of local anesthetics based on their chemical structures and the way in which they are metabolized: ***amino esters and amino amides***. Technically there is a newer, 3rd class of local anesthetic, where an agent in one of the other classes is transformed into a novel agent by creating a chiral form. This is done by creating one of two stereoisomers of one of the more traditional local anesthetics that possess novel properties[5].

Ester-type local anesthetics possess a CO-O, or ester linkage, while amide local anesthetics possess an N-H, or amide linkage. Ester-type local anesthetics are metabolized by the plasma enzyme pseudocholinesterase to paraaminobenzoic acid (PABA). Three of the most commonly used ester-type local anesthetics are procaine, tetracaine, and cocaine.

The second class of local anesthetic is composed of those of the ***amide-type***. This class is metabolized by microsomal enzymes in the liver. A few of the most commonly used amide-type local anesthetics are lidocaine, bupivacaine, and mepivacaine[4]. A stereoisomer of bupivacaine, called ropivacaine, is a member of the third chiral-form class of local anesthetics.

Durations of action

In most otologic procedures, the time frame usually does not exceed 3 hours, so any of the more commonly used agents e.g. Lidocaine or Mepivacaine, should suffice. The duration of action of lidocaine with epinephrine is the order of 4 hours - more than enough time to complete most otologic procedures. The duration of mepivacaine with epinephrine is even greater - around 6 hours.

Both lidocaine and mepivacaine have rapid onset of action. On the other hand, the commonly used ester-type agent, procaine, has a relatively short duration of action - 45 minutes without and about 90 minutes with epinephrine[6].

Maximum dose

For 1% (10 mg/mL) lidocaine the maximum dose should not exceed 4.5 mg/kg, and used with epinephrine this maximum dose can be as high as 7 mg/kg. For mepivacaine, the maximum allowable dosage is 5 mg/kg without and 7 mg/kg with epinephrine. If a large area of skin is going to be anesthetized, then a relatively low concentration of the agent should be used so as not to exceed the maximum dose allowed. In such a situation, for instance, the concentration of lidocaine could be decreased from 1% or 2% down to 0.5%.

Sensitivity/allergy

Another very important factor to account for in choosing a local anesthetic is a patient's sensitivity to, or history of allergic reaction to, a given anesthetic. As a class, the ***ester-type local anesthetics carrier a much higher risk of adverse, or allergic, reaction*** as compared to the amide class of local anesthetics. One of the primary metabolites for two of the most commonly used local anesthetics in the ester class, procaine and tetracaine, is PABA. Therefore, neither of these agents should be used in patients who are allergic to PABA.

Sedatives and Anxiolytics

Preoperative or intraoperative sedatives or anxiolytic agents can be used in combination with local anesthesia. Agents such as benzodiazepines (Valium®) are very effective anxiolytic drugs and can be used as an adjuvant to local anesthesia. Other agents such as meperidine (Demerol®), an analgesic with sedative properties, or hydroxylzine (Vistaril®), an older antihistamine, can also be used. However, if the choice is made to add these other agents to a purely local anesthetic case, then additional monitoring and resuscitation equipment such as EKG and pulse-oximetry is advisable. Also, rescue drugs such as Narcan® should be on hand. Overall, the addition of adjuvant agents adds another layer of complexity, partly detracting from the attractiveness of performing a case under strictly local anesthesia.

Local Anesthesia in Ear Surgery

Advantages of Local Anesthesia in Ear Surgery

Local anesthesia is an accepted method by which to perform otologic surgery, is used routinely, and has many advantages over general anesthesia.

- Safety is superior to that of general anesthesia. This includes avoidance of intubation and elimination of the remote possibility of laryngotracheal complications as well as removal of any potential for cardiopulmonary complications related to general anesthetic agents
- Less bleeding (although most surgeons still use injectable and topical local anesthesia during general anesthesia)
- Ability to assess a patient's hearing and detect any vertigo during surgery (especially valuable during stapedectomy)
- Avoidance of a potentially lengthy and/ or disruptive emergence from anesthesia (advantageous in stapes surgery and ossicular reconstruction procedures)
- Less postoperative nausea and vomiting
- Less expensive[3]

Auricular Injection Techniques

Several techniques have been advocated, and are generally "variations on a theme". Hence only a few methods will be addressed in detail.

Plester injection technique (*Figures 9-12*)

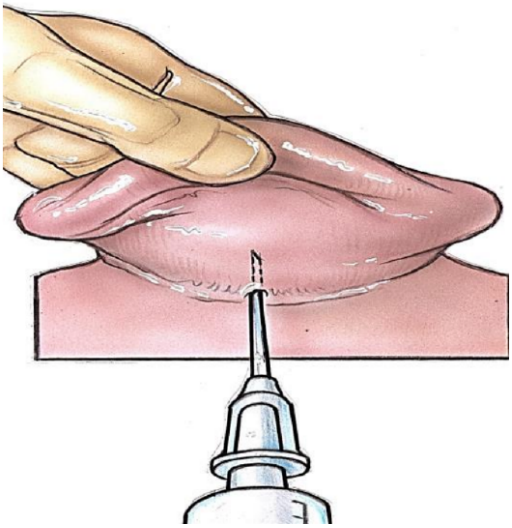


Figure 9: Postauricular injection technique proposed by Plester (From Yung 1996)

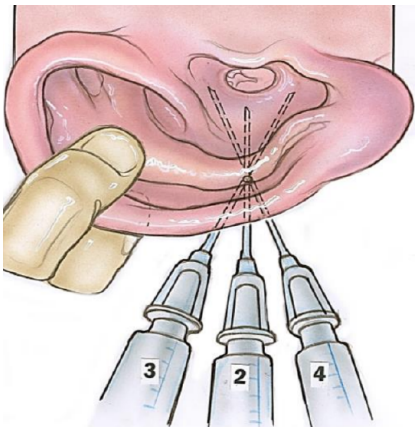


Figure 10: Postauricular injection Steps 2-4 of Plester technique (From Yung 1996)

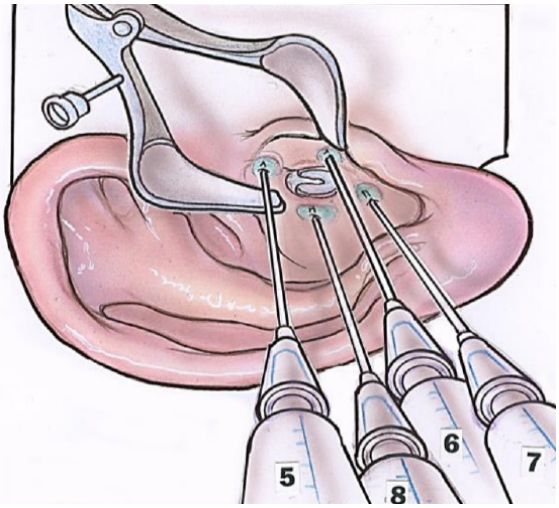


Figure 11: Canal injection steps 5-8 of Plester technique (From Yung 1996)

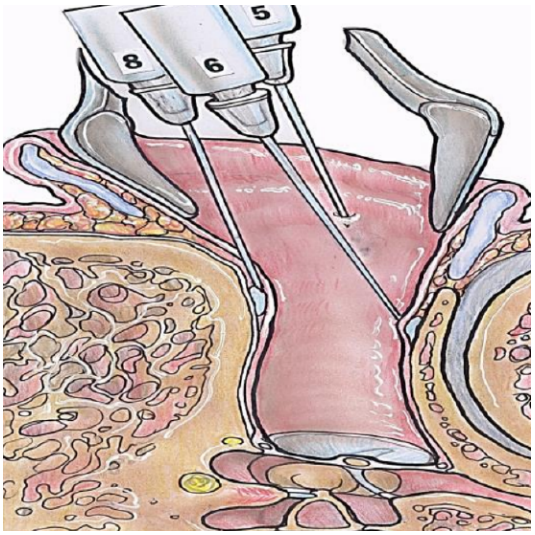


Figure 12: Axial view of canal injection of Plester technique (From Yung 1996)

- Step 1: Inject the region of the postauricular fold (*Figure 9*)
- Steps 2 - 4: Without removing the needle in Step 1, advance the needle in 3 vectors: directly toward the posterior external ear canal, superior to the external ear canal and inferior to the external ear canal (*Figure 10*)
- Steps 5 - 8: Inject the 4 quadrants of the ear canal in a stepwise fashion (*Figures 11 & 12*)[7]. This anesthetizes the external ear canal while at the same time achieving hemostasis of the skin of the ear canal and tympanic membrane. Take care during each of the canal injection steps to avoid the formation of hematomas or vesicles that could impair healing or obscure the tympanic membrane during surgery[7].

Fisch injection technique

Fisch's technique uses fewer injection sites and the sites are differently placed[5].

- Insert the needle about 1 cm behind the postauricular crease at a point halfway between the mastoid tip and the top of the ear

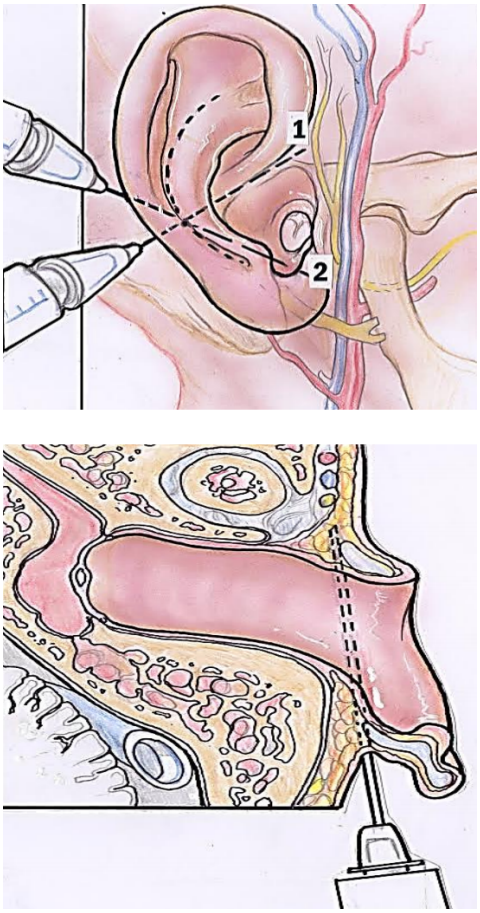


Figure 13: Fisch postauricular injection technique (from Lancer and Fisch 1988)

- Pass the needle anteriorly and inferiorly toward the tympanomastoid sulcus and inject local anesthetic lateral to, but overlying the stylomastoid foramen (*Figure 13*)
- Direct a 2nd needle pass anterosuperiorly toward the incisura and inject more local anesthetic (*Figure 13*)
- Wait 10 minutes [3] (In general, this is advisable when working under local anesthesia also to allow more time for vasoconstriction to occur
- Inject the external ear canal; Fisch's technique differs from that of Plester in that only one canal injection is performed initially. This initial injection is placed superiorly in the region of the tympanosquamous suture line. After this initial canal injection, the other areas of the canal are tested for sensitivity and the other quadrants are injected only if needed

A drawback of the Fisch technique is a high risk of temporary facial nerve paresis due to injection in the region of the stylomastoid foramen; this can be very distressing for the patient and surgeon alike. Using this injection technique in a series of 32 patients, Fisch reported that 97% developed a temporary postoperative facial weakness. For this reason we recommend that no injections be administered below the level of the external auditory canal.

Additional Intraoperative Analgesia

More local anesthetic can be administered in any of these local anesthetic techniques if the patient feels pain during the surgery. However the surgeon should ensure that a running total of the amount of local anesthetic agent is kept so as not to exceed the maximum allowable dose.

Jacobson's nerve (supplies the middle ear mucosa) can be anesthetized if a patient experiences pain during the ***middle ear part of the procedure***, by the placing a cotton ball or gelfoam soaked with 1% lidocaine or 4% tetracaine[7] on the promontory.

Field blocks

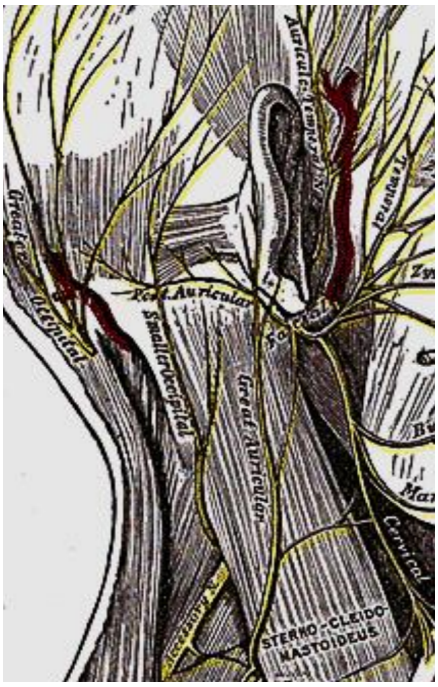


Figure 14: Nerves suitable for field block: greater auricular, auriculotemporal and lesser ("smaller") occipital nerves; note superficial temporal artery

Field block is a form of regional anesthesia that takes advantage of the subcutaneous course of somatosensory cutaneous nerve branches. A larger area can be anesthetized with fewer injections by infiltrating the region of the course of any given nerve. Ideally, this injection is done in an area more proximal than the area in which an incision is going to be made so as to provide anesthesia distal to the injection site. It requires less anesthetic agent to be used as well as keeping the incision site undistorted[5]. Field blocks require an understanding of the anatomy of auricular innervation. Nerves amenable to a field block for ear surgery are the auriculotemporal, greater auricular, and the lesser occipital nerves (*Figure 14*).

Auriculotemporal nerve field block

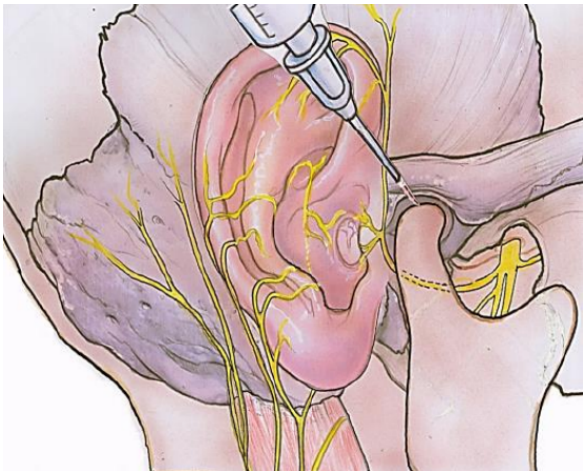


Figure 15: Auriculotemporal nerve block.

The auriculotemporal nerve exits from the parotid gland in front of the ear (*Figure 15*). The area to infiltrate is located by palpating the superficial temporal artery as it passes over the zygoma (*Figure 14*). The injection is placed in between this point and the incisura - near the root of the zygoma. About 2-3 mL of local anesthetic is used to block the nerve[5].

V3 nerve regional block

A more complete, truly regional auriculotemporal nerve block can be achieved by performing a V3 nerve block. This block provides excellent anesthesia over the bulk of the cheek along with the upper preauricular and auriculotemporal hair covered regions. The anesthetized area abuts the region supplied by the great auricular nerve more posteriorly[8].

- Palpate the sigmoid notch of the mandible as an initial landmark. The notch is located inferior to the zygomatic arch about 2.5 cm anterior to the tragus
- While placing a finger in the area of the notch and asking the patient to open the mouth; the mandibular condyle is felt sliding under the examiner's finger
- Ask the patient to close the mouth; the examining finger will stay in the notch
- Mark this point with a marking pen
- Inject a small volume of local anesthetic in this area before proceeding to perform the block
- Insert a 5 cm spinal needle perpendicular to the skin at the site where you marked the sigmoid notch (*Figure 15*)
- At a depth of about 4 cm, the needle will hit the lateral pterygoid plate
- Withdraw the needle almost to the skin and redirect it 1 cm posterior to the 1st pass, and to the same depth
- Aspirate to ensure that the tip of the needle is not in a vessel
- Slowly inject 3-4 mL local anesthetic

Greater auricular nerve field block

The great auricular nerve block numbs the lower third of the ear and the lower postauricular skin (*Figure 14*). We describe two techniques below.

The first technique blocks the nerve more proximally and is therefore more of a regional block.

- Identify the anterior and posterior borders of the sternocleidomastoid muscle, and draw parallel lines to delineate these borders of the muscle
- Draw a third line parallel to and in the middle of these two lines to mark the middle of the muscle
- Draw a line from the inferior edge of the external auditory canal 6.5 cm inferiorly to meet the midline mark on the sternocleidomastoid
- At this point, inject a few ml of local anesthetic[8]

The alternative technique takes advantage of the fact that the nerve exits from around the posterior border of the sternocleidomastoid muscle and then splits into anterior and posterior branches (*Figure 14*). By locating the mastoid tip and injecting local anesthetic both anterior and posterior to the mastoid the two branches of the nerve can be blocked[5].

Lesser occipital nerve block

A lesser occipital nerve block anesthetizes most of the skin overlying the mastoid.

- Locate the posterior border of the origin of the sternocleidomastoid muscle at the base of the skull (*Figure 14*)
- Introduce a needle at this point directly posteromedial and slightly cephalad until the bone of the calvarium is reached
- Withdraw the needle by few millimeters
- Aspirate to ensure that he tip is not in the occipital artery
- Inject a few ml of local anesthetic

Vagus nerve field block

Although usually anesthetized during the infiltration of other regions of the postauricular sulcus, the auricular branch of the vagus can be pinpointed and blocked by injecting local anesthetic where the nerve exits the skull base between the mastoid process and the tympanic plate[9].

Other nerves

Even though the concha and middle ear mucosa are innervated by the 7th and 9th cranial nerves, these nerves are not amenable to a regional block. Anesthesia in the distribution of these nerve can be achieved by local infiltration of the external ear canal and topical anesthesia to the middle ear.

Effectiveness of Local Anesthesia for Middle Ear Surgery

Several authors have commented on the effectiveness of local anesthesia for otologic surgery. Caner reported on 100 consecutive patients undergoing various middle ear procedures under local anesthesia with IV sedation, including mastoidectomy[10]. In this paper, 96% of patients who underwent stapes surgery or tympanoplasty alone said that they had no pain during surgery; of all patients 22% said that pain was distressing. The most distressing experiences were anxiety (44%) and noise created by the procedure (33%). However 73% of patients in this study said they would have a similar operation done again under local anesthesia. Furthermore, only one patient had a transient facial weakness. In a similar paper by Yung, 108 patients that underwent

various otologic procedures including mastoidectomy reported similarly favorable results[7]. The most frequent complaints were that of noise during the operation (30%) and anxiety (24%). Interestingly, otalgia was reported as the lowest specified discomfort (2%). As in Caner's paper, a high percentage (89%) reported that they would prefer local anesthesia for a similar procedure. Lancer and Fisch also reported a high success rate with local anesthesia and that both patients and surgeons were highly satisfied with local anesthesia that there had been no adverse effects[3]. One major concern of the latter paper was the 97% rate of transient (partial to total) facial nerve paralysis. Although transient, it was still unpleasant for a significant number (55%) of patients. These few studies corroborate the notion that otologic surgery done under local anesthesia is not only and effective technique, but was acceptable to both patient and surgeon. It should be noted, however, that in all these studies adjuvant sedation was used in addition to local anesthesia.

References

1. Hollinshead WH. Anatomy for sur geons: Vol 1. The head and neck. Philadelphia: Lippincott Williams & Wilkins; 1982
2. Peuker ET, Filler TJ. The nerve supply of the human auricle. Clin Anat 2002; 15:35-7
3. Lancer JM, Fisch U. Local anesthesia for middle ear surgery. Clin Otolaryn gol 1988;13:367-74
4. Auletta MJ, Grekin RC. Local anesthesia for dermatologic surgery. New York: Churchill Livingstone; 1991
5. Raj PP. Textbook of regional anesthesia. New York: Churchill Livingstone; 2002
6. McLeod IK, Gallagher DJ III, Revis DR, Seagle MB. "Local Anesthetics." eMedicine. July 22, 2008. May 28, 2010 http://emedicine.medscape.com/article/873879-overview
7. Yung MW. Local anesthesia in middle ear surgery: survey of patients and surgeons. Clin Otolaryngol 1996;21: 404-8
8. Zide BM, Swift R. How to block and tackle the face. Plast Reconstr Surg 1998;101:840-51
9. Cousins MJ, Bridenbaugh PO. Neural blockade in clinical anesthesia and management of pain, 3rd Ed. Philadelphia: Lippincott-Raven; 1998
10. Caner G, Olgun L, Gültekin G, Aydar L. Local anesthesia for middle ear surgery. Otolaryngol Head Neck Surg 2005; 295-7

Authors

Alexander G. Bien, M.D
St. Louis
Missouri, USA
bienag@gmail.com

Richard Wagner, M.D., F.A.C.S.
Director
Global ENT Outreach
Coupeville, WA, 98239, USA
rwagner@geoutreach.org

Eric P. Wilkinson, M.D., F.A.C.S.
House Clinic 2100 W. Third Street, #111
Los Angeles, CA 900 USA
ewilkinson@hei.org

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.2: Otology Outreach Surgery in Developing Countries Under Local and Regional Anesthesia- Techniques and Pitfalls

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Richard Wagner, Greg Torr

This chapter describes some techniques to safely perform middle ear and mastoid surgery in outreach ear surgery programs and discusses tips and pitfalls. It should be read in conjunction with the chapter: Local and regional anesthesia techniques for otologic (ear) surgery which provides a more detailed account of local anesthesia technique for ear surgery.

When surgeons travel to developing countries to do outreach ear surgery, they often lack the convenience of having a qualified anesthetist, trained recovery room staff, adequate monitoring equipment for safe general anesthesia, and are faced with long lines of patients requiring ear surgery. It is under such circumstances that ear surgery is ideally done under local or regional anesthesia.

Performing otology procedures under local, as opposed to general anesthesia has many advantages and can be described as “God’s Gift to Otology”. It allows one to perform middle ear surgery and monitor vestibulocochlear function without expensive (and often unavailable) equipment, along with reducing risks associated with general anesthesia.

It is critical that the surgeon has both the level of experience and comfort to perform middle ear surgery under local anesthesia with sedation. Although rather rare (<1% of cases), situations do arise when even an experienced surgeon must abandon an operation or convert from local to general anesthesia to complete the surgery.

Even qualified anesthetists may lack experience with using only a limited range of drugs to provide IV sedation. Under such circumstances it may be important that the surgeon assist the anesthetist to select the appropriate drugs that will provide sufficient hours of analgesia and sedation.

Caveat: Intravenous sedation can be a dangerous practice if performed without adequate monitoring or if the sedation practitioner is unfamiliar with the agents presented to him/her.

Rationale of ear surgery under local anesthesia with sedation

Safety: Patient safety is the priority when performing surgery. Safety of properly administered local anesthesia with intravenous sedation is well established providing that the attending surgeon have both the experience and confidence in the practice of local/regional anesthesia and sedation.

Reliability: As long as patients are selected according to the criteria listed below and reliable drugs are administered, the methods described provide a reliable alternative to general anesthesia in >90% of cases.

Anesthetic technique and safety: In developing countries there is a greater risk of anesthetic-related complications or deaths due to frequent use of non-physicians to administer anesthesia, inadequate monitoring equipment, and unreliable drugs. It is the surgeon’s responsibility to manage the operating theater and to lead the surgical team, which includes communicating with the anesthetist and agreeing on drugs to use to achieve adequate levels of anesthesia of sufficient duration.

Comorbidities: Unrecognized and untreated comorbidities can cause complications 2 and even deaths. In patients with known comorbidities, local anesthesia with sedation is a safer technique to employ.

Shorter recovery room time: Patients are essentially awake immediately after the surgery and go to the recovery room for observation to ensure that there is no rebound respiratory compromise and that vital signs are stable. Intravenous sedation therefore requires a shorter recovery room time than general anesthesia and patients are generally ready for discharge after being observed for 30 minutes.

Intraoperative monitoring of vestibular, cochlear and facial nerve function: A patient in a semiconscious state can respond to questions during surgery; hence the surgeon can assess the ossicular chain reconstruction intraoperatively. With stapes surgery, vestibular function can be ascertained and errors such as inserting a too long piston can be avoided. While removing bone from the facial ridge during canal wall down mastoidectomy, the facial nerve can be monitored by watching the face and by asking the patient to smile or open the eyes.

The Patient

Not all patients are suited to ear surgery under local anesthesia with IV sedation.

Age: Patients should be at least 18 years old to understand the concept of undergoing ear surgery while awake. Younger children tend to be too anxious and are less understanding. Older patients can cause problems as sedative drugs dosages need adjustment and a cautious titrated approach is advised to avoid excessive sedation.

Prior surgery: Patients who have had prior ear surgery frequently do not tolerate revision surgery under local anesthesia. This may be because fibrosis and scarring inhibit delivery of lidocaine to the surgical field to ensure adequate anesthesia.

Mental status: Very fearful or anxious patients, or those with underlying mental conditions are not considered ideal candidates.

Counseling and consent

Once a patient has been counseled about risks, benefits and surgical options, then administration of anesthesia is discussed. The surgeon counsels the patient about the diminished risks of local anesthesia compared to general anesthesia, and the benefits in terms of being able to monitor cochleovestibular function during surgery and to optimize hearing outcome.

Fasting

The patient should be starved for a minimum of 6 hours (adults) prior to surgery, even if general anesthesia is not anticipated.

Monitoring during middle ear surgery

Patients receiving IV sedation and local anesthesia for middle ear surgery need to be carefully monitored. A pulse oximeter, EKG machine, and blood pressure monitor need to be used. However, in developing countries there is often not a functioning anesthetic machine, there may not be inhalational agents, or monitoring equipment, trained anesthetists or nurse anesthetists.

Pulse oximetry: Pulse oximetry is critical to monitor blood oxygen saturation. Oxygen saturation should be maintained at 90-100%. When supplemental oxygen is not available, careful monitoring is even more critical to avoid over-sedation, depressed breathing, hypoxia and hypercarbia. One may even have to assist ventilation with an Ambu bag. Treatment of low oxygen saturation with supplemental oxygen is only a short term solution and can mask a greater problem... that of hypoventilation and hypercarbia. If it is possible, rather communicate with the patient and encourage deep breathing maneuvers.

Blood pressure: Hypertensive patients require medication to make them normotensive. It occurs more commonly with patients who have undiagnosed hypertension and should be detected during preoperative medical screening. Hypertension can be severely exacerbated by systemic absorption of the adrenaline/epinephrine in the dental cartridges of Lignocaine/Lidocaine. In such cases consideration might have to be given to using local anesthetic without adrenaline/epinephrine, or to postpone surgery until the patient is normotensive.

EKG monitoring: The pulse and EKG tracing may reveal tachycardia following injection of epinephrine. The tachycardia is usually short-lived, and usually settles after 3-5 minutes. Alternatively, a gentle massage of the carotid artery may help. Rarely a short-acting beta-blocker can be administered.

Resuscitation equipment

Equipment for resuscitation in the event of an adverse reaction to any of the local anesthetics, sedatives and/or antibiotics must not only be present and in working order, but the practitioner needs to familiarize him/her with their use and function. These include a powerful suction machine and airway suction device e.g. Yankhauer sucker, a working laryngoscope (and spare bulbs and batteries), endotracheal tubes of appropriate sizes, and an Ambu bag.

Drugs

Emergency drugs that must be available include Adrenaline/Epinephrine, Atropine, steroids and antihistamines.

Drugs are employed to achieve analgesia such that patients do not feel pain and to achieve sedation such that they are less aware of the surgery and anxiety is minimal. You have to plan to have the correct drugs available to use, or adapt your anesthetic technique to the drugs that are available.

Lidocaine (1% or 2%) is appropriate for local analgesia. Its analgesic effect lasts 2-4 hours (majority of middle ear surgeries take 98% of cases, which is well below the maximum adult dose of lidocaine of 7 mg/kg.

Adrenaline (epinephrine) provides hemostasis and a dry surgical field. Half a ml (half an ampoule) of adrenaline 1:1000 is added to 9 mL of lidocaine drawn up into a 10 mL syringe to achieve a concentration of lidocaine:epinephrine of 1:30,000. It is well tolerated by patients; although rarely a patient might develop tachycardia which usually subsides within <5 minutes.

Systemic analgesia is administered intravenously in combination with the injection of lidocaine & epinephrine, e.g. Fentanyl, morphine sulphate, or Meperidine (Demerol). With all systemic analgesics it is ***imperative to monitor the patient's breathing and oxygen saturation***. The choice of intravenous analgesic often depends on its availability. Because the 1st author most frequently encounters fentanyl on his travels, it is his 1st-line agent. In the average person weighing 130-150 lbs (59- 68 kg), he starts by titrating 50 µg of fentanyl. A further 50 bolus can be given if the patient tolerates this well without hypoventilation. For patients with a body mass closer to 200 pounds (91 kg) he uses up to 125-150 µg of fentanyl (titrated). In countries like American Samoa where the body mass index is of the highest in the world, it is not unusual to administer up to 300 µg of Fentanyl. With Demerol, the author generally administers about 75 mg for an average sized person; for morphine sulfate, he administers 7.5-10 mg.

Benzodiazepines are used to reduce anxiety. The author generally uses diazepam (valium) or Midazolam (Versed). The author prefers diazepam because of its slower onset and longer action. Diazepam is however frequently not available, while Midazolam is generally available in developing countries. Midazolam has a much more rapid induction and shorter duration of action but has a higher risk of respiratory depression.

Note that a ***combination of Benzodiazepines and Opioids can be additive***, especially in patients that are drug/medication-naïve. Caution should be exercised when administering these medications and a titrated approach is advised, starting with smaller doses and working up to those stated above.

Reversal agents: It is strongly advised that the operator familiarizes him/herself with Opioid and Benzodiazepine reversal agents and their use and doses in the event of over-sedation.

- *Naloxone*: 1 ampoule = 0.4 mg. Dilute into 4 mL with saline and titrate 1 mL/0.1 mg IVI every 2-3 minutes until the patient recovers consciousness and (airway) reflexes.
- *Flumazenil*: Comes as a 0.1 mg/mL preparation. Dosage 0.2mg IVI titrated every 2 minutes until consciousness is regained.
- *Overdosing* with either of these drugs can cause hypertension and severe pain.

Microscopes



Figure 1: Older model Zeiss (OPMI-1) operating microscope with incandescent bulb



Figure 2: OPMI-1 incandescent light bulb

In many developing countries it is difficult to secure a functioning operating microscope. Frequently we find an old Zeiss microscope that uses an incandescent light bulb (*Figures 1, 2*). One should enquire what microscope is to be used and ensure that spare light bulbs are available or bring light bulbs along. Even though these microscopes work well, the light intensity is poor when compared to new microscopes.

The objectives should be 10x power and a 250 mm lens is preferred. A 300 or 200 mm lens can also be used as long as one refocuses the eyepieces to their limits to adjust for the best depth of field. To provide live video for teaching one should take along a beam splitter; video adapter; C-mount coupler; video camera, and appropriate video cables. The camera is attached to a computer monitor or TV depending on the output connection. (VGA, HDMI, DVI, S-video) (*Figure 3*). It is therefore important to contact your host to find out what monitors are available.

Endoscopic ear surgery

The author favors the microscope, but endoscopic surgical techniques may have advantages for middle ear surgery in outreach settings as the equipment is compact and portable. See chapter: Endoscopic cholesteatoma, tympanoplasty and middle ear surgery. However, one requires a very cooperative patient as the head has to be kept very still throughout the procedure to avoid the endoscope injuring the ear should the head suddenly move. It should also be noted that patients in developing countries usually have much more advanced ear disease because the diagnoses are usually delayed. Therefore, especially in patients with cholesteatoma, a canal-walldown modified or radical mastoidectomy is generally preferred and is performed easier with a microscope than an otoscope.

Operating room setup and positioning (Figure 3)

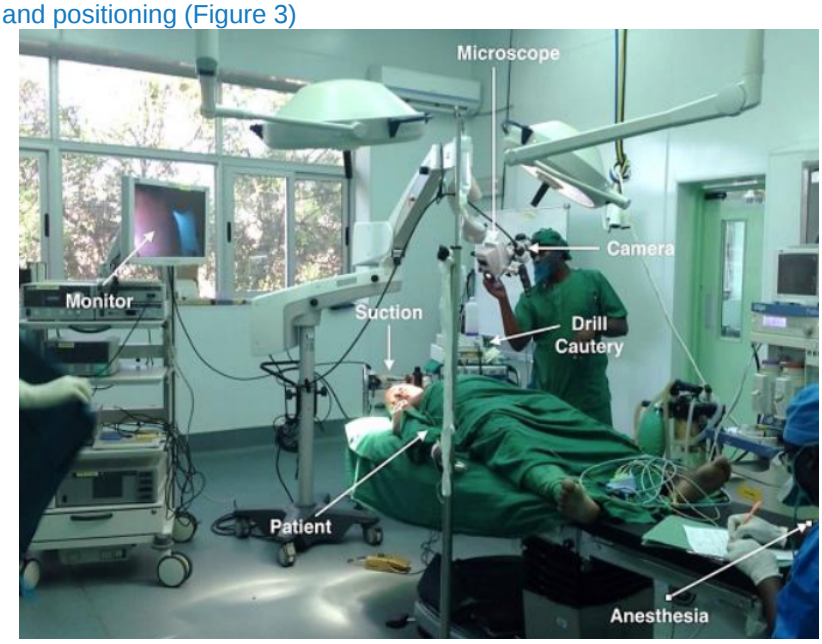


Figure 3: Operating room setup & camera system

Sterilizing surgical instruments

Depending on what is available in the country one is visiting, instruments may be sterilized by a variety of methods e.g. autoclaving with steam vapor; or soaking instruments in alcohol, “cidex” or in acetone. Irrespective of the sterilization technique, instruments should be rinsed in a sterile saline solution before use.

Surgical equipment

The instruments listed below are the author’s preference and are adequate to allow one to perform tympanoplasty, mastoidectomy, canalplasty, temporal bone resection, and other middle ear surgeries.

Knife handle
Weitlaner self-retaining retractors (2)
Adson forceps w/ teeth
Iris scissors curved
Iris scissors straight
Senn retractor
Joseph Skin Hook, 2 prong
Beckmann nasal speculum
Suction tips 10, 14, 18 ,20 F
House double-ended large spoon curette sizes 2 x 3.2 mm & 1.6 x 2.6 mm
Freer elevator
Ear speculum 4, 5, 6, 7, 8 mm
Bellucci scissors
Hartmann forceps
Malleus nipper
Cup forceps
Cutting block
Needle holder
Suture scissors
Round knife 2.5 & 1.0 mm
Annulus elevator
Rosen pick
Fish rasp (right & left)
Sickle knife
45^{o} pick

Table 1: List of ear instruments required

Audiology

It is imperative that all patients have an audiogram done before ear surgery. It should ideally be done by someone trained to test hearing, because an untrained tester will e.g. not understand how to mask and will therefore get erroneous results.

Surgical steps of middle ear surgery under local anesthesia with sedation

A time window of 1-2 hours should be available to complete surgery by using 5-9 mL of local anesthetic solution and a titrated intravenous dose of up to 150 ug of fentanyl or up to 10 mg of morphine. Should a patient require more sedation or analgesia

during surgery, either drug can be given depending on the needs.

Induce IV analgesia and sedation

- Administer IV analgesia & sedation (Fentanyl & valium as described above)
- Wait for the drugs to take effect (within 5 minutes)
- Assess that adequate sedation has been achieved by asking the patient to respond to simple questions or commands (e.g. “squeeze my hand”)
- Note: If the eyelid reflex is lost the patient is too deeply sedated and is bordering on general anesthesia!
- The patient should be rousable by speech or gentle touch.
- Proceed to injecting local anesthesia

Auricular block

- Mix 0.5 mL (half ampoule) of adrenaline 1:1000 and 9 mL of lidocaine in a 10 mL syringe
- Use a 27-gauge needle (small gauge causes less pain and tissue trauma)
- Start injecting the local anesthetic
- Note any pain reaction from the patient

Three sites are injected to achieve an adequate ear block

1. ***Postauricular injection***

- Begin infiltrating at the level of the external auditory canal

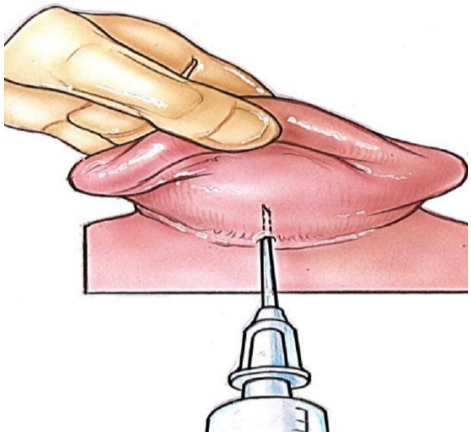


Figure 4: Begin infiltrating at level of external auditory canal

- Slowly inject about 0.5 mL of local anesthetic to form a small blister under the skin (*Figure 4*)
- Rotate the needle superiorly and advance it under the skin to the top of the helix
- Inject 2-3 mL solution while slowly advancing the needle inferior to the site of the original blister; as this is done, the area of infiltration should puff up
- Using the initial injection site, insert the needle under the concha so that the tip is close to the external auditory canal skin at the level of the spine of Henle

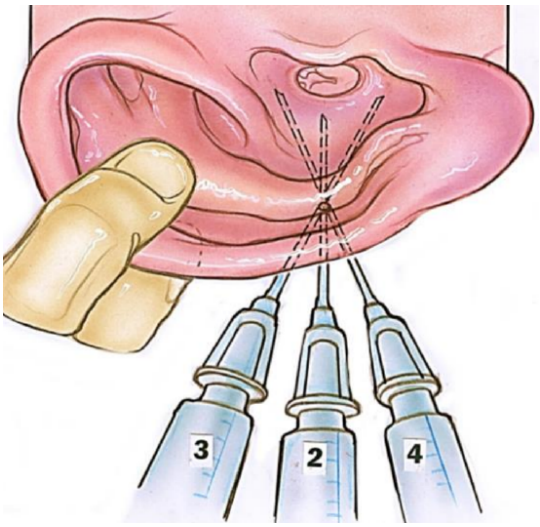


Figure 5: Infiltrate local ana=esthetic in a radial fashion

- Infiltrate local anesthetic in a radial fashion approximately 3 times, infiltrating 1-1.5 mL of anesthetic (*Figure 5*)

2. ***Intracanal injection*** (*Figures 6a, b*)

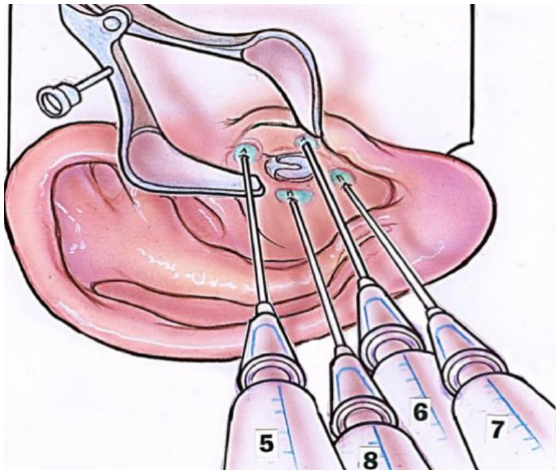


Figure 6a: Canal injection

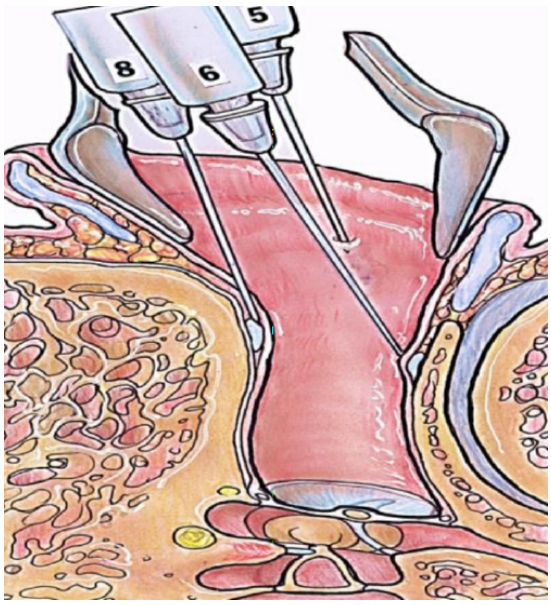


Figure 6b: Axial view of canal injection

- Insert the largest ear speculum that fits into the ear canal, and view the canal with the operating microscope
- Infiltrate the canal skin with 3 to 4 injections of solution; each injection is 0.25-0.40 mL
- Initiate the 1st injection at the junction of the medial 1/3 of the canal lacking appendages, and the lateral 2/3 at the 9 o'clock position where there is hair and subcutaneous tissue.
- Commence the injection at the level of the most medial hair cells
- Then advance the needle a few millimeters onto the bone with its bevel down before infiltrating
- As the infiltration is done, blanching of the stria vascularis is seen
- Commence the 2nd injection at a 12 o'clock position
- Commence the 3rd injection at a 6 o'clock position
- The 6 and 12 o'clock injections provide anesthesia for the canal cuts that are made when elevating the conchomeatal flap

3. ***Preauricular injection*** (*Figure 7*)

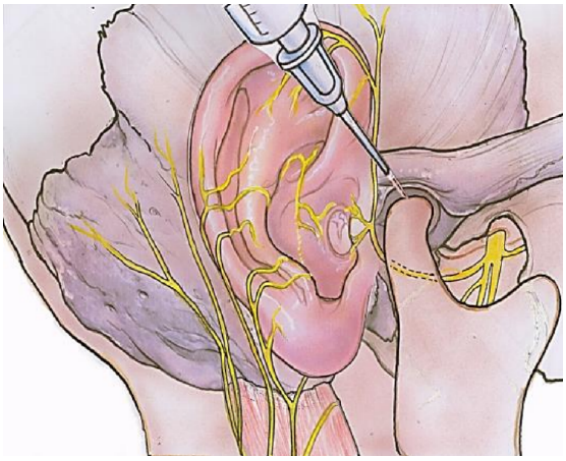


Figure 7: Preauricular injection to block the auriculotemporal nerve

- This injection provides anesthesia to the anterior canal, which is supplied by the auriculotemporal division of the trigeminal nerve
- Insert the needle at a 45^{o} angle in front of the tragus
- Advance the needle towards the angle of the mandible
- Commence infiltration after the needle has reached its maximum depth and inject 0.5-0.75 mL solution as the needle is advanced outward

Middle ear surgery technique

It is critical that a surgeon performing ear surgery has both the experience and comfort to perform middle ear surgery under local anesthesia with IV sedation. Under ideal circumstances an experienced ear surgeon is able to perform tympanoplasty (underlay or overlay), stapes surgery, modified or radical mastoid surgery, lateral temporal bone resection, and even endolymphatic sac decompression under IV sedation and local anesthesia.

Consumables checklist for outreach surgery

- 4/0 Monocryl sutures
- Gelfoam (Johnson & Johnson)
- Xeroform gauze
- Quinolone antibiotic solution
- Silastic sheeting - I use surgical gloves
- Kerlix gauze bandages (3 or 4")
- Syringes
- Needles
- Lidocaine
- Adrenaline
- Systemic analgesic
- Analgesics for postoperative pain relief

Cleaning solutions

Microscope and audiovisual equipment: Check on available microscope and spare bulbs

ENT clinic equipment

- Tuning forks
- Jobson-Horne
- Otoscopes
- Suture scissors
- Etc.

Ear surgery instrumentation

Pearls & Pitfalls

1. Critical to carefully select patients
2. Preoperative audiogram imperative (unless impossible to obtain)
3. It is important to monitor patients during surgery with EKG, oximeter, and blood pressure monitor
4. More important is a human monitor. If a qualified anesthetist is not available, then either the surgeon (yourself) or a trusted nurse must watch the patient and monitor and encourage him/her to breathe deeply when needed.
5. Inject atraumatically using the smallest needle possible, but no smaller than a 27-gauge, keeping the bevel facing down
6. Be sure that the drugs that you are using are not fake or adulterated; I have frequently encountered such medications in developing countries that do not function properly
7. When you notice a patient becoming more awake, notify the anesthetist
8. If the patient experiences pain while operating in the middle ear, irrigate the middle ear down the canal with 2 mL of 1-2% lidocaine without epinephrine, leaving it in the middle ear for 2 minutes before suctioning it out
9. If mucosal bleeding from the middle ear persists, irrigate the middle ear with 2 mL pure epinephrine down the canal and leave it there for 2 minutes before suctioning it from the middle ear cleft
10. Be prepared to handle any and all complications you may encounter, such as repairing a CSF leak, and repairing the facial nerve if injured
11. Power failures are common in some developing countries, especially in rural settings, and should be anticipated. If the drill stops functioning / power fails after a mastoidectomy has been commenced, then the surgeon may have to resort to a hammer and gouge technique to compete the surgery: See chapters: Hammer and gouge for cholesteatoma; Hammer and gouge for acute mastoiditis

Pointers for teams planning outreach surgery in resource limited countries

When the author works in developing countries, his visits are coordinated through an NGO, a local doctor or through a medical society. Irrespective of who is the host, it is imperative that the following rules be followed:

1. The primary goal should be to share knowledge and skills by teaching local doctors about ear disease and surgery
2. Arrange for local doctors to schedule patients and manage follow up
3. If there is no local ENT doctor to participate in the program, it is imperative that one identifies another doctor to take responsibility for postoperative care, using telemedicine for advice
4. In the absence of a microscope one may be required to bring along a portable operating microscope
5. In the absence of a locally based microscope it is impossible for the local doctor to do microscopic post-operative ear care. In such cases the surgery must be tailored in such way to make it possible for the local doctor to manage ears postoperatively without a microscope:

- With tympanoplasty, pack the ear canal with resorbable Gelfoam; with a modified meatoplasty, place gauze e.g. Xeroform in the lateral canal and instruct the doctor to remove the gauze at 10-12 days and then begin placing Ciprofloxacin eardrops (5 gtts bid) over the Gelfoam and to wait 3-4 weeks before doing otoscopy to ensure healing has occurred
- When performing canal-wall-down open cavity mastoidectomy, the author places temporalis fascia over the reconstructed area, then Gelfoam. This is followed by a strip of surgical glove which serves as an inert barrier so that when the doctor subsequently removes the gauze from the mastoid cavity, the surgical reconstruction is not disrupted. Once the gauze and strip of glove are removed, ciprofloxacin eardrops (5 gtts bid) are placed over the Gelfoam. Otoscopy is performed 3-4 weeks later to ensure healing has taken place

6. It is imperative to continue to communicate with the doctor who is managing the patients postoperatively, also to advise how to manage delayed complications such as swelling, discharge, facial paralysis, vestibular dysfunction, or hearing loss. The author does this through Skype, although other platforms such as FaceTime, Viber etc. can be used

Wishing to do otology outreach surgery?

Visit the following webpage to team up with established outreach programmers: http://www.entdev.uct.ac.za/support/

Recommended reading

- Local and regional anesthesia techniques for otologic (ear) surgery
- Endoscopic cholesteatoma, tympanoplasty and middle ear surgery
- Hammer and gouge for cholesteatoma
- Hammer and gouge for acute mastoiditis
- ENT Outreach in Africa: Rules of Engagement

Authors

Richard Wagner MD, FACS
Director
Global ENT Outreach
Coupeville, WA, 98239, USA
rwagner@geoutreach.org

Greg Torr MBChB, FCA (SA)
Anesthetist
Cape Town, South Africa
gregtorr@mweb.co.za

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.3: Hammer and Gouge Mastoidectomy for Acute Mastoiditis

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan & Robert Jackler

This surgical guide is intended for the many surgeons in the Developing World who do not have access to modern mastoid surgery equipment such functioning mastoid drills, or are regularly faced with power cuts and therefore may be compel led to proceed with a mastoidectomy using a hammer and gouge, and possibly only a headlight and operating loupes.

The text and illustrations are based on the description of mastoid surgery: A Treatise on the Surgical Technique of Otorhinolaryngology (1939) by Georges Portmann. The text has been modified to incorporate modern principles of otology. This operative guide should be read in conjunction with the chapter Hammer and Gouge Radical Mastoidectomy for Cholesteatoma, also on the IFOS educational website.

Mastoid surgery can only be safely performed when the surgeon has an intimate knowledge of temporal bone anatomy. It is imperative that surgeons practice temporal bone dissections as described in the IFOS educational website.

Informed Consent

This should include anesthetic and surgical risks and issues relating to aggravated hearing loss, facial nerve injury, vertigo, taste disturbance, injury to the brain and meninges, and wound complications

Anesthesia

Surgery may be performed under local or general anesthesia.

General anesthesia: Avoid muscle paralysis to facilitate detection of facial nerve irritation or injury.

Local anesthesia: See chapters

- Local and regional anesthesia techniques for otologic (ear) surgery
- Otology outreach surgery in developing countries under local and regional anesthesia: Techniques and pitfalls

Magnification and lighting

Magnification is ideally required once dissection reaches the middle ear, and for removal of the facial ridge. Should an operating microscope not be available, then operating loupes with 2.5x magnification should be used. Good lighting is essential, especially when working in the middle ear. In the absence of an operating microscope or strong operating lights, a headlight may suffice.

Instrumentation (*Figures 1a, b*)

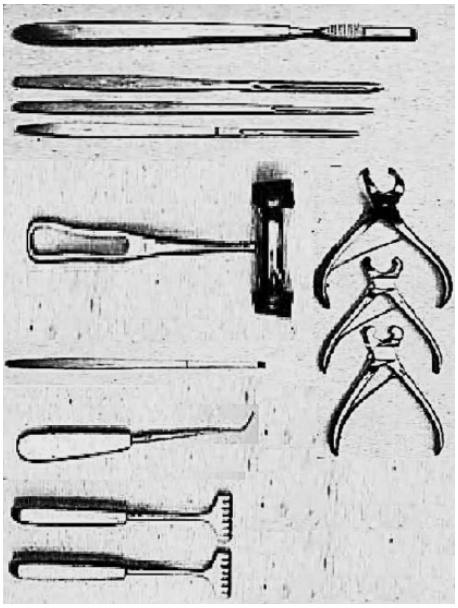


Figure 1a: Instruments for bone work



Figure 1b: Mallet, rasp, chisels, curette and gouge (From Professor Malick Diop)

Gouges and chisels should be kept extremely sharp, to ensure controlled bone resection. Blunt instrumentation requires undue force to be applied, and gouges/ chisels may slip off bone and plunge and damage critical structures such as brain, lateral sinus, facial nerve, inner ear, and carotid artery. For the bone work the surgeon requires the following:

- Curved periosteal elevator
- Mallet
- Three gouges: Large, medium, small
- Flat chisel
- Curettes
- Rongeurs/bone nibblers (small, medium and large)
- Retractors (2), ideally self-retracting
- Canal elevator/McDonalds dissector
- Blunt probe
- Microinstruments: Curved needle, Plester knife, sickle knife, curette
- Suction tips

Position of Patient

The patient is laid supine with the head turned towards the normal ear.

Position of Surgeon and Assistants

The surgeon stands on the side of the affected ear. Two assistants are stationed on the other side, facing the surgeon. The 1st assistant is nearest to the head. The 2nd assistant is exactly opposite the surgeon.

Operative Field

The mastoid, auricle, and preauricular regions are extensively swabbed with tincture of iodine. The patient is covered to the neck with a sterile sheet. The operative field is isolated by four towels. Over them is placed a fenestrated sheet, the orifice of which encircles the auricle and mastoid.

Antibiotics

No antibiotics are required for mastoidectomy for uncomplicated cholesteatoma, other than when there is secondary infection (mastoiditis).

BIPP Paste

BIPP Paste can be prepared and used to impregnate ribbon gauze. This can be used to pack the mastoid cavity or ear canal, and because of its antiseptic properties, may be left in place for a few weeks. Bismuth subnitrate 20% w/w, iodoform 40% w/w, paraffin liquid 40% w/w (w/w = weight for weight).

Surgical anatomy for Mastoidectomy

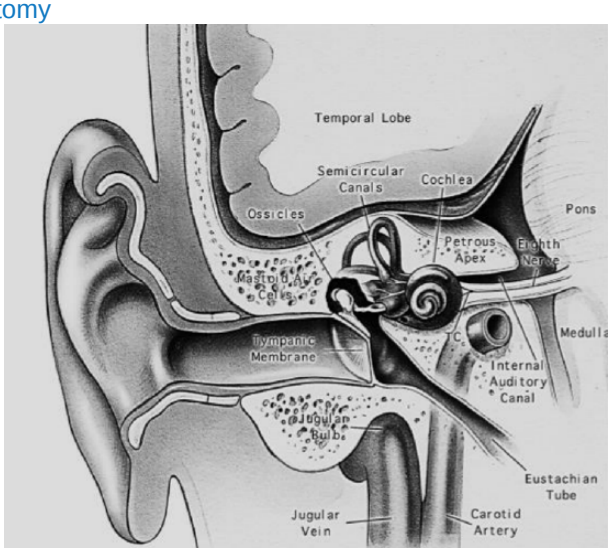


Figure 2: Coronal section through middle ear and temporal bone

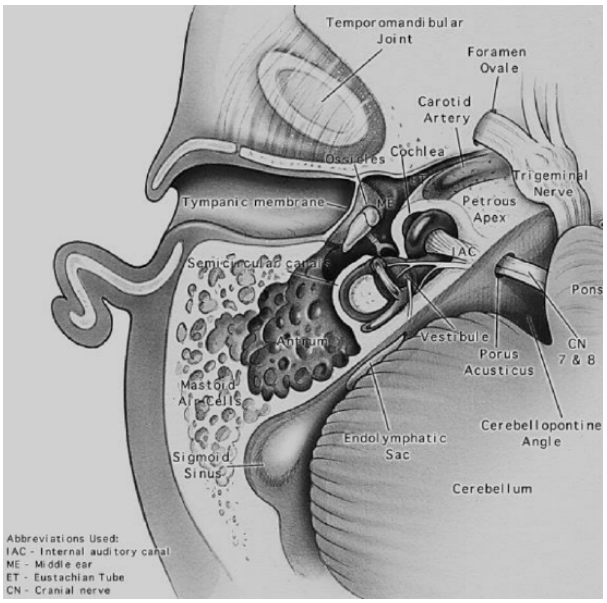
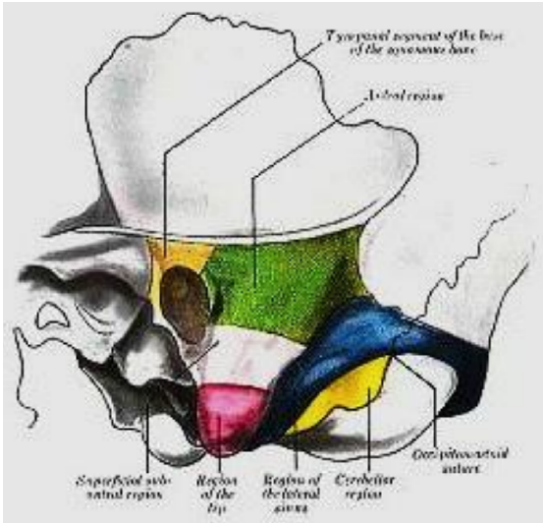


Figure 3: Axial view of temporal bone anatomy



***Brown**: Tympanic segment of base of squamous bone; **Green**: Antral region; **Rose**: Subantral region; **Red**: Region of tip; **Blue**: Sinus region; **Yellow**: Cerebellar region or region of mastoid vein*

Figure 4: Surface boundaries of mastoid regions

Surgical Steps: Cortical Mastoidectomy

Unlike with mastoid surgery for cholesteatoma, mastoidectomy for acute mastoiditis may be associated with ***significant blood loss***, especially in the absence of mono- or bipolar coagulation. Patients may even require blood transfusion.

First Step: Incision of Superficial Tissues



Figure 5: Incision of Superficial Tissues

The 1st assistant retracts the auricle towards himself, using both hands. The 3rd finger of the lower hand is pressed strongly under the mastoid tip in order to compress the posterior auricular artery. The other assistant is prepared to sponge/swab with mastoid sponges/swabs held in angular forceps. The surgeon incises the retroauricular crease down to bone from left to right, from the linea temporalis to the inferior part of the crease, or vice versa (*Figure 5*). In the event of a retroauricular abscess, the abscess cavity may be entered at this point or during periosteal elevation.

Second Step: Periosteal Elevation

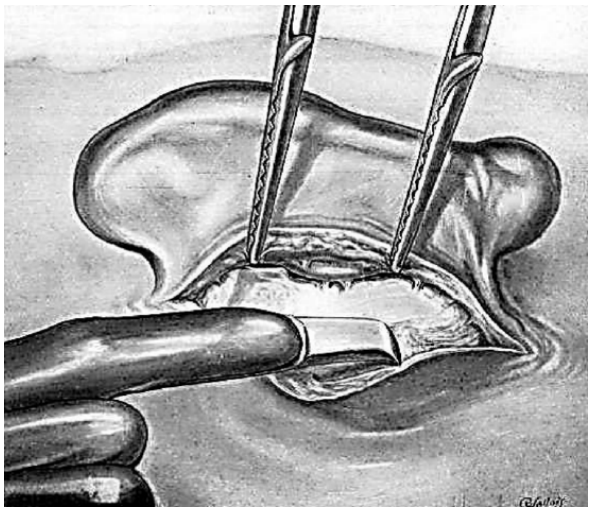


Figure 6: Periosteal elevation

Following hemostasis and ligation of bleeding vessels, the mastoid is completely exposed proceeding posteriorly to the incision, without elevating the anterior cartilaginous canal. This is easy in the superior portion where the periosteum frees itself but becomes more laborious toward the inferior and posteroinferior portions where the muscular insertions must be sectioned with the elevator. *Figure 6* demonstrates how the cartilaginous canal has been respected (*Figure 6*).

Third Step: Exploration of Bone

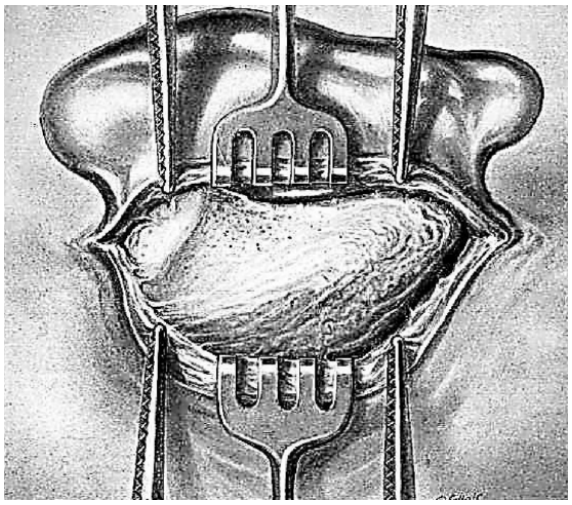


Figure 7: Examine the mastoid surface

In the absence of electrocoagulation, 2 Kocher hemostats are applied to the periosteum, one in front and one in back, assuring hemostasis. Two sharp toothed retractors are held by the assistant. One is placed forward to retract the auricle in the canal without separating it from the bone. The other embraces the posterior lip of the wound, retracting it backward to uncover the operative surface. A self-retaining retractor may also be employed. After completing the periosteal elevation, the surgeon carefully examines the mastoid surface for changes in form, color, and surface (*Figure 7*).

Form: In adjoining illustration one sees the crest of the linea temporalis, the spine of Henlé, and the sieve-like region, the retromeatal depression, and the bulge of the posterosuperior region. The anterior mastoid portion is free of all muscular insertions. The muscles from the nape of the neck and the sternocleidomastoid muscle are inserted into the posterior portion of the mastoid. These two regions are separated by the posterior external petrosquamous suture. With acute mastoiditis these landmarks may be absent and the mastoid may then present an evenly rounded bulge, having the appearance of an egg. The spine of Henlé remains and is the only really important landmark.

Color: Normally the bone appears white or oozes blood through the porous portions of the retromeatal region. However, in mastoiditis the external cortex bleeds diffusely due to the deep inflammatory process. If there is underlying empyema, the wall appears bluish.

Surface: Some irregularities may appear along the surface of the mastoid. These often consist of inflammatory granulations which are apparent through the external posterior petrosquamous suture or of a fistula, which may be verified with the aid of a probe. The existence of a fistula is sought wherever the incision has uncovered free pus.

Fourth Step: Trephining - Exploration of Superficial Antral Region

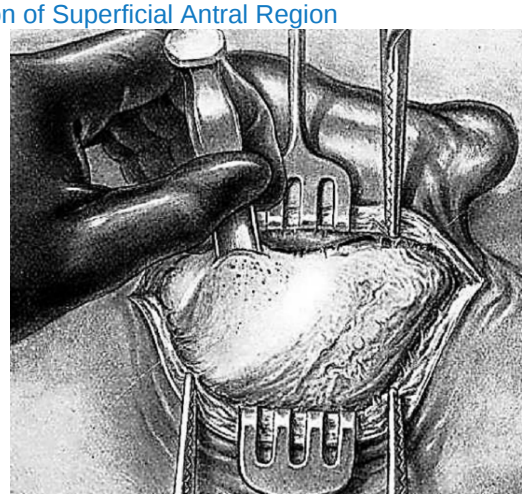


Figure 8: Trephining and exploring antral region

A large gouge is placed immediately below the linea temporalis (*Figure 8*). It is held between the thumb and first two fingers, with the ring finger serving as a brake. The instrument is held in the position shown in the illustration, being directed vertically at right

angles to the bone surface.

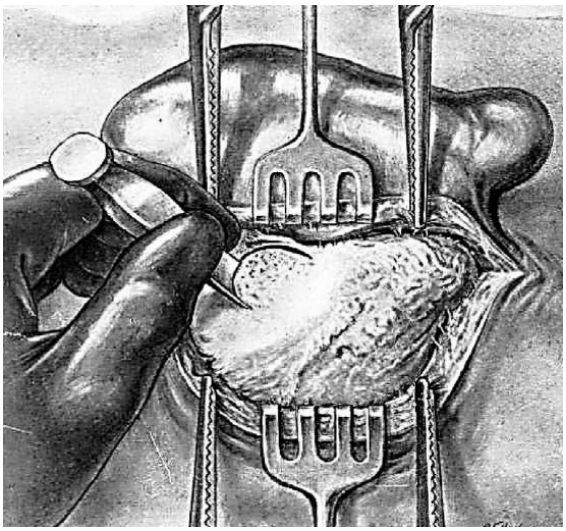


Figure 9: 1st & 2nd cuts



Figure 10: completing a circle of trephination

Site of Trephination: If a fistula is present and is at the level of the antral region or its immediate vicinity, the trephine is performed at that level. If no fistula exists or is very far from the antral region, the trephining is done as follows. An area of approach is outlined with the gouge by applying it above and behind the canal at the following points (*Figures 9, 10*):

- 1st cut: 2-3 mm behind spine of Henlé
- 2nd cut: just below linea temporalis
- 3rd cut: parallel, but 1 cm below 2nd cut
- 4th cut: 1 cm behind 1st, thus completing a circle of trephination
- The 1st 3 taps of the gouge are perpendicular to the bony surface
- The 4th tap is applied obliquely to avoid the lateral sinus which may be superficial or prominent.

Fifth Step: Exploration of Superficial Subantral Region and Tip

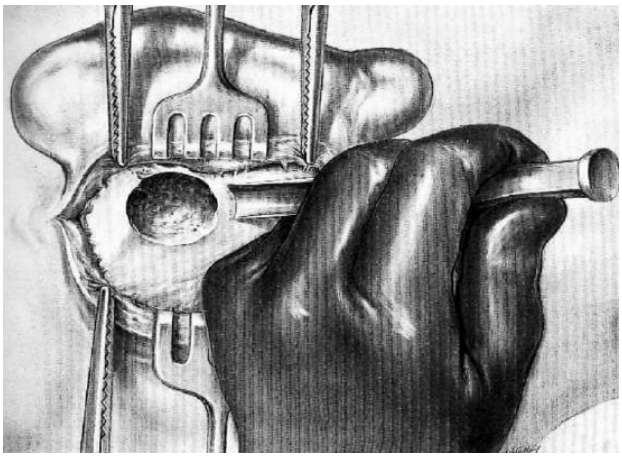


Figure 11: Gouge directed toward inferior portion of mastoid

After trephining and curetting the superficial antral region, the gouge is directed toward the inferior portion of the mastoid, making a superficial vertical trench. The instrument is held between the thumb and first two fingers of the left hand with the two remaining fingers resting on the bony surface to provide control and to avoid dangerous slip of the gouge (*Figure 11*).

Sixth Step: Opening of Apical Region

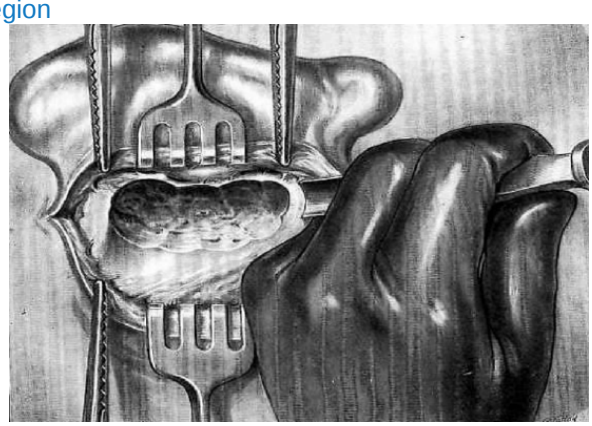


Figure 12: Creating a vertical trench

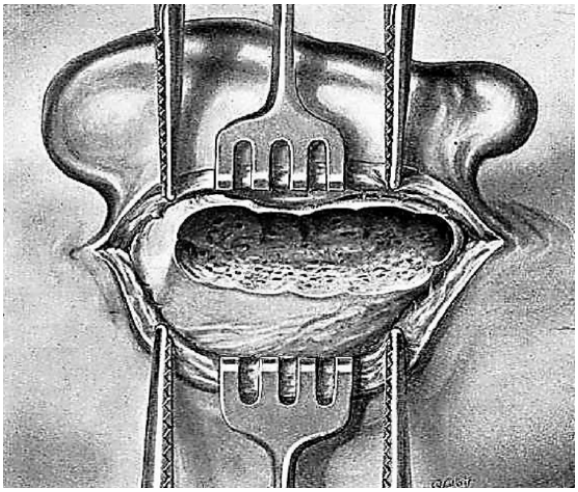


Figure 13: Vertical trench

After exploring and curetting the antral and subantral regions, the surgeon works toward the tip, creating a superficial, vertical trench, and exposing diseased mastoid cells (*Figures 12*, *13*). Only if the tip is osteitic need it be resected with the gouge or rongeur.

Seventh Step: Exploration of Posteroinferior Region

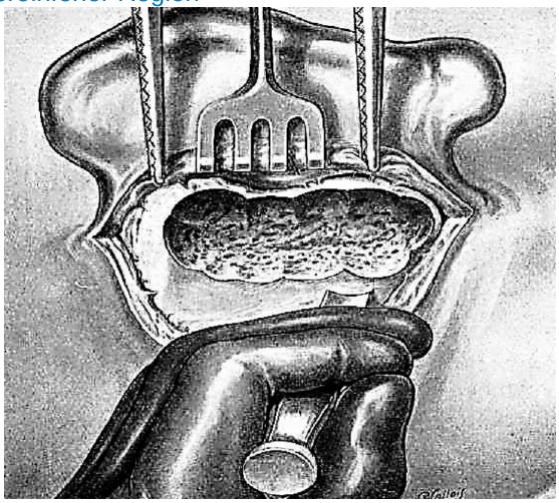


Figure 14: Opening posteroinferior region

The posteroinferior region, which is also called the region of the mastoid vein, is opened with the gouge. The instrument is held in the same position as described previously but is slanted obliquely from behind forward and gently forced in with light taps of the mallet. The procedure progresses backward toward the posterior portion of the mastoid from below up. (*Figure 14*)

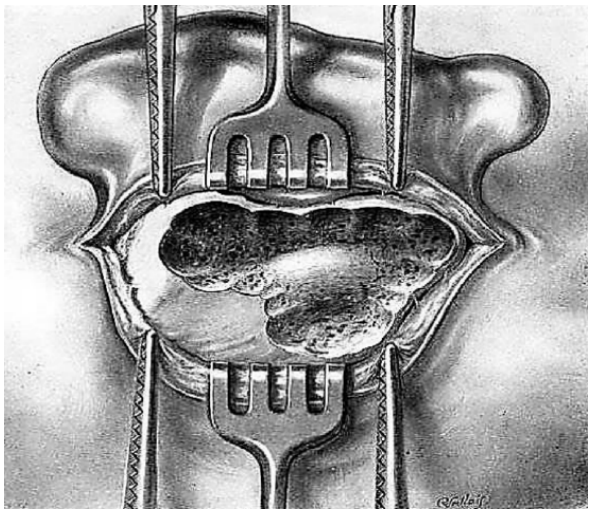


Figure 15: Completed posteroinferior dissection

Opening this posteroinferior region exposes the inner table of the skull which at this level forms the bony outer shell of the lateral sinus. This region is meticulously curetted (*Figure 15*).

If the bony disease is very extensive, the soft tissues may have to be sectioned by a horizontal incision perpendicular to the retro-auricular incision, forming a “T”, and additional posterior exposure of the mastoid bone done.

Eighth Step: Exploration of Posterosuperior Region and Lateral Sinus / Sinodural Angle (*Figure 16*)

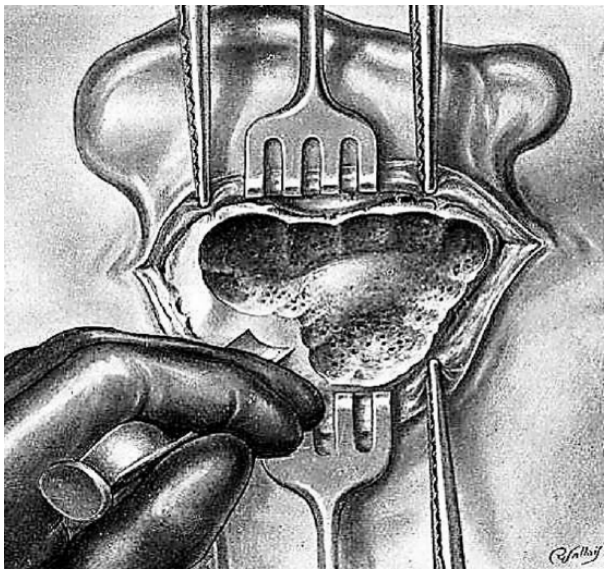


Figure 16: Exploring the sinodural angle

Trephination is continued from below up and behind forward, burrowing progressively into the mastoid and to join the superficial antral region. The taps on the gouge are performed cautiously. They are made on a tangent to permit the gradual removal of the cortex over the lateral sinus or even to uncover the venous wall, if this should be necessary. The rongeur is dangerous when handled blindly and may penetrate dura and injure the brain. The gouge is much more manageable; its action more easily controlled. The posterior limit of trephination is determined by the status of the bone. The process continues until normal resistant bone, which does not bleed, is encountered. If hemorrhage occurs from the mastoid vein, this may be cauterized or occluded with bone wax. A gauze pack impregnated with the adrenaline and kept in place for several minutes may reduce bleeding.

Ninth Step: Exploring Lateral Sinus

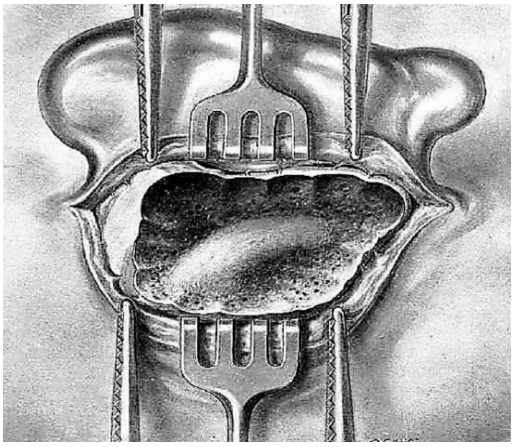


Figure 17: The lateral sinus

The posterosuperior region of the mastoid is also called the *region of the lateral sinus* (*Figure 17*).

Since this vessel is sometimes very superficial, the gouge is the only instrument that should be used. It is held between the thumb and the first two fingers of the left hand and placed obliquely on the bony surface. Small slanting blows made with the gouge permit a very careful sculpturing of the cortex of the lateral sinus.

Lateral Sinus Thrombosis and Perisinus Abscesses



Figure 18: Thrombosed (L) lateral sinus with posterior fossa abscess

Acute mastoiditis may be complicated by a perisinus (extradural) abscess, lateral sinus thrombosis, or there may be pus within the sinus (*Figure 18*). In the absence of preoperative CT scanning facilities, the sinus should be uncapped of bone. If a perisinus abscess is encountered, it is drained into the mastoid cavity. The sinus is aspirated with a needle and syringe. Should there be no free flow of blood, it might be thrombosed, or there may be an intrasinus abscess that needs to be drained.

Tenth Step: Search for Antrum

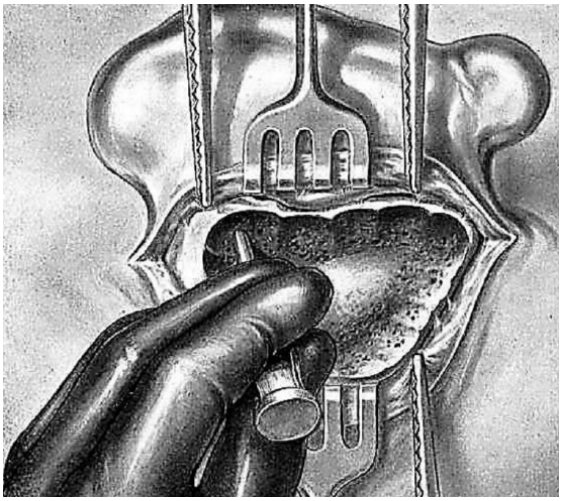


Figure 19: Accessing the antrum

The antrum is sought with a small gouge directed from behind forward towards the spine of Henlé, paralleling the canal and excavating down towards the antrum with small taps of the mallet (*Figure 19*).

With the superficial antral region open, this step is particularly easy and the antrum is accessible even when small and deeply located. The antrum is enlarged above and posteriorly, either with a gouge or curette. Small curettes which may result in dangerous slips should not be used. The aditus is located with a blunt angular probe. This permits a determination of the status of the *tegmen tympani* superiorly, especially at the level of the antral roof.

Eleventh Step: Opening the Deep Antral Region

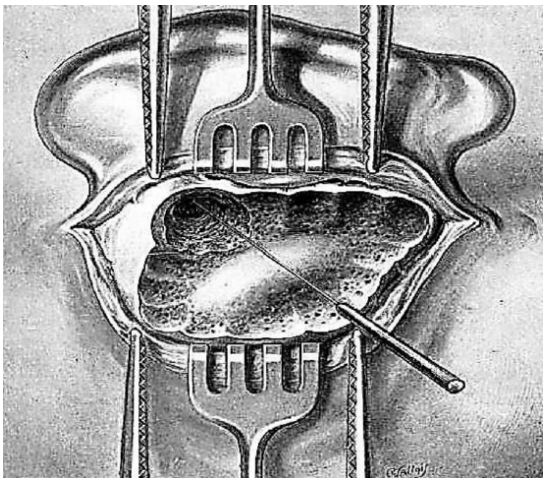


Figure 20: Probing the aditus

After widely opening the antrum, the aditus is sought with a blunt curved probe (*Figure 20*). It is carefully cleansed with a medium sized curette. Very small curettes should not be used since they may slip and cause serious injuries.

Twelfth Step: Opening the Deep Antral Region (*Figure 21*)

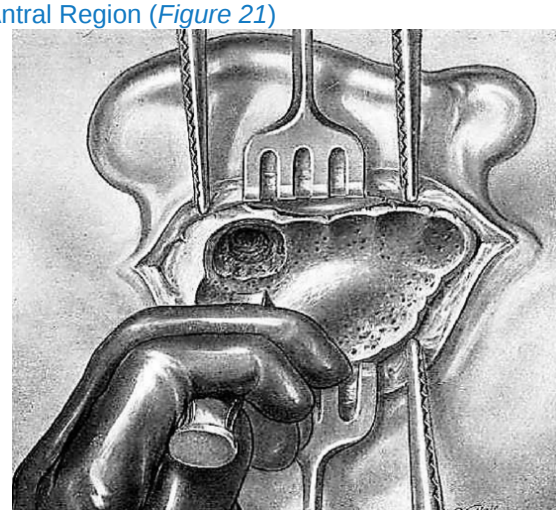


Figure 21: Approaching deep antral region

The antrum is enlarged toward its posterior part. Between the posterosuperior region just opened and the antrum there is a bony ridge which should be resected. This resection is performed with a gouge of medium caliber held obliquely from behind forward between the thumb and first two fingers of the left hand; the remaining two fingers rest on the bony surface. Thus, a horizontal trench is made which is almost perpendicular to the anterior vertical one.

Thirteenth Step: Exploration of Deep Subantral Region (Retrofacial Groove)

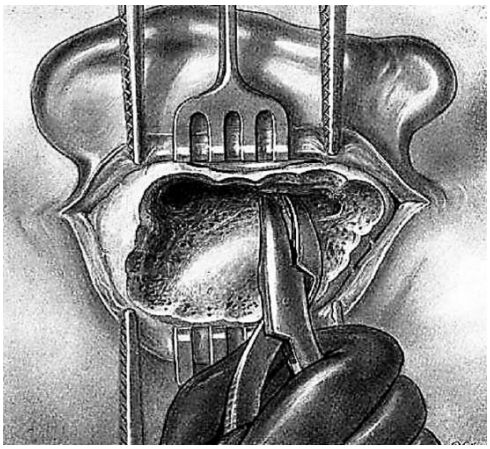


Figure 22: Using a narrow-jawed curved rongeur in the deep subantral region

Between the deep antrum and mastoid tip there remains a bony, often cellular, mass which it is wise to remove. The antrum is thus continued below by a deep vertical trench. Exploration of this region sometimes reveals large cells located very deep in the bone. This resection may be performed with the gouge, using vertical blows first in front of the sinus then against the posterior wall of the canal which must be preserved. The curette, directed from above downwards, may be used. It is controlled by the index finger of the left of hand to avoid injury to the lateral sinus or a too deep curettage towards the facial nerve anteriorly. If the deep subantral region is narrow and the lateral sinus prominent, it is preferable to use a narrow jawed curved rongeur (*Figure 22*). The instrument is held in the right hand with the jaws parallel to the anterior aspect of the mastoid; this permits safe progress into the deeper regions between the facial nerve in front and the lateral sinus at the back.

Fourteenth Step: Exploration and Cleansing of Operative Cavity (*Figures 23, 24*)

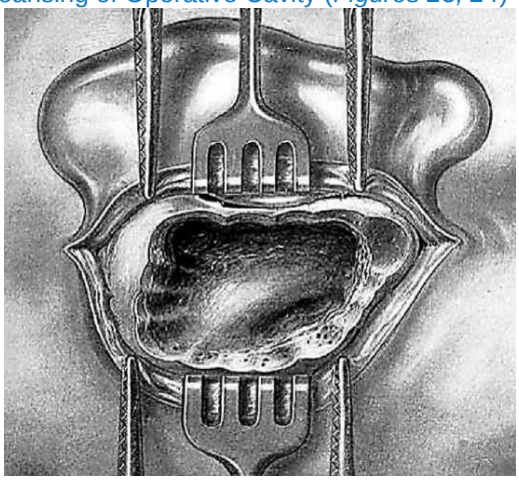


Figure 23: Cleaned cavity

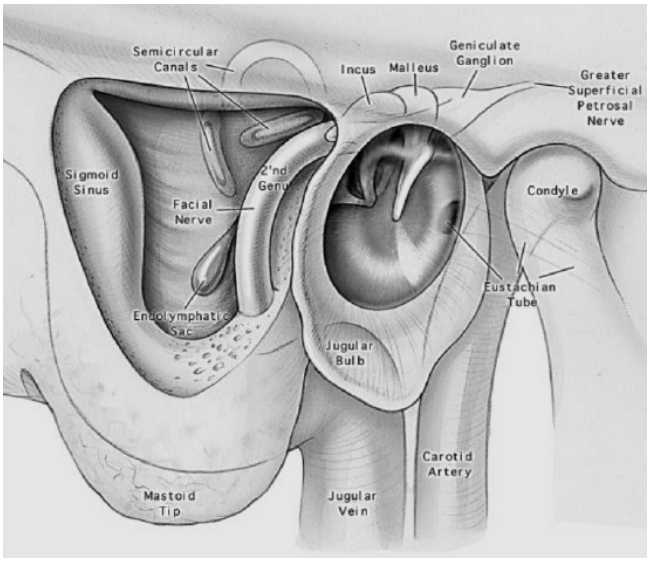


Figure 24: Schematic representation of anatomy of final cavity

The cavity is thoroughly explored and cleared of loose or adherent bony spicules. The edges and bottom are smoothed with a curette or rongeur. Suspicious areas are explored with a blunt probe which locates previously unnoticed cells and determines the presence of inflammatory granulations on the dura mater.

Fifteenth Step: Drainage and suturing and postoperative Care



Figure 25: Pencil drain protruding from wound

A glove/corrugated/pencil drain is inserted (*Figure 25*). The skin edges are carefully approximated. A pressure dressing is applied held in place by a bandage wrapped around the head.

Postoperative antibiotics are administered. The patient should be carefully monitored for several days to detect intracranial septic complications, as posterior fossa collections can have subtle clinical signs.

TEMPOROZYGOMATIC MASTOIDITIS

The pneumatic cells adjacent to the middle ear may develop not only in the mastoid but also above the canal and the temporomaxillary joint i.e. at the base of the squamous bone (zygomatic arch). The base of the squamosa may be pneumatized either by way of the intermediary of the antral system or through the cells opening directly into the attic. This pneumatization, however, may extend very high into the squama temporalis. Infection of the cells in the base of the squamous bone constitutes a paramastoiditis or temporozygomatic mastoiditis and necessitates a special operative technique.

If the infection in the base of the squamous bone is a consequence of an infection of the antral system, i.e. a true mastoiditis, the opening of the cells of the tympanic and temporomaxillary segments will only be an additional procedure to the mastoidectomy, which has previously been described.

If, on the other hand, the temporozygomatic mastoiditis is the result of an infection arising directly from the tympanic cavity and not including the mastoid itself, which may be verified easily by the absence of clinical symptoms at this level and by a normal radiographic picture of the mastoid, the operation will consist only of the opening of the cells in the temporozygomatic region.

First Step: Incision

The cutaneous incision of the mastoidectomy is extended 3.0 or 4.0 cm. above and in front of the auricle of the ear. This incision obliquely crosses the linea temporalis; it goes through to the bone, including the temporal muscle and the periosteum.

Second Step: Periosteal Elevation

The bone of the squama temporalis is exposed above and in front of the canal, if necessary, as far as the zygomatic arch. Whenever temporozygomatic mastoiditis is a complication of mastoiditis, the periosteal elevation naturally extends to include the entire external surface of the mastoid.

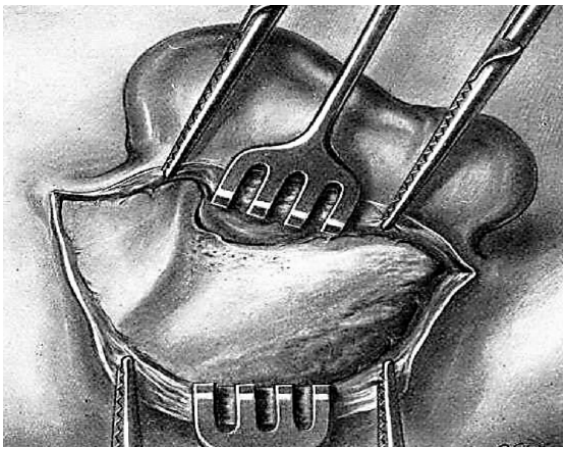


Figure 26: Exposed bone

Third Step: Exploration of the Bone

Kocher hemostats are applied to the periosteal flaps and the portion of the temporal muscle, which bleed freely. Ligatures are applied to the muscular vessels. Two hooked retractors are held by the second assistant. The region being well exposed, the surgeon examines it for alterations in color, form, and surface. He verifies the areas of osteitis and the possible presence of a fistula, which may be located in the squama temporalis under the muscle (deep temporozygomatic mastoiditis) or on the zygomatic arch immediately above the canal (superficial temporozygomatic mastoiditis).

Fourth Step: Trephining



Figure 27: Trephination done above the ear canal

If a complete mastoidectomy has been performed, systematic exploration is carried out with a small gouge, starting from the antral region and including the entire base of the squamous bone, being guided by the existing lesions. If the mastoid is normal and if the radiological and clinical examinations have shown absolute integrity of the antral system, trephination is done above the canal in

order to curette and cleanse the cavities of empyema and osteitic foci (*Figure 27*). This is continued until normal bone is encountered.

Fifth Step: Exploration and Cleansing of the Operative Cavity

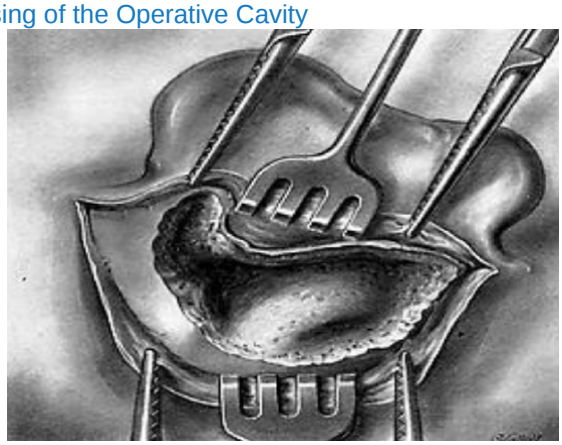


Figure 28: Final cavity

The cavity is explored with great rare. All the bony spicules, whether free or adherent are removed. The edges of the interior of the cavity are smoothed with the fine angular rongeur (*Figure 28*). The succeeding steps of this operation are the same as those in the mastoidectomy.

CERVICAL SEPSIS

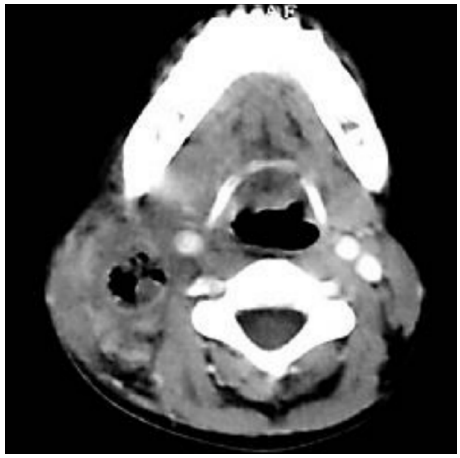


Figure 29: Extension of sepsis down internal jugular vein

Lateral sinus thrombosis may be complicated by extension of sepsis down the internal jugular vein into the neck (*Figure 29*).

Infection of the mastoid may also lead to the formation of cervical abscesses which vary according to their form of exteriorization:

- Abscess of nape of neck in postero-inferior mastoiditis
- Substernomastoid abscess (Bezold's abscess)
- Internal aspect of mastoid tip, along digastric muscle
- Deep jugulodigastric cervical abscess (mastoiditis of Mouret)

INTRAOPERATIVE INCIDENTS

Accidental Opening of the Lateral Sinus or Mastoid Vein

Opening of the lateral sinus is more severe if accidentally produced with a rongeur. The use of this instrument is therefore discouraged in the posterior region of the mastoid. Injury to the venous wall with the gouge is usually very limited and quickly settles. Bleeding can usually be controlled by packing off the sinus with surgical. If the hemorrhage persists or threatens to recur, the cavity is firmly packed with iodoform impregnated ribbon gauze, the end of which exits from the wound next to the drain. It is removed a few days later.

Exposure of Meninges: Exposure of the meninges is not a concern. No change in management is required.

Tear of Meninges with Cerebrospinal Fluid leak: A tear of the meninges is simply repaired with silk or other suture. If necessary, muscle or fascia can be used to augment the repair.

Opening of lateral or posterior semicircular canal: The canal is simply covered with fascia, which is held in place by muscle or gauze packing.

ANTROTOMY IN THE INFANT

Antrotomy is the surgical opening of the antrum, which is the principal mastoid cavity in the infant. Antrum is fully developed, as opposed to the mastoid that is not fully developed. The facial nerve is more superficial at the mastoid tip than in the adult. Indications include: Early acute mastoiditis unresponsive to antibiotics; complicated mastoiditis; subperiosteal abscess; intracranial complications (meningitis, abscess); facial paralysis secondary to mastoiditis; suspected tuberculous mastoiditis (remove sequestrum and obtain tissue for diagnosis of TB; and mastoiditis secondary to cholesteatoma.

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Robert Jackler MD
Sewall Professor and Chair
Department of Otolaryngology-Head & Neck Surgery
Associate Dean, Postgraduate Medical Education
Stanford University School of Medicine
Stanford, CA 94305-5101, USA

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2.4: Hammer and Gouge Mastoidectomy for Cholesteatoma

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan & Robert Jackler

This surgical guide is intended for the many surgeons in the Developing World who do not have access to modern mastoid surgery equipment such functioning mastoid drills, or are regularly faced with power cuts and therefore may be compel led to proceed with a mastoidectomy using a hammer and gouge, and possibly only a headlight and operating loupes.

The text and illustrations are based on the description of mastoid surgery: A Treatise on the Surgical Technique of Otorhinolaryngology (1939) by Georges Portmann. The text has been modified to incorporate modern principles of otology. This operative guide should be read in conjunction with the chapter Hammer and Gouge Radical Mastoidectomy for Acute Mastoiditis, also on the IFOS educational website.

Mastoid surgery can only be safely performed when the surgeon has an intimate knowledge of temporal bone anatomy. It is imperative that surgeons practice temporal bone dissections as described in the IFOS educational website.

Informed Consent

This should include anesthetic and surgical risks and issues relating to aggravated hearing loss, facial nerve injury, vertigo, taste disturbance, injury to the brain and meninges, and wound complications.

Anesthesia

Surgery may be performed under local or general anesthesia.

General anesthesia: Avoid muscle paralysis to facilitate detection of facial nerve irritation or injury.

Local anesthesia: See chapters

- Local and regional anesthesia techniques for otologic (ear) surgery
- Otology outreach surgery in developing countries under local and regional anesthesia: Techniques and pitfalls

Magnification and lighting

Magnification is ideally required once dissection reaches the middle ear, and for removal of the facial ridge. Should an operating microscope not be available, then operating loupes with 2.5x magnification should be used. Good lighting is essential, especially when working in the middle ear. In the absence of an operating microscope or strong operating lights, a headlight may suffice.

Instrumentation (*Figures 1a, b*)

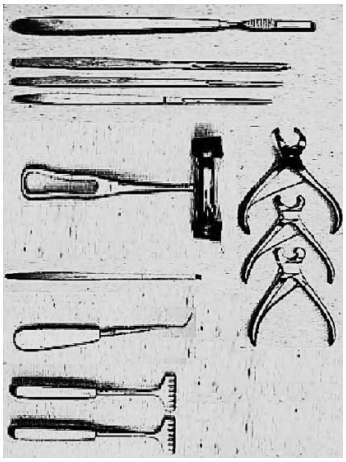


Figure 1a: Instruments for bone work



Figure 1b: Mallet, rasp, chisels, curette and gouge (From Professor Malick Diop)

Gouges and chisels should be kept extremely sharp, to ensure controlled bone resection. Blunt instrumentation requires undue force to be applied, and gouges/chisels may slip off bone and plunge and damage critical structures such as brain, lateral sinus, facial nerve, inner ear, and carotid artery. For the bone work the surgeon requires the following:

- Curved periosteal elevator
- Mallet
- Three gouges: Large, medium, small
- Flat chisel
- Curettes
- Rongeurs/bone nibblers (small, medium and large)
- Retractors (2), ideally self-retracting
- Canal elevator/McDonalds dissector
- Blunt probe
- Microinstruments: Curved needle, Plester knife, sickle knife, curette
- Suction tips

Position of Patient

The patient is laid supine with the head turned towards the normal ear.

Position of Surgeon and Assistants

The surgeon stands on the side of the affected ear. Two assistants are stationed on the other side, facing the surgeon. The 1st assistant is nearest to the head. The 2nd assistant is exactly opposite the surgeon.

Operative Field

The mastoid, auricle, and preauricular regions are extensively swabbed with tincture of iodine. The patient is covered to the neck with a sterile sheet. The operative field is isolated by four towels. Over them is placed a fenestrated sheet, the orifice of which encircles the auricle and mastoid.

Antibiotics

No antibiotics are required for mastoidectomy for uncomplicated cholesteatoma, other than when there is secondary infection (mastoiditis).

BIPP Paste

BIPP Paste can be prepared and used to impregnate ribbon gauze. This can be used to pack the mastoid cavity or ear canal, and because of its antiseptic properties, may be left in place for a few weeks. Bismuth subnitrate 20% w/w, iodoform 40% w/w, paraffin liquid 40% w/w (w/w = weight for weight).

Surgical anatomy for Mastoidectomy

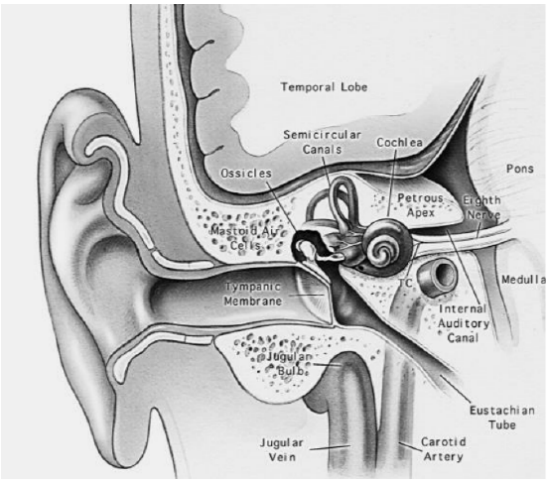


Figure 2: Coronal section through middle ear and temporal bone

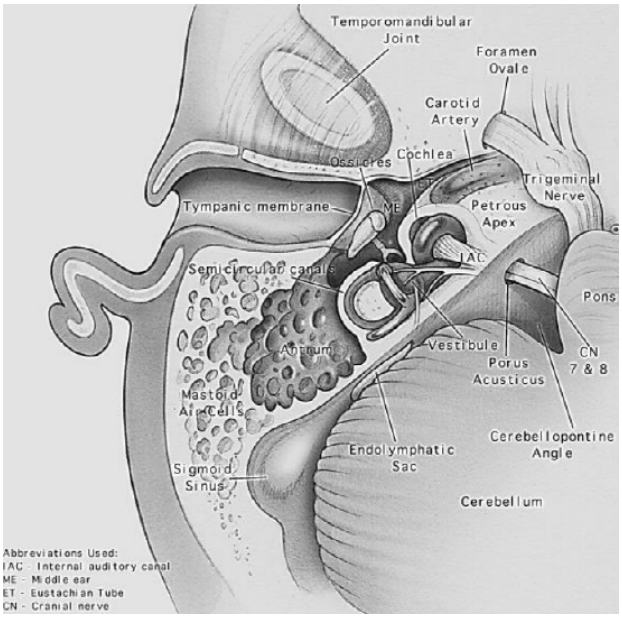
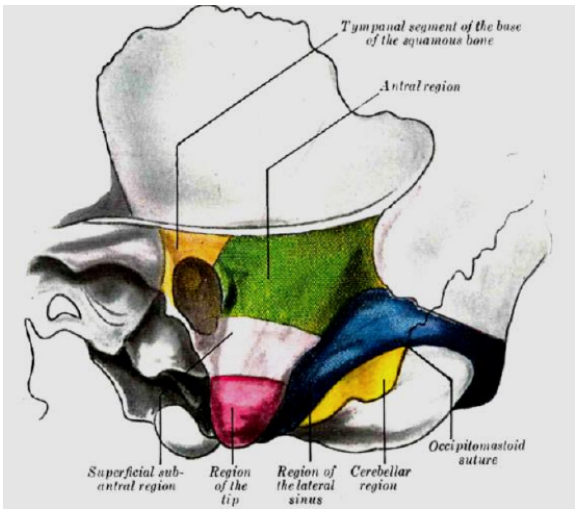


Figure 3: Axial view of temporal bone anatomy



Brown: Tympanic segment of base of squamous bone; **Green**: Antral region; **Rose**: Subantral region; **Red**: Region of tip; **Blue**: Sinus region; **Yellow**: Cerebellar region or region of mastoid vein

Figure 4: Surface boundaries of mastoid regions

Surgical Steps: Radical Mastoidectomy

First Step: Incision of Superficial Tissues



Figure 5: Incision of Superficial Tissues

The 1st assistant retracts the auricle towards himself, using both hands. The 3rd finger of the lower hand is pressed strongly under the mastoid tip in order to compress the posterior auricular artery. The other assistant is prepared to sponge/swab with mastoid sponges/swabs held in angular forceps. The surgeon incises the retroauricular crease down to bone from left to right, from the linea temporalis to the inferior part of the crease, or vice versa (*Figure 5*).

Second Step: Periosteal Elevation

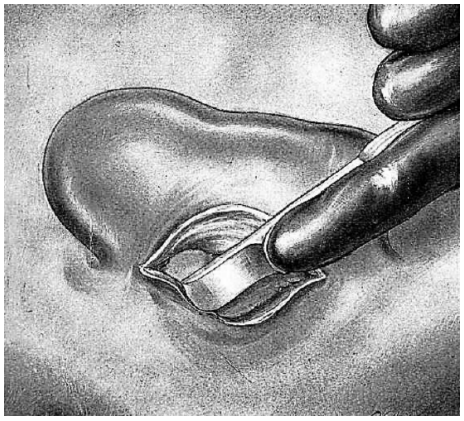


Figure 6: Periosteal elevation

After hemostasis and ligation of bleeding vessels, the periosteum of the antral region posteriorly is detached from the mastoid bone with the periosteal elevator; this is firmly retracted using a hooked retractor (*Figure 6*). Anteriorly a periosteal elevator separates the posterior wall of the canal from the spine of Henlé.

Third Step: Separation of Canal

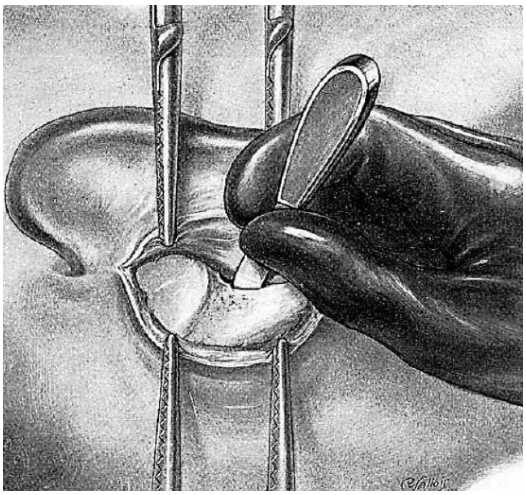


Figure 7: Separate canal skin from bone

A canal elevator is slipped against the posterior bony wall of the auditory canal and lowered forward in order to free the membranous canal (*Figure 7*). A pronged or self-retaining retractor grasps the membranous canal and auricle and retracts them forward. The elevator is then removed.

Fourth Step: Exploration of Operative Region

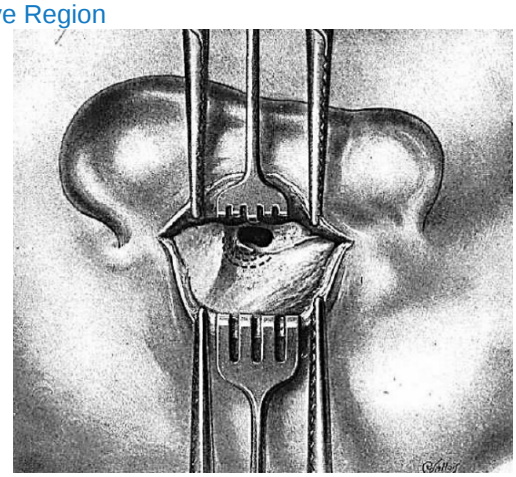


Figure 8: Transected ear canal and exposure of spine of Henlé and tympanic membrane

The skin of the posterior canal wall is transected parallel to the annulus of the tympanic membrane, thereby entering the ear canal, and exposing the tympanic membrane. The bony auditory canal is identified anteriorly and the tympanic cavity medially (*Figure 8*). Above, the finger identifies the crest of the linea temporalis. Above and behind the canal is the spine of Henlé; this is the guiding landmark to direct the following step.

Fifth Step: Search for Aditus and Antrum

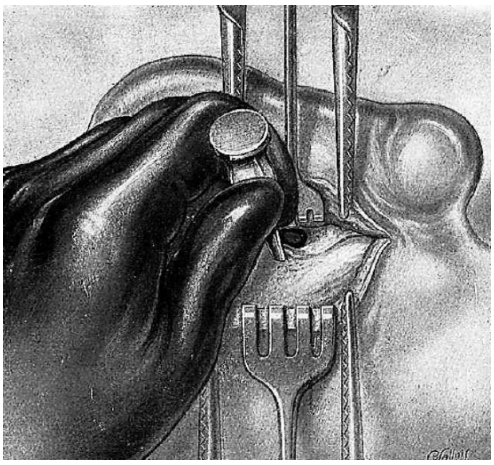


Figure 9: Gouge placed behind spine of Henlé

The search for the antrum begins by enlarging the auditory canal postero-superiorly. In *Figure 8* the black dotted concentric lines indicate the course to be followed with the gouge during trephination; it is centered at the spine of Henlé. A large gouge is placed immediately behind the spine of Henlé, which is removed (*Figure 9*).

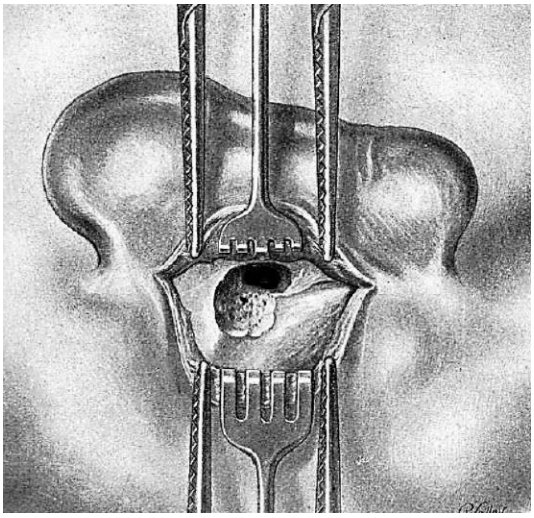


Figure 10: Excavation towards antrum

The instrument is held between the thumb and first two fingers of the left hand with the last two fingers resting on the bony surface, acting as a buffer to avoid plunging. The first tap of the gouge determines the direction of those following, which will be eccentric to it but always in the same direction. The canal is thus progressively enlarged by successive bites of the gouge, which should not extend above the linea temporalis (*Figure 10*). The excavation proceeds deeper until the gouge slips into a cavity: the antrum. The gouge is removed as soon as it penetrates to the cavity. The angular probe locates the aditus ad antrum, which confirms the presence of the antrum.

Sixth Step: Enlargement of Antrum

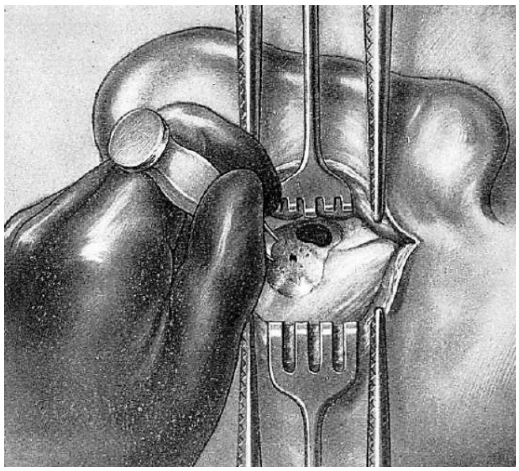


Figure 11: Entering the antrum

After ascertaining the presence of the antrum, the cavity is enlarged with the gouge along its superior, posterior, and inferior walls (*Figure 11*). The objective is to create a smooth, well rounded, regular cavity. The gouge is held between the thumb and first two fingers of the left hand with the last two fingers resting on the adjacent bony surface and acting as a buffer to avoid mishaps. The gouge is successively placed as follows: Superiorly it should not go beyond the linea temporalis, which approximately outlines the separation between the mastoid and middle cranial fossa dura, so as not to uncover the dura mater superiorly. Posteriorly it is handled very carefully and directed obliquely to avoid rupturing the lateral sinus, which may be prominent.

Seventh Step: Opening of Tympanomastoid Canal

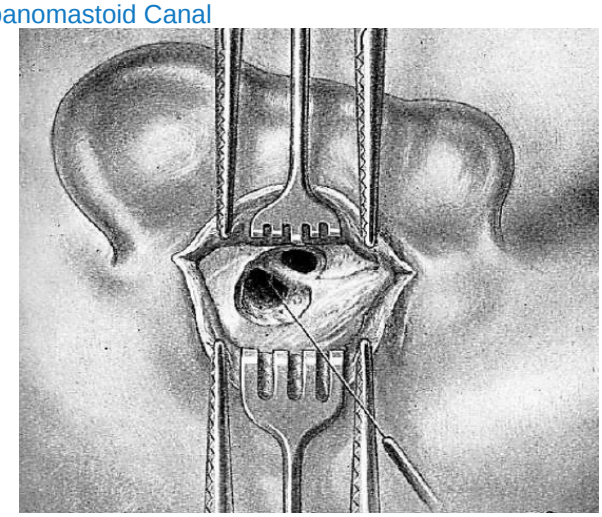


Figure 12: Probing the aditus to determine width of bony bridge

After extensively widening the antrum with a gouge, the surgeon reduces the thickness of the bony bridge, which forms the external wall of the aditus, and which separates the antrum from the tympanic cavity. Removal of this bridge is required to create a free communication via the tympanomastoid canal between the tympanic and mastoid cavities. The width of the bridge is determined by placing a curved probe in the aditus so that the tip is visible in the tympanic cavity (*Figure 12*).

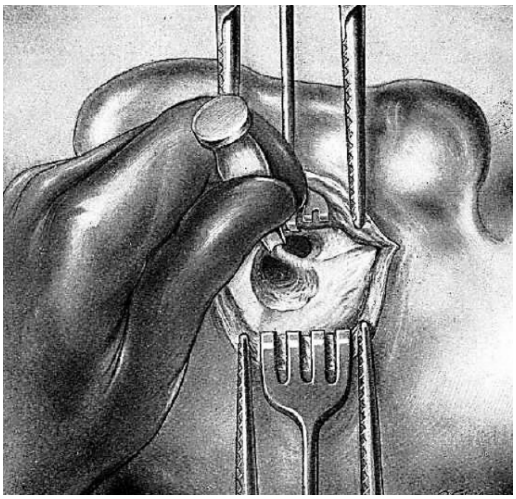


Figure 13: Removing bony bridge

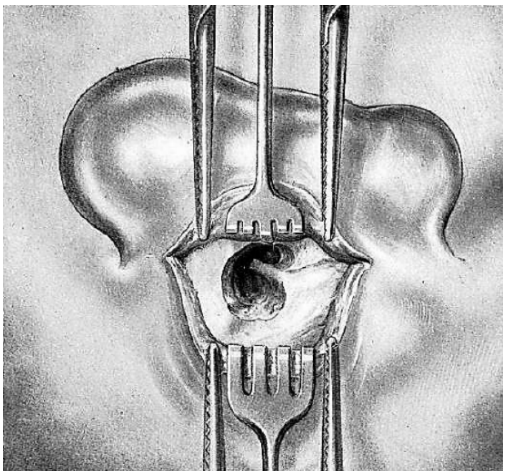


Figure 14: Removing bony bridge

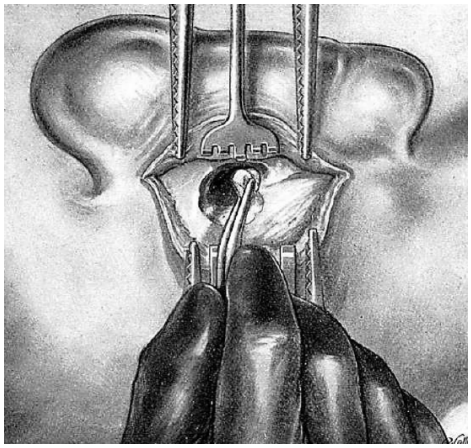


Figure 15: Removing bony bridge

When the bony bridge has been sufficiently reduced in size, its superior portion is removed with a gouge (*Figures 13, 14 & 15*).

The instrument is held perpendicularly between the thumb and first two fingers of the left hand, the other two fingers resting on the adjacent bone. The concavity of the gouge always faces inferiorly. At this point the operator ***should avoid injury to the facial nerve*** which is found much lower and also the lateral semicircular canal, which is internal to and below the line of section. Light taps of the gouge are applied horizontally at the superior end of the bony bridge where there is no danger of injuring the facial nerve, and should extend upwards and forwards over the wall of the attic. The tympanomastoid canal is reached by light taps of the hammer and is thus opened.

The wall of the middle ear is then completely smoothed with the gouge, which is always held in the same direction, in order to bring the roof of the antrum, the tympanic cavity, and the aditus to the same level. No bony ridges or irregularities are left.

Eighth Step: Removal of Facial Ridge

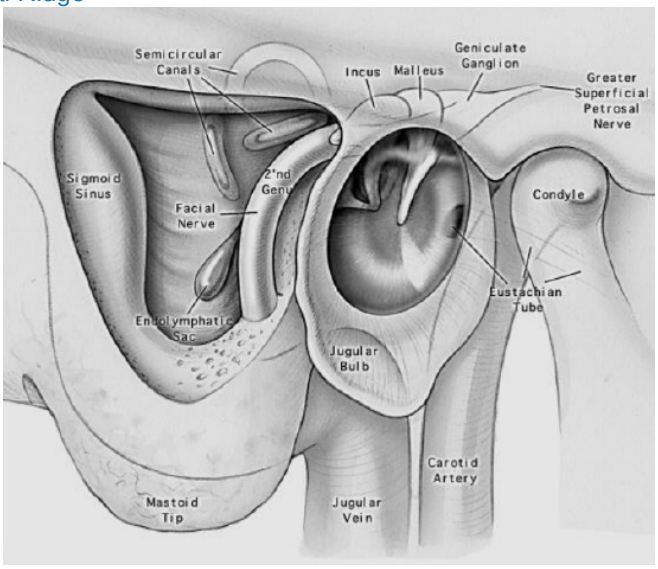


Figure 16: Anatomical relations of facial nerve

The middle ear and the antrum thus constitute a common bean-shaped cavity. They communicate widely superiorly but are separated inferiorly by the inferior margin of the aditus. A rounded elevation is present inferiorly in the antrum; this is the bony shell of the lateral semicircular canal. It serves as a useful marker for the location of the 2nd genu of the facial nerve, which is located anteroinferiorly to the lateral semicircular canal. The inferior aspect of the aditus is particularly thick and contains the 2nd genu of the facial nerve giving rise to the vertical limb of the Fallopian canal (*Figure 16*).

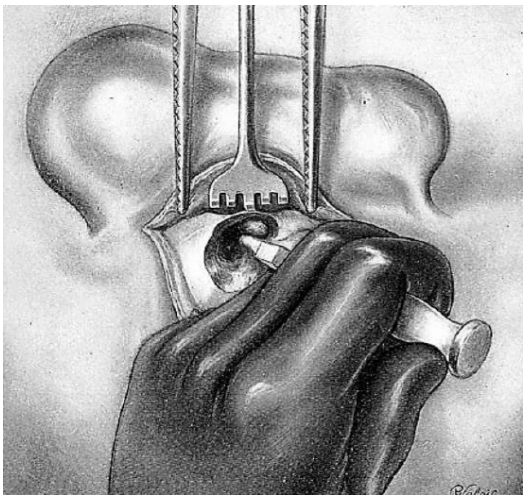


Figure 17: Removal of facial ridge

Removal and lowering of the facial ridge is a very delicate but necessary procedure for a good operative result. A small gauze pledget is placed in the tympanic cavity to catch the bony debris which otherwise would remain in the cavity. Removal of the facial ridge is accomplished with light taps of the mallet on the chisel. They are directed obliquely upwards from the base (inferiorly) to the summit (superiorly), the top of which overhangs the aditus (*Figure 17*).

Since the inferior portion is very thick, there is not much danger of injury to the facial nerve. However, the summit is adjacent to the 2nd genu. The operator proceeds very cautiously, chipping off smaller and smaller pieces of bone as the aditus is approached.

The anesthetist is advised not to paralyze the patient, and is asked to focus his attention on the patient's face to observe muscular contractions in the area of distribution of the facial nerve, and to immediately advise the surgeon of any contractions which are indicative of trauma in the vicinity of the nerve. The surgeon stops at the slightest warning from the anesthetist. Generally the

procedure is straightforward. Sometimes, however, the bone may bleed. This indicates proximity to the stylomastoid artery, which is external/superficial to the facial nerve. This is an important sign of proximity to the nerve.

All irregularities are removed, leaving a bony cavity with rounded contours and a smooth surface. The summit is continuous with the floor of the aditus. A rounded elevation appears on the internal slope of the facial ridge towards the antrum; this is the bony shell of the lateral semicircular canal.

Ninth step: Curettage of Tympanic Cavity

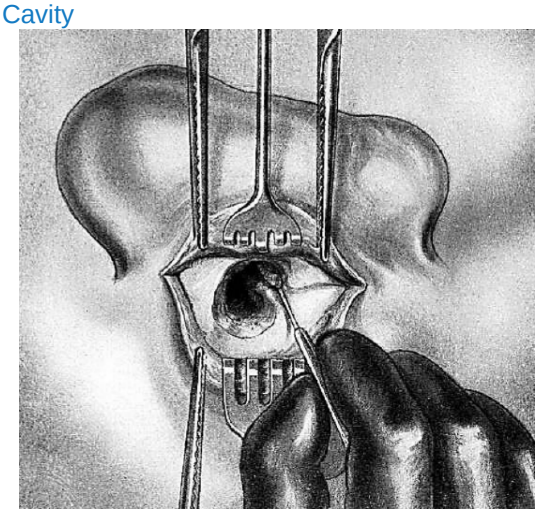


Figure 18: Curettage of middle ear, and removal of incus and malleus

The small pledget in the tympanic cavity is removed. The tympanic cavity is often filled with cholesteatomatous shreds and inflammatory granulations. All that remains to be done is curettage of this cavity. During this operative step, the anesthetist continues to watch the patient's face and to warn the surgeon of any injury to the facial nerve. A small, middle ear curette is used. First to be removed are the malleus and incus, whose necrotic fragments are identified. The stapes is left undisturbed (*Figure 18*).

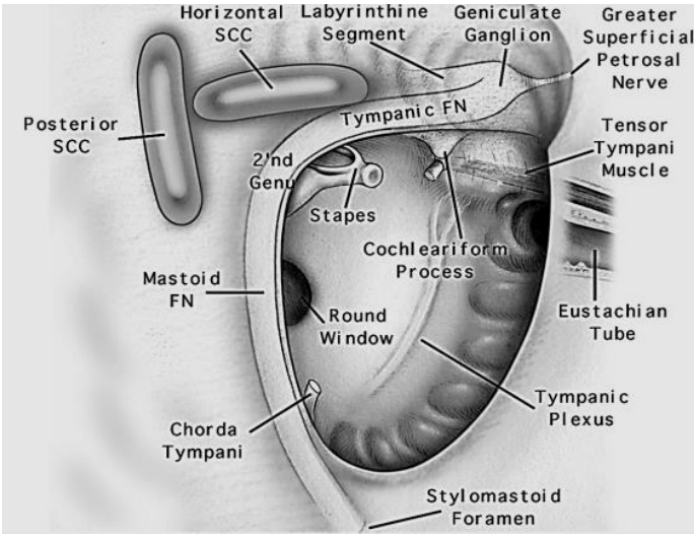


Figure 19: Anatomy following radical mastoidectomy and removal of malleus and incus

The walls are curetted systematically. The danger of dehiscence of the bone or of accidentally breaking through the bone with the curette should be constantly kept in mind. Curettage should therefore be very carefully performed. The superior wall (tegmen tympani) is very thin and is adjacent to the temporal meninges. The floor is slightly resistant and immediately above the jugular bulb. The medial wall contains the oval window with the stapes superstructure and round window, and the facial nerve which is often dehiscent and exposed by osteitis (*Figure 19*).

It is necessary to see clearly, sponge or suction often, use small pledgets of adrenaline, and utilize magnification e.g. magnifying loupes, an endoscope or a microscope. The operation is terminated with curettage of the anterior wall. This wall contains the orifice

of the Eustachian tube, the medial edge of which is adjacent to the carotid canal. The cutting edge of the curette should therefore be turned outwards as the lateral wall offers no dangers.

Tenth Step: Cleaning and Exploring Operative Cavity

The entire cavity is sponged/suctioned and irrigated with saline. Bony debris is meticulously removed; the slightest unevenness is smoothed with the gouge or curette. The blunt probe is used to determine that neither the dura mater nor the lateral sinus has been exposed in the tympanic cavity or antrum/mastoid. Carefully examine, with magnification, the lateral semicircular canal to rule out a labyrinthine fistula. This appears as a greyish dot where the probe reveals a loss of bony substance.

Eleventh Step: Meatoplasty

The next procedure is to adapt the auditory canal and auricle to the new cavity. A piece of gauze is placed in the tympanic cavity and antrum. The assistant retracts the pinna forward and introduces a gouge into the membranous canal with its concavity directed against the concha. The pinna and gouge are then angled forward towards the cheek. The surgeon incises the posterior wall of the membranous canal over the gouge from front to back. The gouge protects the underlying tissues as it guides the scalpel. The gouge is removed and the pinna, held by the assistant with both hands, is returned to its normal position.

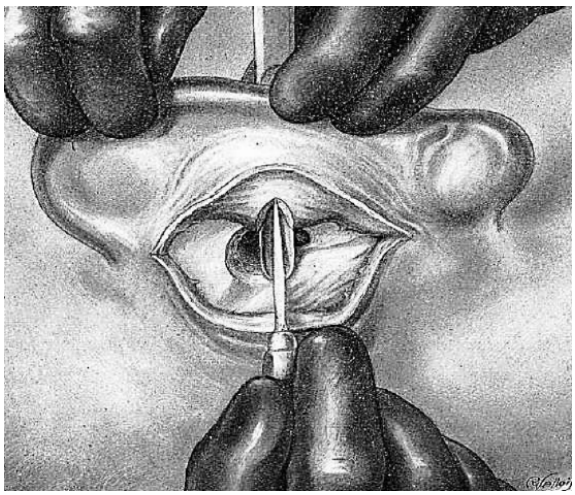


Figure 20: Initial meatoplasty incision

The scalpel is introduced into the canal from below, passing up through the operative gap. The blade is turned toward the auricle and follows the transverse incision backwards to the centre of the concha (*Figure 20*).

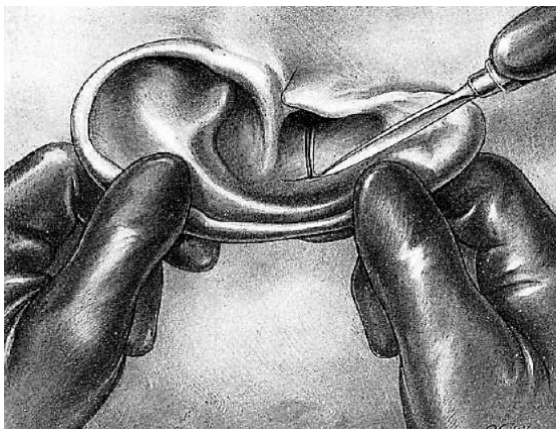


Figure 21: “T” incision in concha

The scalpel is removed and a “T” incision is made in the concha at right angles to the original incision (*Figure 21*). In this manner two triangular flaps are obtained, one superiorly and one inferiorly.

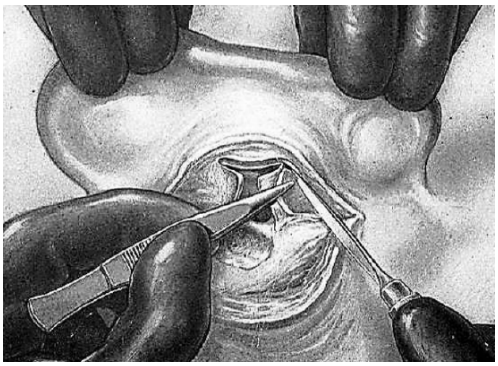


Figure 22: Thinning of flaps

The flaps are very thick and consist of the skin of the concha and canal as well as the lining cartilage and adipose tissue. Only the skin should be preserved in order to obtain a pliable flap that will conform to the cavity. The pinna is again drawn forward and the tips of the flaps are successively grasped with tissue forceps. Using the scalpel, the cartilage is then separated and excised from its adherent tissues. This excision causes minor hemorrhage and necessitates cautery or a few ligatures. The two flaps are then ready to be stitched into place. The surgeon now turns his attention to the posterior edge of the concha and here, too, excises the cartilage. The skin is grasped with tissue forceps and the scalpel separates the cartilage, of which 2 or 3 mm is resected (*Figure 22*).

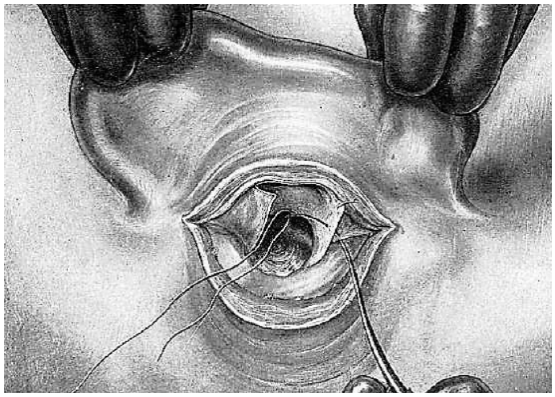


Figure 23: Suturing inferior flap

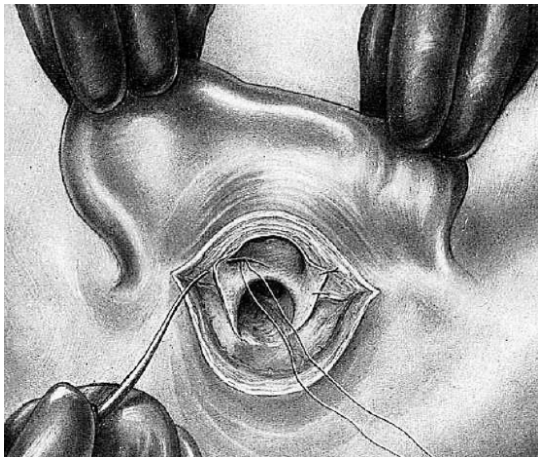


Figure 24: Suturing superior flap

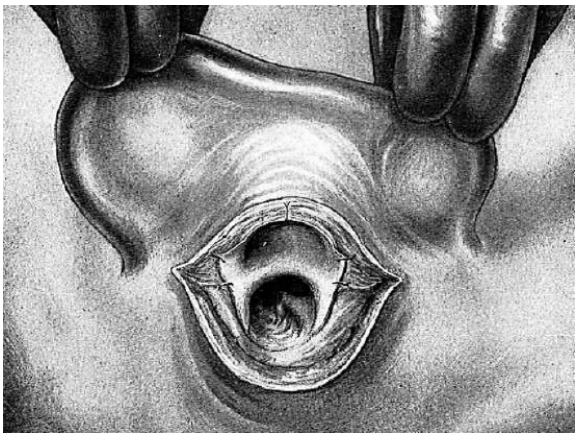


Figure 25: Suturing posterior lip

The concha, thus prepared for the meatoplasty, consists of two flaps and the posterior edge of the vertical incision. These two thin cutaneous flaps are the primary source of epithelialization of the bony cavity. They are everted and successively stitched to the adjacent tissues of the pinna so that they are well placed in relation to the contours of the antrum. The inferior flap, held with the tissue forceps, is transfixed. It is lightly turned back and the needle grasps the cellular tissue of the pinna beneath the flap. The flap is stitched with catgut/vicryl so that its everted free edge lies on the inferior part of the antrum (*Figure 23*). The same maneuver is executed with the superior flap which corresponds to the edge of the superior antral wall (*Figure 24*). The posterior lip of the conduit is then everted by two or three stitches (*Figure 25*). The meatoplasty is completed. The pinna remains mobile since at no point is it fastened to the mastoid.

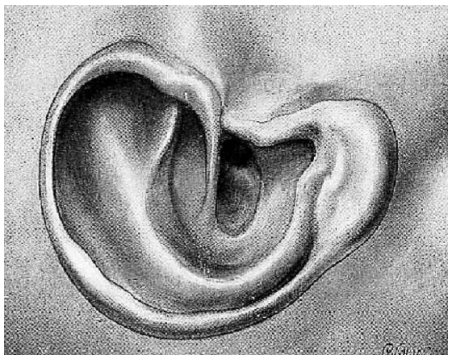


Figure 26: Final meatoplasty

After removing the temporary packing in the operative cavity, the pinna is returned to its original position. The surgeon should carefully inspect the meatoplasty to ascertain that there is no retraction of the skin of the pinna and that the orifice in the concha gives adequate access to the antrum and tympanic cavity for subsequent inspection and cleansing (*Figure 26*).

Twelfth Step: Packing of Cavity

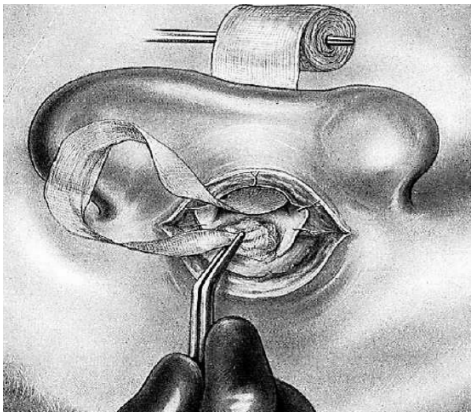


Figure 27: Ribbon gauze has been pulled through the meatoplasty to pack the mastoid cavity

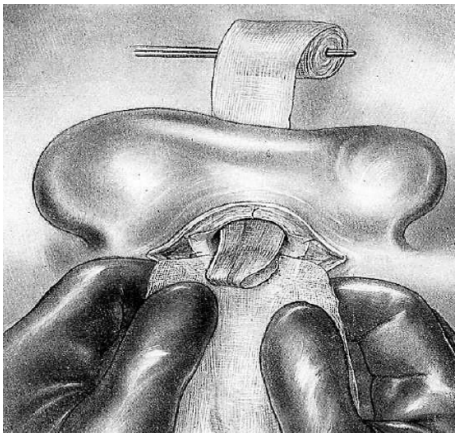


Figure 28: Interposed gauze prevents pressure on dressings of bony cavities during packing of meatus

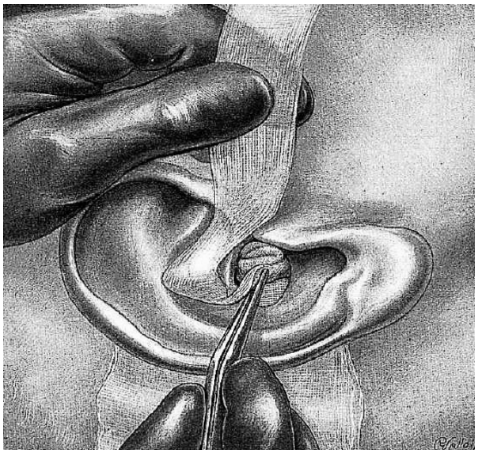


Figure 29: Packing the meatus

The operative cavity is packed with BIPP impregnated ribbon gauze mounted on a hemostat. The assistant retracts the pinna slightly forward. The end of the gauze passes through the orifice of the concha and exits into the retroauricular wound. The surgeon then pulls several centimeters of ribbon gauze towards himself; with it he packs the bony cavity (*Figure 27*).

Packing is done in the following manner (*Figures 27-29*): The end of the ribbon gauze is held in a forceps and is folded upon itself. It is inserted first in the tympanic cavity, which is filled without being tightly packed. The ribbon is next placed in the aditus and then the antrum. After packing the cavities, the surgeon packs the concha with the remainder of the ribbon. A gauze sponge/swab is placed in the retroauricular groove, isolating the pinna from the antrum and tympanic cavity. The concha is filled with the ribbon gauze which is tightly packed here since its object is to serve as support for the meatoplasty flaps. The interposed gauze sponge/swab prevents the latter packing from creating pressure on the dressings of the bony cavities.

Thirteenth Step: Retroauricular Suture and Dressing

The skin is carefully approximated and closed with three or four sutures.



Figure 30: Sutured wound

A small ball of absorbent cotton is placed at the entrance of the concha against the ribbon gauze so the latter will not adhere to the gauze dressing. A gauze sponge/swab is placed in the retroauricular groove; two or three other gauze sponges/swabs are placed on the pinna. The entire area is covered with sterile absorbent cotton which is held in place by a bandage wrapped around the head.

Postoperative Care

The surgeon assesses the facial nerve function. Patients are generally discharged the day following surgery. The mastoid dressings are removed 1-2 weeks following surgery. The mastoid cavity generally requires regular toilette lifelong at variable intervals.

Special Problems

Difficulty Finding Antrum

Locating the antrum is one of the main difficulties during the course of radical mastoidectomy. The bone is frequently sclerotic and the antrum small. The technique described always leads to the aditus, which the operator should be particularly anxious to locate. Should he/ she fail to find the antrum, a blunt probe, carefully directed and inserted into the tympanic cavity is used to locate the course of the tympanomastoid canal, and the location of the aditus ad antrum.

Exposure of Lateral Sinus or Temporal Meninges

The lateral sinus is sometimes inadvertently uncovered with the first taps of the gouge. The temporal meninges are covered by the thin bony tegmen tympani and may be exposed by osteitis of the roof of the tympanic cavity or by curettage. It is prudent to use a blunt probe quite often to explore the superior wall of the tympanic cavity, the aditus, or the antrum before curetting or when trauma with an instrument is feared. Extreme caution is always required. However exposure of the above structures does not generally present any serious danger. No special measures are required. In the postoperative course a close watch is kept for the possible appearance of intracranial complications.

Automastoidectomy

A cholesteatoma which has been present for a period of years may erode the bone to such an extent that it result in an autoradical mastoidectomy. The aditus may be deeply excavated and the antrum vast. Oftentimes the medial cortex is also destroyed. The task of the surgeon in such cases is much simpler and the bony surface is white and smooth. The only necessary procedure required is to complete the opening of the aditus and remove the facial ridge.

Labyrinthine Fistula

An unsuspected labyrinthine fistula, generally of the lateral semicircular canal, may be discovered during the course of the operation by careful inspection with magnification, probing, or the presence of a nystagmus noticed by the anesthetist; or by vertigo in the awake patient. The fistula should not be disturbed but simply covered with a patch of temporalis fascia.

Facial Nerve

The facial nerve may be affected preoperatively to various degrees. Some spontaneous contractions of the muscles of the face may have been noticed. Paresis or paralysis may be present. Whenever the facial nerve has been affected all maneuvers in the tympanic cavity and aditus should be done very cautiously. Facial nerve paralysis also raises the possibility of tuberculous mastoiditis.

Tuberculous mastoiditis requires a lesser operation than for acute mastoiditis, the object being only to remove bony sequestra, and to obtain tissue for histological and bacteriologic diagnosis.

Complete paralysis as an unfortunate result of the operative procedure, is uncommon. Await resolution of local anesthetic, as it might be responsible for the paralysis. The mastoid packing should be loosened as it may be pressing on a dehiscent nerve. If there is a suspicion of the nerve having been transected or compressed by a spicule of bone, the ear should be urgently explored and the nerve decompressed, repaired, or grafted with a segment of greater auricular nerve.

Intracranial Complications

Meningitis and, less frequently, thrombophlebitis of the lateral/sigmoid sinus are serious complications during the first few postoperative days in patients with mastoiditis.

Labyrinthine Complications

During the immediate postoperative period of a radical mastoidectomy, the patient may experience dizziness and have nystagmus. These may be perilabyrinthine phenomena produced by mild irritation in the neighborhood of an unrevealed fistula, or may be due to a labyrinthine fistula, or dislocation of the stapes.

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Robert Jackler MD
Sewall Professor and Chair
Department of Otolaryngology-Head & Neck Surgery
Associate Dean, Postgraduate Medical Education
Stanford University School of Medicine
Stanford, CA 94305-5101, USA

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2.5: Myringotomy and Ventilation Tube Insertion

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris & Thomas Linder

Ventilation tubes (grommets) are generally inserted for refractory middle ear effusions with persistent conductive hearing loss, present for a minimum duration of 3 months and with hearing loss exceeding 25dB. They may also be inserted as an adjunct procedure in acute mastoiditis secondary to acute suppurative otitis media.

Preoperative assessment

- Pneumatic otoscopy to confirm the diagnosis
- Pure tone audiometry within the preceding 3 months, or age appropriate hearing test, as well as tympanometry
- A middle ear effusion may be caused by pathology (benign or malignant) in the nasopharynx which causes tubal dysfunction. Therefore, particularly in adult patients the nasopharynx should be examined, and the neck palpated for metastases from a nasopharyngeal malignancy
- A CSF leak may present as a middle ear effusion. A high index of suspicion is therefore necessary in the presence of a clear serous or watery effusion or when the history is suggestive of a CSF leak.

Surgical technique

Temporary ventilation tube insertion

- General anesthesia is used for children
- Local anesthesia may be employed with adults. Topical anesthetic spray (e.g. xylocaine) can be applied to the tympanic membrane 10 minutes before the procedure. Alternatively, Emla cream® (lidocaine 2.5% and prilocaine 2.5%) can be applied to the tympanic membrane 30 minutes prior to the procedure, or the deep ear canal may be injected with local anesthesia with a dental needle

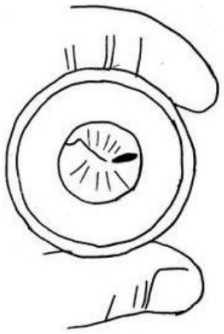


Figure 1: Ear speculum in place right ear with radial incision placed anteroinferiorly

- An ear speculum is introduced into the ear canal and held in place with the left hand (Right-handed surgeon) (*Figure 1*)



Figure 2: Typical myringotomy knife

- Using an operating microscope or endoscope, a radial incision is made in the anteroinferior quadrant around the region of the light reflex with a myringotomy knife (*Figures 1 & 2*). Incisions in the posterosuperior quadrant are avoided as they can injure the ossicular chain or the chorda tympani. The incision must be large enough to accommodate a ventilation tube.
- The middle ear effusion may be aspirated with a microsuction tube before inserting the grommet



Figure 3: Examples of short stay tubes

- A ventilation tube is picked up with crocodile forceps and introduced into the ear canal using the right hand (*Figure 3*)

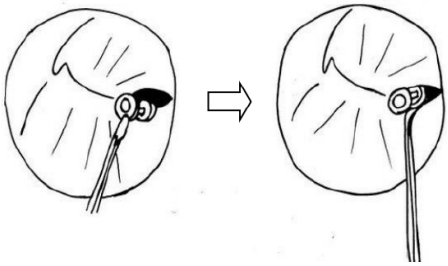


Figure 4: Placement of tube on right tympanic membrane, followed by advancement of tube with a hook

- The tube is placed on the tympanic membrane adjacent to the myringotomy opening (*Figure 4*)
- Using a 1,5 mm, 45° hook the inner flange is rotated through the myringotomy incision so that the tube straddles the tympanic membrane (*Figure 4*)

Long-term ventilation tube insertion



Figure 5: Example of a T-tube

For long-term middle ear ventilation, a ventilating T-tube is used (*Figure 5*). It remains in place for up to 3 years. After extrusion or removal, it results in a chronic perforation of the tympanic membrane in about 16-19% of cases.[2, 3]

- The flanges of the T-tube are grasped with crocodile forceps



Figure 6: The flanges are both trimmed

- The flanges are then trimmed so that the ends are pointed; this facilitates insertion of the tube through the myringotomy opening (*Figure 6*)
- A myringotomy is made in the anteroinferior quadrant of the tympanic membrane (*Figure 1*)
- The T-Tube is grasped with a fine crocodile forceps and the pointed end of the flange is inserted through the myringotomy incision

Special problem: Ventilation tube falls into middle ear

- Although tubes are inert and are unlikely to cause damage when left in the middle ear, removal should be attempted because of the potential for foreign body reaction.[4]
- If the grommet lies close to and can be seen through the myringotomy incision, then it may be possible to retrieve it using small crocodile forceps, and then reinserted correctly
- If the tube however lies beyond the confines of the mesotympanum, cannot be seen and removal would be difficult, then one option is to leave it in situ and for the patient to return regularly for surveillance and otomicroscopy[4]
- Surgical removal when one has a healed, intact tympanic membrane entails a wide myringotomy and removal of ventilation tube
- Very rarely an exploratory tympanotomy may be required

References

1. Fisch U, May J. Tympanoplasty, Mastoidectomy and Stapes Surgery. New York: Thieme; 1994
2. Van Heerbeek N, De Saar GM, Mulder JJ. Long term ventilation tubes: results of 726 insertions. Clin Otolaryngol Allied Sci. 2002;27(5): 378-83
3. Kay DJ, Nelson M, Rosenfeld RM. Meta-analysis of tympanostomy tube sequelae. Otolaryngol Head Neck Surg. 2001;124(4):374-80
4. Rosenfeld RM, Bluestone CD. Evidence Based Otitis Media. 2nd Ed. Hamilton: BC Decker Inc; 2003

Author

Tashneem Harris MBChB, FCORL, MMED (Otol), F*isch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Thomas Linder, M.D. Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.6: Meatoplasty

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Tashneem Harris & Thomas Linder

Meatoplasty is an operative technique to widen the lateral cartilaginous part of the external auditory canal. Cartilage displaced anteriorly from the *cavum conchae* of the pinna, as well as bulky underlying soft tissue can cause narrowing of the lateral part of the ear canal.[1] The aim of a meatoplasty is to enlarge the lumen of the entrance of the ear canal by removing the obstructing cartilage of *cavum conchae* as well as the underlying soft tissue.

Indications for surgery

There are 2 clinical scenarios where a meatoplasty may be required i.e. as an integral part of another otological procedure, or where there is lateral stenosis of the external ear canal.

As integral part of other otological procedures

- Open mastoidoepitympanectomy (MET): Meatoplasty is an essential routine step at the end of an open MET to provide easy access for cleaning and to assist with ventilation of the mastoid cavity. Failure to do an adequate meatoplasty will result in a lifelong problem of a chronic draining ear. This type of meatoplasty is discussed in the chapter Mastoidectomy and Epitympanectomy
- Tympanoplasty, canalplasty, removal of exostosis (bony canal wall intact): In these procedures it may be mandatory to perform a meatoplasty to improve intraoperative surgical exposure.

For lateral stenosis of the external ear canal: Meatoplasty becomes necessary when wax impaction as a result of canal stenosis causes recurrent otitis externa or hearing loss and requires frequent visits to an otolaryngologist.

Canal stenosis may be a result of:

- Congenital stenosis
- Otitis externa
- Iatrogenic following surgery or irradiation
- Trauma

M-Meatoplasty

See video

The authors favor the M-Meatoplasty technique first described by Mirck in 1966.[2]

Anesthesia

- Antibiotic prophylaxis is not required
- It is performed under local anesthesia as an outpatient procedure
- The retro-auricular skin behind the conchal cartilage and the underlying soft tissue are infiltrated with 1% lidocaine and 1: 100 0000 adrenaline
- The skin and subperichondrial layer of the conchal bowl as well as the posterior ear canal wall are infiltrated with the same solution

Creating the skin flaps

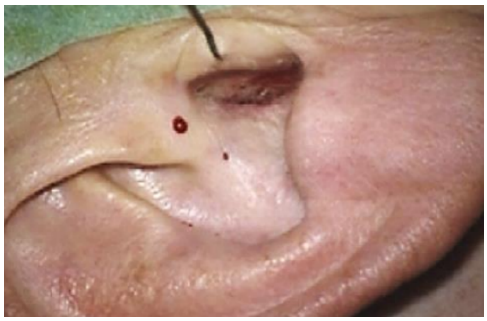


Figure 1: Microhook retracting tragus

- An assistant retracts the tragus using a microhook to improve exposure (*Figure 1*)

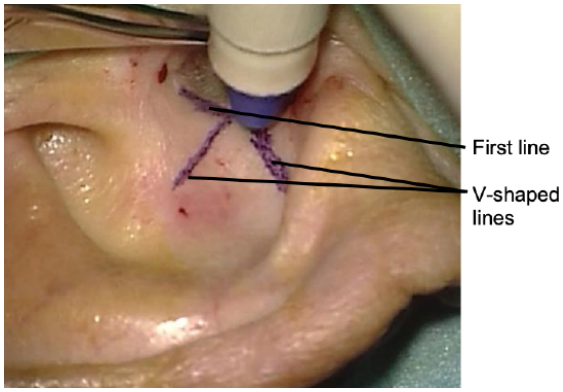


Figure 2: Marking the incisions

- The incisions are mapped out with a marking pen. (*Figure 2*)
  - The first line is placed at the anterior border of the cavum conchae and at the entrance to the external auditory meatus (*Figure 2*)
  - Two skin markings each measuring 1 cm in length and orientated as an inverted “V” are commenced in the center of the first skin marking (*Figure 2*)



Figure 3: Three skin incisions

- Skin incisions along these lines are made using a #15 blade resulting in three triangular skin flaps (*Figure 3*)

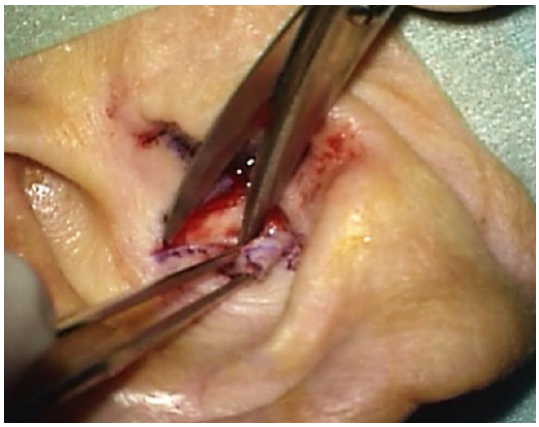


Figure 4: Elevating skin flaps

- Skin flaps are developed by separating the skin from the underlying cavum cartilage using sharp-pointed scissors (*Figure 4*)

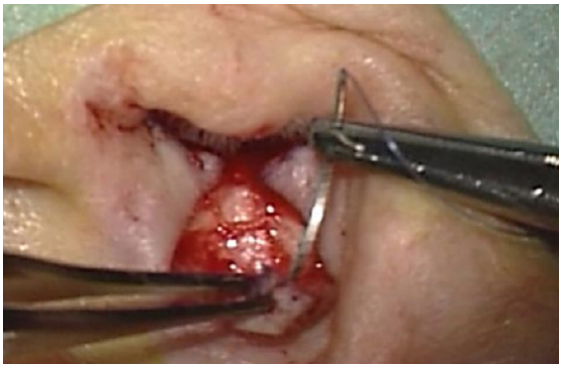


Figure 5: Guide suture being inserted into posterior flap

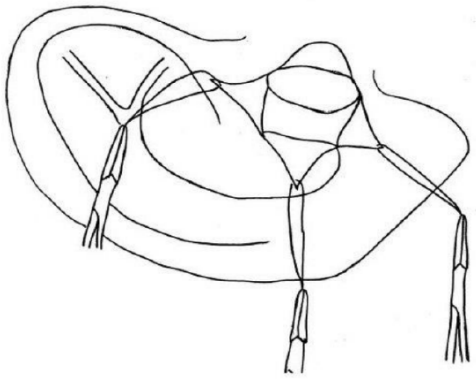


Figure 6: Guide sutures in all 3 flaps

- Guide sutures are placed at the apices of the 3 triangular skin flaps and mosquito clamps placed at the end of each suture to hold the skin flaps aside (*Figure 5 & 6*)

Excision of obstructing cavum cartilage and underlying soft tissue

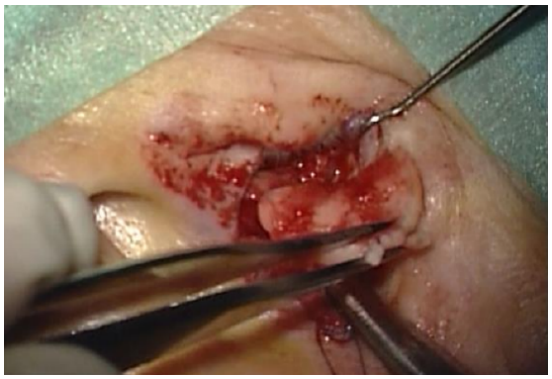


Figure 7: Circle cut out of cavum cartilage

- A circle of about 1 cm diameter is cut out of the cavum cartilage (*Figure 7*)



Figure 8: Subcutaneous tissue is excised

- The underlying subcutaneous tissue is often bulky and is also excised (*Figure 8*)

V-Y plasty

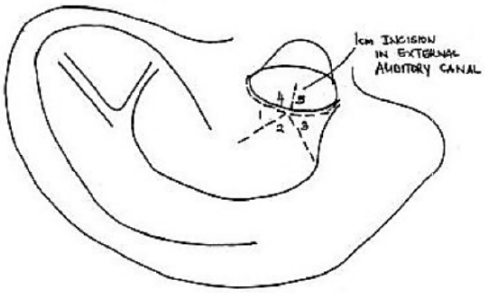


Figure 9

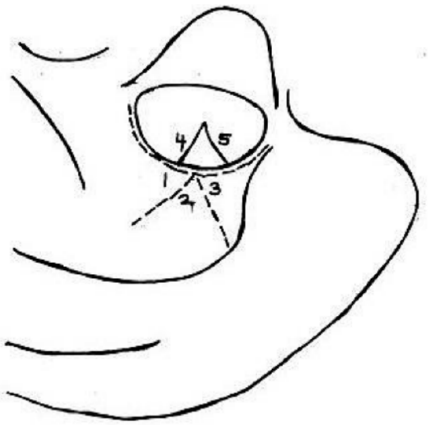


Figure 10

- A fourth 1 cm transverse incision is made in the posterior canal wall, thus creating two intrameatal skin flaps (*Figure 9 & 10*)
- 6/0 Nylon sutures are used to suture the skin flaps as follows:

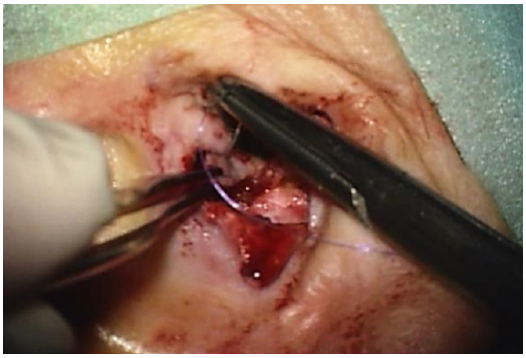


Figure 11: Sutures placed between ends of the intrameatal skin flaps

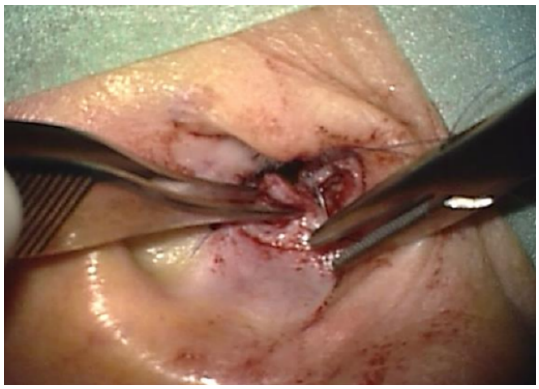


Figure 12: Sutures placed between ends of the intrameatal skin flaps

- Sutures are placed between the pointed ends of the two intrameatal skin flaps and either side of the base of the central triangular skin flap (*Figures 11 & 12*)

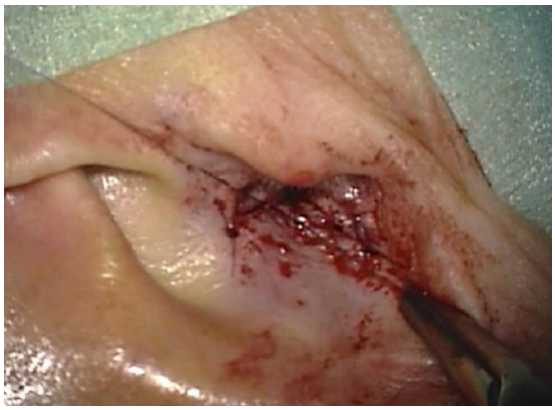


Figure 13: Suture placed at beginning of the intrameatal skin incision and apex of middle triangular skin flap

- A suture is placed at the beginning of the intrameatal skin incision and the apex of the middle triangular skin flap. This step widens the entrance of the external ear canal (*Figure 13*)

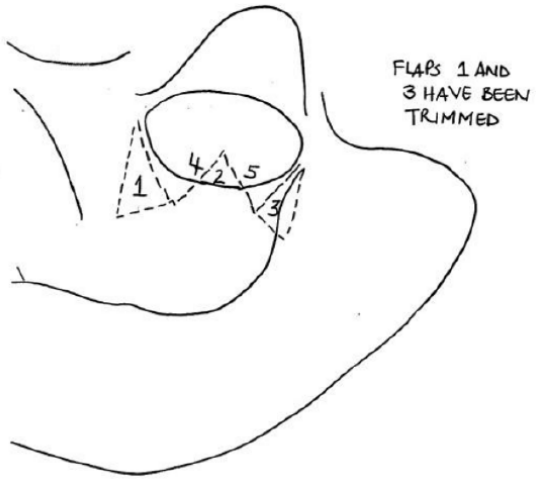


Figure 14



Figure 15

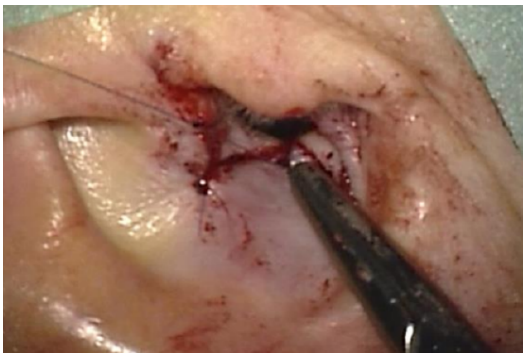


Figure 16

- The two redundant triangular skin flaps are excised, and sutures are placed between the remaining edges of skin of the cavum concha and the intrameatal skin flaps. (*Figure 14,15,16*)



Figure 17

- This results in a scar shaped like an “M” (*Figure 17*)
- A Terracortril (ointment containing a steroid and antiseptic agent) gauze is placed in the external ear canal for 5 days
- Sutures are removed after 1 week

View meatoplasty video

References

1. Fisch U, May J, Linder T. Tympanoplasty, Mastoidectomy, and Stapes Surgery. New York: Thieme; 2008.
2. Mirck PG. The M-meatoplasty of the external auditory canal. Laryngoscope. 1996; 106(3):367-69.

Author

Tashneem Harris MBChB, FCORL, MMED (Otol), *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Prof Thomas Linder, M.D.
Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.7: Mastoidectomy and Epitympanectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris & Thomas Linder

Chronic otitis media, with or without cholesteatoma, is one of the more common indications for performing a mastoidectomy. Mastoidectomy permits access to remove cholesteatoma matrix or diseased air cells in chronic otitis media. Mastoidectomy is one of the ***key steps*** in placing a cochlear implant. Here a mastoidectomy allows the surgeon access to the middle ear through the facial recess. A complete mastoidectomy is not necessary; therefore, the term anterior mastoidectomy is often used (anterior to the sigmoid sinus). A mastoidectomy is ***often an initial step*** in lateral skull base surgery for tumors involving the lateral skull base, including vestibular schwannomas, meningiomas, temporal bone paragangliomas (glomus tumors), and epidermoids or repair of CSF leaks arising from the temporal bone.

Definition of Cholesteatoma

Cholesteatoma is a chronic middle ear infection with squamous epithelium and retention of keratin in the middle ear and/ or temporal bone with progressive bone erosion. A middle ear atelectasis does not retain keratin, although it also reveals skin in the middle ear space due to the retraction pocket.

Aims of Cholesteatoma Surgery

- Eradication of disease and preventing residual disease
- Improving middle ear ventilation and preventing recurrent disease
- Creating a dry, self-cleansing cavity
- Reconstitution of the hearing mechanism

Types of Mastoidectomy

The terminology around mastoid surgery is not uniform. In fact, several terms are used to describe the different types of mastoidectomy as summarized in *Table 1*.

Table 1: Types of mastoidectomy

Canal wall up mastoidectomy	Canal wall down mastoidectomy
Combined approach	Radical mastoidectomy
Intact canal wall mastoidectomy	Modified radical mastoidectomy
Closed technique	Open technique
	Front-to-back mastoidectomy
	Atticoantrostomy
	Open mastoidoepitympanectomy

One of the problems is that the terminology does not in fact entail specific information about what was done either to the middle ear or the mastoid. It is the authors' preference to use the terms open/closed mastoidoepitympanectomy and to state separately whether a tympanoplasty or ossiculoplasty was done e.g. left open mastoidoepitympanectomy and tympanoplasty type III.

The most commonly used terms for canal wall down mastoidectomy are radical or modified radical mastoidectomy. The classical radical mastoidectomy is not favored by the authors as it results in a large cavity which frequently discharges and therefore does not satisfy the ultimate goal of mastoid surgery which includes having a "trouble free" cavity.

The method of open and closed mastoidoepitympanectomy as described in this text is standard. Common to both open and closed mastoidoepitympanectomy is the bony work involving the mastoid cavity. It involves first ***identifying the important landmarks*** (=

skeletonization = leaving a thin shelf of bone covering the important structure) before removing the disease and maximum exposure for ***complete exenteration*** of the disease.

A closed technique, keeping the posterior canal wall in place and working transcanal (following a proper canalplasty) and transmastoid (with or without posterior tympanotomy) is suggested in moderately pneumatized and ventilated ears with sufficient exposure to remove the disease.

Open mastoidoepitympanectomy involves complete exenteration of the mastoid air cell system (e.g. retrosigmoid, retrofacial, perilabyrinthine) and the epitympanum (removal of incus and malleus head, exenteration of the supralabyrinthine and supratubal cells) and is indicated in poorly pneumatized and ventilated ears with limited access and exposure. It requires skeletonization of the facial nerve along the mastoid segment to lower the posterior canal wall to the facial nerve (still covered by bone). The mastoid area behind the facial nerve is later obliterated with a muscle flap to keep the volume of the final cavity low and avoid discharging ears.

The other method of “canal wall down” mastoidectomy is front-to-back mastoidectomy. Surgeons may elect this approach when it has been decided in advance that the canal wall will be taken down e.g. with a sclerotic mastoid. The principles of this method are that one follows the disease, i.e. the mastoid is only opened as far as the extent of the disease. The only problem with this approach is that one must be certain that there are no more mastoid cells present as incomplete exenteration will cause a discharging cavity.

Surgical Terminology

Canalplasty: Enlargement of the external ear canal while avoiding injury to the temporomandibular joint anteriorly and the mastoid air cells posteriorly

Epitympanotomy: Partial removal of the lateral wall of the attic to *expose* the head of the malleus and incus in order to remove soft tissue pathology in the epitympanum; the ossicles are left in place

Epitympanectomy: Removal of the lateral wall of the attic, with *removal* of the incus and head of malleus and with exenteration and exteriorisation of supralabyrinthine cells

Cortical mastoidectomy: Also referred to as *simple mastoidectomy*, it entails exenteration of the mastoid air cells and is performed most commonly for acute mastoiditis

Posterior tympanotomy: Drilling away of the bone between the pyramidal (mastoid) segment of the facial nerve, and the lateral bony canal and *chorda tympani* resulting in access to the middle ear from the mastoid. Posterior tympanotomy may be done for the following reasons:

- As part of a closed mastoidoepitympanectomy (combined approach) when removing cholesteatoma
- To remove pus from the region of the round window in acute bacterial or viral otitis media with sensorineural hearing loss
- To provide access to the promontory or round window in cochlear implant surgery and access to incus or round window with insertion of the *Vibrant Soundbridge*

Closed mastoidoepitympanectomy with tympanoplasty: This includes a canalplasty, mastoidectomy, epitympanectomy, (posterior tympanotomy) and tympanoplasty. The external bony canal is preserved. The drawback of this approach is the limited view into the anterior epitympanum and the *sinus tympani* in cases of limited pneumatisation and cholesteatoma formation

Open mastoidoepitympanectomy (with obliteration): This involves the radical exenteration of the tympanomastoid tracts with exteriorization of the surgical cavity and lowering of the posterior bony canal wall to the level of the skeletonized facial nerve. In order to reduce the size of the cavity, especially with moderately-well pneumatized mastoids, the mastoid tip is removed and a myosubcutaneous occipital flap is created to reduce the size of the cavity. Meatoplasty is routinely performed.

Open/Closed Mastoidoepitympanectomy

Age is not a limiting factor as children behave equally well with open MET’s as do adult patients!

Deciding whether to do ***open or closed cavity mastoidoepitym-panectomy*** may depend on the factors listed in *Table 2*.

Factor	Closed MET	Open MET

Extent of disease	Limited Primary surgery with sufficient space	Large cholesteatoma Labyrinthine fistula Other complications Recurrent cholesteatoma after previous closed MET
Pneumatization	Good pneumatization	Poor pneumatization
Aeration	Air in middle ear and mastoid air cells	Glue in middle ear Granulation tissue in mastoid air cells Bleeding
Follow-up	Good 5-year follow-up anticipated	Poor 5-year follow-up anticipated

Table 2: Indications for closed vs. open cavity mastoidoepitympanectomy (MET)

Applied Anatomy

Knowledge of middle ear and temporal bone anatomy is vital to understanding the concepts of surgical management. It is imperative to practice the surgery and learn the 3-dimensional temporal bone anatomy in a temporal bone laboratory. The important landmarks and structures will be highlighted with the surgical steps.

Preoperative assessment

History

Patients with chronic ear disease frequently have a longstanding history of hearing loss or chronic otorrhoea. It is important to establish whether there is a history of previous surgery. Foul smelling otorrhoea is a clear hint of cholesteatoma.

Otomicroscopy

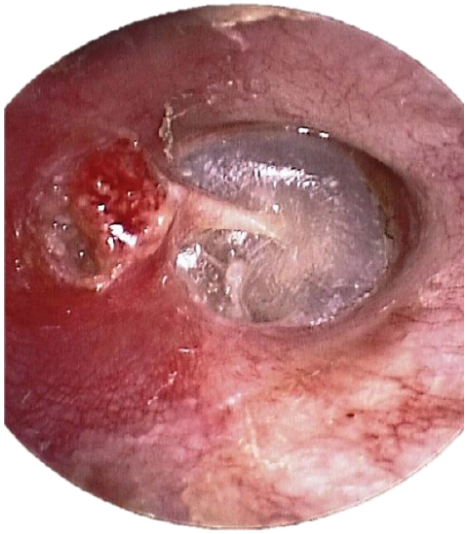


Figure 1: Right ear: Granulation tissue in the attic and a retracted tympanic membrane; bony erosion of the superior canal wall; lenticular and long process of the incus is present with retraction of posterosuperior quadrant of tympanic membrane; tympanic membrane is in direct contact with the stapes superstructure (myringostapediopexy)



Figure 2: Right ear: Polyp obscuring posterosuperior retraction pocket

This is an important means to determine the presence of cholesteatoma and it helps to define the extent of disease. The ear should be thoroughly cleaned of secretions and debris. Findings may include a retraction pocket with accumulation of keratin in the attic or in the posterosuperior quadrant of the tympanic membrane, granulation tissue or a polyp (*Figures 1 & 2*). A polyp "signals" an underlying cholesteatoma.

Pneumatic otoscopy

This should be routinely performed to determine the presence of a positive fistula response. A negative response however does not exclude a fistula.

Audiology

Pure tone audiometry should be obtained with air and bone conduction, and also speech reception thresholds should be determined. These should be done within 3 months of surgery.

High resolution CT (HRCT) scan

All patients undergoing surgery should ideally have preoperative imaging as HRCT (0.5 mm cuts) is invaluable for both for diagnosis and surgical planning. *Preoperative counseling* is mandatory with any surgical procedure. Information gained from the CT scan enables the surgeon to discuss in detail with the patient what the surgical goals and risks of the surgery are, as well as the possibility of a staged procedure and follow-up routine.

Diagnostic value of HRCT

- Specificity is poor with mass lesions which may include granulation tissue, secretions, cholesterol granuloma or a neoplasm
- It therefore cannot be used to definitively diagnose ***cholesteatoma, which remains a clinical diagnosis based on otoscopic findings***
- Findings highly suggestive of cholesteatoma include the presence of an expansile soft tissue mass; retraction of the tympanic membrane; erosion of the scutum; erosion of the ossicles; sharp erosion of bone; extension of the lesion medial to the otic capsule; and erosion of the tegmen tympani

Surgical planning with HRCT

HRCT of the temporal bone is the otologist's road map and one should have a systematic approach when evaluating the CT scan. The decision whether to do an open or closed cavity operation depends on the degree of pneumatization and ventilation of the temporal bone and extent of disease, all of which can be determined on HRCT. Axial as well as coronal images are needed for preoperative evaluation and should always be in the operating theater and visible to the surgeon as intraoperative reference (and not in the patient's chart!)

CT scan checklist

1. *Pneumatization*: The temporal bone may be well pneumatized, may have reduced pneumatization, or be sclerotic. This gives important information about what the eustachian tube function during the first 4 years of the patient's life was like. It is important to assess the pneumatization of the petrous apex as well. Poor ventilation favours an open cavity procedure

2. *Ventilation*: This is assessed by the aeration of the middle ear and mastoid air cells. Opacification of the middle ear or mastoid cells suggests poor ventilation of the middle ear cleft. This gives the best information about eustachian function at the present time. Poor ventilation of already-impaired pneumatized cell tracts favors an open cavity procedure
3. *Ear canal*: Evaluate the thickness of the bone anteriorly and posteriorly. This is important when one needs to do a canalplasty as the anterior relation of the tympanic bone is the temporomandibular joint and posteriorly are mastoid air cells. These should not be breached when doing a canalplasty
4. *Size and presence of emissary vein*: A large emissary vein can cause troublesome bleeding if not anticipated!
5. *Sigmoid sinus and its relation in the mastoid cavity*: In children the sigmoid may be very close to the lateral surface of the mastoid; in adults a sigmoid sinus malformation may only be appreciated on preoperative CT scan. When the sigmoid sinus lies very anteriorly in the mastoid cavity it may be difficult to perform a posterior tympanotomy due to very limited exposure. In revision surgery, it is important to assess whether the sigmoid sinus has been exposed or whether it is still covered by bone. If the sigmoid sinus has been exposed at previous surgery, it will be covered with scar tissue which becomes difficult to elevate thus risking breaching the sinus when elevating the periosteal flap
6. *Jugular bulb*: Is it high-riding (up to the level of annulus)? Is it dehiscent?
7. *Carotid artery*: Is there dehiscence, especially at the level of the eustachian tube?
8. *Tegmen tympani*: What is the shape of the tegmen? Is it flat or does it slope upwards with cells lying medial to it? Is it low-lying? Is it dehiscent? A bony defect of the tympanic tegmen or anterior wall of the epitympanum should raise the suspicion of an encephalocoele or cholesteatoma extending into the middle cranial fossa. This requires further imaging in the form of an MRI
9. *Facial nerve*: The tympanic segment may be dehiscent, especially in children or in the presence of cholesteatoma. In cases of revision surgery, it is important to know whether the facial nerve has been left exposed in an open cavity when elevating the tympanomeatal flap
10. *Is there a fistula of the lateral semicircular canal?*
11. *Extent of disease*: Does it only involve the mesotympanum or does it extend further into the mastoid cavity? Is the petrous apex involved?
12. *Status of ossicular chain*: Are the ossicles present or have they been eroded?

Preoperative preparation

Drugs: A single intravenous dose of *amoxicillin with clavulanic acid* and an *antiemetic* is given preoperatively. However, antibiotics are unnecessary with a dry ear, even in presence of a cholesteatoma. Low dose subcutaneous *heparin* is recommended to prevent deep vein thrombosis with prolonged surgery.

Positioning: The patient lies supine with the head rotated away from the surgeon. Avoid overextension in children; Down's syndrome is associated with atlantoaxial subluxation.

Facial nerve monitoring: Avoid longacting muscle relaxants so that the facial nerve can be monitored.

Closed Mastoidoepitympanectomy

Skin Incision and flap

- Infiltrate the area of the postauricular skin incision as with local anesthetic (lidocaine 1% and adrenaline diluted to 1:200 000)



Figure 3: Postauricular skin incision (left ear)

- Make a curved skin incision about 1.5 cm behind the postauricular sulcus with a #10 blade extending from just above linea temporalis to the mastoid tip. Do not place the incision in the postauricular sulcus (*Figure 3*)
- When approaching the mastoid tip, the skin incision follows the skin tension lines which run directly inferiorly (not curved) towards the neck



Figure 4: Flap elevated in plane just superficial to temporalis fascia

- Elevate the skin flap towards the external ear canal. Cut through the postauricular muscle to reach the correct plane just superficial to temporalis fascia. A large rake can be used to retract the pinna forward (*Figure 4*)
- For adequate exposure the superior incision must be made at the 12 o'clock position relative to the bony ear canal (*Figure 4*)

Periosteal flap

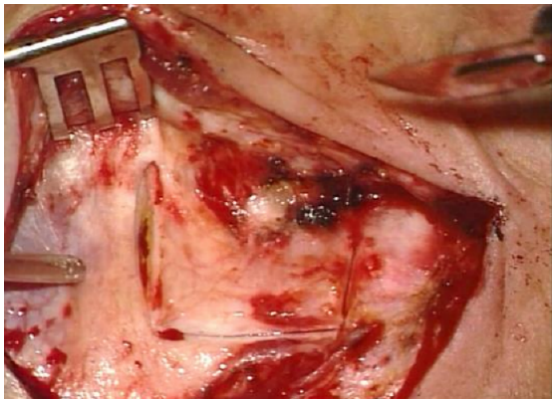


Figure 5: Periosteal flap

- An anteriorly based periosteal flap is developed, about 1.5 cm in length (*Figure 5*)

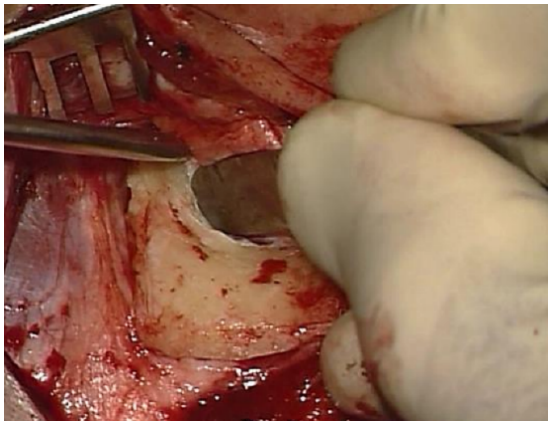


Figure 6: Raspatory used to elevate flap until spine of Henlé and the entrance to bony canal come into view

- A periosteal raspatory is used to elevate the flap from the bone until the spine of Henlé and the entrance to bony canal come into view (*Figure 6*)

- A sharp towel clip can be placed on the periosteal flap at the level of the ear canal to retract the pinna forward
- In an adult two self-retaining retractors are placed between the skin edges and soft tissue for exposure; one selfretaining retractor is usually sufficient in a child

Canalplasty

- If there are any bony overhangs a canalplasty is performed
- A canalplasty should always be ***done first*** as it defines the anterior limit of your mastoidectomy
- ***For a detailed description of the surgical technique readers are referred to the canalplasty chapter***

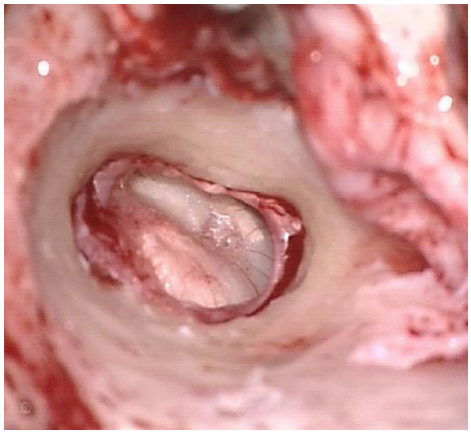


Figure 7: Completed canalplasty with entire annulus visible

- The entire annulus should be visible with one view of the microscope following canalplasty (*Figure 7*)

Elevation of tympanomeatal flap

- The posterior meatal skin flap is elevated towards the annulus using a microraspatory in one hand and a piece of ribbon gauze which has been soaked in adrenaline
- The microsuction is never placed directly onto the meatal skin for risk of injury of the skin flap

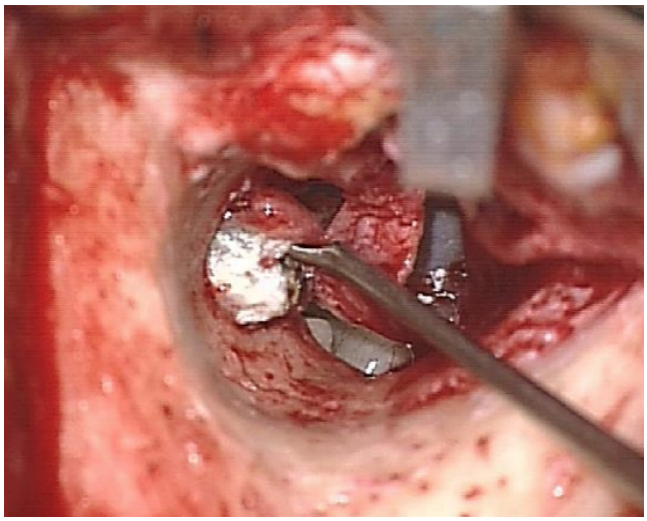


Figure 8: Tympanomeatal flap and annulus have been elevated and middle ear is entered below the pathological area

- Elevate the annulus from its sulcus away from the pathological area e.g. a posterior retraction pocket would preclude entering the middle ear at the level of the posterior tympanic spine as this would breach the cholesteatoma sac (*Figure 8*)

Inspection of middle ear

- The middle ear in Figure 8 has been entered at 6 o'clock after excluding a dehiscent jugular bulb on CT scan
- Define the extent of disease in the middle ear and around the ossicular chain

Division of incudostapedial joint

- To avoid causing a sensorineural hearing loss when working in the epitympanum, the incudostapedial joint is divided using a small joint knife

Antrotomy and Mastoidectomy

Note: Always perform antrotomy and/or mastoidectomy ***after*** the canalplasty has been done

- The principal surgical landmarks are linea temporalis superiorly, the bony ear canal and spine of Henlé anteriorly and the mastoid tip inferiorly

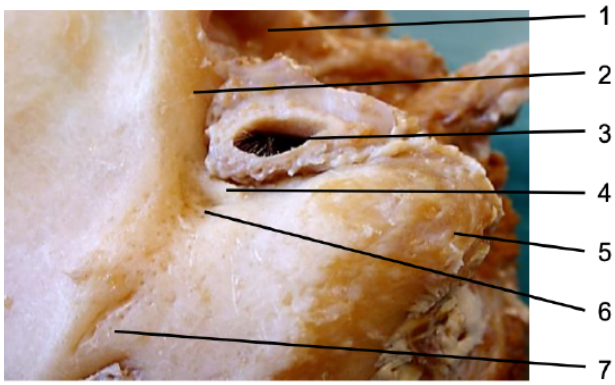


Figure 9: Surface markings of left ear: Temporomandibular joint (1); root of zygoma (2); external ear canal (3); suprameatal spine (4); mastoid tip (5); Macewen's triangle (6); opening of emissary vein (7)

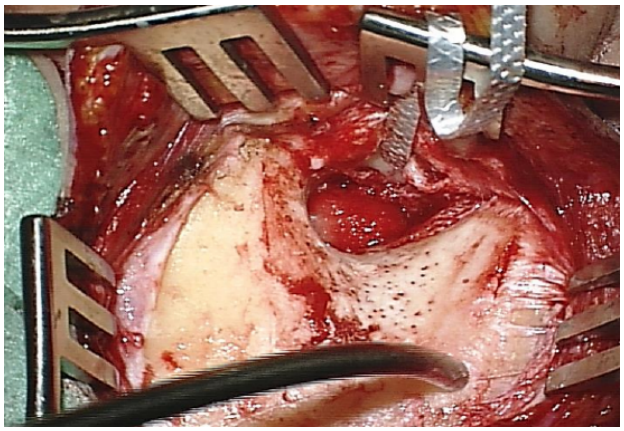


Figure 10: Completed bony exposure

- Identify and expose the surgical landmarks (*Figures 9, 10*)
- Using the mastoid raspatory, reflect the periosteal tissue superiorly in order to expose the ***linea temporalis***; then reflect periosteum posteriorly where you may encounter an ***emissary vein***, and inferiorly to the ***mastoid tip***

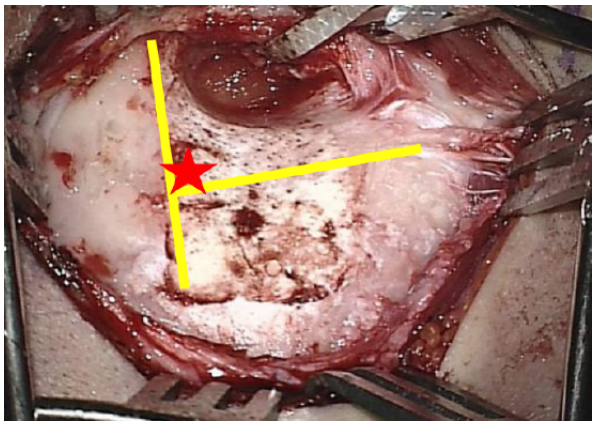


Figure 11: Yellow lines indicate where to drill; red star indicates where to commence drilling

- Identify ***Macewen's triangle*** which is situated posterosuperiorly to the external auditory canal. It is bounded anteriorly by the ***Spine of Henlé*** and approximates the position of the antrum medially (*Figure 10, 11*)

Antrotomy

- A common mistake is to search for the antrum very low, thus endangering the facial nerve
- The safest way to finding the antrum is to follow dura
- The *tegmen tympani* marks the superior limit of the dissection

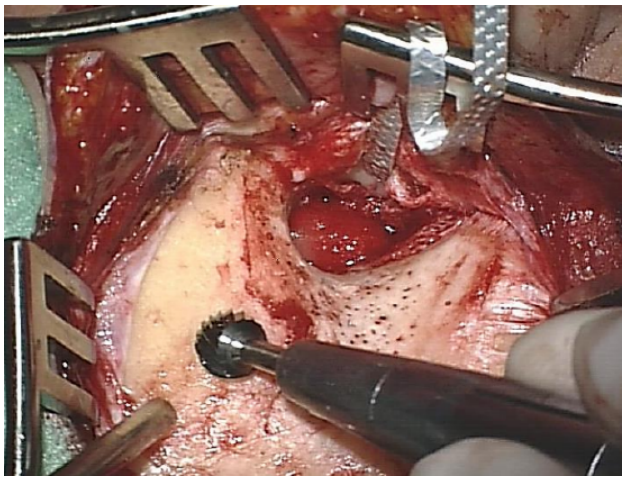


Figure 12: Drilling along linea temporalis

- Start drilling above *linea temporalis* (*Figures 11, 12*)
- Expose ***tegmen tympani*** (middle cranial fossa dural plate); it is identified by a change in color of the bone and change in pitch of the burr (*Figure 13*)
- Always skeletonize the dura of the middle cranial fossa (dura seen shining through thin layer of bone) and follow the dural plate of the middle cranial fossa in an anteromedial direction

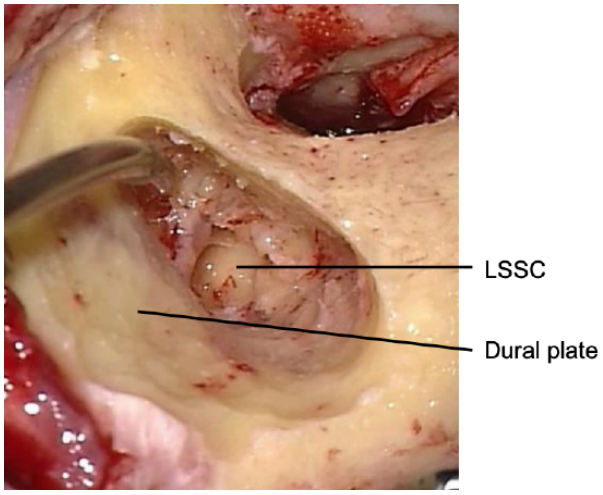


Figure 13: Dural plate and lateral semicircular canal

- The ***lateral semicircular canal*** is encountered next (*Figure 13*)
- The direction of the drilling now must be changed to a medial-to-lateral action to avoid touching the ossicles which would induce sensorineural hearing loss

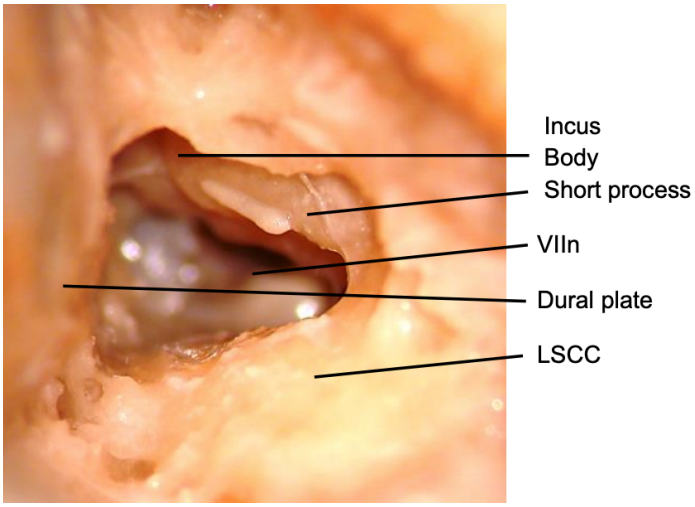


Figure 14: Postero-anterior view through antrotomy and aditus ad antrum into epitympanum

- The ***body and short process of incus*** are the next landmarks one encounters; the incus is often first identified by its refraction in the irrigation fluid (*Figure 14*)
- Medial to the incus the tympanic segment of the ***facial nerve*** (VIIn) is identified (*Figure 14*)

Drilling tips

- Avoid keyhole surgery; work through a wide space
- The tip of the drill should ***always*** be visible
- ***Never*** drill ***behind*** edges of bone
- Drilling should always be ***parallel to any structure*** you are trying to preserve e.g. facial nerve, sigmoid sinus
- When drilling deeper in the mastoid cavity the burr needs to be lengthened



Figure 15: Correct length of a cutting burr in the drill

- One cannot lengthen a cutting burr as this will cause the drill to jump with the risk of injuring structures (*Figure 15*)



Figure 16: A diamond burr can be lengthened to safely drill deeper in the mastoid

- Therefore, if it is necessary to lengthen the burr, then change to a rough diamond or diamond burr (*Figure 16*)

Mastoidectomy

- Follow the sinodural plate posteriorly up to the sinodural angle, which is the area between the sigmoid sinus and dura
- Like the dural plate, the sinus plate is identified by the change in color of the bone and a change in the pitch of the burr

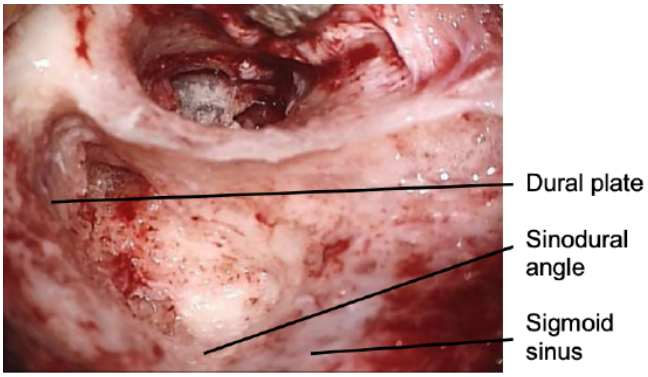


Figure 17: Sigmoid sinus, sinodural angle and dural plate

- Skeletonize the ***sigmoid sinus***; do not expose the sigmoid sinus but leave a covering of bone over the sinus (*Figure 17*)
- The ***lateral and posterior semicircular canals*** are identified and the retrolabyrinthine air cells are exenterated
- Next identify the ***facial nerve***

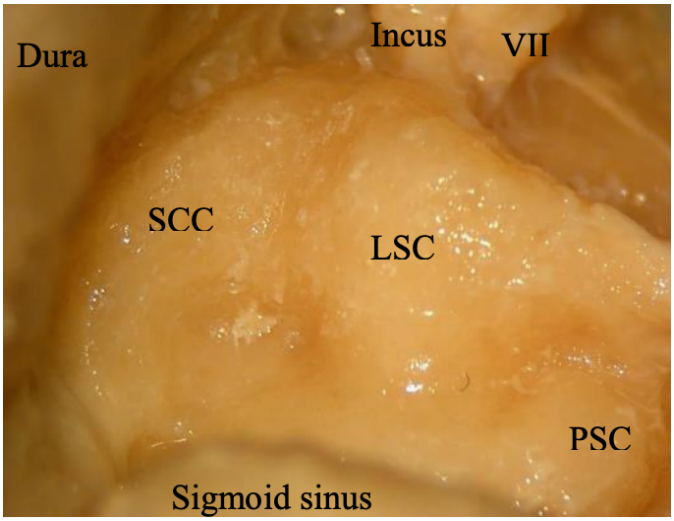


Figure 18: Relations of VIIn to short process of incus; superior semicircular canal (SCC); lateral semicircular canal (LSC); posterior semicircular canal (PSC); dura; and sigmoid sinus

- The superior landmarks for the mastoid segment of the facial nerve are the lateral semicircular canal, to which the facial nerve runs anteroinferiorly, and the posterior semicircular canal, to which the nerve runs 2.5 mm anterior to. The figure below is a cadaver dissection which demonstrates the relationship between the lateral semicircular canal, posterior semicircular canal and facial nerve (*Figure 18*)
- Therefore, if it is necessary to lengthen the burr, then change to a rough diamond or diamond burr (*Figure 16*)
- Follow the sinodural plate posteriorly up to the sinodural angle, which is the area between the sigmoid sinus and dura
- Like the dural plate, the sinus plate is identified by the change in color of the bone and a change in the pitch of the burr
- Skeletonize the sigmoid sinus; do not expose the sigmoid sinus but leave a covering of bone over the sinus (*Figure 17*)
- The lateral and posterior semicircular canals are identified and the retrolabyrinthine air cells are exenterated
- Next identify the facial nerve
- The superior landmarks for the mastoid segment of the facial nerve are the lateral semicircular canal, to which the facial nerve runs anteroinferiorly, and the posterior semicircular canal, to which the nerve runs 2.5 mm anterior to. The figure below is a cadaver dissection which demonstrates the relationship between the lateral semicircular canal, posterior semicircular canal and facial nerve (*Figure 18*)

- Finding the facial nerve along digastric ridge and the stylomastoid fibers is a very safe way of identifying the facial nerve away from any mastoid pathology
- It requires proper drilling technique and can easily be learned in the temporal bone laboratory
- When searching for the mastoid segment of facial the nerve, a large (4-5 mm) diamond burr is used
- Use ample irrigation to prevent thermal injury to the nerve
- The digastric ridge is the distal landmark for the mastoid segment of the facial nerve. It is a smooth convex bone found close to the mastoid tip. The digastric ridge can be difficult to find in poorly pneumatized temporal bones. Once the sigmoid sinus has been skeletonized the digastric ridge is found by drilling inferiorly to the sinus, close to the mastoid tip, from laterally to medially, in a horizontal direction.
- Periosteal fibers run anteriorly from the digastric ridge in a plane perpendicular to the ridge. The facial nerve can be located proximal to the stylomastoid foramen by drilling the last of these periosteal fibers. One often encounters the sensory branch of facial nerve (which innervates the posterior wall of the external auditory canal and a portion of the tympanic membrane) just above the stylomastoid foramen.

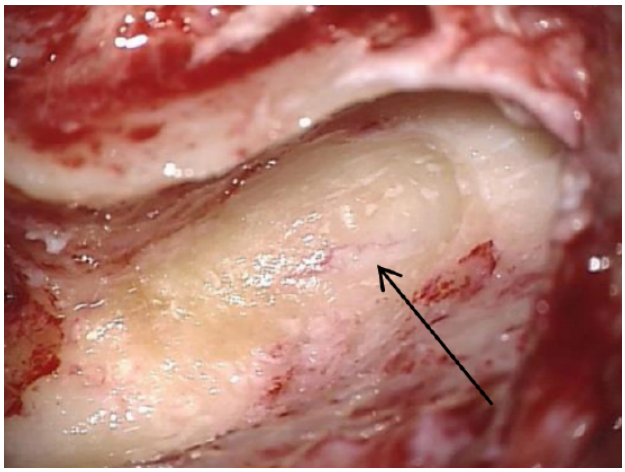


Figure 19: Distal portion of mastoid segment of facial nerve (arrow) is identified close to digastric ridge

- Skeletonize the nerve by drilling in a wide plane between the lateral semicircular canal proximally and the stylomastoid foramen distally, working from anteriorly to posteriorly (*Figure 19*)
- Always drill parallel to the course of the facial nerve and use lots of water for irrigation. Drill along the lateral aspect of the nerve; do not drill behind and medial to the fallopian canal
- Watch out for an early take-off of the chorda tympani close to the stylomastoid foramen
- Once the facial nerve has been identified, the retrofacial cells can be exenterated

Posterior tympanotomy

- The facial nerve is skeletonized leaving a thin shelf of bone covering the nerve
- It is followed proximally towards its pyramidal segment, just inferior to the lateral semicircular canal

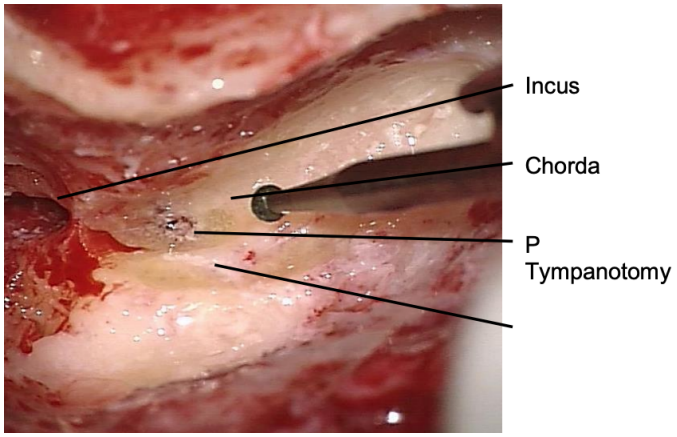


Figure 20: Landmarks for posterior tympanotomy are VIIn, chorda tympani and short process of incus

- The ***facial recess*** is approached by drilling away the bone situated between the pyramidal segment of the facial nerve posteriorly, the chorda tympani, and the fossa incudis superiorly (*Figure 20*)
- In the absence of disease in the facial recess, the stapes superstructure is visible through the tympanotomy
- For removal of cholesteatoma in facial recess one must work from both sides of the intact posterior external auditory canal wall

Epitympanotomy

- If the cholesteatoma does not extend significantly into the epitympanum, an epitympanotomy (atticotomy) is performed
- This involves exposure of the head of the malleus and the incus to remove soft tissue from the epitympanum

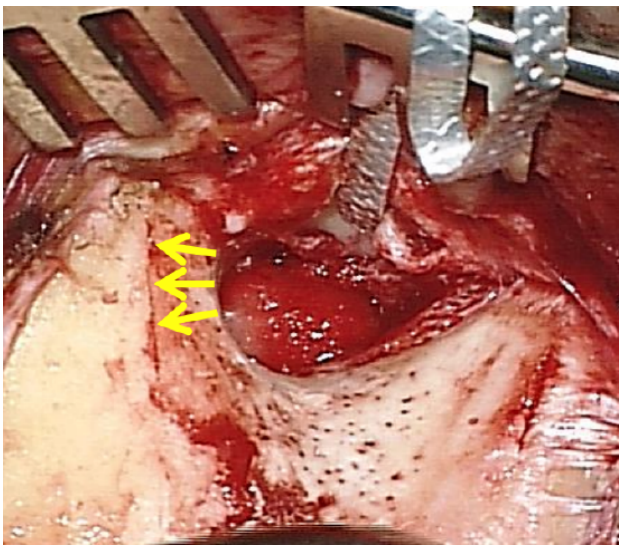


Figure 21: Direction of drilling with epitympanotomy or epitympanectomy

- The ***lateral wall of the epitympanum or attic is removed*** with a diamond burr; drilling is commenced at 12 o'clock relative to the ear canal, taking care not to make drill contact with the malleus or incus which is immediately medial to the outer attic wall, or to breach the dural plate above (*Figure 21*)

Epitympanectomy

- This is indicated when cholesteatoma extends medial to the ossicles or overlies the lateral semicircular canal; in cases of bony erosion of the ossicles due to cholesteatoma, the ossicles need to be removed
- Only recently, KTP laser evaporation of cholesteatoma matrix has been discussed
- The ***incus is removed*** by mobilizing it with a 2.5 mm. 45° hook and rotating it laterally, taking care not to injure the underlying facial nerve
- The ***malleus head is severed*** with a malleus nipper applied across its neck. The malleus nipper is held anteriorly between the thumb and index finger to stabilize it when the malleus head is divided
- The ***head of the malleus is removed*** leaving the tensor tympani tendon intact
- ***Clear cholesteatoma from the epitympanum***
- ***Detailed knowledge of facial nerve anatomy is crucial to avoid injury to the nerve when drilling or removing cholesteatoma in the epitympanum***
- The tympanic and labyrinthine segments and geniculum all lie in this very confined space and may be dehiscent

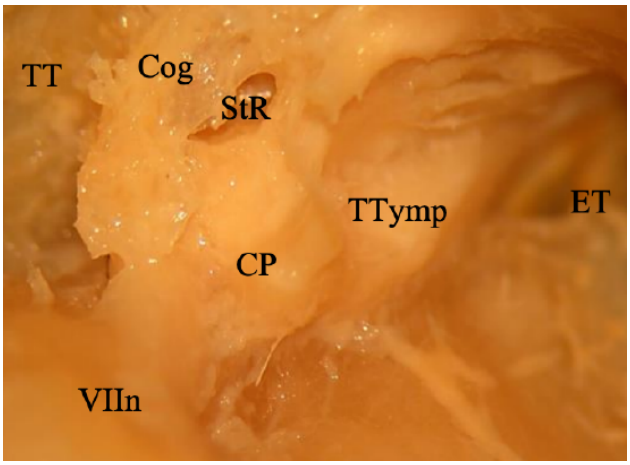


Figure 22: Anatomy of anterior epitympanic recess: Facial nerve (VIIn); Tegmen tympani (TT); Cog; Supratubal recess StR; Cochleariform process (CP); Eustachian tube (ET)

- The tympanic segment lies in the floor of the ***anterior epitympanic recess*** (*Figure 22*)
- The ***cochleariform process*** is a fairly consistent landmark and the nerve lies directly superior to it; the semicanal of the tensor tympani is sometimes mistaken for the facial nerve; however, this canal ends at the cochleariform process (*Figure 22*)
- The ***cog*** is a bony process in the anterior epitympanum which extends from the tegmen tympani and points to the facial nerve (*Figure 22*)

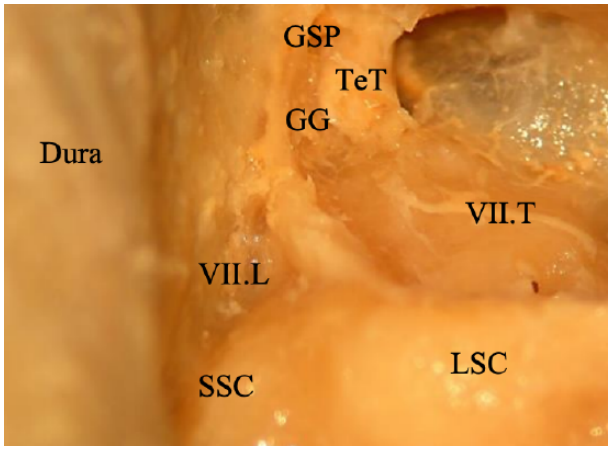


Figure 23: View of epitympanum with cog and cochleariform process drilled away: Tympanic (VII.T) and Labyrinthine (VII.L) segments of facial nerve and Geniculate Ganglion (GG) and Greater Superficial Petrosal nerve (GSP); Superior Semicircular Canal (SSC); Lateral Semicircular Canal (LSC); Dura; Tensor Tympani tendon (cut) (TeT)

- *Figure 23* above shows the ***geniculate ganglion and greater superficial petrosal nerve*** once the Cog and cochleariform process have been drilled away

Key points: Completed closed mastoidoepitympanectomy (Figure 24)

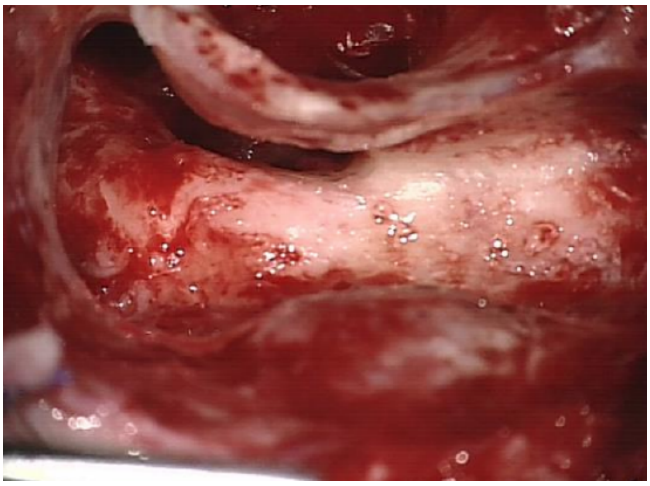


Figure 24: Completed closed mastoidoepitympanectomy

- The posterior canal wall should not be too thin
- Avoid drilling too far anteriorly while exposing the facial nerve and fenestrating the posterior wall of the external auditory canal
- Avoid fenestrating the posterosuperior canal wall
- Identifying the facial nerve along its course in the mastoid is the best way of avoiding injury to the nerve
- Most injuries occur when the facial nerve has not been adequately visualized

Ossiculoplasty

Refer to the chapter on ossiculoplasty and incus interposition for detailed surgical steps.

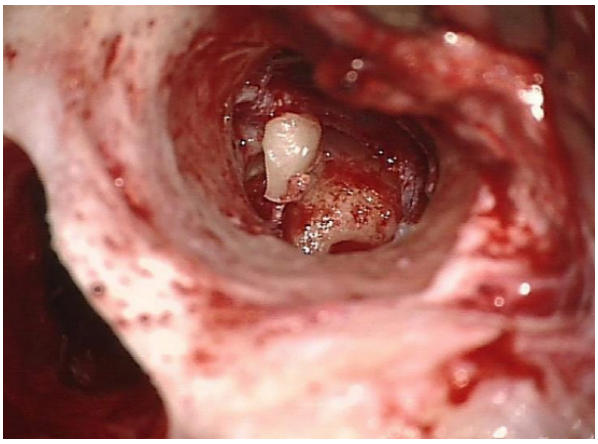


Figure 25: Incus interposition

The following conditions should be present in order to proceed to an incus ***interposition at the time of the primary surgery*** (*Figure 25*)

- Malleus handle present
- Stapes superstructure intact
- Footplate mobile
- Choleasteatoma limited and could be removed entirely
- Incus free of cholesteatoma
- Anterior third or half of the eardrum is preserved and defines the proper plane

Second-stage surgery is done at 6-12 months to ensure stabilization of the graft in cases of perforation; to verify eradication of cholesteatoma; and to assess whether there is good middle ear ventilation and whether eustachian tube dysfunction is present,

Posterior canal wall reconstruction

- Conchal or tragal cartilage is used to reconstruct the posterosuperior canal wall
- The cartilage is cut into 2-3 thin pieces (use a new 10 or 20 #blade)

- These pieces are aligned to slightly overlap each other

Tympanic membrane reconstruction

Refer to chapter on Myringoplasty and tympanoplasty for detailed surgical steps.

- Temporalis fascia or cartilage is harvested
- If there is diseased middle ear mucosa or retraction of the pars tensa, then silastic sheeting (1 mm thickness) is introduced into the tympanic cavity and protympanum to prevent adhesions between the graft and the promontory
- The graft always lies medial to the handle of malleus (if present); therefore, a slit must be made to accommodate the tensor tendon

Wound closure and packing

- The meatal skin flap is replaced and gelfoam pledgets are placed strategically over the meatal skin flap and fascia to secure it over the tympanic sulcus
- The external canal is packed with a strip of gauze impregnated with antibiotic ointment
- An easyflow drain or tube of a suction drain (without suction!) is placed in the mastoid cavity through a separate skin incision and the wound is closed in layers
- A mastoid pressure bandage is applied for 1 day

Open Mastoidoepitympanectomy (MET)

Skin incision: As for *Closed MET*

Periosteal flap: A *small* periosteal flap is made in order to preserve the soft tissue for myosubcutaneous occipital flap

Canalplasty: As for *Closed MET*

I***nspection of middle ear and division of incudostapedial joint***: As for *Closed MET*

Antrotomy

- As for *Closed MET*
- With *Open MET* you may already have lowered the posterosuperior canal wall

Mastoidectomy and epitympanectomy

- Radical exenteration and exteriorization of all cell tracts, including retrofacial, retrolabyrinthine, supra-labyrinthine, and supratubal cell tracts
- A common error is not to saucerise the cavity; this limits exposure and creates a larger cavity
- The more bone one removes, the smaller the cavity
- Incomplete exenteration will result in a discharging cavity
- Never leave bony overhangs

Lower the facial ridge over the mastoid segment of facial nerve

- A high facial ridge may cause a discharging mastoid cavity
- Therefore, it is important to skeletonize the facial nerve in order to lower the facial ridge sufficiently
- Lower the facial ridge with a large diamond burr and continuous suction irrigation
- Skeletonize the facial nerve, keeping the nerve intact within the bony fallopian canal, but lowering the bone to the level of the facial nerve
- The course of the nerve can clearly be identified inferior to the lateral semicircular canal, anterior to the posterior canal, and along the stylomastoid periosteal fibers at the level of the digastric ridge

Removal of mastoid tip

- Removal of the mastoid tip will help reduce the size of the cavity by allowing soft tissue to collapse into the cavity
- The stylomastoid foramen is medial to the digastric ridge
- Anteriorly where it extends into the external ear canal, the drill therefore remains lateral to the digastric ridge
- The mastoid tip is weakened when one drills with a diamond drill lateral to the digastric ridge to expose the muscle at its attachment along the mastoid tip and will develop a fracture line
- A rongeur is used to remove the mobilized mastoid tip by rotating it outwards

- The remaining soft tissue attachment can be cut with scissors pointing to the bone

Tympanoplasty

See chapter on Myringoplasty and tympanoplasty for detailed technique. Note that if the tympanic membrane and annulus are deficient then a tympanic sulcus is drilled out with a small diamond burr in order to support the fascial graft.

Obliteration of mastoid cavity

The mastoid cavity is small after exteriorization of a poorly pneumatized mastoid and does not require obliteration. However following exenteration of all tracts in a highly pneumatized mastoid, one may be left with a large cavity; in such cases obliteration is necessary to create a dry cavity.

Mastoid obliteration with myosubcutaneous occipital flap

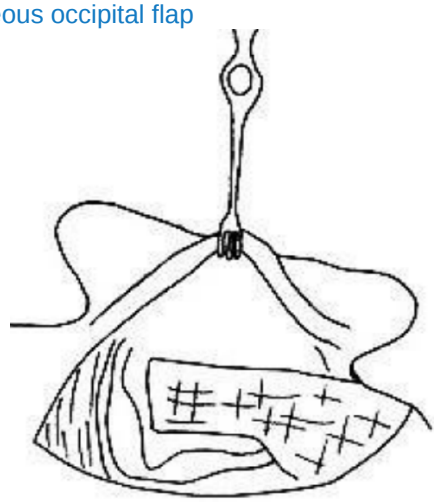


Figure 26: Inferiorly-based myosubcutaneous occipital flap

- This is an ***inferiorly-based flap*** based on the occipital artery which is rotated into the mastoid cavity (*Figure 26*)
- The flap comprises subcutaneous fascia and muscle
- It extends superiorly behind the mastoidectomy cavity from the mastoid tip where it is pedicled; the pedicle has to be kept wide (3.5 cm) enough so that blood supply is adequate
- The tip of the flap is just below the level of the temporalis muscle; the length is approximately 7.5 cm
- Elevate the retroauricular skin from the subcutaneous fascia using electrocautery
- Use a mastoid raspatory to elevate the flap from the bone
- Mastoid emissary veins may be encountered; bleeding is stopped with bipolar coagulation and/or diamond drilling of the bony foramen with a large diamond burr without irrigation
- Vicryl 2/0 sutures are used to suture the flap to the exposed digastric muscle to hold the flap in place in the mastoid cavity

Meatoplasty

Failure to do a meatoplasty with an open cavity can lead to a chronic draining ear. A meatoplasty is therefore ***routinely performed*** because for exteriorization and selfcleansing

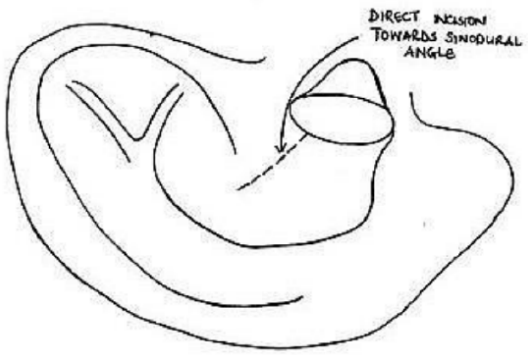


Figure 27: Initial incision

- A #11 blade is inserted into the external ear canal and is directed posterosuperiorly toward the sinodural angle; the concha is incised through both skin and cartilage (*Figure 27)*
- Hold the skin with forceps and using curved scissors, separate the skin from the conchal cartilage; it is important to direct the curvature of the scissors towards the cartilage and not upwards towards the skin as this may injure the skin

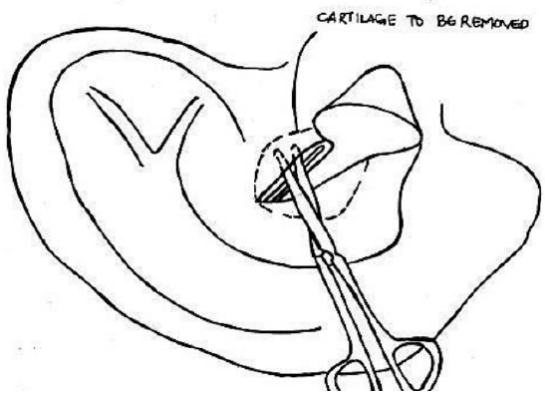


Figure 28: Exposing cartilage, and illustrating cartilage to be removed

- Once enough cartilage has been exposed, excise cartilage circumferentially with tympanoplasty scissors; this results in 2 crescent-shaped pieces of cartilage (*Figure 28*)
- The opening is approximately the size of the surgeon's finger



Figure 29: Completed meatoplasty

- The conchal skin flaps are inverted by placing 2/0 Vicryl sutures through the skin flaps and suturing them to the temporal muscle superiorly and to the mastoid soft tissues inferiorly. It may be necessary to place more sutures to improve the shape of the meatal opening (*Figure 29*)
- It is important that there are no exposed edges of the cartilage as this can lead to perichondritis

Wound closure and packing

- The retroauricular wound is closed in two layers using 2/0 Vicryl for subcutaneous tissue and skin clips or 3/0 Nylon for the skin. An easy-flow drain may be inserted
- Gelfoam is placed medially in the ear canal
- Gauze impregnated with Terracortril ointment is used to fill the lateral portion of the mastoid cavity and ear
- A mastoid pressure dressing is applied

Postoperative care (Figure 30)



Figure 30: Epithelialized mastoid cavity and meatoplasty 4 weeks after surgery

- Mastoid drain removed after 24 hours
- Mastoid pressure bandage removed after 24 hours
- Sutures/clips removed after 7-10 days
- Ribbon gauze with Terracortil is changed every 2 weeks for 2 months
- After the ribbon gauze has been removed, topical eardrops (e.g. Otosporin) are applied for 2-4 weeks

Postoperative Imaging

- CT cannot accurately define cholesteatoma postoperatively, because the CT attenuation of cholesteatoma is not specific enough to differentiate it from granulation tissue or effusion
- Non-EPI MRI has better tissue differentiation for cholesteatoma and has a high sensitivity and specificity for cholesteatomas measuring >5 mm
- The senior author (T.L) recommends routine imaging, ideally with non- EPI diffusion weighted MRI, at 1 & 3 years following closed mastoidoepitympanectomy when there is concern about recurrent or residual cholesteatoma

References

Fisch U, May J. Tympanoplasty, Mastoidectomy, and Stapes Surgery. New York: Thieme; 1994

Jindal M, Riskalla A, Jiang D, Connor S, O'Connor AF. A systematic review of diffusion-weighted magnetic resonance imaging in the assessment of postoperative cholesteatoma. Otol Neurotol 2011; 32(8): 1243-9

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Author

Tashneem Harris MBChB, FCORL, MMED (Otol), *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Thomas Linder MD
Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.8: Incus- and Malleostapedotomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris & Thomas Linder

Stapedotomy refers to the calibrated fenestration of a fixed footplate and insertion of a prosthesis. Prof Ugo Fisch first introduced the terms ***incus-stapedotomy*** where the prosthesis is attached to the long process of the incus, vs. ***malleostapedotomy*** where the prosthesis is attached to the malleus handle.[1] The surgical steps of both procedures as described by Prof Fisch will be described.

Otosclerosis is the most common indication for stapedotomy. Histology of temporal bone specimens show that there may be a fairly high incidence (up to 30%) of ***additional malleal fixation*** in otosclerosis.[2] Hyalinization and ossification of the anterior malleal ligament are related to the duration of otosclerosis.[2] Fixation of the malleus head and incus body are usually found in narrow external ear canals. The reported incidence of malleal fixation in clinical studies varies significantly for both primary (0.6-6%)[3,4] and revision surgery (3-37%).[5,6] In a recent study (unpublished data) conducted by the senior author (T.L), the incidence was found to be 5% with primary surgery.

The best way to ***assess mobility*** of the ossicles and the anterior malleal ligament is by visual assessment of the mobility of the ossicles on direct palpation. This requires adequate surgical exposure; it is difficult to assess via a limited transcanal approach. Partial fixation may be overlooked when using a limited approach.

It is the practice of the senior author (T.L) to routinely use the ***endaural approach*** and to systematically ***expose the anterior malleal ligament*** as this allows for proper assessment and identification of impaired ossicular mobility at the time of the ***primary surgery***. If there is even partial fixity of the malleus or incus at primary surgery, then a malleostapedotomy is performed. The rationale behind the endaural approach with an enlarged tympanomeatal flap and partial anterosuperior canalplasty as described by Fisch is primarily to improve surgical exposure in order to properly assess ossicular mobility.[7]

Indication for surgery

Patients with otosclerosis and a conductive hearing loss with an air-bone gap (ABG) of >20 dB are candidates for surgery.

Goals of surgery

The aim of surgery is to achieve maximum hearing gain with minimal damage to the membranous labyrinth; it may be considered in 3 different categories depending on the cochlear reserve of the patient:

- To achieve normal hearing in patients with normal cochlear reserve (<10 dB postoperative air-bone gap)
- To achieve serviceable hearing in patients with minimal reduction in cochlear reserve and possibly to eliminate the need for a hearing aid
- To improve hearing aid satisfaction

Note that patients with advanced otosclerosis and poor cochlear reserve who no longer benefit from amplification are candidates for cochlear implantation.

Preoperative evaluation

Otomicroscopy: A normal stable tympanic membrane without retraction pockets should be confirmed in otomicroscopy.

Tuning fork tests: Tuning fork tests are a simple means to confirm a conductive hearing loss and can help confirm the validity of the audiogram. They only assess a single frequency (commonly 440Hz) at a time and should be done by the surgeon.

Audiological evaluation

- Audiometric testing should be recent (15 dB at 2 kHz)
- Enables the surgeon to decide which ear requires surgery[8]
- It includes pure tone audiometry which typically indicates conductive hearing loss involving the lower frequencies with a Carhart notch at 2 kHz
- The size of the ABG provides an indication of the gain that may be achieved by surgery[7]

- A typical audiogram for otosclerosis has a larger ABG in the low frequencies and good sound transmission at high frequencies (4 kHz). A consistent pancochlear ABG is not typical for otosclerosis!
- A Carhart notch is characterized by the apparent elevation of bone conduction threshold of 15 dB at 2 kHz and is the hallmark audiologic sign of otosclerosis
- One can accurately determine the degree of secondary cochlear loss by making allowance for the Carhart notch when interpreting bone conduction thresholds; if the bone conduction threshold is larger than 15 dB at 2 kHZ it suggests underlying cochlear otosclerosis. This can help the clinician with preoperative counseling about the anticipated outcome of surgery
- In the absence of a Carhart notch it is important to exclude other causes of conductive hearing loss which may mimic otosclerosis
- *Speech discrimination* is especially useful to determine the presence of cochlear otosclerosis when the ABG is >15 dB at 2 kHz)

Tympanometry: Type A curve

Stapedial reflexes: Absent in otosclerosis

High Resolution CT (HRCT)

It is important to emphasize at this point that ***otosclerosis is a clinical diagnosis*** made on history, audiometric findings and confirmed at surgery. However, the role of HRCT in preoperative planning and patient counseling cannot be underplayed.

HRCT (0.5 mm) is useful (but not mandatory) because it can help to confirm the presence of otosclerosis[9]; it may identify other middle ear disorders which may mimic otosclerosis or be coexistent; it may confirm cochlear involvement by the otosclerotic focus; it is useful to assess postoperative failures and complications e.g. sensorineural hearing loss (SNHL) or disabling vertigo and may identify problems which need to be managed promptly e.g. too long a prosthesis.[10]

The absence of a Carhart notch suggests another cause for the conductive hearing loss. There have also been numerous case reports and series of ***superior semicircular canal dehiscence*** and other pathology which may mimic otosclerosis and are unmasked by stapedotomy (stapedial reflex is present in cases of dehiscence only).[11,12,13,14]

It is the practice of the senior author (T.L.) to do a HRCT scan (0.5 mm-1 mm) whenever patients have the following features on pure tone audiogram:

- Conductive hearing loss but absent Carhart notch
- Equal ABG across all frequencies
- Mixed hearing loss
- All cases of revision stapes surgery

The following pathologies can be excluded with preoperative HRCT scan:

- Conductive hearing loss with an absent stapedial reflex:
  - Fixation of head of malleus to lateral tympanic wall
  - Fixation of incus or erosion of incus
  - Congenital ossicular deformity
  - Round window atresia
  - Tympanosclerosis causing obliteration of footplate
- Conductive hearing loss with an intact stapedial reflex:
  - A 3rd window: superior or posterior semicircular canal dehiscence
  - Tympanic facial nerve neuroma blocking the stapes
  - Gusher syndrome: enlarged internal auditory meatus, enlarged endolymphatic aqueduct
  - Anomalous facial nerve

CT scan checklist prior to performing stapedotomy

- Can one see an otosclerotic focus (fissula ante fenestrum)?
- Is there obliteration of the oval and round windows?
- Is there cochlear otosclerosis? (It is possible to have fairly extensive cochlear otosclerosis with minimally reduced hearing loss)
- Is there a risk of a CSF gusher (enlarged aqueduct, enlarged internal auditory meatus)?
- Is there semicircular canal dehiscence?
- What is the position of the tympanic segment of the facial nerve?

- Are there any other ossicular abnormalities e.g. fixation of the malleus to the lateral wall of the epitympanum?
- Is there a stapedial artery?

CT checklist for revision surgery

- Is the prosthesis in the correct position or is it displaced?
- In cases of vertigo, what is the depth of insertion into the vestibule?
- Is there evidence of obliterative otosclerosis, particularly of the round window, which may have been missed at the primary surgery?
- Is there superior canal dehiscence or any other 3rd window?
- Is there additional fixation of the malleus and/or incus?

Anesthesia

- General or local anesthesia may be used
- Performing the procedure under local anesthesia depends on the patient and level of experience and level of comfort of the surgeon
- Antibiotics are not routinely used
- Antiemetics are administered intraoperatively

Surgical steps

Endaural approach (right ear)

- Infiltrate the site of the endaural skin incision with local anesthetic (lidocaine 1% and adrenaline diluted to 1:200 000)
- Insert a nasal speculum in the external ear canal to improve exposure
  Infiltrate the skin of the external ear canal anteriorly and posteriorly

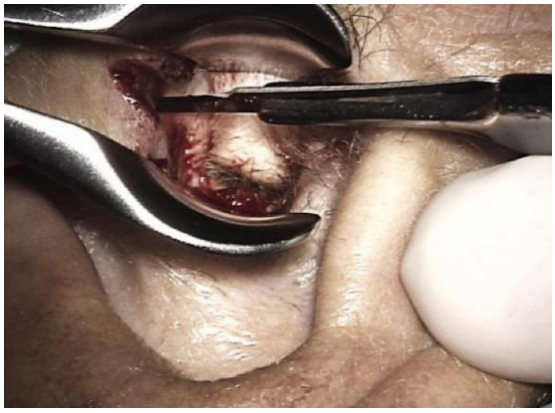


Figure 1: Helicotragal incision

- A helicotragal incision is made using a #15 blade (*Figure 1*)
- It is vital to achieve adequate hemostasis at this point to avoid subsequent troublesome bleeding

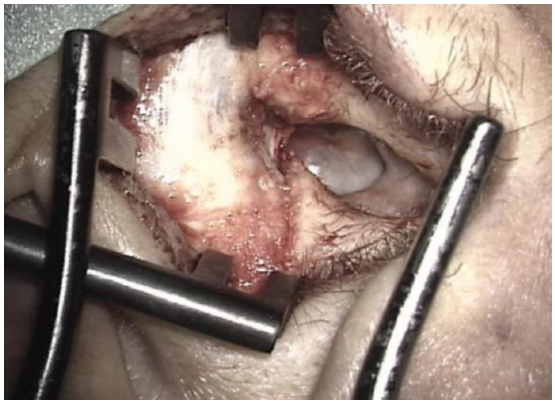


Figure 2: Exposing the ear with two retractors

- Place two endaural retractors in the entrance of the external ear canal. The 1st retractor is placed vertically; the 2nd is placed horizontally (*Figure 2*)

Meatal skin flap

- Make a posterior incision in the skin of the ear canal using a #11 blade, starting at the annulus at 7 o'clock (5 o'clock for left ear) and ascending upwards to end at 12 o'clock
- A 2nd incision starts anterior to the lateral process of the malleus at 3 o'clock (right ear) and passes above the tympanosquamous suture to meet the end of the endaural incision at 12 o'clock
- It is important that the tympanomeatal flap is made long enough anteriorly and that the incision stays medial to the cartilage plates
- An endaural raspatory is used to separate the skin and soft tissue from the bone both anteriorly and posteriorly
- The meatal skin flap is elevated using a Fisch microraspatory and an otosclerosis suction with adrenaline gauze to separate the soft tissue from the bone as atraumatically as possible. The working end of the Fisch micro-raspatory is held at right angles to the bone and the shoulder of the instrument pushes the adrenaline gauze strip towards the soft tissue. The suction never touches the tympanomeatal flap, but sucks on the gauze

Anterosuperior canalplasty

- The exposure may occasionally be limited by a very prominent tympanosquamous suture which requires removal with a curette or a diamond drill

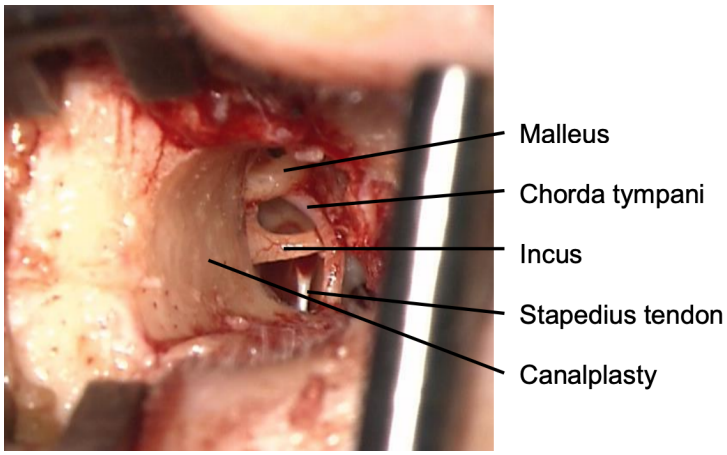


Figure 3: Anterosuperior canalplasty improves exposure

- In cases where there is a very prominent anterior bony overhang which prevents adequate exposure of the anterior tympanic spine, a limited anterior canalplasty is performed using a 3 mm diamond burr (*Figure 3*).
- It is very important that all bony work is done before raising the tympanic part of the tympanomeatal flap to avoid contamination of the middle ear with bone dust

Exposure of oval window

- Elevate the tympanomeatal flap towards the posterior tympanic spine in order to elevate the annulus from the sulcus
- The *pars flaccida* is elevated until the lateral process of the malleus and the anterior malleal ligament are visible

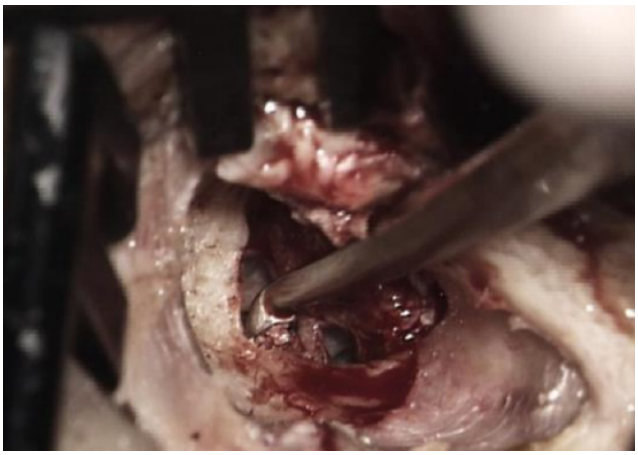


Figure 4: Small curette used to remove posterior tympanic spine

- A small curette is used to remove the posterior tympanic spine taking care to avoid damage to the underlying *chorda tympani* (*Figure 4*)

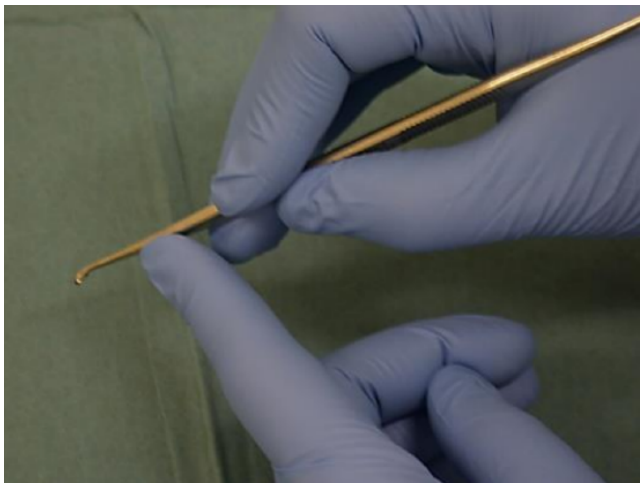


Figure 5: Correct handling of curette

- Remove the rim of bone obscuring the inferior portion of the incudomallear joint with a curette. It is important when using the curette, to avoid subluxing the incus. The small end of the curette is used. The index finger of the non-dominant hand stabilizes the curette anteriorly (*Figure 5*)
- Always preserve *chorda tympani*. It is mobilized but kept attached to the tympanic membrane; this facilitates retraction of the chorda away from the surgical field

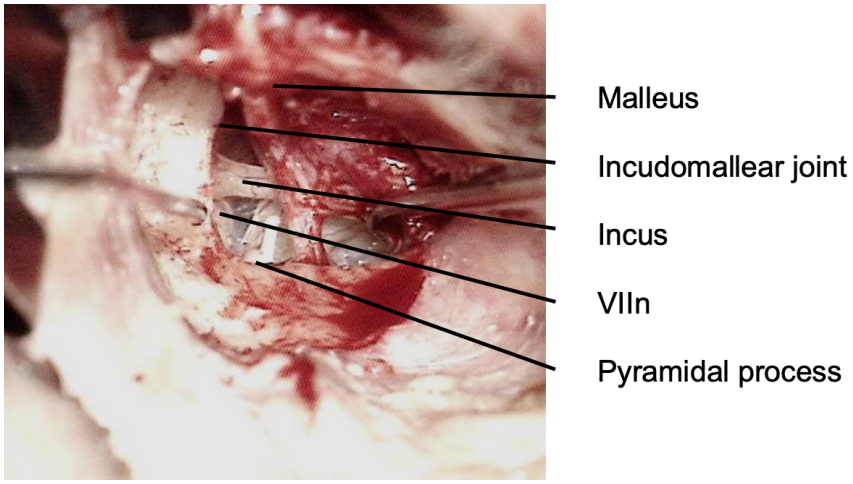


Figure 6: Final correct exposure

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- Inspecting the *round window* is important to exclude obliterative otosclerosis reaching the round window membrane and rarely, congenital round window atresia[11]

Checking mobility of ossicular chain

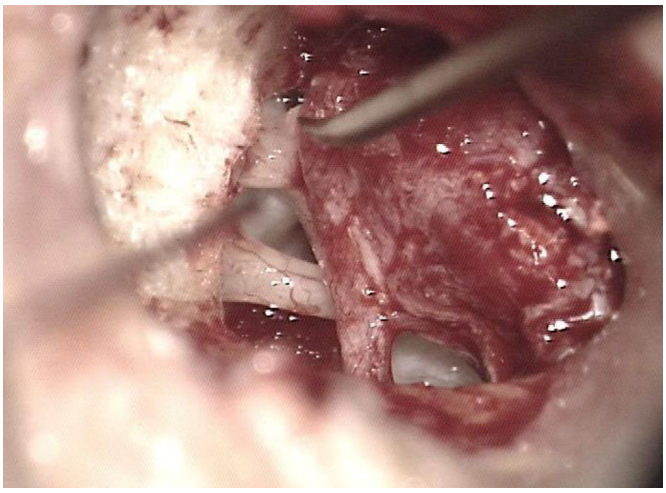


Figure 7: Checking mobility of lateral ossicular chain

- Check the mobility of the malleus and incus with a 1.5mm, 45° hook (*Figure 7*)

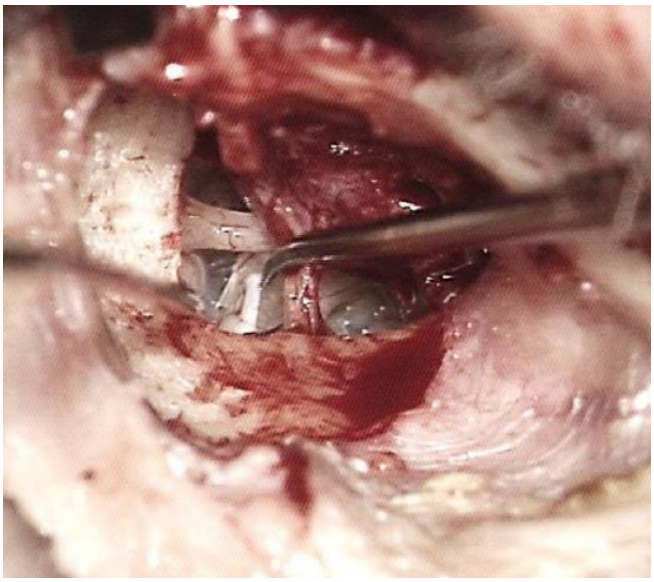


Figure 8: Checking mobility of stapes

- Check the mobility of the stapes (*Figure 8*)
- *If malleus and/or incus are fixed, then proceed to malleostapedotomy*
- *If the malleus and incus are mobile and the stapes is fixed* then, using the 1.5 mm 45° hook, elevate the malleus handle to determine where the incudostapedial joint is
- Use a joint knife to separate the incudostapedial joint
- Check mobility of the stapes again

Removal of stapes arch

- Cut the stapes tendon with fine Bellucci scissors
- Cut the posterior crus of the stapes with (left or right) crurotomy scissors
- Exposure of the pyramidal process is essential to provide sufficient space for the crurotomy scissors
- Fracture the anterior crus at the level of the footplate, using a 2.5 mm, 45° hook

- To fracture the anterior crus, insert the 2.5 mm, 45° hook between the incus and the malleus neck, close to the footplate. The tip of the hook is close to the level of the footplate, even if the entire anterior crus is not visible
- The hook is rotated towards the promontory
- If correctly fractured, the stapes superstructure has a long anterior and a short posterior crus
- Bleeding may occur from the mucosa when the superstructure is removed, in which case gelfoam with Ringer's lactate or diluted adrenaline solution is placed over the footplate to achieve hemostasis (wait 2-3 minutes)

Determining length of prosthesis

- *Accurate measurement of the length of the prosthesis is crucial*
- A piston that is too long can contact or even pierce the underlying membranous labyrinth
- A piston that is too short will be displaced easily when the patient sneezes or performs a *Valsalva* maneuver

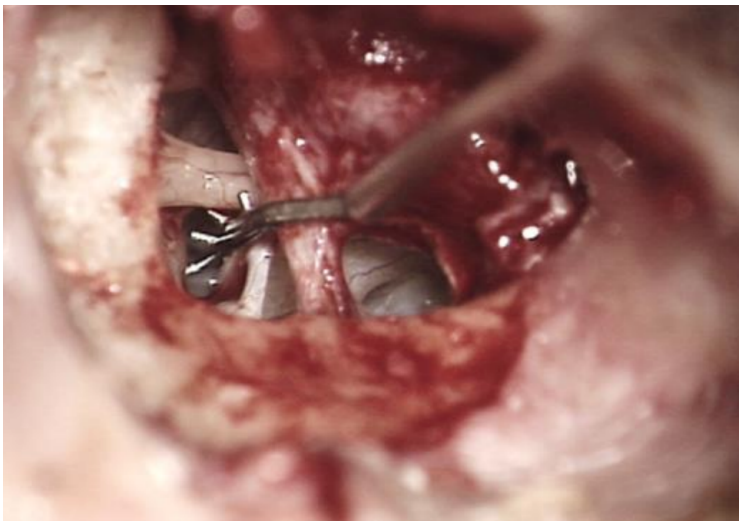


Figure 9: Measuring rod used to determine length of prosthesis

- A malleable measuring rod is used to determine the distance between the footplate and the lateral surface of the long process of the incus (*Figure 9*)
- Add 0.5 mm to the measured distance to account for the protrusion of the prosthesis into the vestibule

Trimming prosthesis

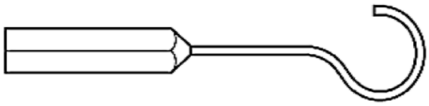


Figure 10: Teflon-wire prosthesis

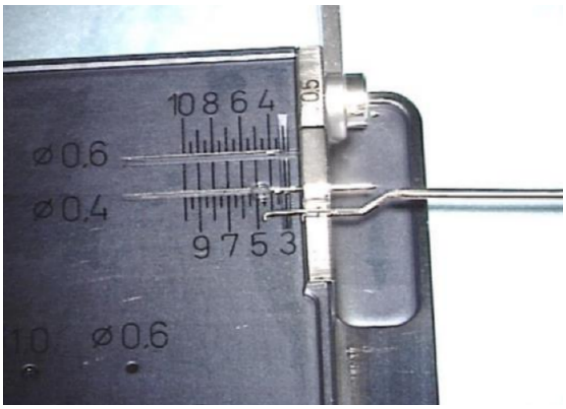


Figure 11: Cutting block

- The Storz titanium stapes piston is placed on a special cutting block which holds the prosthesis (*Figures 10, 11*)
- The trimmed prosthesis is handled with watchmaker's forceps and placed upright in the 4 mm hole of the cutting block while proceeding to stapedotomy

- The Storz titanium stapes piston is hygroscopic and is therefore easier to work with when wet. Therefore, the cutting block is moistened with a few drops of water before placing the piston on it

Perforating the footplate

- A set of four manual perforators are (0.3-0.6 mm) are used to make the stapedotomy

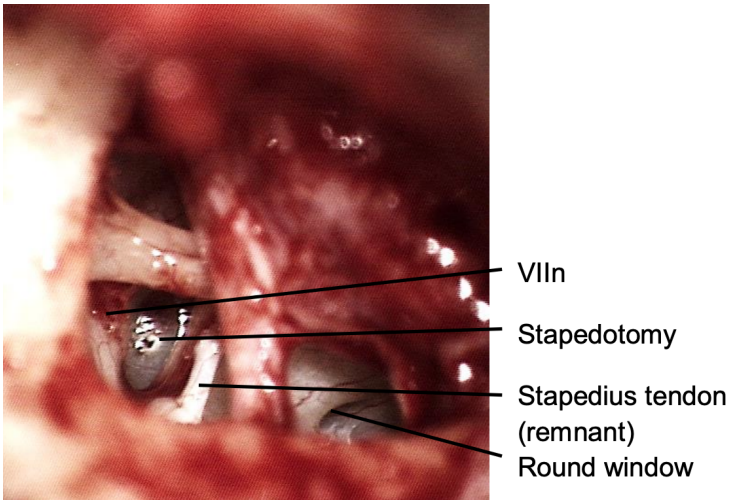


Figure 12: Initial small stapedotomy

- Start with the smallest perforator (0.3 mm) and ensure that there is no evidence of a CSF gusher before enlarging the stapedotomy with the larger perforators (*Figure 12*)
- The safest place to make the stapedotomy opening is in the posterior two-thirds of the stapes footplate (see below)

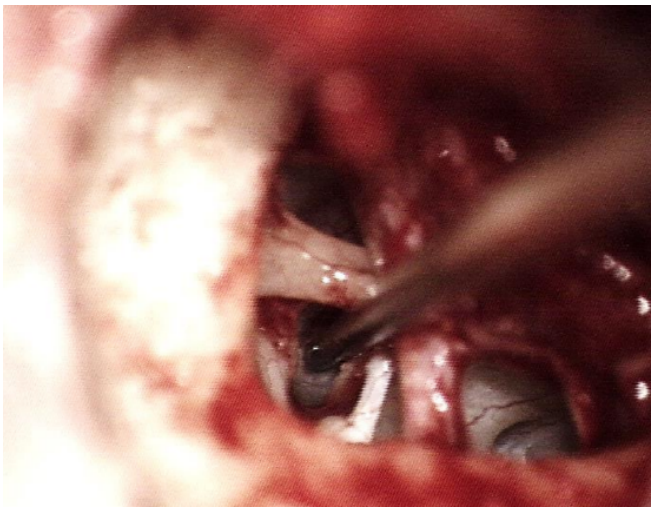


Figure 13: Making the final 0.5 mm stapedotomy

- For a 0.4 mm prosthesis the ideal diameter is a stapedotomy of 0.5 mm (*Figure 13*)
- The tip of the perforator is gently applied to the footplate without using any force at all

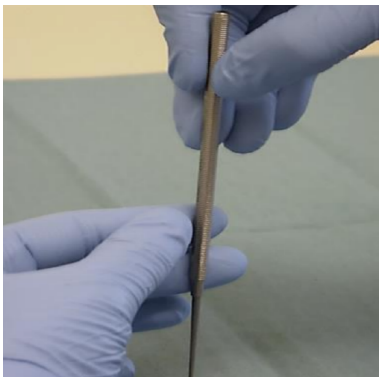


Figure 14: The perforator is gently rotated between the thumb and index finger of the right hand while the left hand stabilizes it

- The perforator is held vertically to the stapes footplate and is gently rotated between the thumb and index finger of the right hand while the left hand stabilizes it (*Figure 14*)
- The tip of the perforator only partially enters the vestibule as the stapedotomy opening is created by the shoulder of the perforator

Additional important points and clinical scenarios

Safest position for stapedotomy

- The risk of stapedotomy is damage to the membranous utricle and saccule which lie in close proximity to the stapes footplate
- Surgeons should know the safety margins required to perform the procedure without damaging the underlying vestibule
- The minimum distances to the utricle are at the posterior (0.58 mm) and superior (0.62 mm) borders of the footplate; therefore placing a prosthesis to a depth of 0.5 mm in this region of the footplate will place the utricle at risk of injury[15]
- The minimum distance to the saccule is at the anterior border of the footplate (0.76-1 mm)[14]
- All other measurements from the footplate to the underlying membranous utricle and saccule are >1 mm
- The safest area for manipulation is therefore the ***central third in the inferior segment*** of the footplate

Choice of instrument for stapedotomy

- In the senior author's (T.L.) experience, the type of footplate is important when selecting a perforator
- An alternative to manual perforators is laser or a Skeeter drill. Lasers that have been used for stapes surgery include CO_2, KTP, Argon, Diode and Erbium:YAG lasers
- When one encounters a biscuit (thick) footplate, or a thick footplate which is only partially fixed, then there is a risk of causing a floating footplate
- If the footplate is too thick, then it is preferable to use a drill

Footplate fracture during stapedotomy

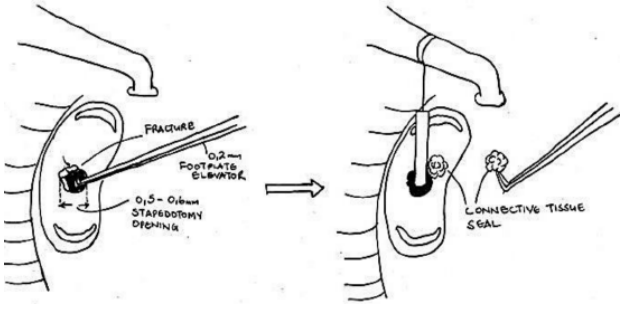


Figure 15: Carefully elevate bony fragments with 0.2mm footplate elevator

- If only small bony fragments surround the stapedotomy opening and the opening is of the desired size, then one can carefully elevate the fragments with a 0.2 mm footplate elevator to avoid the fragments from entering the vestibule and causing vertigo postoperatively (*Figure 15*)

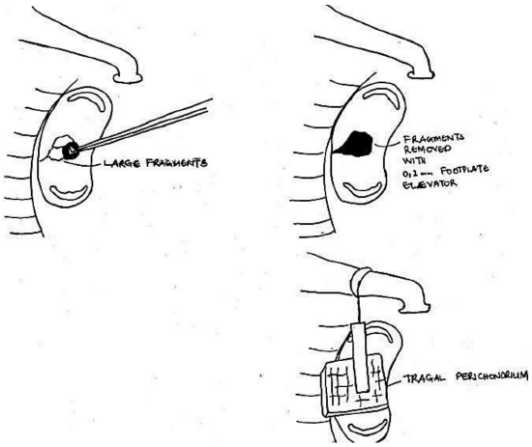


Figure 16: Partial stapedectomy sealed with a graft before inserting prosthesis

- If the footplate has been fractured but the stapedotomy is still too small and it is not possible to enlarge the opening without displacing the bony fragments, then the fractured segments can be removed with either a 0.2 mm footplate elevator or a 0.5 mm, 45° hook, such that a partial or total stapedectomy is performed. A graft is then placed over the (partial) stapedectomy before inserting the prosthesis (*Figure 16*)

Floating footplate

The footplate may become completely mobile before the stapedotomy has been made. Management options in this situation are:

- Proceed with the stapedotomy using a laser
- Proceed with a total stapedectomy and seal the oval window a graft (perichondrium / vein / fascia) before placing the piston prosthesis
- Postpone the surgery for one year if the stapes superstructure is still intact; the annular ligament will progressively become refixed due to otosclerosis

Inserting and crimping the prosthesis

- The prosthesis is picked up with a large crocodile forceps from its hole in the cutting block by its wire loop
- For first-time correct placement of the loop over the long process of the incus it is essential to pick up the prosthesis at the correct angle
- The prosthesis is placed onto the footplate with the loop over the incus
- One can estimate at this point whether the prosthesis is too long and needs to be shortened, or too short and needs to be replaced

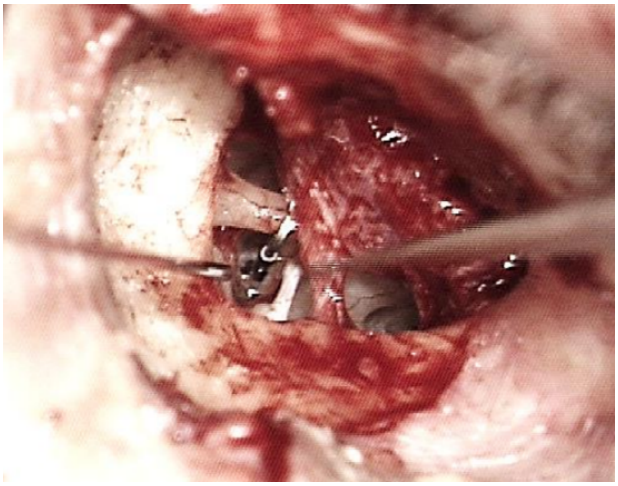


Figure 17: The loop is hooked over incus with the piston resting on the footplate

- Using a 1 mm, 45° hook, move the loop of the prosthesis along the long process of the incus to guide the shaft of the piston towards the stapedotomy opening (*Figure 17*)

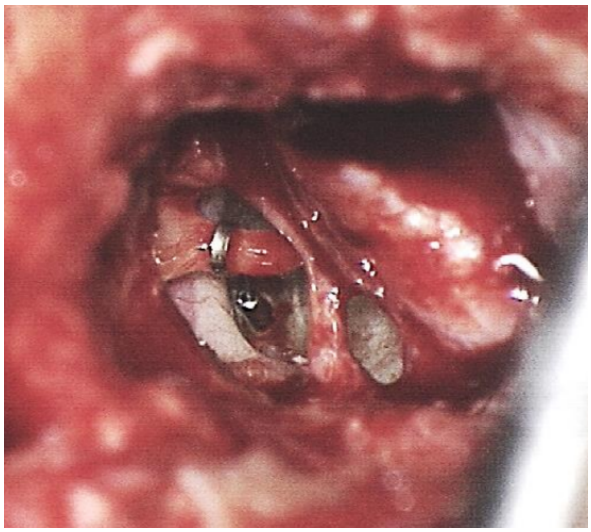


Figure 18: Crimped prosthesis with piston in stapedotomy; note position of facial nerve immediately adjacent to the prosthesis

- Once the piston is positioned within the stapedotomy opening, the loop of the prosthesis is crimped with a large smooth crocodile forceps to achieve a more stable coupling of the prosthesis to the incus; this is repeated with smaller smooth crocodile forceps (*Figure 18*)
- Using a 1.5 mm 45° hook, check the mobility of the ossicular chain with the prosthesis in place
- There should be no free movement of the prosthesis on the incus when the incus is moved

Crimping technique

- To achieve good results correct crimping is absolutely essential
- Loose coupling of the prosthesis to the incus will result in reduced sound transmission and inferior acoustic results[16]

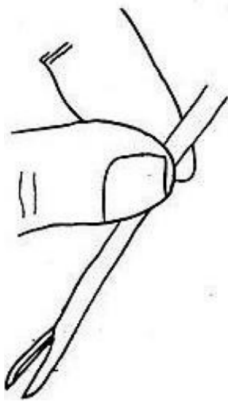


Figure 19: Crocodile forceps is held with right hand and stabilized with left hand using thumb and index finger

- To crimp the loop of the prosthesis, the crocodile forceps is held with the right hand and stabilized with the left hand using the thumb and the index finger (*Figure 19*)
- It may be necessary to remove the horizontal retractor in order to gain more space to crimp the prosthesis correctly

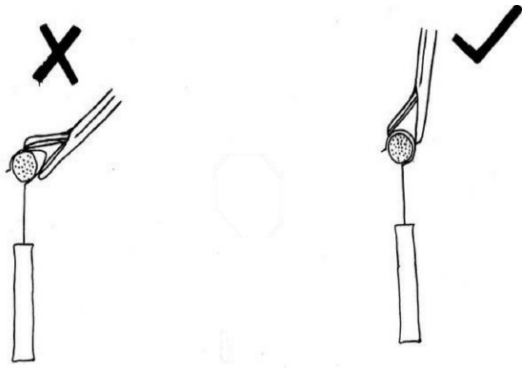


Figure 20: Crimping is performed from the most superior part of the loop

- Crimping is performed from the most superior part loop, so that the prosthesis loop makes even contact with the incus (*Figure 20*)

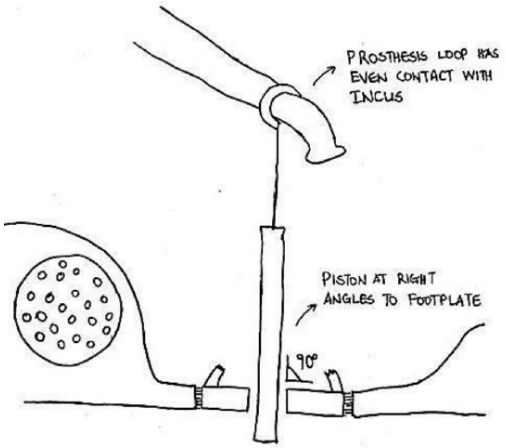


Figure 21: Prosthesis must be at right angles to footplate for optimal hearing results

- Correct angulation of the piston relative to the footplate is crucial to achieve good acoustic results. The piston must be at right angles to the footplate to avoid contact of the piston with the bony edges of the stapedotomy which will result in attenuation of vibration and reduced sound transmission[17] (*Figure 21*)
- Kwok, Fisch et al reported that crimping results depend on the instrument used for crimping and the material of the stapes prosthesis, but not on the surgeon. The straight crocodile forceps was shown in their study to produce better crimping results than the McGee crimper[17]

Sealing stapedotomy opening

Connective tissue placed around the piston serves as a seal to prevent perilymph leakage. Once the seal has matured it also prevents displacement of the piston. The connective tissue seal also increases the sound transmitting area, so that a 4 mm piston is equivalent to the surface area of a 6 mm piston, therefore improving sound transmission and achieving better acoustic results. If one performs tympanometry at 2 weeks and no vertigo is induced, then the seal is adequate and it is safe for patients to fly.

- Connective tissue from the endaural incision is used to seal the stapedotomy opening
- Use a 1.5 mm, 45° hook to place pieces of connective tissue around the stapedotomy
- Venous blood taken from the patient at the beginning of the procedure is stored at 3-4°C to prevent the blood from clotting until it is needed; this blood is now used to seal the stapedotomy opening

Repositioning tympanomeatal flap

- The tympanomeatal flap is repositioned
- If any small tears in the tympanomeatal flap are noticed, then temporalis fascia is harvested and underlay grafting is done

Packing and wound closure

- Gelfoam pledgets are placed in the bony canal to secure the meatal part of the flap

- Do not place gelfoam pledgets over the tympanic membrane as they could swell and displace the prosthesis inwards causing vertigo
- Two pieces of Ivalon® are placed in the external ear canal
- The endaural incision is closed with 4/0 nylon sutures. One subcutaneous stitch may help in readapting the wound edges
- An outer strip of gauze which has been impregnated with antibiotic ointment (Terracortril) is placed in the lateral part of the external ear canal

Postoperative care

- Outer gauze dressing is removed after one week together with the Ivalon® ear wick
- Postoperative audiograms are done at 1-2 months, 1 year and 5 years

Reversal of stapedotomy

Fisch described reversing the steps of the stapedotomy procedure in order to reduce complications relating both to the incus (luxations/subluxations) and footplate (subluxations/fractures/floating footplate). The point of departure for the following description of the surgery is exposure of the oval window as previously described.

- Check ossicular chain mobility and confirm stapes fixation
- Determine prosthesis length and trim the prosthesis accordingly
- Stapedotomy is performed
- Introduce the prosthesis and crimp it to the incus with the stapes arch still intact

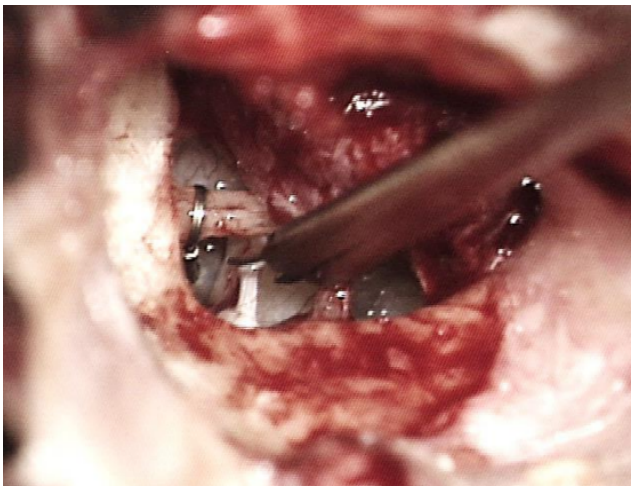


Figure 22: Stapedius tendon and posterior crus being cut with stapes prosthesis already in final position and crimped to incus

- Cut the stapedius tendon and remove the arch of the stapes (*Figure 22*)
- Check the mobility of the ossicular chain with the prosthesis in place
- Seal the stapedotomy opening as previously described

Malleostapedotomy

This is a technique whereby both the incus and stapes are replaced by a single prosthesis in order to establish a direct connection between the malleus and the vestibule. It is indicated for stapes fixation with pathology of the incus and/or malleus head that rules out an incus-stapedotomy.

Surgical exposure

The ***initial surgical steps*** relating to endaural approach, elevation of a tympanomeatal flap, and exposure are identical to that we have already described in this chapter for incus-stapedotomy. The point of departure of the description of the surgery that follows is exposure of ossicular chain and oval window.

- Elevate the annulus, starting at the posterior tympanic spine
- The chorda tympani is left attached to the tympanic membrane
- The tympanic membrane is reflected until the anterior malleal process and ligament are exposed
- Assess the mobility of the malleus using a 1.5 mm 45° hook
- Use a joint knife to separate the incudostapedial joint

- Mobility of the malleus and incus is reassessed

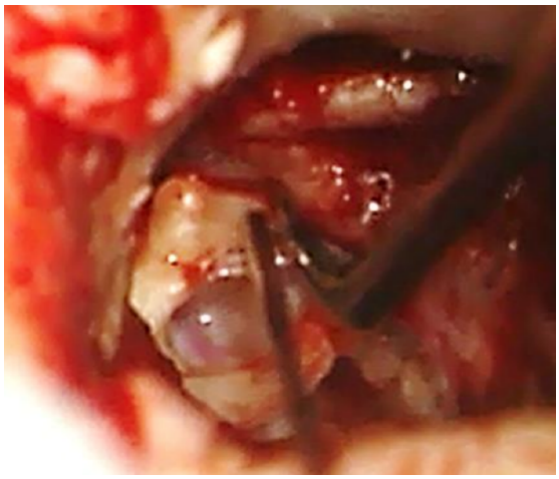


Figure 23: Elevating Shrapnell's membrane from proximal part of handle of malleus

- Use a 2.5 mm 45° hook to elevate Shrapnell's membrane from the proxymal part of the handle of the malleus (just 1 mm distal to the lateral malleal process) (*Figure 23*)

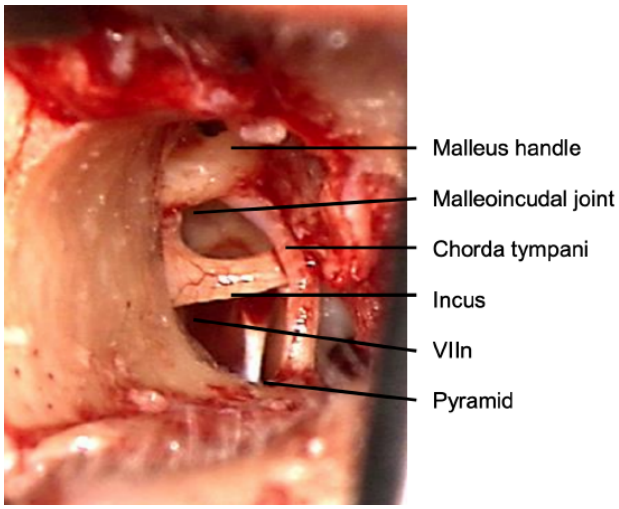


Figure 24: Final view of middle ear structures before proceeding to remove incus

- The final exposure for malleostapedotomy includes the pyramidal process, oval window niche, tympanic segment of facial nerve, inferior part of the incudomallear joint and anterior malleal process and ligament (*Figure 24*)

Removal of incus and malleal head

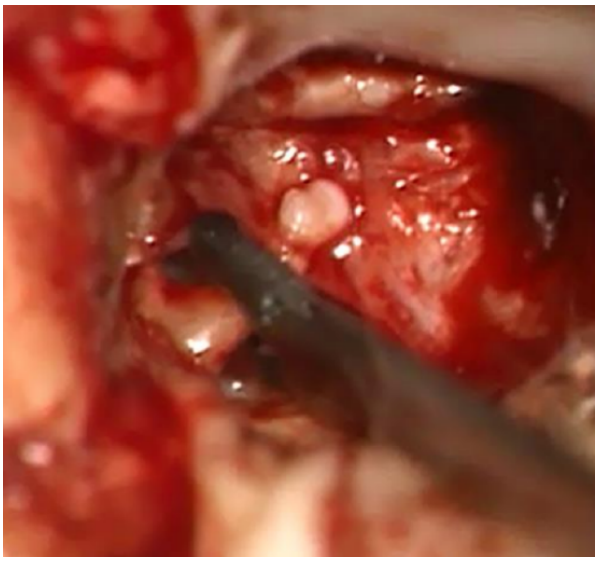


Figure 25: Removing incus with crocodile forceps

- Laterally rotate and mobilize the incus with a 1.5 mm 45° hook, and remove it with crocodile forceps (*Figure 25*)
- If the incus is bulky then the long process of the incus is cut with a malleus nipper so as not to injure *chorda tympani*

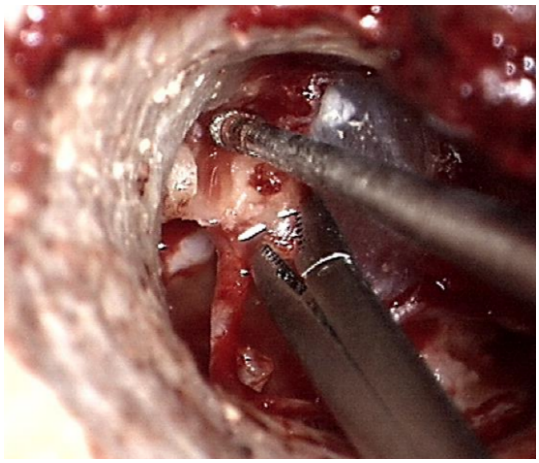


Figure 26: Diamond burr being used to excise neck and anterior process of malleus so that malleus head may be removed

- If the ligament of the malleus is ossified, then a 0.8 mm diamond burr is used to excise the neck and anterior process; separate the *chorda tympani* from the under surface of the neck of malleus with a 2.5 mm, 45° hook before drilling (*Figure 26*)
- The malleus head is then removed

Removal of arch of stapes



Figure 27: Anterior and posterior crura have been cut close to footplate

Crurotomy scissors are used to cut the anterior and posterior crura close to the footplate. Note in *Figure 27* that the anterior and posterior crura are equal length; in incus-stapedotomy the posterior crus would be shorter than the anterior crus.

Preparation of prosthesis

- A 0.4mm diameter titanium piston with a total length of 8.5 mm is used
- The distance between the stapes footplate and the lateral surface of the malleus handle (just below the lateral process) is measured with a malleable measuring rod; 0.5 mm is added to this measurement
- Using the technique described for incus-stapedotomy the desired length is achieved by cutting the prosthesis on a special cutting block

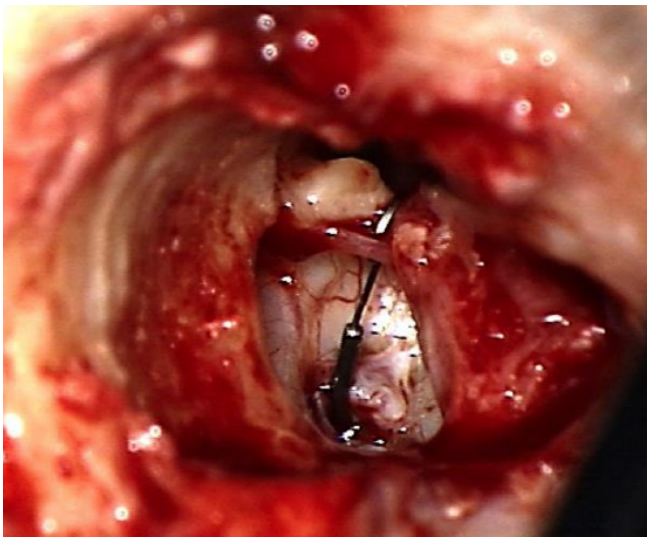


Figure 28: Prosthesis placed in middle ear to check its length

- To confirm the correct length, the prosthesis is introduced into the middle ear with a large crocodile forceps, so that it extends between the malleus handle and stapes footplate (*Figure 28*)
- If the prosthesis extends above the malleus handle by 0.5 mm, then the length is correct. A prosthesis that is too long may need to be cut shorter. If is too short then it needs to be replaced.
- To accommodate the slightly off-center position of the malleus relative to the stapes footplate, the shaft of the piston must be adapted so that it will lie perpendicular to the stapes footplate
- The loop of the prosthesis it must be enlarged in order to fit over the malleus handle by stretching it open by moving it along 1.5 mm, 45° hook with a watchmaker's forceps
- The loop may need to be adapted so that it is oriented at 90° to the malleus handle

Performing the stapedotomy

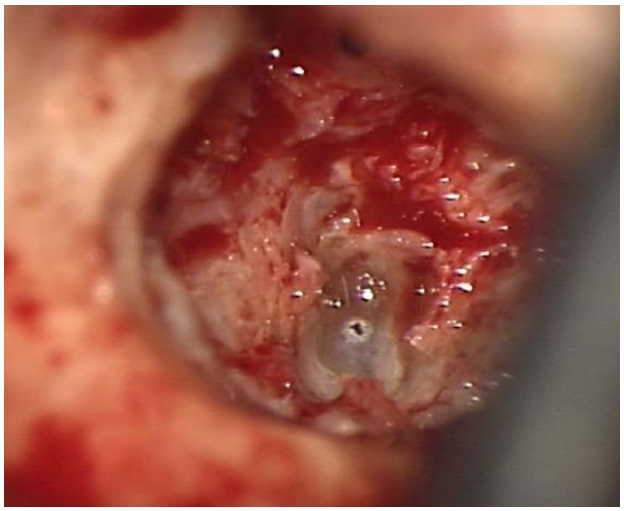


Figure 29: Initial small stapedotomy

- A perforation is made between the middle and inferior 1/3 of the footplate with a manual perforator or laser as for incus-stapedotomy (*Figure 29*)

Introducing and crimping the prosthesis

- Accurate crimping is crucial to obtain good results; the larger exposure afforded by the approach described facilitates accurate crimping
- The prosthesis is picked up by its loop with a large alligator forceps at the required angle and placed on the footplate
- The loop of the prosthesis is placed over the malleus just distal to the lateral malleal process
- The loop is crimped to the malleus by applying the alligator forceps perpendicularly to the handle of the malleus. A McGee Crimper/Wire Closure Forceps may be helpful to deal with the angle between the stapedotomy and malleus

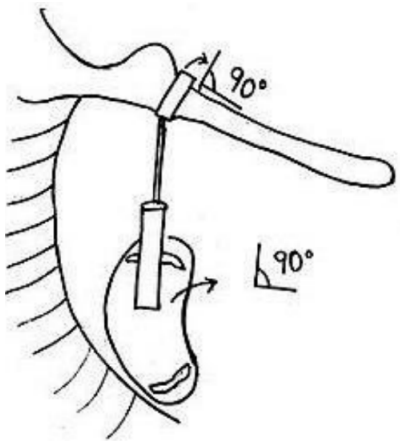


Figure 30: The loop is perpendicular to malleus handle and shaft is perpendicular to footplate

- If correctly crimped, the loop of the prosthesis should be perpendicular to the inclination of the malleus handle and the shaft should be perpendicular to the stapes footplate (*Figure 30*)

Sealing the stapedotomy

The stapedotomy opening is sealed with connective tissue from the endaural incision and blood taken from the patient as described for incus stapedotomy.

Repositioning the tympanomeatal flap and wound closure: As for incusstapedotomy

Postoperative care

- As for incus-stapedotomy
- Patients can fly after 2 weeks (as for incus-stapedotomy)
- Patients who have undergone malleostapedotomy are not permitted to scuba dive

References

1. Fisch U, May J. Tympanoplasty, Mastoidectomy and Stapes Surgery. New York: Thieme; 1994.
2. Nandapalan V, Pollak A, Langner A, Fisch U. The anterior and superior malleal ligaments in otosclerosis. Otol Neurotol. 2002;23(6):854-61
3. Vincent R, Sperling NM, Oates J, Jindal M. Surgical findings and longterm hearing results in 3,050 stapedotomies for primary otosclerosis: a prospective study with the otologyneurotology database. Otol Neurotol. 2006;27(8 Suppl 2):S25-47
4. Vincent R, Lopez A, Sperling NM. Malleus Ankylosis: A Clinical, Audiometric, Histologic, and Surgical Study of 123 Cases. Am J Otol. 1999; 20:717- 25
5. Dalchow CV, Dünne AA, Sesterhenn A, Teymoortash A, Werner JA. Malleostapedotomy: The Marburg experience. Adv Otorhinolaryngol. 2007;65:215-21
6. Fisch U, Acar GO, Huber AM. Malleostapedotomy in revision surgery for otosclerosis. Otol. Neurotol. 2001;22: 776-85
7. Linder TE, Fisch U. A checklist for surgical exposure in stapes surgery: how to avoid misapprehension. Adv Otorhinolaryngol. 2007;65:158-63
8. Probst R. Audiological evaluation of patients with otosclerosis. In Otosclerosis and stapes surgery. Arnold W, Häusler R (eds): otosclerosis and stapes surgery. Adv Otorhinolaryngol. Basel Karger, 2007, vol 65, pp 119-26

9. Ayacha D. Lejeune D, Williams. Imaging of postoperative complications of stapes surgery. In Otosclerosis and Stapes Surgery. Arnold W, Häusler R (eds): Otosclerosis and Stapes Surgery. Adv Otorhinolaryngol. Basel Karger, 2007, vol 65, 308-13
10. Linder TE, Ma F, Huber A. Round window atresia and ist effect on sound transmission. Otol Neurotol. 2003; 24(2):259-63
11. Van Rompaey V, Offeciers E, De Foer B, Somers T. Jugular bulb diverticulum dehiscence towards the vestibular aqueduct in a patient with otosclerosis. J Laryngol Otol. 2012 Mar;126(3):313-5
12. Neyt P, Govaere F, Forton GE. Simultaneous true stapes fixation and bilateral bony dehiscence between the internal carotid artery and the apex of the cochlea: the ultimate pitfall. Otol Neurotol. 2011.32(6):909-13
13. Merchant SN, Rosowski JJ, McKenna MJ. Superior semicircular canal dehiscence mimicking otosclerotic hearing loss in Otosclerosis and stapes surgery. Adv Otorhinolaryngol. Basel Karger, 2007, vol 65, 137-45
14. Pauw BK, Pollak AM, Fisch U. Utricle, saccule, and cochlear duct in relation to stapedotomy. A histologic human temporal bone study. Ann Otol Rhinol Laryngol.1991;100(12):966-70
15. Huber AM, MA F, Felix H, Linder T. Stapes prosthesis attachment: the effect of crimping on sound transfer in otosclerosis surgery. Laryngoscope. 2003;113(5):853-8
16. Hüttenbrink KB. Biomechanics of stapesplasty: A review. Otol Neurotol. 2003;24:548-59
17. Kwok P, Fisch U, Strutz J, May J: Stapes surgery: how precisely do different prosthesis attach to the long process of the incus with different instruments and different surgeons? Otol Neurotol 2002;23:289-95

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Author

Tashneem Harris MBChB, FCORL, MMed (Otol), *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Thomas Linder, M.D.
Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.9: Subtotal Petrosectomy

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris & Thomas Linder

Subtotal petrosectomy involves complete exenteration of all air cells of the temporal bone (middle ear and mastoid). It includes the following cell tracts: retrosigmoid, retrofacial, antral, retrolabyrinthine, supralabyrinthine, infralabyrinthine, supratubal and pericarotid cells. Only a few cells in the petrous apex are left behind. The otic capsule is either kept intact or removed (subtotal petrosectomy with or without removal of the otic capsule). The external auditory canal is closed as a blind sac and the cavity obliterated with abdominal fat and a temporalis muscle flap. Complete removal of disease is important before obliterating the cavity.

Indications



Figure 1: Chronically discharging mastoid cavity

- Chronic otitis media when there is no possibility of hearing reconstruction and one wishes to attain a dry, safe ear (*Figure 1*)

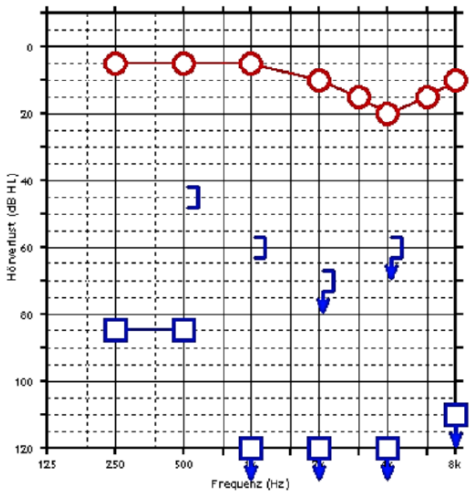


Figure 2: Audiogram showing dead left ear

- Chronic otitis media in a completely deaf ear (*Figure 2*)



Figure 3: Type B temporal paraganglioma

- Middle ear tumors (*Figure 3*)
- CSF leaks which may be traumatic, iatrogenic or (rarely) spontaneous
- Supralabyrinthine and/or infralabyrinthine cholesteatoma

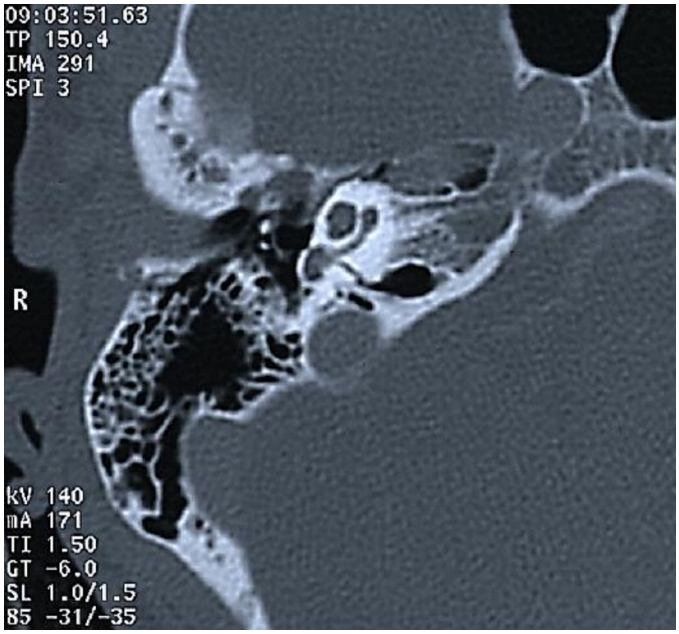


Figure 4: Transverse temporal bone fracture of right ear involving vestibule

- Transverse temporal bone fracture (*Figure 4*)
- In combination with another neurotologic procedure e.g. Transotic and Infratemporal fossa approaches “Types A, B or C”

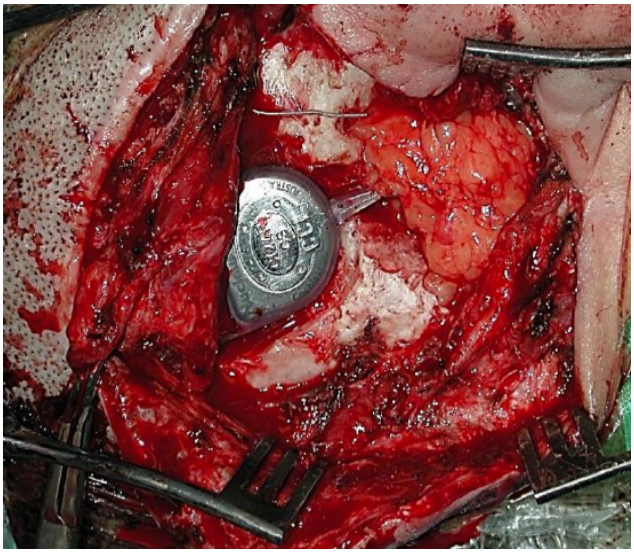


Figure 5: Subtotal petrosectomy and cochlear implant

- Cochlear or middle ear implantations where an open cavity has previously been performed (*Figure 5*)
- Cochlear implantation in the case of congenital cochlear dysplasia where there is a high risk of a CSF gusher
- Osteoradionecrosis of the temporal bone

Preoperative management

Imaging

- Patients undergoing subtotal petrosectomy require High Resolution CT (HRCT) scan prior to surgery
- Refer to the preoperative CT checklist in the chapter on Mastoidectomy and epitympanectomy
- If patients have had previous surgery, it is particularly important to pay attention to structures which may have been exposed at the primary surgery e.g. facial nerve, sigmoid sinus and dura

Audiogram

- Review audiograms to decide whether it is necessary to remove the stapes superstructure or if it should be preserved
- If there is no possibility of hearing reconstruction e.g. a dead ear, then the stapes superstructure may be removed
- If hearing is reasonable then it may be wise to preserve the stapes superstructure as the patient may decide to have a semi-implantable hearing aid (Vibrant Soundbridge) fitted in the future.

Perioperative antibiotics: Amoxicillin with clavulanic acid

Operative site

- The patient's hair is shaved for a distance of 7 cm above and behind the hairline
- The inferior abdominal quadrant and suprapubic areas are shaved and prepared for harvesting a fat graft



Figure 6: Positioning of patient

Positioning: The patient lies supine with the head turned away from the surgeon (*Figure 6*)

Facial nerve monitoring: Avoid longacting muscle relaxants as the facial nerve should be monitored intraoperatively

Surgical Steps

Skin Incision

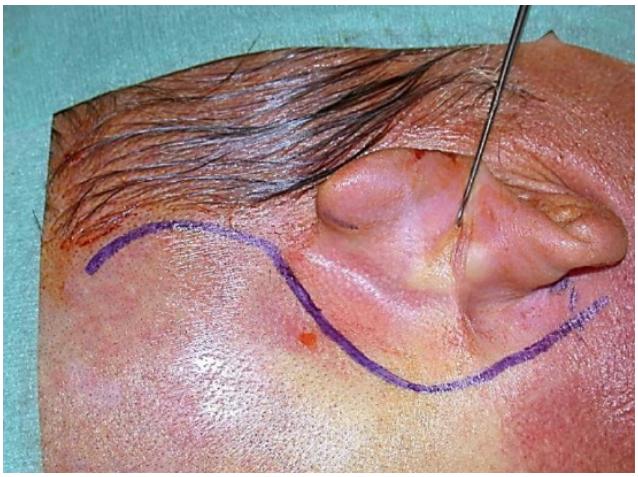


Figure 7: Postauricular S-shaped incision

- A postauricular S-shaped incision is made from the temporal region to 1 cm below the mastoid tip (*Figure 7*)
- The superior part of the incision above the temporal line is only made at the end of the procedure when a temporalis muscle flap is needed

Mastoid periosteal flap

- This flap is used as a 2nd layer in the closure of the external auditory canal and is therefore left attached to the cartilaginous canal
- Using a surgical scalpel with a #10 blade, the skin is reflected anteriorly remaining superficial to temporalis fascia and muscle

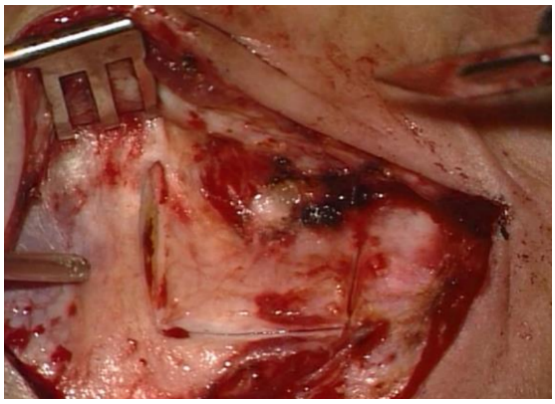


Figure 8: Mastoid periosteal flap

- The anteriorly based periosteal flap is developed measuring about the size of the surgeon's finger. (*Figure 8*)
- It must be long enough to achieve closure of the external canal especially in the case of previous surgery with an open cavity where the periosteal tissue may be of poor quality

Blind sac closure of external auditory canal

Transection of the auditory canal

- The periosteal flap is elevated until the bony-cartilaginous junction of the external auditory canal is reached

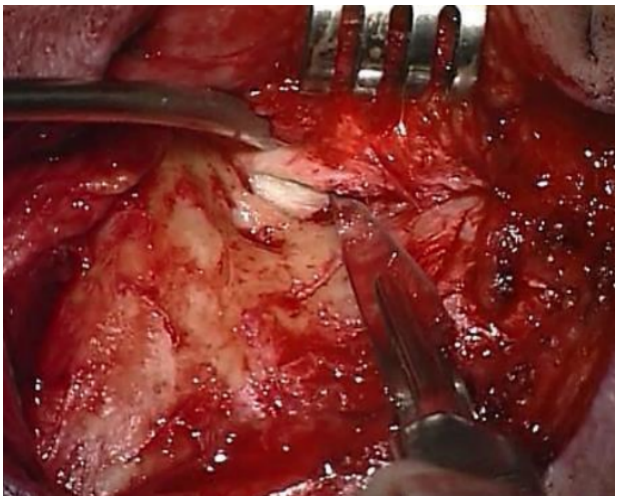


Figure 9: Incision in ear canal

- An incision is made from 6-12 o'clock in the posterior auditory canal (*Figure 9*)
- To transect the *anterior* portion of the canal, use a curved clamp to find the tragal cartilage
- A large curved artery clamp is then used to develop a plane anterior to the tragal cartilage separating the parotid from the cartilage

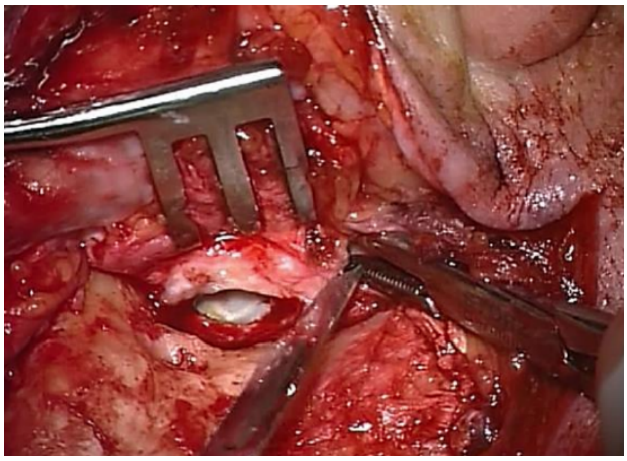


Figure 10: Safely transecting anterior wall of ear canal

- Holding the curved clamp in this position, a #15 blade is used to safely transect the anterior canal by cutting onto the curved clamp. This avoids injury to the facial nerve (*Figure 10*)

Eversion of auditory canal skin

- Ocular magnifying loupes are useful for this step

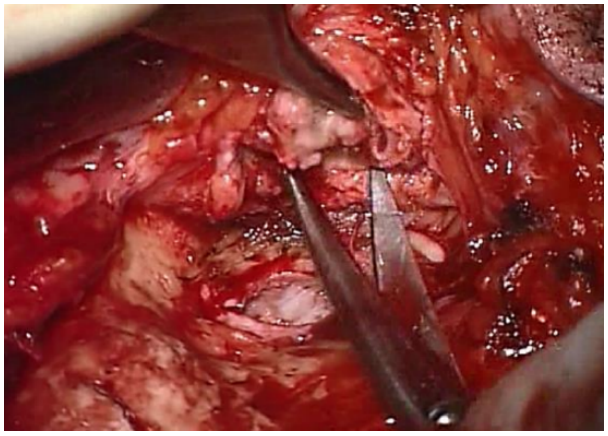


Figure 11: Elevating skin of external canal

- The skin of the cartilaginous canal is elevated for 1 cm from the cut margin with tympanoplasty scissors to facilitate eversion of the canal (*Figure 11*)
- It is important that the skin of the external canal is not breached. To avoid this, direct the curve of the tympanoplasty scissors towards the cartilage
- It may be difficult to find the correct plane, especially if a previous open mastoidectomy with a wide meatoplasty was performed

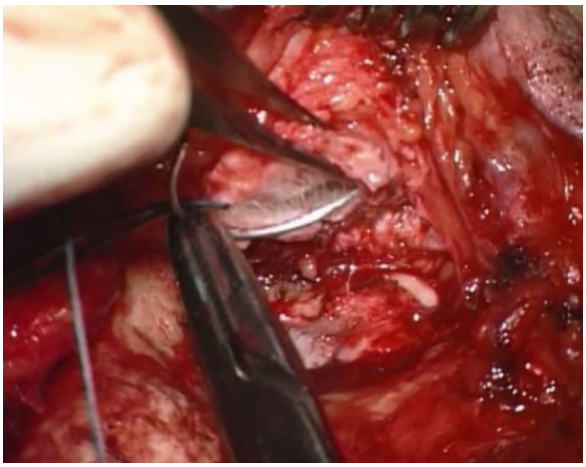


Figure 12: Placing stay sutures

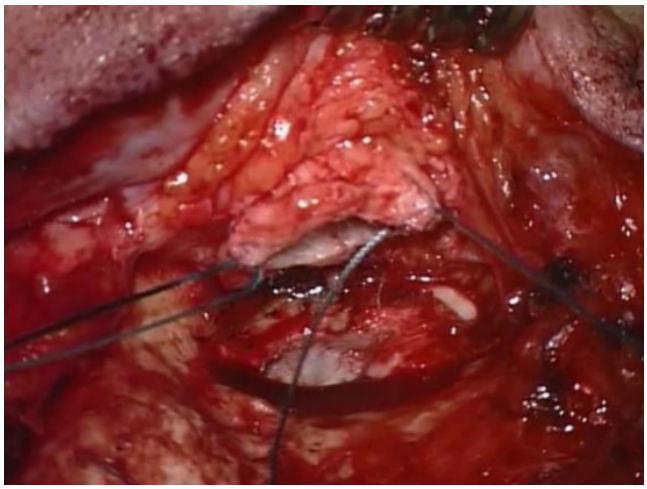


Figure 13: Stay sutures

- Two 2-0 vicryl stay sutures are placed at 6 and 12 o'clock. These are placed as 2 purse string sutures with the free ends on the inside of the canal (*Figures 12, 13*)



Figure 14: Everting skin of the ear canal

- A curved artery clamp is passed through the canal from externally and applied to each of the free ends of the two stay sutures. Tension is applied to the stay sutures to evert the canal skin (*Figure 14*)

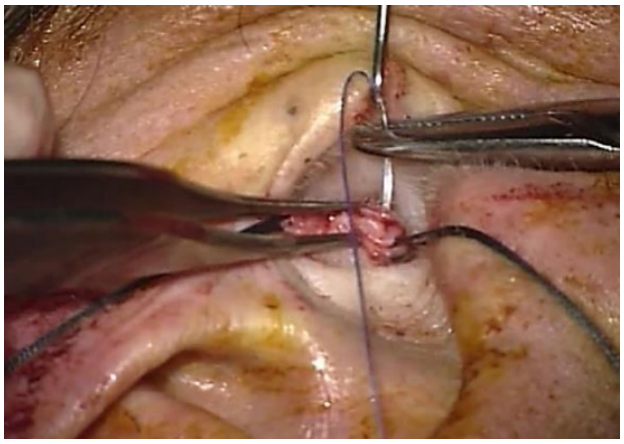


Figure 15: Oversewing canal

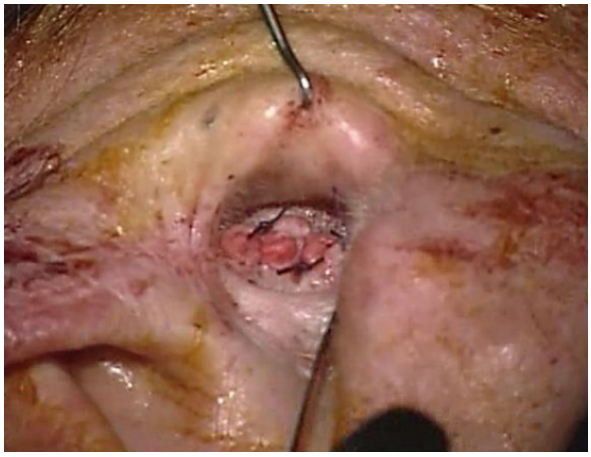


Figure 16: Oversewn canal

- The tragus is retracted with a skin hook and the skin edges are oversewn with 4-0 vicryl suture (*Figures 15, 16*)

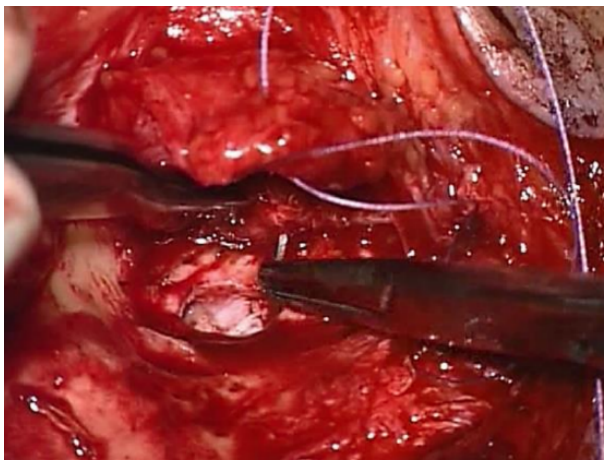


Figure 17: Oversewing the sac with the periosteal flap

- The periosteal flap is folded back as a 2 nd layer to the blind sac closure of the external auditory canal (*Figure 17*). It is sutured to the cartilage of the external auditory canal with 2-0 vicryl

Removal of lateral external auditory canal skin

- The skin of the bony external canal is elevated with a Key raspatory

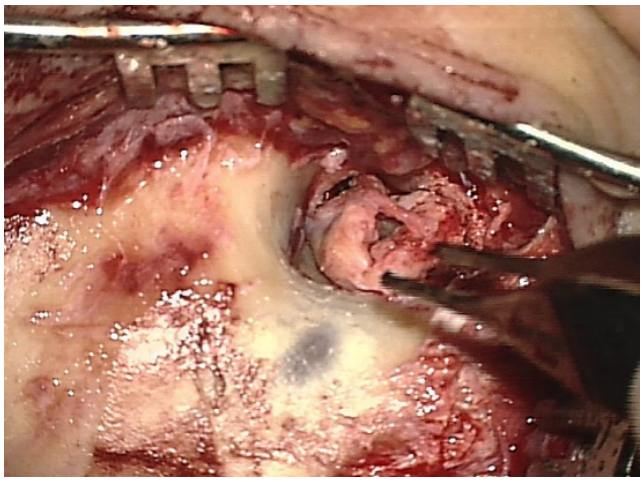


Figure 18: Removing skin of ear canal

- This skin cuff is removed with tympanoplasty scissors (*Figure 18*)

Removal of medial external auditory canal skin

- A microraspatory and small strip of adrenaline gauze is used to elevate the remnants of the external auditory canal skin to the annulus
- The middle ear is entered at the posterior tympanic spine and the annulus is elevated. The short process of malleus, chorda tympani and incudostapedial joint are now visible
- *Chorda tympani* is divided with a large Bellucci scissors
- The incudostapedial joint is separated with a 45° 1.5 mm hook
- The malleus is cut at its neck with a malleus nipper
- Tensor tympani tendon is cut with a large Bellucci scissors
- The *tympanic membrane* (with handle of malleus attached) is now be removed along with the incus and head of malleus

Mastoidectomy

- It is important that all mastoid cells are exenterated, and no mucosa is left behind as this can potentially form mucocoeles
- Structures like dura, sigmoid sinus and facial nerve must be skeletonized, not exposed
- Using a mastoid raspatory elevate the soft tissues off the mastoid
- Free the sternocleidomastoid muscle from its insertion into the mastoid tip
- Place a 2-0 silk stay suture from the edge of temporalis muscle to its fascia to expose the area above the temporal
- Next proceed as for open mastoidoepitympanectomy (see chapter on mastoidectomy)
- After performing an open mastoidoepitympanectomy the additional cells are removed to complete the subtotal petrosectomy
- The stapes superstructure is removed using crurotomy scissors to cut the anterior and posterior crura
- The inferior surface of the external ear canal can be lowered to the level of the hypotympanum
- It is important to review the CT scan to confirm again that the jugular bulb is not high-riding before skeletonizing the jugular bulb
- The pericarotid cells are exenterated by first approaching the anterocarotid cells. The carotid is recognized by its whitish color beneath the bone. The carotid is not infrequently dehiscent at its bend medial to Eustachian tube
- The mastoid tip may be left in place, but is drilled down to the level of the digastric ridge

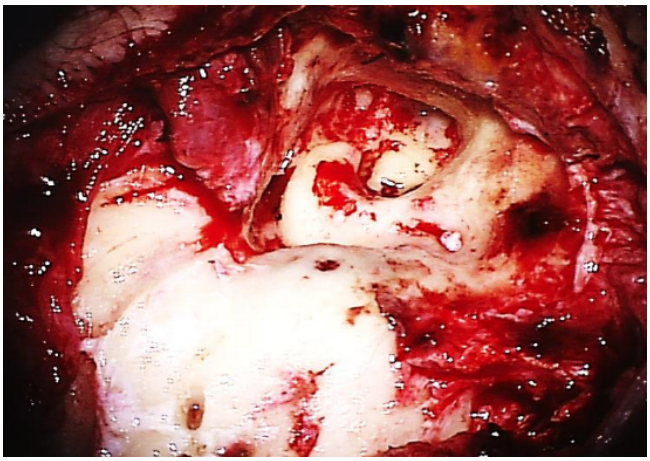


Figure 19: Mastoid cavity with all cell tracts having been exenterated

- Retrofacial, retrosigmoid, retrolabyrinthine, supralabyrinthine, infralabyrinthine, and supratubal cells are all exenterated. *Figure 19* shows the mastoid cavity once all the cell tracks have been exenterated

Technical points

- When drilling in the supralabyrinthine segment a diamond drill is used in reverse when operating on the right ear to avoid injuring the facial nerve
- The mucosa of the middle ear can be removed by using the microraspatory and scraping the mucosa with a small cotton ball, taking care not to sublux the stapes superstructure if left intact

Obliteration of Eustachian tube

- The internal carotid artery is followed superiorly to the medial wall of the Eustachian tube (watch out for a dehiscent carotid at this point!)
- The mucosa of the bony Eustachian tube is removed as far as the isthmus with a 2 mm/3 mm diamond burr

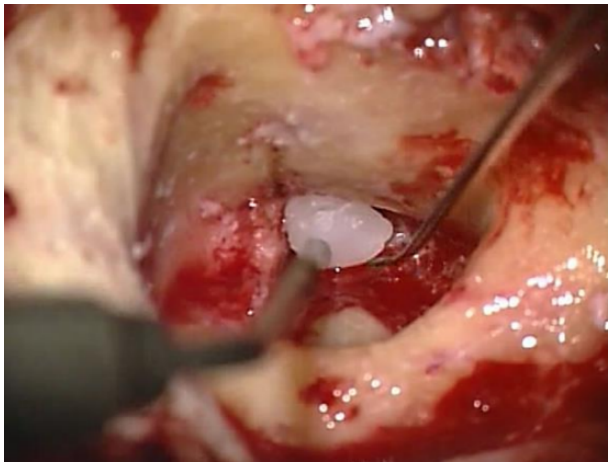


Figure 20: Eustachian tube obliterated with bone wax

- At this point the remaining mucosa is coagulated with bipolar forceps and the Eustachian tube is obliterated with bone wax (*Figure 20*)

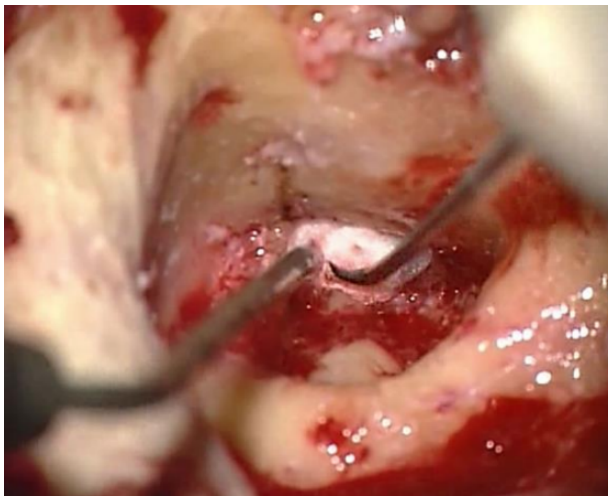


Figure 21: Eustachian tube obliterated with bone wax

- Using a cottonoid, the bone wax may be pushed into the orifice of the Eustachian tube with a suction tip. The tip of the microraspatory is directed ***away*** from the carotid (*Figure 21*)
- A temporalis muscle musculofascial graft is used as an additional seal of the orifice by placing it lateral to the bone wax

Technical points

- The tensor tympani muscle can be dissected out of its semicanal by drilling its lateral surface and reflecting it anteriorly with a microraspatory into the protympanum and the Eustachian tube orifice
- Bone wax is then placed over this so that the muscle lies sandwiched between two layers of bone wax, thus obliterating the Eustachian tube

Obliteration of Operative Cavity



Figure 22: Abdominal fat

- The middle ear cleft is obliterated with abdominal fat harvested from the lower quadrant of the abdomen (*Figure 22*)
- It is important to achieve meticulous hemostasis as a hematoma of the abdominal wound is the most common complication of subtotal petrosectomy
- A suction drain is placed in the abdominal wound
- The abdominal wound is closed in layers using subcutaneous 3-0 vicryl and monocryl 3-0 or nylon 3-0 to skin
- With osteoradionecrosis of the temporal or chronic infection it is advisable not to use abdominal fat to obliterate the cavity. Rather use only temporalis muscle

Transposition of temporalis muscle

- The skin incision is extended superiorly above the temporal line to expose the temporalis muscle
- Remaining in a plane above the temporalis fascia, the skin and soft tissue edges are undermined
- Using two skin rakes, the assistant retracts the skin edges for adequate exposure
- The posterior 2/3 of the temporalis muscle is mobilized by creating a flap using a diathermy knife

- To facilitate mobilization and transposition of the temporalis flap over the mastoid cavity, a small inverted V shaped incision is made at the base of the temporalis muscle

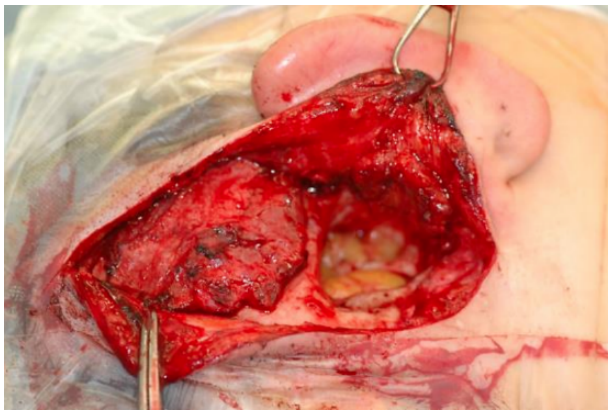


Figure 23: Temporalis flap and abdominal fat in petrosectomy defect

- The muscle flap is rotated inferiorly over the cavity and sutured to the sternocleidomastoid muscle and soft tissues of the occiput with 2-0 vicryl (*Figure 23*)

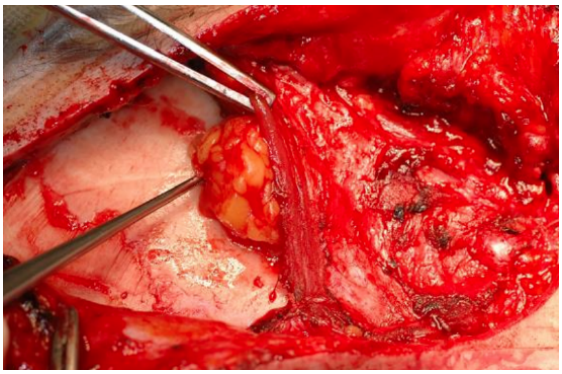


Figure 24: Additional fat placed in defect

- Inevitably the fat used to obliterate the cavity will atrophy; therefore, more fat is placed in the cavity once the temporalis muscle has been sutured to the soft tissues via the superior pocket created by the transposed temporalis flap (*Figure 24*)

Wound Closure

- A 3 mm suction drain is placed under the scalp over the squamous part of the temporal bone and not over the mastoid cavity
- The wound is closed in layers with 2-0 vicryl sutures subcutaneously and skin clips
- A compression bandage is applied

Postoperative care

- Antibiotics (amoxicillin with clavulanic acid) are continued for one week postoperatively
- The drain is left in place until the drainage is less than 10mL/24hrs.
- If the surgery was done for a CSF leak, then the drain is removed on the first postoperative day
- The abdominal drain is removed when the drainage is less than 10mL/24hrs
- Clips/sutures are removed after 10 days
- The resorbable vicryl sutures within the external ear canal are removed at 4 weeks

Long-term follow-up

Imaging

- Where subtotal petrosectomy is performed for chronic otitis media, CT scans are routinely performed after one year and then again at 3 years
- In cases of previous cholesteatoma, a diffusion weighted non-EPI MRI would detect recurrent disease

Auditory rehabilitation

This depends on the status of hearing of opposite ear, the degree and type of hearing loss and cochlear function. The options are a bone anchored hearing aid (BAHA) if the inner ear function has been preserved of the ipsilateral or contralateral ear; active middle ear implant (e.g. Vibrant Soundbridge) where there is good cochlear reserve; or a cochlear implant (bilateral deafness).

References

1. Fisch U, Mattox D, eds. Microsurgery of the Skull Base. Stuttgart,Germany: Georg Thieme Verlag, 1988.
2. Linder T, Schlegel C, DeMin N, van der Westhuizen S.Active Middle Ear Implants in Patients Undergoing Subtotal Petrosectomy: New Application for the Vibrant Soundbridge Device and Its Implication for Lateral Cranium Base Surgery. Otol Neurotol. 2008; 30:41-7

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Authors

Tashneem Harris MBChB, FCORL, MMed, *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Thomas Linder, M.D.
Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.10: Ossiculoplasty

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris, Thomas Linder

Ossiculoplasty may be defined as restoring the hearing mechanism between the tympanic membrane and the oval window by re-establishing a functioning ossicular chain. It is indicated with ossicular ***discontinuity*** following erosion, trauma or ossicular ***fixation*** due to tympanosclerosis, adhesions etc. Operating on an ***only hearing*** ear is an ***absolute contraindication*** for ossiculoplasty.

Chronic otitis media may also cause ossicular disruption due to erosion of the ossicular chain. Ugo Fisch classified ossicular defects seen in chronic otitis media in accordance with the expected functional hearing outcomes (*Table 1*).[1]

ABG	**Preop status of ossicles and mastoid**
<10dB	Malleus: Handle intact **Incus: Absent** Stapes: Intact
<20dB	Malleus: Handle intact **Incus: Absent** **Stapes: Fixed /no superstructure**
<30dB	**Open/closed cavity mastoidectomy** **Malleus: Absent** **Incus: Absent** **Stapes: Mobile/fixed/mobile footplate**

Table 1: Anticipated postoperative airbone gap (ABG) according to preoperative status of ossicular chain and type of mastoidectomy (Fisch U, May J. Tympanoplasty, Mastoidectomy and Stapes Surgery)

Patient selection

Patient selection is based on the preoperative audiogram AND the potential to regain serviceable hearing. A patient will benefit if the hearing level of the poorer hearing ear is raised to within 15 dB of the better hearing ear. Second stage ossiculoplasty is usually less invasive and can be done by an endaural approach. One can anticipate the likely course of the ossiculoplasty from otoscopy and audiogram findings.

Methods of ossicular reconstruction

The principal determinants of the method of reconstruction and the expected hearing results are

- Mobility of the stapes footplate
- Integrity of the stapes superstructure
- Presence/absence of a malleus handle

Mobility of the footplate is assessed by placing a few drops of saline in the round window niche. The saline is carefully observed while gently touching the stapes head. Mobility of the footplate is verified when the water moves as the stapes head is touched. If the mobility of the stapes is restricted due to adhesions or granulation tissue, then the tissue may be carefully removed before again assessing stapes mobility using the above technique before proceeding with ossiculoplasty.

Ossiculoplasty using a ***Partial Ossicular Reconstruction Prosthesis (PORP)*** is done when the ***stapes superstructure is intact***. Ossiculoplasty with ***Total Ossicular Reconstruction Prosthesis (TORP)*** is required when the ***stapes superstructure is absent***, and the footplate is mobile.

The ***malleus handle*** is an important clinical audiological prognostic factor for ossiculoplasty.[12,13] Anchoring the prosthesis to the manubrium of the malleus provides better stabilization and reduces extrusion. The angle of the prosthesis relative to the stapes is also important in order to achieve good acoustic results; placing the prosthesis at >45° causes loss of acoustic transmission and carries the risk of subluxation onto the promontory resulting in a complete conductive block (A-B gap >60 dB).[9] If the manubrium of the malleus is very anterior to the stapes or there is a large distance between malleus and stapes, the prosthesis would lie at >45° angle. In such cases better hearing results are obtained by placing the prosthesis in direct contact with the tympanic membrane with an interposed cartilage graft.

Staging the surgery

In some cases, it may be preferable to do ossiculoplasty as a staged procedure i.e. not at the same time as doing a tympanoplasty or mastoidectomy. The possibility of a 2nd stage operation should always be discussed with the patient at the time of primary surgery. Staging improves the outcomes of ossicular reconstruction for the following reasons:

- Better assessment of the position of the tympanic membrane and eustachian tube function 6-12 months after primary surgery
- Should the mucosa around the oval window have been traumatized, there is a risk of scarring of the oval window if ossiculoplasty is performed in as single stage procedure; staging allows damaged mucosa of the middle ear to first to heal
- With cholesteatoma surgery, to verify that no residual cholesteatoma is present; the 2nd stage (ossiculoplasty) surgery is delayed for about a year after the primary surgery
- It may be preferable to stage ossiculoplasty if only the stapes is present in the setting of a tympanic membrane perforation

If ossiculoplasty is staged and the middle ear mucosa has been traumatized and/or eustachian tube function is poor, then thin silastic sheeting is placed in the *protympanum* of the middle ear to allow the middle ear mucosa to heal and to reduce adhesions that may form between the middle ear mucosa and the tympanic membrane.

Before undertaking 2nd stage or revision surgery the surgeon needs to know the following:

- What was the status of the ossicular chain at the time of primary surgery?
- Was reconstruction attempted and what was used in the reconstruction?
- Is the *chorda tympani* nerve intact?
- Was silastic sheeting placed in the ear?
- Was temporalis fascia harvested? If so, then the postauricular incision may need to be extended superiorly to access temporalis fascia. This must be anticipated when draping and preparing the surgical site

Materials used for ossiculoplasty

Autologous ossicle: This is the gold standard of ossicular reconstruction. Whether it can be employed depends on the presence of ossicular remnants. Autologous ossicles are easily shaped to the required size and shape with diamond burrs. Disadvantages include prolonged operating time and the possibility of them harboring microscopic remnants of cholesteatoma. Advantages include low extrusion rates, low cost, biocompatibility and zero risk of transmitting disease. Failure of ossicular reconstruction relate to lateralization, bony fixation, atrophy and displacement.[1]

Autologous bone graft: Cortical bone grafts may be used for ossicular reconstruction, although it is fairly controversial when one examines the literature. While some studies report the functional results of cortical bone grafts to be as good as with ossicular bones[2,3] others quote less favorable outcomes.[4,5] The most common causes of deterioration of hearing are atrophy and bony fixation.[4,5]

Cartilage: The use of cartilage is controversial. Some studies show evidence of cartilage resorption over the long term.[4,5] Yet other studies report long term stability with good functional results.[6,7] Advantages include versatility, availability, cost, biocompatibility, and low extrusion rates; however operative time may be prolonged as cartilage has to be harvested and molded. Tragal cartilage is most commonly used; conchal and chondral cartilage has been used.

Homologous ossicle: Some years ago, it used to be common practice for otolaryngology departments to have their own “ossicle banks”. Healthy ossicles that were removed from patients for various reasons during middle ear and mastoid surgery or from cadavers were stored in alcohol and used for ossiculoplasty in other patients. Concerns about transferring prions of *Creutzfeldt Jacob Disease* as well as the advent and ready availability of ossicular prostheses have minimized this practice. However, some countries still permit allogeneic ossicles to be used based on donor selection criteria and special processing methods. *Lubbe* reviewed the risks associated with homologous ossicles and provides detailed guidelines about preparation and storage of

homologous ossicles.[8] (Homograft ossicles). “Ossicle banks” may therefore be appropriate in centers that cannot afford middle ear prostheses.

Alloplastic prostheses: A variety of synthetic materials have been used to manufacture prostheses. Advantages of such presculpted prostheses are reduced operating time, and no risks of residual cholesteatoma or transmitting disease. Disadvantages are higher extrusion rates and expense.

Alloplastic grafts may be divided into three categories based on the body’s reaction i.e. ***bio-inert***, ***biotolerant***, and ***bio-active***.[9]



Figure 1: Titanium prostheses

• ***Bio-inert materials***: The body does not react to bio-inert materials and they are not degraded by inflammatory processes. Bio-inert alloplastic implants include stainless steel, gold, platinum, and titanium (*Figure 1*).

Titanium is an excellent biocompatible material, is light but strong, and allows for many different prosthetic designs; it has good long-term success rates.[10] Cartilage needs to be interposed between the titanium prostheses and the tympanic membrane to prevent extrusion.



Figure 2: Examples of biotolerant prostheses

- ***Biotolerant materials***: Biotolerant materials are initially recognized by the body as foreign. However they soon develop a strong capsule to which endogenous proteins attach themselves; this shields the implant from the immune system. Examples of bio-tolerant materials include Plastipore® (high density polyethylene sponge), and Teflon (polytetrafluorethylene) (*Figure 2*). Teflon has been in longest use and is most frequently used. Excellent long term audiological results have been reported particularly in stapes surgery.[11] Flex H/A and Hapex are both composite allografts, the former consisting of hydroxyapatite and silastic; the latter consists of hydroxyapatite and polyethylene.
- ***Bio-active materials***: Bio-active materials have favorable biocompatibility but high biodegradability. Resorption rates are increased with inflammatory processes.[9] Examples of bio-active materials are glass ceramics and hydroxyapatite (HA). The biocompatible nature of HA allows the prosthesis to be placed directly in contact with the tympanic membrane.

Ossiculoplasty for partial or complete absence of incus

When the long process of the incus is eroded, continuity of the ossicular chain may be re-established by interposing autologous incus, head of malleus, a cortical bone chip, cartilage, or a PORP between the stapes head and malleus handle. These techniques are

next discussed in greater detail.

Autologous incus interposition

Autologous incus is used whenever possible as it does not cost anything, is situated in the surgical field, and has a low extrusion rate through the tympanic membrane. There are however times when this technique it is unsuitable: the incus may be absent, eroded, or covered by cholesteatoma. Alternative interpositions are also indicated when the incus does not fit well e.g. when the stapes superstructure and/or the malleus handle are absent. Incus interposition is performed at the time of primary surgery other that when the anterior half of the tympanic membrane is absent, or if there is a large perforation. ***In these two situations it is necessary to stage the procedure***. The techniques for open and closed cavities are similar. Where the malleus head has been removed e.g. in an open cavity or with a medialized malleus, incus interposition can still be done without compromising the hearing result. It is vital to preserve the tensor tympani tendon as it stabilizes and prevents anterior migration the malleus handle which is important for a good functional outcome.

Incus interposition: Surgical steps

Point of departure: Endaural approach and inspection of ossicular chain reveals an eroded long process of incus

- The incus is removed by rotating it laterally with a 45° hook
- The Fisch microraspatory is a useful means to assess the size and inclination of the modified incus. The working end of the microraspatory is 2.5 mm in length and usually corresponds to the distance between stapes head and the malleus handle

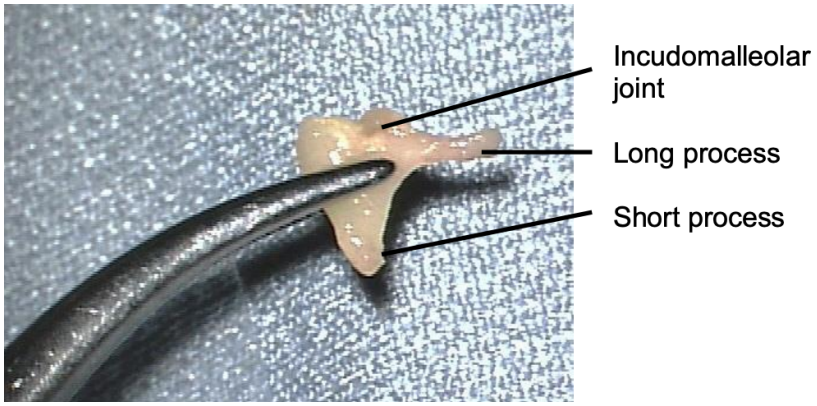


Figure 3: Incus held by its body

- A small curved clamp is used to hold and stabilize the body of the incus while shaping it with a diamond drill (*Figure 3*)

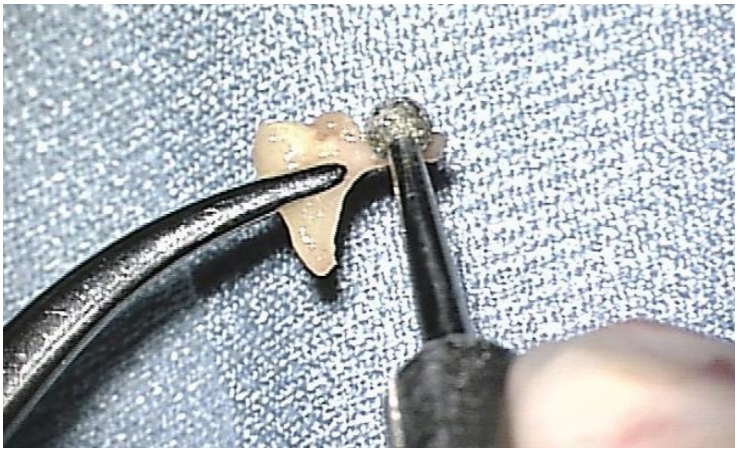


Figure 4: Removing long process

- Looking through the microscope, the surgeon removes the long process with a diamond drill (*Figure 4*)

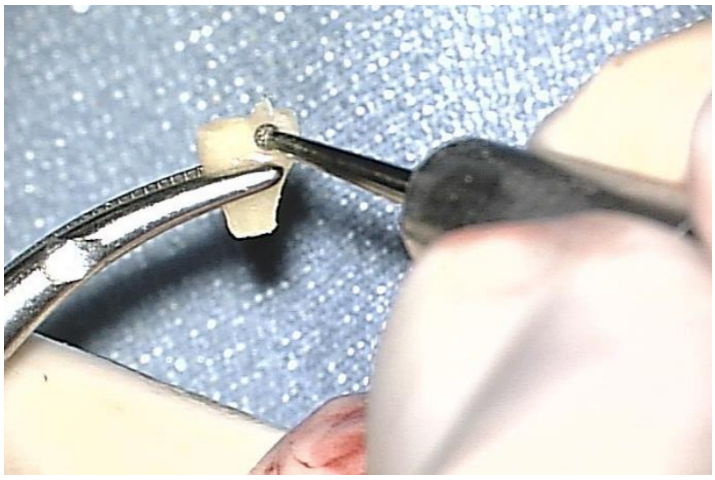


Figure 5: Shaping the articular surface to accommodate malleus handle

- The articular surface of the incus is shaped to accommodate the malleus handle (*Figure 5*)

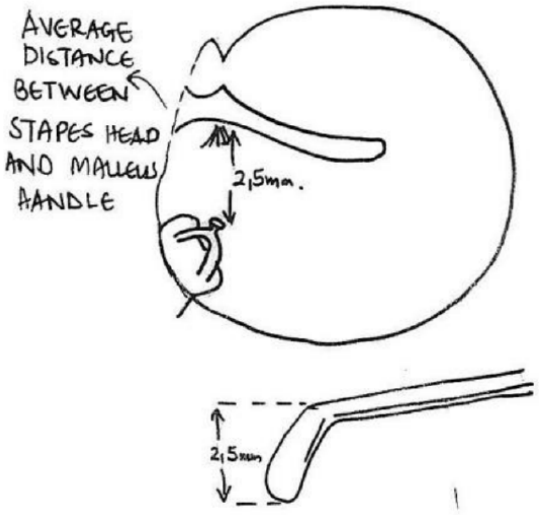


Figure 6: Fisch microraspatory used to determine the distance between malleus and stapes

- The modified incus should fit snugly between the stapes head and malleus handle. A notch is drilled in the body of the incus to accommodate the stapes head using 0.6 mm and 0.8 mm diamond burrs. The required depth of the notch is estimated by using the Fisch microraspatory to measure the distance between the malleus handle and stapes superstructure (*Figure 6*)
- Use the largest microsuction tube to pick up the prosthesis and place it in the middle ear, lateral to the preserved chorda tympani
- The groove drilled on the articular surface of the modified incus is maneuvered into contact with the malleus handle using a 1.5 mm 45° hook
- While maintaining the incus against the proximal malleus handle just below the lateral process, use the 1.5 mm 45° hook to position the notch drilled in the body of incus over the head of stapes

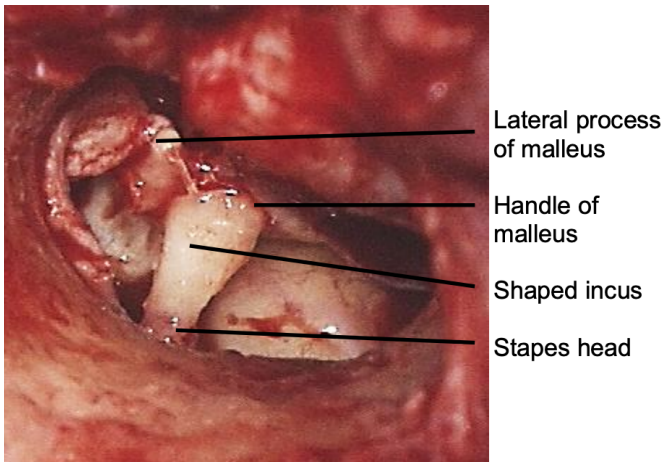


Figure 7: Incus interposition

- *Figure 7* shows an autologous incus interposed between malleus handle and stapes head. (Note: malleus head has been removed)

Head of malleus interposition

The head of the malleus may be used when the incus is either missing or has been eroded such that the remaining incus is too small to use. The head of the malleus is amputated with a malleus nipper. Holding the malleus with an artery forceps, it is shaped with a burr to create a notch which fits the malleus handle and a hole on the opposing side to accommodate the stapes head.

Cortical bone interposition

Cortical bone can be obtained from the temporal squama or from the mastoid cortex along the edge of the mastoid cavity. For small defects such as when only the distal part of the long process of the incus has been eroded, a square-shaped bone graft is be harvested. An acetabulum is drilled for the head of the stapes on one surface; on the opposing surface a groove is drilled for the remaining long process of the incus. For larger defects the bone can be sculpted in a shape similar to an incus interposition with a groove for the malleus and an acetabulum drilled for the head of the stapes. To harvest bone from the temporal squama, elevate the temporalis muscle and expose the temporal squama above the temporal line. Using a small diamond drill, only the outer table of the cortex is drilled in the shape of a small square. This can be lifted off the underlying bone using a straight chisel. Bone chips can be also harvested from the mastoid cortex using a straight chisel along the free edge of the mastoid cavity.

Cartilage interposition

Cartilage may be harvested from tragal cartilage (conchal cartilage is thinner and tends to be more curved) and modeled into the shape of an autogenous incus interposition.

PORP interposition

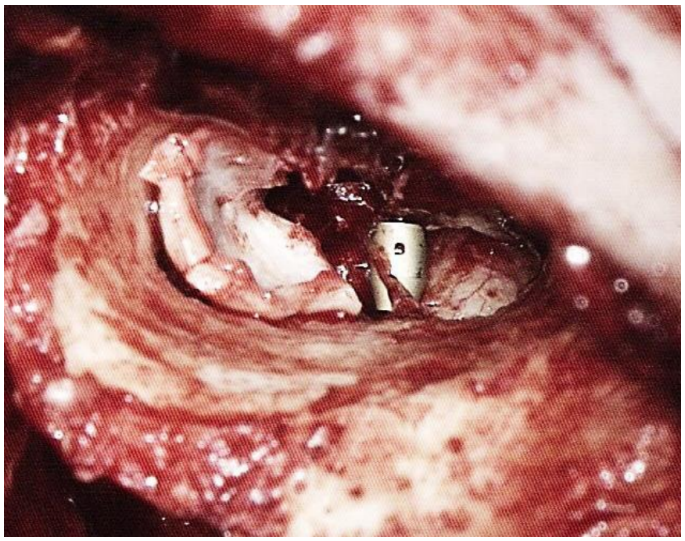


Figure 8: Titanium incus interposition with reconstruction of posterosuperior canal wall with cartilage

Prostheses may be manufactured from hydroxyl-apatite, plastic or titanium (*Figures 1, 2, 8*).

The PORP is placed on the stapes head. To prevent extrusion, a piece of cartilage is interposed between the prosthesis and tympanic membrane. If only a small distal portion of the lenticular process is eroded, then a prosthesis can be used which fits over the head of the stapes and has an arm which embraces the remaining long process of the incus.[14]

Ossiculoplasty when only stapes is intact

1. ***Stapes superstructure intact, mobile footplate***
    1. A stapes elevation technique can be performed by placing cartilage over the capitulum of the stapes (Type III tympanoplasty). A notch may be drilled on the surface of the cartilage with a small drill to accommodate the stapes head
    2. Alternatively, a PORP may be placed over the mobile stapes. *If the malleus handle is intact the prosthesis is placed between the stapes and the handle of malleus*
    3. A TORP can be placed between the crura of the intact stapes; this allows for a more stable reconstruction. All alloplastic implants must be covered by cartilage to prevent extrusion
2. ***Stapes superstructure eroded, mobile footplate***
    1. Tragal cartilage may be harvested and trimmed into the shape of a "T" and interposed between the tympanic membrane and the footplate to create a columella effect
    2. A TORP may be placed onto the stapes footplate.

Techniques used to stabilize the foot of the prosthesis on the footplate include:

- Perforation of the center of the footplate with a wire spike placed in the foot of the prosthesis[1, 15]
- Placing gelfoam at the footplate around the prosthesis
- Cutting small wedges of cartilage and placing them on the footplate on either side of the prosthesis
- Fisch devised a cartilage shoe with a central perforation to accommodate the shaft of the Fisch titanium total prosthesis to stabilize the prosthesis on the footplate.[1,15] Tragal cartilage is harvested and the perichondrium is removed. A hole is made in the cartilage with a 0.6 mm diamond burr. A disc is cut around the perforation in the cartilage to the dimensions of 1.5x3mm; these dimensions are slightly larger than the oval window. Using a microscope the final sizing is done to fit the oval window niche. The prosthesis shaft is placed through the central perforation of the cartilage disc before placing it in the oval window niche.
- Along a similar concept, Hüttenbrink et al developed a cartilage guide for the oval window niche. An oval 2.5 x 3.5 mm cartilage with a central hole is cut out of a thin (0.2-0.3 mm) cartilage plate with a cartilage punch. The cartilage is placed into the oval niche and the shaft of the prosthesis is guided through the hole of the cartilage shoe onto the center of the foot-plate.[16,17]

References

1. Fisch U, May J. Tympanoplasty, Mastoidectomy and Stapes Surgery. New York: Thieme; 1994
2. Romanet P, Duvillard C, Delouane M. Mastoid cortical bone grafts in ossiculoplasty. Ann Otolaryngol Chir Cervicofac. 2000;117(2):105-9
3. Mudhol RS, Naragund AI, Shruthi VS. Ossiculoplasty Revisited. Indian J Otolaryngol Head and Neck Surg. doi:10.1007/s12070-011-0472-7
4. Hüttenbrink KB. Die Chirurgische Therapie der chronischen Otitis media. III: Mittelohrrekonstruktion. HNO. 1994;42(11):701-18
5. Kley W, Draf W. Histologische Untersuchungen über autotransplan-tierte Gehörknöchelchen und Knochenstückchen im Mittelohr beim Menschen. Acta Otolaryngol. 1965;59:593- 603
6. Belal A, Linthicum FH, Odnert S. Fate of cartilage autografts for ossiculoplasty: an electron microscopic study. Clin Otolaryngol. 1981;6:231-6
7. Quaranta N, Fernandez-Vega Feljoo S, Piazza F, et.al. Closed tympanoplasty in cholesteatoma surgery, long term (10 years) hearing results using cartilage ossiculoplasty. Eur Arch Otorhinolaryngol. 2001;258:20-4
8. Lubbe D, Fagan JJ. Revisiting the risks involved in using homograft ossicles in otological surgery. J Laryngol Otol. 2008;122(2):111-5
9. Beutner D, Huettenbrink KB. Passive and active middle ear implants. GMS Curr Top Otorhinolaryngol Head Neck Surg.doi:10.3205/cto000061
10. Fong JC, Michael P, Raut V. Titanium vs autograft ossiculoplasty. Acta Otolaryngol. 2010 ;130(5):554-8
11. Vincent R, Sperling NM, Oates J, Jindal M. Surgical findings and longterm hearing results in 3,050 stapedotomies for primary otosclerosis: a prospective study with the otologyneurotology database. Otol Neurotol. 2006;27(8 Suppl 2):S25-47
12. Bared A, Angeli SI. Malleus handle: determinant of success in ossiculoplasty. Am J Otolaryngol. 2010;31(4): 235-40
13. De Vos C, Gersdorff M, Gerard JM. Prognostic factors in ossiculoplasty. Otol Neurotol. 2007; 28(1):61-7
14. Hornung JA, Brase C, Bozzato A, Zenk J, Iro H. First experience with a new titanium clip stapes prosthesis and a comparison with the earlier model used in stapes surgery. Laryngoscope. 2009;119(12):2421-7
15. Fisch U, May J, Linder T, Naumann IC. A new L-shaped titanium prosthesis for total reconstruction of the ossicular chain. Otol Neurotol. 2004;25(6): 891-902. DOI: 10.1097/00129492- 200411000-00007
16. Beutner D, Luers JC, Huttenbrink KB. Cartilage "shoe": a new technique for stabilization of titanium total ossicular replacement prosthesis at centre of stapes footplate. J Laryngol Otol. 2008;1-5 DOI:10.1017/S0022215108002545
17. Hüttenbrink KB, Zahnert T, Beutner D, Hofmann G. Der Knorpelschuh zur Stabilisierung einer Columella-Prothese auf der Fußplatte. Laryngo-RhinoOtol. 2004;83(7):450-6. DOI: 10.1055/ s-2004-814447

Author

Tashneem Harris MBChB, FCORL, MMed (Otol), *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Prof. Thomas Linder, M.D.
Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.11: Myringoplasty and Tympanoplasty

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Tashneem Harris & Thomas Linder

The goals myringoplasty and tympanoplasty are to achieve a dry, self-cleansing ear while preserving or restoring hearing.

Myringoplasty refers to grafting of the tympanic membrane without inspection of the ossicular chain.

Tympanoplasty entails grafting of the tympanic membrane with inspection of ossicular chain with/without reconstruction of the middle ear hearing mechanism.

Ossiculoplasty is reconstruction of the hearing mechanism using either an autologous graft or prosthesis.

Meatoplasty involves enlargement of the lateral cartilaginous portion of the external auditory canal. A narrow entrance to the ear canal within the cartilaginous portion of the canal prevents proper ventilation and self-cleaning of the ear canal, and may compromise hearing aid fitting.

Canalplasty is partial or total widening of the bony portion of the external ear canal. In order to visualize the tympanic annulus, particularly in anterior or subtotal perforations, canalplasty is essential and may be an integral part of myringoplasty or tympanoplasty.

Preoperative assessment

Otomicroscopy: Both the size and site of the perforation determine the surgical approach

- *Size of perforation*: Is the perforation limited or subtotal? Microperforations may have a higher failure rate than larger perforations
- *Site of perforation*: Does the perforation extend far into the anterosuperior quadrant? Does it only involve the posterior quadrant?
- *What is the status of the middle ear mucosa?* Is it normal or granular/ polypoidal? Is there airflow through the perforation with a Valsalva maneuver?
- *Is the handle of the malleus medialized?* This may necessitate an ossiculoplasty even in the presence of an intact ossicular chain
- *Is an ossiculoplasty required?*
- *Does the ossiculoplasty need to be staged?*
- *What is the status of the contralateral ear?*

Audiometry: This should have been done recently i.e. within the preceding 3 months. Correlate the size of the perforation with the audiogram, particularly the air-bone gap. Lerut, Pfammater & Linder investigated the correlation between air-bone gap and perforation size. There was a strong correlation between air-bone gap and increasing perforation size; however, the location (anterior/posterior) had no impact on hearing. The greatest changes in airbone gap were at 0.5 and 4 kHz, and the smallest changes at 2 kHz. The audiograms thus revealed a consistent “V”-shaped pattern with the turning point at 2 kHz. This can be explained by the fact that 2 kHz is the resonance frequency of the middle ear; thus, hearing is better preserved at this frequency. The clinical significance is that one can predict the expected air-bone gap by looking at the size of the perforation. If the audiogram does not correspond with the expected findings, then additional middle ear pathology must be expected. ***If the air-bone gap is greater than 30 dB, then an ossiculoplasty may be required.***

Tympanometry: Tympanometry provides additional information regarding the patient’s middle ear function; it can also be used to assess eustachian tube dysfunction (see below). The curve is always flat in the presence of a tympanic membrane perforation, but the volume measurements are of interest.

Eustachian tube function: Successful myringoplasty depends on ventilation of the middle ear and mastoid which in turn affects the final position of the reconstructed tympanic membrane.

- ***CT scan***: The best assessment of eustachian tube function is a CT scan of the mastoid; favorable findings are a well-aerated middle ear and a well pneumatized mastoid

- ***Tympanometric volume***: This is a good indicator of eustachian tube function and ventilation of the middle ear in the presence of a tympanic membrane perforation when CT scanning is not available. As a general rule, values for ear canal volume in the presence of an intact tympanic membrane should be approximately 1.5-2.0 mL (adults). With a perforation of the tympanic membrane, the ear canal volume measurement should be high, because the instrument will measure the volume of the entire middle ear space and mastoid in addition to the volume of the ear canal (4-5 mL in adults). If the volume is less than this (e.g. 2.5-3 mL) then ventilation of the middle ear cleft and mastoid must be poor.
- ***Valsalva maneuver***: Absence of a positive Valsalva test i.e. absence of airflow through the perforation on performing a Valsalva maneuver, identifies patients at risk of poorer outcome

Surgical Approaches

Optimal graft take depends on securing the graft; this in turn depends on having sufficient surgical exposure in order to stabilize the graft. ***Three different approaches*** may be used i.e. ***transcanal, endaural or retroauricular***.

Transcanal approach: The ear operation is performed through an ear speculum placed in the external ear canal. Because exposure is one of the limiting factors of the transcanal approach, its use is limited to repairing traumatic perforations or in cases where there is a wide ear canal with a posterior perforation. The ear canal must be wide enough, and one should be able to visualize the entire margins of the perforation; most often this would apply to posterior perforations. The anterior margin of an anterior perforation may be obscured by an overhanging canal wall.

Endaural and retroauricular approaches: These afford better exposure. These two approaches will next be discussed in more detail.

Endaural Approach

The endaural approach entails making an incision between the tragus and helix; the entrance to the ear canal is then stretched open with endaural retractors. It is a good approach to use for posterior perforations. While the view is better than with a transcanal approach, it is ***not suited to anterior perforations***.

Surgical Steps

- Infiltrate the site of the endaural skin incision as well as the ear canal in 4 quadrants with local anesthetic (lidocaine 1% and adrenaline diluted to 1:200 000), using a nasal speculum to expose the ear canal

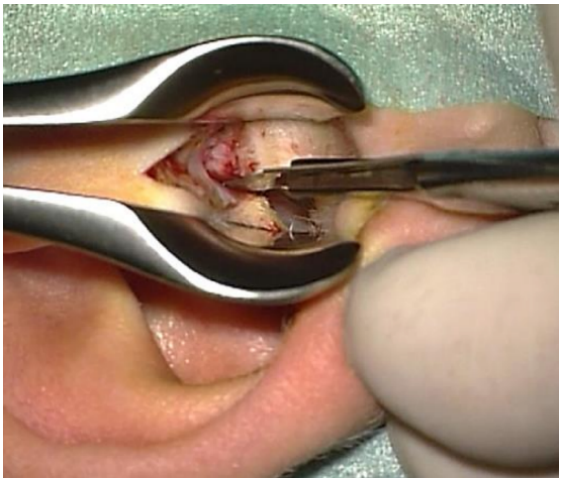


Figure 1: Endaural incision at 12 o'clock in right ear canal

- A skin incision is made in the bony external canal with a #15 blade from the 12 o'clock position, spiraling upwards between the cartilages of the helix of the pinna and tragus (*Figure 1*). The incision is 1.5 cm in length and extends down to the bone
- Hemostasis is achieved using bipolar coagulation

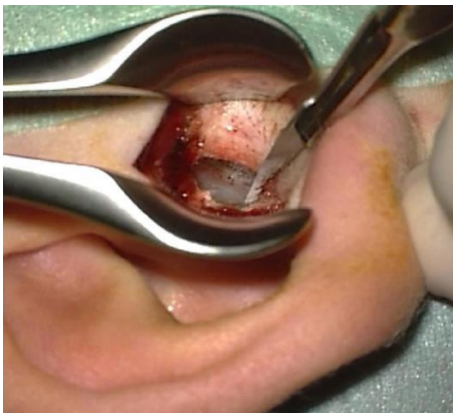


Figure 2: Posterior canal incision that meets endaural incision

- Using a #11 blade, a skin incision is made in the posterior aspect of the bony external canal parallel to the annulus, starting at 8 o'clock (for right ear) and ascending in a spiral fashion to meet the endaural incision at 12 o'clock (*Figure 2*)

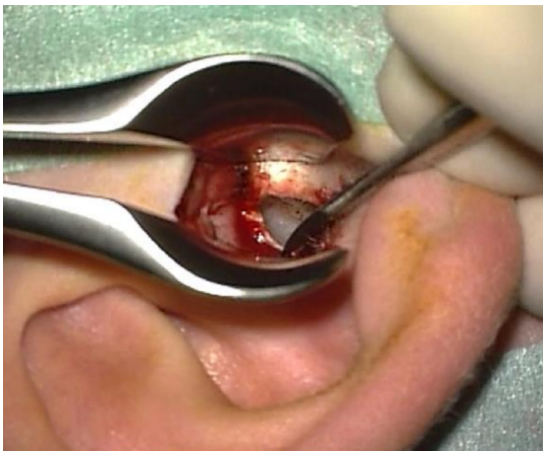


Figure 3: Reflecting canal skin and soft tissue laterally

- A Key raspatory is used to reflect the canal skin and soft tissue laterally and away from the edges of the tympanomeatal flap (*Figure 3*)

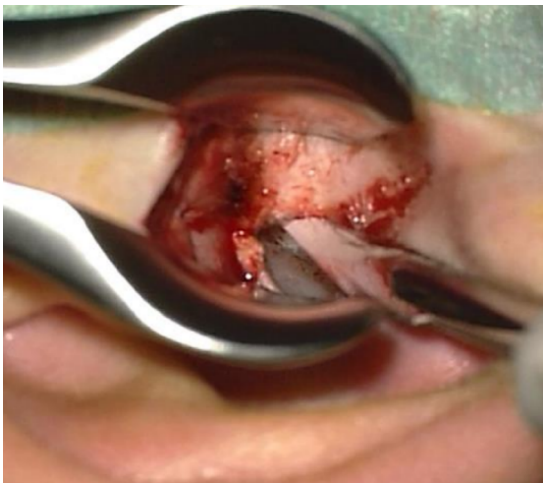


Figure 4: Anterior incision starting at 2 o'clock

- An incision is made anteriorly in the bony canal skin, parallel to the annulus and remaining medial to the cartilage of the ear canal. It starts at 2 o'clock and meets the endaural skin incision at 12 o'clock (*Figure 4*)



Figure 5: Placement of retractors

- Two endaural retractors are next placed in the ear canal to improve exposure (*Figure 5*)
- The edges of the perforation are freshened using a sickle knife before elevating the tympanomeatal flap
- A tympanomeatal flap is elevated using a Fisch microraspatory and adrenaline gauze

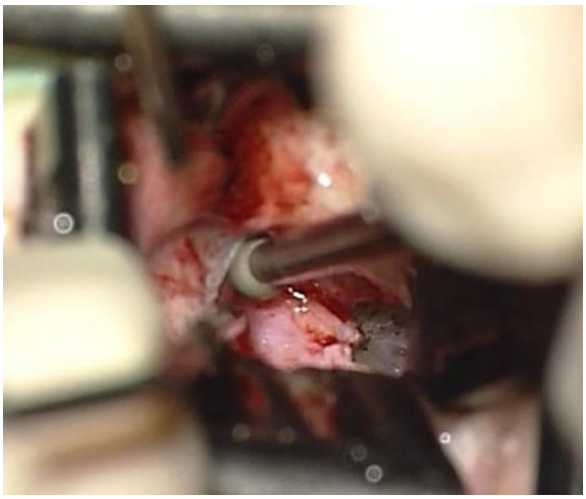


Figure 6: Tympanosquamous suture drilled away

- If a prominent tympanosquamous suture prevents good exposure, then it needs to be drilled away using a 2.7 mm diamond drill (*Figure 6*). To avoid bone dust from entering the ear, place gelfoam soaked in Ringer's lactate into the perforation. Never leave gauze or cotton in the surgical field that can be caught up in the drill bit.



Figure 7: Elevating the tympanomeatal flap

- The middle ear is entered by elevating the tympanomeatal flap at the level of the posterior tympanic spine (*Figure 7*)
- The annulus starts at this level and can be easily dissected free of its sulcus using the microraspatory as a shovel
- Identify and preserve the chorda tympani immediately beneath the tympanic spine at this level

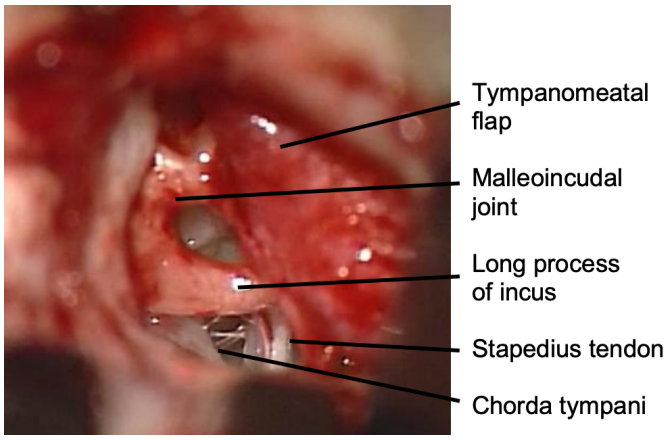


Figure 8: Middle ear structures after curetting posterior tympanic spine

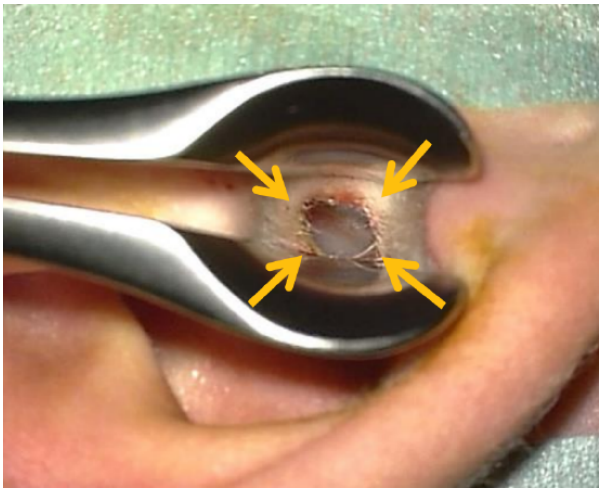
- In order to assess ossicular chain mobility, use the small end of a curette to remove the posterior tympanic spine and bone of the posterior canal wall until the incus, incudostapedial joint, lateral process of the malleus and round window are visible (*Figure 8*)
- Use a 1.5 mm, 45° hook to palpate the malleus and incus. If the ossicular chain is intact, then proceed to graft the perforation
- Tragal perichondrium is generally harvested via the endaural incision and placed as an underlay graft beneath the edges of the perforation. Posteriorly and superiorly it is laid onto the bony canal lateral to the posterior tympanic sulcus. Temporalis fascia may also be harvested via the endaural incision or through a separate postauricular incision and used as a graft
- The tympanomeatal flap is returned to its original position and gelfoam pledgets are placed over the graft to secure it over the posterior tympanic sulcus
- The endaural skin incision is closed with 3/0 Nylon sutures

Retroauricular Approach

A retroauricular incision is made close to the hairline with soft tissue and pinna reflected anteriorly. It is favored for anterior perforations. It allows one to do a circumferential canalplasty in cases where there is a significant anterior bony overhang.

Surgical Steps

- Using local anesthetic (lidocaine 1% and adrenaline diluted to 1:200 000), infiltrate the post-auricular sulcus. Then advance the needle and infiltrate the tissues anteroinferiorly and anterosuperiorly


Figure 9: Points of injecting ear canal

- Using a Lempert's speculum to visualize the bony-cartilaginous junction of the ear canal, inject the 4 quadrants of the skin of the ear canal (*Figure 9*)
- A postauricular incision is made about 2 cm behind the retroauricular sulcus extending from the upper border of the pinna to the level of the mastoid tip. Light crosshatchings are made with a scalpel before incising the skin, to facilitate aligning the skin when closing the wound

- Use a large rake retractor to reflect the pinna anteriorly with the left hand while developing a tissue plane anteriorly toward the external ear canal, using a scalpel with a #10 blade
- The scrub nurse or assistant uses a large suction tube to clear excess blood so that no time is lost trying to achieve hemostasis while elevating the skin

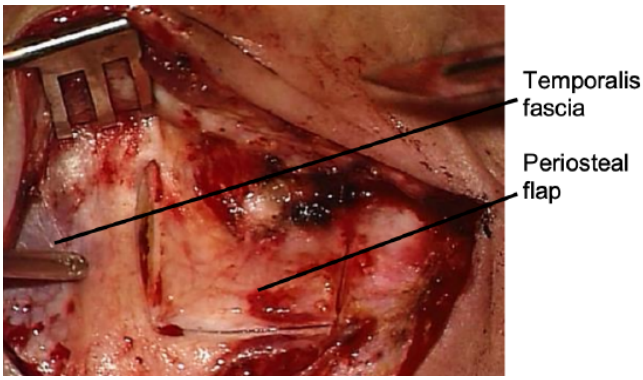


Figure 10: Temporalis fascia and retroauricular periosteal flap

- As the flap is developed the posterior auricular muscle is encountered. This is transected in order to get into the correct surgical plane. Superiorly, the temporalis fascia comes into view (*Figure 10*)
- A retroauricular periosteal flap is now developed which is anteriorly based. The vertical incision is made approximately 1.5 cm from the ear canal (*Figure 10*). Using a #10 blade, the superior incision is extended anteriorly along the linea temporalis up to 12 0’ clock relative to the bony ear canal. The inferior incision is extended to the inferior border of the ear canal
- The periosteal flap is elevated from the bone with a mastoid raspatory until both the Spine of Henlé and the bony external canal up to the 12 o’clock position, are exposed

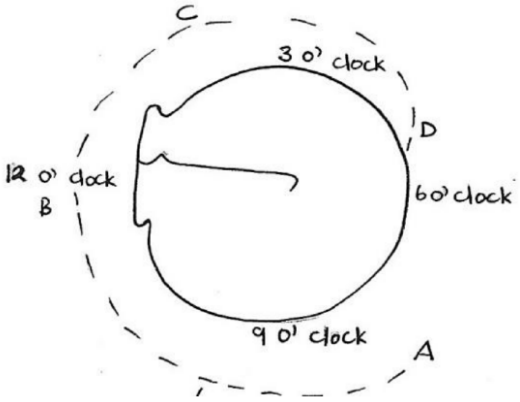


Figure 11: Incisions for spiral flap technique

The next step is to raise a meatal skin flap. The authors favor a ***spiral flap technique***, which should be practiced in the temporal bone laboratory and will next be described (*Figure 11*).

- Elevate the periosteal flap up to about 2 mm deep to the lateral edge of the bony external ear canal

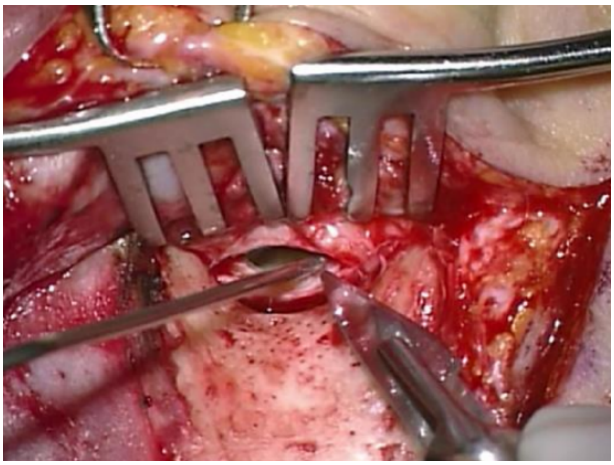


Figure 12: Incising posterior ear canal

- Using a #11 blade, enter the ear canal via a transverse incision in the posterior ear canal skin at about 8 o'clock (right ear). The lumen of the ear canal is then visible through the incision (*Figure 12*)

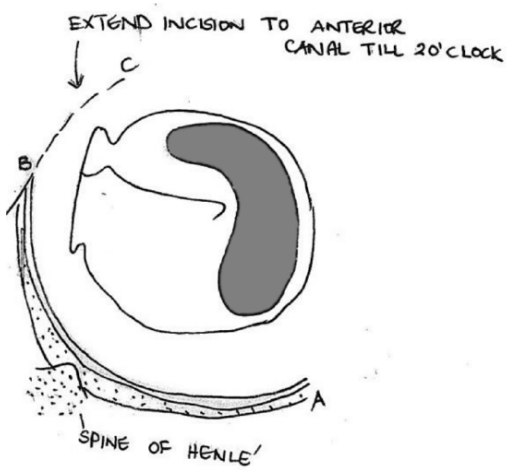


Figure 13: Posterior incision extended as spiral incision to anterior canal wall

- Cut with the scalpel in a cephalad direction and extend the incision superiorly up to 12 o'clock. It is important that the blade remains on the bone. The first incision now extends from A - B (*Figures 11, 13*)

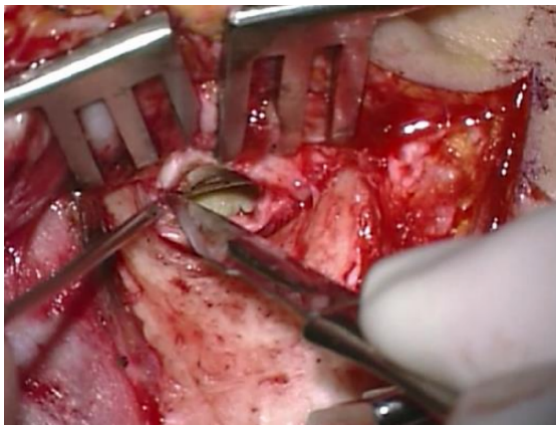


Figure 14: Incising anterior ear canal

- An incision is now made from C - B in the skin of the anterior wall of the ear canal starting at 2 o'clock and extended superiorly to meet the previous incision at 12 o'clock (*Figure 13, 14*). This incision runs lateral to the tympanosquamous suture line and also has to remain on bone and medial to tragal cartilage; if the incision is placed too laterally then the tragal cartilage will be injured

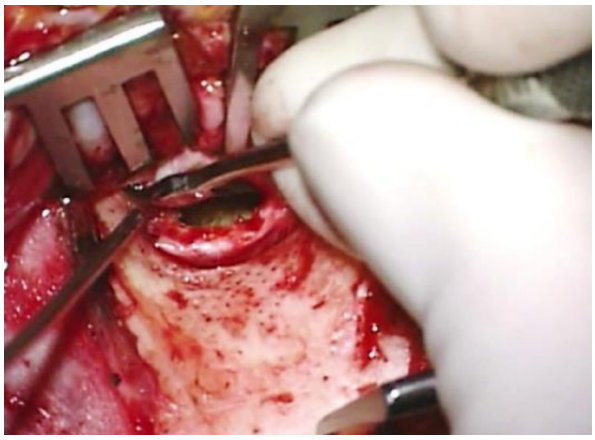


Figure 15: Elevating skin from bone

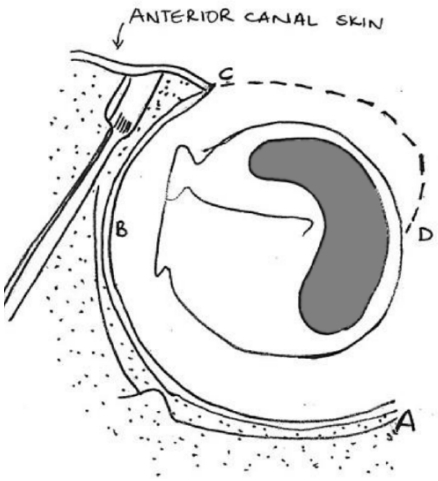


Figure 16: Completing incision in anterior canal wall

- Use a Key raspatory to elevate the lateral canal skin from the underlying bone (*Figure 15, 16*)
- Attach a sharp towel clip to the periosteal flap at the level of the canal to reflect the pinna and soft tissue forward
- Two self-retaining retractors are placed superiorly and inferiorly and used to reflect the soft tissue and improve exposure. In children, one retractor is sufficient
- The meatal skin is now further incised anteroinferiorly from D to C, starting close to the tympanic membrane at about 5 o'clock (*Figure 16*). The incision spirals laterally and superiorly along the anterior canal wall to meet the earlier incision made in the anterior canal at 2 o'clock (right ear)
- A common mistake when doing this flap for the first time is not incising the skin fully onto the bone and this causes the flap to tear when elevating it with the microraspatory; it is therefore important that the blade stays hard on bone when making the canal incisions



Figure 17: Fisch microraspatory used to elevate meatal skin off bone

- The meatal skin flap is circumferentially elevated from the underlying bone with a Fisch microraspatory (*Figure 17*)

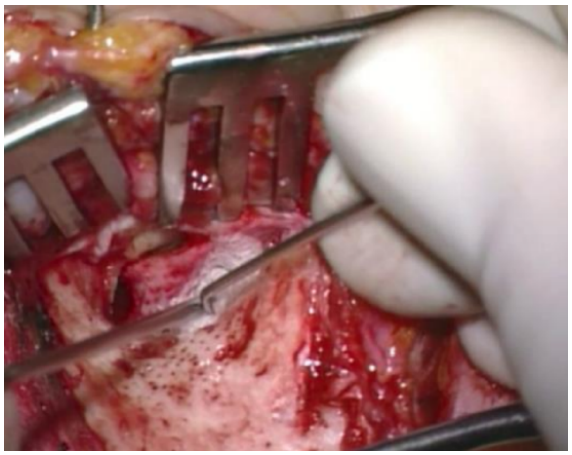


Figure 18: Elevating meatal skin

- To keep this dissection blood-free and to avoid injuring the skin flap, adrenaline-soaked gauze is placed between the Fisch microraspatory and the meatal skin. Suction is never directly applied to the meatal skin flap; rather the excess blood is suctioned through the adrenaline-soaked gauze. The blade of the Fisch microraspatory stays vertical to the bone and the shoulder of the instrument is used to push against the adrenaline gauze which then atraumatically elevates the very fragile meatal skin (*Figures 17, 18*)
- The meatal skin is elevated until the posterosuperior margin of the tympanic membrane and the anteroinferior overhang of bone are exposed
- At the tympanosquamous suture line (located posterosuperiorly) the skin flap is very tightly bound to the underlying bone and may be dissected free using the following technique: Using the raspatory like a shovel, free the skin flap posterior to the suture. Then elevate the flap anterior to the suture.
- After freeing the flap posteriorly and then anteriorly, there may still be a remaining bridge of soft tissue connections to the suture which is cut with Bellucci scissors

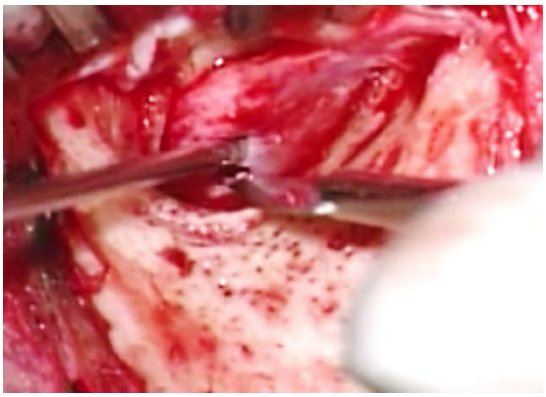


Figure 19: Incising posterior limb of meatal skin flap 2 mm lateral to annulus

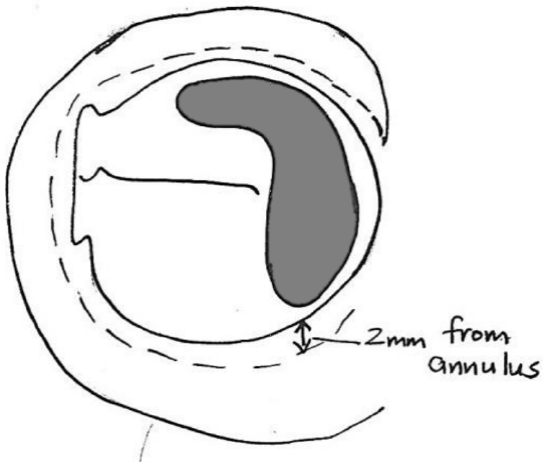


Figure 20: Incise posterior limb of meatal skin flap 2 mm lateral to and parallel to the annulus

- Using a #11 blade incise the posterior limb of the meatal skin flap 2 mm lateral and parallel to the annulus (*Figures 19, 20*)

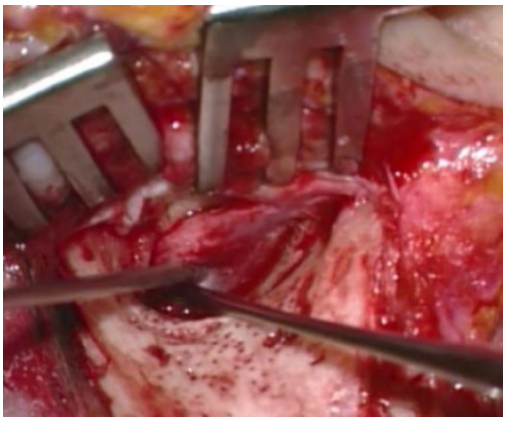


Figure 21: Extending incision anteriorly, remaining 2 mm lateral to and parallel to annulus

- Bellucci scissors are then used to continue incising the meatal skin flap 2 mm lateral to and parallel to the annulus until the anterior part of the flap is reached (*Figures 20, 21*)
- Transect the remaining meatal skin to 6 o'clock, 2 mm lateral to the annulus, using an Iowa raspatory or a round knife (*Figure 21*)

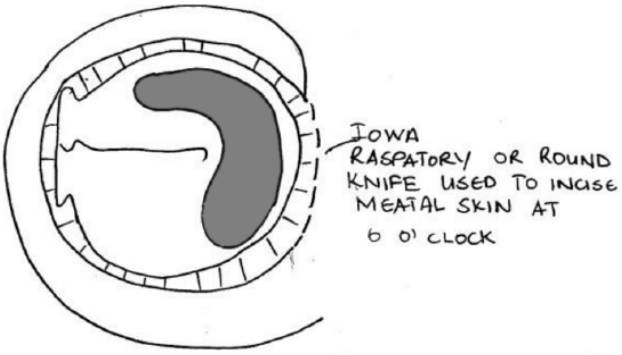


Figure 22: Transect remaining meatal skin to 6 o'clock, 2 mm lateral to the annulus

- Using the larger (Iowa) raspatory the meatal skin lateral to this circumferential incision is dissected free from the bony canal. Using a bigger instrument avoid injuring the inferiorly based pedicle (*Figure 22*)

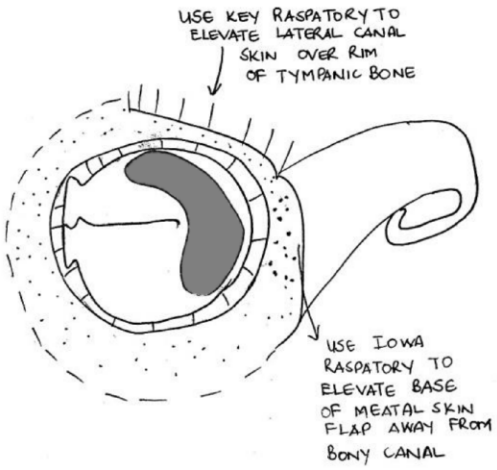


Figure 23: Flap pedicled inferiorly and elevated from canal wall

- Elevate the lateral aspect of the anterior meatal skin flap with a Key raspatory and using two hands, advance the raspatory over the lateral rim of the tympanic bone (*Figure 23*)

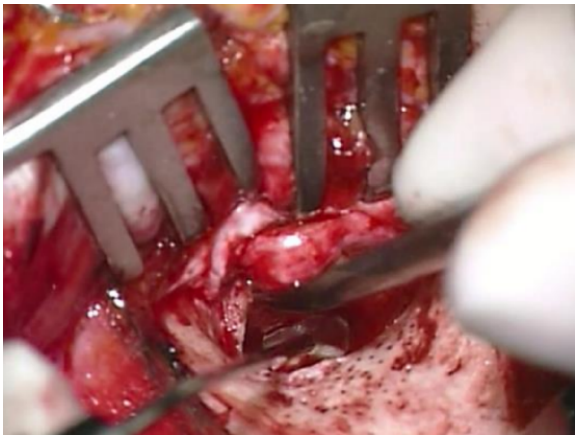


Figure 24: Soft tissue is elevated out of the bony external canal

- Once the lateral edge of the tympanic bone is reached, keep the tip of the instrument in contact with the bone and underlying tissue but swing the handle of the Key raspatory anteriorly so that the soft tissue is elevated out of the bony external canal, leaving it pedicled inferiorly (*Figures 23, 24*)

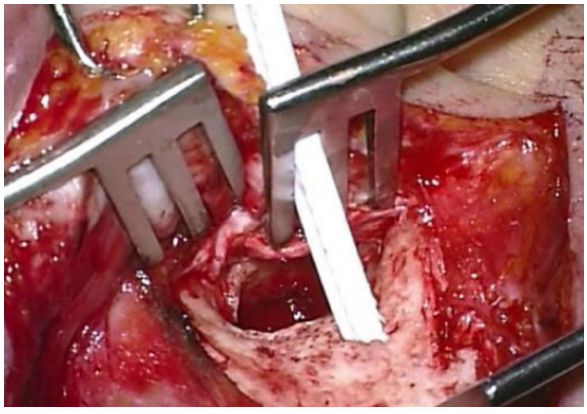


Figure 25: Ribbon passed through teeth of self-retaining retractor

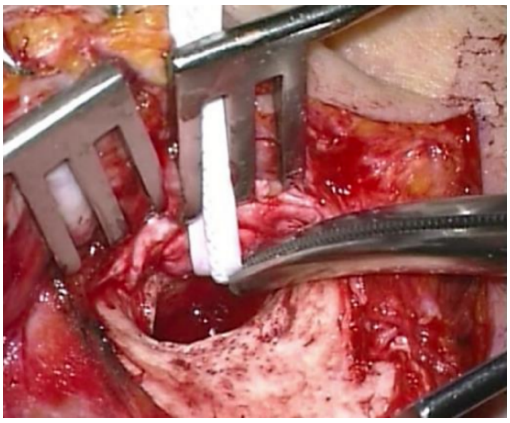


Figure 26: Ribbon passed around meatal spiral flap

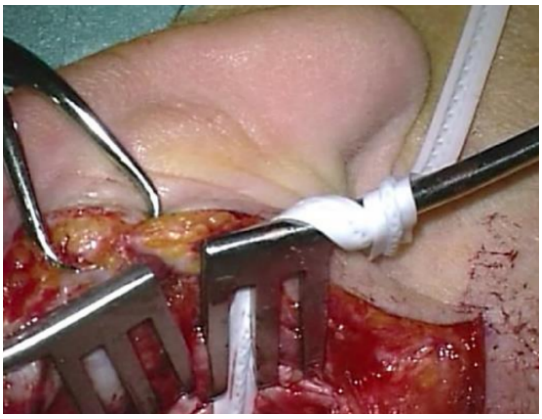


Figure 27: Ribbon secured to selfretaining retractor

- The spiral of elevated meatal skin is kept out of the surgical field by using the aluminum strip or ribbon of the surgeon's mask which has been sterilized. First, the ribbon is passed through the teeth of the self-retaining retractor (*Figure 25*). Then artery forceps are used to place it against or pass it around the meatal skin flap (*Figure 26*). The ribbon is then folded back over the top of the retractor (*Figure 27*)

Canalplasty

It is imperative to have an adequate view of the annulus as well as all the edges of the perforation to do an adequate myringoplasty or tympanoplasty operation. With perforations only involving the posterior quadrant where the entire margin of the perforation is visible, performing a canalplasty is unnecessary. However, there is often a bony overhang anteriorly and/or posteriorly which restricts the surgeon's view. If the perforation extends to involve the anterior quadrant then it is necessary to do a canalplasty.

Surgical steps

- Standard retroauricular approach
- Elevate meatal spiral flap
- If there is a tympanic membrane perforation, gelfoam soaked in Ringer's Lactate is placed over the perforation to avoid bone dust entering the middle ear
- Starting with a 2.7 mm rough diamond burr, enlarge the ear canal by drilling away any bony overhang
- Commence drilling posteriorly, then move inferiorly and finally drill the anterior canal wall
- The technique of skeletonization is important. With the correct technique the bluish color of the temporomandibular joint (TMJ) will show through the irrigation; this should alert one to stop drilling before the joint is entered
- It is important to check that burr sizes are correct by first placing a new burr in the canal before using it
- Always ***drill under direct vision*** and never behind overhanging edges of bone. In this way one avoids opening mastoid air cells or injuring the facial nerve posteriorly and TMJ anteriorly

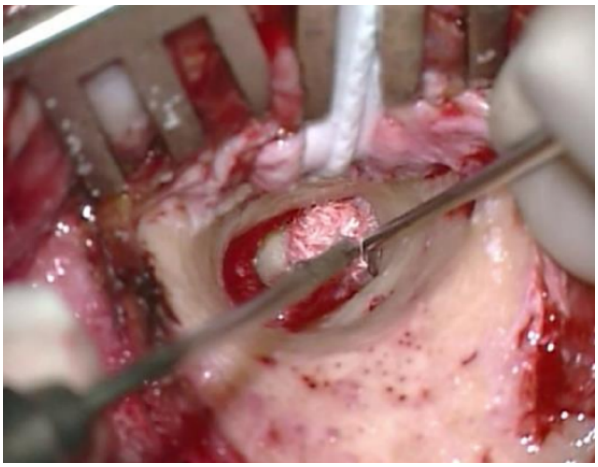


Figure 28: Microraspatory used to elevate meatal skin using adrenaline-soaked gauze

- Use the Fisch microraspatory (with adrenaline gauze) to elevate the meatal skin before drilling away bony overhangs (*Figure 28*)
- When drilling close to meatal skin, a diamond burr is used so that the meatal skin is not injured by the burr

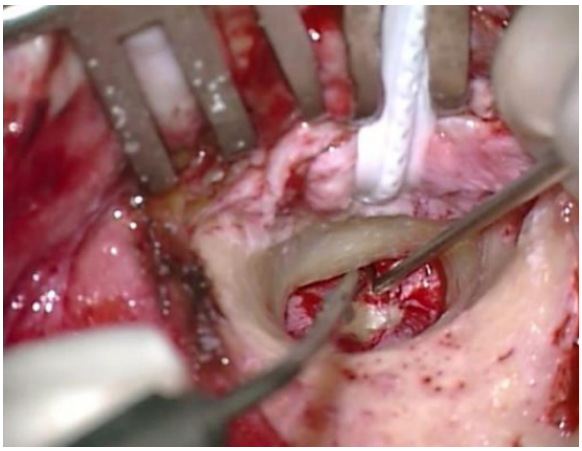


Figure 29: Tip of microraspatory used to determine how much bone needs to be removed lateral to annulus

- The microraspatory is held perpendicularly to the bone at the level of the annulus; the tip of the microraspatory is not visible because of the anterior bony overhang. Using this technique, one can determine how much bone needs to be removed before reaching the annulus (*Figure 29*)

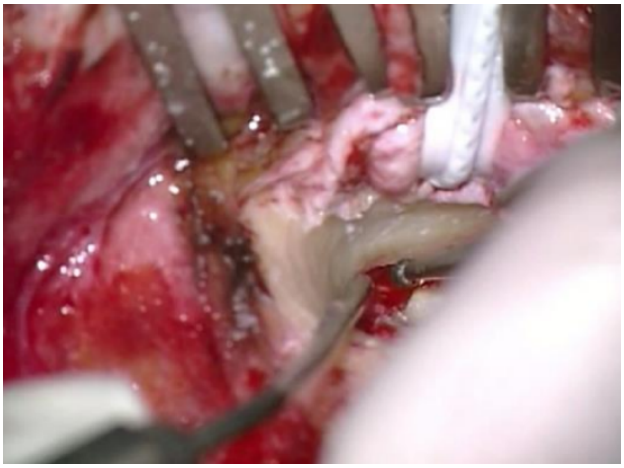


Figure 30: Bony overhang drilled away using a small diamond burr

- This bony overhang is then drilled away, using a small diamond burr (*Figure 30*)

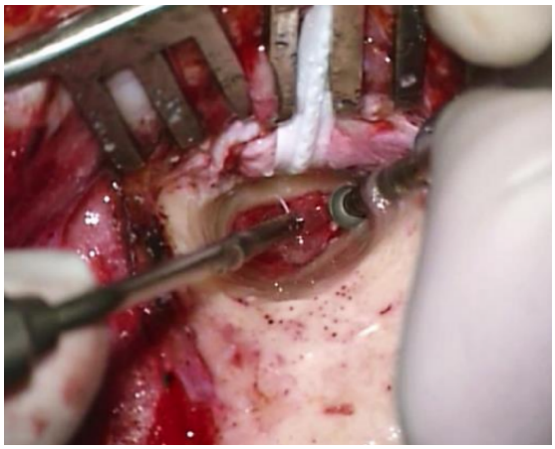


Figure 31: Inferior trough technique

- The ***inferior trough technique*** allows the surgeon to gauge the depth of the annulus: using a diamond burr, drill at 6 o'clock from medially to laterally to create a groove. Continue to drill until the white color of the annulus becomes visible at the level of the sulcus (*Figure 31*)
- Now continue to expand the drilling from the groove outwards and circumferentially

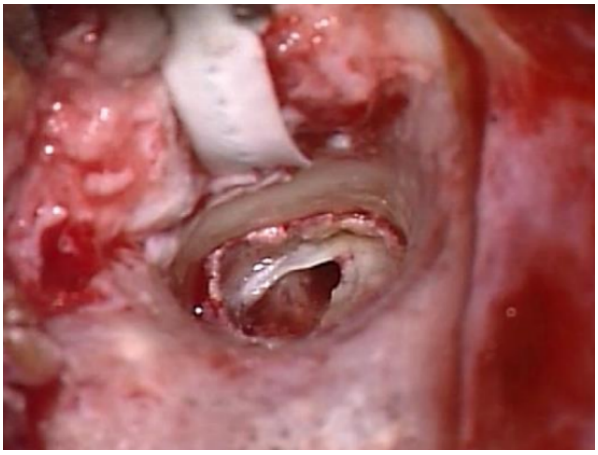


Figure 32: Completed canalplasty with entire annulus visible and no bony overhang

- Once the canalplasty has been completed the ***entire annulus should be visible with one view of the microscope*** and no bony overhang should remain (*Figure 32*)

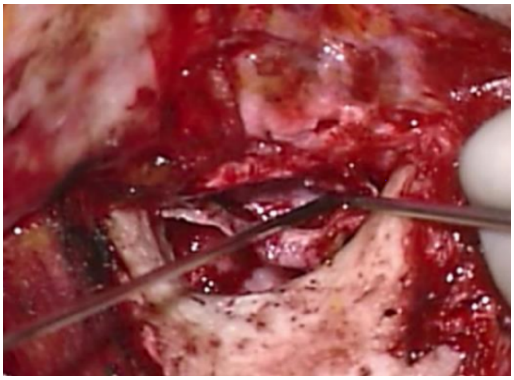


Figure 33: Meatal skin flap being replaced

- Following grafting of the tympanic membrane perforation (see later) the meatal skin flap is replaced (*Figure 33*)



Figure 34: Ivalon®

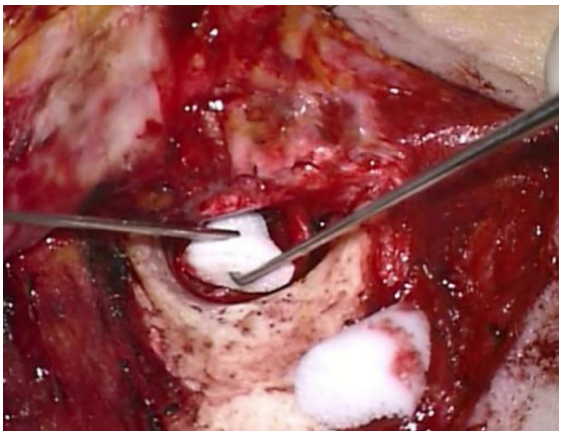


Figure 35: Ivalon® used to secure the meatal skin

- The meatal skin is secured with gelfoam pledgets placed medially over the graft. Two pieces are cut from an Ivalon® ear wick and inserted laterally into the ear canal over the meatal flap (*Figures 34*, *35*). Ivalon® has a smooth surface which is placed on the outside (facing the meatal skin) to allow for atraumatic removal one week postoperatively

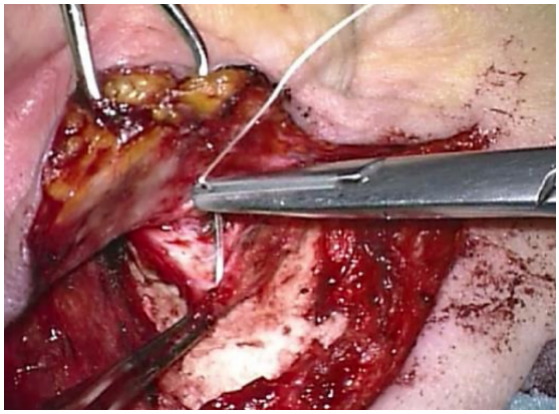


Figure 36: Securing the retroauricular periosteal flap

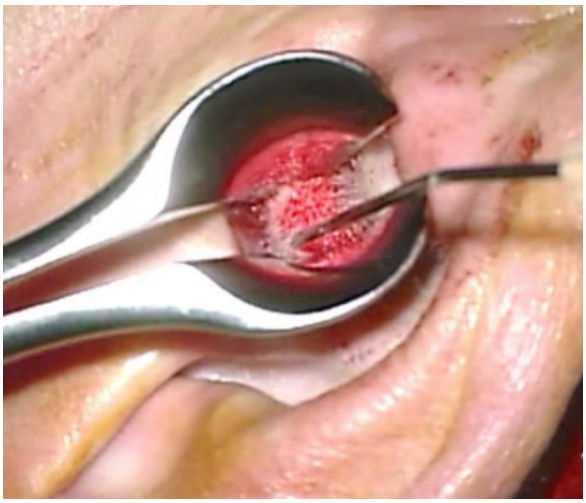


Figure 37: Checking correct placement of meatal skin

- The postauricular periosteal flap is replaced and secured with 3/0 Vicryl sutures (*Figure 36*)
- Ensure that the skin of the meatal flap is applied to the bony canal and extends lateral to the Ivalon® ear wick (*Figure 37*)

Antrotomy

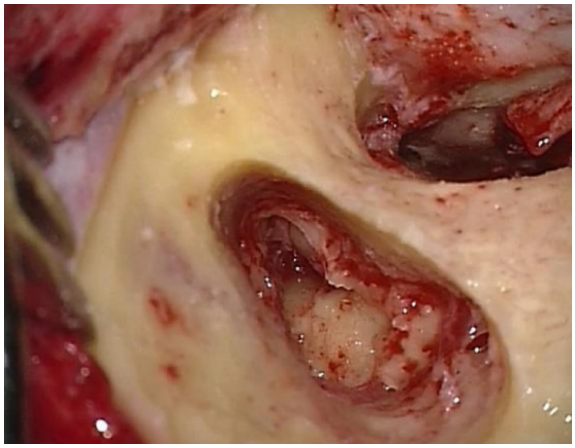


Figure 38: Antrotomy defect

An antrotomy is performed in conjunction with a myringo- or tympanoplasty when eustachian tube function is questionable or in the presence of polypoidal middle ear mucosa obstructing the epitympanum (*Figure 38*).

The detailed surgical steps for antrotomy are presented in the chapter on Mastoidectomy and epitympanectomy

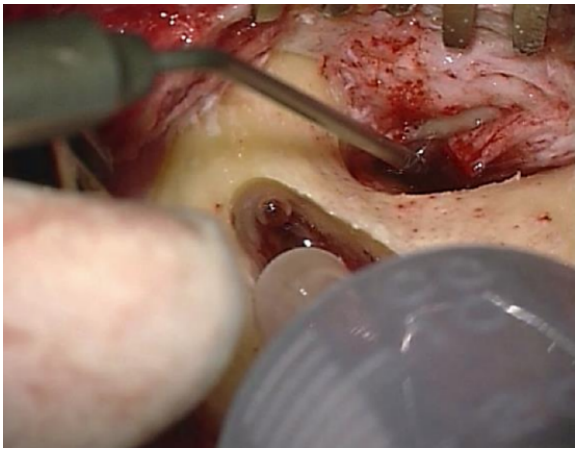


Figure 39: Antrum irrigated with Ringer's solution

Epitympanic patency is determined by means of the water test: Ringer's solution is irrigated into the antrum to test whether there is free communication between the antrum and the middle ear (*Figure 39*)

- If the test is ***positive***, there is no need to further explore the epitympanum
- If the test is ***negative***, then one needs to explore the epitympanum
- If abnormal mucosa is removed from the epitympanum but the ossicles are left intact, this is defined as an ***epitympanotomy***.
- If malleus head and incus need to be removed to re-establish patency, this is referred to as an ***epitympanectomy***
- Following the procedure, a groove is drilled posteriorly into the mastoid bone to accommodate a transmastoid drain
- A separate stab incision is made posterior to the retroauricular skin incision and the drain is fixed to the skin using a silk suture
- The patient may perform Valsalva maneuvers from the 2nd day following surgery
- The mastoid drain is usually removed after 2-4 days

Grafting tympanic membrane perforations

Choice of graft material

- ***Temporalis fascia*** is widely used to reconstruct the tympanic membrane. It is easily accessible and long-term results are comparable to that of cartilage tympanoplasty. An advantage of temporalis fascia is that recurrent or residual cholesteatoma can easily be identified behind the reconstructed tympanic membrane
- ***Tragal perichondrium***
- ***Cartilage*** is preferred in certain instances due to its resilience: it may be used to reinforce an atrophic tympanic membrane; it is used in addition to fascia in a closed mastoidoepitympanectomy to reconstruct the posterior canal wall; and certain middle ear prostheses require reinforcement of the overlying tympanic membrane to prevent extrusion through tympanic membrane

Harvesting temporalis fascia

Temporalis fascia consists of a superficial and a deep layer. The deep layer is used for grafting because it is thicker and more resilient. The fascia is easily harvested from the retro-auricular region if a retroauricular approach has been used via the same incision. It is preferable to harvest the fascia at the end of the procedure once the surgeon knows how much fascia is required.

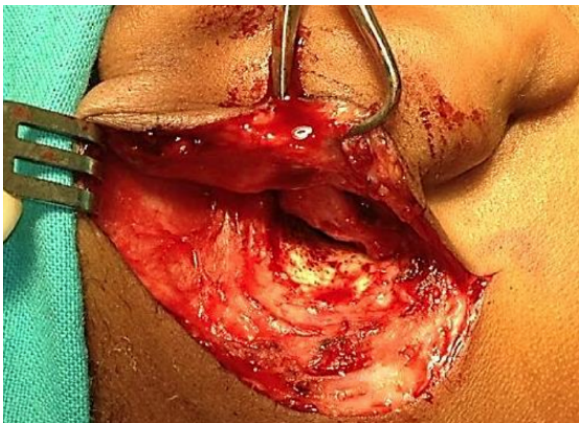


Figure 40: Exposing temporalis fascia

- An assistant exposes the fascia by superiorly retracting skin and soft tissue with a rake retractor (*Figure 40*)
- The superficial layer of fascia is divided and separated from the deep layer with tympanoplasty scissors

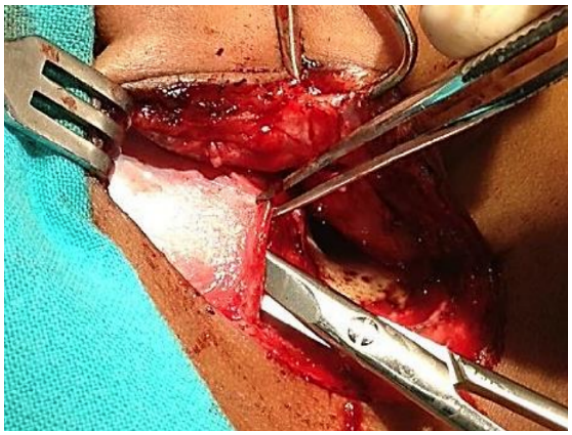


Figure 41: Undermining deeper layer of temporalis fascia

- A transverse incision is made in the deep layer of fascia parallel to linea temporalis with a #11 blade. The undersurface of the fascia is undermined through this incision and separated from the temporalis muscle with scissors (*Figure 41*)
- Harvest the appropriate amount of fascia with scissors taking only as much as is needed so that should the patient require revision surgery, additional fascia can be harvested
- The fascial graft is compressed between two gauze swabs, but not dried

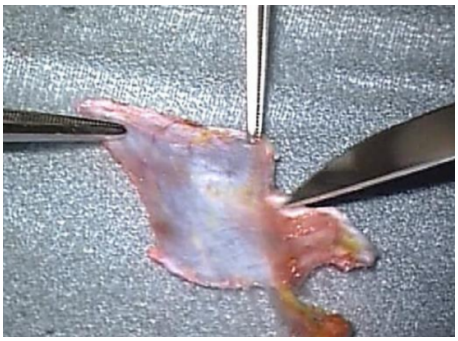


Figure 42: Scraping muscle off fascia

- The graft is then placed on a silicone block. The scrub nurse holds one corner of the graft, while the surgeon holds the other corner with anatomical forceps, and using a #10 blade, the graft is scraped clean of muscle fibers (*Figure 42*)
- Uneven edges are trimmed with a #10 blade

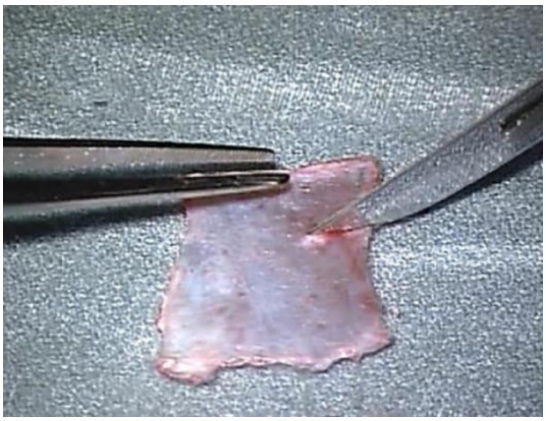


Figure 43: Incision to accommodate tensor tympani tendon

- An incision is made in the flap with a knife to accommodate the tensor tympani tendon at the anticipated location of the malleus handle (*Figure 43*)

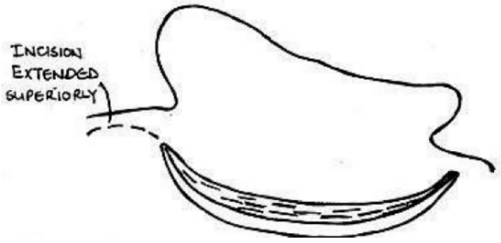


Figure 44: Extended postauricular incision for additional temporalis fascia

- When doing revision surgery, it is possible to extend the postauricular incision superiorly in order to find additional temporalis fascia (*Figure 44*)

Harvesting tragal cartilage and tragal perichondrium

Tragal cartilage is easily harvested by exposing the upper end of the tragal cartilage through an endaural approach.

- Hold the tragal cartilage with surgical forceps while dissecting the soft tissue off the cartilage with tympanoplasty scissors
- After exposing the amount of cartilage required for reconstruction, resect cartilage with overlying perichondrium with tympanoplasty scissors
- Using the operating microscope strip the tragal perichondrium from the cartilage with a microraspatory. The perichondrium may also be left attached to the tragal cartilage when reconstructing the posterosuperior canal wall
- To thin cartilage, hold it with Hudson Brown forceps and section the cartilage with a new #10 blade

Grafting Techniques

The authors use the terms "***underlay***" and "***overlay***" to refer to position of the graft relative to the bony (annular) sulcus. (In other texts it may refer to the position of the graft in relation to the tympanic membrane)

- With ***underlay technique*** the graft is placed medial to the remnant of the tympanic membrane and anterior tympanic sulcus
- With ***overlay technique*** the graft is placed lateral to the tympanic sulcus

Underlay technique is most often used for perforations involving the anterior quadrant. The graft is always placed medial to the malleus handle. Larger perforations often require a combination of anterior underlay ***and*** posterior/inferior overlay grafting technique.

Grafting limited perforations of the posterior quadrant (Figure 45)

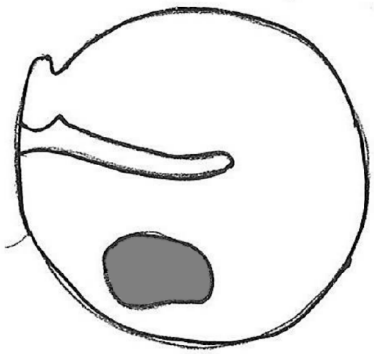


Figure 45

These surgical steps are discussed in detail under ***endaural approach***.

Grafting perforations that reach the anterior quadrant (Figure 46)

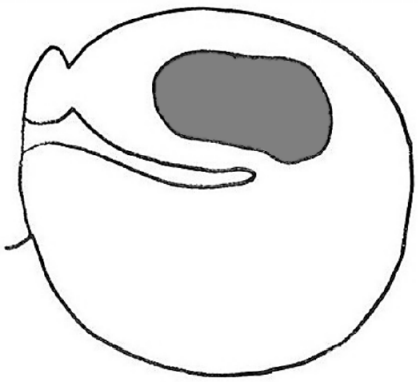


Figure 46

- Retroauricular approach is used
- Canalplasty is done
- The ***annulus is not elevated between 2 and 4 o'clock*** (right side) as this will cause blunting of the anterior tympanomeatal angle and lateralization of the tympanic membrane resulting in reduction of vibratory properties of the tympanic membrane

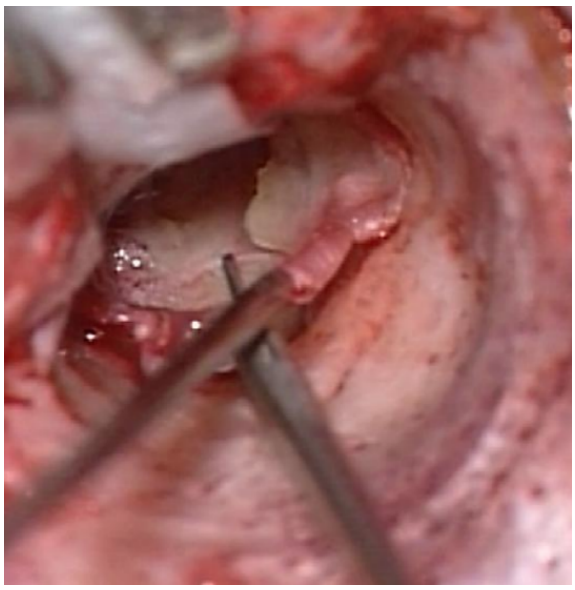


Figure 47: Dividing the tympanomeatal flap posteriorly

- If the perforation involves the anteroinferior quadrant then the tympanomeatal flap is divided posteriorly after it has been elevated (*Figure 47*)
- Scrape the undersurface of the tympanic membrane remnant with a 1.5 mm, 45° hook
- Anteriorly, the graft is underlaid under the edge of the tympanic remnant
- If the perforation extends inferiorly or posteriorly then the graft is underlaid anteriorly but overlaid posteriorly in the inferior or posterior quadrants

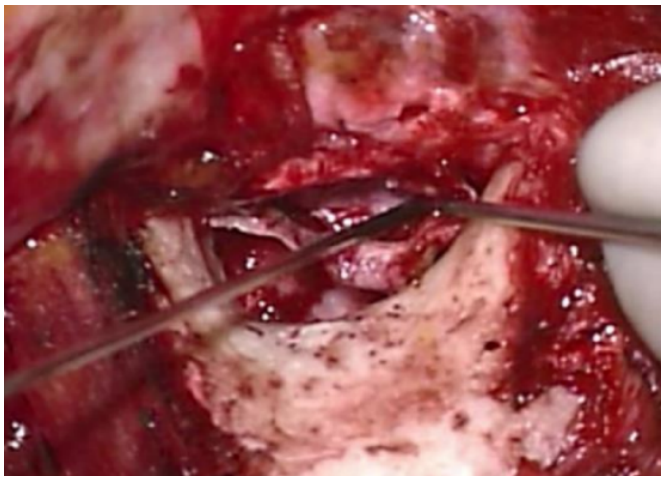


Figure 48: Meatal skin flap is being replaced

- The meatal skin flap is replaced (*Figure 48*)
- The fascia and meatal skin flap are secured with Gelfoam

Grafting perforations that reach the anterosuperior quadrant (Figure 49)

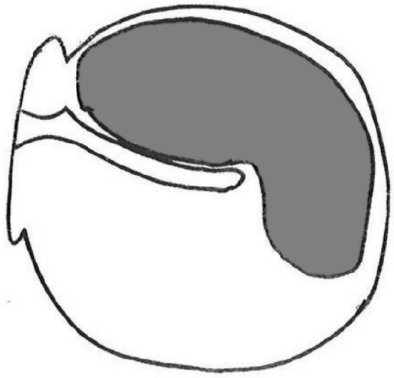


Figure 49

- Retroauricular approach is used
- Canalplasty is done
- Elevate and divide the tympanomeatal flap posteriorly (*Figure 47*)
- Scrape the undersurface of the tympanic membrane remnant with a 1.5 mm, 45° hook
- *Fixing the graft anteriorly requires special anterior support*

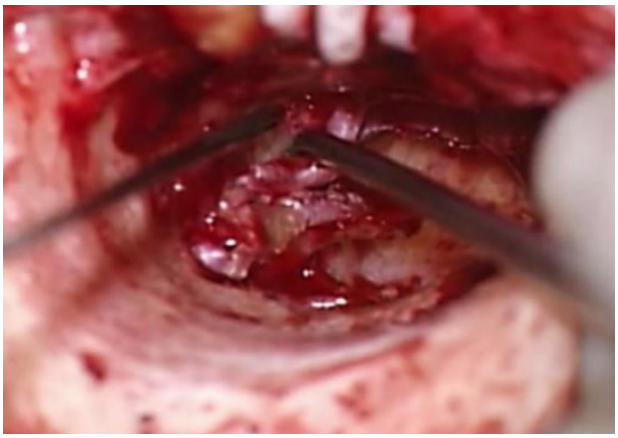


Figure 50: Detach tympanic annulus between 1 and 2 o'clock to create "buttonhole" anteriorly

- Detach the tympanic annulus between 1 and 2 o'clock (right ear) using a microraspatory to create a "buttonhole" anteriorly between annular ligament and bone (*Figure 50*)

- The facial graft is placed medial to the malleus
- A small “tongue” of the graft is maneuvered with a 1.5 mm 45° hook, to as close as possible to the “buttonhole”

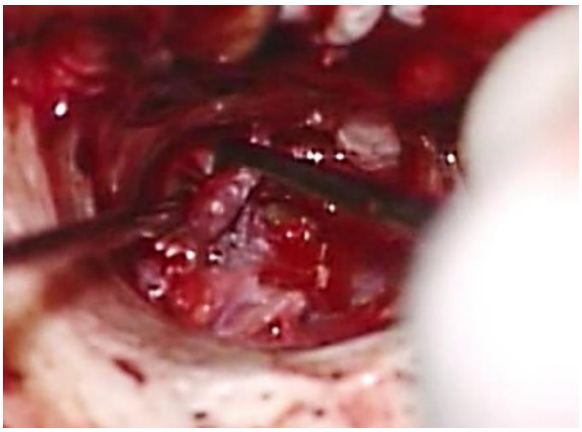


Figure 51: Use a microsuction tube to suck and pull “tongue” of temporalis fascia through “buttonhole”

- Use a microsuction tube to suck and pull the “tongue” of temporalis fascia through the “buttonhole” and then use a 1.5 mm hook to advance the graft into position (*Figure 51*)

Grafting subtotal perforations (Figure 52)

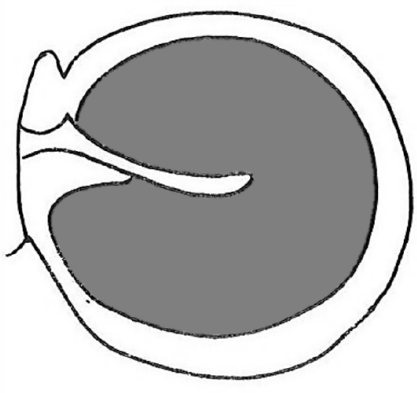


Figure 52

- Retroauricular approach is used
- Canalplasty is done
- Elevate and divide the tympanomeatal flap posteriorly (*Figure 36*)
- Subtotal perforations may only have a limited remnant of the tympanic membrane anteriorly
- Scrape the undersurface of the tympanic membrane remnant and adjacent bone with a 1.5mm, 45° hook
- The graft is underlaid both under the tympanic membrane and malleus handle

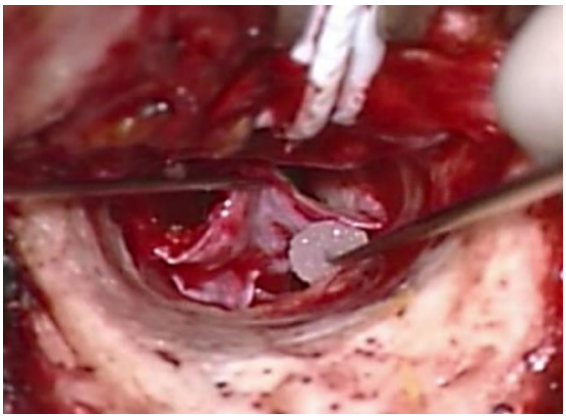


Figure 53: Graft supported anteriorly by Gelfoam soaked in Ringer’s lactate

- The graft is supported anteriorly by placing small pieces of Gelfoam soaked in Ringer's lactate beneath the graft (*Figure 53*)
- Superiorly both limbs of the fascia overlap just above the neck of the malleus (*Figure 43*)
- Posteriorly and inferiorly, the graft is positioned as an overlay graft

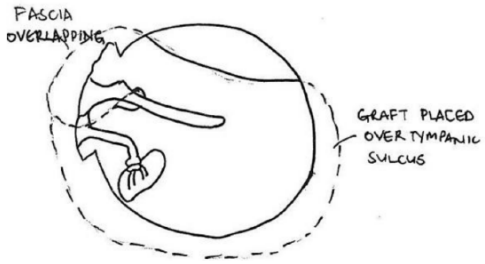


Figure 54: Fascia overlaps just above neck of malleus

- Gelfoam is then placed laterally over the graft to secure it in place over the tympanic sulcus (*Figure 55*)

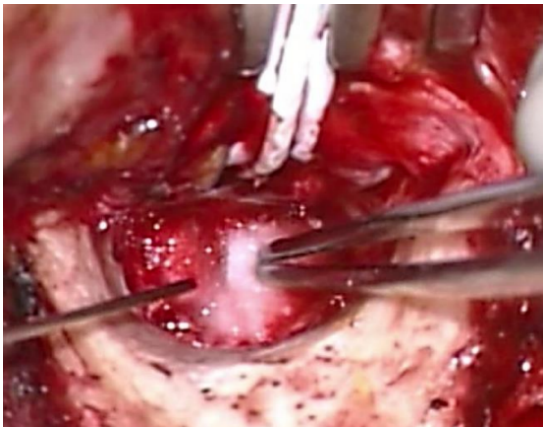


Figure 55: Gelfoam placed laterally to secure graft

Management of severely retracted malleus with chronic otitis media with

Occasionally patients with longstanding chronic otitis media do not develop erosion of the incus, but the malleus handle becomes medialized. In severe cases the umbo of the malleus touches or even attaches to the promontory. This presents a challenge insofar as that the tympanic membrane perforation needs to be reconstructed and at the same time the hearing needs to be improved. If fascia is placed as an underlay graft it will result in Grade 4 atelectasis and may subsequently reperforate. ***Lateralization of the malleus*** is easily achieved once the incus has been removed. The following is an effective technique to manage a severely retracted malleus:

- The malleus head and anterior mallear ligament are removed leaving the tensor tympani tendon intact
- An incus interposition is then done
- The perforation is grafted with fascia or cartilage by underlay technique
- Because the malleus has been lateralized it facilitates placement of the graft in the proper position

Reconstruction with closed mastoidoepitympanectomy

See the mastoidoepitympanectomy chapter for a description of reconstruction at the time of primary surgery

- The defect is often located superiorly in the epitympanum
- Cartilage is used to reconstruct the defect in the epitympanum

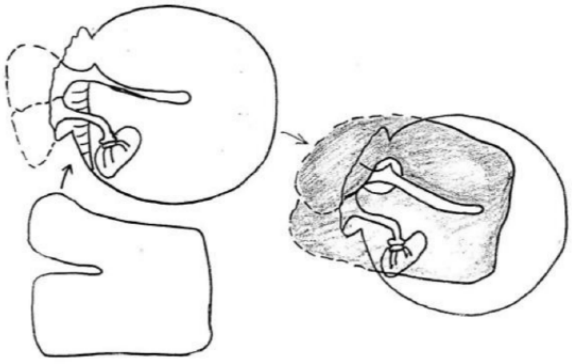


Figure 56: Temporalis fascia placed beneath handle of malleus so that two tongues of fascia overlap

- Temporalis fascia is placed beneath the handle of the malleus so that the two tongues of the fascia overlap each other in the epitympanum (*Figure 56*)

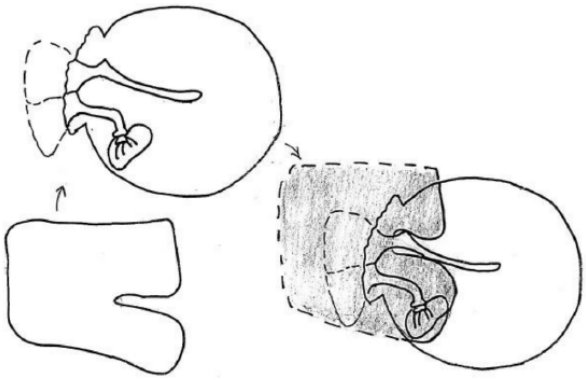


Figure 57: Two tongues overlap in middle ear beneath malleus handle

- An alternative technique is to position the graft such that the two tongues are positioned around the malleus and overlap each other in the middle ear beneath the malleus handle (*Figure 57*)

Reconstruction with open mastoidoepitympanectomy

See the Mastoidectomy and epitympanectomy chapter for a description of reconstruction at the time of primary surgery

- A circumferential tympanic groove is drilled with a small diamond burr to form a new tympanic sulcus
- The graft is placed as with repair of a subtotal perforation
- If a 2nd stage ossiculoplasty is planned, then it becomes necessary to place silastic sheeting in the middle ear and protympanum

Ossiculoplasty

Ossiculoplasty is defined as reconstruction of the hearing mechanism by establishing a connection between the tympanic membrane and the oval window. It is covered in detail in the chapter "Ossiculoplasty."

References

1. Fisch U, May J, Linder T. Tympanoplasty, Mastoidectomy, and Stapes Surgery. New York: Thieme; 2008
2. Lerut B, Pfammatter A, Moons J, Linder T. Functional Correlations of Tympanic Membrane Perforation Size. Otol Neurotol. 2012; 33:379-86
3. Hol KS, Nguyen DQ, Schlegel Wagner C, Pabst G, Linder TE. Tympanoplasty in chronic otitis media with an intact, but severely retracted malleus: A treatment challenge. Otol Neurotol. 2010; 31:1412-6

Acknowledgments

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Author

Tashneem Harris MBChB, FCORL, MMed (Otol), *Fisch Instrument Microsurgical Fellow*
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Senior Author

Thomas Linder, M.D.
Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.12: Canalplasty and Exostosis

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Loren Britto & Thomas Linder

Definition of Exostosis

Exostosis is an abnormal benign bony growth within the external ear canal. It is frequently multiple and bilateral and is very common in individuals with repeated exposure to cold water and wind. Patients may develop conductive hearing loss and/or recurrent ear infections due to trapped water and earwax between the tympanic membrane and the exostosis.

Indications for Canalplasty

Retention of cerumen and keratin in the external ear canal (EAC) associated with recurrent episodes of external otitis.

Preoperative assessment

Otomicroscopy

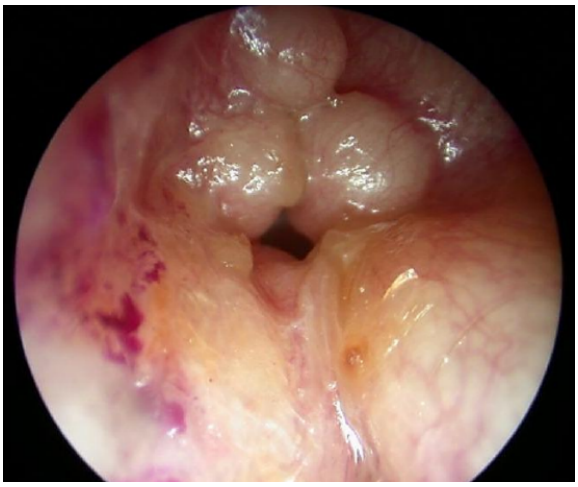


Figure 1: Multiple exostoses

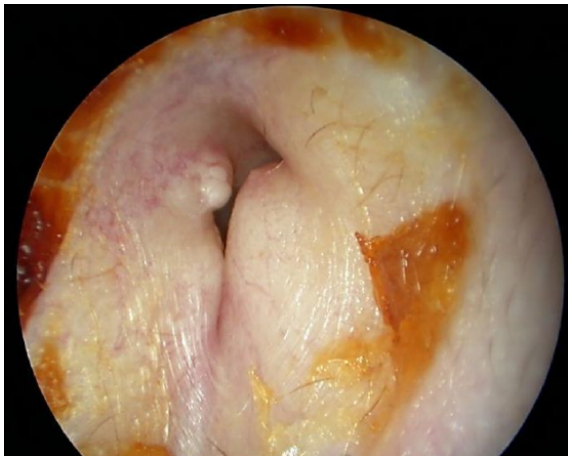


Figure 2: Exostoses

The findings are partial or total obstruction of the bony external ear canal and retention of cerumen. In some cases it is not possible to visualize the eardrum at all. It is important to assess the cartilaginous entrance to the ear canal in order to plan for a meatoplasty at a later stage (*Figures 1, 2*).

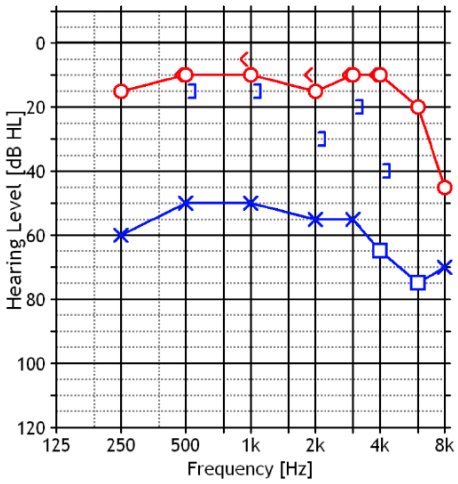


Figure 3: Conductive hearing loss in the left ear

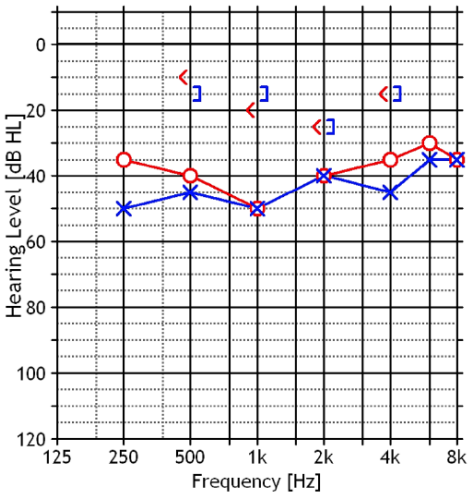


Figure 4: Bilateral conductive hearing loss

The audiogram may be normal in case of partial obliteration or may reveal a conductive hearing loss in cases of complete or almost total exostoses with retention of cerumen (*Figures 3, 4*).

Imaging



Figure 5: Multiple, bilateral exostoses with retention of cerumen on the left side

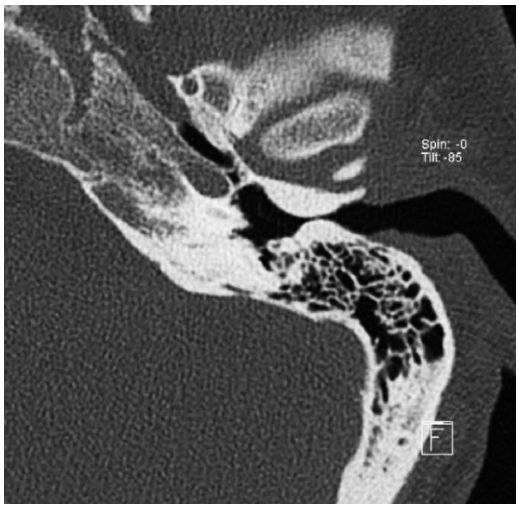


Figure 6: Axial CT scan of left ear with anteroposterior exostoses without retention of cerumen

CT scan shows the extent of the exostoses and helps the surgeon to determine the amount of bone that needs to be removed and avoiding injuries to nearby structures (*Figures 5, 6*).

Surgical Principles

- Removal of external canal exostoses requires complete elimination of the overhanging bone lateral to the tympanic annulus
- The meatal skin should be kept intact and vital to promote rapid reepithelization following enlargement of the bony ear canal
- With a narrow ear canal entrance, meatoplasty is combined with the canalplasty, removing the excess conchal cartilage and subcutaneous tissue, thereby yielding a large cartilaginous external canal that ensures excellent visibility of the exostotic posterior canal
- In cases of severe bilateral exostosis, wait three months to operate on the other side

Surgical Approaches

The pathology can be addressed by an endaural or a retroauricular approach. The endaural approach is well suited to less severe exostoses and for surgeons who are familiar with endaural approaches for other pathologies. Less experienced surgeons may favor a retroauricular approach as the exposure is more familiar to them and there is a wider field of action.

Endaural Approach

Video

General Considerations

Although the surgery can be performed under local anesthesia with sedation, we prefer general anesthesia due to the uncomfortable drilling noise. Antibiotic prophylaxis is not required.

Surgical Steps (left ear)

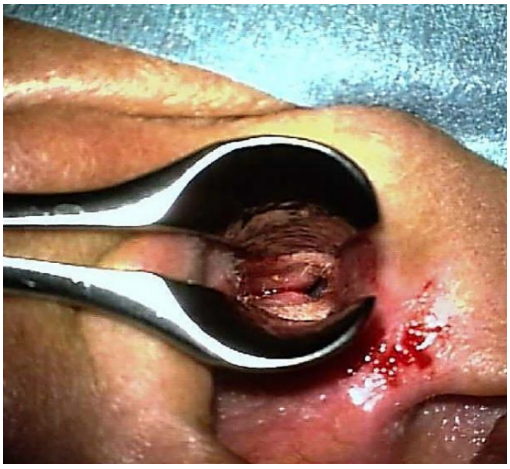


Figure 7: Speculum aiding infiltration

- Infiltrate the site of the endaural skin incision as well as the ear canal in 4 quadrants with local anesthetic (lidocaine 1% & adrenaline diluted to 1:200 000) (*Figure 7*)

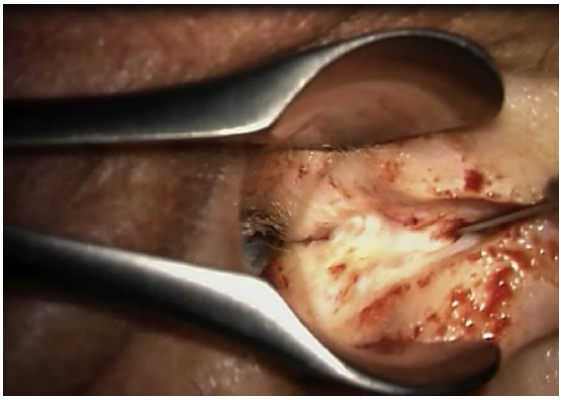


Figure 8: Helicotragal incision

- Using a nasal speculum, make a helicotragal incision with a #15 blade and (*Figure 8*)

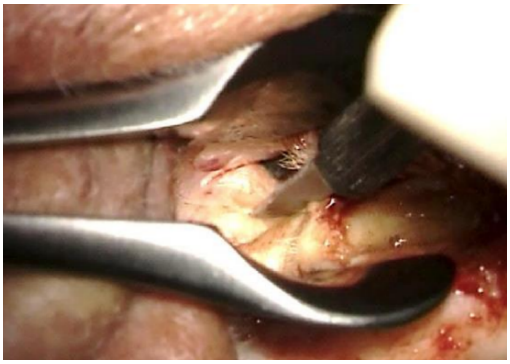


Figure 9: Posterior incision

- Make a posterior semicircular incision over the edge of the exostosis, meeting the endaural incision at 12 o'clock (*Figure 9*)

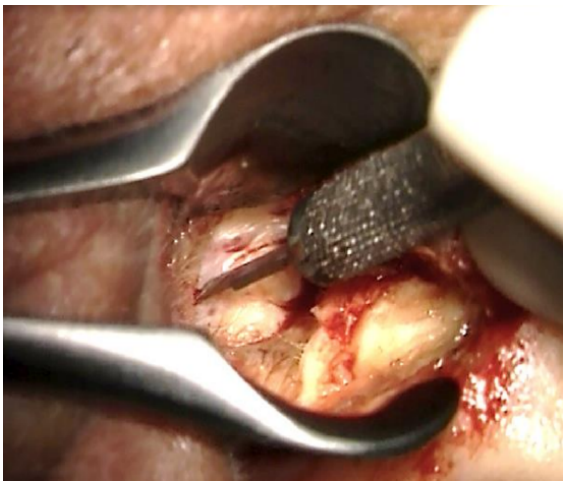


Figure 10: Prolong the posterior incision

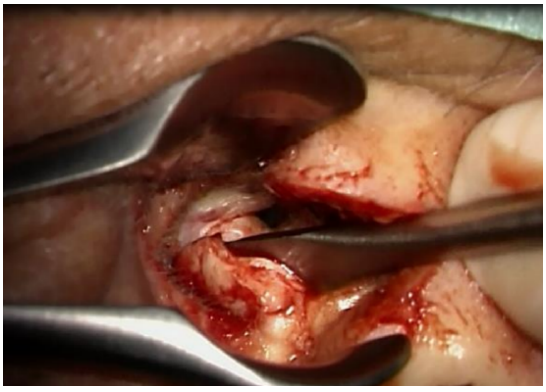


Figure 11: Reflect posterior skin laterally

- Prolong the inferior part of the incision posteriorly and reflect the posterior skin laterally (*Figures 10*, *11*)
- Enlarge the entrance of the canal with two Fisch endaural retractors
- An anterior semicircumferential incision is made along the lateral margin of the anterior exostosis

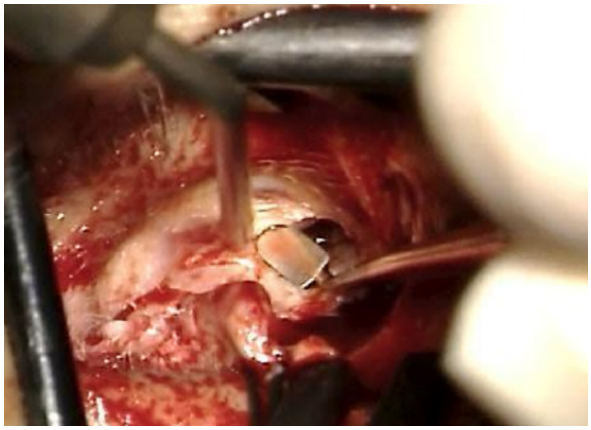


Figure 12: Elevate anterior skin laterally

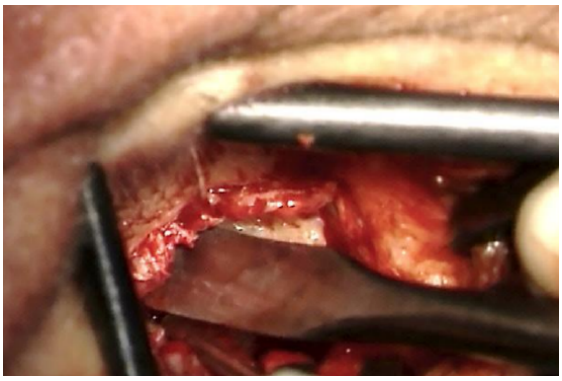


Figure 13: Elevate anterior skin laterally

- Reflect the anterior canal skin and soft tissue laterally using a Fisch or Iowa microraspatory and a Key raspatory. A round knife may also be used, but will get blunt when dissecting on bone (*Figures 12, 13*)

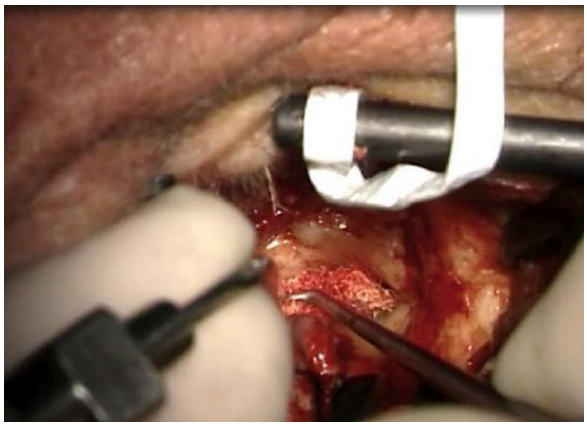


Figure 14: Elevate skin with Fisch microraspatory and adrenaline gauze

- The anterior skin flap is kept elevated and retracted from the lumen with an aluminium strip anchored to the Fisch endaural retractor (*Figure 14*)
- Elevate the skin over the exostotic bone using microraspatories and small gauze strips (1-1.5 cm in length) soaked in adrenaline solution. The gauze strips allow careful dissection between skin and bone and avoid lacerations to the skin flaps (*Figure 14*)

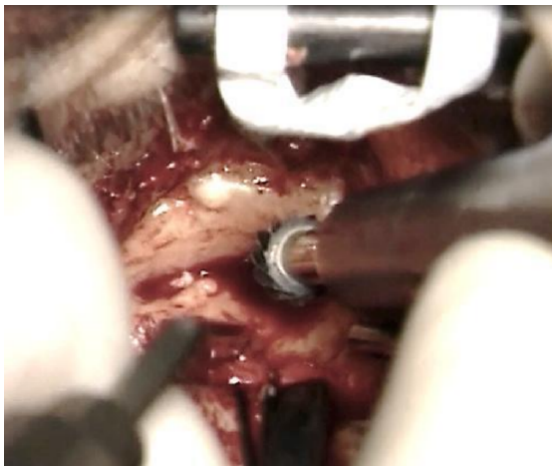


Figure 15: Sharp burr

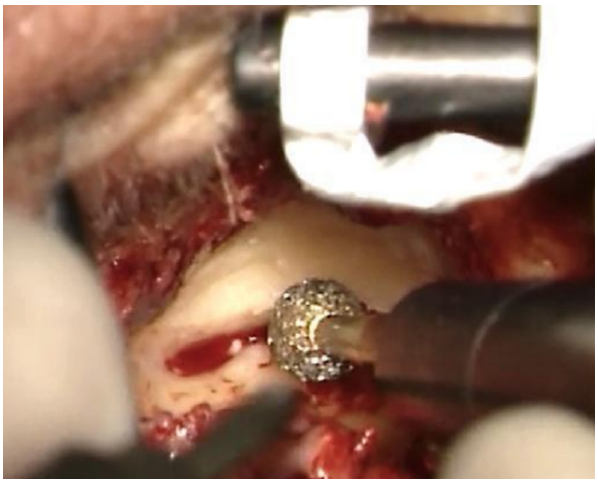


Figure 16: Diamond burr

- Remove the excess bone along the canal wall. A sharp drill is only used at the outer entrance to the bony ear canal far away from the skin flaps. Once the dissection proceeds into the bony ear canal, diamond burrs are used. (*Figures 15, 16*)
- Since preservation of the ear canal skin is vital to allow proper wound healing, the following steps and tricks are helpful to achieve this goal:
  - The left hand (for right-handed surgeon) cleans the field holding otosclerosis suction tips and assists the right hand while drilling
  - Continuous irrigation is mandatory to see any color changes within the bone (appearance of temporomandibular joint anteriorly or mastoid air cells posteriorly)
  - To protect the skin from damage, a groove or sulcus is made in the exostosis, leaving a thin layer of bone covering the elevated skin. Avoid drilling on the edge; always stays behind the edge of the groove/sulcus. The outer limits are the temporomandibular joint anteriorly and the mastoid air cells posteriorly



Figure 17: Skin protected

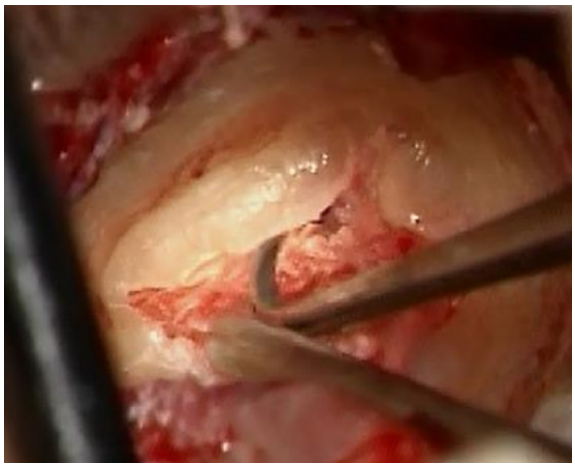


Figure 18: Elevating skin with adrenaline gauze



Figure 19: Checking vitality of the skin



Figure 20: A groove is made, and the skin left protected medially

- Elevate the skin with an adrenaline gauze, leaving the skin safe medial to the edge of bone (*Figures 17-20*)
- Drilling should be discontinued if a bluish color in the bone is noted anteriorly while irrigating to avoid entering the temporomandibular joint



Figure 21: Silastic sheet

- Approaching the eardrum, drill at the edge, using a silastic sheet to protect the skin (*Figure 21*)

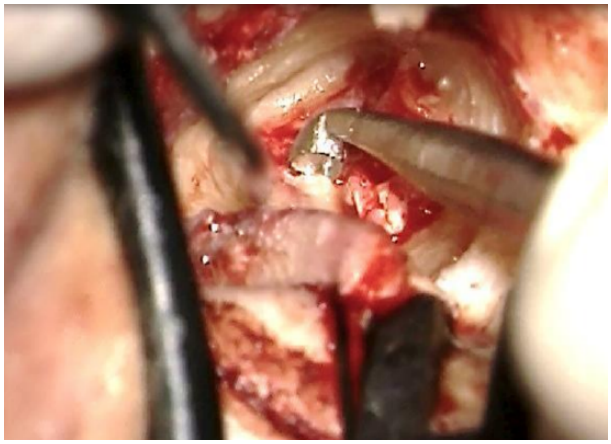


Figure 22: Curetting bone over annulus

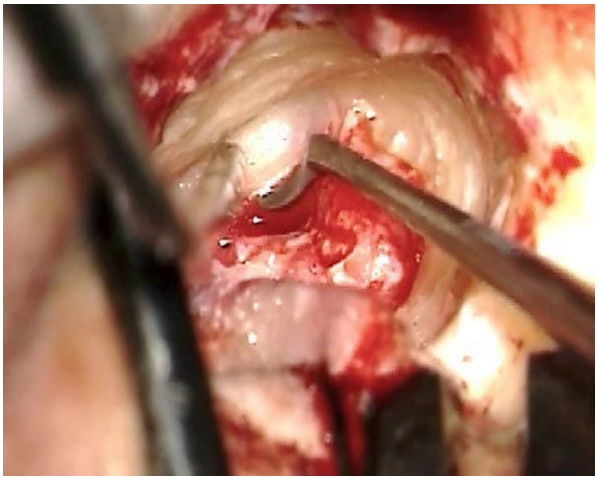


Figure 23: Curetting bone over annulus

- When the tympanic annulus appears through the posterior side of the flap, the eggshell of bone protecting the meatal skin is removed with a Fisch microraspatory and curette (*Figures 22, 23*)
- The EAC is shaped into an inverted truncated cone
- Correct widening of the EAC requires elimination of all overhanging bone lateral to the tympanic annulus. Failure to open the tympanomeatal angle at the level of the annulus causes accumulation of keratin with recurrence of the exostoses

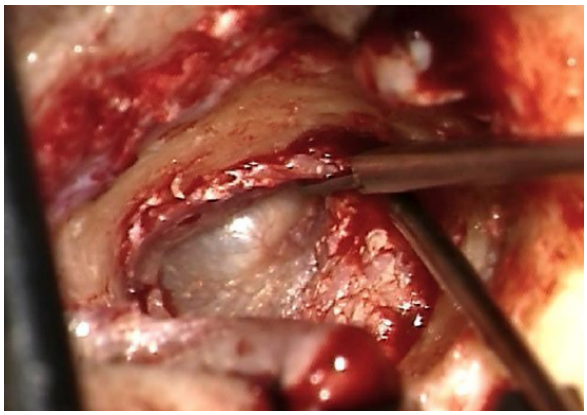


Figure 24: Incising at 1 & 5 o'clock

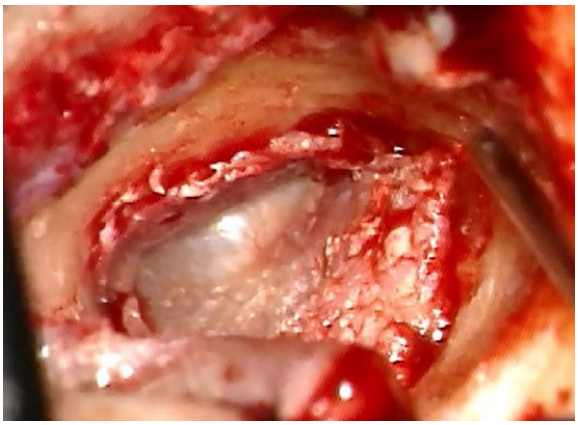


Figure 25: Incising at 1 & 5 o'clock

- The flap of ear canal skin is placed back in position. Releasing cuts are made at 11 and 7 o'clock (right ear) to accommodate the skin properly on the new bone canal (*Figures 24, 25*)



Figure 26: Repositioning posterior meatal skin and covering it with gelfoam

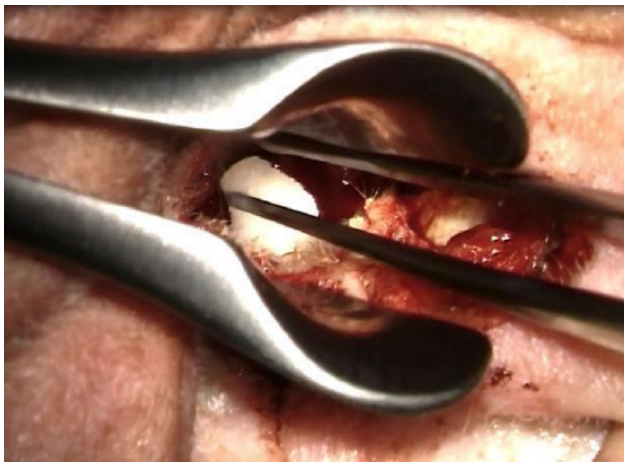


Figure 27: Positioning the gelfoam

- The meatal skin flap is repositioned and covered with Gelfoam pledgets soaked in corticosporin (*Figures 26*, *27*)
- The endaural incision is closed with 3/0 Vicryl and 4/0 Prolene sutures

Retroauricular Approach

Video

This approach allows better visualization of the canal.

Indications

- Total exostosis without lumen
- Less experienced surgeon (better landmarks, larger operative field, same outcome)

General Considerations

The surgery is performed under general anesthesia (local anesthesia is possible, but noise of drilling burr can be difficult for the patient to accept). Antibiotic prophylaxis is not required.

Surgical Steps (Left ear)

- Using local anesthetic (lidocaine 1% and adrenaline diluted to 1:200 000), infiltrate the postauricular sulcus. Then advance the needle and infiltrate the tissues anteroinferiorly and anterosuperiorly
- Use a Lempert's speculum to visualize the bony-cartilaginous junction and injecting the 4 quadrants of the skin of the ear canal

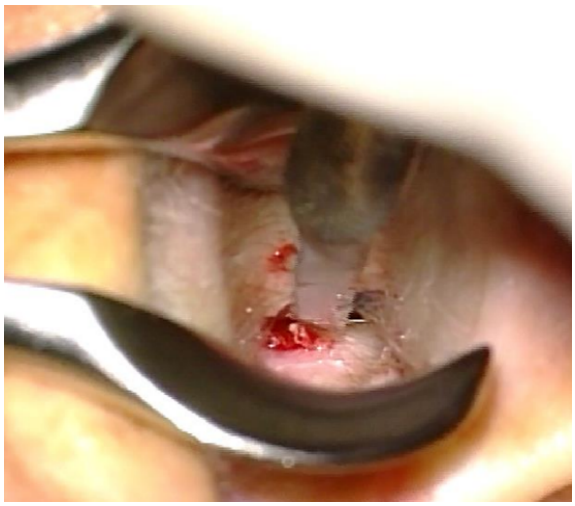


Figure 28: Posterior incision

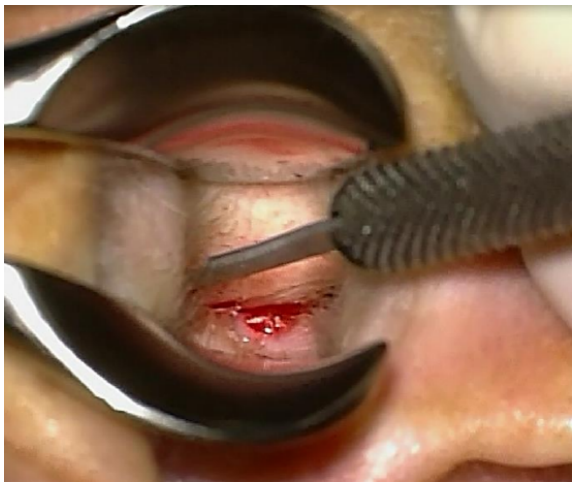


Figure 29: Extending the posterior incision inferiorly

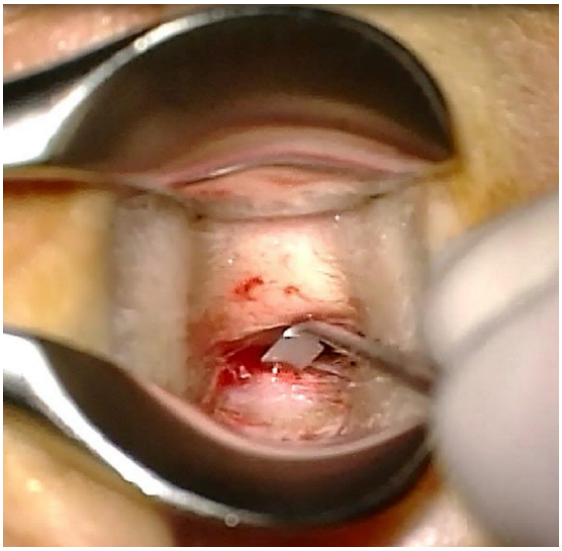


Figure 30: Reflecting the posterior flap

- Using a Lempert's speculum, make a posterior transcanal incision over the edge of the exostosis, with an inferior extension. Reflect the skin flap laterally (*Figures 28-30*)



Figure 31: Retroauricular skin incision

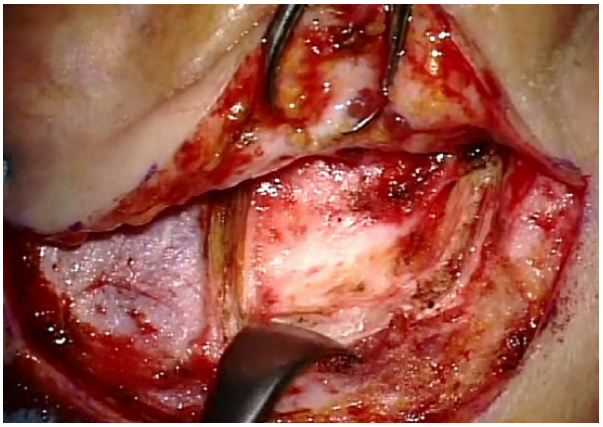


Figure 32: Periosteal flap

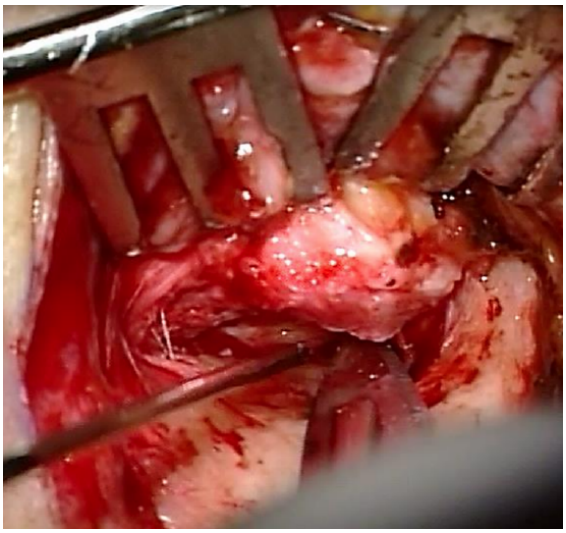


Figure 33: Anterior incision

- Start the retroauricular approach like for tympanoplasty (*Figures 32, 33*) (Myringoplasty & tympanoplasty chapter)
- The end of the periosteal flap elevation meets the posterior transcanal incision

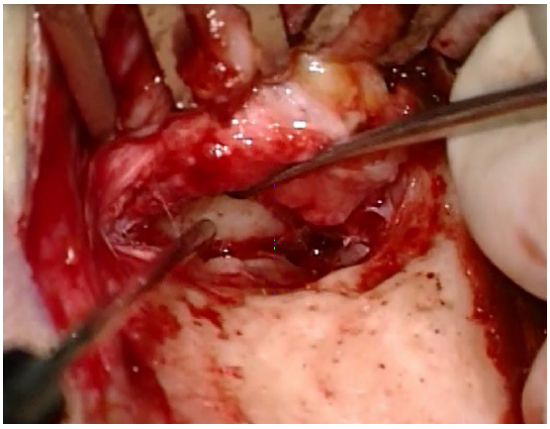


Figure 34: Reflecting the anterior skin flap laterally

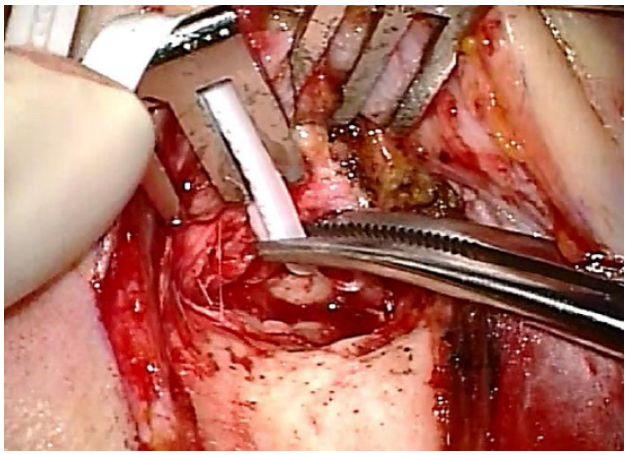


Figure 35: Aluminium strip

- Incise the anterior canal wall with an #11 blade and reflect the skin laterally. Keep the anterior skin out of the surgical field with an aluminium strip (*Figures 33-35*)

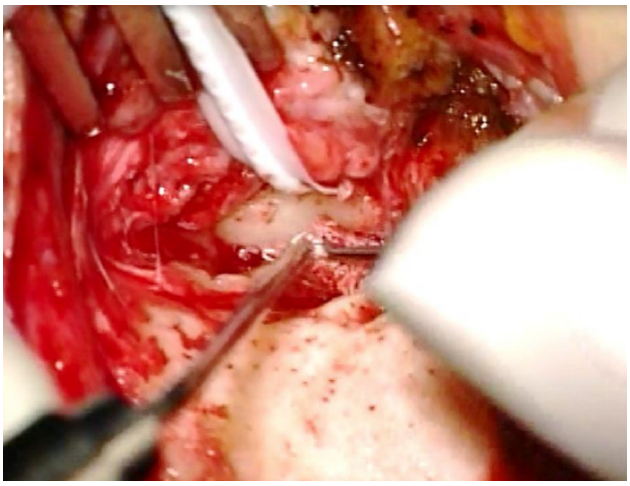


Figure 36: Elevating canal skin with Fisch microraspatory and adrenaline gauze

- Perform the next steps as for Endaural approach (*Figure 36*)
- Cover the skin with Gelfoam pledgets soaked in corticosporin
- Suture the retroauricular incision with 3-0 Vicryl and 4-0 Prolene

Videos

Exostosis surgery: Endaural approach

Exostosis surgery: Retroauricular approach

Author

Loren Britto M.D.
Fisch Instrument Microsurgical Fellow
Lucerne Canton Hospital, Switzerland
lorenbritto@uol.com.br

Senior Author

Thomas Linder, M.D.
Professor, Chairman and Head of Department of Otorhinolaryngology, Head, Neck and Facial Plastic Surgery
Lucerne Canton Hospital, Switzerland
thomas.linder@ksl.ch

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Muaaz Tarabichi

The introduction of the binocular operating microscope was a landmark in modern otology as it changed the scope and character of ear surgery. The endoscope offers a new perspective of cholesteatoma and related surgical procedures; it increases the surgeon's understanding of the disorder and its extension through the temporal bone and provides a wide field of view of the middle ear compared to the microscope.

Even though it has been two decades since endoscopy was first used to explore mastoid cavities, the endoscope is used infrequently for surgical management of ear disease; most otologists have not felt compelled to master the newer endoscopic techniques.[1-6] In addition, there has been a focus on using smaller diameter endoscopes for ear surgery which is counterproductive, as it eliminates the main (and possibly only) advantage of endoscopy i.e. wide field of view compared to that of the microscope.

The rationale, advantages, limitations, technique are discussed in this chapter.

History

The author first used the endoscope for ear surgery in 1993. In recent years, many surgeons have adopted it for middle ear surgery as opposed to the microscope.[7-10] Transtympanic middle ear endoscopy was first reported by Nomura and Takahashi.[3,4] Poe and Bottrill used transtympanic endoscopy to diagnose perilymphatic fistulae and to identify other middle ear pathology.[5] Kakehata used microendoscopy and transtympanic endoscopy to evaluate conductive hearing loss and inspect retraction pockets.[11-13] Thomassin reported on the use of operative ear endoscopy for mastoid cavities and designed an instrument for that purpose.[1]

Badr-el-Dine and El-Messelaty reported on the value of endoscopy as an adjunct in cholesteatoma surgery and documented a reduced risk of recurrence when the endoscope was used.[14,15] A reduction in residual disease was confirmed by Yung and Ayache.[16,17] Baki used endoscopy to evaluate disease within the sinus tympani.[18] Mattox reported on endoscopy-assisted surgery of the petrous apex.[19] Magnan[20], Bader-el-Dine & El-Garem[21-23], and Rosenberg[24] reviewed the role of the endoscope in neurotologic procedures. McKennan described 2nd look endoscopic inspection of mastoid cavities through a small postauricular incision.[6] Presutti & Marchioni described primary transcanal endoscopic ear surgery in a similar fashion to that reported in this chapter.[25,26]

Rationale for Endoscopic Ear Surgery

Acquired cholesteatoma is usually a manifestation of advanced tympanic membrane retraction; the sac retracts into the tympanic cavity proper and then extends into areas such as the sinus tympani, facial recess, hypotympanum, and attic.[27] Only in advanced cases does cholesteatoma progress further to reach the mastoid cells.

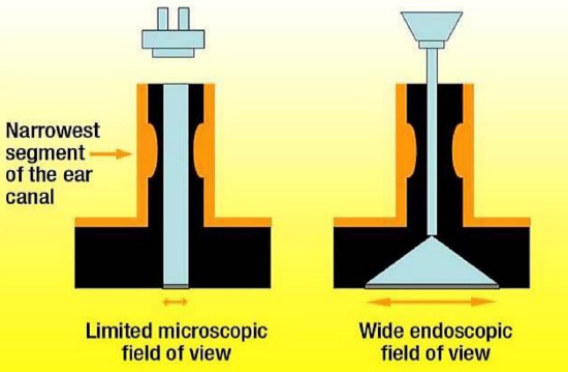


Figure 1: The view through the microscope during transcanal surgery is defined and limited by the narrowest segment of the ear canal; the endoscope bypasses this narrow segment and provides a very wide view that allows the surgeon to "look around corners," even when the zero-degree scope is used

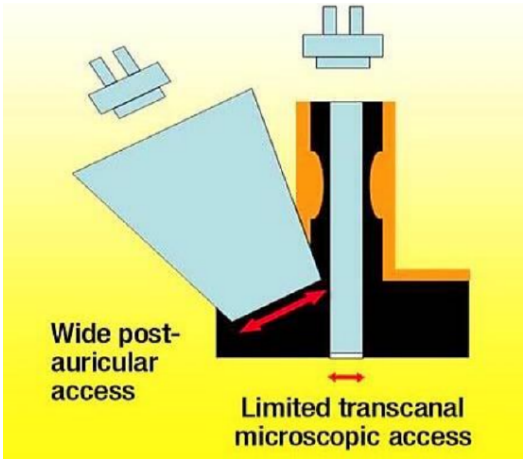


Figure 2: Limited view afforded by the microscope during transcanal procedures requires a postauricular mastoidectomy by which a port is created parallel to the attic after a considerable amount of healthy bone has been removed to enable anterior keyhole access to the attic



Figure 3: Coronal CT of temporal bone: A line drawn through the ear canal ends in the attic rather than mesotympanum; this almost universal anatomic orientation enables a natural transcanal access to the attic

Most surgical failures following a postauricular approach occur within the tympanic cavity and its hard-to-reach extensions, rather than within the mastoid.[28,29] Therefore transcanal access to the tympanic membrane and tympanic cavity to remove cholesteatoma with subsequent step-by-step pursuit of the sac as it extends through the middle ear is the most logical approach. The microscopic view provided by transcanal access is defined and limited by the narrowest segment of the ear canal (*Figure 1*). This limitation compels surgeons to create a parallel port via a postauricular transmastoid approach to gain keyhole access to the attic, facial recess, and hypotympanum (*Figure 3*). Transcanal operative endoscopy however bypasses the narrow segment of the ear canal and provides a wide view that enables surgeons to look “around the corner,” even when a zero-degree endoscope is used (*Figure 2*).

Another anatomic observation that favors transcanal access to the attic, which is the most frequent site of cholesteatoma[30], is the orientation of the ear canal in relation to the attic. *Figure 3* shows a coronal computed tomographic (CT) section through the temporal bone and illustrates that a line drawn through the ear canal ends in the attic rather than in the mesotympanum. The only structure that is in the way is the scutum; its removal allows wide access to the attic, which is the natural cul de sac of the external auditory canal.

Rediscovering the ear canal as the access port for cholesteatoma surgery has been the main advantage of endoscopic ear surgery. It allows more natural and direct access to pursue cholesteatoma located within the middle ear cleft. In contrast, traditional approaches to the attic and facial recess provide primarily keyhole access through postauricular mastoidectomy; many surgeons use the ear canal to access the anterior part of the attic, even during postauricular tympanomastoidectomy. Other areas, such as the hypotympanum and sinus tympani are minimally accessible even with extensive postauricular mastoidectomy. The wide view provided by the endoscope enables minimally invasive transcanal access to all these areas and facilitates complete extirpation of disease without the need for a postauricular approach.



Figure 4: Wide-angled telescope



Figure 5: The surgeon operates while watching the monitor which is positioned across the operating room table. The surgical assistant also has a clear view of the monitor

Eighteen-centimeter-long, 4 mm, wide angled, zero-degree and 30-degree Hopkins II telescopes are most often used (*Figure 4*). Recently a smaller 3 mm endoscope with a very similar field of view to the 4 mm endoscope has been introduced. Smaller diameter scopes are used sparingly. Video equipment consists of a 3-chip video camera and a monitor. Procedures are performed directly off the monitor and recorded. Standard microscopic ear surgery instruments are used (*Figure 5*).

Important safety issues with endoscopic ear surgery

Thermal injury: This is evident only when a Xenon light source is used. Because of the small size of the cavity, adequate illumination of the middle ear space can be accomplished with a regular light source on lower settings without the need for a Xenon system. While the tip of the endoscope heats up quickly, it cools down quickly too. The tip of the endoscope requires continuous cleaning with antifog solution which probably also helps to cool the endoscope.

Trauma by the tip of the endoscope due to accidental head movement: The relatively large diameter of the endoscope (4 mm) and the anatomical configurations of the ear canal and middle ear space usually preclude introduction of the endoscope beyond the tympanic ring.

Endoscopic anatomy of middle ear cleft

Transcanal endoscopic approaches provide a new way of looking at the anatomy of the tympanic cavity and more specifically at cholesteatoma-bearing areas. The endoscope allows a better understanding of ligaments and folds of the middle ear and how they affect ventilation of the different spaces. This section highlights the endoscopic anatomy of the middle ear cleft and reviews the concept of the epitympanic diaphragm which plays an important role in the pathophysiology of attic cholesteatoma[31-32-33].

Facial Recess

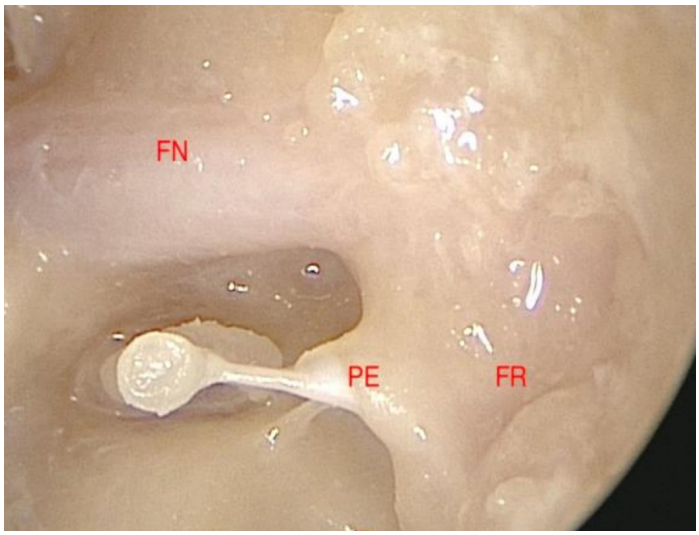


Figure 6: Left ear. Endoscopic view through transcanal endoscopic access after minor removal of bone; the facial recess (FR) is a very shallow and flat depression, more or less at the same level as the pyramidal eminence (PE) and tympanic segment of the facial nerve (FN)

Using a transcanal endoscopic approach, the facial recess is a very accessible, shallow depression on the posterior wall of the tympanic cavity (*Figure 6*). In contrast, a postauricular posterior tympanotomy gives keyhole access to this important area.

The pyramidal eminence and the vertical segment of the facial nerve form the medial wall of the recess. It marks the depth of the vertical segment of the facial nerve in this area. The bony annulus forms the lateral wall of the recess and can be taken down safely as long as the pyramidal eminence is continuously kept in view. The relationship of the bony annulus to the vertical segment of the facial nerve is very variable as one moves inferiorly beyond the pyramidal eminence; great care should therefore be paid when removing bone from the inferior/posterior aspect of the ear canal and bony annulus.

Retrotympanum

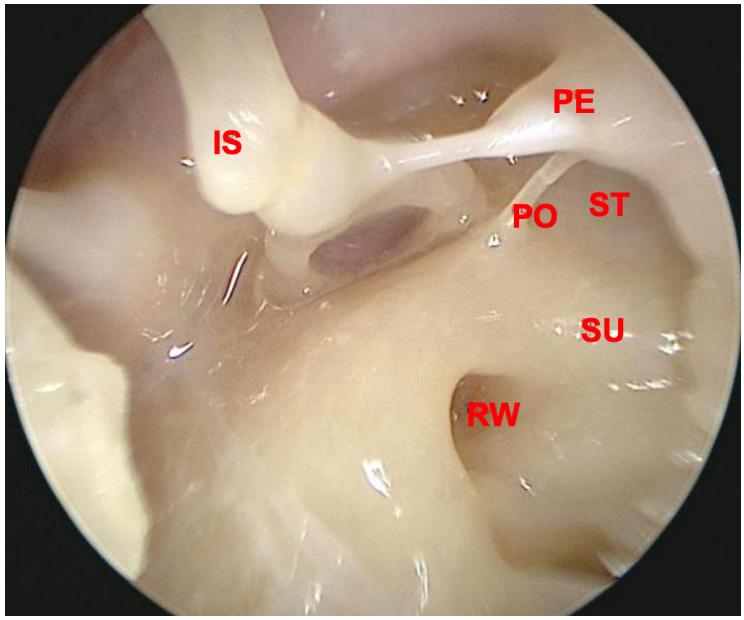


Figure 7: Left ear: View of retrotympanum (IS: incudostapedial joint; PE: pyramidal eminence; PO: ponticulus; ST: sinus tympani; SU: subiculum; RW: round window)

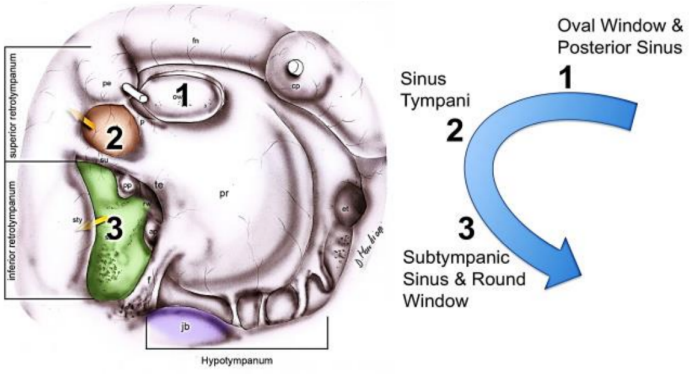


Figure 8: Right ear: Schematic drawing of retrotympanum. It is useful to start superiorly at the oval window and move inferiorly: posterior sinus, then sinus tympani, sinus subtympanicum, and then hypotympanum (Fn: facial nerve; pr: promontory; sty: styloid prominence; te: temen of round window; p: ponticulus; su: subiculum; jb: jugular bulb)

When observing the anatomy of the retrotympanum it is a useful surgical exercise to start superiorly with the posterior sinus and stapes footplate and to move inferiorly identifying the ponticulus, sinus tympani, subiculum, ending up with the sinus subtympanicum where the round window is located (*Figures 7*, *8*). The stapes footplate is located within the posterior sinus that extends around and posterior to it. The round window is located within the sinus subtympanicum that extends posterior and inferior to it. Between these two sinuses lies the sinus tympani.

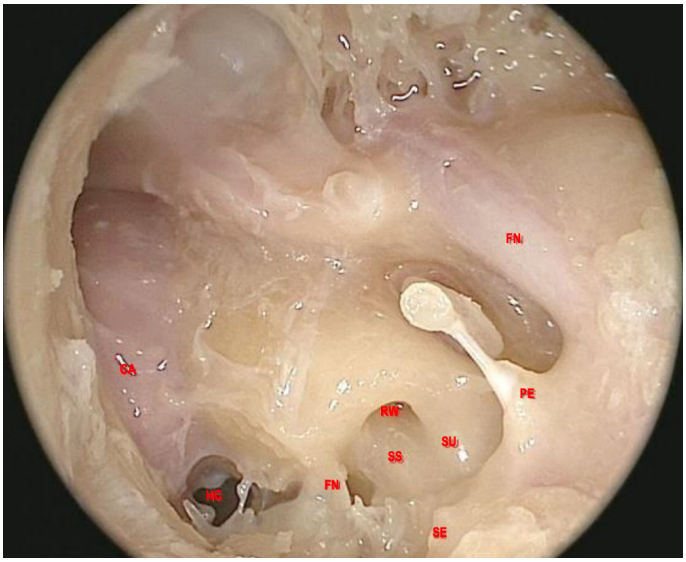


Figure 9: Left ear: Tympanic cavity with special attention to retrotympanum (FN: facial nerve; SU: subiculum; SS: sinus subtympanicus; SE: styloid eminence; RW: round window; FN: finiculus; CA: carotid artery; HC: hypotympanic air cell)

More inferiorly is the hypotympanum; this is separated from the sinus subtympanicum by the finiculus (*Figure 9*).

Attic

The endoscope permits a much better understanding of the anatomy of the attic and why it is distinct and separate from the mesotympanum both anatomically and in term of ventilation. Attic retraction pockets often present as isolated features with normal ventilation and findings in the mesotympanum. The concept of an epitympanic diaphragm has been advocated by clinicians, temporal bone histologists and pathologists[31-33]. However, this concept has not made much of an impression clinically because of the difficulty of communicating and understanding the difficult anatomy.

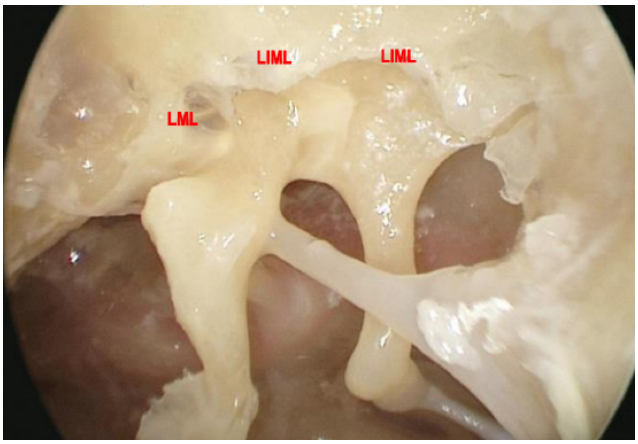


Figure 10: Left ear: Lateral attic is closed off from mesotympanum by lateral incudomallear and mallear ligaments. Note the relatively straight insertion line of the lateral incudomallear ligament (LIML) and the downward sloping insertion line of the lateral mallear ligament (LML)

The attic is a reasonably busy place and contains the bulk of the ossicular chain and many suspensory ligaments and folds. In the lateral attic, the lateral incudomallear and the lateral mallear folds form a lateral wall that does not allow for ventilation of the attic via the mesotympanum laterally (*Figure 10*). The anterior part of these lateral folds forms the medial wall of Prussak's space.

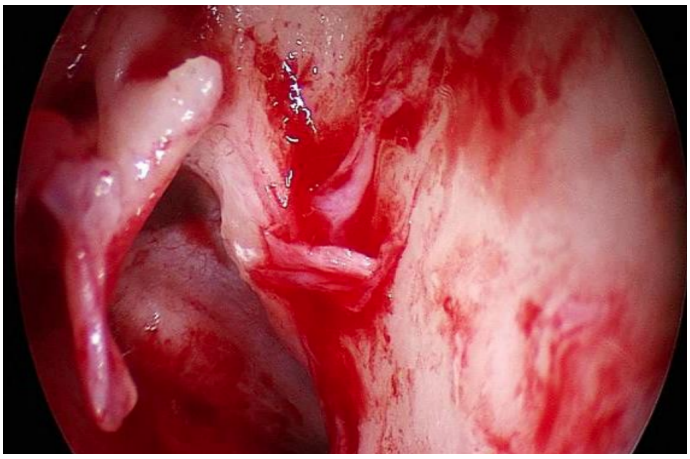


Figure 11: Right ear: Using a 70^{o} endoscope and looking posterosuperiorly one sees a poorly developed supratubal recess. The tensor fold is seen as an almost horizontal structure

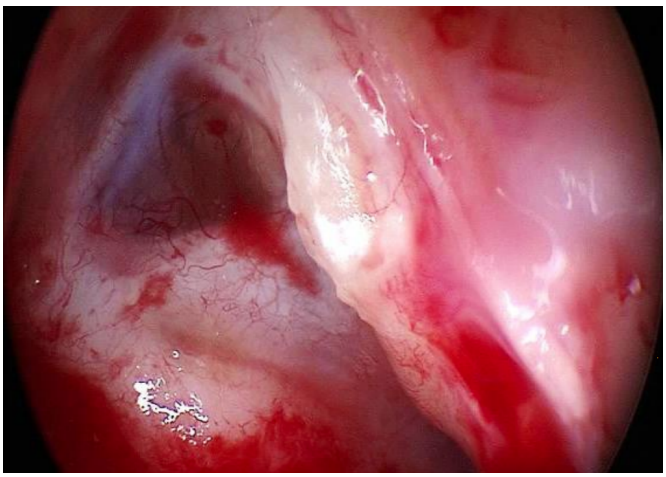


Figure 12: Right ear: Closeup view of the tensor fold seen in Figure 32

Anteriorly the attic is often separated from the mesotympanum and Eustachian tube by the folds of the tensor tympani. There are two main variations of this structure: The first is an almost horizontal orientation where the folds attach to the tensor tendon posteriorly and to the tympanic wall anteriorly very close the anterior tympanic spine (*Figures 11 & 12*).



Figure 13: Left ear: Anatomy of tensor fold in a specimen with a well developed supratubal recess. The tensor fold is composed of two segments, a vertical part that attaches to the COG and a horizontal part that forms a partial floor of the supratubal recess

The second is when the supratubal recess is well developed and it pushes the folds to an almost vertical position (*Figure 13*).

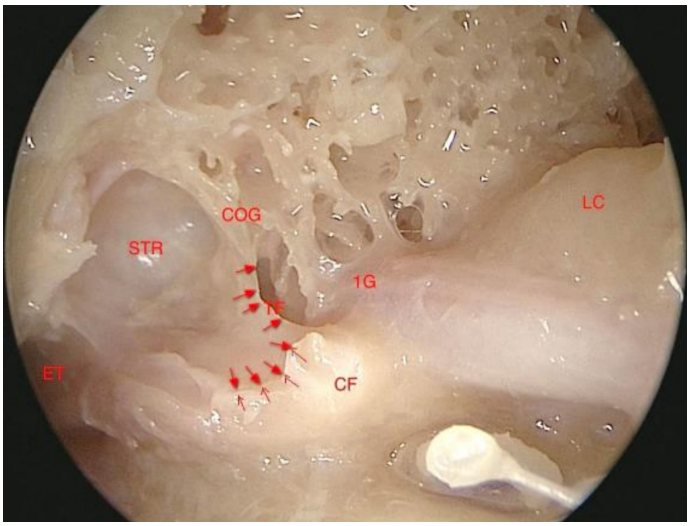


Figure 14: Left ear with tensor tendon transected, handle of malleus, anterior spine, anterior mallear ligament and chorda tympani removed: Note the distinction between the smooth wall of the supratubal recess and the numerous tags and excrescences of the anterior attic. (COG: Sheehy's COG; TM: remnant of tensor fold; Single arrows: insertion of partially removed vertical segment of the tensor fold; Double arrows: insertion points of completely removed horizontal segment of tensor fold; STR: supratubal recess; ET: Eustachian tube; CG: cochleariform process; 1G: first genu of facial nerve and the geniculate ganglion; LC: lateral semicircular canal)

The attic and the supratubal recess are two distinct areas anatomically and developmentally. The supratubal recess is often a smooth-walled cavity compared to the attic wall that has numerous tags and excrescences. The transverse crest is a semicircular bony ridge that starts at the medial wall of the attic, runs across the roof, and then along the lateral wall of the attic. It marks the boundary between the tags and excrescences in the anterior attic and the smooth-walled supratubal recess (*Figure 14*).

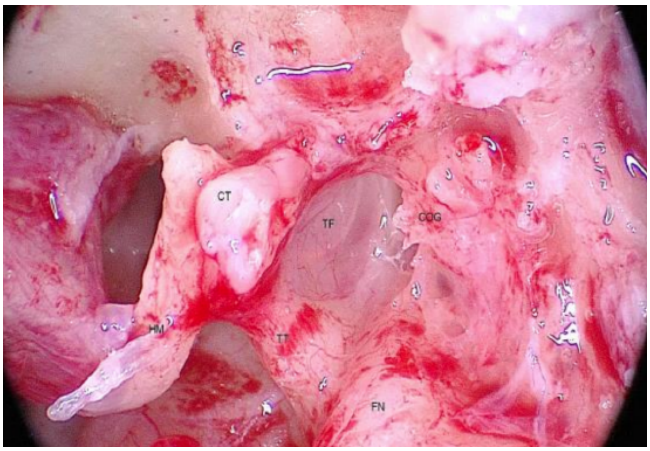


Figure 15: Left ear: Intraoperative view from posterior toward the anterior attic (FN: horizontal segment of facial nerve; HM: handle of malleus; CT: cut edge of chorda tympani; TT: tensor tympani tendon; TF: posterior aspect of tensor fold)

Its medial limb starts from the area of the cochleariform process and forms the COG, a commonly recognized surgical term for a bony protrusion on the medial wall of the anterior attic.[34] The tensor fold always inserts more anteriorly than the COG; this leaves space for entrapment of cholesteatoma (*Figure 15*).

Developmentally the middle ear spaces evolve from four pouches or sacs (saccus anticus, saccus medius, saccus superior, and saccus posticus) that bud from the Eustachian tube[35]. The attic is formed from the saccus medius, which divides into three saccules i.e. anterior, medial, and posterior. The supratubal recess may be formed by the saccus anticus. The anterior saccule of the saccus medius meets the slower growing saccus anticus at the level of the semicanal of the tensor tympani, thus forming the horizontally aligned tensor tympani fold. The space thus formed above the tensor fold and anterior to the tensor tendon is the anterior attic compartment.[36] Alternatively the saccus anticus may occasionally extend upward to the tegmen pushing the tensor fold into an almost vertical position and in the process, forming a well-developed supratubal space[36]. The expansion from the bony Eustachian tube to form the supratubal recess begins at a late foetal stage and continues throughout childhood[37]. By contrast, growth of the tympanic cavity, attic and mastoid antrum is virtually complete at birth.[38]

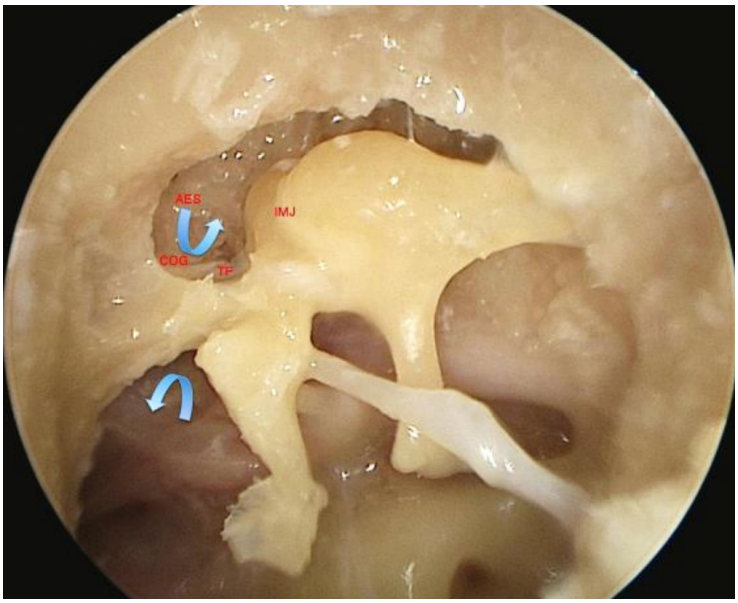


Figure 16: Left ear: Anterior attic separated from supratubal recess and Eustachian tube by tensor fold so that there is no direct communication or ventilation anteriorly between attic and Eustachian tube

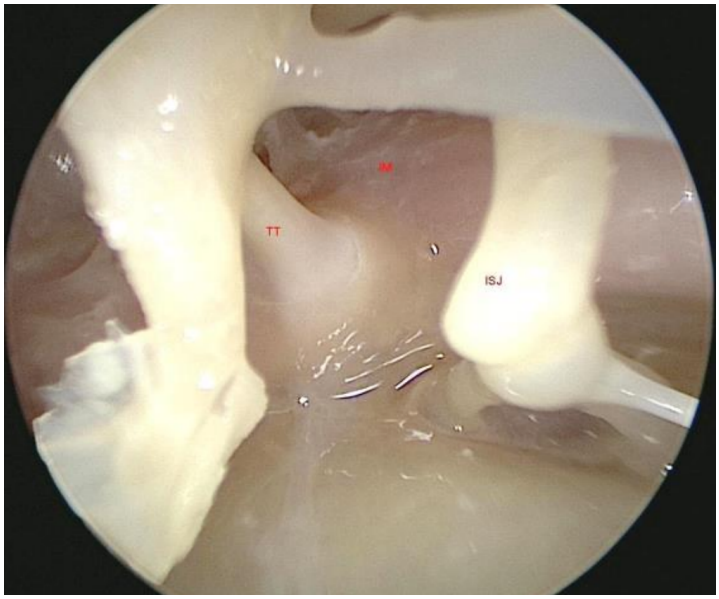


Figure 17: Left ear: IM: isthmus forms the only pathway for attic ventilation in the presence of complete tensor folds (TT: tensor tympani tendon; ISJ: incudostapedial joint)

With an intact tensor fold, a fully formed diaphragm separates the attic from the mesotympanum (*Figure 16*). This diaphragm is formed by the lateral incudomallear and mallear folds laterally and the tensor folds anteriorly. The only ventilation ports are through the anterior and posterior isthmi. The anterior isthmus extends between the incudostapedial joint and tensor tympani tendon (*Figure 17*).[32]

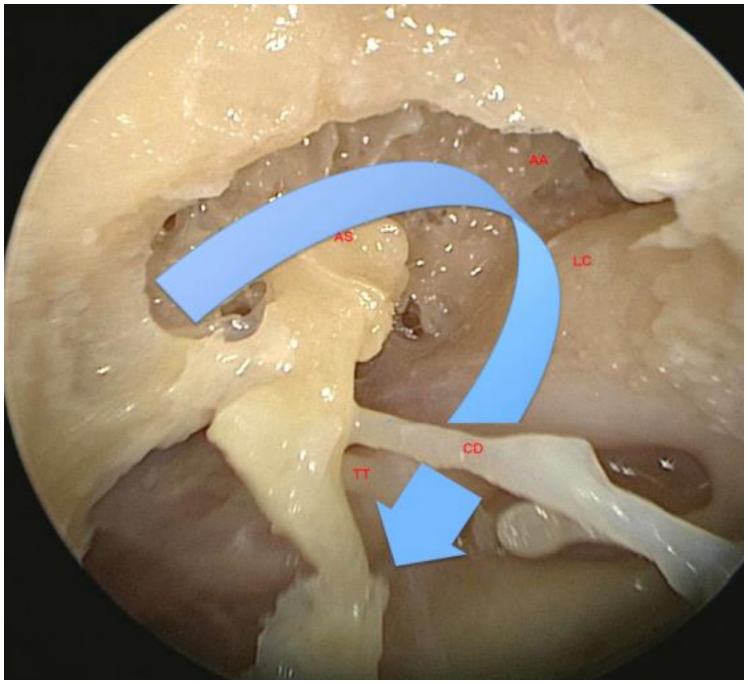


Figure 18: Left ear: Incus has been removed to demonstrate the long narrow channel for ventilation of the attic through the isthmus, medial attic, and upper attic

The posterior isthmus is the area posterior to the incudostapedial joint. It is often extremely narrow and contains the chorda tympani and pyramidal eminence. So the anterior isthmus or “isthmus” is the main path of attic ventilation via a very long channel that extends medial and then superior to the ossicles to ventilate the lateral and anterior attic (*Figure 18*). This long channel is also populated by other partial folds and suspensory ligaments which provide other opportunities for impaired ventilation.

Cholesteatoma: Technique & management algorithms

Preoperative planning based on high resolution CT and endoscopic examination is important. However definitive management decisions are made in the operating room and patients need to understand the range of possible interventions that may be used.

Three endoscopic approaches may be used for cholesteatoma. These echo principles and lessons borrowed from traditional tympanomastoid surgery.

1. ***Endoscopic transcanal management of limited cholesteatoma***
2. ***Endoscopic open cavity management of cholesteatoma***
3. ***Expanded transcanal approach to cholesteatoma***

The first question to ask whether the ear canal provides an adequate port for complete removal of cholesteatoma?

- If the answer is “yes”, then ***endoscopic transcanal management of limited cholesteatoma*** is employed; a wide tympanomeatal flap is elevated, atticotomy performed, the sac is identified and is pursued along with removal of overhanging bone
- If the answer is “no”, then an ***expanded transcanal approach*** is used; This entails improving transcanal access by removing skin of the ear canal and enlarging the bony canal

The mastoid then needs to be addressed

- ***Limited cholesteatoma*** that extends only to the aditus ad antrum can be completely removed through a ***transcanal approach***

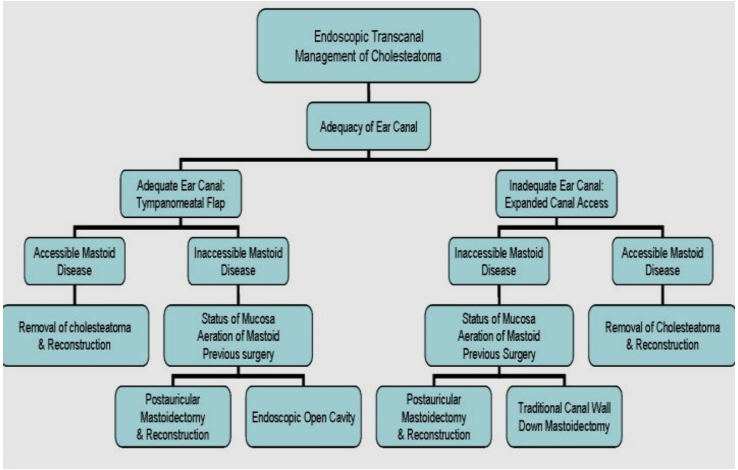


Figure 19: Algorithm: Endoscopic Transcanal Management of Cholesteatoma

- If the ***mastoid is involved***, a decision is made whether to address the disease through a ***postauricular mastoidectomy or whether to exteriorize it by endoscopic open cavity management of the cholesteatoma***; this entails aggressive removal of bone superiorly and posteriorly all the way to the mastoid cavity proper (*Figure 19*).

Endoscopic transcanal management of limited cholesteatoma

The attic (especially anterior part) is poorly visualized via traditional microscopic approaches. An endoscopic approach however enables a surgeon to start in the mesotympanum and follow the sac along its twists and turns around the ossicles and ligaments. This good access facilitates better preservation of the ossicles while ensuring complete removal of matrix, rather than piecemeal removal via different access ports.

Technique

A wide posterior tympanomeatal flap is elevated. The sac is pursued under direct vision and the bony rim is curetted or drilled just enough to enable dissection to be continued under direct vision. Appropriate ossicular chain work is done, and the attic defect is closed with a composite tragal graft.

Clinical example

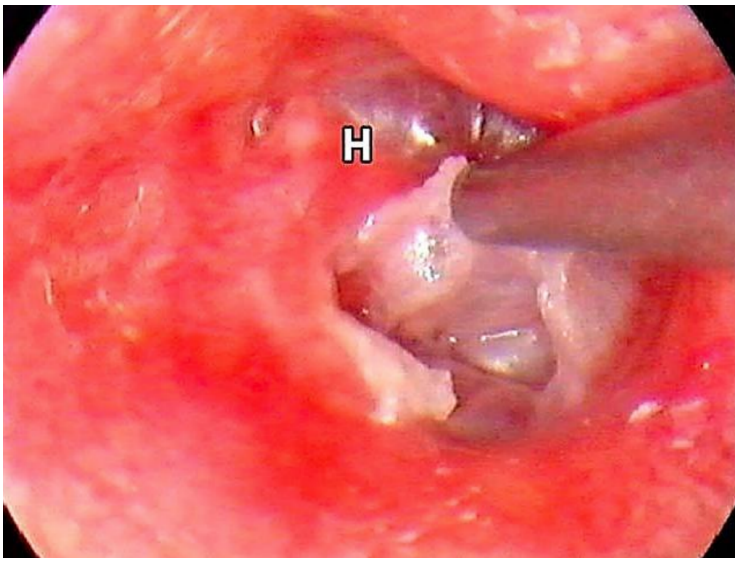


Figure 20: Right ear: Retraction and cholesteatoma (H: handle of malleus)

Figure 20 shows a right ear with evidence of severe retraction and debris in a cholesteatoma sac.

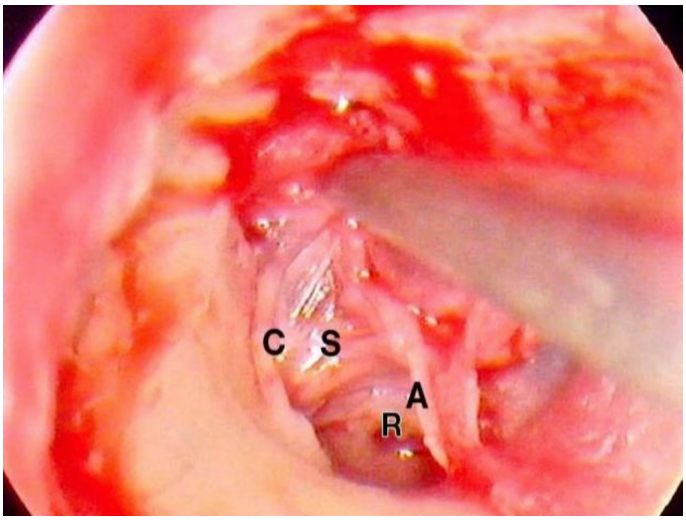


Figure 21: Right ear: Tympanomeatal flap has been elevated, middle ear has been entered, and cholesteatoma sac has been exposed (C: chorda tympani; S: cholesteatoma sac; A: annulus; R: round window)

Endoscopic transcanal approach was undertaken, a wide tympanomeatal flap was elevated, and the middle ear was entered (*Figure 21*).

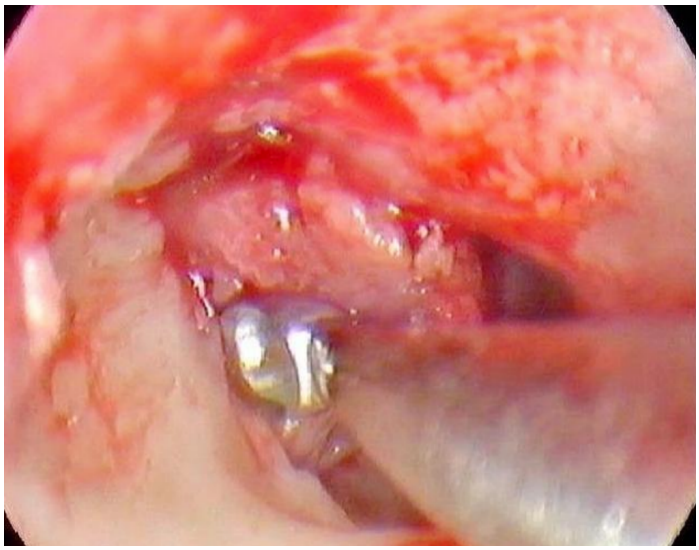


Figure 22: Right ear: wide atticotomy performed with curette

A wide atticotomy was performed with a curette (*Figure 22*).

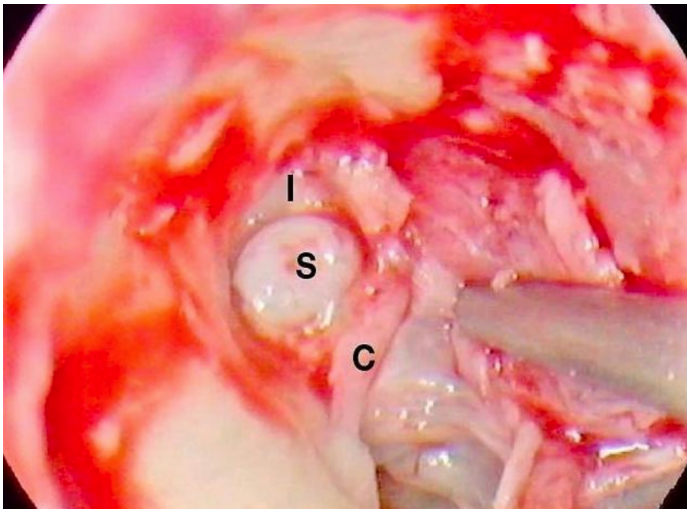


Figure 23: Right ear: Sac (S) has been pulled down from attic, lateral to body of incus and medial to scutum. Body of incus (I) can be seen. Chorda (C) forms a collar around the neck of the sac

The cholesteatoma sac was identified; it extended to the lateral attic and was pulled downward lateral to the body of the incus and medial to the removed scutum (*Figure 23*).

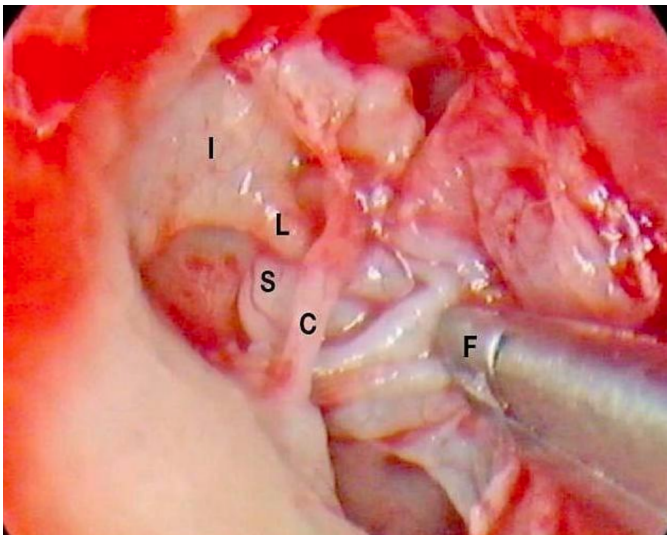


Figure 24: Right ear: Sac has been completely delivered from area lateral to body of incus (I), but another process of the sac (S) has rotated posteriorly and medially around the incudostapedial joint, medial to long process of the incus (L). Cupped forceps (F) are used to pull the sac from underneath the chorda (C)

Another extension of the sac had rotated posteriorly and medially around the incudostapedial joint and the superstructure of the stapes and had advanced medial to the long process of the incus (*Figure 24*).

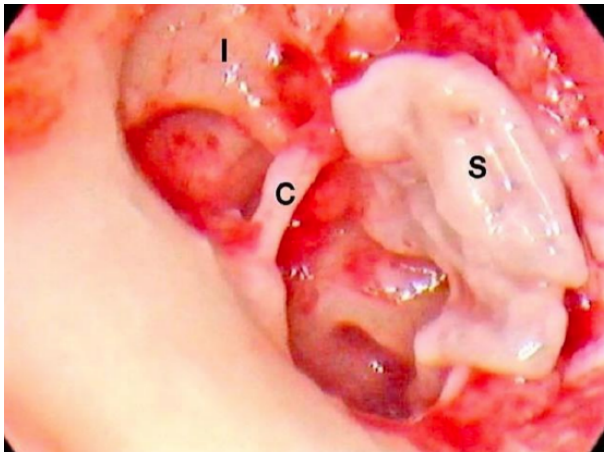


Figure 25: Right ear: Sac (S) has been completely delivered and deflected over the tympanomeatal flap with incus (I) and chorda (C) in view

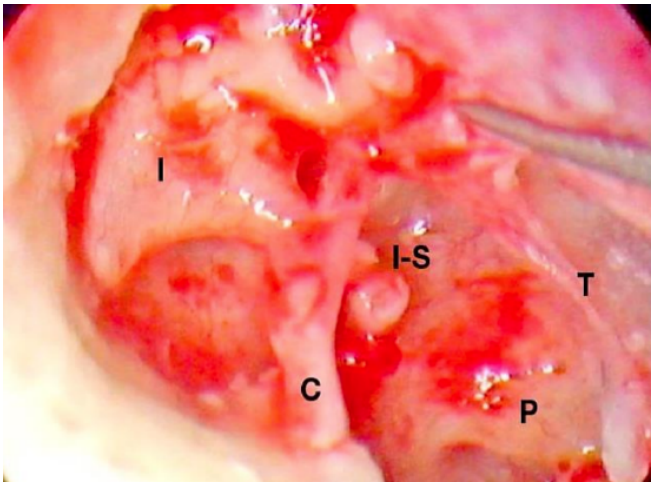


Figure 26: Right ear: Sac is removed. Cholesteatoma has eroded incudostapedial joint (I-S). The incus (I), chorda (C), and promontory (P) are clearly seen. The anterior edge of the tympanic membrane retraction (T), now a perforation, is also visible

The sac is delivered (*Figure 25*). It was evident that the sac had eroded the incudostapedial joint (*Figure 26*).

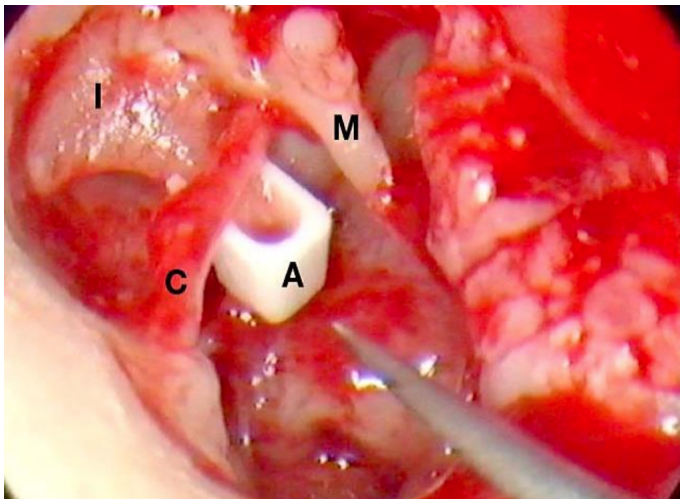


Figure 27: Right ear: A prosthesis (A) is used to reconstruct the incudostapedial joint. Handle of malleus (M) and incus (I) and chorda (C) are seen

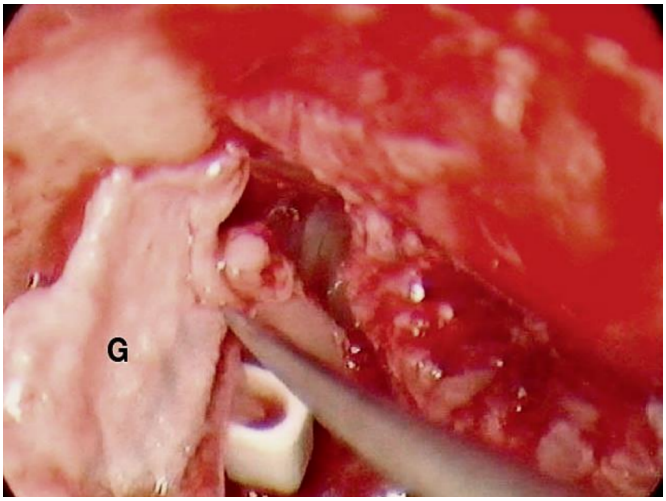


Figure 28: Right ear: Attic defect being reconstructed with a composite tragal cartilage graft (G)

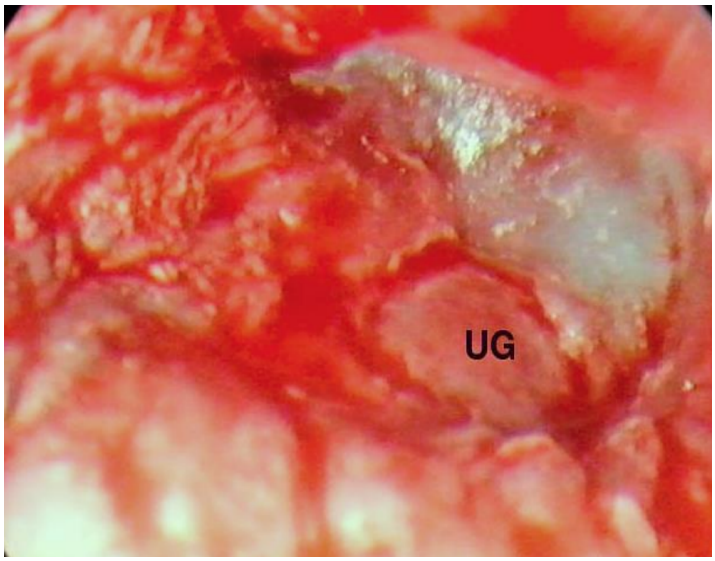


Figure 29: Right ear: Tympanomeatal flap is repositioned over underlay graft (UG)

A prosthesis was used to reconstruct the ossicular chain (*Figure 27*). A tragal composite graft with perichondrium was used to reconstruct the attic defect (*Figure 28*). The defect in the tympanic membrane was reconstructed with a perichondrial underlay graft, and the tympanomeatal flap was repositioned (*Figure 29*).

Endoscopic open cavity management of cholesteatoma

In canal wall down procedures all disease containing cavities are exteriorized to provide aeration and direct access to the disease in an ambulatory (clinic) setting. However, during the process of accessing the disease, large cavities that may require lifelong maintenance are created. In addition, unpredictable healing, fibrosis, and meatal stenosis, which are associated with postauricular canal wall down procedures, may prevent later ossicular reconstruction.

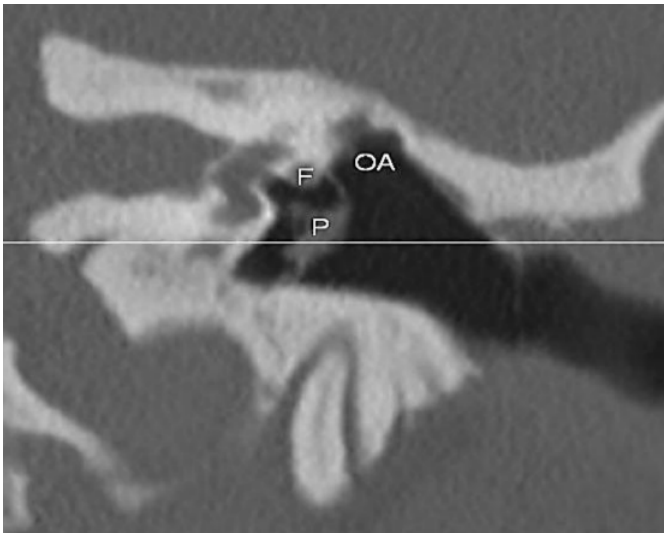


Figure 30: Left ear: Coronal CT following endoscopic open cavity management of cholesteatoma. Neotympanic membrane is reconstructed up to level of horizontal segment of facial nerve (FN); attic is left open (OA)

Endoscopic techniques permit transcanal exploration of disease-containing area without opening areas that are not involved by cholesteatoma. The transcanal endoscopic approach opens only diseased areas, preserves many healthy air cells, and leaves the cortical bone intact. It also allows one to create two separate cavities; a small reconstructed tympanic cavity that conducts sound through the middle ear and is small enough to be serviced by the (usually dysfunctional) eustachian tube, and a larger attic, antrum, and mastoid cavity, which is joined to the ear canal and exteriorized (*Figure 30*).

Such an approach was described by Tos in 1982.[27] It enables one to reconstruct the middle ear in a highly predictable fashion, and in turn creates a better foundation for ossicular and tympanic membrane reconstruction.

A major concern for many surgeons is the possibility of closing off an open attic. This concern is based on results of traditional open mastoid surgery in which damage to the cartilaginous ear canal produces a vicious circle: trauma to the ear canal causes fibrosis and narrowing of the meatus which forces the surgeon to design a more aggressive meatoplasty which in turn causes more trauma, secondary fibrosis, and narrowing. A large meatus is created to compensate for fibrosis and narrowing. In contrast, the very limited trauma to the cartilaginous ear canal caused with endoscopic surgery allows surgeons to avoid such complications and produces a small, shallow, benign, problem-free cavity.

Technique

With endoscopic open cavity management of cholesteatoma, a wide posterior tympanomeatal flap is elevated as described above. A transcanal atticotomy is performed. The incus and head of malleus are removed from the attic. Aggressive bone removal is then performed to provide open endoscopic access to the attic and all the way into the antrum posteriorly. Tympanic membrane defects inferior to the horizontal segment of the facial nerve (including atelectatic areas) are reconstructed with perichondrial grafts which are placed directly onto the horizontal segment of the facial nerve superiorly and on a bed of Gelfoam packed in the middle ear inferiorly. The ear canal and opened attic are then packed with Gelfoam. This technique should result in a small, closed, reconstructed tympanic cavity and membrane anteriorly and inferiorly (to service the impedance-matching function of the middle ear) and an open attic and antrum superiorly and posteriorly (*Figure 30*).

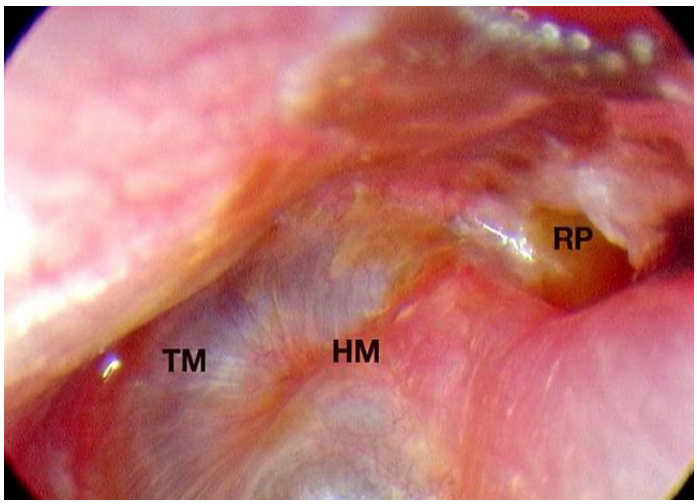


Figure 31: Left ear: Large retraction pocket (RP) with recurrent infections and granulation tissue (HM, handle of malleus; TM, tympanic membrane)

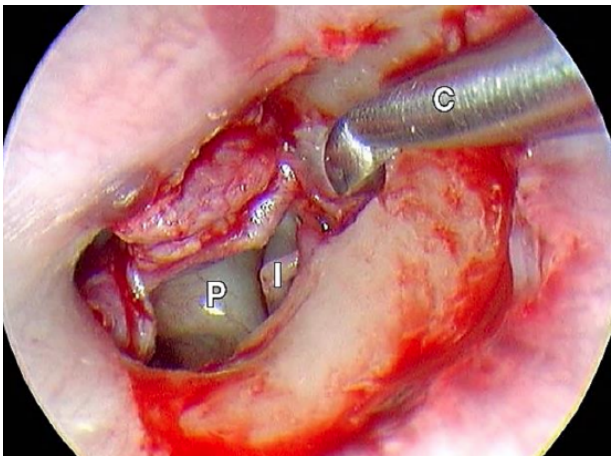


Figure 32: Left ear: Wide tympanomeatal flap is elevated. Promontory (P) and incudostapedial joint (I) are seen. A curette (C) is used to create an extended atticotomy

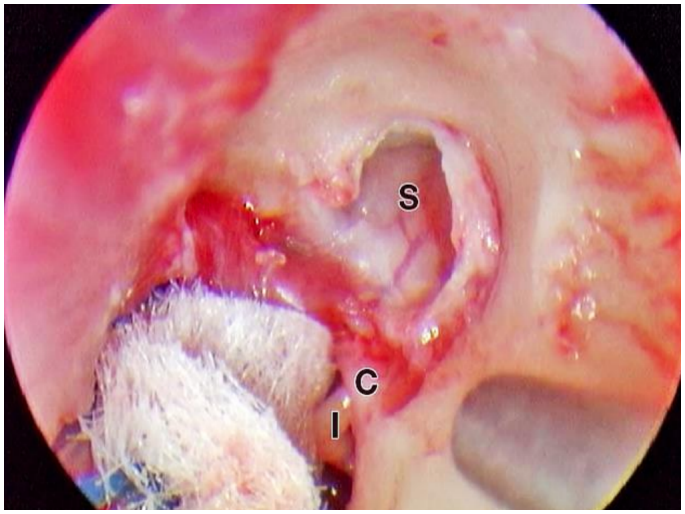


Figure 33: Left ear: Extended atticotomy and thick sac (S); (C, chorda tympani; I, incudostapedial joint)

Figure 31 shows a large attic retraction pocket after it was emptied of dermal debris. A wide tympanomeatal flap has been elevated and a thick vascularized sac can be seen after the atticotomy was extended (*Figures 32 & 33*).

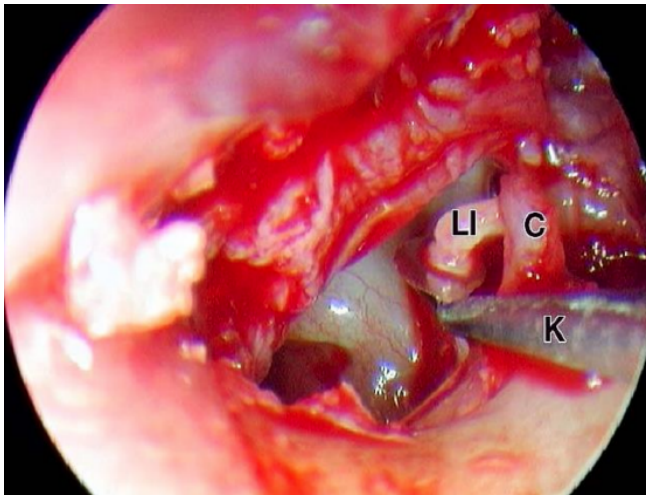


Figure 34: Left ear: Incudostapedial joint (LI) is dislocated with a small round knife. (C, chorda tympani)

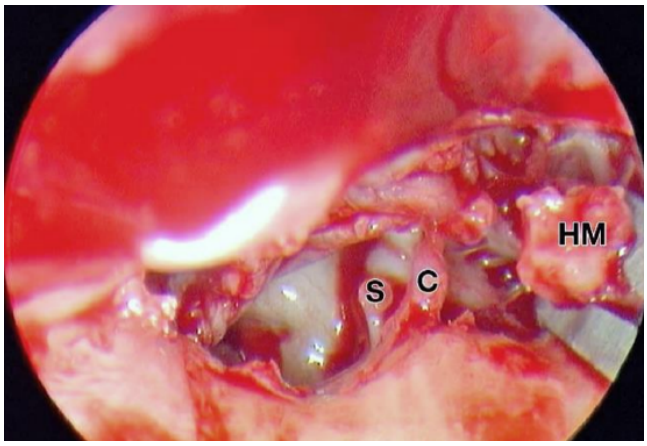


Figure 35: Left ear: Incus has been removed and head of malleus (HM) is being extracted. Note that head of malleus is separated from handle with malleus nipper proximally to preserve ligaments stabilizing handle of malleus. S, stapes; C, chorda tympani

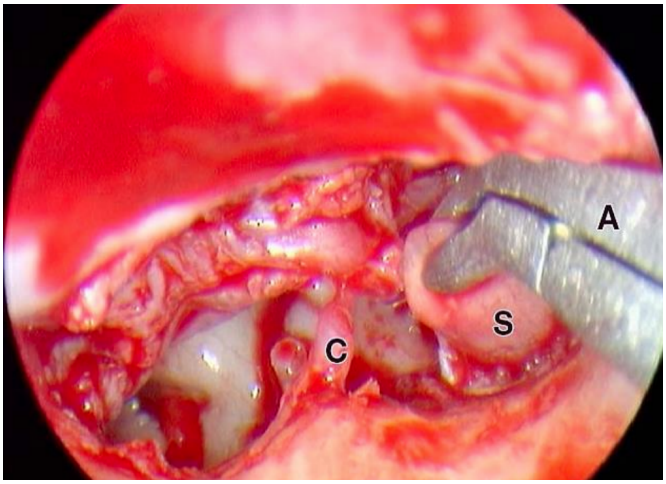


Figure 36: Left ear: Sac (S) being delivered (C, chorda tympani)

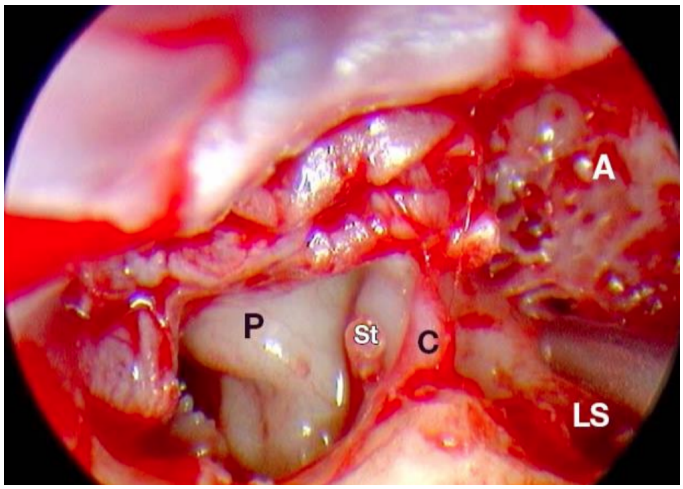


Figure 37: Left ear: Sac has been completely removed. (A, Attic; P, promontory; C, chorda tympani; S, stapes; LS, lateral semicircular canal)

The incus and the head of malleus were removed after dislocating the incudo-stapedial joint (*Figures 34*, *35*). The anterior epitympanum was cleared of disease. The remainder of the sac deep to the removed ossicles was removed after further widening the atticotomy (*Figure 36*). All disease was excised and specific attention was paid to the attic and the tympanic cavity (*Figure 37*).

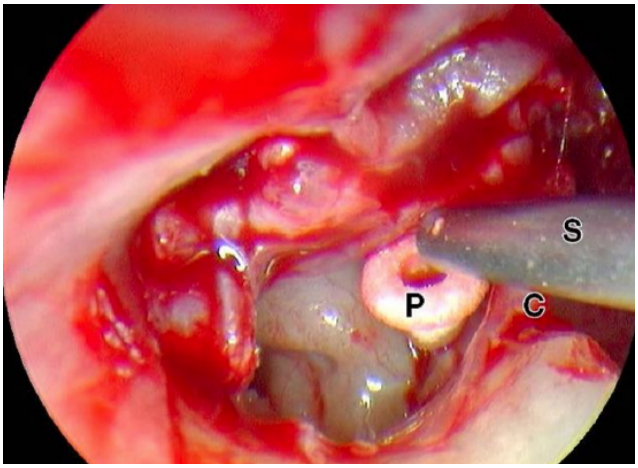


Figure 38: Left ear: Ossicular chain reconstructed with a prosthesis (P). C, chorda tympani; S, suction

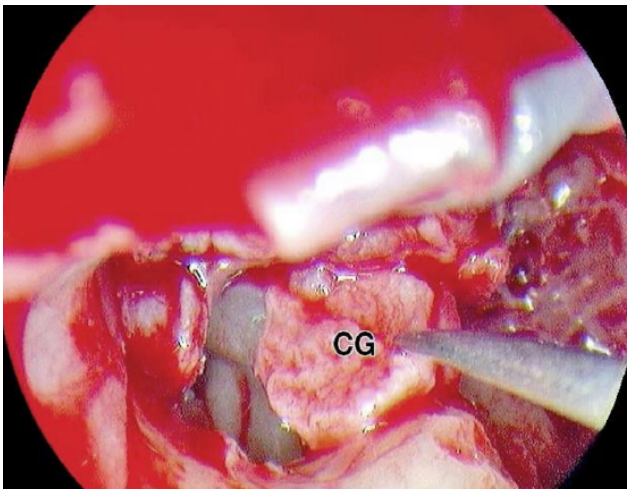


Figure 39: Left ear: Composite tragal cartilage (CG) is used on top of prosthesis

A prosthesis is used to reconstruct the ossicular chain (*Figure 38*) and a composite cartilage graft is positioned on top of the prosthesis (*Figure 39*).

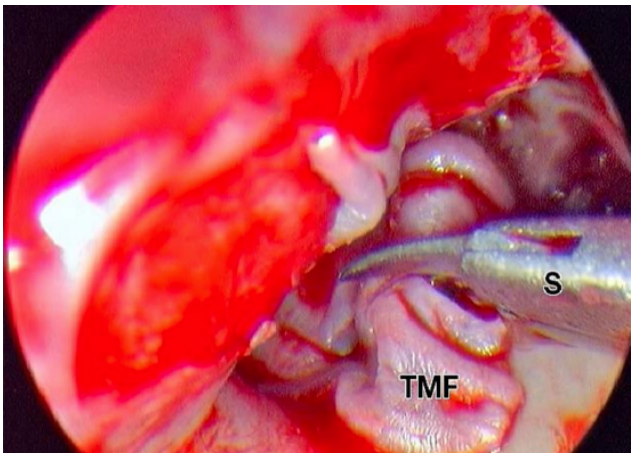


Figure 40: Left ear: Tympanomeatal flap is cut longitudinally with middle ear scissors

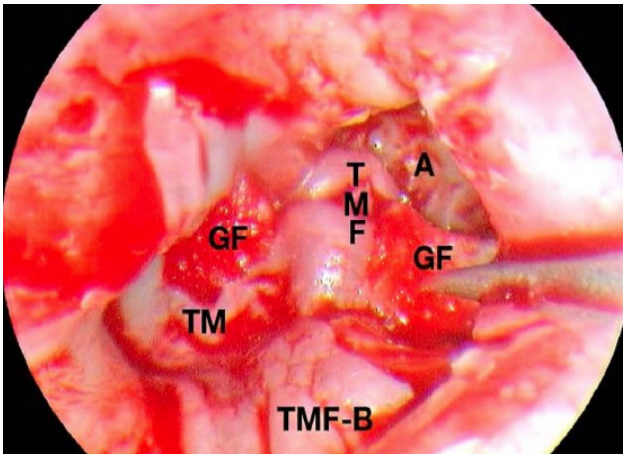


Figure 41: Left ear: Inferior part of tympanomeatal flap (TMF-B) is repositioned over ear canal while superior part of tympanomeatal flap (TMF) is reflected over horizontal segment of facial nerve into open attic (A). Small pieces of gelfoam (GF) are used to pack open the attic and ear canal. (TM, tympanic membrane)

The tympanomeatal flap is divided longitudinally (*Figure 40*); the inferior part is positioned over the ear canal, the superior part is draped over the horizontal segment of the facial nerve (*Figure 41*), and the attic is packed open with small pieces of gelfoam.

Expanded transcanal access to middle ear and petrous apex

Although the endoscope allows a more expanded transcanal access to the middle ear compared to the microscope, a small, angulated ear canal can sometimes be very limiting and preclude adequate exposure. In order to perform adequate and safe endoscopic surgery, as well as to provide wide access to disease in the anterior part of the middle ear, eustachian tube and petrous bone, it is essential to overcome limitations that may hamper access prior to addressing the disease.

Technique

The extent of the disease is determined by endoscopic examination and review of CTs of the temporal bone. The anterior part of the middle ear, eustachian tube, and significant disease within the hypotympanum often require an expanded transcanal approach. After defining factors in the ear canal that restrict access one has to decide whether to address such factors.

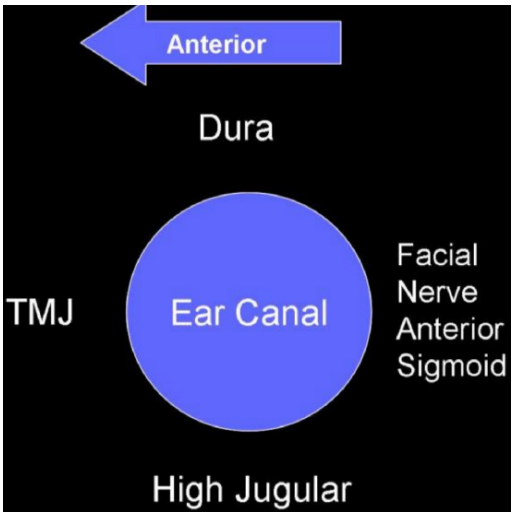


Figure 42: Structures to be considered when enlarging the ear canal

When enlarging the ear canal the surgeon needs to be keenly aware of important structures that lie in close proximity (*Figure 42*). One should also think of all the structures that border the tympanic cavity when enlarging the ear canal. The bony annulus has wide anatomical variations.[39] Posteriorly are the facial nerve and sigmoid sinus.[40] Inferiorly, a high jugular bulb may be laterally located and abut the ear canal.[41] Breaching the glenoid fossa anteriorly is usually a non-event, but can be a limiting factor.

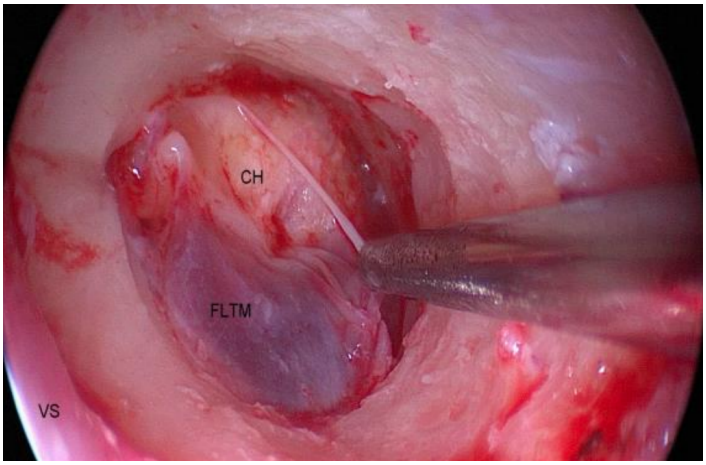


Figure 45: Right ear: Skin of ear canal is elevated in continuity with the epithelial layer of tympanic membrane with preservation of vascular strip, followed by enlargement of ear canal. VS: vascular strip; FLTM: fibrous layer of tympanic membrane; CH: cholesteatoma

The expanded transcanal approach is similar to Sheehy's lateral graft tympanoplasty. The skin of the ear canal is removed along with the epithelial outer layer of the tympanic membrane. A vascular strip is preserved (*Figure 45*). The ear canal is enlarged with a drill as needed. The annulus and fibrous layer of the tympanic membrane are elevated either partially or completely to provide access. The entire overhanging bony annulus is curetted to provide wide access to the middle ear. After the necessary ossicular chain work has been completed the remaining tympanic membrane is repositioned, a lateral graft is applied, and the skin of the ear canal is repositioned and held in place with packing.

Clinical example



Figure 43: Right ear: Anterior whitish lesion behind intact tympanic membrane

A patient with longstanding right-sided hearing loss and dizziness had an anteriorly located whitish lesion behind an intact tympanic membrane (*Figure 43*).

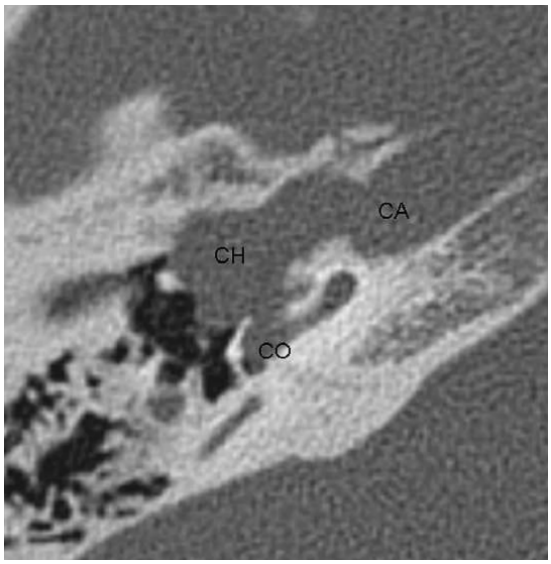


Figure 44: Right ear: Axial CT of temporal bone. CO: basal turn of cochlea; CA: carotid artery; CH: cholesteatoma

Audiometry indicated a “dead” right ear. CT scan showed extensive cholesteatoma of the petrous bone eroding cochlea and carotid artery (*Figure 44*). Using an "expanded transcanal access" technique, the vascular strip is preserved, the ear canal skin is removed, the fibrous layer of the tympanic membrane is preserved, and the ear canal is enlarged (*Figure 45*).

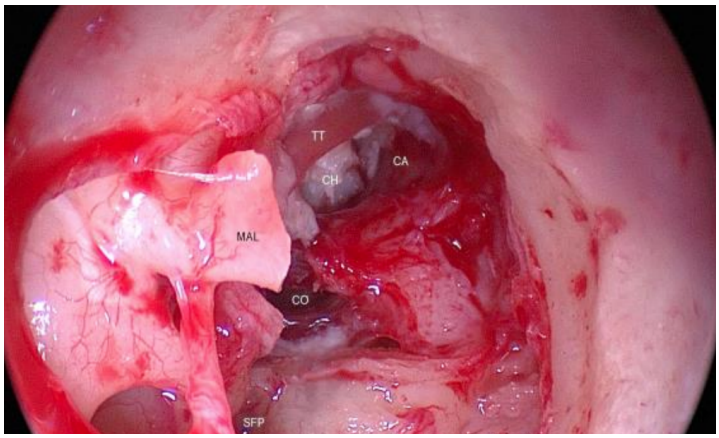


Figure 46: Right ear: Much of the cholesteatoma eroding the cochlea has been removed (MAL: malleus with handle transected; SFP: stapes footplate; CO: eroded middle turn of the cochlea; CA: eroded carotid artery canal; CH: cholesteatoma in petrous apex surrounding TT: tensor tympani muscle)

An extensive cholesteatoma had eroded the bony covering of the tensor tympani muscle and carotid and middle and apical turns of the cochlea (*Figure 45*). The cholesteatoma was completely removed from the petrous apex (*Figure 46*).

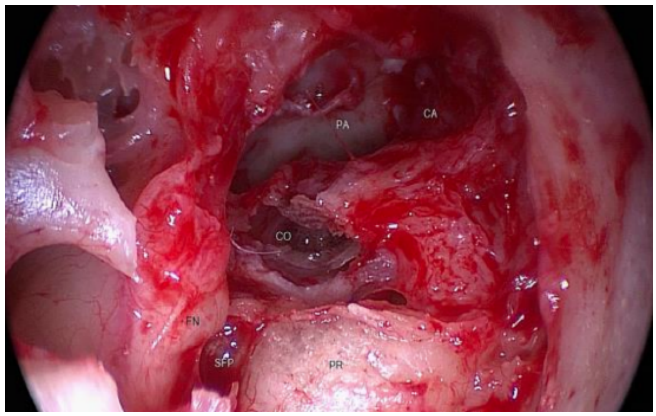


Figure 47: Right ear: View after complete removal of cholesteatoma (PA: petrous apex; CA: carotid artery; CO: eroded middle turn of cochlea; FN: dehiscent facial nerve; SFP: stapes footplate; PR: promontory)

Endoscopic tympanoplasty

Depending on the anatomy of the ear canal and the size and location of the perforation, the author uses either of two approaches to graft the tympanic membrane:

1. ***Endoscopic transcanal medial graft tympanoplasty***: Small and well exposed perforations
2. ***Endoscopic Sheehy's lateral graft tympanoplasty***: Total perforations, surgical failures and for ear canals that limit access

Endoscopic transcanal medial graft tympanoplasty

Medial graft tympanoplasty is commonly practiced. Adequate exposure of the whole tympanic perforation is key to its success. When using a microscope, unfavorable ear canal anatomy and/or anterior perforations make for technically challenging transcanal procedures and a postauricular approach may be needed to provide adequate access. The endoscope allows for a wide transcanal, all-encompassing view of all the elements of this surgery i.e. the ear canal, tympanic ring, and tympanic membrane, without needing to continuously reposition the microscope, even in the presence of an anterior overhang.

Technique

All surgical steps are performed with an endoscope. This includes injection of the ear canal, debridement of the edges of the perforation, elevation of a tympanomeatal flap, inspection of the middle ear for disease and ossicular integrity, positioning of a medially placed graft on a bed of gelfoam, repositioning of the tympanomeatal graft and packing the ear canal with gelfoam.

Clinical example

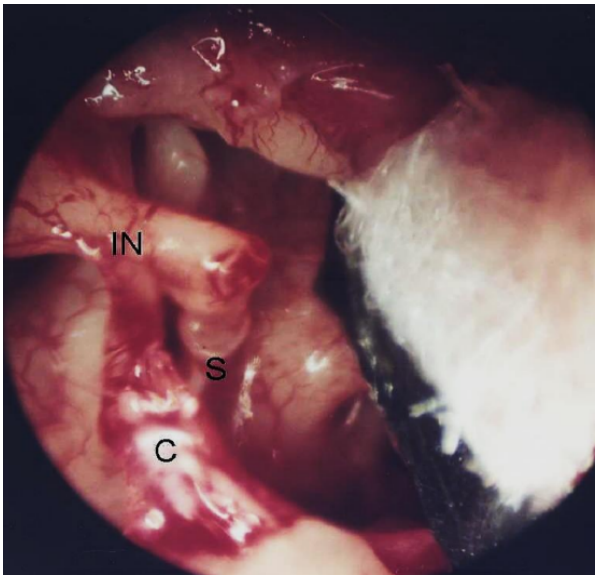


Figure 48: A tympanomeatal flap is reflected anteriorly to reveal the incus (IN), stapes (S) and chorda (C)

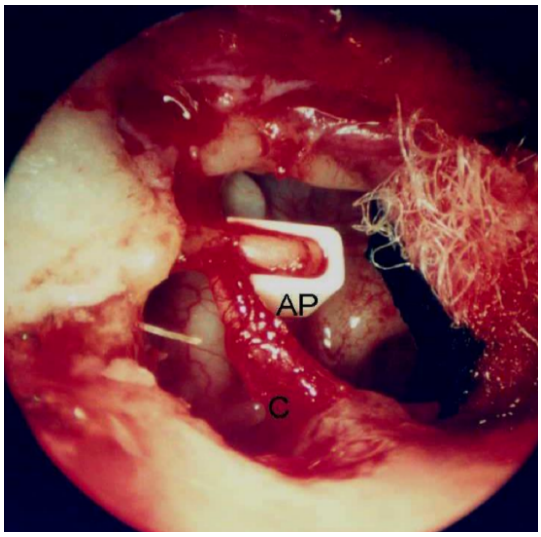


Figure 49: Applebaum prosthesis (AP) is used to bridge the incudostapedial joint

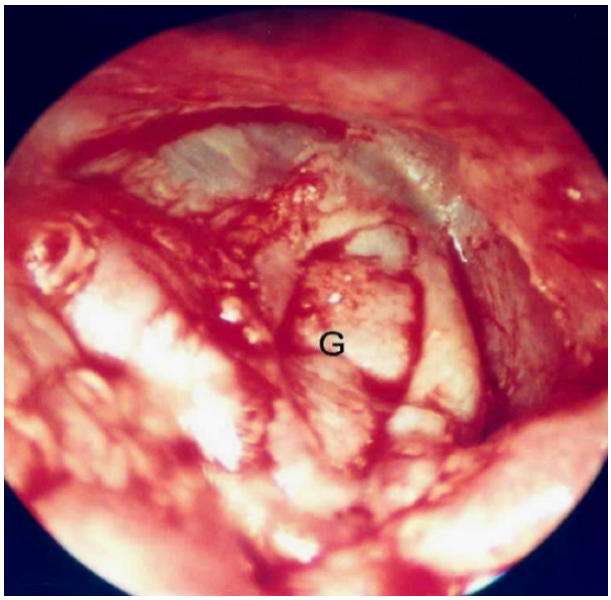


Figure 50: Graft (G) in place

Figures 48 - 50 illustrate a case of central tympanic membrane perforation with moderate conductive hearing loss. Transcanal endoscopic medial graft tympanoplasty is performed and the incudo-stapedial joint dislocation is addressed with an Applebaum prosthesis.

Endoscopic Sheehy lateral graft tympanoplasty

Lateral graft tympanoplasty has stood the test of time as an effective surgical approach for large perforations. It involves more extensive surgery than transcanal medial graft technique, but usually produces a higher success rates. Critical to it's success is a wide exposure of the ear canal which classically involves a postauricular approach. The endoscope offers a wide transcanal access and view of the ear canal and tympanic membrane without the need for a postauricular approach.

Technique

Using transcanal endoscopy, the skin of the ear canal is elevated along with the epithelial layer of the remaining tympanic membrane with the preservation of vascular strip. The ear canal is then enlarged as needed with a drill. The middle ear is packed with gelfoam. The graft is positioned lateral to the fibrous layer of the membrane and is tucked under the handle of malleus. The skin of the canal is then repositioned and the canal is packed with gelfoam.

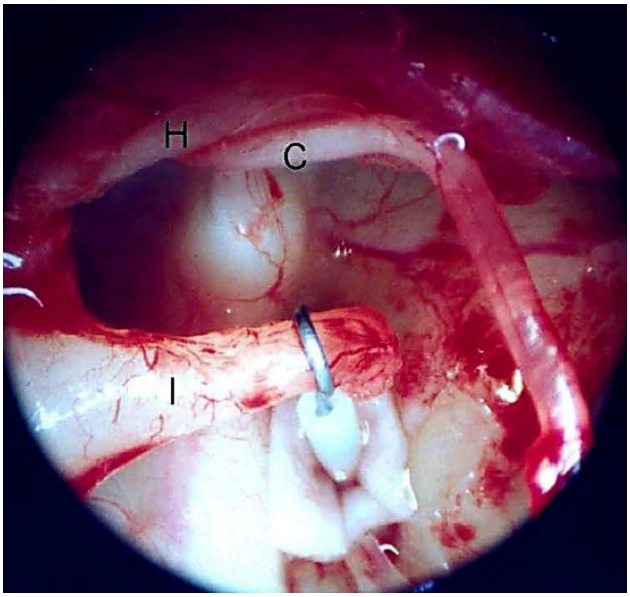


Figure 51: Stapes prosthesis in place

Although experienced endoscopic surgeons probably prefer the using the endoscope, there are no compelling reasons to use the endoscope instead of the microscope in stapes surgery as the microscope offers a good view of the region of the stapes (*Figure 51*).

A few issues need to be taken into consideration when using the endoscope for stapes surgery. The first is that the endoscope's wide angle allows a better view of the footplate without much curetting of bone. However, the improved view does not translate into improved access when using traditional straight picks and drill bits. One needs to overexpose these areas endoscopically in order to allow work to be done using existing straight instruments. The second issue relates to crimping of the wire over the the incus. If the surgeon spends too much time with the light of the endoscope directed at the piston wire prosthesis, the wire is heated and "uncrimps" because of the memory of the metal used and its tendency to return to its original shape when heated. The third issue is that the endoscope deprives the surgeon from using a two-handed technique to placement a bucket handle type prosthesis.

Concluding comments

The story of endoscopic management of cholesteatoma is that of rediscovering the ear canal as the most direct and natural access to cholesteatoma which is limited to the mesotympanum, attic, facial recess, sinus tympani, hypotympanum, and eustachian tube. It offers a fresh outlook on this disease and changes the surgical treatment paradigm of such cholesteatoma.

Editor's comment

Endoscopic otologic surgery presents a cheaper and more transportable option than operating microscopes for surgeons working in resource constrained developing world countries to perform myringotomies, insert ventilation tubes (grommets) and do tympanoplasties.

References

1. Thomassin JM, Korchia D, Doris JM. Endoscopic-guided otosurgery in the prevention of residual cholesteatomas. Laryngoscope 1993;103:939-43
2. Hawke M. Telescopic otoscopy and photography of the tympanic membrane. J Otolaryngol 1982;11:35-9
3. Nomura Y. Effective photography in otolaryngology-head and neck surgery: endoscopic photography of the middle ear. Otolaryngol Head Neck Surg 1982;90:395-8
4. Takahashi H, Honjo I, Fujita A, Kurata K. Transtympanic endoscopic findings in patients with otitis media with effusion. Arch Otolaryngol Head Neck Surg 1990;116:1186-9
5. Poe DS, Bottrill ID. Comparison of endoscopic and surgical explorations for perilymphatic fistulas. Am J Otol 1994;15:735-8
6. McKennan KX. Endoscopic 'second look' mastoidoscopy to rule out residual epitympanic/mastoid cholesteatoma. Laryngoscope 1993;103:810-4
7. Tarabichi M. Endoscopic management of acquired cholesteatoma. Am J Otol 1997;18:544-9
8. Tarabichi M. Endoscopic middle ear surgery. Ann Otol Rhinol Laryngol 1999;108:39-46

9. Tarabichi M. Endoscopic management of cholesteatoma: long-term results. Otolaryngol Head Neck Surg 2000; 122:874-81
10. Tarabichi M. Endoscopic management of limited attic cholesteatoma. Laryngoscope 2004;114:1157-62
11. Kakehata S, Futai K, Sasaki A, Shinkawa H. Endoscopic transtympanic tympanoplasty in the treatment of conductive hearing loss: early results. Otol Neurotol. 2006 Jan;27(1):14-9
12. Kakehata S, Hozawa K, Futai K, Shinkawa H. Evaluation of attic retraction pockets by microendoscopy. Otol Neurotol. 2005 Sep;26(5):834-7
13. Kakehata S, Futai K, Kuroda R, Shinkawa H. Office-based endoscopic procedure for diagnosis in conductive hearing loss cases using OtoScan Laser-Assisted Myringotomy. Laryngoscope. 2004 Jul;114(7):1285-9
14. Badr-el-Dine M. Value of ear endoscopy in cholesteatoma surgery. Otol Neurotol 2002;23:631-5
15. El-Meselaty K, Badr-El-Dine M, Mandour M, Mourad M, Darweesh R. Endoscope affects decision making in cholesteatoma surgery. Otolaryngol Head Neck Surg 2003; 129: 490-6
16. Yung MW. The use of middle ear endoscopy: has residual cholesteatoma been eliminated? J Laryngol Otol 2001;115:958-61
17. Ayache S, Tramier B, Strunski V. Otoendoscopy in cholesteatoma surgery of the middle ear. What benefits can be expected? Otol Neurotol. 2008 Dec;29(8):1085-90
18. Abdel Baki F, Badr-El-Dine M, El Saiid I, Bakry M. Sinus tympani endoscopic anatomy. Otolaryngol Head Neck Surg. 2002; 127: 158-62
19. Mattox DE. Endoscopy-assisted surgery of the petrous apex. Otolaryngol Head Neck Surg. 2004;130:229-41
20. Magnan J, Sanna M. Endoscopy in neuro-otology. Stuttgart: Georg Thieme Verlag; 2003
21. Badr-El-Dine M, El-Garem HF, Talaat AM, Magnan J. Endoscopically Assisted Minimally Invasive Microvascular Decompression of Hemifacial Spasm. Otol Neurotol 2002; 122-8
22. El-Garem HF, Badr-El-Dine M, Talaat AM, Magnan J. Endoscopy as a Tool in Minimally Invasive Trigeminal Neuralgia Surgery. Otol Neurotol 2002 132-5
23. Badr-El-Dine M, El-Garem HF, ElAshram Y, Talaat AM, Magnan J. Endoscope Assisted Minimal Invasive Microvascular Decompression of Hemifacial spasm. Abstracts of the 9th International Facial Nerve Symposium. Otol Neurotol Suppl. 2002; 23 (3): 68- 72
24. Rosenberg SI, Silverstein H, Willcox TO, Gordon MA. Endoscopy in otology and neurotology. Am J Otol 1994;15:168-72
25. Presutti L, Marchioni D, Mattioli F, et al. Endoscopic Management of Acquired Cholesteatoma: Our Experience. Otolaryngol Head Neck Surg, 2008: 37, (4), 1-7
26. Marchioni D, Mattioli F, Ciufelli MA, Presutti L. Endoscopic approach to tensor fold in patients with attic cholesteatoma. Acta Otolaryngol 2008,19:1-9
27. Tos M. Modification of combinedapproach tympanoplasty in attic cholesteatoma. Arch Otolaryngol 1982;108:772-8
28. Sheehy JL, Brackmann DE, Graham MD. Cholesteatoma surgery: residual and recurrent disease. A review of 1,024 cases. Ann Otol Rhinol Laryngol 1977;86:451-62
29. Glasscock ME, Miller GW. Intact canal wall tympanoplasty in the management of cholesteatoma. Laryngoscope 1976;86:1639-57
30. Kinney SE. Five years experience using the intact canal wall tympanoplasty with mastoidectomy for cholesteatoma: preliminary report. Laryngoscope 1982;92:1395-400
31. Chatellier HP, Lemoine J. Le diaphragme interattico-tympanique du 612 nouveau-né. Description de sa morphologie considérations sur son role 613 pathogénique dans les otomastoidites cloisonnées du nourisson. Ann Otolaryngol Chir Cervicofac (Paris) 1945;13:534-66
32. Aimi K. The tympanic isthmus: its anatomy and clinical significance. Laryngoscope 1978;88(7 Pt 1):1067-81
33. Palva T, Ramsay H. Incudal folds and epitympanic aeration. Am J Otol 1996; 17:700-8
34. Palva T, Ramsay H, Böhling T. Tensor fold and anterior epitympanum Am J Otol 1997;18:307-16.
35. Hammar JA. Studien Uper Die Entwicklung Des Vorderdarms und Einiger Angrenzenden Organe. Arch Mikroskop Anat 1902;59: 471-628
36. Proctor B. The development of the middle ear spaces and their surgical significance. J Laryngol Otol 1964;78: 631-48
37. Tono T, Schachern PA, Morizono T, Paparella MM, Morimitsu T. Developmental anatomy of the supratubal recess in temporal bones from fetuses and children. Am J Otol 1996;17:99-07
38. Schuknecht HF, Gulya AJ. Anatomy of the Temporal Bone with Surgical Implications. Philadelphia, Pa: Lea & Febiger; 1986:89-90
39. Adad B, Rasgon BM, Ackerson L. Relationship of the facial nerve to the tympanic annulus: a direct anatomic examination. Laryngoscope 1999;109: 1189-92

40. Gangopadhyay KP, McArthur D, Larsson SG. Unusual anterior course of the sigmoid sinus: report of a case and review of the literature. J Laryngol Otol 1996;110:984-6
41. Philip J. Moore.The high jugular bulb in ear surgery: three case reports and a review of the literature. J Laryngol Otol 1994;108:772-5

Surgical videos on YouTube

Author

Muaaz Tarabichi MD
Center for Ear Endoscopy
Kenosha, Wisconsin, USA
& American Hospital Dubai, Dubai UAE
mtarabichi@ahdubai.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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Malou Hultcrantz



Figure 1a: Titanium fixture anchored in the bone with an abutment attached. The processor is connected to the abutment with a snap coupling.



Figure 1b: Titanium fixture with abutment

Bone anchored hearing implants/aids (BAHI/BAHA) utilize a bone anchored hearing aid system to assist people with conductive hearing loss who cannot use traditional hearing aids. It was introduced in the 1970s in the field of dentistry by Swedish Professor Per-Inge Brånemark who implanted titanium dental fixtures in the jaw. He then proceeded to develop titanium implants to anchor hearing aids to the skull with Dr Anders Tjellström, a Swedish ENT surgeon[1]. The system comprises an osseointegrated implant, an abutment, and a processor (*Figures 1a, b*).

The fixture uses the characteristics of titanium to osseointegrate into bone. Bone cells (osteoblasts) adhere to the titanium surface of the implant without any other cells or capsules developing in-between. The biocompatibility of the metal is dependent on the titanium oxide layer on the surface of the implant and the lack of tissue interface between the bone and the titanium, all of which improve bone conduction of sound[2]. The surface and shape of the implant and its abutment have since been refined. Different surfaces of the abutment have been tested and refinements continue.

Surgical techniques continue to evolve. Historically there was a long tradition of a “skin thinning technique”. The idea was to minimize the depth of the skin down to the periosteum and to remove all subcutaneous tissue as well as hair roots to avoid bacterial penetration. The ideal thickness of the skin was recommended to be 0.2-0.5 mm. In the early days a full skin transplant replaced the removed tissue and the surgical procedure took up to 5 hours[3]. With new tools and new surgical flap techniques (semicircular flaps, dermatome, pre-drawn fixtures/abutments, one-step surgery etc.) the operating time was reduced to about 1 hour. The dermatome was introduced in 2006 to create a skin flap of predesigned thickness - a measure that also reduced the surgery time - but with the drawback that flap necrosis occurred more commonly[4]. The surgical procedure was further simplified by changing the surgical tools and implant design. Further refinements were introduced in 2007 when the skin thinning technique was replaced by a “*non-skin thinning*” or “*tissue preserving*” technique. Nowadays one simply makes small openings in the skin without skin reduction by punching a hole through which the abutment is externalized[5]. This requires longer abutments which are commercially available. This technique has reduced the surgical time to 10-15 min. The situation has also changed over the years in pediatrics; now the implantation is done in a single step in children[6]. The most recent development is implants placed under the skin with the processor connected via a magnet.

Physiology of bone conduction

The BAHA/BAHI employs direct percutaneous coupling of sound vibrations from a transducer to a titanium implant anchored in the skull. Hearing through direct bone conduction is defined as “sound transmission via bone conduction without the skin and soft tissue being part of the vibration transmission pathway between the transducer and the skull bone.” Direct bone conduction provides a sensitive input for vibrations to the skull, high-quality transmission of sound with sufficient gain and power output, and also improved patient comfort.

It is the cochlear function that is important; if sensorineural hearing is sufficient, then a bone-conduction hearing aid can transmit sound to the cochlea. The degree of conductive hearing loss is of minor importance since the bone-conducted sound bypasses the middle ear; the benefits of BAHA/BAHI are therefore independent of the external and middle ears[7].

When an acoustic stimulus is presented to one ear there is a reduction in intensity of the sound perceived by the opposite ear. This phenomenon is called ***interaural attenuation***. For air conduction, the reduction approximates 35 dB, but for bone conduction, it is <10 dB. Consequently the sound delivered with a bone-anchored solution is delivered to the opposite cochlea without much loss.

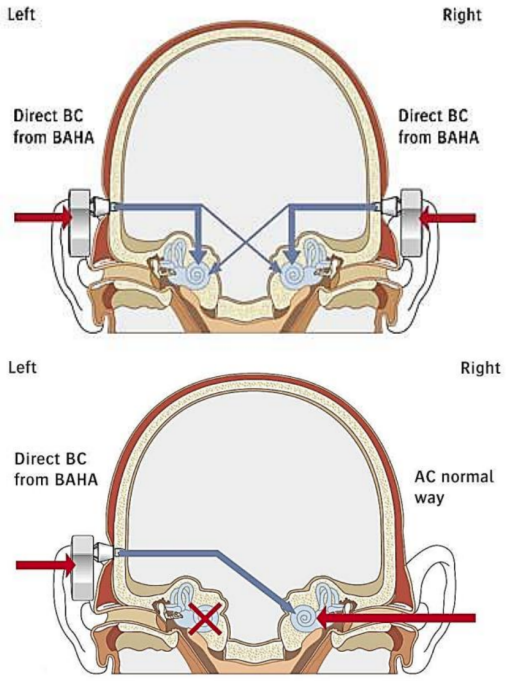


Figure 2: Sound conduction in the case of two normal cochleae (above) or with only a functioning right cochlea and left SSD

Hearing with two ears ***(binaural hearing)*** makes it possible to localize the source of a sound and to hear better in noisy environments. If one has only one hearing ear i.e. single sided deafness (SSD) or ear canal atresia etc., the absence of a time lag between sounds reaching each ear means that one’s ability to localize the source of a sound is lost. The BAHI has been shown to be of value when there is only one functioning cochlea with SSD; sound waves from the processor on the deaf side are transmitted to the contralateral functioning cochlea (*Figure 2*). However even though binaural hearing will not develop if implanted in adulthood, it might be possible to achieve binaural hearing if the implant is placed early in childhood.

BAHA/BAHI



Figure 3a: Cochlear osseointegration system with coupling inside the abutment



Figure 3b: Oticon system: Left-to-right: Sound processor; Coupling; Screw; Abutment; Implant. The coupling is on the outside of the abutment

The BAHA/BAHI has 3 parts (*Figure 3*):

1. Titanium fixture introduced into the skull behind and above the pinna
2. Skin-penetrating abutment attached (screwed) to the fixture
3. Conventional microphone and amplifier (processor) connected by a snap coupling to the abutment

Patient selection

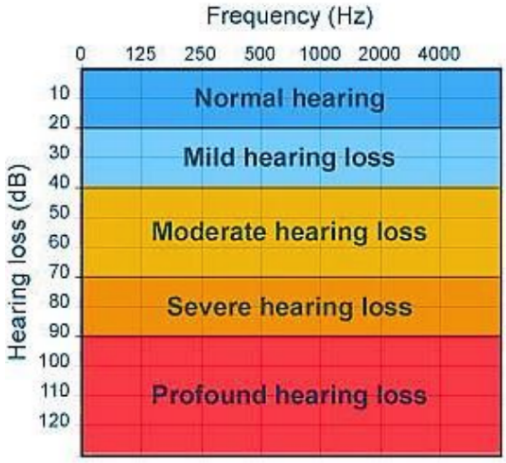


Figure 4: Classification of hearing loss

Degree of HL	Hearing loss (dB HL)
Normal	–10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55

Moderately severe	56 to 70
Severe	71 to 90
Profound	91+

Table 1: Classification of hearing loss (HL)

All patients who need a hearing aid but cannot have it fitted into the ear canal may benefit from a BAHI - within certain limits depending on the patient, implant and processor. *Figure 4* and *Table 1* and below show one of the more commonly used classification systems (degree of hearing loss = severity of loss). Many vendors recommend BAHI as a solution for patients with moderate-to-severe mixed hearing loss.

To identify a suitable patient requires an audiogram with classification of type of hearing loss and at least a 3-4 weeks trial of a BAHI on a soft band at home and in working situations. If a patient is still interested to proceed after such a trial, surgery can be planned. This selection process hopefully reduces the number of future nonusers. The benefit is limited by inner ear “cochlear” function. However, even if a patient does not fall within the recommended domain of hearing loss, it may be worth a trial of a BAHI with a headband for 3 weeks. Some patients do benefit even if it is difficult to predict according to existing hearing tests.

Indications for BAHI include:

1. Conductive hearing loss, when using conventional hearing aids is impossible (ear canal problems, allergy to hearing aid material), or when hearing aids are contraindicated (ear must be kept dry) or ineffective
2. Mixed hearing loss (both conductive and sensorineural hearing loss)
3. Chronic otitis media, or chronic suppurative otitis media with otorrhoea (impossible to use a conventional hearing aid)
4. Congenital microtia or canal atresia (no ear canal for fitting)
5. Chronic otitis externa (skin problems)
6. Discomfort with conventional hearing aids (pain, moist, recurrent infection)
7. Ineffective conventional hearing aids due to considerable air-bone gap (not enough ”gain”, bad occlusion or feedback)
8. Single sided deafness (SSD); note that BAHI devices do not restore binaural hearing
9. Bilateral and single sided conductive hearing loss (CHL)
10. Bilateral hearing problems/infections where surgery is planned for the two ears at different times (hearing while waiting)

Selecting an appropriate BAHA/BAHI

Different devices are recommended in accordance with hearing loss and individual preference. General examples are given below.

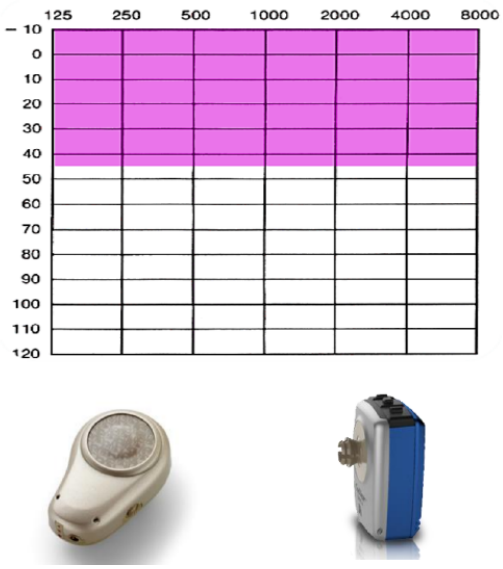


Figure 5: Hearing loss area for patients to benefit from Ponto processors (Oticon) & Baha[4] (Cochlear).

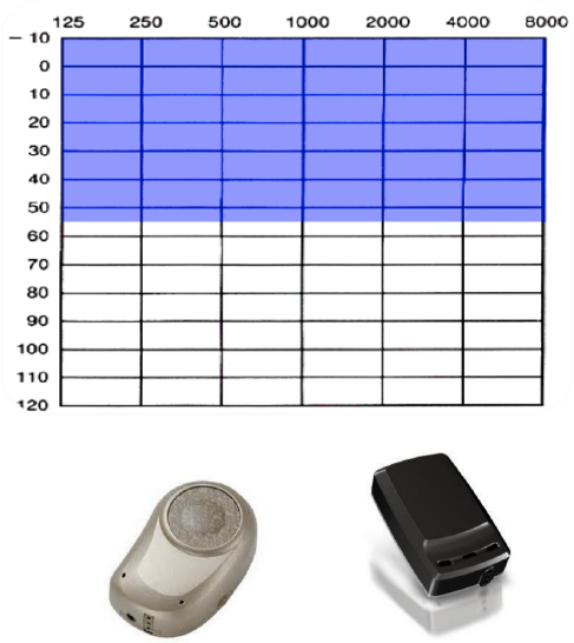


Figure 6: Ponto Pro Power® (Oticon)[8] & Baha[3] Power Sound Processor ® (Cochlear)[9]

Figure 5 illustrates the recommended hearing loss area for patients to benefit from Ponto processors & BAHA[4]. *Figure 6* illustrates the recommended hearing loss for patients to benefit from a more powerful Ponto Pro Power ® (Oticon)[8] & Baha[3] Power ® (Cochlear)[9].



Figure 7: BAHI Cordell, the most powerful device and body worn

Figure 7 illustrates the recommended hearing loss area for patients to benefit from a BAHI Cordell, which is the most powerful device and is body worn.

Surgical procedure



Figure 8: Normal hair cover 5 years after surgery

Older techniques that employ skin thinning are still used in many countries. However newer skin preservation techniques have proven to be safe in the long-term and have significant benefits[10] i.e. reduced surgical time; quicker healing; earlier loading of the processor; less peri-implant infections; no numbness around the implant site; and normal hair cover (*Figure 8*).

Skin thinning technique

The older skin thinning technique (dermatome and variety of flap techniques) has been so frequently used all over the world and will only be briefly described. It is often performed under general anesthesia and the surgical time about 45 min. The principal step is to raise a flap either with a dermatome or with a knife and to reduce the subcutaneous tissue down to periosteum. This can also be achieved by totally removing a circle of skin for a new skin graft. The skin is thinned and hair follicles reduced; the hole in the skull bone is drilled; the implant with pre-drawn abutment is introduced; a hole is punched through the thinned skin where the abutment is externalized; and the wound is closed and dressed.

Linear incision with tissue preservation



Figure 9: Patient anesthetized with head in lateral position

- Most adults cases are done under local anesthesia as an outpatient procedure with the head turned to the side; general anesthesia can be done with a laryngeal mask (*Figure 9*)

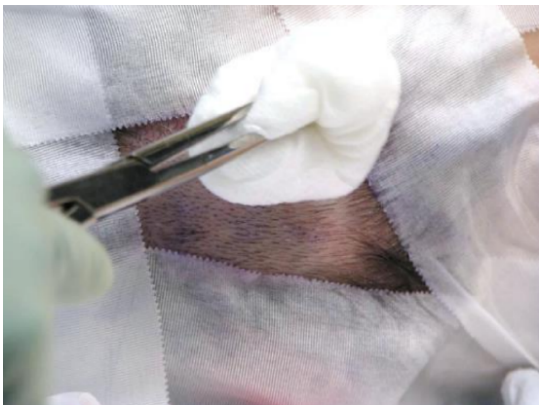


Figure 10: Washing and then redrawing so that the designated spot is visible

- Clean the skin and drape the surgical area (*Figure 10*)
- Shave a small part of the surgical area if necessary



Figure 11: Blue mark indicates position of implant

- Mark the position of the implant with dye e.g. methylene blue, approximately 5.5 cm behind and above the opening of the external ear canal (*Figure 11*)
- Take care to choose the right position if the patient wears glasses so that the processor will not interfere with the earpiece of the glasses; if an otoplasty is to be done in the future, the skin incision is placed in a more posterior location (*Figure 44*)



Figure 12: Cut a hole in the superior drape for the ear and surgical field

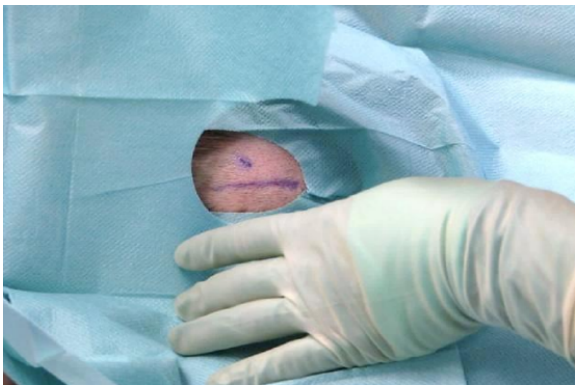


Figure 13: Cut a hole in the inferior drape for the ear and surgical field



Figure 14: U-shaped sheets taped……



Figure 15: …and pasted to the skin

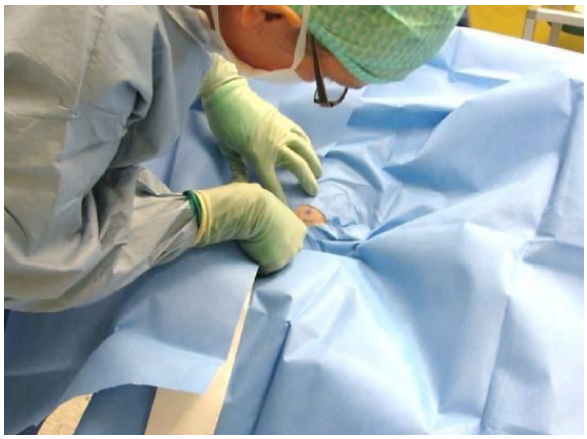


Figure 16: Apply an adhesive transparent plastic sheet (optional)

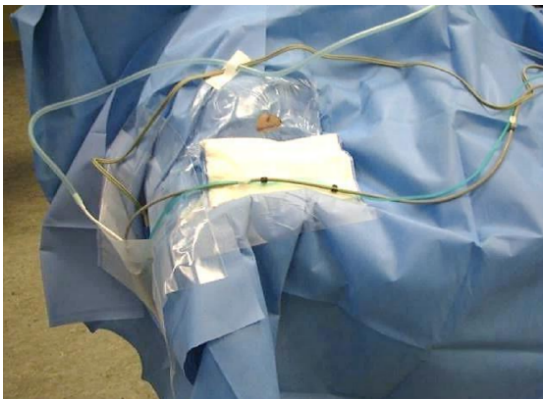


Figure 17: Final view of draped field

- Drape the patient (*Figures 12-17*)

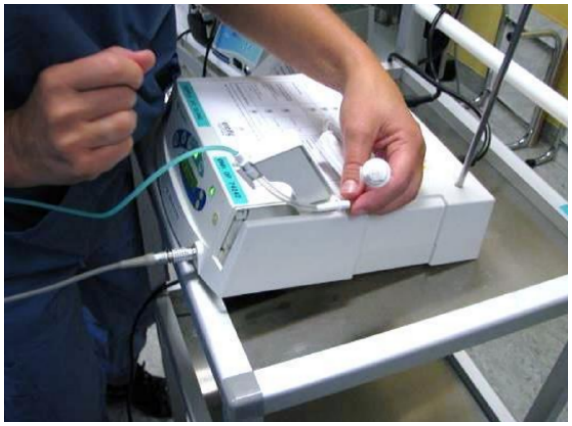


Figure 18: Mount the drill irrigation tubing to the drilling machine (if such system is not available irrigate with a syringe filled with NaCl) to cool the drilling of the bone



Figure 19: Attach the irrigation solution

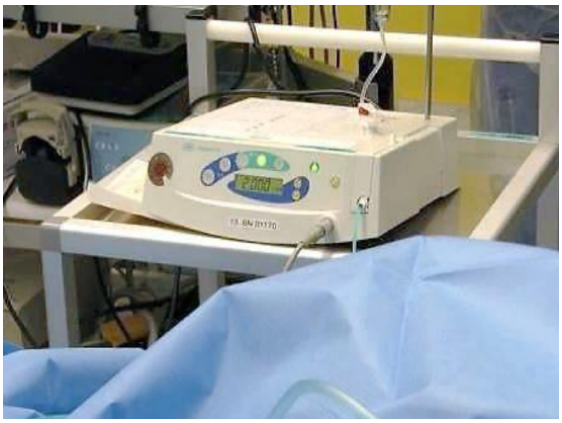


Figure 20: Set the drill speed



Figure 21: Check the drill and integrated irrigation system



Figure 22: Drill bits

- Prepare the drill system (*Figures 18-22*)



Figure 23: Instruments required

- Set out the required instruments (*Figure 23*)
- Measure the skin thickness either now (or later as in *Figure 27*) with a needle through the blue marked spot, mark the depth and measure with a ruler

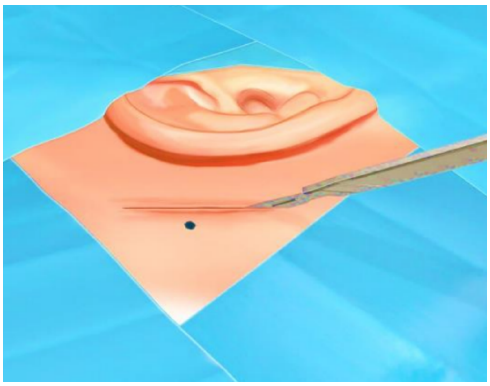


Figure 24: Straight 30-40 mm linear incision down to periosteum



Figure 25: Vertical 4 cm incision down to bone

- Make a straight 30-40 mm linear incision down to periosteum in front of the spot as indicated in *Figures 24, 25*

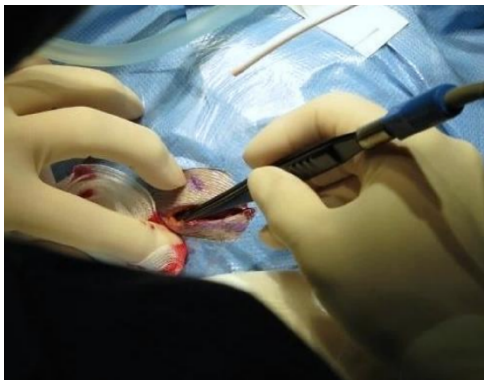


Figure 26: Use electrocautery for hemostasis

- Obtain hemostasis (*Figure 26*)
- Incise the periosteum

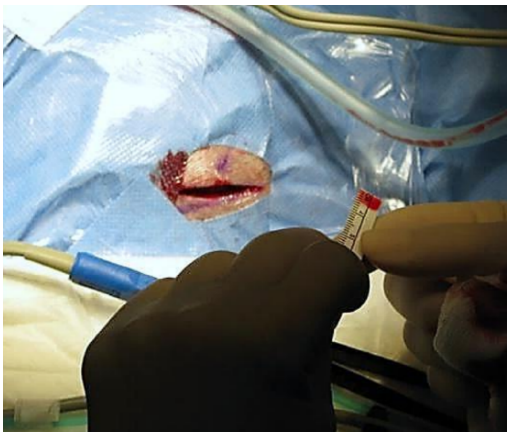


Figure 27: Measure the skin thickness

- Measure the skin thickness (*Figure 27*)



Figure 28: Drill setting for initial drill holes

- Set the drill at 2000 rpm (*Figure 28*)



Figure 29: 3 mm drill bit with plastic “stopper”



Figure 30: Note: 2nd hole is drilled in children for a "sleeping fixture"

- Drill a 3 mm deep hole in the bone in the selected place with a high speed drill (2000 rpm) with a plastic “stopper” on (*Figures 29, 30*)
- If there is still bone in the bottom of the hole, remove the plastic stopper on the drill piece and continue drilling until the next stop is reached and a 4 mm depth is achieved. This allows a 4 mm fixture to fit into the hole with good stability for the abutment (*Figure 29, 30*)

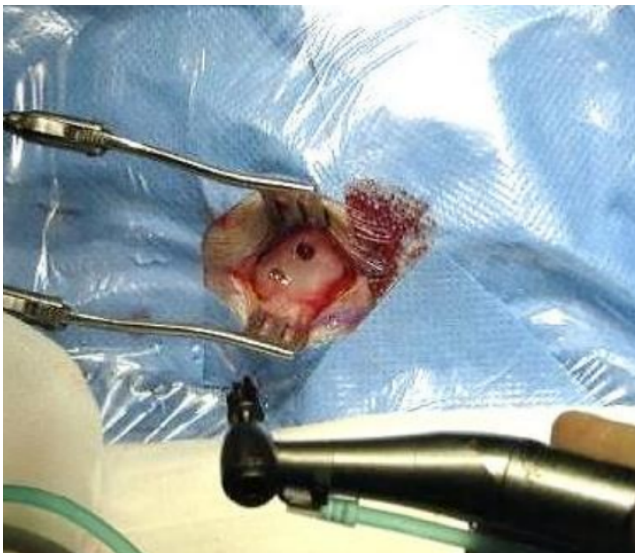


Figure 31: One hole has been enlarged with the countersink drill (child)

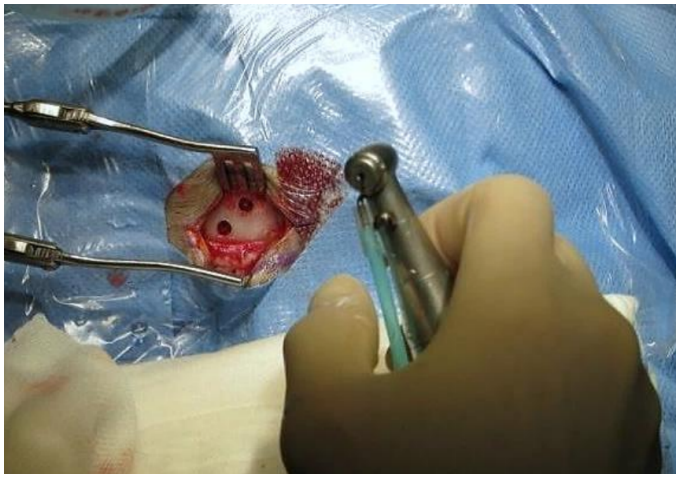


Figure 32: Both holes have been enlarged (child)

- Widen the drill hole with a “countersink” burr, still at 2000 rpm drill speed (choose a 3 or 4 mm countersink depending on the depth of the burr hole) (*Figures 31*, *32*)
- Select the correct fixture according to the drill hole (3 or 4 mm) and the predrawn correct abutment according to the skin thickness (6-12 mm long)



Figure 33: Drill setting for inserting the fixture

- Set the drill at a low speed and at a power setting of 40-50 Ncm (adults, and ca 25 Ncm for children) (*Figure 33*)

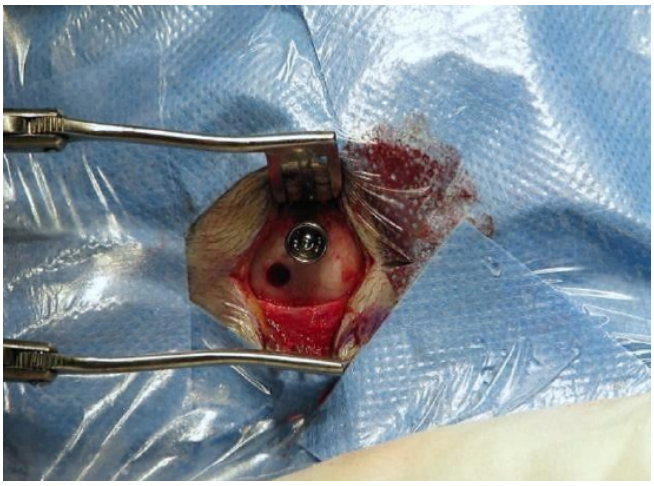


Figure 34: Fixture screwed into bone

- Set the drill at a low speed and at a power setting of 40-50 Ncm (*Figure 34*)

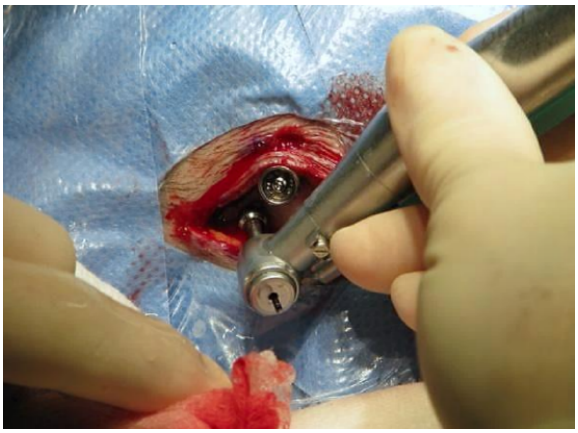


Figure 35: 2nd fixture being inserted (child)

- Screw the fixture into place (*Figure 35*)

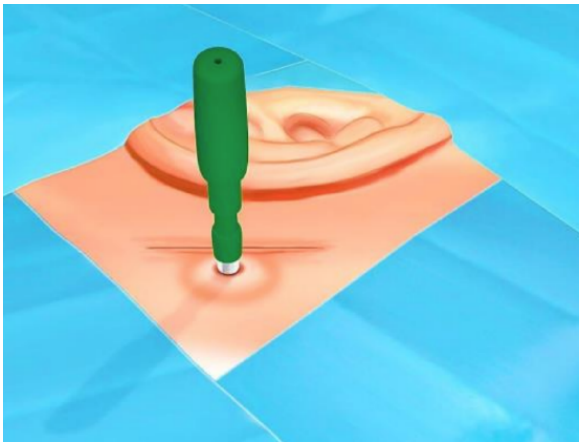


Figure 36: Punching a hole in the skin



Figure 37: Punch a hole through the skin and apply a cover screw to the 2nd fixture in children

- Punch a hole in the skin at the marked place with a 5 mm diameter skin punch (*Figures 36, 37*)



Figure 38: Pass the abutment through the hole in the skin

- Externalize the abutment through the hole (*Figure 38*)

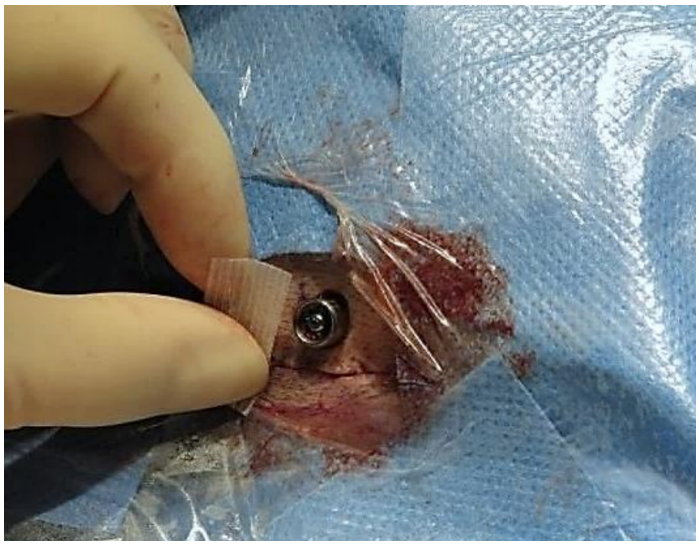


Figure 39: Taping the incision

- Close the skin with resorbable subcuticular sutures (*Figure 38, 39*)

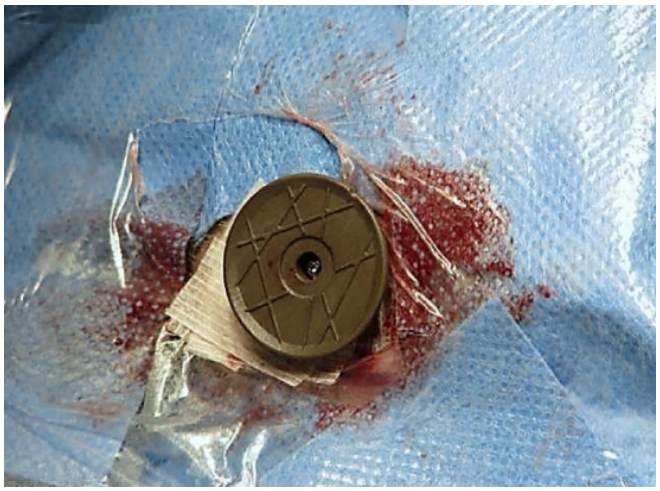


Figure 40: A healing cap is applied

- Attach a healing cap to the abutment (*Figure 40*)

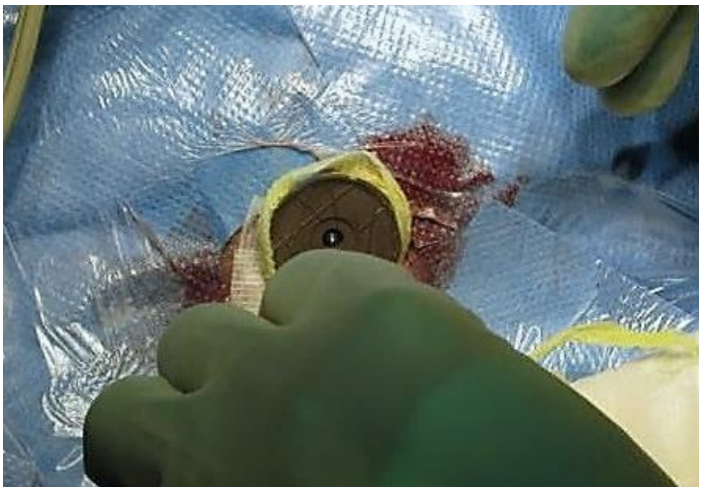


Figure 41: Terracortril ribbon gauze rolled under the healing cap

- Gently wind gauze impregnated with antibiotic ointment around the abutment and under the cap (*Figure 41*)



Figure 42: Fluffed gauze is placed over the wound



Figure 43: Apply a head bandage

- Place fluffed gauze over the wound and apply a head bandage (*Figures 42*, *43*)
- Remove the healing cap after 7-10 days together with the gauze
- The processor can be loaded to the abutment after another 2-4 weeks[5, 11]

Video of surgical technique of linear incision with tissue preservation

Biopsy punch technique (Figures 44a, b)

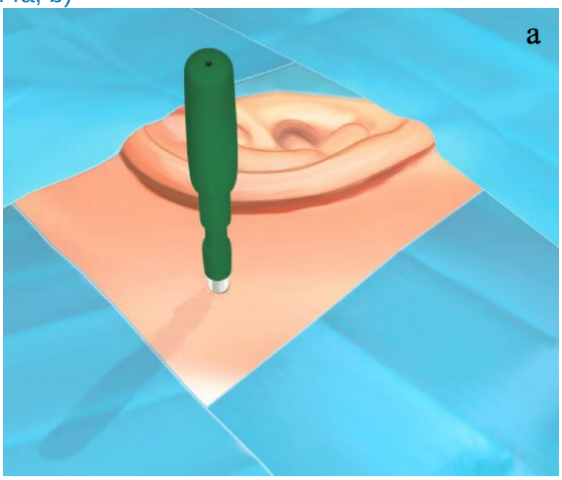


Figure 44a: Removing skin and soft tissue (also the periosteum) with a wide punch

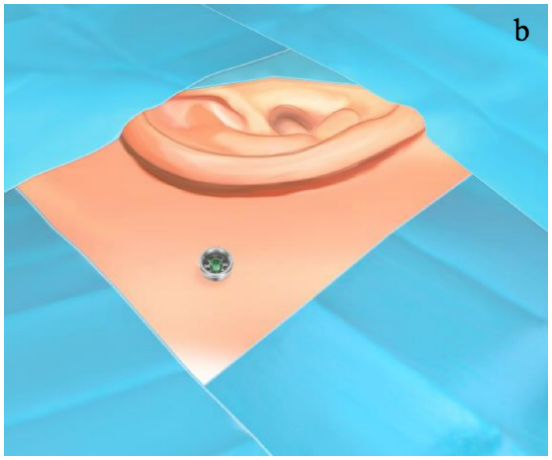


Figure 44b: Abutment in place (With permission from Oticon Medical)

- Mark the implant site
- Measure the skin thickness with a needle
- Inject local anesthesia
- Remove the skin and soft tissue with a wide punch down to periosteum
- Drill a hole in the bone through the punch hole to an appropriate length (3 or 4 mm)
- Introduce the pre-drawn fixture with an abutment of the correct length
- No suturing is required unless a very wide punch (12 mm) has been used 12
- Note: The emissary veins in the bone can bleed briskly when drilled into, so always be prepared for this event e.g. open the skin wider, bone wax etc.

Surgical procedures in children



Figure 45: BAHI on a soft band

If a child is born with severe hearing loss, single or double-sided atresia or SSD, it is recommended to refer the child to an audiological center early. Testing with a BAHI on a soft band can then be done and the BAHI fitted later (*Figure 45*).

With atresia, outer ear reconstruction is recommended when enough rib cartilage has developed at the age of 5-10 years. Outer ear canal reconstruction can be considered when children are able to decide for themselves (14-16 years of age). If a new ear canal has been surgically constructed the child needs to see an ENT specialist every 6-12 months to clean the ear canal to avoid retention of debris and development of cholesteatoma. There is a trend today to avoid the difficult surgery to reconstruct the ear canal, since the results have not been good enough, and instead to reconstruct an outer ear in a cosmetically acceptable way and to use a BAHI for hearing. Children with double-sided atresia must use a BAHI on a soft band from a young age (3 months) for language acquisition, whereas others should start as soon as possible, and always 3-4 weeks before a decision is made to operate.

Children with single-sided atresia benefit from training the hearing pathways early on the atretic side. Previously no rehabilitation was given to these children since they developed speech normally. However, in the busy society of today it has been shown that these children will have problems later on and that the earlier they are fitted with a BAHI the better. A headband at an early age gives the child the possibility to get used to binaural hearing. Reports show that as many as 1/3 of these children need to repeat one year at school and that every other child needs extra resources during schooling. Some children with single-sided atresia, even if they do not have other syndromes, will never develop strategies to cope with their hearing handicap[13].

A permanent fixture and abutment for the bone conducting hearing aid is easier to utilize for a child than a headband and also gives better hearing. The time at which to introduce the permanent fixture can be decided when the skull bone thickness is >2.5 mm, which is usually around the age of 2.5-3 years.

BAHI surgery in children is usually done under general anesthesia. The procedure can be performed as a 1-stage or a 2-stage procedure depending on how thick the skull bone appears to be at surgery. If the bone is >2.5-3 mm thick, then surgery can be performed as a 1-stage procedure in the same manner as described for adults. If the skull is thinner, a 2-stage procedure is preferable.



Figure 46: Two fixtures placed in the skull



Figure 47: Processor placed a bit further back due to pending outer ear reconstruction

Two fixtures are usually placed in the bone in children; one is used with the abutment and the 2nd as a sleeping “rescue fixture” to be used if the 1st implant is removed after trauma or infection (*Figure 46*). (In such cases one simply needs to punch through the skin overlying the sleeping fixture as the implant is already osseointegrated). The 2 fixtures are introduced and the skin is closed. The system is left undisturbed for 2-3 months for osseointegration to occur. At the 2nd surgical stage the skin over the selected fixture is punched out and the abutment is introduced under general anesthesia. The processor is loaded quite soon thereafter[6] (*Figure 47*). It is recommended that the child uses a “safe line” to attach the processor to his/her clothes in order not to lose the processor.

Loading the sound processor

Two manufacturers currently produce BAHA/BAHI fixtures and abutments. The Cochlear processor only fits onto the Cochlear abutment[8], while both the Oticon and Cochlear processors fit onto the Oticon abutment[9] allowing the patient and audiologist the flexibility to select the processor best suited to the individual’s hearing loss.

Once the fixture has osseointegrated after 2-3 weeks, the audiologist or audiology technician fits the processor according to the individual audiogram using the corresponding software program. Usually 2-3 appointments with the audiologist are required to adjust and tune the processor to optimize the sound perception.

New better processors are constantly being released with new features e.g. streamers, that make it possible to direct sound from a mobile telephone directly to the aid.

Complications

Problems encountered with percutaneous (implant passes through skin) systems include peri-implant infection, loss of the abutment (infection or trauma), cosmetic factors, skin numbness and the fact that the skin needs lifelong daily care etc.

Peri-implant infection



Figure 48: Peri-implant infection

Peri-implant infections occur commonly around the abutment (*Figure 48*). The *Holgers classification system* grades soft tissue reactions at the implant site[14]:

Grade 1: Redness with slight swelling around the abutment

Grade 2: Redness, moistness and moderate swelling

Grade 3: Redness, moistness and moderate swelling with tissue granulation around the abutment

Grade 4: Overt signs of infection resulting in removal of the implant

Infection can be avoided if the correct skin care is applied daily.

Cleaning the skin around the abutment is an important task for the patient who must learn the signs and properties of their skin. Recommended tools for skincare are a soft toothbrush to clean the abutment site, water and soap, the correct type of hair shampoo and an ointment if the skin is dry. If infection is noted, then more intensive cleaning is necessary and an ointment with antibiotics should be applied. Cauterizing agents like silver nitrate can be used on the skin for granulation tissue around the abutment and oral antibiotics can be prescribed if a bacteriological sample shows any growth. The abutment has to be removed only if the infection persists (uncommon) to get rid of the infection and to allow the skin to heal. The osseointegrated fixture can be used again at a later stage. Such infections are less troublesome and recurrent if new skin preserving surgical techniques are used.

Skin pockets

The area close to the abutment can deepen, creating a skin pocket. Such pockets can be difficult for a patient to clean and meticulous skin care necessary in such cases is difficult for health care centers to provide. Deep skin pockets are seldom seen with the newer surgical techniques.

Poor osseointegration and fixture loss

This can be due to infection, biological factors, poor bone quality etc. and starts early after implantation or later after a first successful osseointegration. Surgical revision is required once the skin has healed after removal of the fixture.

Flap necrosis

This is seen if a procedure creating a thin skin flap has been used, and delays healing. This problem is not often encountered if the skin is preserved.

Numbness around the abutment

If wide subcutaneous tissue removal is done as with the surgical flap technique, nerves supplying the skin are destroyed and permanent numbness in an area of up to 10 cm may ensue. Numbness is a minor issue and is seldom seen with the modern techniques; it may be confined to only a small area around the abutment.

Deep pain

Hyperaesthesia sometimes occurs around the abutment. If deeper pain occurs from bone it may be necessary to drill out the osseointegrated fixture.

Traumatic loss of abutment/fixture

Any direct trauma to the head and the implant area may lead to a loss of the implant. The skin heals over the fixture extremely quickly (1-2 days). If only the abutment is lost, a new abutment can be introduced as an outpatient procedure under local anesthesia through a newly punched hole. If the entire fixture is lost, then a new surgical procedure has to be performed in adults. In children the sleeping fixture can be used for fixation of a new abutment.

Skin overgrowth (Figure 49)



Figure 49: Skin overgrowth over the abutment which makes it impossible to use the processor

With earlier flap techniques when the skin was extensively thinned and only 5.5 mm abutments were available, skin at times overgrew the abutment and prevented good connection with the processor.

In children, new bone formation under the reduced skin was common and caused skin overgrowth. Another surgery was then necessary to thin the skin again and eventually drill some bone away. Skin overgrowth is less problematic today as skin thinning is not done and with the availability of a range of abutments that allow one to unscrew an abutment that is too short and replace it with a longer one; this can be done also in children as an outpatient procedure without any local anesthesia.

New implants on the market

Four new implants were recently released as described below, and another is soon to be released (BCI, Oticon) that is implanted under the skin in order to avoid skin-related problems.



Figure 50: Sophono Alpha 2®

Sophono Alpha 2® (Sophono): This is a magnetically coupled bone anchored hearing device without an external abutment[15]. The abutment is placed under the skin (*Figure 50*). The system can only be used for mild hearing loss.



Figure 51: The Bonebridge® vibrator is placed into the mastoid

Bonebridge® (MedEl): This is an active BAHI placed under the skin. The vibrator (9 mm diameter) is buried deep into the mastoid bone and requires extensive drilling to be fitted. The vibration is transferred through 2 screws that attach the vibrator to the bone. Patients have to have a CT scan performed before surgery to determine whether the mastoid bone can accommodate the implant. It is MRI compatible[16] (*Figure 51*).



Figure 52: Baha 4 Attract®: The two implant components are deep to skin

Baha 4 Attract® (Cochlear): The sound processor attaches to an external magnet, which transmits the sound to an internal magnet hidden under the skin. The magnet is attached to the implant, which delivers vibrations through the skull to the cochlea. The surgery can be performed under local anesthesia. The implant is not MRI compatible[9] (*Figure 52*).



Figure 53: Soundbite® attached around the teeth

SoundBite ® (Sonitus Medical): This is a non-surgical hearing solution using bone conduction transmission via the teeth[17] (*Figure 53*).

Even with the many new innovations to come, the standard BAHI that penetrates the skin will still have its place as it is a quick surgical procedure performed under local anesthesia, and is a reliable aiding solution.

Instructional video

Linear incision with tissue preservation surgery technique

References

1. Tjellström A, Håkansson B, Lindström J, et al. Analysis of the mechanical impedance of bone-anchored hearing aids. Acta Otolaryngol 1980; 89: 85-92
2. Albrektsson T, Brånemark PI, Hansson HA, et al, Osseointegrated titanium implants: requirements for ensuring a long-lasting direct bone-to-implant anchorage in man. Acta Orthop Scand 1981; 52: 155-70
3. Håkansson B, Lidén G, Tjellström A, et al. Ten years of experience with the Swedish bone-anchored hearing system. Ann Otol Rhinol Laryngol Suppl. 1990 Oct;151:1-16
4. Stalfors J, Tjellström A. Skin reactions after BAHA surgery: a comparison between the U-graft technique and the BAHA dermatome. Otol Neurotol. 2008 Dec;29(8):1109-14
5. Hultcrantz M. A clinical trial using the bone-anchored hearing aid (Baha) method without the skin thinning step. Otol & Neurotol 2011;32(7):1134-9
6. Lanis A, Hultcrantz M. Percutaneous osseointegrated implantation without skin thinning in children: A retrospecttive case review. Otol Neurotol 2013; 34 (4):715-22
7. Eeg-Olofsson M, Stenfelt S, Taghavi H, et al. Transmission of bone conducted sound - correlation between hearing perception and cochlear vibration. Hear Res. 2013 Dec;306:11-20
8. http://www.cochlear.com/wps/wcm/connect/sv/home
9. http://www.oticonmedical.com/
10. Hultcrantz M, Lanis A. A five year follow-up on the osseointegration of bone-anchored hearing aid implantation without tissue reduction. Otol Neurotol. 2014 (In press)
11. Hultcrantz M. Linear incision surgery with tissue preservation. Educational film 2012 www.youtube.com/watch?v=7lQsaV6GTA8
12. Goldman RA, Georgolios A, Shaia WT. The punch method for bone anchored hearing aid placement. Otolaryngol Head Neck Surg 2013;148:878- 80
13. Cho Lieu J. Speech, language and educational consequences of unilateral hearing loss in children. Acta Otolaryngol Head Neck Surg, 2004;130:524-30
14. Holgers KM. Soft tissue reactions around clinical skin-penetrating titanium implants. PhD thesis, ISBN 91- 628-1334-X. Gothenburg University, Gothenburg, Sweden, 1994
15. http://sophono.com/
16. http://www.medel.com/int/vbb
17. http://www.sonitusmedical.com/product/

Author

Malou Hultcrantz MD, PhD
Professor
Department of Otolaryngology
Karolinska University Hospital
Stockholm,
Sweden
Malou.Hultcrantz@ki.se

Editors

Claude Laurent MD, PhD
Professor in ENT
ENT Unit Department of Clinical Science
University of Umeå, Umeå, Sweden
claude.laurent@ent.umu.se

De Wet Swanepoel PhD
Professor
Department of Communication Pathology
University of Pretoria
Pretoria, South Africa
dewet.swanepoel@up.ac.za

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.15: Otoplasty Surgical Technique

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Caroline Banks & Mack Cheney

Otoplasty is defined as surgical correction of external auricular deformities. Correction of the ***prominent ear***, or ***Prominauris***, the most common auricular deformity with an estimated incidence of 0.5% to 15% in newborns, and is the focus of this chapter.[1] Children and adults with auricular deformities may suffer significant social and psychological trauma. Dramatic psychosocial improvements after otoplasty are well-documented.[2,3]

Anatomy

Surgical correction of the prominent ear requires a thorough understanding of the complex anatomy of the auricle. The external ear is composed of fibroelastic cartilage covered by perichondrium. The skin is adherent to the perichondrium anteriorly. Posteriorly the skin is less adherent due to a loose layer of areolar connective tissue above the perichondrium. The lobule does not contain cartilage and is composed of thicker skin and connective tissue.

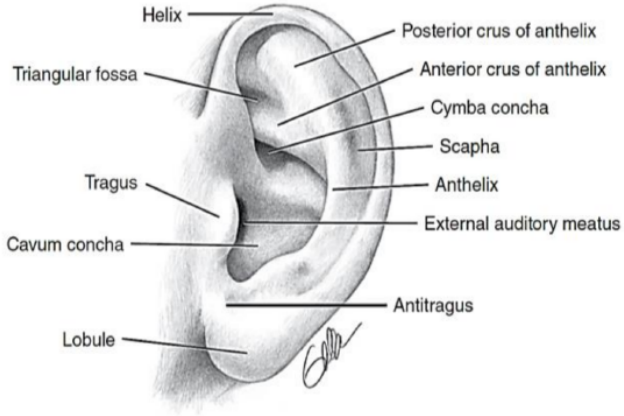


Figure 1: Anatomy of the auricle

The anatomic elements of the ear are the root of the helix, helix, antihelix, superior (posterior) crus of antihelix, inferior (anterior) crus of antihelix, tragus, antitragus, triangular fossa, scaphoid fossa, concha cymba, concha cavum, and lobule (*Figure 1*).

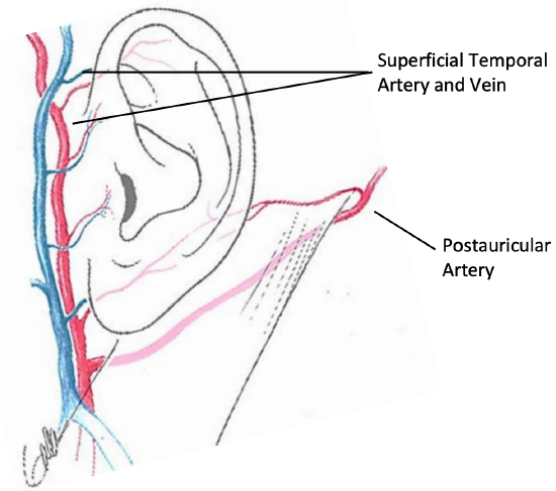


Figure 2: Blood supply of the auricle

The extrinsic muscles of the auricle are the anterior, superior, and posterior auricular muscles. The auricle is supplied by branches of the external carotid artery, including the superficial temporal and postauricular arteries (*Figure 2*).

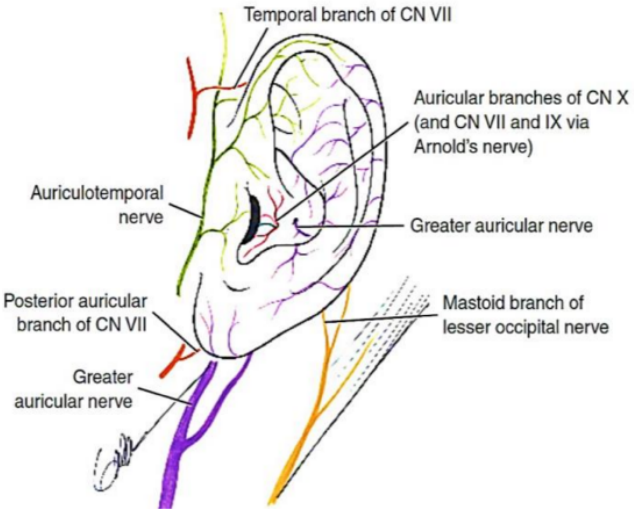


Figure 3: Nerve supply of the auricle

The auricle is innervated by the great auricular nerve, the auriculotemporal nerve (V3), the lesser occipital nerve, and the greater branch of the vagus nerve (Arnold's nerve) (*Figure 3*).

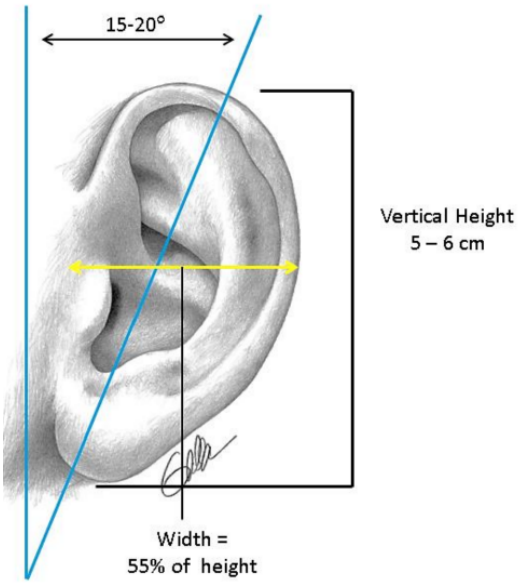


Figure 4: The vertical height of the ear is 5-6 cm. The width is approximately 55% of the vertical length. The vertical axis of the ear is inclined 15-20° posteriorly

The vertical height of the ear is 5-6 cm and should approximately match the distance between the orbital rim and the helical root. The width is approximately 55% of the vertical length. The vertical axis of the ear is inclined 15-20° posteriorly (*Figure 4*).



Figure 5: The superior most point of the ear should be at the same level as the lateral eyebrow, and the inferior part of the lobule should be level with the subnasale

The superior-most point of the ear should be at the same level as the lateral eyebrow, and the inferior part of the lobule should be level with the subnasale (*Figure 5*).

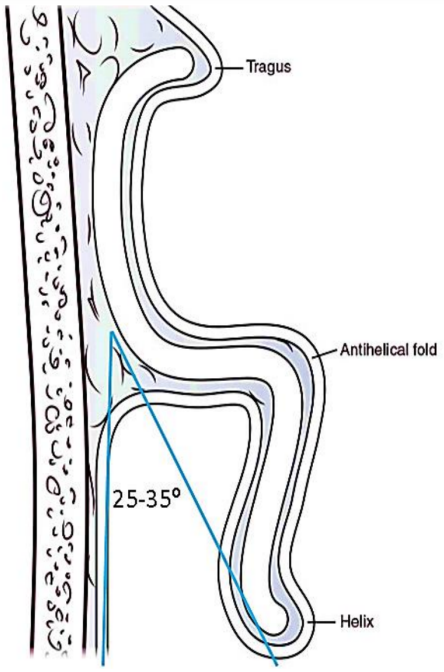


Figure 6: The auriculocephalic angle, defined as the protrusion of the auricle off of the scalp, should range between 25-35°

The auriculocephalic angle, defined as the protrusion of the auricle off of the scalp, should range between 25-35° (*Figure 6*).

To assess auricular protrusion, measurements are made at the most superior aspect of the rim, the most lateral projection point in the mid-auricle, and at a point at the level of the inferior helical rim. The average measurements for these points range from 10-12 mm superiorly, 16-18 mm at the middle point, and 20-22 mm at the most inferior point.

Goals of surgery

The primary goal of otoplasty is achievement of a natural, symmetric, and aesthetic auricle. The specific surgical goals of otoplasty are summarized by Litner et al[4]

- Correction of precise anatomic defects
- Alignment of the superior and inferior poles with the concha

- Establishment of appropriate auriculocephalic angles
- Preserving the position of the helical rim lateral to the antihelix
- Maintaining the postauricular sulcus
- Maintaining interaural symmetry within 3 mm
- Ensuring that surfaces are smooth and without visible scars

Timing of Otoplasty

Most surgeons prefer to wait until patients are at least 5 years of age, as the auricle is then 90-95% of adult size. Performing otoplasty on young children has the important advantage of minimizing the social implications of the deformity. Additionally, the cartilage in children is more pliable, and ear deformities may be corrected more easily by cartilage-sparing methods.

Evaluation

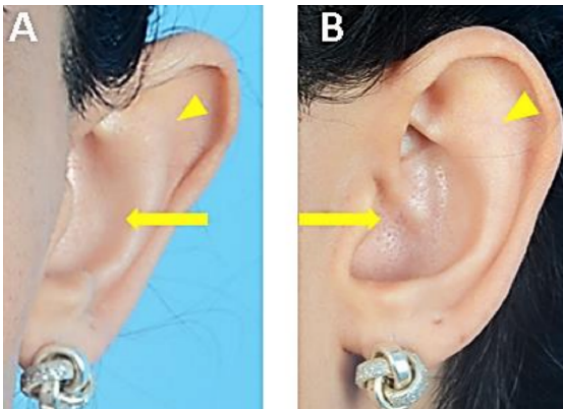


Figure 7: Frontal (A) and lateral (B) photographs of a prominent ear demonstrating both underdevelopment of the antihelix (arrowhead) and increased projecttion of the conchal bowl (arrow)

A thorough preoperative evaluation includes examination of ear symmetry, size, shape, and projection. Evaluation also includes documentation of specific anatomic abnormalities. The two most common auricular defects are underdevelopment of the antihelix and increased projection of the conchal bowl. These defects may occur separately or simultaneously (*Figure 7*).

Anesthesia

The authors prefer doing the surgery under local anesthesia for adolescents and adults using 1% lidocaine with 1:100,000 epinephrine. General anesthesia is commonly required for children.

Surgical Technique

Hundreds of techniques have been described for correction of prominent ears. They can be classified into ***2 broad categories i.e. cartilage-cutting and cartilage-sparing operations***.

Cartilage-cutting techniques include incisions, excisions, scoring, and/or abrasion of cartilage. The major advantage of cutting techniques is long-term stability of results. Disadvantages include disruption of cartilaginous support and creation of contour irregularities.

Cartilage-sparing methods were developed to decrease the incidence of contour irregularities and to maintain the structural support of the cartilage; however, longevity of results may be decreased when compared to cutting techniques.

Modern otoplasty favors a graduated approach by combining suture techniques, and, when appropriate, adding cartilage-cutting methods in a stepwise fashion until the desired correction is achieved.[4,5]

Surgical Steps

The authors most commonly use a combination of Mustarde sutures[6] for shaping of the antihelix and Furnas sutures[7] for conchal setback. Cartilage shaving is performed when appropriate to decrease projection of the conchal bowl.

Excising skin and soft tissue









Figures 8A-D: Excising skin and soft tissue

- A fusiform excision is marked based on the postauricular sulcus, preserving 1.5 cm of free auricle (*Figure 8A*)

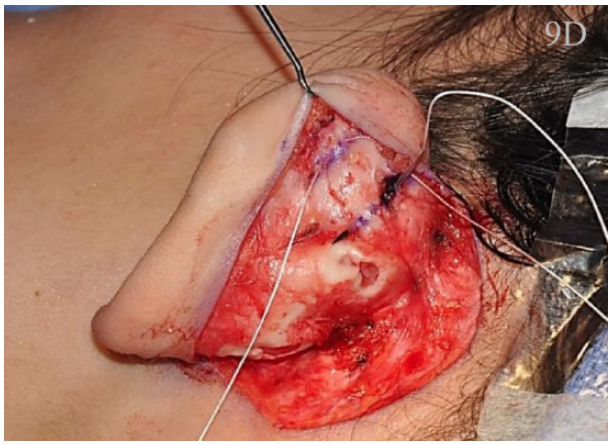
- Inject the area with 1% lidocaine with 1:100,000 epinephrine
- Use a 15 blade to make the planned incision (*Figure 8B*), and sharply excise the skin and soft tissue off the posterior cartilaginous framework (*Figure 8C*)
- In patients with a deep conchal bowl, elliptical shave excision of cartilage is performed with a 15 blade until the ear can be rotated to the proper position (*Figure 8D*)

Antihelix Formation with Mustarde Sutures





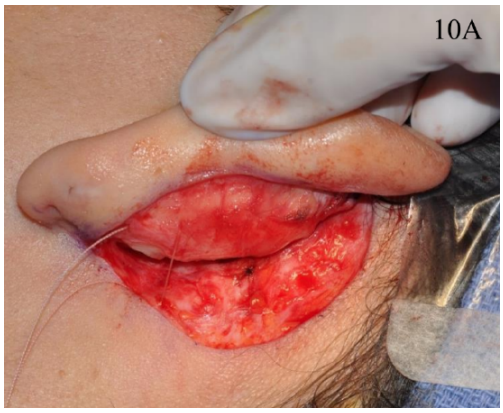


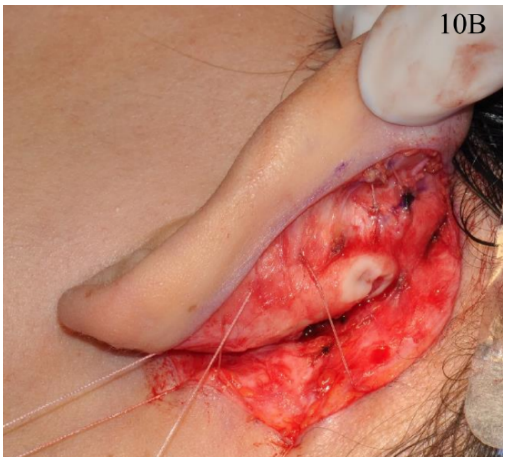


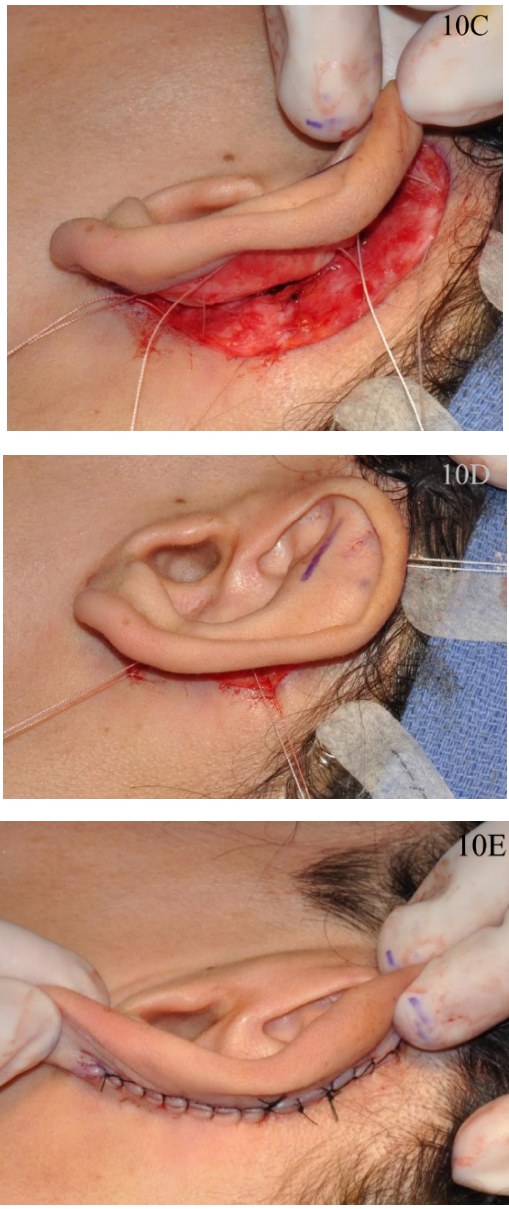
Figures 9A-D: Antihelix Formation with Mustarde Sutures

- Undermine the skin posteriorly over the free edge of the auricle to expose the area for placement of the Mustarde sutures (*Figure 9A*)
- Apply pressure to the ear to determine the appropriate position of the antihelical fold. Mark this position with two 30-gauge needles (*Figure 9B*)
- To recreate the antihelical fold, place two to three non-absorbable horizontal mattress sutures through the posterior perichondrium, cartilage, and anterior perichondrium, avoiding the anterior skin and ligate them (*Figures 9C, D*)

Conchal Setback







Figures 10A-E: Conchal Setback

- Place three non-absorbable horizontal mattress sutures in a parallel fashion from the concha to the mastoid periosteum. These sutures are passed through the posterior perichondrium, cartilage, and anterior perichondrium, but do not go through skin.
- The sutures are not secured until all sutures are in place.
- The first suture is placed from the concha cymba to the mastoid periosteum (*Figure 10A*)
- The second suture passes between the concha cavum and the mastoid periosteum (*Figure 10B*)
- The superior suture is placed in the floor of the fossa triangularis, pulling the concha posteriorly and medially (*Figures 10C, D*)
- Close the incision with a running 4-0 black nylon suture, taking care not to disrupt the conchal setback sutures (*Figure 10E*)

Cartilage-Cutting Techniques [8,9] (Figure 11)

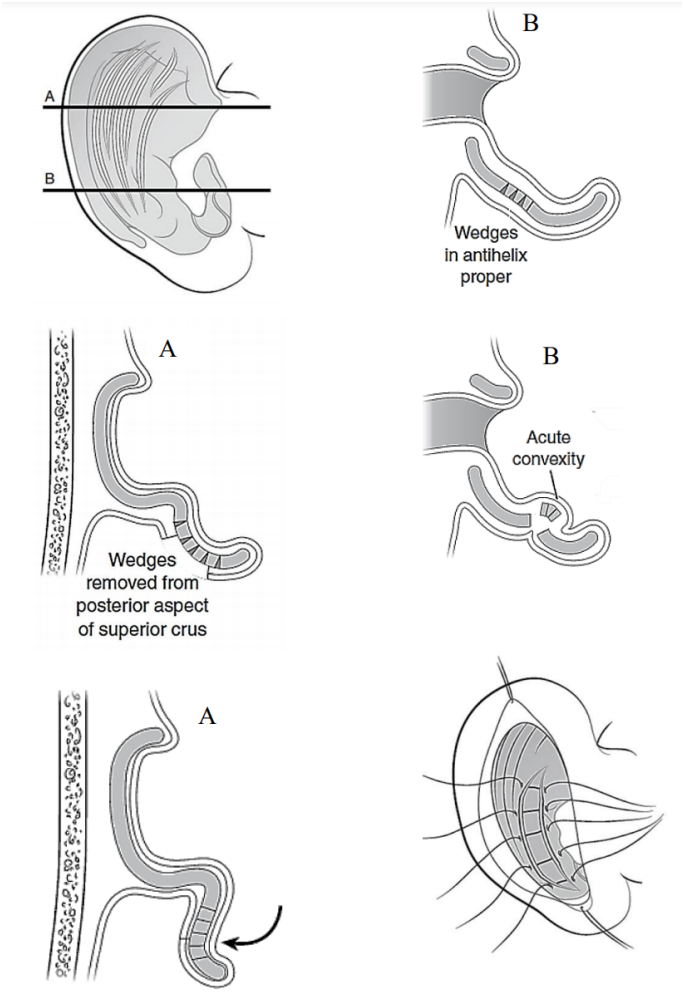


Figure 11: Cartilage cutting technique. A. At level of superior crus; B. At level of antihelix proper

Multiple cartilage-cutting techniques have been described and may involve scoring, cutting, and abrasion of cartilage. The cartilage-cutting technique described by Farrior[8] is a follows:

- Place an incision immediately lateral to the site of the new antihelix
- Elevate the anterior skin
- Remove wedges of cartilage along the axis of the antihelix from the posterior aspect of the neo-antihelix
- Tube the antihelix anteriorly and place mattress sutures

Treatment of Protuberant Lobule or Lobule Excess

- A protuberant lobule may be addressed by trimming the cauda helicis
- For lobule excess, the posterior auricular incision from the initial otoplasty is extended inferiorly and a small triangle of posterior skin is excised
- A small wedge of anterior skin is also excised
- The skin is closed with 6-0 nylon interrupted sutures

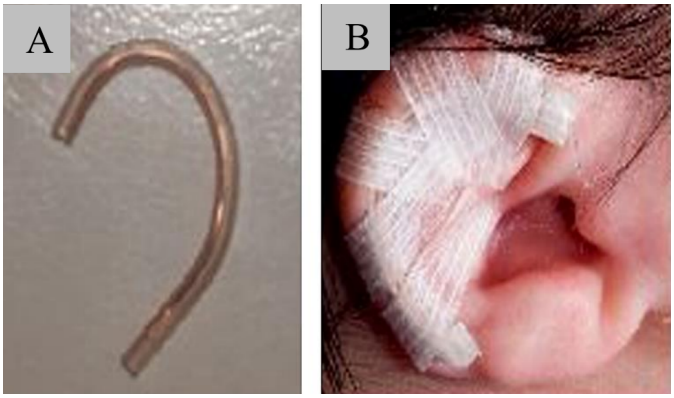
Postoperative Care

- Apply Bacitracin ointment to the suture line, and dress the incision with nonstick gauze pads
- Wrap the head with an elastic bandage
- Discharge the patient home on 1 week of oral antibiotics and analgesia
- Instruct the patient to wear the bandage for the first 24 hours
- Thereafter the patient may shower and gently wash the hair
- A cotton headband is then placed; the headband is worn continuously until the post-operative appointment on Day 12
- During this visit, sutures are removed

- Instruct the patient to wear the headband at night for an additional 2 weeks

Non-Surgical Techniques: Ear Splinting and Molding

Congenital auricular deformities, including prominent ears, are amenable to correction with splinting and molding, especially when initiated within the first three days of life.[10-12] A variety of materials have been successful[11] including:



Figures 12 A, B: A: Splint made from 6-Fr silicone feeding tube with 24-gauge copper wire core; B: Splint applied to the newborn ear with Steri-Strips



Figures 12 C-F: Nonsurgical techniques. Commercially available Earwell Infant Correction System TM (Beacon Medical, Naperville IL)

- Splints made from 6-Fr or 8-Fr silicone tubing with a 24 gauge copper wire core, applied with Steri-Strips[10,12] (*Figures 12A, B*)
- Commercially available molding devices, such as The Earwell Infant Correction System TM (Beacon Medical, Naperville IL) (*Figures 12C-F*)

The splint or mold remains in place 24 hours a day and is replaced as necessary. The duration of splinting varies from center to center, most commonly ranging from 2-12 weeks. The ear is inspected weekly for skin irritation and breakdown. Fair-to-good results are reported in 70-100% of patients, with better results in younger patients.[11]

Complications

Complications of otoplasty may be divided into early complications, occurring hours to days after the procedure, and late complications, occurring weeks to years later.[5,13,14]







Figures 13 A-C: A. Postoperative auricular hematoma; note fullness and discoloration of the auricle; B. Following incision and drainage; C. Final result

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Figure 14: Cauliflower ear deformity following unevacuated hematoma

- ***Hematoma***: Hematomas occur in up to 3.5% of cases.[14] Meticulous hemostasis should be achieved at the close of the procedure to minimize the risk of hematoma formation. Hematomas typically present with increased or excessive asymmetric pain, bloodsoaked dressings, bruising, and/or swelling. Urgent evacuation of a hematoma (*Figures 13A-C*) is critical to prevent fibrosis and ultimately, permanent deformity of the auricle, known as "cauliflower ear" (*Figure 14*). Obtain careful hemostasis during hematoma evacuation and place a drain and a pressure dressing. Discharge the patient on oral antibiotics and follow the patient closely until the hematoma has completely resolved.
- ***Infection***: Wound infection occurs in < 5% of otoplasties.[13] As with hematomas, prompt identification and treatment are essential to avoid permanent deformity. Infections may present with pain, erythema, swelling, and drainage. Management includes drainage and irrigation of the wound, followed by treatment with oral anti-pseudomonas antibiotics. Patients with severe infection may require IV antibiotics.

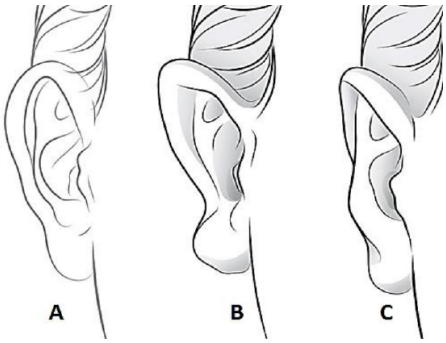
Late Complications

- ***Loss of Correction or Relapse of Auricular Deformity***: This occurs more commonly after cartilage-sparing techniques. There are multiple technical causes of inadequate correction, including pulling of sutures over time, improper placement of sutures, failure to correct deformity during surgery, failure to anchor sutures firmly on the mastoid periosteum, or failure to weaken noncompliant cartilage. Inadequate correction requires revision otoplasty.
- ***Suture-Related Complications***: Nonabsorbable sutures may extrude or cause foreign body reactions. Braided sutures cause more reactions as compared to monofilament sutures; however, many prefer braided sutures due to their handling properties. In cases of inflammatory reaction or extrusion, removal of the suture resolves the complication, though the final result may be compromised



Figure 15: Postauricular keloid

- ***Hypertrophic Scarring and Keloid***: The postauricular area may develop hypertrophic scars or keloid (*Figure 15*), especially in patients with darker skins, younger patients, or patients with a history of hypertrophic scarring or keloid. In susceptible patients one should avoid unnecessary tissue trauma and ensure a tension-free closure. Treatment of hypertrophic scarring and keloids includes triamcinolone injections every 4-6 weeks for 6 months.[14]



Figures 16 A-C: Normal anatomy (A), telephone ear deformity (B), and reverse telephone ear deformity (C)

- ***Telephone and Reverse Telephone Ear Deformities***: Telephone ear deformity occurs with overcorrection in the middle third of the ear and relative undercorrection of the superior and inferior poles (*Figures 16A, B*). Reverse telephone ear deformity occurs when the middle third of the auricle remains prominent relative to the superior and inferior poles (*Figure 16C*). Both deformities are avoidable with correct placement of the conchal set-back sutures.
- ***Narrowing of External Auditory Canal***: This may be seen after conchal setback with improperly placed sutures. When placing Furnas conchal setback sutures, care must be taken to pull the concha superomedially to avoid canal narrowing.

References

1. Weerda. Surgery of the Auricle: Tumors, Trauma, Defects, and Abnormalities. 1st ed. New York: Thieme; 2007
2. Macgregor FC. Ear deformities: social and psychological implications. Clin Plast Surg. Jul 1978;5(3):347-50
3. Bradbury ET, Hewison J, Timmons MJ. Psychological and social outcome of prominent ear correction in children. Br J Plast Surg. Feb-Mar 1992; 45(2):97-100
4. Adamson PA, Litner JA. Otoplasty technique. Otolaryngol Clin North Am. Apr 2007;40(2):305-18
5. Petersson RS, Friedman O. Current trends in otoplasty. Curr Opin Otolaryngol Head Neck Surg. Aug 2008; 16(4):352-8
6. Mustarde JC. The correction of prominent ears using simple mattress sutures. Br J Plast Surg. Apr 1963;16:170- 8
7. Furnas DW. Correction of prominent ears by conchamastoid sutures. Plast Reconstr Surg. Sep 1968;42(3):189-93
8. Farrior RT. Modified cartilage incisions in otoplasty. Facial Plast Surg. 1985;2:109-18
9. Manz RW, B. Otoplasty: Surgical Correction of the Prominent Ear. In: Cheney MH, T.A., ed. Facial Surgery, Plastic and Reconstructive: CRC Press; 2014

10. Petersson RS, Recker CA, Martin JR, Driscoll CL, Friedman O. Identification of congenital auricular deformities during newborn hearing screening allows for non-surgical correction: a Mayo Clinic pilot study. Int J Pediatr Otorhinolaryngol. Oct 2012;76(10): 1406-12
11. van Wijk MP, Breugem CC, Kon M. Non-surgical correction of congenital deformities of the auricle: a systematic review of the literature. J Plast Reconstr Aesthet Surg. Jun 2009;62 (6): 727-36
12. Tan ST, Shibu M, Gault DT. A splint for correction of congenital ear defor mities. Br J Plast Surg. Dec 1994;47 (8):575-8
13. Adamson PA, Litner JA. Otoplasty technique. Facial Plast Surg Clin North Am. May 2006;14(2):79-87, v
14. Owsley TG, Biggerstaff TG. Otoplasty complications. Oral Maxillofac Surg Clin North Am. Feb 2009;21(1):105- 18, vii

Authors

Caroline A. Banks, M.D.
Clinical Fellow
Division of Facial Plastic and Reconstructive Surgery
Department of Otolaryngology/Head and Neck Surgery
Harvard Medical School/Massachusetts
Eye and Ear Infirmary
Boston, Massachusetts, USA
Caroline_Banks@meei.harvard.edu

Mack Cheney, M.D.
Director, Office of Global Surgery and Healthy
Division of Facial Plastic and Reconstructive Surgery
Department of Otolaryngology/Head and Neck Surgery
Harvard Medical School/Massachusetts
Eye and Ear Infirmary
Boston, Massachusetts, USA
Mack_Cheney@meei.harvard.edu

Editor

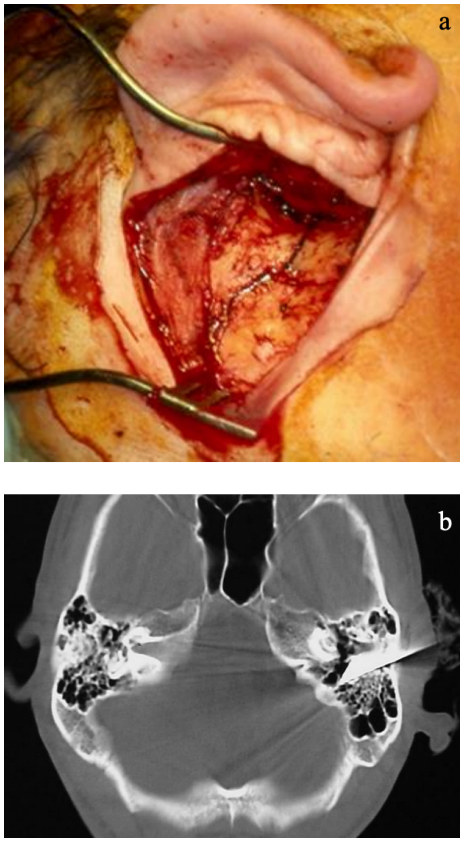
Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.16: Surgery for Temporal Bone Trauma

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Vincent Cousins



Figures 1a, b: Fracture of mastoid bone entering the ear canal; Knife that transected the facial nerve

Trauma to the temporal bone is commonly seen. It occurs most frequently as part of blunt head trauma but may also be due to penetrating injuries including gunshots and stabbings (*Figures 1a, b*).

Classifications

Fractures may be unilateral or bilateral. Classically, fractures of the temporal bone are classified into ***longitudinal*** or ***transverse*** according to its long axis which passes from its base posterolaterally to the petrous apex anteromedially. The direction of a single trauma force may cause a longitudinal fracture on one side and a transverse on the other. Any combination of all fracture types is possible depending on the nature and severity of the trauma involved.

Longitudinal fractures generally pass through the external auditory canal, the middle ear and Eustachian tube. They commonly involve the bony external canal, lacerate the tympanic membrane and may disrupt the ossicular chain. The inner ear is generally preserved and facial nerve lesions are mostly compressive from hematoma or displaced bone fragments.

Transverse fractures cross the long axis of the temporal bone and more commonly involve the inner ear. Facial nerve injuries are more likely to cause partial or complete disruption of the facial nerve.

Isolated fracturing of the ***anterior wall of the external canal*** may also occur from posterior displacement of the mandibular condyle seen with front-on facial injuries.

Fractures may be ***more complex*** and not readily fit the above classification. This led Kelly & Tami to propose a different classification based on involvement of the inner ear[1].

Clinical Presentation

A fracture of the temporal bone should be suspected in any case of significant head trauma. This may be part of a high impact injury as seen in motor vehicle collisions, or low speed injuries such as falls onto a hard surface. Penetrating trauma involving the temporal bone or the external ear canal alone may also cause the same pattern of injuries.

The classical sign of a fracture of the temporal bone is bleeding from the ear canal. A conscious patient may complain of hearing loss, vertigo and facial weakness.

Physical Examination

Assessment and treatment of associated head, spinal and other life-threatening injuries must take precedence over those of the temporal bone trauma.

The ear should be examined and the source of bleeding identified. Skin lacerations of the external ear, scalp or neck should be identified. The ear canal should be examined and blood gently cleared from its outer end.



Figure 2: Battle's sign that appeared four days after the temporal bone fracture

"***Battle's sign***" refers to bruising that may appear over the mastoid process four or more days after a fracture of the temporal bone has occurred (*Figure 2*).

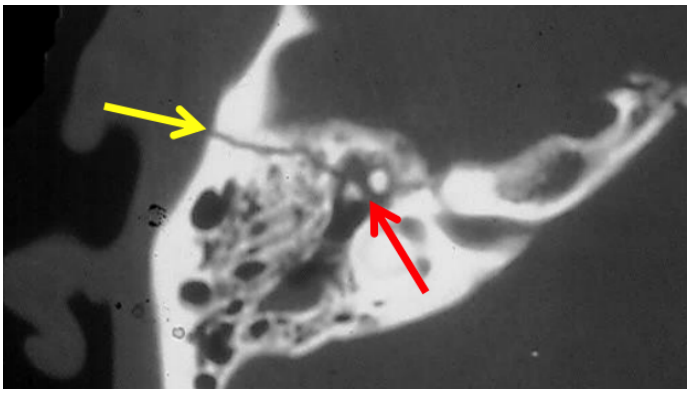


Figure 3: Halo sign of CSF mixed with blood

Cerebrospinal fluid (CSF) may be identified issuing from the ear canal. If mixed with blood it may not be easily detected. Dry stains on the bedding may show a "***Halo sign***" where the blood forms the inner darker stain and the CSF seeps more peripherally producing a paler rim or halo (*Figure 3*).

The canal should not initially be cleared aggressively as clotting seals the canal helping to prevent contamination of the canal which may be transmitted to the subarachnoid space. The patency of the canal should however be assessed as it may be crushed requiring early packing to prevent stenosis. The condition of the tympanic membrane should also be assessed as perforations accompanying temporal bone fractures are commonly seen in the posterosuperior quadrant.

If the patient is conscious, hearing should be assessed. Speech and whisper tests can be performed on each side. The Weber and Rinne tuning fork tests are also very pertinent to distinguish between conductive and sensorineural hearing loss.



Figures 4: Longitudinal fracture of temporal bone (yellow). Note separation of incus and malleus (red)

A ***conductive hearing loss*** may be caused by blood in the middle ear (hemotympanum), tympanic membrane trauma or disruption of the ossicular chain (*Figure 4*).

Sensorineural loss will be present if the inner ear is involved; this may be more minor in a concussive type of injury, or complete if the fracture passes through the cochlea or vestibular apparatus (*Figure 6*). Inner ear trauma also causes vestibular loss and may cause nystagmus. Full clinical ***vestibular assessment*** should not be performed in the acute phase, particularly until the cervical spine has been cleared of significant injury.

Facial movement must be assessed as early as possible. Facial grimacing on the side of the fracture in a semiconscious patient is an important sign to elicit. A conscious patient should be asked to perform the full range of facial movement looking for presence and strength of eyebrow elevation, eye closure, cheek wrinkling, smiling or dental exposure and lip pursing. The presence of definite movement indicates that the nerve is anatomically intact. Delayed facial palsy may occur after hours or days and early knowledge of movement has significant management and prognostic implications. Facial palsy that is present immediately after temporal bone trauma or where the time of onset is not known and where no facial movement has been observed raises the possibility of disruption of the nerve and possible need for surgical intervention.

Investigations

Imaging

Although plain x-rays of the temporal bone will show most larger or displaced fractures, CT scanning is the investigation of choice. Fracture lines and displaced fragments will be visible. The mastoid air cell system will be opacified by blood early on and mucosal edema and fluid later on. The ossicular chain should be reviewed. Displacement or dislocation of one or more of the ossicles may be seen e.g. the gap between the incus and malleus may be widened in a subluxation injury (*Figure 4*).

The facial nerve canal should be examined along its course from the internal auditory canal to the stylomastoid foramen for any direct involvement by a fracture.

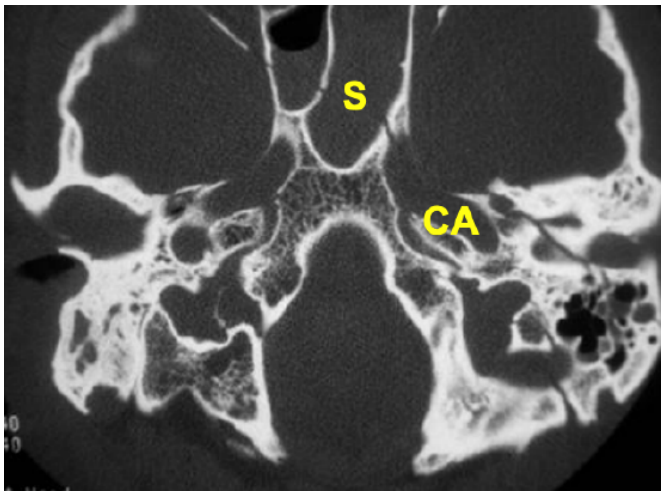


Figure 5: Note proximity of longitudinal fracture line to the internal carotid artery (CA) and traversing the opacified sphenoid sinus (S)

The medial extent of the fracture should be assessed. It may involve the carotid artery as well as the sphenoid sinus (*Figure 5*). Suspected carotid artery involvement may be further assessed by CT angiography.

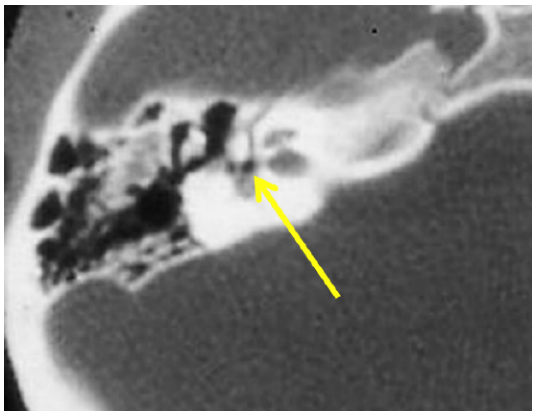


Figure 6a: Transverse fracture of the temporal bone. Fracture seen passing into the vestibule which also contains air

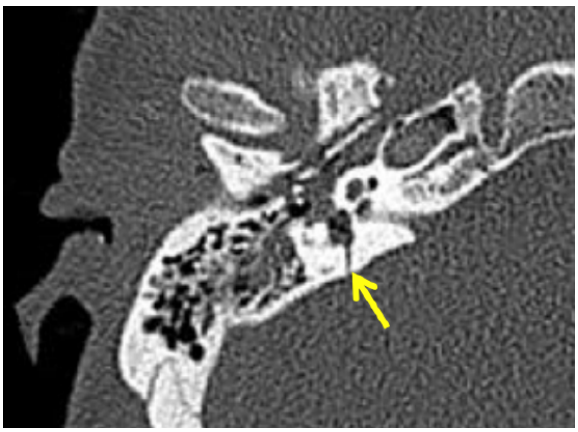


Figure 6b: Transverse fracture of the temporal bone. Fracture seen passing into the vestibule

A fracture involving any compartment of the inner ear (cochlea, vestibule or semicircular canals) is associated with complete ipsilateral hearing loss (*Figures 6a,b*). Air is sometimes seen in the inner ear in such injuries (*Figure 6a*).

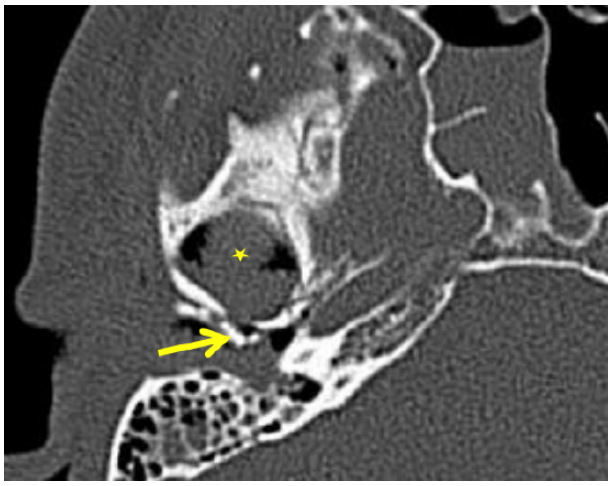


Figure 7: Anterior wall fracture with posterior displacement of bone fragments (arrow). Note blood and air in temporomandibular joint *

Crushing injuries of the external auditory canal with posterior displacement of bone fragments leading to narrowing and potential stenosis is best seen on axial CT scans (*Figure 7*).

Hearing and vestibular assessment

Once a patient is stable and able to cooperate, pure tone and speech audiometry should be performed. Impedance testing should be avoided until the ear canal and tympanic membrane have fully healed.

Formal vestibular function tests may be warranted if the patient has ongoing vertigo or disequilibrium after three months or more.

Management

External Auditory Canal

If severe enough and left untreated, a disrupted ear canal with displacement of its bony walls leads to permanent narrowing or stenosis. Early packing of a collapsed canal helps prevent permanent stenosis. This should be done with appropriate anesthesia and in an aseptic manner. Care needs to be taken to prevent additional trauma, especially to the facial nerve if there is a mobile posterior wall segment.

Meatoplasty for scarring of the outer canal and canalplasty for permanent bony stenosis can be performed as delayed procedures. Small defects of the posterior or other walls due to bone loss can be repaired with cartilage grafting. In cases where there is extensive loss of the posterior wall, conversion to a canal wall down cavity is occasionally warranted.

Hearing Loss

Conductive hearing loss can be treated expectantly in the first instance. Time should be given for middle ear blood and fluid effusions to resolve. Myringoplasty may be indicated if a perforation does not heal spontaneously after three months.

Ossicular chain reconstruction can be performed as a delayed procedure if the conductive hearing loss is significant enough to warrant surgical intervention. A displaced incus can be retrieved, reshaped and interposed. More extensive ossicular disruption may be better treated with alloplastic partial or total ossicular prostheses.

Hearing aids may be appropriate in some cases in line with usual tympanoplasty indications and contraindications and if there is a sensorineural component to the hearing loss.

Facial Paralysis

Facial paralysis can be a significant permanent sequela of a fracture of the temporal bone.

When definite ipsilateral facial movement has been documented one generally adopts an expectant approach as good recovery mostly occurs. The severity of the weakness, the duration of time before movement begins to return and a patient's age are all relevant prognosticators for return of function. Complete paralysis, no sign of recovery for more than four weeks and advanced age are likely to be associated with poorer outcomes. ***When no movement returns***, consideration needs to be given to exploring the relevant segments of the nerve and to repair or graft it.

Where there is immediate paralysis or the time of onset has not been documented, and there is involvement of the bony facial nerve canal by the fracture on CT scan and no response to electrical stimulation, the author favors surgical exploration with the intention of proceeding to nerve repair if necessary. This is better done sooner rather than later, although the patient's general health and other injuries will often necessitate delay.

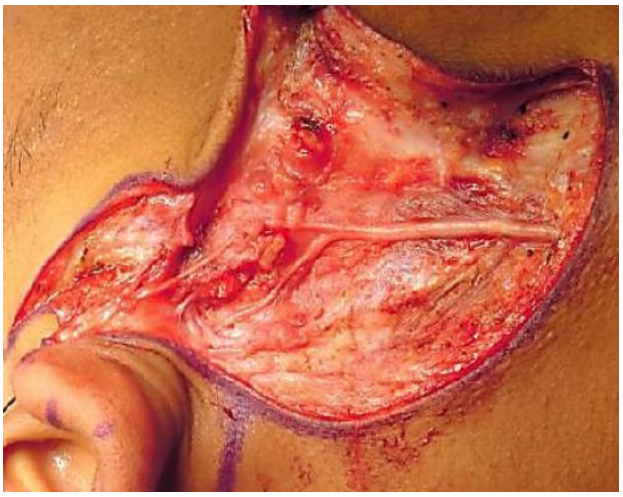


Figure 8: Greater auricular nerve

The nerve is explored and the involved segment isolated. Granulation tissue, bone fragments and scar are removed. The continuity of the nerve is assessed. ***If intact***, the author generally opens the nerve sheath. ***If partially severed but >50% of the nerve's cross-section is intact*** the author leaves the nerve in its position and repairs it as is possible. The author may even place a small inlay nerve graft into the missing segment. The ipsilateral greater auricular nerve usually provides enough graft material (*Figure 8*).

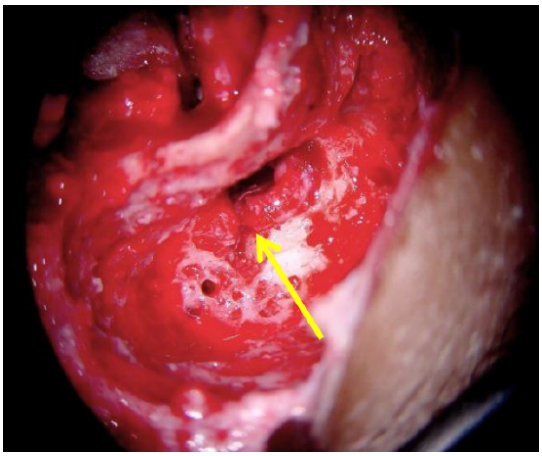


Figure 9: Transected nerve just distal to 2nd genu as viewed via cortical mastoidectomy (Same case as in Figure 1)

Severe crushing or severance of >50% of the nerve's cross-section is an indication for resection of the involved segment and cable grafting of the nerve (*Figure 9*).

In the setting of total hearing loss, the author may drill out the labyrinth to mobilize the nerve to allow for a single anastomosis.





Figures 10a,b: Sural nerve harvesting techniques

When hearing has been preserved, a middle cranial fossa approach may be required to access the internal auditory meatus and labyrinthine segments of the nerve. Although the greater auricular may be used in some cases, the sural nerve is generally used for cable grafting in such cases due to its size and length (*Figure 10*).

The best nerve repair or cable graft results are achieved when done early after nerve injury but acceptable results can be achieved after 3 months and even up to 12 months, but no better than equivalent to a House-Brackman level Grade 3 to 4.

Also see chapters:

- Surgical reanimation techniques for facial palsy paralysis
- Indications and techniques of facial nerve grafting

Dysequilibrium & Vertigo

Vertigo occurs commonly after temporal bone trauma. Benign positional vertigo (BPV) is often seen and generally responds to particle repositioning maneuvers or specific exercises. Permanent loss of vestibular function from a fracture involving the inner ear may cause significant vertigo. Some patients compensate easily. Others may require vestibular rehabilitation physical therapy; a very small number may require formal vestibular ablation, either chemical or surgical.

Reconstructive procedures

A variety of reconstructive procedures may be necessary depending on the specific injuries of the external ear, middle ear and mastoid.

Surgical management of traumatic CSF leak

The author has been required to surgically repair persistent CSF leaks only on rare occasions as CSF leaks with fractures of the temporal bone ***almost always resolve spontaneously***.

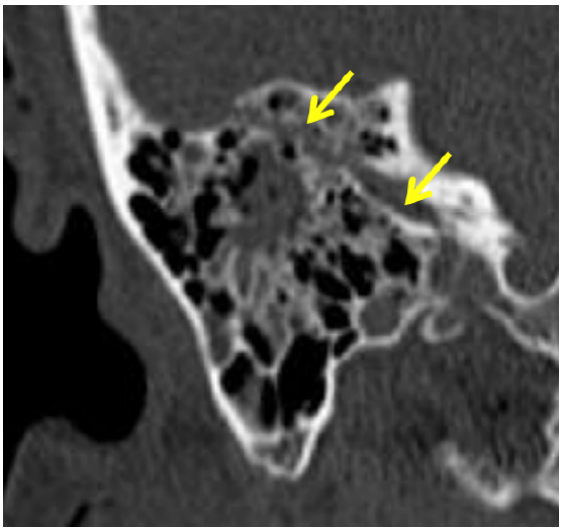


Figure 11: Fracture of tegmen mastoideum

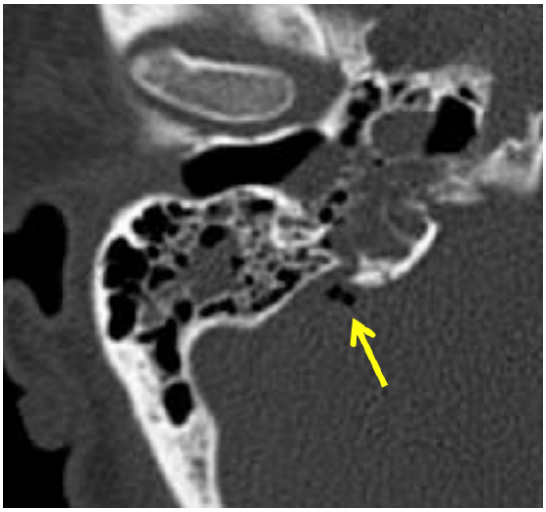


Figure 12: Fracture involving posterior cranial fossa plate with intracranial air

The likely site(s) of persistent CSF leaks are generally apparent on high resolution CT scans, and can originate from both middle and posterior fossa dural defects (*Figures 11, 12*).

When hearing is still serviceable, an attempt should be made to preserve the anatomy of the external auditory canal and mesotympanum. With a localized defect of the posterior fossa dural plate, a cortical mastoidectomy with local repair of the dural defect using temporalis fascia and possibly also a cartilage plate harvested from the tragus or concha, and placed between the bone and the dura, may suffice.

This can be covered with a fat graft taken from the abdominal wall with the mastoid being obliterated as far as the aditus. A small piece of fat can be placed in the aditus and bone wax placed over this to seal the communication with the mastoid. A small amount of fat extending into the attic is likely to atrophy with time and have minimal permanent effect on ossicular mobility. Additional reinforcement of these repairs can be applied when available. Soft tissue dural grafts can be reinforced with tissue glues. Bony defect repairs can be augment-ted with cements, e.g. hydroxylapatite.

Localized defects in the tegmen mastoideum (that are posterior to the aditus) can be managed in the same way. Defects in the tegmen tympani, however, will mostly require removal of the incus and malleus head for access from below. Ossicular chain reconstruction can be performed once the repair is secure.

Larger defects of the tegmen may be associated with a secondary encephalocoele, and are best handled by combined mastoid and middle cranial fossa approaches which permit placement of larger extradural grafts of fascia, bone and pedicled muscle.

Complex defects of the tegmen and/or posterior fossa plate are best treated with subtotal petrosectomy, fascial reinforcement of traumatized dura, Eustachian tube obliteration, and blind sac closure of the external auditory canal. Fat obliteration of the middle

ear cleft ensures closure of a leak via the final common pathway, the Eustachian tube. This technique is particularly applicable if there is no useable hearing in the ear.

Blind sac closure of the external auditory canal technique

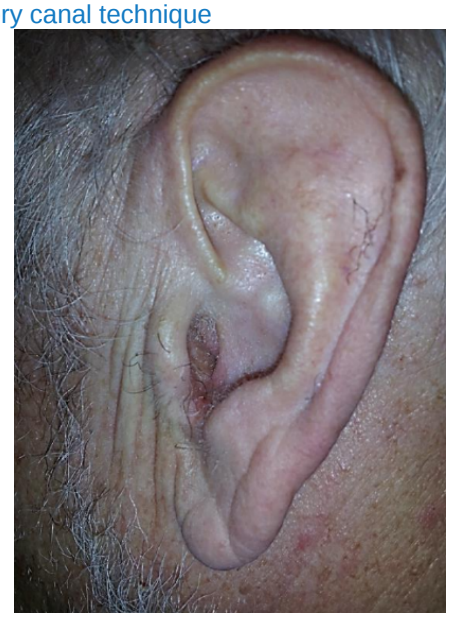


Figure 13: Blind sac closure of external auditory canal

The external auditory canal is permanently occluded

- Transect the bony canal skin circumferentially with a Plester knife
- Reflect the skin of the lateral canal off the underlying bone from the incision line
- Remove the tympanic membrane, medial canal skin, malleus, and incus after formal separation of the incudostapedial joint. The stapes superstructure can also be removed with crurotomy scissors
- Gently elevate the skin of the remaining lateral part of the canal off the cartilage, working from the medial aspect of the pinna
- Take care to keep the skin intact, creating a tube of approximately 1 cm in length
- Place 2 sutures in the subcutaneous tissue at the medial end of the skin tube, one superiorly and the other inferiorly; they are initially left long and held in an artery forceps
- Pass a small artery forceps through the external meatus and clip it onto one suture's end which is then gently pulled through the tube from medial to lateral
- Use a 2nd forceps to deliver the second suture in the same manner
- Gently pull both suture ends laterally to completely evert the tube of skin of the lateral canal. This ensures that the epidermal surface of the tube is completely exteriorized
- Oversew the end of the tube with interrupted absorbable sutures
- Create a 2nd layer of closure medial to the oversewn skin with an anteriorly based musculoperiosteal flap raised from surface of the mastoid bone; this is best created at the time of initial exposure of the mastoid cortex
- Make superior, posterior and inferior incisions in this layer to create a rectangular flap that is based on the soft tissues posterior to the external meatus
- Elevate the flap from the cortex and reflected it forward with the pinna
- Once eversion of the canal skin has been completed, rotate the rectangular flap over its medial end and secure it in place with absorbable sutures

Fat graft (Figure 14)

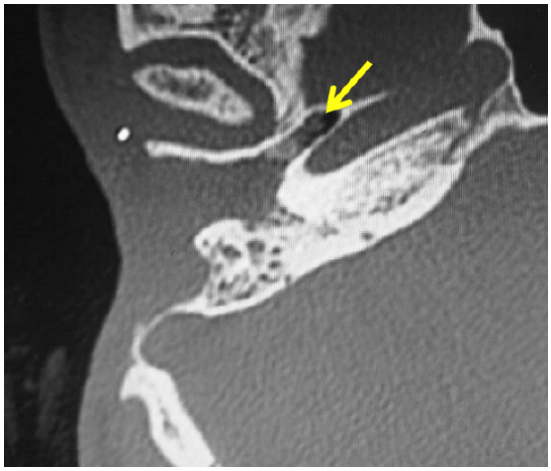


Figure 14: Mastoid cavity obliterated with fat. Note bone pate in Eustachian Tube orifice (arrow)

- This is generally taken from the left lower abdominal quadrant (A right-sided scar may be mistaken for a prior appendicectomy)
- Take care not buttonhole or excessively undermine the skin
- Dissection must remain superficial to the aponeurosis of the external oblique muscle
- The volume of fat taken must be slightly greater than the volume of the bony defect of the mastoidectomy in order to achieve some gentle compression on the dural repair and to allow for subsequent atrophy of the fat
- Close the abdominal wall wound in multiple layers after meticulous hemostasis has been achieved
- A suction drain is left in situ for 48 hours to minimize troublesome hematoma, seroma or abscess

Mastoid, middle ear and Eustachian tube

- Clear the mastoid of all accessible air cells and mucosa
- Denude the mesotympanum of as much mucosa as possible
- Drill out the protympanum (area around the Eustachian tube) to clear surrounding air cells
- Reflect the mucosa of the Eustachian tube into its lumen taking great care not to injure the internal carotid artery which is an immediate medial relation and sometimes without a bony covering in this area (*Figure 14*)
- Do a multiple layered seal using a small piece of fascia placed over the mucosa followed by a small ball of bone wax gently advanced to seal the raw bone of the Eustachian canal. This is covered with an additional small piece of fascia
- Cover the protympanum with bone pate and overly this with a sheet of fascia
- Fill the cavity of the mesotympanum with a small piece of fat
- Place one or more large pieces of fat to fill the mastoid
- Close the wound in multiple layers
- Suction tube drainage is not used, especially in cases of CSF leak
- Apply a well-padded mastoid dressing for 24 hours

Concluding remarks

- Temporal bone fractures are relatively common
- They may involve the outer, middle and/or inner ears
- Early, detailed assessment of the effects of the trauma need to be made
- In most cases, an expectant approach can be adopted and appropriate reconstruction undertaken in a delayed manner
- Facial palsy needs to be fully assessed as early as possible as early surgical intervention may be required to achieve the best outcome

Reference

1. Kelly, KE and Tami, TA. Temporal Bone and Skull Base Trauma in Neurotology Eds Jackler, RK & Brackman, DE (1994) Mosby-Year Book, Inc, Missouri, USA

Author

Vincent C Cousins BMedSci (Hons), MBBS(Hons), FRACS
Head of ENT-Otoneurology Unit
The Alfred Hospital

Melbourne, Australia
Clinical Associate Professor
Monash University
Melbourne, Australia
vccousins@iinet.net.au

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.17: Excision of Preauricular Pits and Sinuses

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Johan Fagan



Figure 1: A typically located preauricular sinus (http://pinna.hawkelibrary.com/pitsandsinuses)

Preauricular pits and sinuses are congenital anomalies located in or just in front of the ascending limb of the helix (*Figure 1*).

They may discharge desquamated keratin debris. Although more common on the right, they may be bilateral. The incidence varies, being as high as 10% in parts of Africa. Preauricular sinuses may be sporadic or inherited (autosomal dominant trait with incomplete penetrance and variable expression) and may be associated with branchio-oto-renal syndrome.



Figure 2: Preauricular sinus abscess. Note puncture wound from needle aspiration

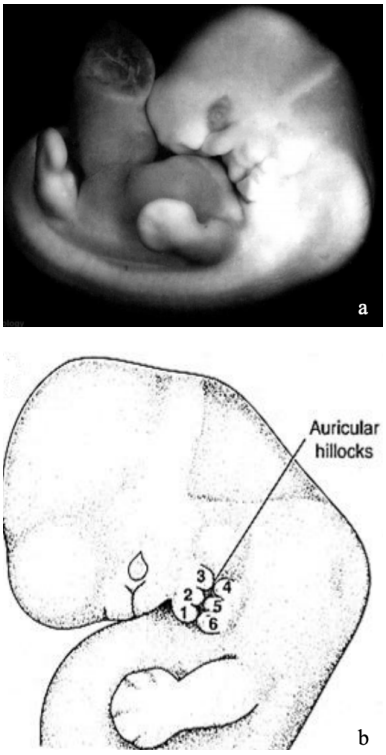


Figure 3: Suppurated lymph node associated with an infected preauricular sinus (http://pinna.hawkelibrary.com/pitsandsinuses)

Even though excising a sinus is a relatively minor surgical procedure, recurrence is not uncommon if an adequate resection is not done. Surgery is only indicated when it is complicated by recurrent infection or abscesses (*Figures 2, 3*). An abscess should first be aspirated with a needle and fully treated with antibiotics before surgery is contemplated.

A preauricular cyst should not be confused with a 1st branchial cleft remnant. Misdiagnosing a 1st brachial cleft remnant as a preauricular sinus tract may place the facial nerve at risk, and incompletely excising the sinus tract. See chapter: Resecting branchial cysts, fistulae and sinuses.

Embryology



Figures 4a, b: Six auricular hillocks at 6 weeks' gestation[1]

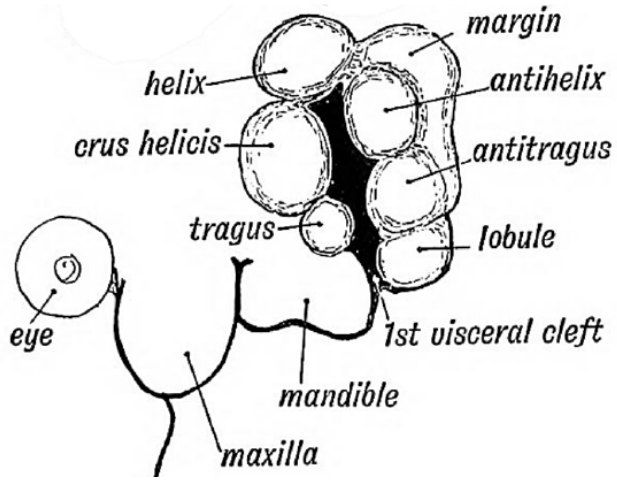


Figure 5: Contributions of hillocks to auricle

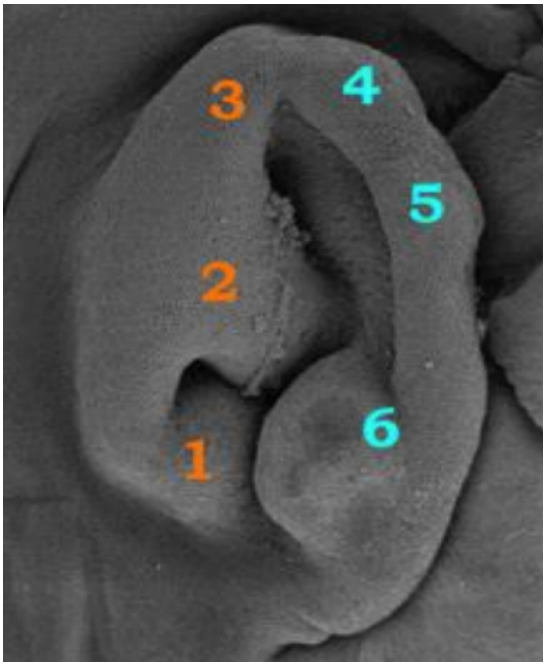


Figure 6: Contributions of hillocks to auricle as seen at 9 weeks' gestation[1]

The auricle originates from 6 auricular hillocks; numbers 1-3 originate from the 1st branchial arch and 4-6 from the 2nd arch (*Figures 4-6*). The external auditory meatus is derived from the 1st branchial cleft.

The hillocks may not fuse completely and leave sinuses between them, most commonly between the tragus and root of the helix, or between the antihelix and helix. It has also been postulated that infolding of ectoderm during development of the auricle may be the cause.

Anomalous development of the hillocks 1-3 may also cause supernumerary hillocks and preauricular tags.

Recommended embryology website

Histopathology

Excised sinuses are lined by stratified squamous epithelium surrounded by connective tissue with evidence of chronic inflammation. The tract may be of variable length, have a tortuous course, and exhibit extensive branching.

Surgical anatomy

The sinus ***remains superficial to temporalis fascia and terminates very close or is adherent to the cartilage of the helix***. The surgeon must be familiar with the following anatomical structures:

Facial nerve (Figures 7, 8)

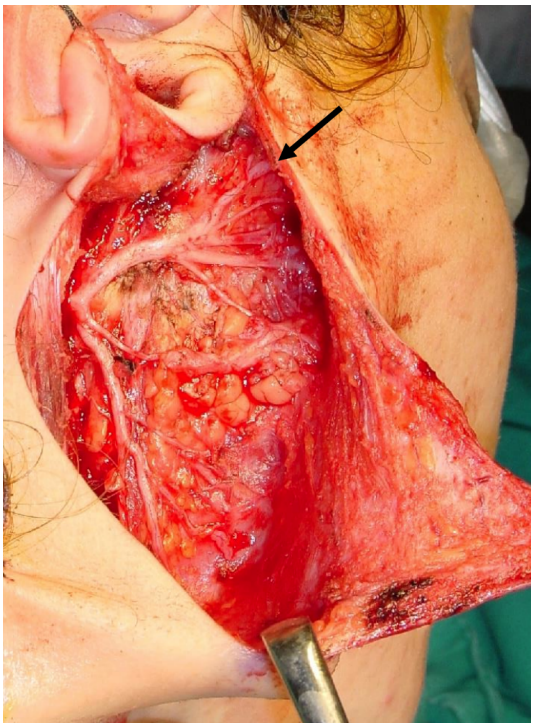


Figure 7: Note the position of the frontal branch of the facial nerve (arrow)

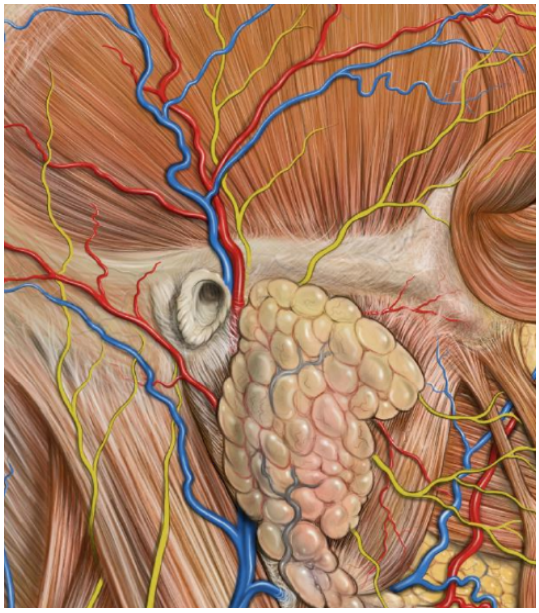


Figure 8: Superficial temporal artery and vein and frontal branch of the facial nerve

Unlike 1st branchial cleft anomalies, preauricular sinuses/cysts are located superior and lateral to the facial nerve and parotid gland. The trunk of the nerve is located far inferior and deep to the normal surgical field. The frontal branch of the facial nerve crosses superficially over the zygomatic arch and is at risk of injury only if the surgeon strays anteriorly during the resection.

Superficial temporal artery and vein

These two vessels are seen in *Figure 8*. If they are lacerated, bleeding is easily controlled by simply ligating the vessel(s).

Auricular cartilage (Figure 9)



Figure 9: Auricular cartilage superimposed on the ear

Preauricular sinuses and cysts are closely associated with the auricular perichondrium. Dunham et al reported that the histologic distance between excised preauricular epithelial sinus tracts and adjacent auricular cartilage measured 50% cases, and that the epithelial tract was in continuity with stromal tissue and histologically indistinguishable from perichondrium in nearly all these cases. Hence some advocate removing of a small portion of auricular cartilage adjacent to the sinus tract to ensure a thorough excision and to reduce recurrence rates.

Temporalis fascia (Figure 10)



Figure 10: The temporalis fascia constitutes the deep dissection plane; note the superficial temporal fat pad anteriorly

The temporalis fascia forms the deepest plane of the dissection. The frontal branch of the facial nerve traverses the superficial temporal fat pad some distance anteriorly (*Figure 10*).

Preoperative investigations

CT or MRI imaging is not indicated unless a sinus is atypically located, or a branchial cleft remnant is suspected.

Surgical principles

Recurrence rates following simple sinusectomy (elliptical incision around sinus and dissection of tract in subcutaneous tissues) of up to 40% have been reported.

Some advocate injecting methylene blue into the cyst or sinus but dye often contaminates the surgical field. Others favor probing the tract with a lacrimal probe, although a lacrimal probe may cause a false tract and cannot identify small branches.

The author uses neither technique and does not attempt to identify the actual sinus tract.

Steps taken to reduce recurrence include:

- Operate under optimal conditions
  - Wait for infection to settle
  - General anesthesia without muscle paralysis (to detect stimulation of facial nerve)
- Completely excise the sinus tract with the surrounding tissue
  - Wide exposure: supra-auricular extension of preauricular incision
  - Do not attempt to identify and excise only the sinus tract, but widely resect all the subcutaneous tissue between temporalis fascia and helix
  - Posterior boundary: auricular cartilage
  - Anteromedial boundary: parotid fascia
  - Deep boundary: temporalis fascia
  - Excise neighboring perichondrium and/or cartilage of the helix

Surgical steps

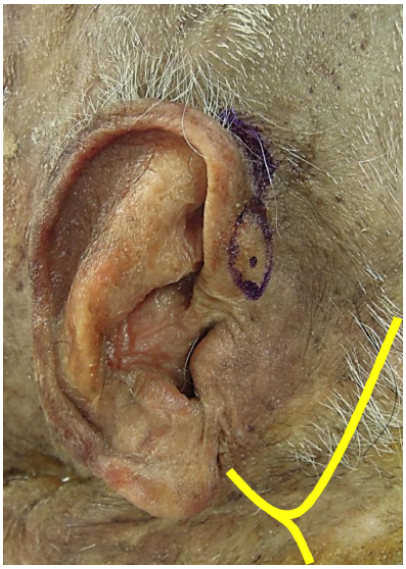


Figure 11: Elliptical incision with supraauricular extension; approximate position of facial nerve in yellow

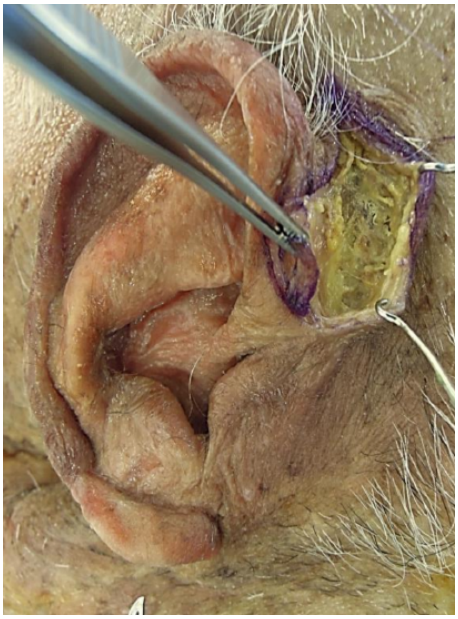


Figure 12: Dissecting down to temporalis fascia

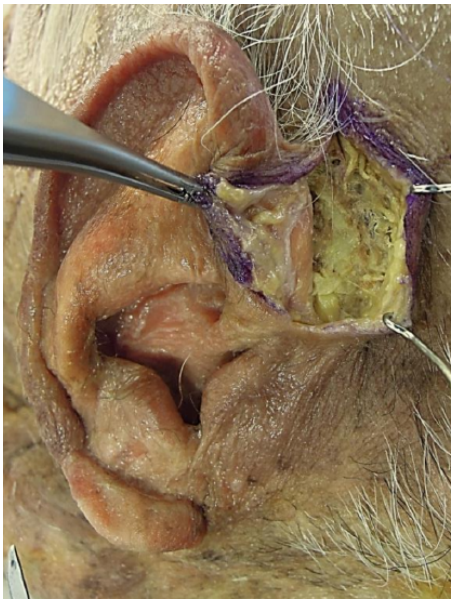


Figure 13: Dissecting along temporalis fascia up to cartilage of helix

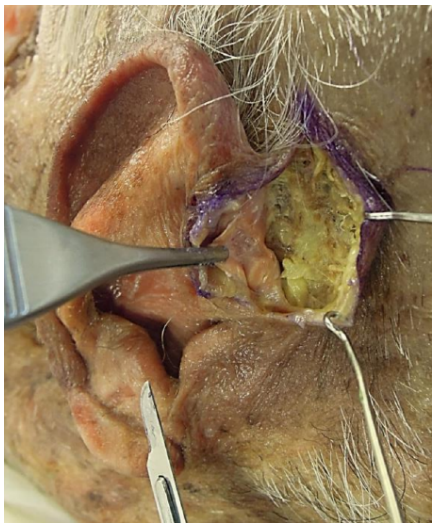


Figure 14: Slither of helical cartilage being excised at apex of sinus tract

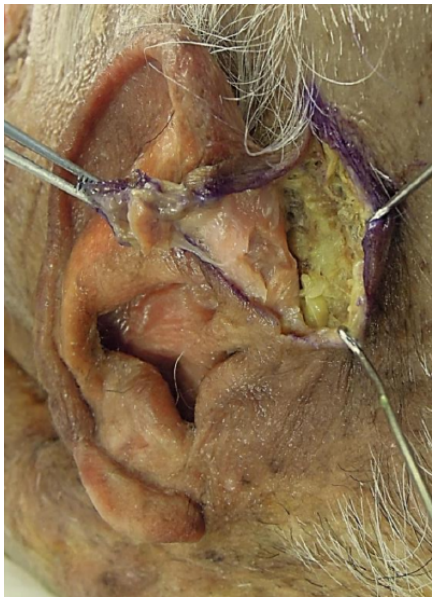


Figure 15: Final part of dissection including an island of helical cartilage



Figure 16: Surgical defect following excision of slither of cartilage at the apex of preauricular sinus

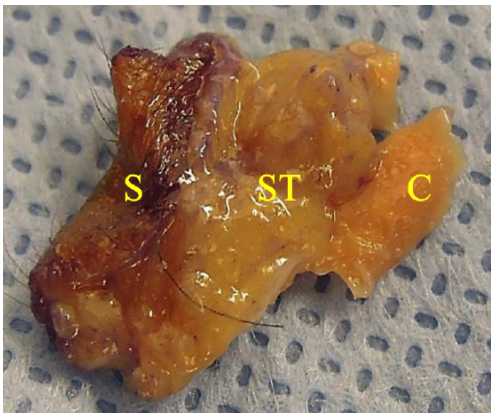


Figure 17: Specimen: skin (S), soft tissue containing preauricular sinus (ST) and cartilage (C)

- Make a vertical elliptical skin incision around the sinus opening (*Figure 11*)
- Extend the incision superiorly into the supra-auricular area (good exposure and hides incision); note the position of the facial nerve (*Figure 11*)
- Dissect (sharp or electrocautery) down to temporalis fascia both anterior and superior to the sinus opening (*Figure 12*)
- Dissect the soft tissues off the temporalis fascia which constitutes the deep dissection plane, in a posteroinferior direction (*Figure 13*)
- Identify the cartilage of the helix (*Figure 13*)
- Dissect along the cartilage, keeping deep to perichondrium (*Figure 14*)
- Excise a slither of cartilage deep to the apex of the preauricular sinus (*Figure 14*)
- Resect the specimen (*Figures 15, 16, 17*)
- Irrigate the wound
- A small drain may be left in situ
- Suture the wound in layers

References

1. Dunham B et al. The histologic relationship of preauricular sinuses to auricular cartilage. Arch Otolaryngol Head Neck Surg. 2009 Dec;135(12): 1262-5
2. Hill MA (2014) Embryology Privacy policy. Retrieved February 8, 2015, https://php.med.unsw.edu.au/embryolo...Privacy_policy
3. Leopardi G et al. Surgical treatment of recurring preauricular sinus: supraauricular approach. Acta Otorhinolaryngol Ital. 2008 Dec;28(6):302–5

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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2.18: Lateral Temporal Bone Resection

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Rajeev Mathew, Tashneem Harris, Parag Patel

Lateral temporal bone resection refers to en bloc resection of the external auditory canal (EAC) with the tympanic membrane (TM). It is generally performed for malignancies involving the EAC, the most common being primary squamous cell carcinoma. Tumors may arise from the skin of the external ear, parotid, glandular adnexa of the ear or may be metastases to parotid nodes.

History and examination

History and examination are directed at making a diagnosis and determining the extent of the tumor. Refractory pain is a hallmark of advanced malignancy of the ear canal. Other presenting symptoms include chronic ear discharge and hearing loss. A lesion of the ear canal may be visible and there may be a discharge. The parotid and neck should be examined for evidence of metastases. Facial nerve function should be documented. Assessing sensation of the face on the affected side as well as the lower cranial nerves is crucial to detect intracranial and inferomedial extension to the jugular foramen. Differential diagnoses include skull base osteomyelitis and inflammatory conditions e.g. TB.

Special investigations

The tumor is biopsied in the office to confirm the diagnosis. Imaging is requested to:

- Determine local extent of the tumor
- Stage the tumor (see below)
- Determine its operability
- Rule out regional nodal metastases to parotid and cervical nodes
- Plan the surgical approach

High resolution CT scans (0.5 mm slices with and without contrast) of the temporal bone, brain, parotid and neck allow assessment of the soft tissue extent, bony destruction, as well as clinical staging. MRI is useful to assess soft tissue involvement particularly if disease appears to have breached the EAC/TM and there is concern about involvement of dura or brain. Pure tone audiometry should be performed. Carotid angiography +/- balloon occlusion is considered if surgery is contemplated and there is concern about carotid artery involvement.

Modified Pittsburgh Staging System

T1: Limited to EAC without bony or soft tissue extension into mastoid/middle ear

T2: Limited EAC erosion (not full thickness) or radiological findings consistent with <0.5cm soft tissue involvement

T3: Full thickness erosion of EAC with <0.5cm soft tissue involvement or facial nerve paralysis

T4: Eroding cochlea, petrous apex, carotid canal, jugular foramen, medial wall of middle ear, dura or with >0.5cm soft tissue extension

Practical application of staging system

T1: Sleeve resection or lateral temporal bone resection

T2: Lateral temporal bone resection

T3: May be suited to lateral temporal bone resection with sacrifice of facial nerve

T4: Not amenable to lateral temporal bone resection

Surgical Anatomy

The lateral 1/3 of the EAC is composed of fibroelastic cartilage and contains the Fissures of Santorini - these communicate with the parotid anteriorly and the soft tissue overlying the mastoid posteriorly. The medial 2/3 of the EAC consists mainly of the tympanic portion of the temporal bone.

Important relations of the EAC include the tegmen tympani superiorly, mastoid bone posteriorly, styloid process inferiorly, and temporomandibular joint (TMJ) anteriorly (*Figures 1 and 2*). The foramen of Huschke is a developmental defect in the EAC and may provide a route of communication to the parotid gland and infratemporal fossa. If disease breaches the EAC it can invade several areas including the stylomastoid foramen, carotid canal, jugular foramen, petrotympanic fissure and eustachian tube.

Lymphatic spread of SCC of the temporal bone occurs in about 10% of patients whilst inflammatory lymphadenopathy occurs more commonly. Tumors of the pinna or EAC can metastasize to preauricular, infra-auricular, parotid, postauricular, or Level 2 nodes. The mucosa of the middle ear and mastoid drain to lymphatics around the eustachian tube which then drain into the deep upper jugular and retropharyngeal lymph nodes. The inner ear has no known lymphatic drainage system.

Surgical steps

Skin incisions

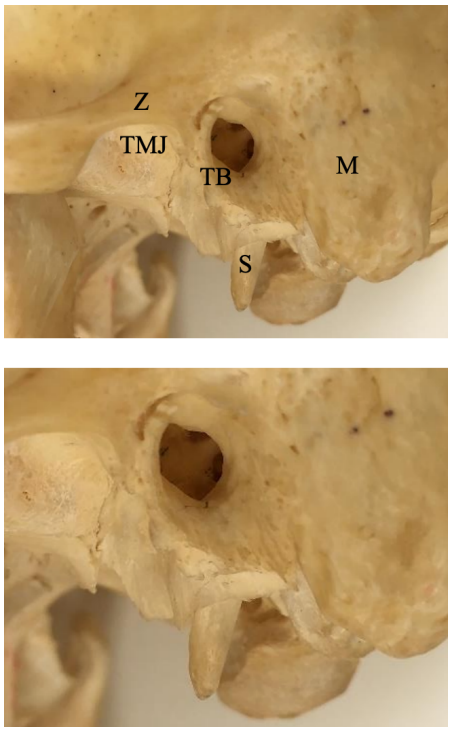


Figure 1: Lateral view of relations of EAC. TMJ = Temporomandibular joint; S = Styloid; TB = tympanic bone; M = Mastoid; Z = Zygoma

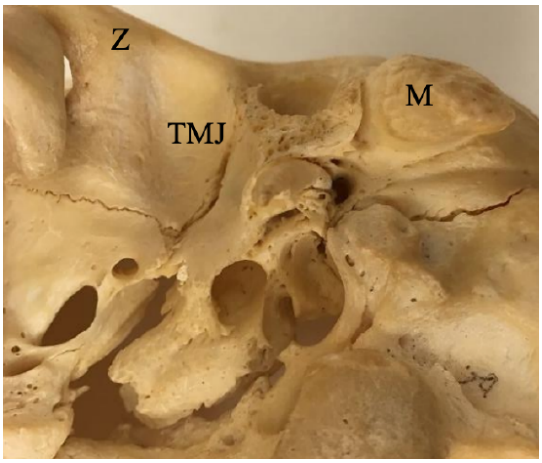


Figure 2: Inferior view of relations of EAC



Figure 3: Example of incision for lateral temporal bone resection involving concha/ tragus resection, parotidectomy and selective neck dissection

- Make a C-shaped postauricular incision (*Figure 1*)
- Place it far posterior to the postauricular crease so that the sigmoid sinus can be adequately exposed
- An adequate margin around the tumor is needed. This typically involves resecting part of the concha and tragus (*Figure 3*) or the entire pinna
- The incision can be modified depending on tumor size and location
- If a neck dissection is planned, the incision is extended into a cervical skin crease
- An anterior limb at the level of the hyoid bone is useful if a parotidectomy is to be performed

Skin flaps and soft tissue dissection



Figure 4: Skin flap elevated anteriorly around resection margins

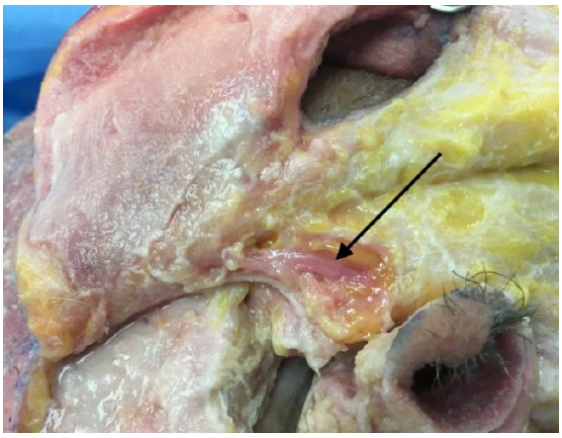


Figure 5: Skin flap elevated forwards over parotid. The superficial temporal artery has been identified and preserved (arrow)



Figure 6: Periosteum over mastoid has been excised and sent for histology. The temporalis muscle has been reflected superiorly

- Raise the skin flap from back-to-front (*Figure 4*)
- If a parotidectomy is required, raise the skin flap with the pinna up to the anterior border of the parotid
- Preserve the superficial temporal artery (*Figure 5*) to maintain the blood supply to the ear if the pinna is being preserved
- Incise the temporalis fascia and muscle along the temporal line (*Figure 6*)
- Expose the root of the zygoma; this is critical as it is the landmark when drilling to expose the TMJ
- Elevate the soft tissue and periosteum over the mastoid bone. This soft tissue can be excised and sent for frozen section histology (*Figure 6*)

Bone dissection

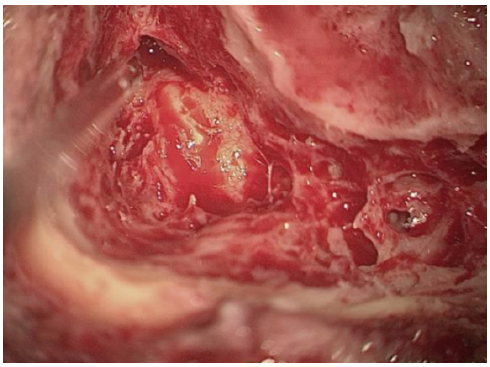


Figure 7: Skeletonize tegmen tympani and sigmoid sinus

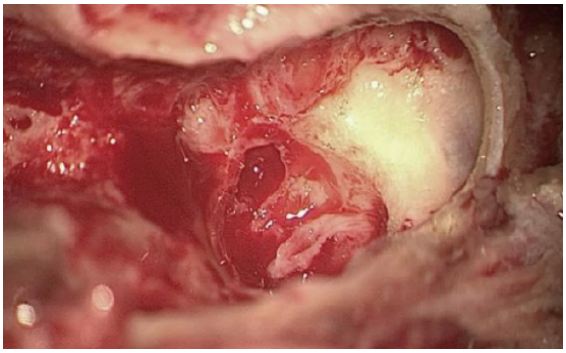


Figure 8: Drill out the mastoid tip to expose digastric ridge and retrofacial air cells

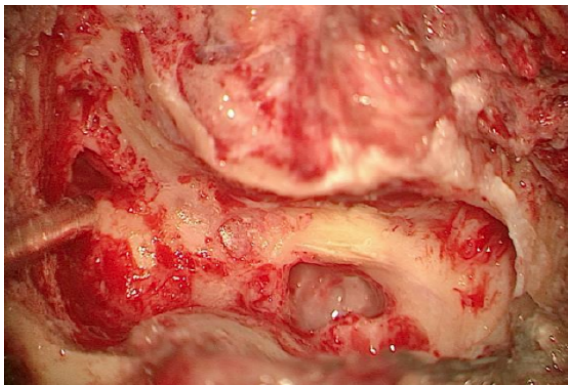
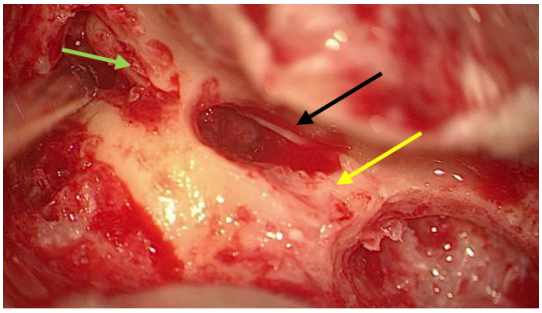
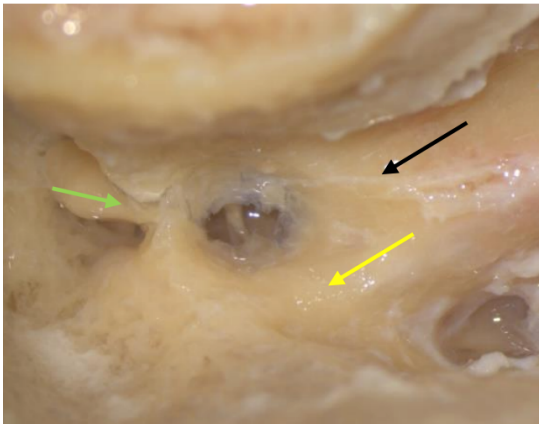


Figure 9: Skeletonize the mastoid segment of the facial nerve





Figures 10ab: The beginnings of a posterior tympanotomy. The chorda tympani (black arrow) forms the anterior boundary and the facial nerve (yellow arrow) the posterior boundary. Note short process of incus in fossa incudes (green arrow)

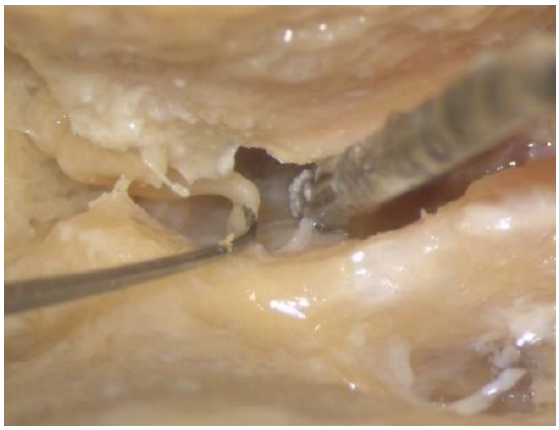


Figure 11: Disarticulating incudostapedial joint

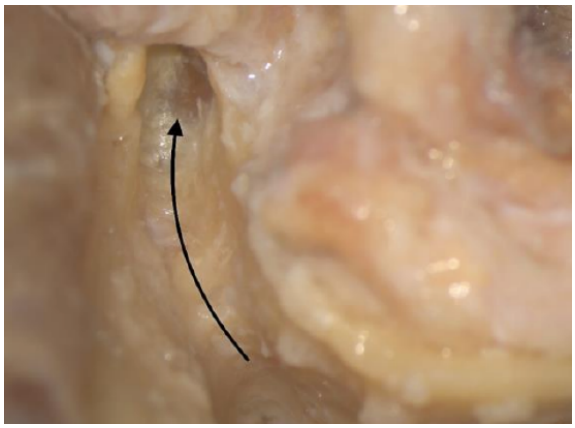


Figure 12: The curved arrow shows the drilling trajectory towards the root of zygoma. Arrowhead points to the TMJ capsule

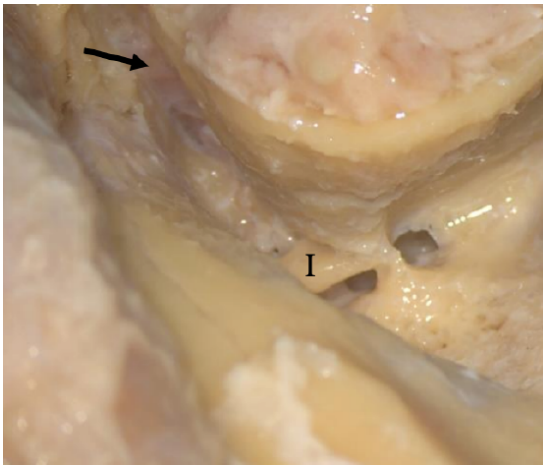


Figure 13: The TMJ (arrow) has been exposed anterior to the ossicular heads, medial to the squamous temporal bone (I = Incus)

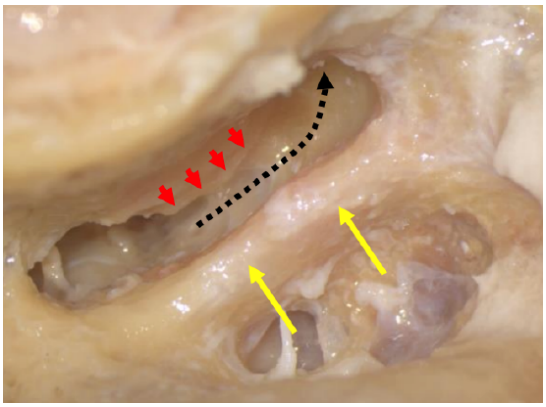


Figure 14: Extended posterior tympanotomy (chorda transected). Facial nerve (Yellow arrow), Annulus (Red arrows)

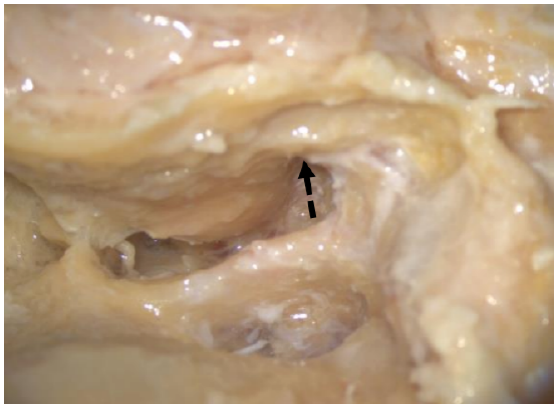


Figure 15: Drilling inferior to the ear canal

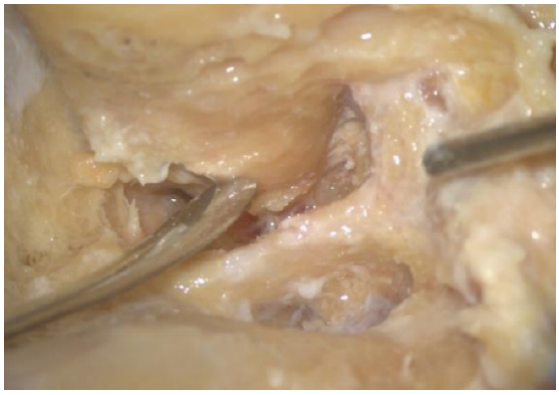


Figure 16: Gentle anterior pressure applied to the bone encasing the EAC to fracture the medial part of the anterior wall of the EAC

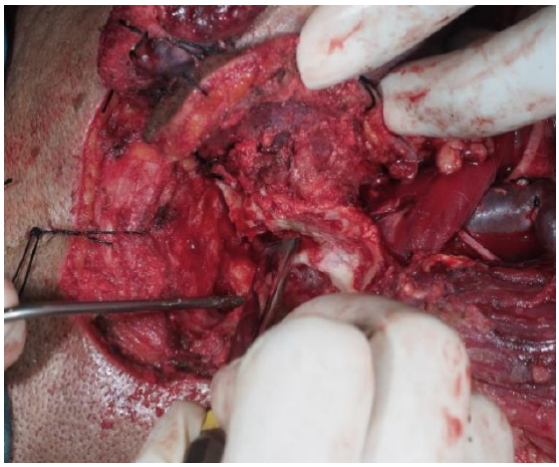


Figure 17: Curved osteotome passed medial to the TM, malleus and incus to fracture the tympanic bone

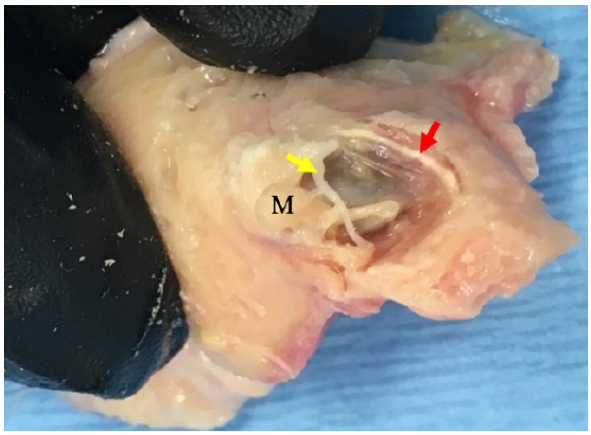


Figure 18: Surgical specimen viewed from medial side. Note the fibrous annulus (red arrow), the malleus (M), the medial surface of the EAC and the chorda tympani (yellow arrow)

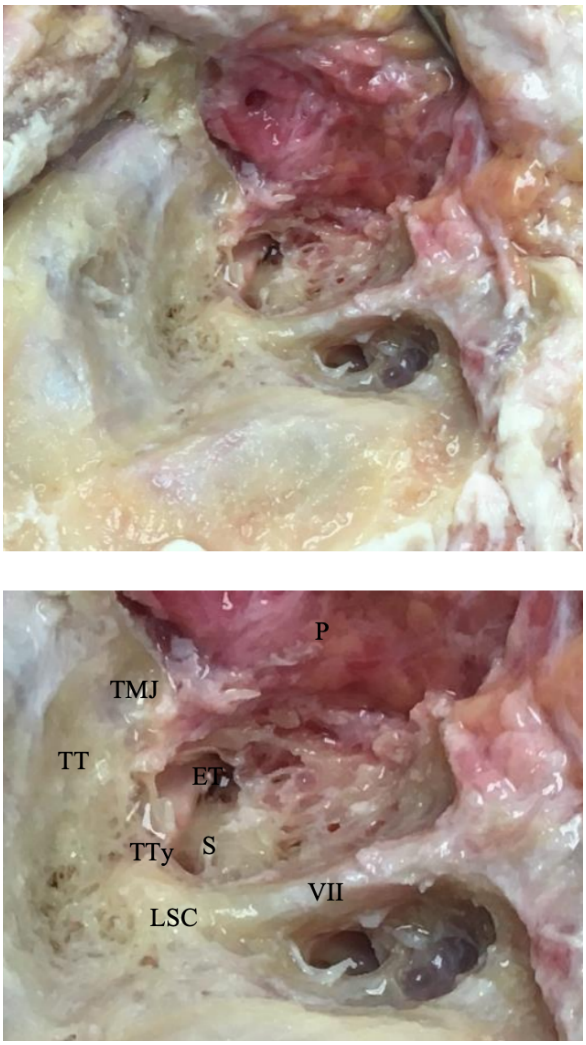


Figure 19: Surgical bed following lateral temporal bone resection; P = parotid; tensor tympani = TTy: tegmen tympani = TT; TMJ = temporomandibular joint; facial nerve = VII; Eustachian tube = ET; stapes = S; lateral semicircular canal = LSC

- Perform a cortical mastoidectomy
- Skeletonize the tegmen tympani and sigmoid sinus (*Figure 7*)
- Drill out the mastoid tip to expose the digastric ridge and retrofacial air cells (*Figure 8*)
- Skeletonize the mastoid segment of the facial nerve (*Figure 9*)
- Keep the posterior bony ear canal relatively thick to avoid inadvertent exposure of cancer
- Perform a posterior tympanotomy (*Figures 10ab*)
- Separate the incudostapedial joint with a joint knife to avoid causing sensorineural hearing loss when drilling in the epitympanum should the burr touch the ossicles (*Figure 11*)
- Drill the bone superior to the EAC towards the root of the zygoma in the space between the tegmen tympani and the EAC, using progressively smaller burrs (*Figure 12*)
- When there is limited space between the tegmen and the ear canal, it may be necessary to remove the bone of the tegmen and expose dura rather than to overthin the ear canal and expose cancer
- Use a diamond burr to avoid injuring the dura and causing a CSF leak
- Avoid sharp ledges of bone over the dura to allow good light into the surgical field
- Once one reaches the 12 o'clock position of the ear canal, direct the drilling trajectory inferiorly
- Expose the anterior epitympanum
- At this point one can remove the incus and use a malleus nipper to remove the malleus head
- Keep drilling anteriorly until the TMJ capsule becomes apparent. It is soft and whiter in color (*Figures 12, 13*)
- Ensure that the TMJ capsule is exposed all the way from the ossicular heads medially to the squamous temporal bone laterally

- Perform an extended posterior tympanotomy by drilling inferiorly along the anterior border of the mastoid segment of the facial nerve – this requires transection of the chorda; the fibrous (tympanic) annulus becomes the medial border of the resection (*Figure 14*)
- Continue the dissection inferior to the bony ear canal in an anterolateral direction (deep to superficial) towards the glenoid fossa
- It is important to use the correct burr: Never use a cutting burr as one needs a longer burr to drill anteriorly. It is dangerous to use a cutting burr, as a long cutting burr can "jump" risking injury to the carotid and jugular bulb. An appropriate sized (2-2.5 mm) diamond burr should rather be used
- It is important to check the height of the jugular bulb on the CT scan to ensure that the jugular bulb is not inadvertently injured!
- Continue drilling until soft tissue is encountered (*Figure 15*)
- The 2nd author (TH) favors a different technique to reduce the risk of the drill injuring the carotid. She drills into the bone in the hypotympanum under direct vision to weaken it, then switches to an osteotome which is directed lateral to the Eustachian tube (carotid forms medial wall of Eustachian tube)
- With an anterior sigmoid sinus, a favorable angle for drilling is obtained by ensuring the bone over the sigmoid is removed - this enables a flatter trajectory so that the jugular bulb and carotid are avoided
- While drilling, it is useful to gently rock the block of bone encasing the EAC anteriorly to determine where it is still attached
- With TMJ capsule exposed superiorly, and glenoid cavity exposed inferiorly, only the thin tympanic bone remains intact anteriorly and is therefore the only remaining bony attachment of the block of bone enclosing the EAC
- Apply gentle anterograde pressure to fracture this thin tympanic bone of the anterior canal (*Figure 16*)
- If the bone does not fracture readily, then a 2 mm osteotome or 2 mm burr can be used through the posterior tympanotomy to fracture the anterior ear canal
- Alternatively, a curved osteotome is passed medial to the TM, malleus and incus (this has been removed) to fracture the tympanic bone, taking care to remain lateral to the Eustachian tube (internal carotid artery passes medial to Eustachian tube). A useful trick is to turn the osteotome so that the bevelled edge faces the promontory and to angle the osteotome so that it points upwards (*Figure 17*)
- At this point, the anterior soft tissue attachments of the EAC can be dissected to remove the bone encasing the EAC with the TM and malleus (*Figures 18 and 19*)

Managing bleeding

- ***Minor sigmoid sinus bleeds with intact bone around the sinus*** can be controlled with bone wax
- ***Bleeding from the sigmoid sinus*** can be ***managed*** with application of hemostatic agents such as Haemopatch, Surgicel or Flowseal with a patty for compression. It is important to remember that venous bleeding should not cause panic and gentle pressure is much better than undue force which will only make the bleeding site widen.
- ***Jugular bulb bleeding*** can be more troublesome. A small bleed from the bulb tip can easily be dealt with using bone wax. However, significant bleeding can occur ***because*** of excess force used when cracking off the last bony attachments, leading to the bone fracturing along the jugular bulb or even the carotid canal.
- This can occur if the bone of the styloid apparatus has not been adequately drilled off the tympanic ring or there has been inadequate drilling around the anterior canal towards the glenoid fossa inferiorly. Jugular bulb bleeding at this site can rapidly fill the surgical field due to brisk sigmoid and inferior petrosal sinus blood flow. Sternocleidomastoid muscle can be mobilized and applied with gentle pressure to plug the area. Free muscle can be oversewn between the glenoid/ parotid tissue and the sternomastoid muscle as a patch. In the event of uncontrolled bleeding, the jugular vein is ligated in the upper neck and the sigmoid sinus and inferior petrosal sinuses are packed with Surgicel through the tear in the jugular bulb.
- The 2nd author applies pressure by packing with Surgicel, then ligates the jugular vein in the neck and the sigmoid in the mastoid cavity
- Skeletonize the sigmoid sinus, then remove the thin shell of bone over a small section of the sigmoid by using a Plester knife
- Use an aneurysm needle threaded with a double silk ligature and pass it behind the sigmoid sinus by making small slits in the dura next to the sigmoid sinus. Remove the needle, leaving behind the double ligature and tie these. This may cause a small CSF leak. This can be plugged using fat
- Complete the operation by obliterating the cavity with a temporalis muscle flap



Figure 20: Aneurysm needle

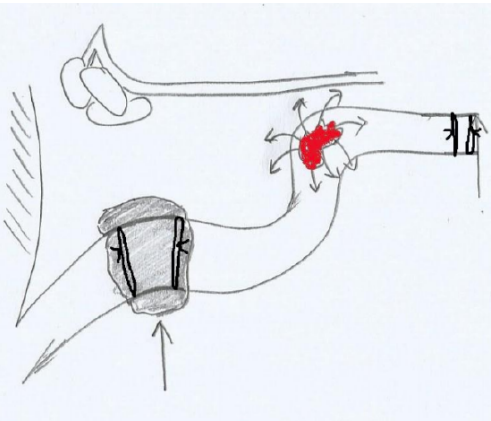


Figure 21: Double ligatures tied around sigmoid sinus

Ancillary procedures

Parotidectomy: If parotidectomy is to be done, it is best to do it before the lateral temporal bone resection. Superficial parotidectomy is usually performed for T1/2 tumors. Total parotidectomy is done for T3/4 tumors. For BCC without parotid invasion, parotidectomy is not required.

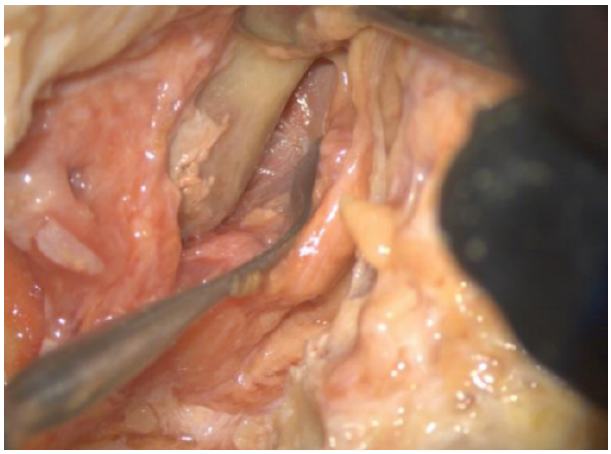


Figure 22: Exposure of mandibular condyle. An incision has been made on the condyle and the periosteum has been elevated so that it can be drilled

Temporomandibular joint: If tumor extends into or near the TMJ, a partial mandibulectomy is performed. Typically, this involves a condylectomy (*Figure 22*), but for more extensive disease the resection may extend from the mandibular notch to the angle of mandible.

Neck dissection: For SCC with or without nodal metastasis, neck dissection including Levels 1b, 2-5 should be considered.

Reconstruction



Figure 23: Temporalis muscle reflected over temporal bone defect



Figure 24: Split skin graft over temporalis muscle

If the ***pinna is preserved*** but the concha and tragus are removed, then reconstruction can be performed using a pedicled muscle flap e.g. temporalis muscle can be rotated over the cavity and sutured to the sternocleidomastoid muscle (*Figure 23*). The canal can be oversewn and the pinna placed back in position. If the pinna is resected, a split skin graft can also be placed over the temporalis muscle: this usually works quite well if one can't do a free flap (*Figure 24*).



Figure 25: Cervicofacial flap

- An alternative is to fashion an open mastoid cavity, but such a cavity will take a long time to heal and regular debridement in the office is required
- When the ***pinna is removed***, local flaps (temporalis; cervicofacial (*Figure 25*), submental, supraclavicular (See clinical example), latissimus dorsi) or free flaps are required. The anterolateral thigh flap is a particularly useful flap as it provides both bulk and skin cover.
- Bone anchored hearing aids are an excellent choice for rehabilitation. Ideally it should be fitted at the time of the resection, as irradiation may compromise osseointegration. Although there may be some artifact with CT scans, most bone anchored hearing aid systems are MRI safe up to 3T with no adverse effects.
- Nonimplanted bone conduction hearing aids or even contralateral routing of sound hearing aids can also be used

Related procedures

Sleeve resection: This can be done for nonaggressive tumors of the cartilaginous EAC without bony invasion. However, patients rarely present early enough for it to be done.

Near-total temporal bone resection: This should be considered for tumors extending medial to the TM or into the mastoid. The resection involves removing the temporal bone leaving only the petrous apex attached to the clivus. The facial and vestibulocochlear nerves are sacrificed. The surgical technique involves a temporal craniotomy, transmastoid and transcervical approaches. If dura is involved, it can be resected with the specimen, but involvement of the brain implies the tumor should be considered incurable.

Total temporal bone resection: This involves en bloc resection of the temporal bone including the petrous apex and sigmoid sinus. There is no evidence that this improves survival and is not part of the authors' practice.

Clinical Example



Figure 26: Extensive squamous cell carcinoma

This patient had extensive squamous carcinoma of the pinna extending into the ear canal and the parotid and nodal metastases. The incision was extended into the neck (“hockey stick”) for a modified radical neck dissection and parotidectomy (*Figure 26*). The facial nerve was intact and a superficial parotidectomy was done by retrograde dissection of the facial nerve.



Figure 27: Mastoid being exposed after neck dissection and superficial parotidectomy have been completed

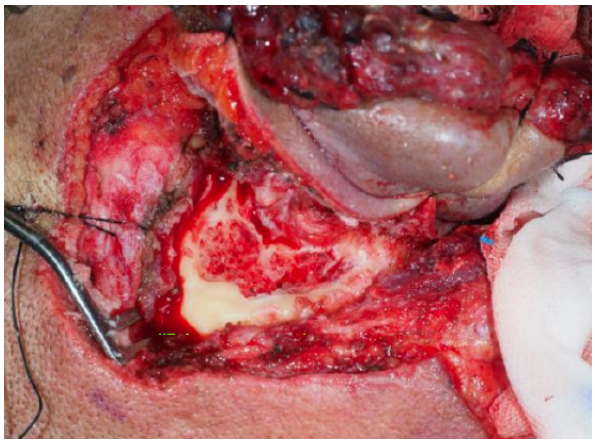


Figure 28: Commencement of cortical mastoidectomy

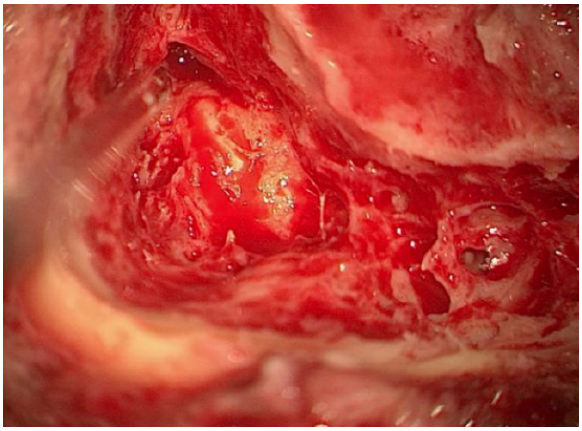


Figure 29: Cortical mastoidectomy with exposure of lateral semicircular canal

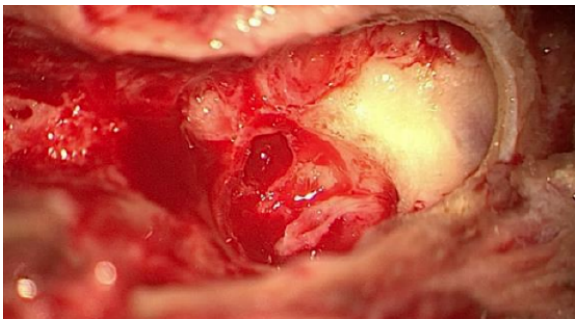


Figure 30: Mastoid tip drilled to expose digastric ridge

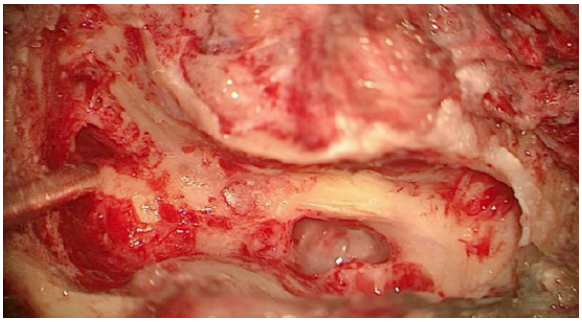


Figure 31: Mastoid segment of facial nerve exposed

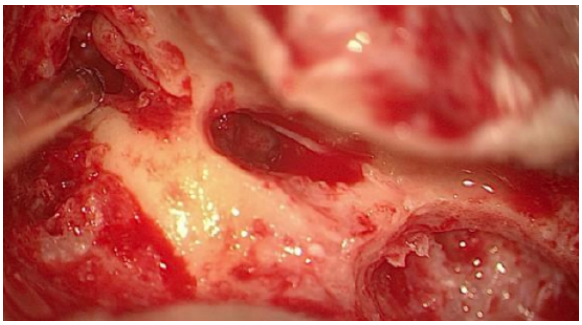


Figure 32: Posterior tympanotomy with chorda tympani visible; sucker tip points to incus

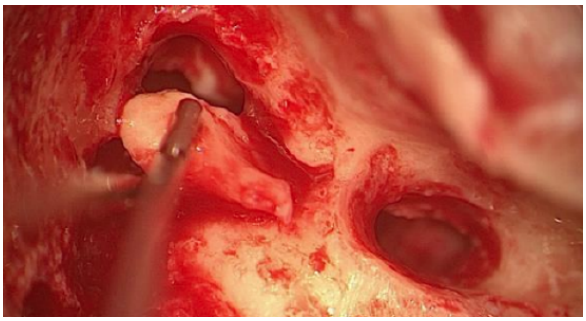


Figure 33: Incus being removed

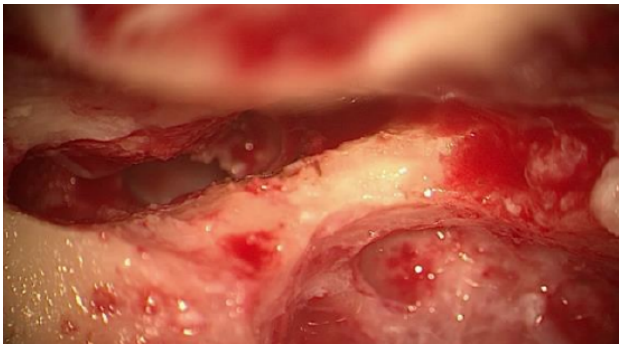


Figure 34: Completed extended posterior tympanotomy

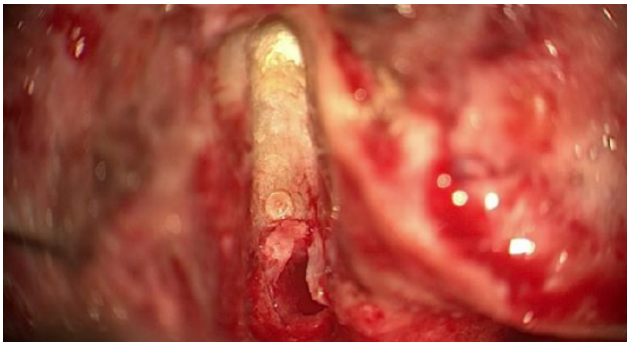


Figure 35: Drilling superiorly toward TMJ

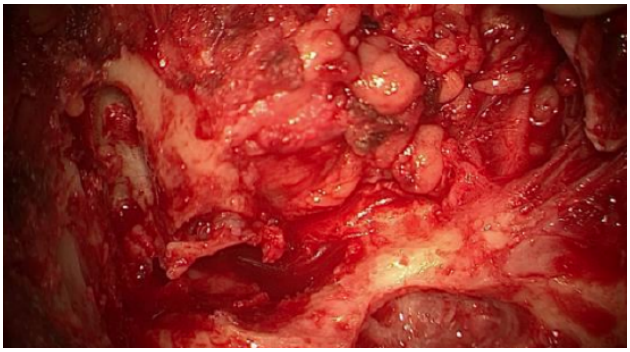


Figure 36: Drilling superiorly toward TMJ

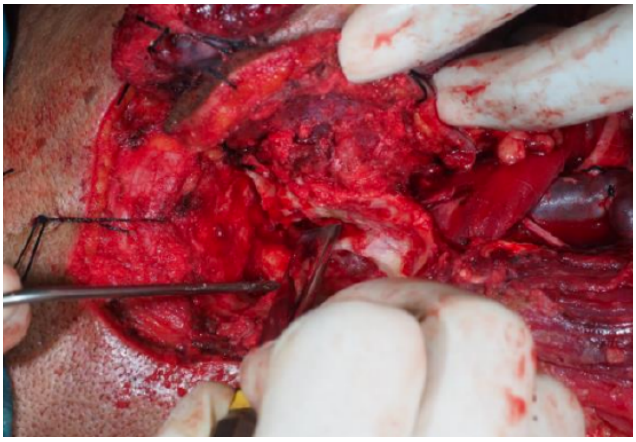


Figure 37: Osteotome used fracture anterior tympanic bone

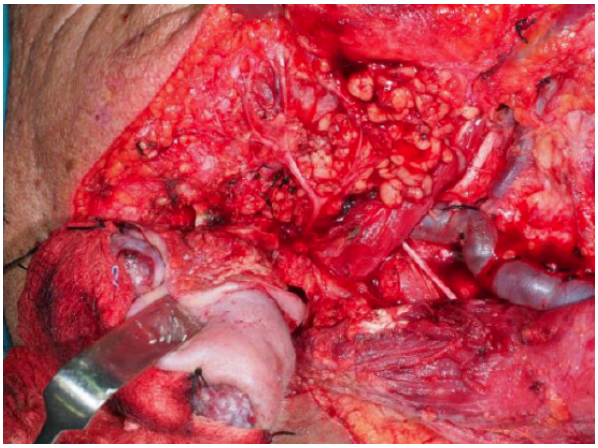


Figure 38: Before removal of specimen

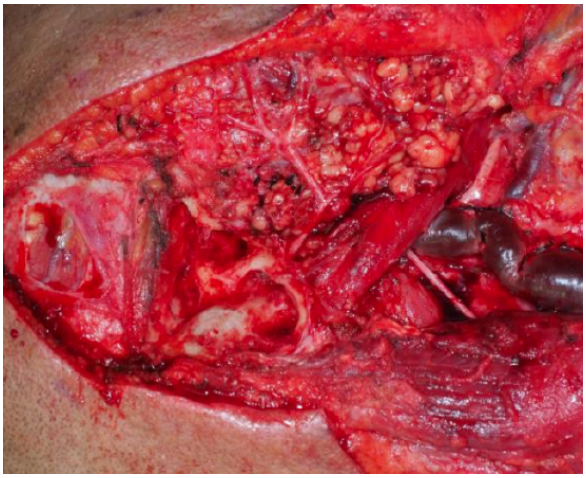


Figure 39: View of completed lateral temporal bone resection and superficial parotidectomy and neck dissection

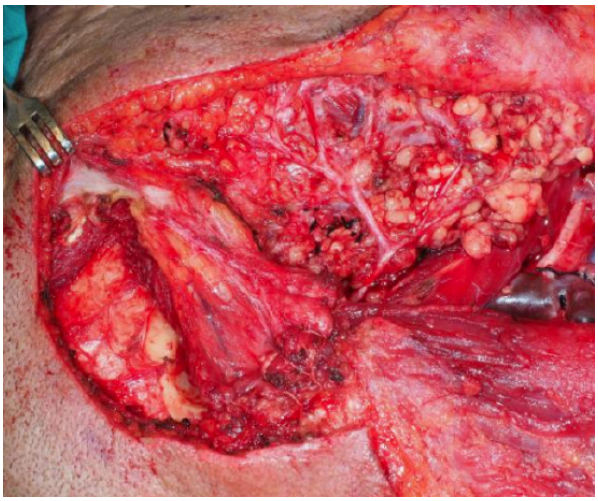


Figure 40: Temporalis muscle reflected over temporal bone defect

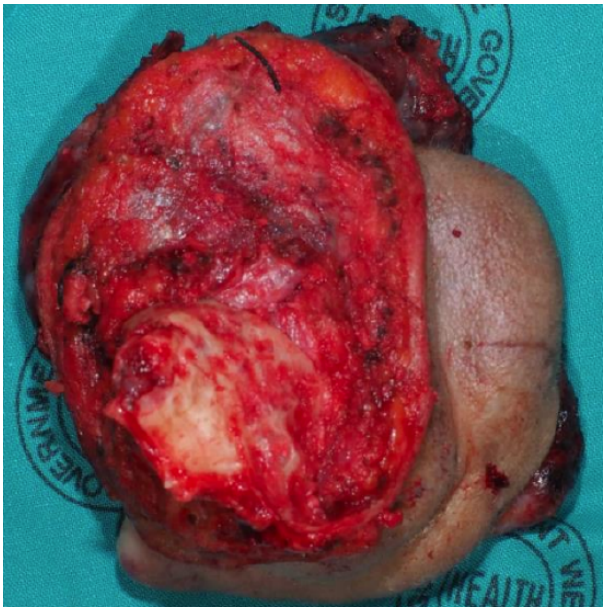


Figure 41: Medial view of specimen



Figure 42: Lateral view of specimen



Figure 43: Supraclavicular flap



Figure 44: Supraclavicular flap

References

1. Ho B, Solares CA, Panizza B. Temporal bone resection. Operative Techniques in Otolaryngology, 2013;24:179-83
2. Chung SJ and Pensak ML. Tumors of the temporal bone. In Neurotology 2nd edition, eds Jackler RK and Brackmann DE, 2005, Mosby Inc
3. Arriaga MA and Leonetti JP. Malignancies of the temporal bone - limited temporal bone resection. In Otologic Surgery 3rd edition, editors Brackmann D, Shelton C, Arriaga M, 2009, Saunders
4. Homer JJ, Lesser T, Moffat D et al. Management of lateral skull base cancer: United Kingdom National Multidisciplinary Guidelines. J Laryngol Otol. 2016. 130(S2),S119-S124

Authors

Rajeev Mathew MBBS, MA, PhD, FRCS
Senior Registrar
ENT Surgery
St George's Hospital NHS Foundation
Trust
Tooting, London
Rajeev.mathew@nhs.net

Tashneem Harris MBChB, FCORL, MMed (Otol)
Fisch Instrument Microsurgical Fellow
ENT Specialist
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
harristasneem@yahoo.com

Parag Patel MBBS, BSc (Hons), MSc, FRCS
Consultant ENT Surgeon
Clinical Lead for Skull Base Surgery
St George's Hospital NHS Foundation
Trust
Tooting, London
Parag.patel2@nhs.net

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.3: Open Cervical Surgery for Congenital H-type Tracheoesophageal Fistulae
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FRENULOTOMY AND FRENULECTOMY FOR ANKYLOGLOSSIA (TONGUE TIE)

Ndivhuwo Diale, Shazia Peer, Jessica McGuire

Frenulotomy (also referred to as frenotomy) and frenulectomy (frenectomy) are surgical procedures used to correct ankyloglossia, a congenital condition in which the lingual frenulum is too short, causing restricted tongue movement. It is commonly called a tongue tie and it affects 4-11% of neonates[1].

Frenulotomy refers to an incision in the frenulum that frees the tongue from the floor of the mouth. Frenulectomy refers to complete excision of the frenulum. It is more invasive and may be difficult to perform on small children; however, the results are more predictable, and the recurrence rate is lower.

Anatomy

The tongue is attached to the floor of the mouth by the lingual frenulum. The frenulum's appearance varies considerably between individuals. Microdissection of cadavers shows that it is a dynamic, layered structure formed by oral mucosa and the underlying floor of mouth fascia, which is mobilized into a midline fold with tongue elevation and/or retraction[2].

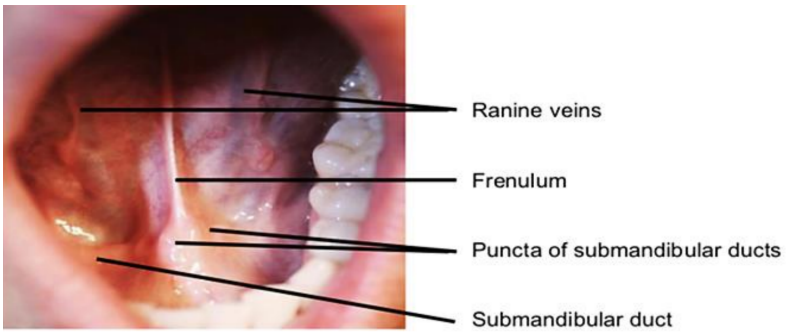


Figure 1: Floor of the mouth and ventral surface of the tongue

The base of the frenulum contains a "V" shaped hump of tissue in the floor of the mouth which houses the two Wharton's ducts on either side. The sublingual salivary glands empty through tiny ducts on either side of Wharton's ducts. Superficial veins running through the base of the frenulum are known as ranine veins (*Figure 1*).

Classification of ankyloglossia (Table 1)

Type 1	Most extreme form, 100% of the tongue is attached to the lingual frenulum and is tethered to the floor of the mouth anteriorly	

Type 2	75% of the tongue is tethered with restricted elevation and extension of the tongue	
Type 3	50% of the tongue is tethered. Tongue appears normal, but mobility is limited.	
Type 4	Limited tongue mobility due to a posterior, fibrous limitation of the most distal portion of the lingual frenulum	

Table 1: Modified grading system developed by Coryllos et al[9]. Type 2-4 images obtained from Yoon et al[10]

Currently, there are no established criteria or grading systems to classify ankyloglossia.

Several studies have suggested various guidelines based on the following criteria:

- Length of the frenulum[3,4]
- Upward tongue mobility (difficulty lifting the tongue to the upper dental alveolus)[5,6]
- Limited tongue protrusion ≤1–2 mm past the lower central incisors[7]
- Impaired lateral mobility of the tongue, 'heart-shaped-tongue-appearance' and thick fibrous cord palpated on physical examination[8]

The classification by Coryllos permits identification of type III and IV frenula, which can go unnoticed with macroscopic examination, by means of palpation (*Table 1*). For a diagnosis of ankyloglossia in neonates it is necessary to combine both functional and anatomical criteria.

Indications for surgery

There has been a surge in frenulotomies performed on neonates in recent years in an attempt to improve breastfeeding. A Cochrane review found that frenulotomy reduced mothers' nipple pain and had for the most part, positive short-term effects on breastfeeding[1].

Indications

- Difficulty feeding, poor latch in breastfeeding babies and poor weight gain
- Difficulty swallowing
- Decreased mobility of tongue
- Speech difficulties
- Significant dental problems

A frenulotomy is appropriate in patients with symptomatic type 2-4 ankyloglossia, provided that the frenulum is not fibrotic. Type 1 ankyloglossia, fibrotic frenula and revision cases would benefit from a frenulectomy.

In neonates and infants, it may be performed under local anesthesia in an outpatient setting. The author has performed this procedure in a 16-week infant. The optimum age to perform a frenulotomy in infants is unclear[1] and the age limit to performing the procedure under local anesthesia is equally unclear. Consider a general anesthesia in babies much older than 16 weeks.

Frenulotomy

Surgical consent is obtained.

a. Outpatient Awake Procedure

Positioning

- The child is swaddled and restrained by an assistant
- The child is then placed flat with head in neutral position and mouth open

Local anesthesia

- Lignocaine HCl 1% m/v local anesthetic with adrenaline 1:160000 is injected on either side of the frenulum
- The dose limit is 7 mg/kg and each 1 mL contains 10 mg of lignocaine
- This is important to bear in mind for small infants

Procedure

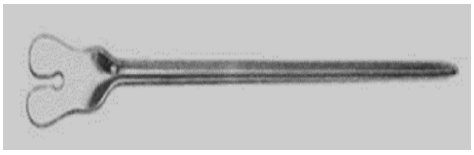


Figure 3: Example of a grooved retractor



Figure 4: Grooved retractor manufactured from a teaspoon



Figure 5: Grooved retractor tenting the frenulum

- A grooved retractor is used to retract the tongue (*Figures 3,4,5*)
- A straight Crile hemostat is used to crimp the frenulum prior to release
- Sterile curved scissors are then used to release the lingual frenulum at its attachment
- The incision should be close to the ventral surface of the tongue to avoid injury to the ductal orifices
- To ensure adequate release of the frenulum, using your finger, gently massage the tongue at the deep end of the cut frenulum.
- The floor of mouth is compressed with gauze to provide hemostasis, if necessary

In the awake child, sucking and oral 50% dextrose syrup may also be used to sooth the infant.

b. General Anesthesia

Intubation

- Intermittent mask ventilation or nasal intubation is preferable for adequate access
- Oral intubation may also be performed

Positioning

- Place the child in a supine position with head extended
- Open the mouth and use the grooved retractor to retract the tongue

Surgical steps



Figure 6: Hemostat clamped parallel to tongue



Figure 7: Middle finger retracting lower lip to avoid injuring it while lingual frenulum is released



Figure 8: Diamond-shaped wound following frenulotomy



Figure 9: In revision cases, or older children, interrupted absorbable sutures can be placed to prevent the release from adhesing back down onto the floor of mouth

- Inject or apply topical pledgets soaked with 1:80000 lignocaine with adrenaline to either side of frenulum
- Use the grooved retractor to retract the ventral tongue to fully expose the lingual frenulum (*Figure 5*)
- Clamp a straight Crile hemostat onto frenulum parallel to the tongue at its ventral surface (*Figure 6*)

- Wait a few seconds, and then release the hemostat
- Use sterile iris scissors to release the lingual frenulum at its attachment (*Figures 6-8*)
- Make the incision close to the ventral surface of the tongue to avoid the submandibular and sublingual salivary gland ducts which open onto the floor of the mouth
- To break down deeper fibrous bands, gentle finger / peanut dissection is recommended (encountered more often in thicker frenula and revision cases)
- The genioglossus muscle is the posterior limit of the frenulum incision
- Compress the floor of mouth with gauze to provide hemostasis
- In revision cases, or with older children, interrupted absorbable sutures can be placed to prevent the release from adhesing back down onto the floor of mouth. Take care near the papilla of the submandibular ducts (*Figure 9*)

Complications of surgery (rare)

- Bleeding
- Infection
- Swelling
- Discomfort
- Injury to Wharton's duct
- Scarring requiring revision

Z-Frenuloplasty

This is recommended in older children and revision cases to improve speech.

Surgical Steps

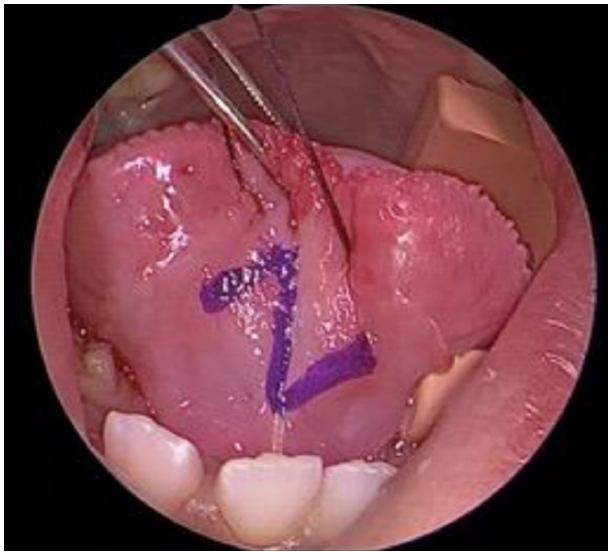
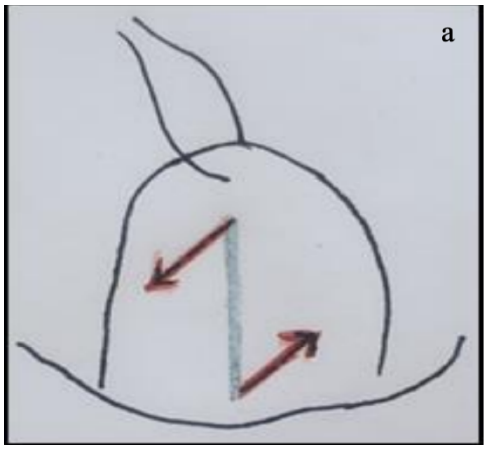
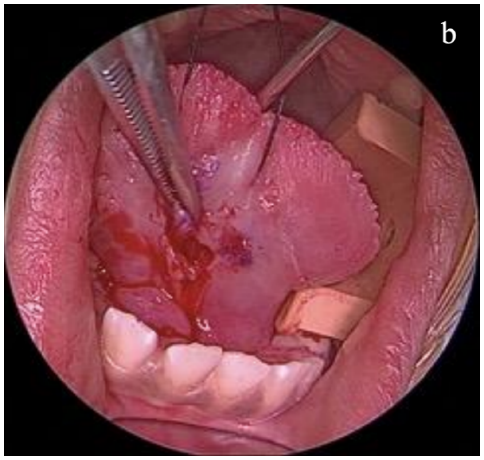


Figure 10: Incisions outlined

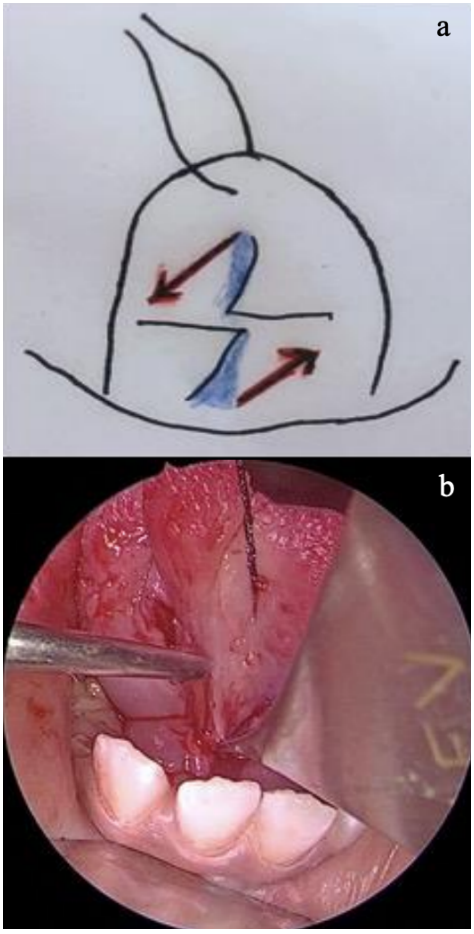


Figure 11: Vertical incision along frenulum

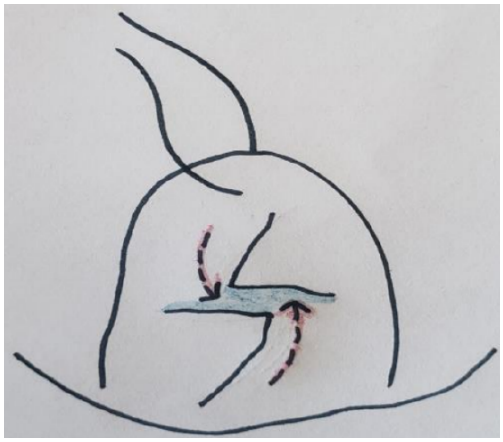


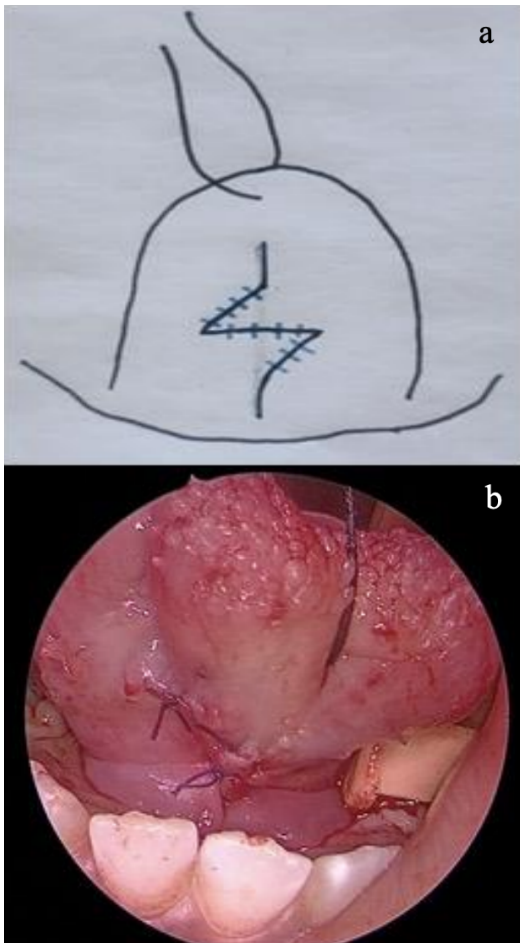


Figures 12a, b: Two incisions at 900 to vertical incision



Figures 13a, b: Two flaps are elevated


Figure 14: Transpose the 2 flaps adjacent to each other to close in the form of a Z-plasty



Figures 15a, b: Sutures flaps to complete the Z-plasty

- Place a silk stitch through the tongue tip to retract the tongue and hold it in place (*Figure 10*)
- Apply lignocaine with adrenaline injection of 1:80 000 or topical pledgets to either side of frenulum
- Draw the Z-plasty incisions (*Figure 10*)
- Make a vertical/longitudinal incision along the length of the frenulum (*Figure 11*)
- Make 2 incisions at 900 to the first vertical one (*Figures 12a, b*)
- Two rectangular flaps are now created and elevated (*Figures 13a, b*)
- Transpose the 2 flaps adjacent to each other to close in the form of a Z-plasty (*Figure 14*)
- Suture with interrupted 5.0 vicryl (*Figures 15a, b*)

References

1. O'Shea JE, Foster JP, O'Donnell CP, Breathnach D, Jacobs SE, Todd DA, Davis PG. Frenotomy for tongue-tie in newborn infants. Cochrane Database of Systematic Reviews. 2017(3)
2. Messner AH, Lalakea ML, Aby J, Macmahon J, Bair E. Ankyloglossia: incidence and associated feeding difficulties, Arch Otolaryngol Head Neck Surg. 126 (2000) 36–9
3. Kotlow LA, Ankyloglossia (tonguetie): a diagnostic and treatment quandary, Quintessence Int. 30 (1999) 259–62
4. Marmet C, Shell E, Marmet R, Neonatal frenotomy may be necessary to correct breastfeeding problems, J Hum Lact. 6 (1990) 117–21
5. Hogan M, Westcott C, Griffiths M, Randomized, controlled trial of division of tongue-tie in infants with feeding problems, J Paediatr Child Health. 41 (2005) 246–50
6. Masaitis NS, Kaempf JW. Developing a frenotomy policy at one medical center: a case study approach. J. Hum. Lact. 12 (1996) 229–32
7. Chu MW, Bloom DC. Posterior ankyloglossia: a case report, Int J Pediatr Otorhinolaryngol. 73 (2009) 881–3
8. Harris EF, Friend GW, Tolley EA. Enhanced prevalence of ankyloglossia with maternal cocaine use, Cleft Palate Craniofac J. 29 (1992) 72–6

9. Coryllos E, Genna CW, Salloum AC. Congenital tongue-tie and its impact on breastfeeding. AAP section on breastfeeding. 2004; Vol. Summer http://www.aap.org/breastfeeding/files/pdf/BBM-8-27%20Newsletter.pdf
10. Yoon AJ, Zaghi S, Ha S, Law CS, Guilleminault C, Liu SY. Ankyloglossia as a risk factor for maxillary hypoplasia and soft palate elongation: A functional–morphological study. Orthodontics & craniofacial research. 2017 Nov;20(4):237-44

Authors

Ndivhuwo Diale MBChB, MMed, FCORL
Otolaryngologist
Sefako Makgatho Health Sciences
University, Gauteng Province, South Africa
ndivhuwobele@yahoo.com

Shazia Peer MBChB, MMed, FCORL
A-Professor, Pediatric Otolaryngologist
Red Cross War Memorial Children's Hospital, Cape Town, South Africa
shazia.peer@uct.ac.za

Jessica McGuire MBChB, MMed, FCORL
Pediatric Otolaryngology
Red Cross War Memorial Children's Hospital, Cape Town, South Africa
jkmcguire2@gmail.com

Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital Cambridge, United Kingdom
nicojonas@gmail.com

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CLOSURE OF PEDIATRIC TRACHEOCUTANEOUS FISTULA: SURGICAL TECHNIQUE

Buhlebenkosi Hlomani, Shazia Peer

A tracheocutaneous fistula (TCF) is an epithelial-lined communication between skin and trachea that persists after decannulation (removal) of a tracheostomy tube. TCF rates are higher in pediatric patients. It is a recognized complication of long-standing tracheostomies and has been linked to longer duration of tracheostomy dependence[1].

Complications associated with a persistent TCF include skin irritation; inadequate glottic closure causing a weak cough and airway compromise; poor phonation; poor cosmesis; increased risk of aspiration during swimming, bathing etc.[2]. Addressing a persistent TCF avoids delays with integration into society and mainstream schooling.

TCF is due to squamous epithelialization of the tracheostomy lumen. Closure is achieved by excising the fistula followed either by primary closure or allowing for healing to occur by secondary intention. Although primary closure provides immediate resolution of the fistula and better cosmesis, it may be associated with life-threatening complications, regardless of the treatment center[3]. Allowing healing by secondary intention minimizes such potential complications. It may however be perceived as “inconvenient” for the patients.

It is however the authors’ preference to allow healing by secondary intention, safety in the immediate postoperative period being the primary reason.

Preoperative evaluation

1. **Patient selection is as important as timing of surgery**: We employ the following eligibility criteria based on etiological and patient factors and use them as a guide for timing of surgery:

- The original reason for the upper airway obstruction that necessitated the tracheostomy has resolved/been reversed
- The child has been successfully decannulated for >1 year; this sees the child through 1 winter season
- Typically, children are >4 years old, weigh >15 kg and have no central neurological deficits or cardiovascular compromise e.g. after cardiac surgery or pulmonary disease
- If the surgery is done on a 2- 4-year-old child weighing >15 kg, it is advisable to insert a tracheostomy tube for the 1st 24 hours immediately postoperatively
- Diagnostic assessment of the upper airways is routinely performed before any decision is taken about surgery. Anatomical and physiological factors are discussed later

2. **Flexible nasendoscopy**: This is typically done in the clinic with the child awake. The nasopharynx, oropharyngeal inlet, base of tongue (BOT), supraglottis and vocal cord mobility are carefully assessed.

3. **Overnight sleep study / Overnight oximetry**: This is useful to assess children with reported sleep disordered breathing. The TCF is covered while asleep to assess for proximal airway obstruction.

4. **Direct laryngoscopy, tracheoscopy and bronchoscopy**

- During induction of anesthesia, the patient must breathe spontaneously and cope well with bag mask ventilation. The TCF can be covered with a dressing
- Flexible bronchoscopy is then done through a laryngeal mask
  - Confirm cord mobility
  - Spray the larynx with topical lignocaine
  - Perform dynamic assessment of upper airways, especially in cases of tracheomalacia and bronchomalacia
  - When aspiration is a concern, a broncheoalveolar lavage (BAL) is also done
- Perform rigid laryngoscopy +/- suspension

- Assess all levels of the airway i.e. oropharynx, BOT, vallecula, epiglottis, supraglottis, false and true cords, subglottis, trachea (proximal to stoma), peristoma, distal trachea down to carina
- If any pathology is identified, a staged approach with initial surgical correction required before the TCF can be addressed e.g. removing a suprastomal granuloma, addressing persistent subglottic stenosis etc o Record the size of the airway using appropriate-sized endotracheal tubes. A child of 4 years must admit at least a 4.5 ETT with a leak at 20 cm H_2O. If older, use a size uncuffed ETT of (Age/4) + 4.

If the child is considered eligible for closure of the TCF, then proceed to surgery

Surgical procedure to close a TCF



Figure 1a: Child placed supine with neck extended and north facing ETT



Figure 1b: Patient with a prominent occiput positioned without a head ring

- Administer a single dose of prophylactic antibiotics (Kefzol), and a single dose of intravenous steroids
- Intubate the airway with an appropriate sized cuffed (0.5 size smaller to accommodate a cuff) north-facing endotracheal tube (*Figures 1ab*)
- Position the child supine with a shoulder roll to extend the neck (*Figures 1ab*)
- A head ring may be required to maintain the head in a neutral position



Figure 2: Infiltration with local anesthetic

- Infiltrate the skin around the TCF with local anesthetic (Lignocaine with adrenaline). Do not exceed the maximum safe dose (*Figure 2*)



Figure 3: Occasionally, the TCF lies off the midline

- After cleaning and draping, identify the midline structures as tracheostomy sites typically are in a paramedian position and the TCF may be further from the midline than expected (*Figure 3*)



Figure 4: Mark the skin around the TCF as an ellipse

- Mark the skin around the stoma in an elliptical shape (*Figure 4*)
- Incise the skin along the elliptical markings around the TCF



Figure 5: Skin incision, elevating the edges and grasping skin with tissue forceps

- Elevate the two ends and grip them using a tissue forceps (*Figure 5*)
- Dissect the soft tissue circumferentially around the stoma using cautery and blunt dissection



Figure 6: Excision of tract, down to trachea

- Stay close to the TCF and expose a 10 mm margin of trachea (*Figure 6*)
- Avoid dissecting into trachea (*Figure 6*)



Figure 7: Resected TCF

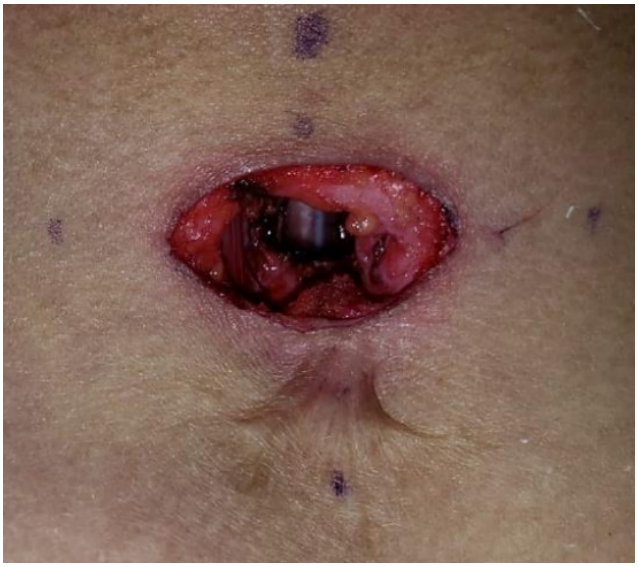


Figure 8: Defect following resection of TCF

- Enter the trachea close to the TCF using an #11 blade, and circumferentially excise the TCF, removing as little tracheal tissue as possible (+/- 5 mm) (*Figure 7*)
- Avoid a large defect by not excising too much of the anterior tracheal wall as it will take longer to close (*Figures 7, 8*)
- Ensure that there is no remaining skin in the tract as this will prevent closure



Figure 9: Approximate wound edges with steristrips



Figure 10: Cover the defect with a pliable dressing

- Oppose the skin with steristrips (*Figure 9*)
- Cover the defect with a pliable dressing that allows for a reservoir of air with the child's breathing (*Figure 10*)

Postoperative care

- The surgeon must accompany the child from the operating room to the recovery room with an unopened appropriately sized pediatric tracheostomy tube to be kept at the bedside
- Once fully recovered, the child must be nursed in a high care ward
- For the first 24 hours, continuous monitoring of oxygen saturation, respiratory rate and heart rate, and watching for signs of respiratory distress, is paramount
- Sedation and good analgesia are recommended as crying and coughing increase the risk of surgical emphysema
- Immediately remove the dressing if there is any breathing difficulty, and reinsert a tracheostomy tube
- The child is transferred to a general pediatric ward for 24-48 hours
- Give strict instructions to the caregiver to avoid water around the revised stoma
- Change the dressing if it becomes soggy
- If secretions are copious, it is preferable to keep the stoma uncovered
- The child is reviewed at 1 week postoperatively



Figure 11: Stoma healed by secondary intention 1-week postoperatively

- The stoma is typically healed by then (*Figure 11*)

Complications

Immediate / 1st 24 hours



Figure 12: Acute pneumothorax

- Respiratory distress from
  - Pneumothorax (*Figure 12*)
  - Pneumomediastinum
- Surgical emphysema
  - As a result of air escaping from the trachea into surrounding tissues
  - May be forced into the mediastinum causing a pneumomediastinum
  - Immediate management requires prompt reinsertion of the tracheostomy tube and oxygen supplementation

Delayed

- Failure of TCF to close
- Peristomal granulation tissue
- Suprastomal (anterior) tracheal collapse
- Tracheomalacia
- Tracheal stenosis

References

1. Ha T, Goyal M, Ongkasuwan J. Duration of tracheostomy dependence and development of tracheocutaneous fistula in children. The Laryngoscope. 2017;127(12): 2709-12
2. Wine T, Simons JP, Mehta DK. Comparison of 2 Techniques of Tracheocutaneous Fistula Closure Analysis of Outcomes and Health Care Use. JAMA Otolaryngol Head Neck Surg. 2014;140(3):237-42
3. Osborn AJ, de Alarcón A, Hart CK, Cotton RT, Rutter MJ. Tracheocutaneous Fistula Closure in the Pediatric Population: Should Secondary Closure Be the Standard of Care? Otolaryngology–Head and Neck Surgery. 2013;149(5): 766–71

Authors

Buhlebenkosi Hlomani MBChB
Otolaryngology resident
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
b_hlomani@yahoo.com

Shazia Peer MBBCh, FCORL, MMed Head, Pediatric Otolaryngology
Red Cross Children's War Memorial Hospital
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
shazia.peer@uct.ac.za

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN CERVICAL SURGERY FOR CONGENITAL H-TYPE TRACHEOESOPHAGEAL FISTULAE (TOF)

Mark Quick, Shyan Vijayasekaran

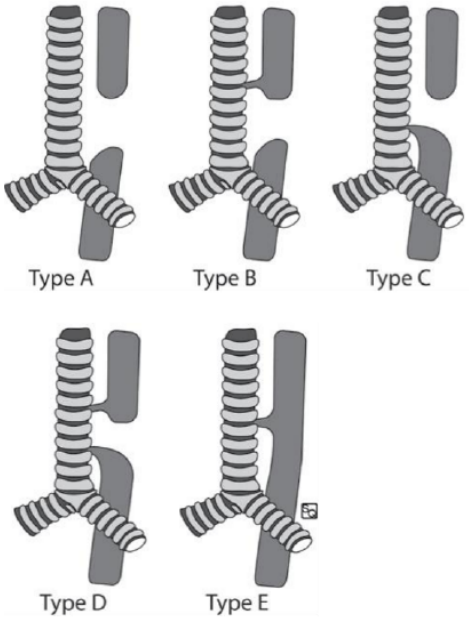


Figure 1: Gross TOF classification[4]

Esophageal atresia (OA) with or without a tracheoesophageal fistula (TOF) has an incidence of 1 in 2500 – 4500 live births.[1] Two distinct TOF classification systems are used, with the initial system by Vogt published in 1929, that was later modified by Gross in 1953 into five types of TOF (*Figure 1*). [2,3]

The most common TOF is Type C (86%) comprising of a proximal blind esophageal pouch and distal TOF into the distal esophagus (*Figure 1*). Type E, better known as an H-type (*Figure 1*) fistula without OA, has an incidence of 4-7% of all TOFs.[4] H-type fistulae have occurs in 1 in 50,000 to 80,000 live births.[5]

Endoscopic procedures have been employed to obliterate TOFs and include using fibrin glue, electrocautery, or laser coagulation of the fistula tract.[6,7] Surgery remains the standard treatment with low recurrence rates.[4,8-10] An open cervical approach is recommended for TOFs located above the level of T2[11] which accounts for majority of H-type TOFs.

Etiology

The etiology of TOF/OA is poorly understood. Although a TOF may occur in isolation, 50% are associated with congenital anomalies with cardiac anomalies being the most common. These associated anomalies are summarized in the genetic syndrome VACTERL (vertebral, anorectal, cardiac, tracheoesophageal, renal and limb abnormalities) (*Table 1*). Other rare associated syndromes include Pierre-Robin, CHARGE or Di George with its chromosomal abnormality on 22q11 associated with esophageal atresia.

Type	Incidence	Anomalies
Vertebral	17%	Scoliosis
Anal	12%	Imperforate anus, Duodenal atresia

Cardiac	20%	VSD, PDA, Tetralogy of Fallot, ASD
Renal	16%	Renal agenesis / dysplasia, hypospadias, polycystic
Limb	10%	Radial anomalies, polydactyly

Table 1: Congenital anomalies associated with TOF/OA[14]

Anatomy and Embryology

The trachea and esophagus develop from a ventral diverticulum of the foregut. Proliferation of endodermal cells around week 3 of intrauterine life occurs over the diverticulum. The division of this cell mass forms the trachea and esophagus. A TOF occurs during this period because of disruption to normal development. The primary mechanism of this disruption is unknown. However several key mutations including that of the Sonic hedgehog (Shh) gene identified in animal models result in failure of tracheoesophageal separation and fistula formation.[12]

Diagnosis

Presentation and examination

TOFs are not easily diagnosed antenatally. Polyhydramnios identified on prenatal ultrasound may be secondary to esophageal obstruction but is nonspecific and should not be used solely as a diagnostic marker.





Figures 2 a, b: Chest X-ray showing curled nasogastric tube at blind-ending esophageal lumen and gastric bubble suspicion for TOF

The diagnosis of OA is made early following delivery and is confirmed by inability to pass a nasogastric tube into the stomach (*Figure 2*).



Figure 3: MLB with posterior tracheal wall TOF identified

The type of TOF is determined at microlaryngoscopy and bronchoscopy (MLB); however, subtle deformities and the level of a TOF can be missed (*Figure 3*).

H-type TOFs has more variable presentations. A delay or even misdiagnosis can occur as the esophagus remains intact without disruption. Common clinical symptoms include choking or cyanotic spells during feeding, abdominal distension leading to splinting during inhalation, or recurrent chest infections. These symptoms can be misdiagnosed as gastroesophageal reflux. A high index of suspicion for H-type TOF is important particularly with patients presenting with recurrent chest infections.

Investigations

Endoscopic evaluation including MLB and esophagoscopy can identify the location, size, and number of TOFs, which are all important for surgical planning. Other associated laryngeal or tracheal abnormalities can be identified at the time of MLB.



Figure 4: Contrast radiographic study showing communication between esophagus and trachea

Contrast radiographic studies (tube esophagograms) are useful in premature and very small neonates where MLB is technically difficult. It avoids a general anesthetic in neonates with complex underlying medical conditions. The neonate is placed supine or in a lateral position and contrast is injected into a nasogastric tube while slowly withdrawing it within the esophagus. If there is a fistula, contrast will spill into the trachea. This is not routinely employed by the senior author (*Figure 4*).

Management

Immediate

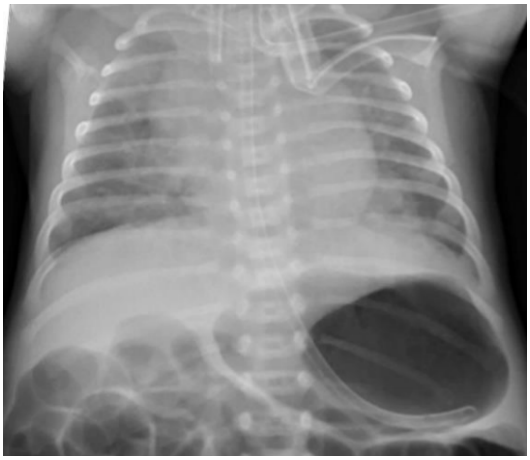


Figure 5: Chest X-ray showing the NGT in the stomach with significant gastric inflation from a suspected TOF

A neonate presenting with difficulties with swallowing or respiratory distress with abdominal splinting following delivery as outlined above, should be transferred to a neonatal intensive care unit. A nasogastric tube (NGT) should be inserted, and its position confirmed on x-ray. Increasing abdominal distension with inhalation and a confirmed gastric position of a NGT should raise the suspicion of an H-type TOF (*Figure 5*).

Aspiration of abdominal gas to alleviate abdominal splinting can be performed to improve breathing. Neonatologists, pediatric ENTs, pediatric general surgeons, and pediatricians should be consulted.

Tracheoesophageal fistula identification



Figure 6: Esophagoscopy identifying Foley catheter cannulated through the TOF from the trachea

Initial management is directed at identifying the TOF, including the level, size, and number of fistulae. Using MLB, the TOF can be cannulated with a size 5/6 FG Foley catheter and then confirmed with esophagoscopy (*Figure 6*). TOFs located above T2 are amenable to open cervical surgery.

Surgical techniques to close H-type TOF: open cervical approaches

Two open cervical surgical options can be used for the H-type TOF i.e., extraluminal or transtracheal ‘keyhole’ techniques. The open cervical approach is selected at the time of the MLB. Patients are intubated with an age-appropriate endotracheal tube (ETT) to confirm that the cuff is located distal to the TOF.

Extraluminal technique

- Following MLB, place the neonate or child in a supine position on a shoulder roll +/- head ring
- Administer a single dose of prophylactic antibiotics
- Identify anterior neck landmarks including thyroid cartilage, trachea, and sternal notch
- Mark a standard horizontal tracheostomy neck incision
- Infiltrate the subcutaneous tissues with local anesthetic (1% lignocaine) and 1:100,000 adrenaline, not exceeding the maximum safe dose
- Prep the skin, and drape to protect the eyes, but to cover the mouth with the anterior neck and upper chest exposed
- Incise skin and subcutaneous tissue
- Raise subplatysmal flaps and retract the flaps with silk stay sutures
- Separate the strap muscles along the median raphe and retract them laterally
- Identify the trachea
- Divide the thyroid isthmus
- Create extraluminal dissection planes along the trachea up to the tracheoesophageal groove, staying on the tracheal adventitia
- Staying close to tracheal adventitia reduces the risk of injury to the recurrent laryngeal nerves
- Palpating a Foley catheter placed through the TOF at the time of the MLB can assist with identification of the TOF

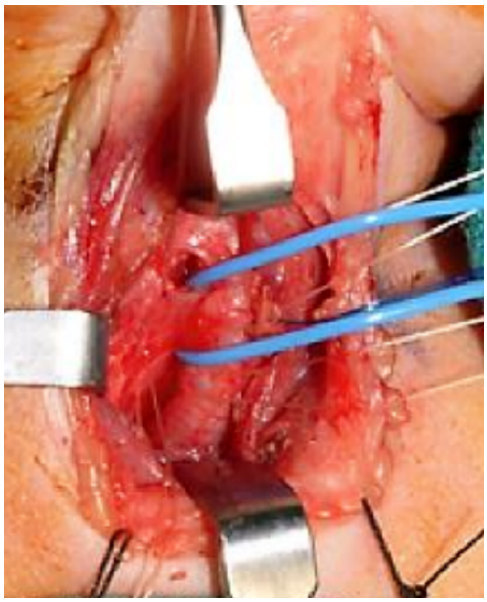


Figure 7: Extraluminal approach with vessel loop isolating the TOF and stay sutures securing the subplatysmal flaps[4]

- Having identified and circumferentially isolated the TOF, place a vessel loop around the TOF and withdraw the Foley catheter if previously placed through the TOF (*Figure 7*)
- Sharply divide the TOF
- Individually close the tracheal and esophageal sides of the TOF
- Close the tracheal side with long lasting absorbable suture 4/0 PDS (Ethicon, Inc., Johnson and Johnson, New Jersey, US)
- Close the esophageal defect using an inverting Connell suture technique with braided absorbable suture 4/0 Vicryl (Ethicon, Inc., Johnson and Johnson, New Jersey, US)
- Reinforce the closure by interposing a local rotation muscle flap using one of the strap muscles, or a free graft of perichondrium from the manubrium sterni, secured with either 4/0 Vicryl and Tisseel glue (Baxter International Inc., Illinois, US)
- Do a layered closure of the neck with absorbable sutures over a Yates drain and apply a skin dressing

Transtracheal 'Keyhole' technique

The transtracheal technique reduces the risk of injuring the recurrent laryngeal nerves as it does not require circumferential extraluminal (tracheal) dissection. It permits a pouch-free closure of the trachea but requires an airtight seal and repair of the extended tracheotomy incision.

- Following MLB, place the neonate or child in a supine position on a shoulder roll +/- head ring
- Administer a single dose of prophylactic antibiotics
- Identify the anterior neck landmarks including thyroid cartilage, trachea, and sternal notch
- Mark a standard horizontal tracheostomy neck incision
- Infiltrate the subcutaneous tissues with local anesthetic (1% lignocaine) and 1:100,000 adrenaline, not exceeding the maximum safe dose
- Prep the skin, and drape to protect the eyes, but to cover the mouth with the anterior neck and upper chest exposed
- Incise skin and subcutaneous tissue
- Raise subplatysmal flaps and retract the flaps with silk stay sutures
- Separate the strap muscles along the median raphe and retract them laterally
- Identify and expose the anterior trachea
- Divide the thyroid isthmus
- The number of tracheal rings exposed is dependent on TOF position and the tracheostomy site
- The level of the TOF has already been identified at MLB or is reconfirmed by flexible bronchoscopy via the ETT and withdrawing the ETT proximal to the TOF
- Place tracheal stay sutures at each side of the trachea
- Make a vertical extended transtracheal incision over the TOF position extending several rings inferiorly to incorporate a tracheostomy

- A temporary tracheostomy tube (reinforced / armored ETT) is placed and secured to the anterior chest wall and the transoral ETT is removed
- The vertical tracheostomy incision is usually incorporated into the extended transtracheal incision, or can be a separate incision
- Identify the TOF on the posterior tracheal wall

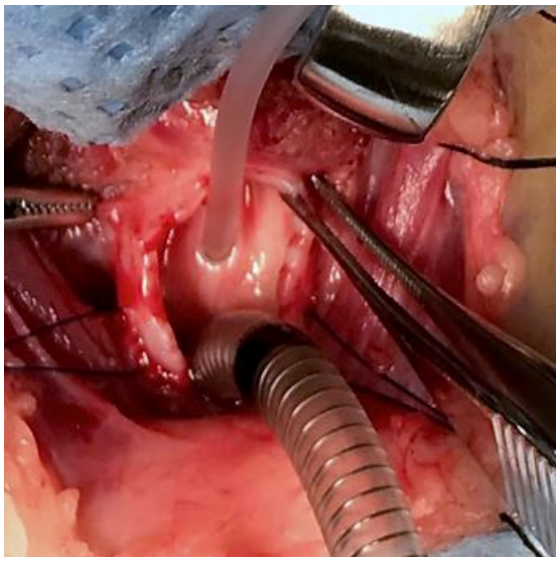


Figure 8: Transtracheal technique with extended vertical tracheostomy incision, temporary tracheostomy (reinforced ETT below TOF) and confirmation of TOF with Foley catheter cannulation

- Cannulate the TOF with a Foley catheter transtracheally as a guide (*Figure 8*)
- Make an elliptical incision around the TOF in a vertical plane to isolate the TOF

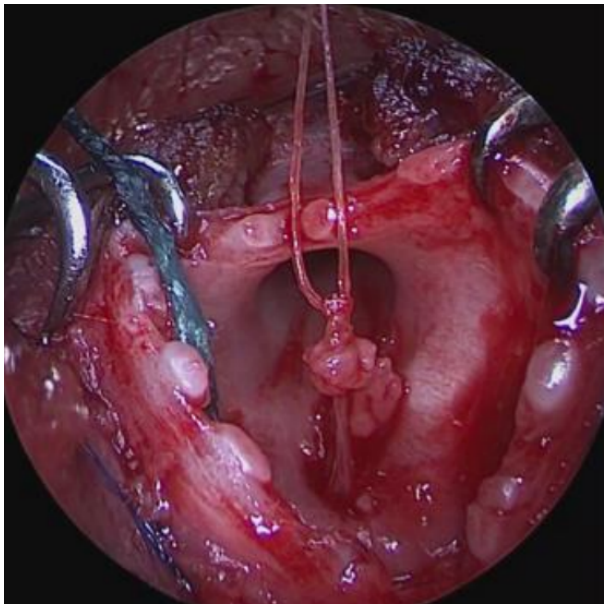


Figure 9: TOF isolated freely with elliptical incision from the posterior tracheal wall[4]

- Dissect the TOF free of the trachealis muscle and retract it anteriorly with a stay suture (*Figure 9*)
- Once isolated (remove Foley catheter if used as a guide), close the TOF with a Connell suture technique as for the extraluminal technique
- The repair can be reinforced through the posterior tracheal defect with periosteum harvested from the manubrium sterni

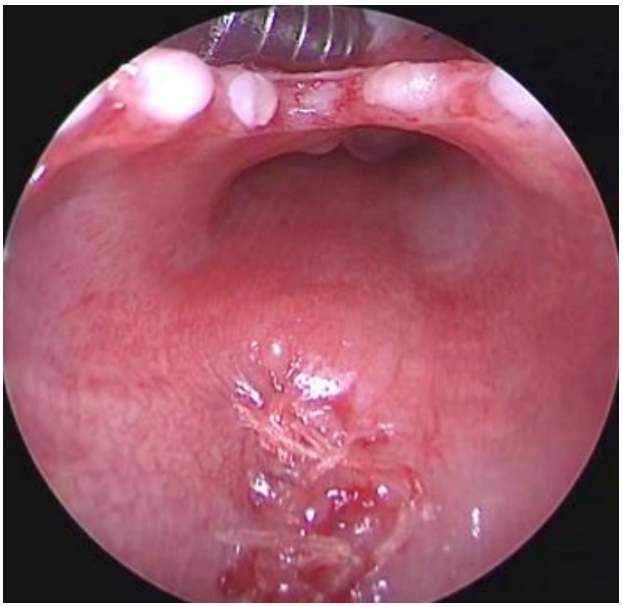


Figure 10: Intraluminal closure of the trachealis muscle[4]

- Close the trachealis muscle with 5/0 Vicryl to create well-opposed muscle edges to reduce formation of a tracheal pouch (*Figure 10*)
- Intubate the child transnasally such that the cuff of the ETT is inflated below the level of the transtracheal incision, and mark the position of the ETT at the nasal aperture
- Remove the temporary tracheostomy tube
- Close the anterior tracheal incision with interrupted 5/0 PDS
- Tisseel glue can be applied over the tracheal repair
- Perform a Valsalva maneuver to confirm an airtight seal
- Do a layered closure of the neck with absorbable sutures over a Yates drain and apply a skin dressing

Postoperative care

- Transfer the intubated patient to the neonatal or pediatric intensive care unit (NICU/ PICU)
- Extubate in NICU/PICU at 48-72 hours depending on clinical parameters
- Remove the Yates drain at 72 hours
- Continue IV antibiotics until the Yates drain is removed
- Request a contrast swallow study 1 week after surgery

Complications and long-term follow up

- ***Recurrent laryngeal nerve injury***: Staying close to the tracheal adventitia with the extraluminal approach reduces the risk of injury
- ***Persistent TOF or recurrence***: Reinforcing the closure with a rotation muscle flap and/or perichondrium reduces the small risk of failure and recurrence
- ***Surgical emphysema***: Ensure an airtight tracheal closure
- ***Persistent, large, or recurrent TOF***: These are difficult to manage surgically. Slide tracheoplasty has been used to treat these complex fistulae[13]

References

1. Goyal A, Jones MO, Couriel JM, Losty PD. Esophageal atresia and tracheooesophageal fistula. Arch Dis Child Fetal Neonatal Ed. 2006;91(5): F381-F384
2. Gross RE. The Surgery of Infancy and Childhood: Its Principles and Techniques. WB Saunders; 1953
3. Vogt E. Congenital esophageal atresia. Am J Roentgenol. 1929;22:463-5
4. Quick ME, Giblett N, Uwiera TC, Herbert H, Vijayasekaran S. A novel approach in managing challenging tracheoesophageal fistulae. Int J Pediatr Otorhinolaryngol. 2020;138:110261

5. Zani A, Jamal L, Cobellis G, et al. Long-term outcomes following H-type tracheoesophageal fistula repair in infants. Pediatr Surg Int. 2017;33(2): 187-90
6. Bhatnagar V, Lal R, Sriniwas M, Agarwala S, Mitra DK. Endoscopic treatment of tracheoesophageal fistula using electrocautery and the Nd:YAG laser. J Pediatr Surg. 1999;34(3):464- 7
7. Tzifa KT, Maxwell EL, Chait P, et al. Endoscopic treatment of congenital HType and recurrent tracheoesophageal fistula with electrocautery and histoacryl glue. Int J Pediatr Otorhinolaryngol. 2006;70(5):925-30
8. Coran AG. Redo esophageal surgery: The diagnosis and management of recurrent tracheoesophageal fistula. Pediatr Surg Int. 2013;29(10):995-9
9. Kovesi T, Rubin S. Long-term complications of congenital esophageal atresia and / or tracheoesophageal fistula. Chest. 2004;126:915-25
10. Bruch SW, Hirschl RB, Coran AG. The diagnosis and management of recurrent tracheoesophageal fistulas. J Pediatr Surg. 2010;45(2):337-40
11. Al-Salem AH, Mohaidly M Al, AlBuainain HMH, Aljadaan S, Raboei E. Congenital H-type tracheoesopha-geal fistula: a national multicenter study. Pediatr Surg Int. 2016;32(5): 487-91
12. Ioannides AS, Henderson DJ, Spitz L, Copp AJ. Role of Sonic hedgehog in the development of the trachea and oesophagus. J Pediatr Surg. 2003;38 (1):29-36
13. Provenzano MJ, Rutter MJ, Von Allmen D, et al. Slide tracheoplasty for the treatment of tracheoesophageal fistulas. J Pediatr Surg. 2014;49(6): 910-4
14. Gayle JA, Gómez SL, Baluch A, Fox C, Lock S, Kaye AD. Anesthetic considerations for the neonate with tracheoesophageal fistula. Middle East J Anaesthesiol. 2008;19(6):1241-54

Authors

Mark Quick BSc, MBBS, MEng
Department of Otolaryngology
Perth Children's Hospital
Nedlands, WA, Australia
quickymark@gmail.com

Shyan Vijayasekaran MBBS, FRACS
Department of Otolaryngology
Perth Children's Hospital
Nedlands, WA, Australia
Faculty of Health and Medical Sciences, University of Western Australia, WA, Australia
shyan_vijayasekaran@me.com

Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nicojonas@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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PEDIATRIC BRONCHOSCOPY FOR FOREIGN BODIES

Nico Jonas

This chapter only addresses the management of foreign bodies in the airway from the laryngeal inlet down to and including the bronchi.

Anatomical considerations

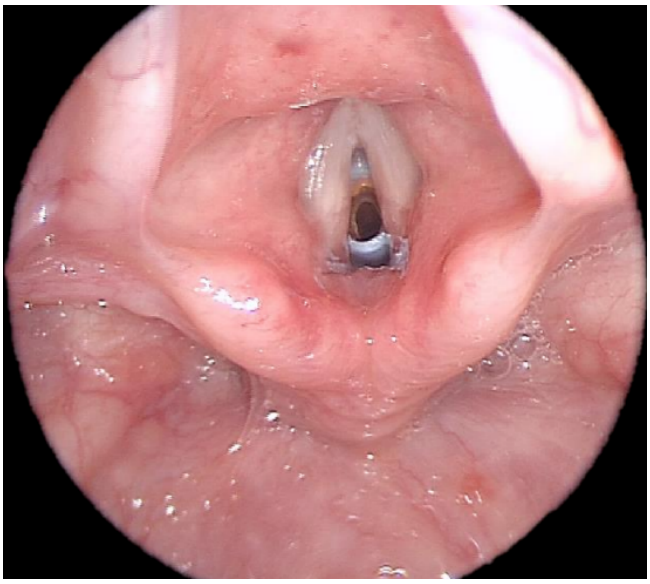


Figure 1: Subglottic non-organic foreign body

Due to the cone shape of the pediatric cricoid cartilage, the subglottis is the narrowest part of the trachea in the pediatric patient (*Figure 1*). If an aspirated foreign body is small enough to pass beyond the subglottic area then the most likely site of impaction is in the main bronchi. The right main bronchus is more vertically aligned and therefore the most common location of a distally lodged foreign body.

Classification

Foreign bodies are generally classified as organic vs. non-organic.

Decision to perform bronchoscopy



Figure 2: Collapse of right lung secondary to radiolucent foreign body in right main bronchus

The decision whether a bronchoscopy is required is based on the history, clinical examination and chest x-ray findings. If there is strong suspicion of a foreign body based on history, clinical findings and/or x-ray, then bronchoscopy should be performed. It is acceptable to have negative bronchoscopy findings, but unacceptable to miss a foreign body because bronchoscopy was omitted. X-ray findings can be conclusive in cases of radio-opaque foreign bodies, or subtle when dealing with radiolucent ones. In the latter case findings may include hyperinflation during air trapping, segmental consolidation or collapse (*Figure 2*).

Timing of procedure

Distressed patients or patients with suspected caustic foreign bodies (batteries) should have the foreign body removed as soon as possible. Asymptomatic patients or patients with longstanding symptoms should have bronchoscopy and removal of the foreign body done on the next available elective list to ensure an optimal operating room environment.

“Sharing the airway”

Foreign body retrieval from the airways can be extremely challenging both for surgeon and anesthetist. An understanding about sharing the airway with the anesthetist is paramount during the procedure, making good communication with anesthetic staff absolutely essential.

The surgeon should discuss how the patient will be induced and anesthetized and how the airway will be maintained during the procedure. It is also important to discuss how the airway will be maintained prior to inserting the ventilating bronchoscope. Options include ventilation by means of a nasopharyngeal airway, laryngeal mask, facemask, or by means of temporary endotracheal intubation. Prior to commencing the procedure, discuss with the anesthetist what you would do should the patient desaturate i.e. place a ventilating bronchoscope down to the level of the carina and ventilate the patient via the bronchoscope.

Preoperative procedure

Age	Bronchoscope Size
1-6 months	3.0
6-18 months	3.5
18 months-3 yrs	4.0
3-6 yrs	4.5
6-9 yrs	5.0
9-14 yrs	6.0

Table 1: Age-appropriate bronchoscope sizes

Age-appropriate ventilating bronchoscopes should be ready; one size smaller should be on standby (*Table 1*).



Figure 3: Equipment required for airway foreign body removal: 1. Side-arm forceps 2. Optical forceps & accompanying endoscope 3. Rigid ventilating bronchoscope & accompanying endoscope 4. Flexible sucker & adrenaline 5. Proximal bronchoscope fittings

It is essential that the surgeon be familiar with all the bronchoscopy equipment, especially how to assemble and disassemble the ventilating bronchoscopes (*Figure 3*). Equipment should be set out and ready to use (white balancing done, lenses cleaned with anti-fog and tested) prior to putting the patient to sleep.

Instructional Video: **How to assemble a Pediatric Bronchoscope**

Anesthetic

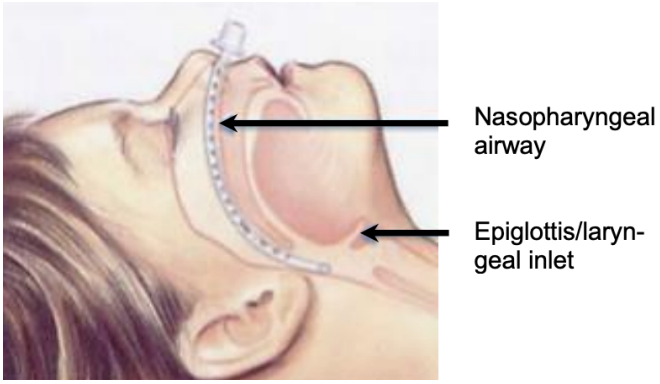


Figure 4: Position of nasopharyngeal tube for ventilation

The most commonly employed anesthetic technique is gas induction with the patient breathing spontaneously and maintaining his/her own airway. The anesthetist will thereby gain some information about how stable the airway is, how much support is required and what oxygen saturation the patient is maintaining. As soon as the patient is asleep, topical local anesthetic is sprayed onto the vocal cords. The airway can then be maintained using a facemask, nasopharyngeal airway (*Figure 4*), laryngeal mask or endotracheal tube ventilation until the ventilating bronchoscopes is inserted.

Positioning the patient

A shoulder roll is used to hyperextend the neck and a head ring is employed to stabilize the head. Care should be taken in patients with known or suspected atlantooccipital instability.

Equipment

An age-appropriate ventilating bronchoscope is used (*Table 1*). Note that a size 3.5 ventilating scope is the smallest bronchoscope that will allow the use of a flexible suction catheter as well as permit sufficient ventilation.

Procedure

A gum/tooth guard is inserted. The bronchoscope is then inserted. The anesthetist's laryngoscope can be used to facilitate passage of the bronchoscope through the vocal cords. Withdrawing the endoscope within the bronchoscope allows visualization of the

entire circumference of the tip of the bronchoscope and allows easy placement of the bronchoscope into the larynx. As soon as the bronchoscope is passed through the vocal cords the anesthetist can ventilate the patient through the bronchoscope.

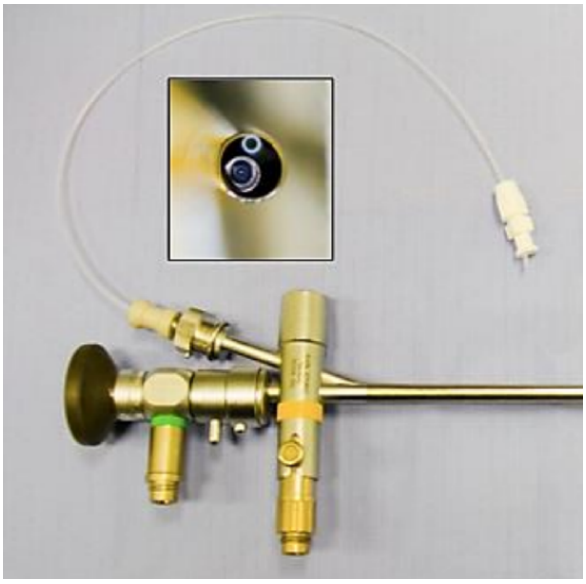


Figure 5: Flexible suction catheter inserted via side-arm of bronchoscope. Inset shows endoscope and suction catheter side-by-side at distal end of bronchoscope

The trachea and bronchi should be thoroughly examined. If a foreign body is identified, then careful suctioning should be done around it using a flexible suction catheter that is passed through the side port of the bronchoscope (*Figure 5*).

When there is consolidation, air trapping or collapse on preoperative X-ray due to a foreign body preventing free movement of air, then topical adrenaline can be very beneficial. Applying adrenaline onto the foreign body via the flexible suction causes vasoconstriction and decongestion of the surrounding mucosa. This may improve ventilation of the affected lung; it also reduces bleeding from inflamed mucosa and granulation tissue that surrounds the foreign body. Improved ventilation is evidenced by air bubbles forming around the foreign body due to air escaping from the affected airways and lung distal to the entrapped foreign body.

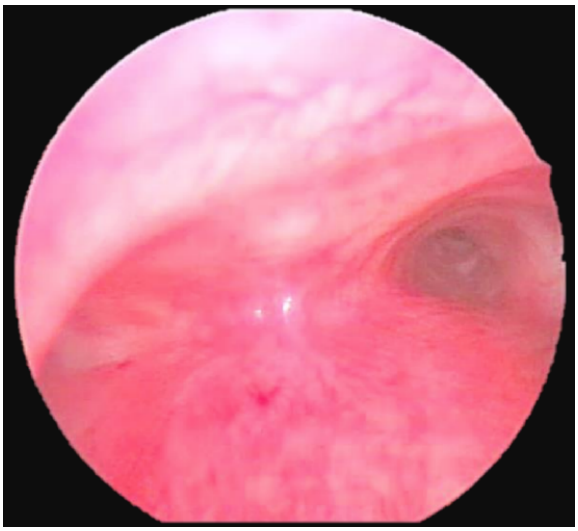


Figure 6: Placement of bronchoscope in distal trachea just above carina to facilitate optimum ventilation of both lungs

In order to ensure maximum oxygenation and delivery of anesthetic gases to the patient, always place the bronchoscope just above the carina and disconnect the suction if you are not actively doing anything (*Figure 6*).

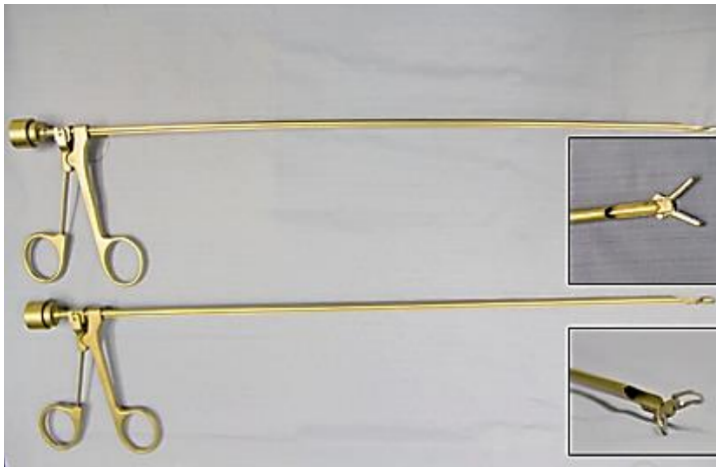


Figure 7: Optical foreign body removal forceps: “crocodile forceps” (above) and “peanut forceps” (below)

Once you have a good view of the foreign body a decision is made about the most suitable forceps to use (*Figure 7*).

The optical foreign body removal forceps are introduced into the bronchoscope and advanced towards the foreign body. After grabbing hold of the foreign body, it should either be pulled inside the bronchoscope and removed through the bronchoscope, or in cases of large foreign bodies, pulled up to the end of the bronchoscope and retracted and removed with the bronchoscope. In the latter case the anesthetist should revert back to ventilating the patient via nasopharyngeal tube or facemask while the surgeon prepares to reintroduce the bronchoscope. The airway is re-examined to ensure that there are no residual foreign bodies, and bronchial lavage is done if required.

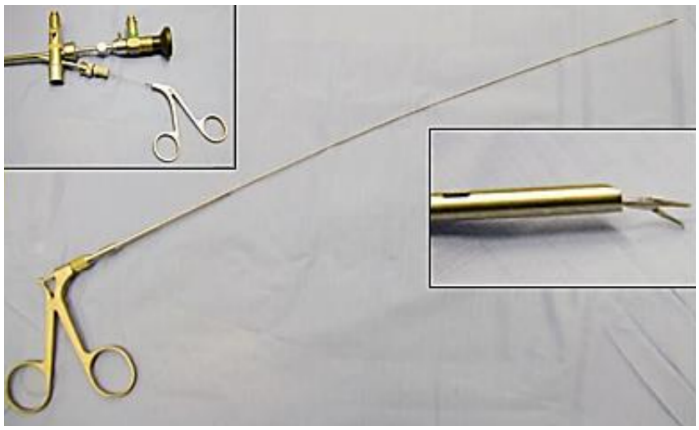


Figure 8: Flexible “sidearm forceps” can be inserted via the side port and is small enough to sit alongside the endoscope inside the bronchoscope

If a foreign body is situated distally in the main bronchus and out of the reach of the optical forceps, a side-arm forceps can be used as it can be advanced to reach a foreign body further down the airway than the optical forceps will reach (*Figure 8*).

Postoperative management

The patient should be observed in hospital for 24 hours and receive chest physiotherapy and antibiotics if indicated. Patients should be rescoped if there was evidence of circumferential granulations due to concerns about airway stenosis developing in future.

Important tips

1. Use 90% of your time to prepare (with topical adrenaline and suctioning) and 10% of your time to remove the foreign body
2. Apply adrenaline to decongest and optimize the visual field
3. Use at least a size 3.5 bronchoscope to enable good ventilation and use of a flexible suction catheter
4. If not actively doing something, disconnect the suction and place the bronchoscope in the distal trachea just above the carina to enable optimum ventilation
5. Examine the postnasal space at the end of the procedure to exclude a foreign body in that location

Instructional Video: How to assemble a Pediatric Bronchoscope

Author and Pediatrics Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.5: Pediatric Tracheostomy

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PEDIATRIC TRACHEOSTOMY

Hasnaa Ismail-Koch and Nico Jonas

The open tracheostomy technique in the pediatric patient differs from that undertaken in the adult. In the pediatric patient a formal stoma is created by suturing the tracheal wall to the skin with maturation sutures in addition to safety stay sutures placed in the tracheal wall.

Terminology

Tracheotomy refers to making an opening into the trachea whilst tracheostomy refers to creating a formal stoma and a communication between the trachea and the overlying skin.

Indications

- Upper airway obstruction due to congenital or acquired causes
- Patients requiring long-term ventilation
- Failure to wean from conventional orotracheal or nasotracheal ventilation (eliminates dead space)
- Pulmonary toilet

Preoperative evaluation

Careful evaluation of each patient must be undertaken as to whether any other intervention might avoid a tracheostomy.

Examination of nasopharynx, oropharynx and microlaryngoscopy and bronchoscopy

Patients with airway obstruction should undergo examination of the upper airways as well as microlaryngoscopy and bronchoscopy to exclude treatable causes of obstruction, thus eliminating the need for tracheostomy. It also permits accurate documentation of airway pathology for future comparison.

Anatomy of the neck

The cricoid and thyroid cartilages are difficult to palpate in the neonate and younger child because the neck is short, the laryngeal structures are more pliable and subcutaneous fat is more prominent. Hyperextending the neck may cause mediastinal structures to present in the neck. Check whether patients have undergone previous surgical procedures e.g. sternotomies resulting in scarring and altered anatomy.

Chest X-ray

Chest X-ray following assessment of the respiratory system is important to detect pulmonary disease that might be improved prior to surgery. It is also useful measure to establish the position of the trachea and to confirm that it is situated in the midline.

Blood tests and coagulopathy

Pediatric patients undergoing tracheostomy will in general have other comorbidities; therefore, blood tests are almost always required. Full blood count and electrolytes may be required for anesthetic purposes. Cross matching blood might be required in patients with anemia, especially in neonates where a small amount of blood loss can be clinically significant. Coagulopathies must be corrected prior to surgery.

Cardiorespiratory status

The cardiorespiratory status should be optimized preoperatively. A cardiology review must be obtained if there is any suspicion of underlying cardiac pathology. Relieving prolonged upper airway obstruction with a tracheostomy may result in respiratory distress due to loss of hypoxic drive because of sudden change in CO_2 levels, or pulmonary edema.

Tracheostomy technique

Microlaryngoscopy and ***bronchoscopy*** should be undertaken prior to tracheostomy if the airway has not been previously assessed. If possible, this is done with the child breathing spontaneously. The surgeon or anesthetist can subsequently intubate the child and the surgeon may then proceed with the tracheostomy.

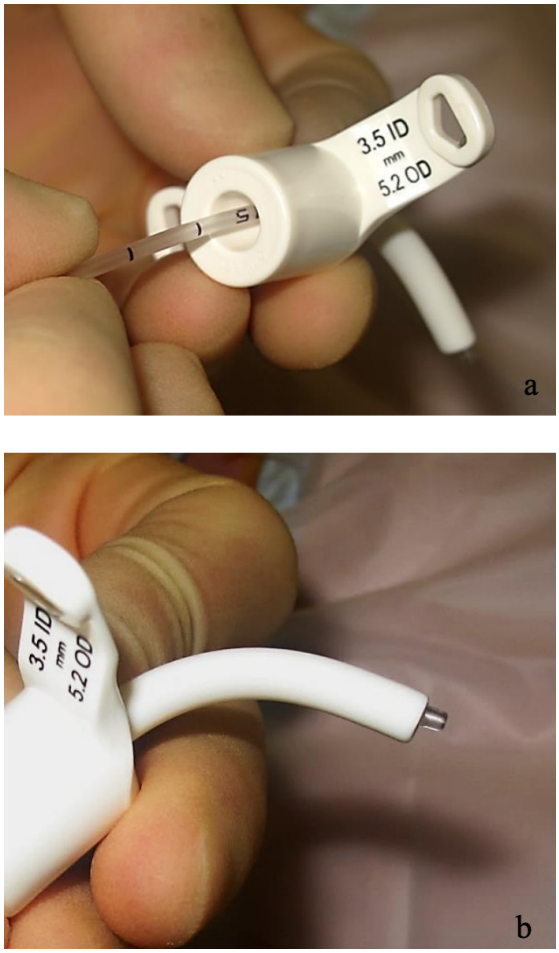
Minimum Kit

A pediatric tracheostomy kit should include: size 11 & 15 scalpels, bipolar diathermy, fine dissecting scissors, fine artery clips x3, toothed forceps, skin retractors, suction, needle holder and suture cutting scissors, a local anesthetic agent, size 4/0 non-absorbable suture (e.g. prolene), and size 4/0 absorbable suture (e.g. vicryl).

Age	Tube size
0-1 month	3.0
1-6 months	3.5
6-18 months	4.0
18 months - 3 yrs	4.5
3-6 yrs	5.0
6-9 yrs	5.5
9-12 yrs	6.0
12-14 yrs	6.5

Table 1: Age-appropriate tracheostomy tube sizes. Tube sizes vary with different companies having different outer diameters. The figures stated refer to Shiley tubes

The tracheostomy tube should be checked prior to the procedure; if a cuffed tracheostomy tube is required, the cuff should be checked for leaks. Select an appropriately sized tracheostomy tube and a one-size smaller tracheostomy tube (*Table 1*). Regarding tracheostomy tube length, a 1 year old child requires a longer ‘paed’ tube.



Figures 1 a, b: Measuring the correct suction tubing length which should not extend >5 mm past the tip of the tracheostomy tube

Select an appropriately sized tracheal suction catheter; usually double that of the tracheostomy tube size e.g. a size 8 catheter for size 4 tracheostomy tube. The length that the tube should be suctioned to should also be measured and recorded; this length is measured using an appropriately sized tracheal suction catheter and is generally accepted to be 0.5cm longer than to the tip of the tracheostomy tube (*Figures 1a,b*).



Figure 2: Connector between tracheostomy tube and anesthetic tubing

Check that the correct anesthetic connectors and tubing between the tracheostomy tube and anesthetic circuit are present (*Figure 2*).

Anesthesia

A child should ideally be intubated. Rarely when it is not possible to intubate the child, the most suitable way of maintaining the airway and oxygenation should be determined; it may vary from facemask ventilation to intubating the child using a ventilating bronchoscope.

Positioning and draping



Figures 3a, b: Positioning with shoulder roll, head ring and chin tape

A shoulder roll is used to extend the neck and a head ring to stabilize the head. The head is taped in the midline position with an adherent surgical tape attached to the operating table, stuck down under the chin and then secured again to the operating table on the other side (*Figures 3a,b*). It may not be possible to fully extend the neck in certain cases for fear of causing atlantoaxial subluxation e.g. with Trisomy 21 (Down's syndrome) or achondroplasia. Care is taken to avoid excessive cervical hyperextension as it may cause mediastinal structures to present in the neck and place them at risk of injury.



Figure 4: Clear sterile drape making it possible to monitor and manipulate the orotracheal tube during surgery

A clear sterile drape is ideally used over the head (*Figure 4*) as it makes it possible to observe the endotracheal tube throughout the procedure and makes it easier for the anesthetist to manipulate the endotracheal tube.

Skin Incision



Figure 5: Surface landmarks: The incision (long line) is placed halfway between cricoid cartilage and suprasternal notch

The site of the incision is marked midway between the cricoid cartilage and suprasternal notch (*Figure 5*). Local anesthetic with adrenaline is infiltrated into the area of the planned incision. The maximum length of incision extends between the anterior borders of the sternocleidomastoid, although this is rarely required. A vertical skin incision is reserved for urgent tracheostomies where preoperative intubation cannot be achieved and a surgical airway is urgently required.

Removal of subcutaneous fat



Figure 6: Removing subcutaneous fat using bipolar dissection technique

The incision is continued through skin into the subcutaneous layer of fat (more prominent in younger children). The subcutaneous fat is removed from both the superior and inferior skin flaps using bipolar diathermy (*Figure 6*); this facilitates positioning of the maturation sutures. Emphasis is placed on ***meticulous hemostasis*** as well as dissecting ***strictly in the midline***.

Exposure and parting of strap muscles

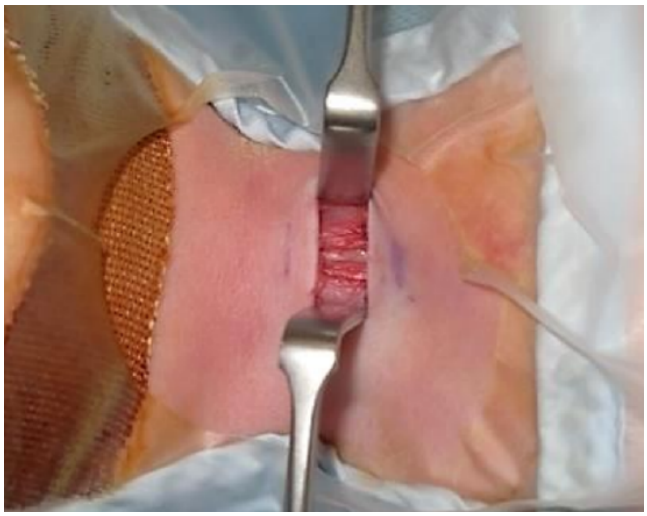


Figure 7: Skin and subcutaneous tissue retracted to expose strap muscles

The platysma muscle is generally absent in the midline. Care is taken not to transect the anterior jugular veins which are just superficial to the strap muscles within the investing cervical fascia; they can be preserved and retracted laterally. The midline cervical fascia between the strap muscles is identified (*Figure 7*). The strap muscles can then be parted in the midline using bipolar diathermy or blunt dissection and retracted laterally to expose the thyroid isthmus.

Dividing thyroid isthmus

The thyroid isthmus is retracted superiorly or divided using bipolar diathermy. The trachea is then cleaned using a small damp gauze swab or a peanut swab. Again, meticulous hemostasis is ensured. The positions of the cricoid cartilage and tracheal rings 2-5 are determined. It is important to avoid injury to the first tracheal ring so that subglottic stenosis does not occur. Care must be taken to avoid the innominate artery which crosses the trachea lower down (usually below the 5^{th} tracheal ring), as injury or pressure of the tracheostomy tube on the artery can rupture the vessel wall and cause fatal hemorrhage.

Stay Sutures

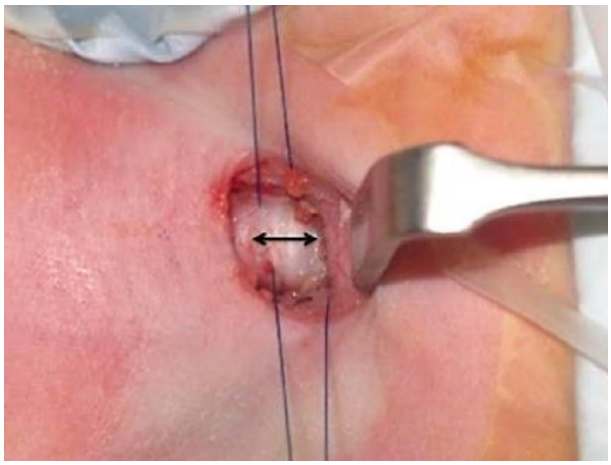


Figure 8: Placement of bilateral stay sutures in the tracheal wall on either side of the planned tracheal incision (double arrow)

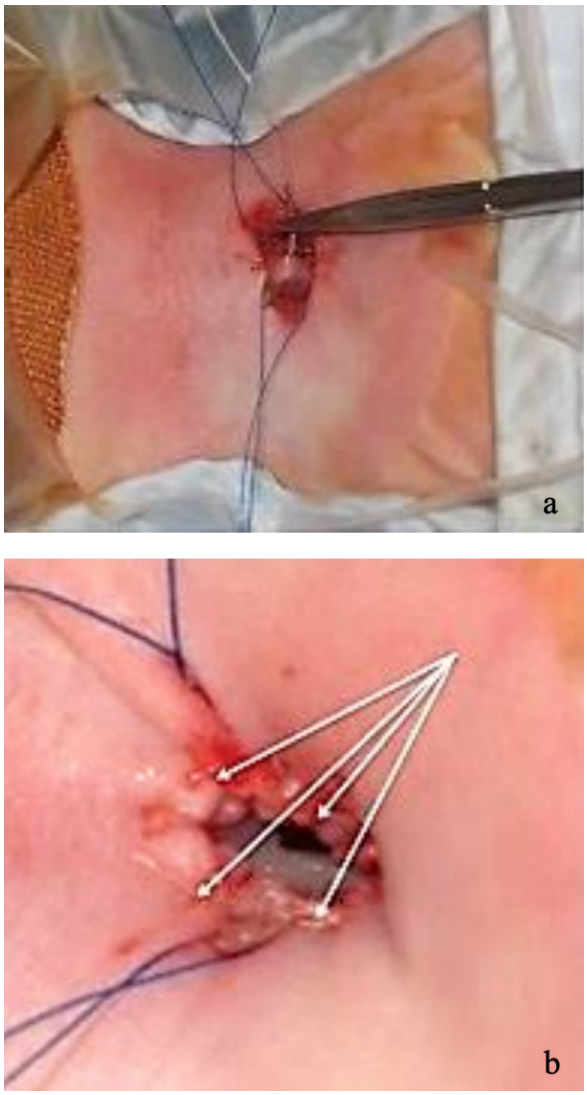
Non-absorbable stay sutures are passed through the tracheal wall on either side of the midline prior to making any tracheal incisions (*Figure 8*).

The needles at the ends of the sutures are then removed and the ends of each suture are secured in an artery clip on each side of the neck. Upward and lateral pull on the stay sutures brings the trachea to the surface to allow easy insertion of the tube in the event of accidental decannulation or loss of the airway following incision of the trachea.

Tracheal incision

A vertical slit is made across two tracheal rings between the stay sutures in the midline of the tracheal wall between the 2^{nd} - 5^{th} tracheal rings.

Maturation sutures



Figures 9 a, b: Placement of first maturation suture (a) and final formal stoma with four maturation sutures in place (b)

Maturation sutures are absorbable sutures that secure the trachea to the skin, creating a formal, safe stoma and making reinsertion of a tracheostomy tube easier in the event of accidental decannulation (*Figure 9*). They are placed prior to insertion of the tracheostomy tube with the endotracheal tube still in place. The inferior maturation sutures are the most important and are placed between the inferior end of the vertical tracheal slit and the inferior skin edge; they obliterate the space between the trachea and the skin and prevent formation of a false tract when inserting the tracheostomy tube.

Between placing successive sutures, the tracheal slit may be occluded in order to prevent anesthetic gases escaping and to aid ventilation, by carefully pulling the stay sutures together and closing the tracheal incision.

Insertion of tracheostomy tube

Once the maturation sutures have been fashioned, the anesthetist is alerted and the anesthetic tubing, the circuit connection, the tracheostomy tube, an artery clip (in case dilatation of the stoma is required) and suction are made available. The surgeon should be ready with the tracheostomy tube while the assistant carefully pulls upwards and laterally on the stay sutures to bring the trachea to the surface.





Figures 10 a, b: Endotracheal tube visible in stoma (a); the anesthetist is asked to withdraw the tube until only the tip is visible prior to insertion of the tracheostomy tube

The anesthetist is asked to slowly withdraw the endotracheal tube until only the distal tip of the endotracheal tube is visible; the tracheostomy tube is then inserted under direct vision (*Figure 10*). The obturator of the tracheostomy tube is then removed and the tube is connected to the anesthetic circuit. The tip of the endotracheal tube should remain in position extending beyond the glottis to just above the tracheostoma until the tracheostomy tube has been secured.

In the event of dislodgement or inability to ventilate via the tracheostomy tube the endotracheal tube can again be advanced past the stoma for the patient to be ventilated. The anesthetist confirms correct placement of the tube by listening to the chest and by confirming the presence of CO_2 on the capnograph. The neck wound can then be partially sutured closed laterally if required. The tube is then secured around the neck using cotton tapes; the tension on the tapes should ensure that the tube is secure and cannot be pulled out when the head is flexed. A useful check to ensure correct tension on the tapes is that it should be possible to insert only one finger beneath the tapes.



Figure 11: Placement of dressing under flanges of tracheostomy tube

The tracheostomy tube should never be secured by suturing it to the skin, as the skin in a pediatric patient is very lax and can result in accidental decannulation while still sutured to the skin. A nonadherent dressing is placed under the flanges of the tracheostomy tube using an artery clip (*Figure 11*).

The position of the tube is then assessed by passing a flexible fibreoptic scope through the tracheostomy tube. Ideally the tip of the tube should be positioned well above the carina so that the tip does not slip down one bronchus on hyperflexing the neck.



Figure 12: Stay sutures are taped to the chest at end of the procedure

The stay sutures are then stuck to the chest wall and labeled “RIGHT” and “LEFT”, and ‘DO NOT REMOVE’ (*Figure 12*).

Early postoperative complications

- Hemorrhage
- Pneumothorax, pneumomediastinum
- Damage to lateral structures such as the recurrent laryngeal nerves, carotid sheath or esophagus
- Loss of respiratory drive
- Pulmonary edema tracheostomy tube problems such as displacement and blockage
- Subcutaneous emphysema (avoid by not suturing skin too tightly)
- Swallowing difficulties
- Local infection

Postoperative care

- Chest X-ray to
  - Exclude pneumothorax
  - Exclude surgical emphysema

  - Check tube length and confirm tip position relative to carina
- If a cuffed tube is required, the pressure in the cuff should be checked and monitored
- Antibiotics may be required for a week postoperatively
- Nursing staff should be informed how to use the stay sutures
- Nursing staff are informed about the correct length of the suction tube to avoid distal tracheal trauma and granulations distal to the tip of the tracheostomy tube
- The child should have a tracheostomy box for his/her sole use at the bedside that contains an introducer/obturator, spare tracheostomy tube of same type and size, tracheostomy tube one size smaller, appropriately sized suction catheters, spare tapes, spare non-adherent dressings, curved round-ended scissors and lubricant jelly. A Swedish nose used for humidification, and speaking valves may also be included
- A small artery clip or appropriately sized tracheal dilator should be available at the bedside

Resuscitation steps

In the event of finding an unresponsive tracheotomized child the following steps should be followed

- Attempt to arouse the child while calling for help
- Attempt to suction the airway
- If there is difficulty suctioning or the tracheostomy tube is blocked, change the tracheostomy tube immediately and attempt suctioning again
- If this fails, the smaller size tracheostomy tube is inserted
- If this fails a tracheal suction tube is passed down the lumen of the smaller tube and an attempt is made to guide the tracheostomy tube over the suction tube (Seldinger technique)
- If still unsuccessful, a flexible endoscope with a tube first threaded over it may be used by experienced staff to insert the tracheostomy tube under direct vision
- Concurrently with the above steps, any other possible means of ventilating the child are employed i.e. bag & mask, endotracheal tube intubation etc.; the possibility of doing this depends on the underlying pathology
- Only experienced personnel should use tracheostomy dilators or an artery clip to dilate the tracheal stoma if it has started to close down
- Check whether the child is breathing after reinserting the tracheostomy tube; a self-inflating bag ventilation device may be required to provide rescue breaths

First tube change

The first tube change should take place one week following tracheostomy. Essential equipment includes suctioning, supplementary oxygen, appropriate tracheostomy tube with tapes already attached, nonadherent dressing, 0.9% sterile saline solution, small sterile pot, water-based lubricant and gauze swabs.

The child is kept starved for several hours to decrease the risk of aspiration. Wrap a younger child in a small sheet or blanket. A shoulder bolster is placed to extend the neck. The assistant swaddles the baby allowing exposure above the shoulders. The tracheostomy is suctioned if required prior to tube change.

The new tracheostomy tube is lubricated at the outside bend of the tube with a tiny amount of water-based lubricant. The stay sutures are left in position but freed from the chest wall in case they need to be used to apply traction to. Once everything is ready the old tube is removed and replaced with the new tube.

The assistant holds the new tube in position while ventilation is observed. While the assistant holds the tube in place the tapes are secured. The stay sutures are then removed.

Follow-up and aftercare

A child with a tracheostomy requires regular microlaryngoscopy and bronchoscopy to exclude granuloma formation or suprastomal collapse and to follow the progress of the underlying pathology that led to the tracheostomy. The frequency of microlaryngoscopy and bronchoscopy depends on the underlying etiology. Corrective surgery can be planned, working towards the ultimate goal of decannulation. As the child grows the tracheostomy tube may need to be upsized or the length adjusted.

Late complications

- Tracheal granulomas
- Accidental decannulation and blockage
- Suprastomal collapse
- Tracheomalacia
- Speech and language development delay
- Persistent tracheocutaneous fistula following successful decannulation

Decannulation

Prior to considering decannulation the initial reason for the tracheostomy should have been resolved or been effectively managed. Microlaryngoscopy and bronchoscopy should be undertaken a maximum of 6 weeks prior to planned decannulation to check the status of the trachea and in particular to look for suprastomal collapse or granulomas that may need treating prior to decannulation.

The child should be well at the time of decannulation; ideally it should be undertaken during seasons when infections are less frequent. The child should be admitted to the hospital for observation during any decannulation regime in case emergency reinsertion of the tube is required.

Decannulation protocol

The following steps should ensure safe decannulation

- Decannulation occurs over several days
- Pulse oximetry is undertaken during this time
- The tracheostomy tube is gradually downsized to size 3; if the child weighs <10 kg then they can be downsized to a size 2.5 tracheostomy tube
- Each tube remains in situ for 24 hrs
- The tube is then blocked, initially during the day for 12 hrs
- If successful, then this can be extended to 24 hrs
- Once the tracheostomy has been successfully plugged for 24 hrs then the tube is removed and the stoma closed with an adhesive dressing
- The child is observed on the ward for an additional 48 hrs
- If there is any airway compromise the procedure is abandoned and the tracheostomy tube is reinserted.
- Chest physiotherapy may be required to help clear secretions
- Parents/carers need to undergo resuscitation training
- The parents/guardians are advised that, should there be any concern regarding the airway, the child should be brought back to hospital
- The child is reviewed in an outpatient clinic 6 weeks following decannulation

Important tips

- Do tracheostomies under general anesthesia with an endotracheal or nasotracheal tube in situ
- Position the patient as described
- Excise sufficient subcutaneous fat
- Dissect in the midline at all times
- Ensure meticulous hemostasis
- Use both stay sutures and maturation sutures

Author

Hasnaa Ismail-Koch BM, DLO, DM, FRCS (ORL-HNS)
Consultant Otolaryngologist (Locum)
Southampton General Hospital
Hampshire, United Kingdom
hasnaa@doctors.org.uk

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.6: Pediatric Nasopharyngeal Airway (NPA)

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PEDIATRIC NASOPHARYNGEAL AIRWAYS (PNA)

Andrés Alvo, Cecilia Sedano, Graeme van der Meer

A nasopharyngeal airway (NPA) is an airway adjunct consisting of a hollow plastic tube designed to stent the nose and nasopharynx. Depending on the level of the obstruction the NPA will terminate in the nasopharynx, oropharynx or hypopharynx. It is better tolerated than an oropharyngeal (Guedel) airway and has the advantage that it can be used in patients with an intact gag reflex, trismus and oral trauma.

Level of obstruction	Etiology
Nose	Pyriform aperture stenosis Choanal atresia
Nasopharynx	Adenoid hypertrophy Underdeveloped midface (Crouzon's, Apert's, Pfeifer's syndromes)
Oropharynx	Tonsil hypertrophy Tumours Macroglossia
Hypopharynx	Micrognathia (Pierre Robin Syndrome) Lingual tonsil hypertrophy Glossoptosis

Table 1: NPAs can be used to alleviate obstruction at any level from the anterior nasal cavity to the hypopharynx

Although NPAs have been mainly used in emergency and anesthetic medicine, they are being increasingly used in pediatric otolaryngology. NPAs can be used to alleviate obstruction at any level from the anterior nasal cavity to the oropharynx (*Table 1*). They are often used to maintain airway patency in patients with a high risk of developing postoperative respiratory complications after adenotonsillectomy.

Relative and absolute contraindications to NPA insertion include severe stenosis or atresia of the nasal cavities, facial fractures, recent surgery of the skull base, active sinonasal infection, active epistaxis, and uncorrected coagulopathies or anticoagulant use.

Age	NPA size	Suction catheter size
Preterm - 1 mo	3	6
1-6 mo	3.5	8
6-18 mo	4	8
18 mo - 3 yrs	4.5	8
3-6 yrs	5	10
6-9 yrs	5.5	10
9-12 yrs	6	12
12-14 yrs	6.5	14

Table 2: NPA size as determined by patient's age



Figure 1: Commercially available NPAs come in different sizes

Commercially available NPAs come in different sizes and materials (*Figure 1*). The size is determined by the patient's age. (*Table 2*). They can also be fashioned from endotracheal tubes (ETT) which are readily available, also in resource constrained settings.

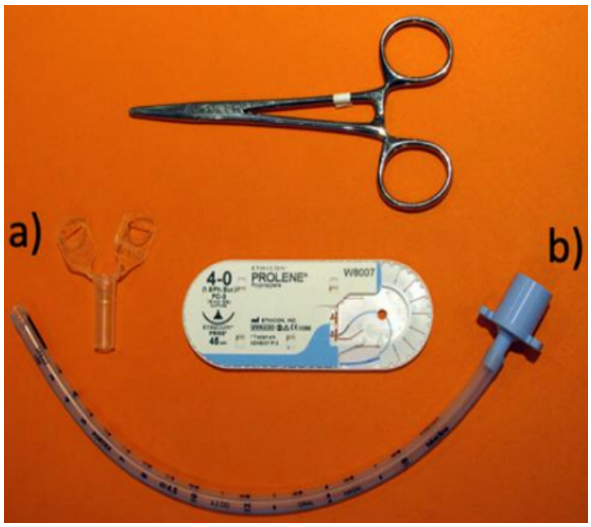


Figure 2: Materials needed to create an NPA from an ETT. a) Portex® tube holder (half-size smaller than the ETT); b) Portex® Blue Line® ETT (ID 0.5 to 1 mm smaller than age-appropriate size, or similar to the diameter of the patient's little finger)

This chapter describes how to manufacture an NPA using an ETT, how to insert and fix it to a patient (*Figure 2*), and its aftercare.

Making an NPA from an Endotracheal Tube (ETT)

- *Figure 2* illustrates materials needed to create an NPA from an ETT



Figure 3: Murphy eye /additional air vent (arrow)

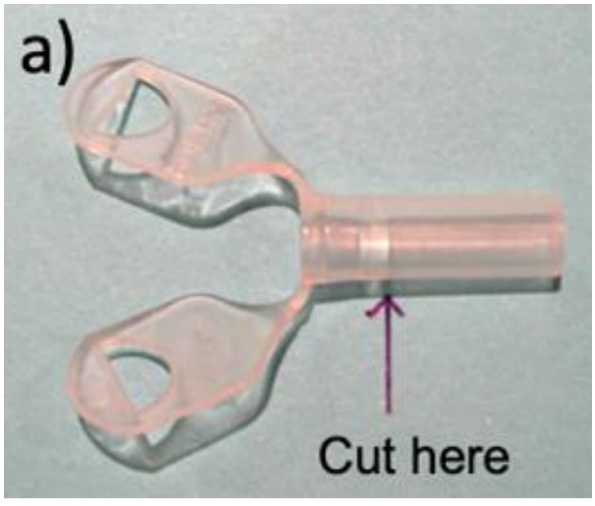
- A soft, uncuffed ETT (Portex® Blue Line®)) is preferred, ideally without Murphy eye (*Figure 3*)

- The inner diameter (ID) should be 0.5 to 1 mm smaller than the age appropriate ETT size



Figure 4: Determine the starting length of the NPA by measuring the distance from the nasal tip to the tragus

- Determine the starting length of the NPA by measuring the distance from the nasal tip to the tragus, adding a few centimeters to allow for adjustments should it be required (*Figure 4*)
- For custom-made NPAs the length is dictated by the level of obstruction that needs to be bypassed
- Cut the ETT to the desired length at its proximal (unbevelled) end
- The bevel of the NPA should face medially, away from the lateral pharyngeal wall to avoid soft tissue of the pharynx blocking the end of the tube. The bevel faces medially by default when the right nasal passage is used
- If the NPA needs to be passed on the left side, a new bevel must first be created by cutting the distal end of the tube obliquely, taking care not to leave any sharp edges
- Once the correct length has been determined, mark the proximal end flush with the nasal rim, and cut the ETT at this point



Figures 5a, b: Cutting tube holder and ETT

- A half-size smaller Portex® tube holder is cut distal to its flanges (*Figures 5a,b*)

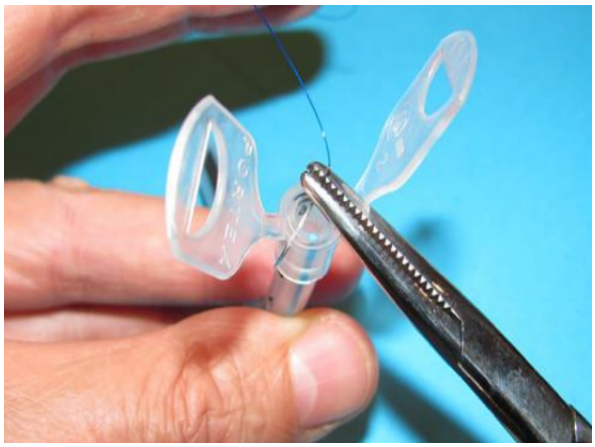


Figure 6: Suturing the tube holder to the ETT; Prolene® 4-0 suture is being used and the knot is tucked inside the lumen

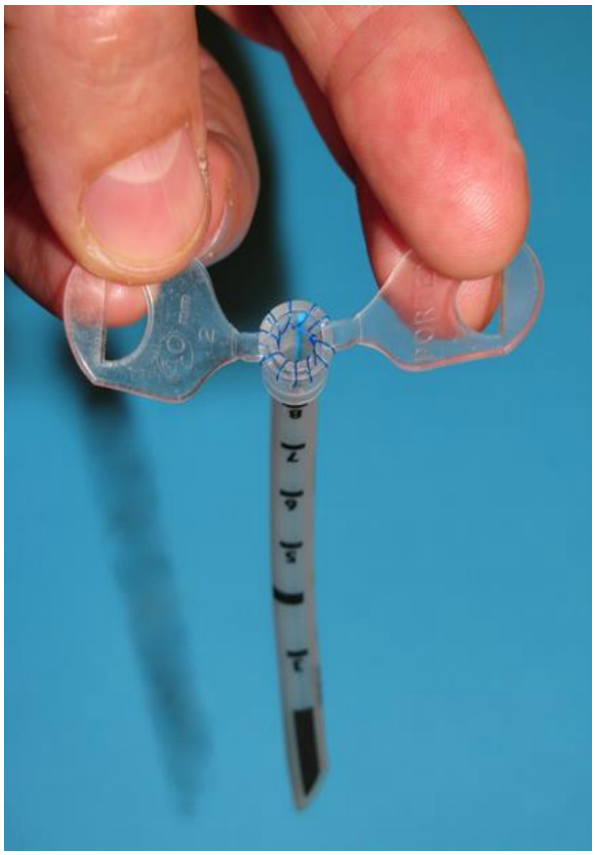


Figure 7: Completed NPA

- Suture the tube holder to the ETT using a Prolene® or nylon 4-0 suture (*Figures 6, 7*)
- Recheck and note the length and reinsert the NPA



Figure 8: NPA in situ and taped to the face

- Secure the flanges to the sides of the child's face with tape (*Figure 8*)



Figure 9: If tube holders are unavailable, one can leave the proximal end of the ETT longer and split it down its length to create two flaps that are taped to the face

- If tube holders are unavailable, the proximal end of the ETT longer can be split lengthwise to create two flanges that can be secured to the face (*Figure 9*)

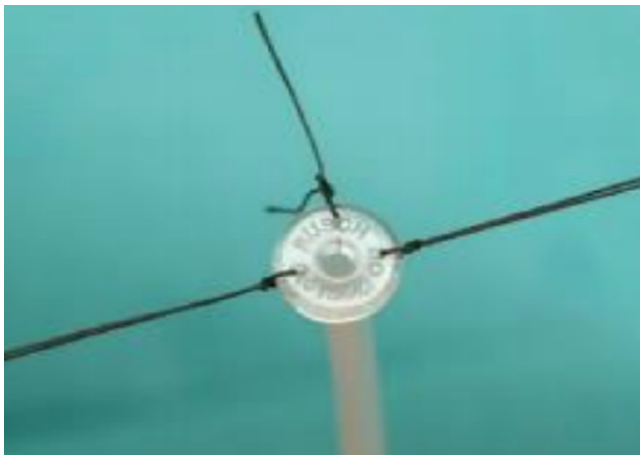


Figure 10: Commercial pre-made NPAs can be secured by passing sutures through the proximal "button" which are then taped to the face

- Note: If commercial NPAs are used, the length is standard for every ID size (but can be trimmed if necessary). The proximal "button" end can be secured by passing sutures which are then taped to the face (*Figure 10*)

Inserting an NPA

- Topical nasal decongestant drops may be applied
- Bend the NPA into a downward curve with the bevel facing medially
- Lubricate the NPA with saline or a lubricant

- Insert it into the nose and direct it along the floor of the nose
- Avoid excessive force, though gentle twisting can assist its passage into the nasopharynx
- If inserted in the operating room, direct inspection of the pharynx should show the tube projecting 1 cm below the free edge of the soft palate
- Alternatively, a flexible nasendoscope can be passed through the tube to measure exactly where the tip of the NPA should be located
- In some cases, such as with retrolingual collapse, the tip of the NPA can be positioned more distally above the epiglottis, if tolerated by the patient

Additional modifications

A standard 15 mm adapter can be used with an NPA customized from an ETT, for connection to mechanical ventilation. Some have adapted commercial NPAs for this purpose.

Caring of NPAs

Maintaining patency: NPAs should be suctioned as required to prevent blockage. The suction catheter should not be inserted more than 0.5 cm beyond the distal end of the NPA. Instillation of saline drops helps to soften secretions and facilitates toilet. Patency can be grossly checked by a mirror fogging / misting test. If an NPA becomes obstructed and cannot be unblocked with suction, the tube is removed and replaced, especially if the patient becomes distressed. Parents should always keep spare NPAs of the same and smaller sizes.

Fixing NPA: Tapes should be checked regularly to avoid accidental displacement of the NPA. The skin around the nostrils and cheeks must be regularly checked and cleaned to avoid infection and pressure ulcers.

Changing NPA: Routine changes of the NPA depends on the amount of secretions, but usually ranges between every 1-4 weeks. Initial insertion and the 1st NPA change should be performed by a member of the otolaryngology team. If insertion is easy, subsequent changes can be performed by trained staff or family members. Family should be advised that if NPA reinsertion becomes difficult, but the patient is stable, no further attempts should be made until an experienced health professional has been consulted.

Cleaning: NPAs can be washed with soap and water, or discarded and replaced, depending on available resources.

Mucosal granulations can develop at the distal end of the NPA. This should be suspected if partial distal blockage is encountered, especially if bleeding is observed. A flexible nasendoscope can be passed through larger NPAs for visual inspection. Management may include vasoconstrictor and steroid drops, shortening the tube or switching it to the contralateral side.

Homecare: When NPAs are used long term, parents and caregivers must be properly trained and have access to the necessary equipment such as a portable suction unit, and materials including suction catheters, spare NPAs, saline, lubricants, gauze, and tapes prior to discharge from hospital.

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Dr Nikki Mills, RN Debby Sandow and SLT Melissa Keesing for providing supporting material

Authors

Andrés Alvo
Otorhinolaryngologist
Hospital Roberto del Río
Hospital Clínico Universidad de Chile
Clínica Alemana de Santiago
Santiago, Chile
andresalvo@gmail.com

Cecilia Sedano
Otorhinolaryngologist
Hospital Roberto del Río
Hospital San José
Santiago, Chile
cecisedano@gmail.com

Graeme van der Meer MBChB, MMed
Otorhinolaryngologist
Starship Children's Hospital
Auckland, New Zealand
GraemeV@adhb.govt.nz

Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke’s Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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PEDIATRIC TONSILLECTOMY

Joe Grainger and Nico Jonas

Tonsil surgery includes ***tonsillectomy*** where the aim is complete removal of the tonsil, compared to tonsillotomy where the aim is to remove part of the tonsil in order to create more space in the oropharynx. The indications for tonsillotomy are limited and includes surgery for sleep disordered breathing in very young children where the aim is to limit morbidity associated with postoperative pain and bleeding.

Anatomy

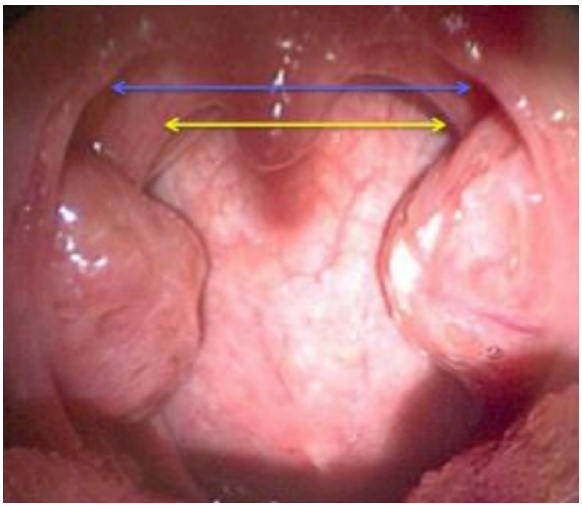


Figure 1: Anterior (blue) and posterior (yellow) faucal pillars

The palatine tonsils are located in the tonsillar fossae which are bounded by the anterior and posterior faucal pillars. These comprise the palatoglossus and palatopharyngeus muscles respectively (*Figure 1*).

Laterally, the tonsil is surrounded by a fibrous capsule that separates the tonsil from the superior constrictor muscle and buccopharyngeal fascia. The glossopharyngeal nerve and facial artery lie in close proximity to the superior constrictor muscle. The tonsillar artery, a branch of the facial artery, is the main blood supply to the tonsil.

Whilst the superior aspect of the tonsil is usually well defined, inferiorly the tonsil often merges with lingual tonsil tissue around the base of the tongue.

Lymphatic drainage of the tonsil is to the jugulodigastric nodes and other upper deep cervical lymph nodes.

Physiology

The palatine tonsils are part of Waldeyer's ring, a ring of lymphoid tissue that forms an important first line of defence for the respiratory and digestive systems. Waldeyer's ring is part of the mucosa associated lymphoid tissue (MALT) and plays a role in the production of B cells following the ingestion or inhalation of hazardous microorganisms.

Whilst the palatine tonsils and adenoids form a significant component of this system, removal of the tonsils (and adenoids) does not seem to have a significant impact on immunity; remaining lymphoid tissue in Waldeyer's ring and in other locations continue to function and prevent immunity problems.

Indications for tonsillectomy

The most frequent indications for tonsillectomy in pediatric practice are:

- Recurrent tonsillitis and/or peritonsillar abscess
- Obstructive sleep apnea syndrome (OSAS)
- Suspected malignancy
- Halitosis caused by debris in the tonsillar crypts



Figure 2: Enlarged tonsils secondary to glandular fever causing oropharyngeal obstruction

Occasionally an "acute" or "hot tonsillectomy" might be indicated. This is reserved for patients requiring a general anesthetic to drain a quinsy abscess who already qualify for tonsillectomy or patients who present with severe acute tonsillitis (usually glandular fever / infectious mononucleosis) causing acute airway obstruction and requiring airway intervention and not responding to conservative management (*Figure 2*).

Recurrent tonsillitis

Recurrent tonsillitis can be a significant burden to child and family due to prolonged episodes of illness, poor school attendance and significant discomfort. Tonsillectomy nearly always causes complete resolution of recurrent acute tonsillitis. However, this comes at the risk of primary (within 24 hours) and secondary (after 24 hours) hemorrhage which in some cases can be fatal.

The decision when to perform a tonsillectomy for recurrent tonsillitis is controversial. Some healthcare systems adopt an evidence based approach to tonsillectomy for recurrent tonsillitis. The Scottish Intercollegiate Guideline Network advocates tonsillectomy for recurrent tonsillitis only in the following circumstances:

- Sore throats due to acute tonsillitis
- Episodes of sore throat that are disabling and prevent normal functioning
- Seven or more well documented, clinically significant, adequately treated sore throats in the preceding year, or
- Five or more such episodes in each of the preceding two years or
- Three or more such episodes in each of the preceding three years

Obstructive sleep apnea syndrome

In obstructive sleep apnea syndrome (OSAS), children have a variable degree of upper airway obstruction usually secondary to adenotonsillar hypertrophy. This may be evident during the day as stertorous mouth breathing but is usually more noticeable when the child is asleep. Reduced muscle tone during deep sleep combined with adenotonsillar hypertrophy causes upper airway obstruction and at times complete airway occlusion. Parents will observe snoring and then periodically obstructive apnea evidenced by chest and abdominal movement but no airflow. These episodes can occur frequently throughout the night and apnea may last several seconds on each occasion. Obstruction results in a degree of arousal and the child then regains a patent yet still compromised upper airway.

These repeated episodes lead to disturbed sleep, poor sleep quality, daytime somnolence and poor school performance. If severe, OSAS can result in relatively prolonged episodes of hypoxaemia and hypercarbia, which may progress to pulmonary hypertension and cor pulmonale.

Other indications

Although ***malignancy*** of the tonsil in childhood is rare, consideration should be given to tonsillectomy to obtain a histological diagnosis in a child with significant tonsillar asymmetry. Malignancy is usually associated with cervical lymphadenopathy and/or hematological abnormalities.

Halitosis may occur from food debris collecting within tonsillar crypts, although halitosis is most commonly caused by gingival disease. Tonsillar halitosis can usually be managed with reassurance and mouthwashes. However, if severe or the child is being affected socially, tonsillectomy may be considered.

Preoperative Evaluation

General health

No preoperative investigations are generally required in an otherwise fit and healthy child undergoing tonsillectomy for recurrent tonsillitis. Investigations should be directed at areas of concern, particularly bleeding diatheses. For most children a preoperative blood grouping is not required; however, this is largely dependent on local facilities and guidance.

Reason for tonsillectomy

Children undergoing tonsillectomy (with or without adenoidectomy) for OSAS are at increased risk of postoperative complications. Evaluation should consist of a measure of the severity of the OSAS. This may take the form of a clinical evaluation only in a low risk child. Overnight oximetry or polysomnography should be performed when the child falls into one or more of the following categories:

- < 2 years of age
- <15 kg
- Failure to thrive (weight <5th percentile for age)
- Obesity
- Significant comorbidity
  - Severe cerebral palsy
  - Moderate to severe neuromuscular disorders
  - Craniofacial abnormalities
  - Storage diseases
  - Congenital cardiac disease
  - Chronic lung disease

Such children and those with proven severe OSAS or ECG changes are more likely to develop postoperative complications and to require admission to intensive care postoperatively.

Tonsillectomy procedure



Figure 3: Basic set of instruments required to perform a tonsillectomy: Drafton rods (1); Bipolar forceps (2); Silk ties (3); Blades for Boyle Davis gag (4); Boyle Davis gag (5); Knot pusher (6); Pillar retractor (7); Tonsil dissector (8); Burkitt straight forceps (9); Curved Negus Forceps (10); Luc's tonsil holding forceps (11)

There are several methods to do a tonsillectomy and to obtain hemostasis. Methods are generally divided into 'hot' (using some form of electrocautery) and 'cold' (using traditional instruments and ties) (*Figure 3*).

The literature suggests that "hot" techniques, using diathermy dissection may have a higher rate of postoperative hemorrhage although they may offer other benefits such as reduced intra-operative blood loss.

For the purposes of this description of tonsillectomy, a 'cold' technique is described using traditional dissection followed by hemostasis with ties.

- Following induction of general anesthesia, the patient is positioned supine on the operating table with the neck slightly extended using a shoulder roll



Figure 4: Boyle Davis tonsil gag and tonsil swabs; the tonsil gag has been fitted with rubber tooth protectors

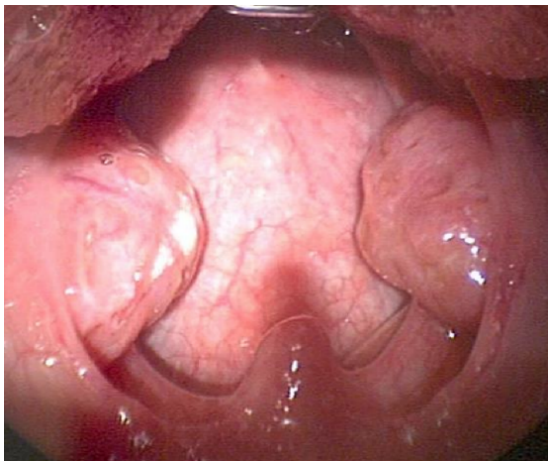


Figure 5: View of tonsils and oropharynx following insertion of Boyle Davis gag

- Select an appropriate length Boyle Davis blade and insert the gag to retract the tongue and expose the oropharynx (*Figure 3*, *4*, *5*)
- The tonsil gag is fitted with rubber tooth protectors (can be made from sections of soft rubber tubing) which can be removed in edentulous patients to avoid the gag slipping off the gum (*Figure 4*)

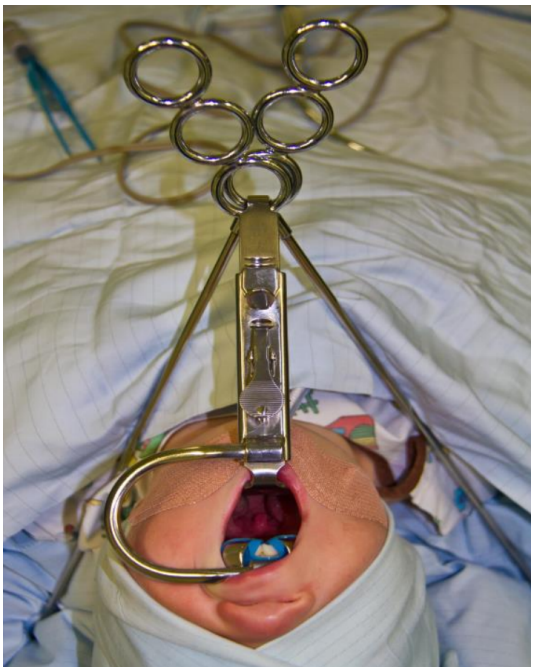


Figure 6: Boyle Davis gag in place suspended and held in place by Drafton rods

- Drafton rods are then placed to suspend and stabilize the gag (*Figures 3 and 6*)

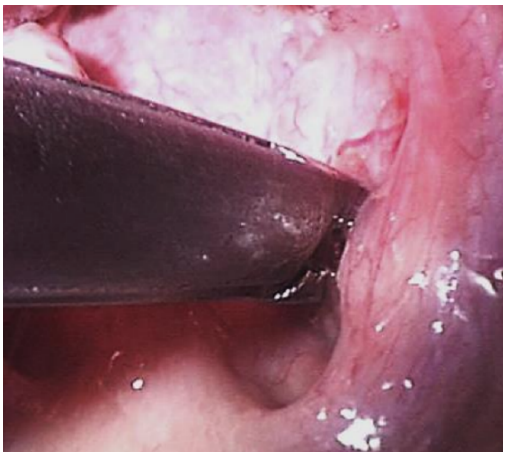


Figure 7: Gripping the right tonsil with tonsil holding forceps

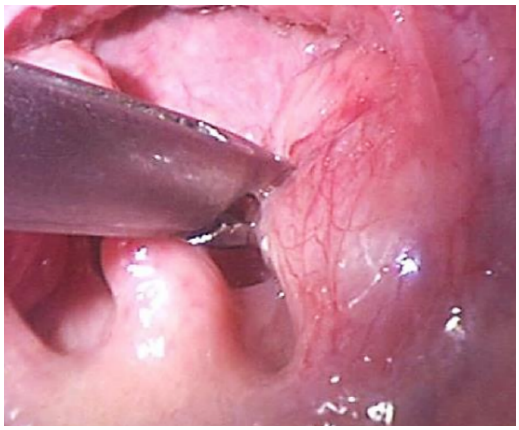


Figure 8: Pulling the tonsil medially to demonstrate the lateral border of the tonsil deep to the palatoglossal fold

- The tonsil is grasped with tonsil holding forceps and pulled towards the midline (*Figures 7 and 8*)

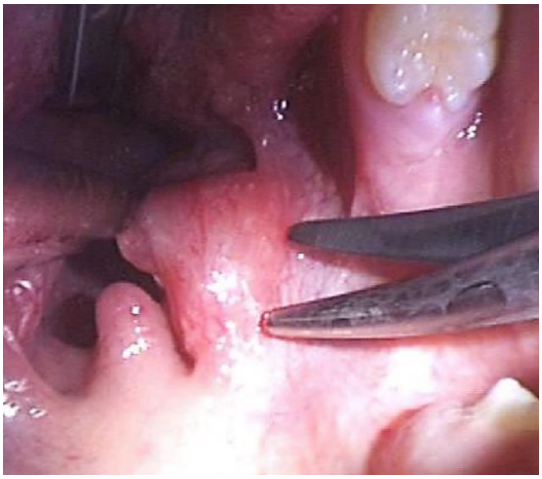


Figure 9: Site of initial incision



Figure 10: Extend the initial incision and define the lateral border of the tonsil by spreading the blades of the scissors

- Scissors are used to incise the mucosa of the anterior faucal pillar as shown (*Figures 9 and 10*). An incision placed too laterally will leave only a small residual anterior pillar and is likely to cause additional postoperative discomfort
- The capsule of the tonsil is identified (*Figure 10*)

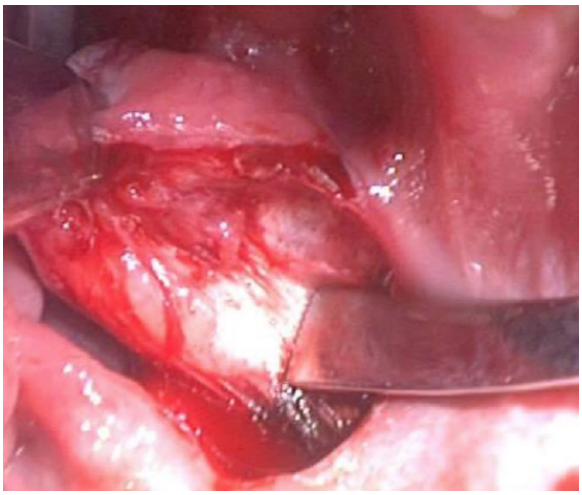


Figure 11: While maintaining medial traction, the tonsil dissector is used to strip the pharyngeal muscle fibers laterally and away from the tonsil

- A tonsil dissector is used to strip the pharyngeal muscle fibers laterally away from the tonsil (*Figure 11*). This process usually commences superiorly and progresses inferiorly. Medial traction on the tonsil should be maintained at all times to facilitate this

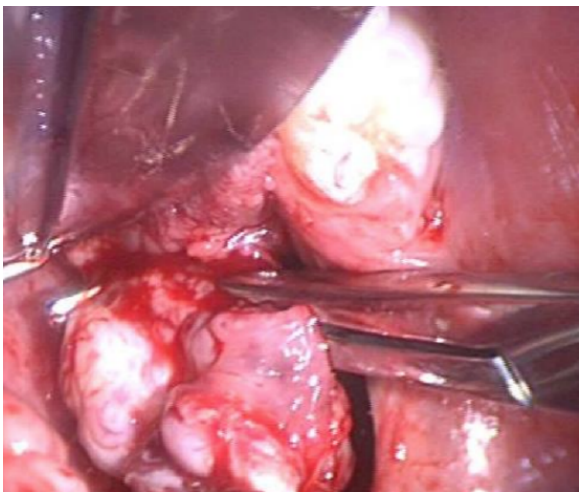


Figure 12: The vascular bundle is clamped inferiorly with curved vascular forceps (Curved Negus)

- As this dissection process continues inferiorly, the tonsil ends up being attached only by a vascular bundle at the tonsillolingual sulcus. This vascular bundle is clamped with curved vascular forceps (*Figure 12*)

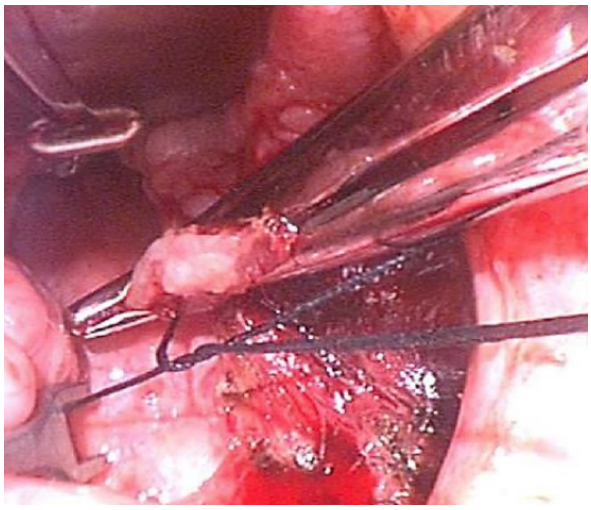


Figure 13: After the tonsil has been removed the vascular bundle is tied using a silk or linen ligature and knot-pusher (left lower corner of picture)

- The vascular bundle is tied to reduce bleeding using a silk or linen ligature and knot-pusher, and the tonsil is removed (*Figure 13*).

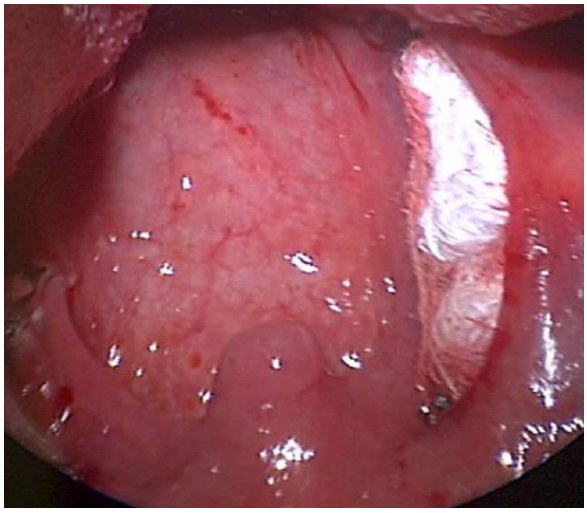


Figure 14: The tonsil fossa is packed with a gauze swab

- The tonsil fossa is packed with a gauze swab (*Figure 14*)
- The process is repeated on the contralateral side

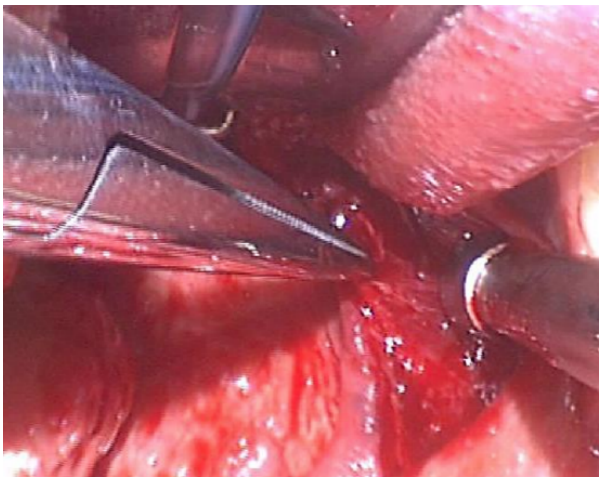


Figure 15: The vessel is clipped with straight vascular forceps

- Each tonsil fossa is revisited, the gauze packing removed, and inspected for bleeding. Minor bleeding from muscle and small vessels will stop spontaneously. Larger bleeding vessels are clipped with straight vascular forceps, and gentle traction is applied to elevate the vessel from the tonsil bed (*Figure 15*).

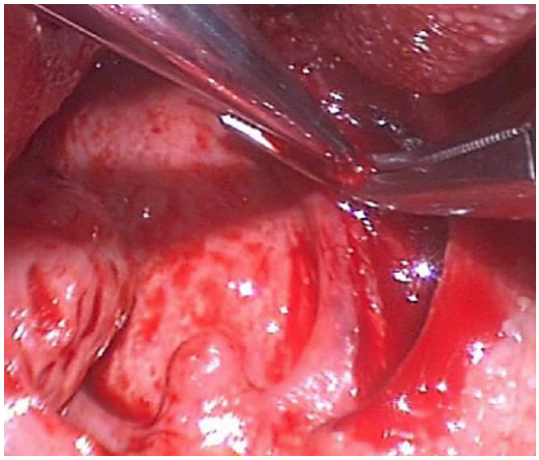


Figure 16: Gentle traction applied to the straight forceps elevates the vessel from the tonsil bed so that the vessel can be cross-clamped with curved forceps

- The vessel is then cross-clamped with curved forceps placed below the tip of the straight vascular forceps (*Figure 16*). This technique facilitates the use of ligatures in a fashion similar to that employed for the vascular bundle at the inferior tonsillar pole
- This process is continued until hemostasis is achieved. Bipolar diathermy, if available, can be used to facilitate hemostasis. If monopolar diathermy is used care must be taken to avoid burn injuries to the lips
- The tension on mouth gag is then released for a short period as further bleeding points may then become apparent
- The postnasal space is suctioned clear of blood clots
- Postoperative analgesia is prescribed
- Antibiotics are not usually indicated

Complications

Accidental extubation



Figure 17: Picture illustrating endotracheal tube stuck in Boyle Davis gag causing accidental extubation when removing the gag at the end of the procedure

Care must be taken when the gag is removed as the endotracheal tube can get trapped in the groove in the center of the gag hence causing accidental extubation when the gag is removed (*Figure 17*). Entrapment of the tube in the tonsil blade can be avoided by initially wrapping adhesive tape around the blade to cover the groove where the tube can get stuck.

Uncontrolled bleeding

Failure to stem bleeding with ligatures or cautery may occur at the time of tonsillectomy, or with a primary or secondary postoperative hemorrhage. This necessitate one to suture the tonsil pillars together after packing the tonsil fossa with surgicel hemostatic dissolvable gauze. It is important to place the pillar sutures through the surgicel to prevent it dislodging and being aspirated. If surgicel hemostatic dissolvable gauze is not available, then a standard surgical gauze swab can be packed and sutured into the tonsil fossa for a few days before removing it.

Primary postoperative hemorrhage

This may occur at the time of surgery when a ***bleeding disorder*** has not been identified. Treatment should be directed at the underlying cause; fresh frozen plasma transfusion or coagulant drugs may be required. Fluid replacement should be initiated and packing of the tonsil fossae may be required for a prolonged period.

Secondary postoperative hemorrhage

This occurs more commonly (approx. 5% of children) and can occur up to 10 days postoperatively. Poor postoperative oral intake due to pain and infection is likely to play a role. If bleeding settles spontaneously, children should be observed in hospital as the bleed may represent a ‘herald bleed’. If bleeding fails to settle following fluid resuscitation, the child should be returned to the operating room. Antibiotics are usually administered due to a presumed element of infection.

Respiratory compromise

Children with OSAS are at higher risk of complications following tonsillectomy. Postoperative airway obstruction may be managed with a nasopharyngeal airway. Rarely, postoperative pulmonary edema may develop. The patient is then admitted to intensive care and supportive management instituted with continuous positive airways pressure.

Sore throat and otalgia

Patients experience significant pain, odynophagia and referred otalgia. The most severe pain is experienced around Day 5-6. Regular analgesia in the form of paracetamol and anti-inflammatory drugs will usually be sufficient.

Further Reading

- Clarke RW. 2007. The causes and effects of obstructive sleep apnea in children. In Graham JM, Scadding GK and Bull PD ed. Pediatric ENT. 2007. Springer, New York, pp 141-151.

- Robb PJ, Bew S, Kubba H, Murphy N, Primhak R, Rollin A-M and Tremlett M. 2009. Tonsillectomy and Adenoidectomy in Children with Sleep-Related Breathing Disorders: Consensus Statement of a UK Multidisciplinary Working Party. Ann R Coll Surg Engl. 2009 July; 91(5): 371–373.
- Royal College of Surgeons of England. 2005. National Prospective Tonsillectomy Audit. Royal College of Surgeons of England, London.
- Scottish Intercollegiate Guidelines Network. 2010. Guideline 117: Management of sore throat and indications for tonsillectomy. Scottish Intercollegiate Guidelines Network, Edinburgh.

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Author

Joe Grainger FRCS, DCH, MedSci
Consultant Pediatric ENT Surgeon
Birmingham Children's Hospital
Birmingham
United Kingdom
joe.grainger@btinternet.com

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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TONSILLOTOMY (PARTIAL) & COMPLETE TONSILLECTOMY - SURGICAL TECHNIQUE

Klaus Stelter and Goetz Lehnerdt

Acute tonsillitis is treated with steroids e.g. dexamethasone, NSAIDs e.g. ibuprofen and beta-lactam antibiotics e.g. penicillin or cefuroxime. Only 10 days of antibiotic therapy has proven to be effective to prevent rheumatic fever and glomerulonephritis.

Tonsillectomy is only done for recurrent acute bacterial tonsillitis, or for noninfectious reasons such as suspected neoplasia.

Partial tonsillectomy (tonsillotomy) is the 1st line treatment for snoring due to tonsillar hyperplasia. It is low-risk, and postoperative pain and risk of hemorrhage are much less than with tonsillectomy. It is immaterial whether the tonsillotomy is done with laser, radiofrequency, shaver, coblation, bipolar scissors or monopolar electrocautery, as long as the crypts remain open and some tonsil tissue remains.

Pain and hemorrhage are the main morbidity of tonsillectomy. Bleeding may occur anytime until the wound is completely healed, which is normally at 2-3 weeks. Patients have to be informed about what to do in case of hemorrhage. Life threatening hemorrhage often is preceded by smaller bleeds, which can spontaneously cease. That is why every hemorrhage, even the smallest, has to be treated as an inpatient. Massive hemorrhage is an extreme challenge for every paramedic or emergency doctor because of difficult airway management.

Function and anatomical structure of tonsils in childhood and adolescence

Tonsils allow one to acquire immunity and provide immune defense by antigen presentation. This is why they contain T-lymphocytes, germinal centers of B-lymphocytes[1] and macrophages. They are the first and easiest-to-reach station of the mucosa associated lymphoid tissue system (MALT)[2-4]. As the main phase of the immune acquisition continues until the age of 6 years, the palatine tonsils are physiologically hyperplastic at this time[5, 6]. This is followed by involution, which is reflected by regression of tonsil size until age 12 years[7].

The lymphoid tissue is separated by a capsule from the surrounding muscle (superior pharyngeal constrictor)[8]. The blood supply originates from four different vessels, the lingual artery, the ascending pharyngeal artery and the ascending and descending palatine arteries. These vessels radiate mainly to the upper and lower tonsillar poles, as well as to the center of the tonsil from laterally[9]. The tonsils have deep crypts that create a large surface area to provide a docking surface for potential antigens[10].

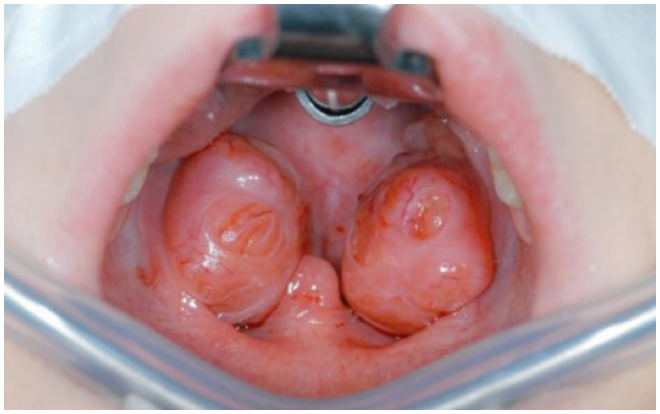


Figure 1: Hyperplastic tonsils in a child

Tonsil diseases

Sore throat episodes (R07.0)

Synonyms include “acute sore throat”, and “throat infection”. "Sore throat" is an imprecise term and does not clinically distinguish between acute tonsillitis and pharyngitis. Neither the cause nor the exact location is determined[11]. In “sore throat” it remains unclear whether one is dealing with acute (bacterial) tonsillitis which, if recurrent, is an indication for tonsillectomy[12].

Acute tonsillitis (J03.0 - J03.9)

Also known as “severe tonsillitis” [13], “true tonsillitis”, or “acute sore throat” [11], this refers to viral or bacterial tonsillitis with odynophagia, swelling and redness of the tonsils, possibly with a tonsillar exudate, cervical lymphadenopathy and fever >38.3°C (rectal)[14, 15]. Odynophagia for 24-48 hours, as part of prodromal symptoms of a common cold (viral infection of upper respiratory tract), is excluded from the term "acute tonsillitis" [11]. Depending on the stage and appearance of the tonsillar deposits or exudate, one can distinguish catarrhal angina with redness and swelling of the tonsils (early stage), from follicular angina with stipple-like fibrin deposits, from lacunar angina with confluent deposits (late stage)[16, 17]. "Acute tonsillitis" can be diagnosed by a specialist purely on clinical grounds[18]. Smears, blood tests or viral evidence are unnecessary in most cases[19-23]. Penicillin or another beta-lactam antibiotic is the first line of treatment.

Chronic tonsillitis (J35.0 and J35.9)

Also called “chronic (hyperplastic) tonsillitis”, it is not well-defined and thus should not be used[24]. It is better to speak of (chronic) recurrent tonsillitis [25, 26], because true chronic tonsillitis with persistentsymptoms lasting >4 weeks with adequate treatment and recovery of the mucosa (as in rhinosinusitis) does not exist.

Recurrent acute tonsillitis (J35.0)

Also called “recurrent tonsillitis” or “recurrent throat infections” [27], this refers to recurrent bouts of acute tonsillitis. In contrast to a single attack of acute tonsillitis, it is usually caused by many different bacterial pathogens[28, 29] and flare up again a few weeks after cessation of antibiotic therapy[30]. Depending on the frequency and severity of such episodes, ***this is an indication for tonsillectomy***.

Peritonsillar abscess (J36)

This is also called “peritonsillitis”, or “quinsy” [31, 32], and is acute tonsillitis complicated by an abscess, typically unilateral[33]. The abscess may form in the intratonsillar, para/ peritonsillar or retrotonsillar spaces. The pathogens are typically staphylococci[34], streptococci and fusobacterium necrophorum[35]. In contrast to acute tonsillitis, viruses play no role in abscesses[36]. A peritonsillar abscess is drained by aspiration or drainage or by unilateral tonsillectomy.

Tonsil hyperplasia (J35.1 and J35.3)

Tonsil hyperplasia[37], also known as (idiopathic) tonsillar hypertrophy[38], refers to abnormal enlargement of the palatine tonsil. It has to be distinguished from physiological pediatric palatine tonsil hyperplasia[39, 40] which is not a sign or consequence of recurrent inflammation[41, 42]. Also, children with tonsil hyperplasia do not suffer from acute tonsillitis[43, 44] or middle ear infections[45]. A pediatric tonsil is only "pathologically" hyperplastic if snoring (with or without obstructive sleep apnoea) or rarely dysphagia[46] or even more rarely dysphonia[47] occur.

Surgical procedures

Tonsillectomy

(Extracapsular) tonsillectomy means that the entire tonsil, including its capsule, is removed from the tonsil fossa; no lymphatic tissue remains between the anterior and posterior palatal arches[48]. Since the late 1960s, with the realization that the tonsil is a focus of infection[49-52], this form of tonsil operation has been the gold standard and is still the most common surgery done in the world[53].

Video 1: Extracapsular tonsillectomy

Tonsillotomy (partial tonsillectomy)

Only the medial part of the tonsil is removed. It requires that the (well-perfused) lymphatic tissue is resected, and that the remaining crypts remain open to the oropharynx[54, 55]. Active lymphatic tissue, with secondary follicles and crypts, is left in the tonsil fossae[56]. Tonsillotomy can be done with most dissecting and coagulating methods. The most common are laser tonsillotomy and radiofrequency tonsillotomy and are described in detail in this chapter.

Video 2: Laser tonsillotomy

Video 3: Radiofrequency tonsillotomy

Intracapsular tonsillectomy

Intracapsular, subcapsular or subtotal tonsillectomy describes a method in which the lymphatic tissue of the tonsil, including all crypts and follicles, is removed [57, 58], but the capsule of the tonsil is preserved; thus the underlying muscles are not exposed[59]. At the end of the operation there is an empty tonsil fossa without typical subsequent scarring[59]. Indications for intracapsular tonsillectomy are fetor ex ore (halitosis) and recurrent detritus (debris) in the tonsillar crypts. It differs from tonsillotomy in which a lot more tonsillar tissue is left behind.

Video 4: Intracapsular tonsillectomy with radiofrequency

Thermal- or cryotherapy of palatine tonsil

The tonsil tissue is heated (or cooled) interstitially; subsequent scarring causes shrinkage of the lymphoid tissue. No tissue is removed and a large part of the lymphoid tissue allegedly remains functional. The indication is mild tonsillar hyperplasia. Synonyms and different techniques include interstitial (electro)coagulation, laser coagulation, thermal coagulation, and cryocoagulation of the palatine tonsil[60, 61], photodynamic therapy, ultrasound therapy[62], radiofrequency-induced thermotherapy[63], temperature-controlled tonsil treatment[64, 65], and tonsil thermotherapy.

Preoperative evaluation, swabs & diagnosis

Pathogens, biofilms, and normal findings

With the discovery of rheumatic fever, group A streptococci (GAS) were primarily blamed for all ills in the upper respiretory tract in the 70's [66-73]. However more recently, anaerobes, e.g. Fusobacterium necrophorum, Streptococcus Intermedius and Prevotella Melaninogenica and Histicola have also been incriminated[28, 74, 75].

Children up to 8 years of age have a tendency towards diffuse intracellular pathogen enrichment with interstitial abscesses, while in adults or adolescents a more superficial bacterial accumulation at the edge of the crypts occurs. Particularly in the case of recurrent tonsillitis, several pathogens and microorganisms play a joint role. These can jointly form biofilms and bacterial clusters and thus evade antibiotics[76]. The oral cavity and especially the furrowed tonsil is a reservoir for multiple pathogens (viruses and bacteria), parasites[77] and fungi[78]. However, all these microbes belong to resident flora with which we have lived symbiotically for eons[28, 79]. Streptococci still play the largest role in acute tonsillitis (30%) [80], followed by Hemophilus Influenza and Neisseria[28]. Mostly, however, mixed infections (viral and bacterial initially) are responsible[81].

Diagnosis

"Acute tonsillitis" in children and adults is a clinical diagnosis[82]. In viral tonsillitis, in addition to pain and fever, primarily cough, hoarseness, and rhinorrhoea occur, while in bacterial tonsillitis, in addition to pain with lymph node swelling, there is mainly a tonsillar exudate and fever >38.3°C [83]. A streptococcal antigen test can confirm the diagnosis and is 98% specific for streptococci, although not particularly sensitive. A problem with these tests is the high number of asymptomatic chronic carriers of staphylococci and streptococci (10% of healthy children), who are definitely not in need of therapy[84-89]. In the early stages, a distinction between viral and bacterial tonsillitis is often difficult to make, especially when one considers that in 97.5% of cases, at least one virus, even in bacterial tonsillitis, is found (adenovirus and parainfluenza virus respectively in 47.5% [90, 91]) [81].

Conservative Treatment

Antibiotic therapy: In clinically apparent or proven bacterial tonsillitis associated with distress, antibiotics (beta-lactam) are justified. Beta-lactam antibiotic therapy also provides relatively reliable protection against the dreaded rheumatic fever and glomerulonephritis which often cause, especially in developing countries, arthritis, myocarditis and death. Studies have shown that antibiotic therapy can prevent sequelae such as peritonsillar abscesses, acute otitis and sinusitis. The penicillins, particularly in children and adolescents, have the greatest benefit at the lowest cost. There is no difference to cephalosporins. Macrolides and clindamycin have more side-effects with the same efficacy and should be reserved for patients with proven penicillin allergy[92, 93].

Postoperative antibiotic therapy is not indicated as it neither reduces pain nor postoperative bleeding[94, 95].

Steroids: In acute tonsillitis or after tonsillectomy, oral or intramuscular steroids (dexamethasone 10 mg), as well as betamethasone (8 mg) and prednisolone (60 mg), significantly improve symptoms with minimal side effects and no adverse effects relating to disease progression[96-98].

Analgesics: Nonsteroidal anti-inflammatory drugs have been used successfully for pain relief for >40yrs [99]. For acute tonsillitis, ibuprofen has the best efficacy with minimal side-effects compared to paracetamol and acetylsalicylic acid (ASA)[100]. Another advantage of ibuprofen is its longer duration of action (6-8 hrs) compared to paracetamol. Both substances have a large therapeutic range and at the correct dosage, the safety is comparable[101, 102]. Diclofenac and ketorolac are very effective, but in children have fewer docking sites and are metabolized more quickly, which is why the dose should be adjusted to a higher level than in adults)[103]. In postoperative management these substances play a role in opioid reduction, but as first-line therapy in pediatrics are not suitable for a sore throat[104, 105]. Metamizol is not recommended as first or second choice analgesic in children due to a small but real risk of agranulocytosis[106].

Complications of tonsillitis

In general, acute tonsillitis runs its course without complications and heals within 3-4 days. Rare but serious complications after streptococcal tonsillitis are ***glomerulonephritis*** and ***rheumatic fever***, which triggers cardiomyopathies and rheumatic-like joint pain[107]. Early and a long course (10 days) of antibiotics (penicillin or cephalosporin) reduces the frequency of both these complications by 70% [108]. In parts of the developing world where rheumatic fever is more common, preventing this complication is the main argument in favor of penicillin therapy[108].

Peritonsillar abscess is a second, more frequent complication. It is typically unilateral, although bilateral abscesses occur in up to 4% [109]. It is preceded by acute tonsillitis in only 1/3 of cases[110]. Even correctly administered antibiotic treatment of acute tonsillitis cannot really prevent peritonsillar abscesses (in contrast to rheumatic fever) [111]. Since peritonsillar abscesses can rapidly spread to the soft tissues of the neck and are potentially life-threatening, the primary therapy is urgent and surgical [112-114]. It does not matter whether the abscess is needle aspirated, incised or treated by tonsillectomy[115]. But the surgeon has to keep in mind that a stab incision can fail to drain inferiorly located abscesses[109, 116]. Before the operation, high-dose steroid therapy, as well as penicillin should be administered, as is often done for mixed infections[117].

Indications for tonsil surgery

Surgery is done for infections, to relieve airway obstruction, for halitosis and for diagnosis when a tumor is suspected. Surgery for recurrent tonsillitis depends on its frequency and severity, and the presence of additional diseases (antibiotic allergies, immunosuppression and PFAPA syndrome).

Paradise criteria for tonsillectomy [118]

Paradise (1984) reported that tonsillectomy significantly lowers the frequency of severe recurrent sore throats in children aged 3-15 years. Most published guidelines incorporate the so-called Paradise criteria for tonsillectomy:

- 7 episodes of tonsillitis per year in one year or,
- 5 episodes of tonsillitis per year in 2 consecutive years or,
- 3 episodes of tonsillitis per year in 3 consecutive years

A diagnosis of "purulent tonsillitis" must however be documented and confirmed by an elevated temperature (>38.3°C), tonsillar exudate, enlarged lymph nodes at the angle of the jaw, and antibiotic treatment[119, 120]. The authors also reported that on average only a few (not all) throat infections can be prevented by tonsillectomy in the following 2 years; 47 of 187 patients withdrew from the planned three-year follow-up[121]. For less severe sore throat inflammation or less frequent throat inflammation, the risk of tonsillectomy does not outweigh the benefits[122].

While tonsils contribute to immune competence until 12 years, a negative long-term effect on the immune system cannot be proven[123]. Nevertheless, in children under 8 years, the indications for complete removal must be strictly adhered to, as the risks of serious or fatal bleeding are higher[124].

With tonsillotomy (unlike tonsillectomy), some active lymphatic tissue is retained; it continues to grow in about 15% of cases, but rarely causes problems such as renewed snoring or recurrent tonsillitis[125]. The fear that frequent tonsillitis or peritonsillar abscesses will occur after tonsillotomy is unfounded[126-128]. All crypts remain open during laser, ultrasound, shaver, high- and radiofrequency technique[129, 130].

Surgical technique

Extracapsular tonsillectomy

Cold steel dissection is the most commonly performed surgical technique in children and adults, and is described in detail in the chapter on Pediatric Tonsillectomy. The technique is similar in adults.

The tonsils are dissected from the tonsil bed partly sharply and partly bluntly with a raspartorium and scissors. The feeding vessels, especially at the upper and lower tonsil pole, are pinched off and then selectively ligated. After removal of the tonsil, a dry swab is pressed for about 1 minute into the tonsil bed to stop bleeding from small vessels. Some surgeons perform additional suturing of the lower pole (so-called “pole suturing”, a controversial method [131]).

This method of tonsillectomy has been known for decades and has been very commonly used, especially in the 70s and 80s with the discovery of that tonsils are a source of infection[132]. Optical magnification (microscope or loupes), makes it possible to specifically identify the smaller vessels and perform bipolar coagulation before dissection[133].

Due to its good long-term results and low morbidity and mortality, cold steel dissection is still the most common method of tonsillectomy[134].

Tonsillotomy (partial tonsillectomy)

The tonsil is not completely removed, but only the portion that bulges into the throat, which due to its size causes functional problems. By preserving some tonsil tissue a lymphatic and immunologically active rudiment is retained.

The tonsil has a rich blood supply and has to be sufficiently cut and coagulated (not crushed) during surgery so that there is no postoperative bleeding, infection or pain. To this end, several dissection procedures have been developed (in principle, a tonsillectomy can also be performed with all these methods):

- CO^2 laser [135] [136]
- Monopolar high frequency current [137]
- Ultrasound scalpel [138]
- Bipolar radiofrequency coblation [139]
- Bipolar scissors [140]
- Argon gas-assisted monopolar needle [141]
- Microdebrider [142]

Advantages of tonsillotomy (regardless of what method is used to reduce the tonsils) are significantly less pain[143] and a lower postoperative bleeding rate 144 compared with tonsillectomy.



Figure 2: Instruments to perform radiofrequency dissected tonsillotomy / partial tonsillectomy

The quickest and easiest way to perform tonsillotomy is with monopolar high frequency dissection (Video 3). Instrumentation is shown in *Figure 2*.

- Following induction of general anesthesia the patient is positioned supine with neck slightly extended
- Select an appropriate length Boyle Davis blade and insert the gag to retract the tongue and expose the tonsils (*Figure 1*)
- Grasp a tonsil with a broad tonsil holding forceps and gently pull it toward the midline. Avoid pulling too hard to avoid doing a complete tonsillectomy
- Insert a Colorado needle into the tonsil at the edge of the anterior faucal pillar
- Spare the mucosa of the velopalatinal arch to avoid bleeding and pain in the incision line

- Amputate the protruding part of the tonsil by dissecting with continuous movements of the needle. Do not remain too long in the same place with the cutting needle as it may burn holes in the tonsil
- Pack the wound with a gauze swab for at least 1 minute
- Minor bleeding stops spontaneously. Larger bleeding vessels can be coagulated with bipolar forceps. A suture or ligature is not required
- Repeat the process on the contralateral side

Intracapsular (subtotal) tonsillectomy

The tonsil capsule covering the underlying muscle remains in the tonsil fossa [145]. Slightly less postoperative pain and earlier food intake have been reported [146]. The instrumentation and technique is similar to tonsillotomy. All the methods of tonsillotomy previously listed may also be used. The microdebrider has been reported to be a useful tool [147-152].

- The surgeon has to pull harder on the tonsil to subluxate the capsule, but the capsule itself has to remain in place and not be breached
- It may be very difficult to determine the exact proportion of residual tonsil that remains in the fossa
- After tonsillitis with subsequent scarring it is difficult even with loupes or a microscope to identify the exact plane of the tonsil capsule and only to remove only the active lymphatic tissue
- Because the vessels are bigger in the abyss of the crypts and near the capsule, bleeding has to be controlled with bipolar forceps more often than with (more superficial) tonsillotomy

Postoperative pain

Tonsillectomy is very painful, especially if the capsule is breached and the muscle is exposed. Severe pain and superinfection of the wound bed can cause delayed healing and prolong hospital stay. Especially adolescent and adult patients report pain, exhaustion and fatigue weeks after surgery. In tonsillectomy the wound remains open and heals in 2-3 weeks secondarily by granulation. Sealing the wound beds postoperatively e.g. with fibrin glue[153] or sucralfate[154] has no advantage in terms of postoperative bleeding or pain.

With tonsillotomy, however, pain was reported as only around 2-3 on the numerical analog scale.

Intracapsular tonsillectomy is allegedly less painful than tonsillectomy [155]. However, it is unlikely that intracapsular tonsillectomy produces as little pain as tonsillotomy. Pain is perceived very differently by individuals. In children and adults, the differences, regardless of surgeon and method, can be enormous [156-158]. Children of African descent have more postoperative pain than Europeans and respond better to opiates [159]. This complicates both objective pain measurement (which does not exist), as well as a standard therapy. Pain therapy must therefore be individualized and adjusted, especially in children. Questionnaires (e.g. Ramsay Sedation Scale [160]) for analgesic use, food intake, otalgia, and downtime use popular surrogate parameters.

Because pain is perceived and processed multimodally, the treatment must be multimodal. Firstly, a local long-lasting pain reliever (e.g. Bupivacaine or Ropivacaine 161) should be injected into the wound postoperatively or perioperatively to pre-vent activation of the early pain pathway 162-164 . Then already perioperatively it should be cooled locally by a cold compress[165] and later a lot of ice should be eaten (local cooling and calorie intake) 166. Mouth-washes with gingicaine, benzocaine or tetracaine also provide pain relief, but also numb the taste buds and respiratory flow receptors, which is often perceived as very unpleasant.

The perioperative and postoperative administration of high-dose steroids (dexamethasone or prednisolone) is clearly recommended in all guidelines. This reduces postoperative nausea and analgesic consumption significantly [167-169].

A fixed analgesic regimen with ibuprofen or diclofenac makes sense in adults and adolescents, but for children and infants rescue medication is often enough [170, 171]. An increased risk of bleeding due to nonsteroidal anti-inflammatory drugs, (except for aspirin) should not be feared [172, 173]. One should therefore adhere to the WHO staging system[174] (http://www.who.int/cancer/palliative/painladder/en/). After tonsillectomy, it may well be that in the first days WHO stage III drugs (strong opioid, e.g. piritramide iv) or even a pain pump must be administered to ensure pain under 4 on the visual analog scale and adequate food intake [175]. Pain and nausea (with and without vomiting) after tonsillectomy are often trivialized by both nurses as well as physicians and therefore it is more likely that few analgesics will be administered postoperatively [176-178].

Post-tonsillectomy bleeding

Early and late postoperative bleeding

Postoperative bleeding can occur anytime until the wound is completely healed, despite careful intraoperative hemostasis and dissection; usually after 2-3 weeks.

Postoperative bleeding occurs either as so-called early bleeding within the first 24 hours, or in the form of late bleeding with a peak incidence between the 5th and 8th day after surgery. From the 3rd postoperative week bleeding occurs only very rarely. Therefore late postoperative bleeding presents a special problem because it often occurs only at home and therefore the time factor to get a professional play a major role.

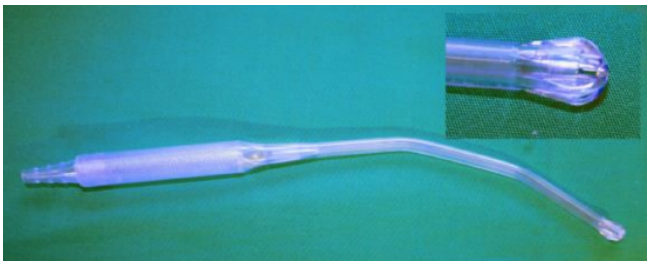


Figure 3: Rigid tonsil or thoracic suction device manufactured by Cardinal Health, IL, USA (Medi-Vac ® Yankauer Suction Handle, REF KEX80)

The most common cause of late bleeding is the physiological detachment of the fibrin layer from the open wound bed and usually results in harmless bleeding. This bleeding almost always ends spontaneously, or due to local icing (sucking ice cubes, applying an ice cravat) or by tranexamic acid intravenously or locally (rinsing) [179]. If bleeding does not spontaneously subside because a larger vessel is bleeding, vessel ligation or suturing under anesthesia is required. Massive hemorrhage is an extreme challenge for every paramedic or emergency doctor because of the difficult airway management. Intubation is only possible with suctioning the airway with suction tubes (*Figure 3*).

During induction and intubation, the ENT doctor should be present and prepared to perform emergency Cricothyroidotomy. Aspirated blood or incorrect intubation is the most common clinical complication of postoperative bleeding. Intraoperatively the surgeon must decide whether targeted bipolar coagulation and swab pressure are sufficient or whether suturing or ligation are necessary. If that fails, either the lingual artery, ascending pharyngeal artery, facial artery or even the external carotid artery must be ligated from externally or embolization the feeding vessels by interventional radiology should be done. Such massive bleeding is signaled in most cases by a minor "warning bleeding" [180, 181], so any bleeding must be taken seriously and the patient must be hospitalized.

Postoperative bleeding depending on method of surgery

In principle, intraoperative and postoperative bleeding can occur with all interventions involving the tonsils. However, for the tonsillotomy the postoperative bleeding rate is, by a factor of 5-10, lower than that for tonsillectomy [182]. In cryptolysis and thermotherapy of the tonsils postoperative bleeding is a rarity [183, 184]. Only extracapsular tonsillectomy remains problematic. "Cold dissection" with ligature or suturing has the lowest postoperative bleeding rates. Significantly more severe late bleeding has been reported after laser, coblation, monopolar or bipolar techniques [185-187].

Videos

Video 1: Extracapsular Tonsillectomy

Video 2: Laser Tonsillotomy

Video 3: Radiofrequency Tonsillotomy

Video 4: Intracapsular Tonsillectomy

References

1. Westermann J. Organe des Abwehrsystems. Springer; 2010. 361-2
2. Brandtzaeg P. The B-cell development in tonsillar lymphoid follicles. Acta Otolaryngol Suppl. 1996;523:55-9
3. Nave H, Gebert A, Pabst R. Morphology and immunology of the human palatine tonsil. Anat Embryol (Berl). 2001 Nov;204(5):367-73
4. Brandtzaeg P. Immune functions of nasopharyngeal lymphoid tissue. Adv Otorhinolaryngol. 2011;72:20-4
5. Perry M, Whyte A. Immunology of the tonsils. Immunol Today. 1998 Sep;19(9):414-21

6. Kaygusuz I, Godekmerdan A, Karlidag T, et al. Early stage impacts of tonsillectomy on immune functions of children. Int J Pediatr Otorhinolaryngol. 2003 Dec;67(12):1311-5
7. Kaygusuz I, Alpay HC, Godekmerdan A, et al. Evaluation of long-term impacts of tonsillectomy on immune functions of children: a follow-up study. Int J Pediatr Otorhinolaryngol. 2009 Mar;73(3):445-9
8. Perry ME, Slipka J. Formation of the tonsillar corpuscle. Funct Dev Morphol. 1993;3(3):165-8
9. Westermann J. Organe des Abwehrsystems. Springer; 2010. 361-362.
10. Drucker M, Drucker I, Neter E, Bernstein J, Ogra PL. Cell mediated immune responses to bacterial antigens on human mucosal surfaces. Adv Exp Med Biol. 1978;107:479-88
11. Georgalas CC, Tolley NS, Narula A. Tonsillitis. Clin Evid (Online). 2009
12. Paradise JL. Etiology and management of pharyngitis and pharyngotonsillitis in children: a current review. Ann Otol Rhinol Laryngol Suppl. 1992 Jan;155:51-7
13. Lange G. [Angina and chronic tonsillitis--indications for tonsillectomy]. Z Allgemeinmed. 1973 Mar 20;49(8):366-70
14. Österreichische Gesellschaften für HalsNasen-Ohren-Heilkunde KuH, Kinderund Jugendheilkunde. Gemeinsame Empfehlung zur Entfernung der Gaumenmandeln (Tonsillektomie). Monatsschr Kinderheilkd. 2008 Mar 7;3(156):268-71
15. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
16. Berghaus A. [Chronic inflammation of the upper airways. Operation instead of antibiotic]. MMW Fortschr Med. 2005 Sep 29;147(39):27
17. Berghaus A, Pirsig W. Mundhöhle und Pharynx. In: Berghaus A, Rettinger G, Böhme G., eds. Hals-Nasen-Ohren-Heilkunde. 1 ed. Stuttgart: Hippokrates Verlag; 1996. 386-453
18. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
19. Stuck BA, Genzwurker HV. [Tonsillectomy in children: preoperative evaluation of risk factors]. Anaesthesist. 2008 May;57(5):499-504
20. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
21. Kurien M, Stanis A, Job A, Brahmadathan, Thomas K. Throat swab in the chronic tonsillitis: how reliable and valid is it? Singapore Med J. 2000 Jul;41(7):324-6
22. Fujikawa S, Hanawa Y, Ito H, Ohkuni M, Todome Y, Ohkuni H. Streptococcal antibody: as an indicator of tonsillectomy. Acta Otolaryngol Suppl. 1988;454:286-91
23. Borschmann ME, Berkowitz RG. Oneoff streptococcal serologic testing in young children with recurrent tonsillitis. Ann Otol Rhinol Laryngol. 2006 May;115(5):357-60
24. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
25. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
26. Burton MJ, Towler B, Glasziou P. Tonsillectomy versus non-surgical treatment for chronic / recurrent acute tonsillitis. Cochrane Database Syst Rev. 2000;(2):CD001802
27. Georgalas CC, Tolley NS, Narula A. Recurrent throat infections (tonsillitis). Clin Evid (Online). 2007
28. Jensen A, Fago-Olsen H, Sorensen CH, Kilian M. Molecular mapping to species level of the tonsillar crypt microbiota associated with health and recurrent tonsillitis. PLoS One. 2013;8(2):e56418
29. Swidsinski A, Goktas O, Bessler C, et al. Spatial organisation of microbiota in quiescent adenoiditis and tonsillitis. J Clin Pathol. 2007 Mar;60(3):253-60
30. Jensen JH, Larsen SB. Treatment of recurrent acute tonsillitis with clindamycin. An alternative to tonsillectomy? Clin Otolaryngol Allied Sci. 1991 Oct;16(5):498-500
31. Raut VV. Management of peritonsillitis/peritonsillar. Rev Laryngol Otol Rhinol (Bord). 2000;121(2):107-10
32. Fried MP, Forrest JL. Peritonsillitis. Evaluation of current therapy. Arch Otolaryngol. 1981 May;107(5):283-6
33. Dalton RE, Abedi E, Sismanis A. Bilateral peritonsillar abscesses and quinsy tonsillectomy. J Natl Med Assoc. 1985 Oct;77(10):807-12
34. Klug TE, Henriksen JJ, Rusan M, Fuursted K, Ovesen T. Bacteremia during quinsy and elective tonsillectomy: an evaluation of antibiotic prophylaxis recommendations for patients undergoing tonsillectomy. J Cardiovasc Pharmacol Ther. 2012 Sep;17(3):298-302

35. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Significant pathogens in peritonsillar abscesses. Eur J Clin Microbiol Infect Dis. 2011 May;30(5):619-27
36. Rusan M, Klug TE, Henriksen JJ, Ellermann-Eriksen S, Fuursted K, Ovesen T. The role of viruses in the pathogenesis of peritonsillar abscess. Eur J Clin Microbiol Infect Dis. 2012 Sep;31(9):2335-43
37. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
38. Semberova J, Rychly B, Hanzelova J, Jakubikova J. The immune status in situ of recurrent tonsillitis and idiopathic tonsillar hypertrophy. Bratisl Lek Listy. 2013;114(3):140-4
39. Perry M, Whyte A. Immunology of the tonsils. Immunol Today. 1998 Sep;19(9):414-21
40. Goldberg S, Shatz A, Picard E, et al. Endoscopic findings in children with obstructive sleep apnea: effects of age and hypotonia. Pediatr Pulmonol. 2005 Sep;40(3):205-10
41. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
42. Ericsson E, Lundeborg I, Hultcrantz E. Child behavior and quality of life before and after tonsillotomy versus tonsillectomy. Int J Pediatr Otorhinolaryngol. 2009 Sep;73(9):1254-62
43. Stelter K, Ihrler S, Siedek V, Patscheider M, Braun T, Ledderose G. 1-year follow-up after radiofrequency tonsillotomy and laser tonsillotomy in children: a prospective, double-blind, clinical study. Eur Arch Otorhinolaryngol. 2012 Feb;269(2):679-84
44. Sarny S, Ossimitz G, Habermann W, Stammberger H. [The Austrian tonsil study 2010--part 1: statistical overview]. Laryngorhinootologie. 2012 Jan;91(1):16-21
45. Braun T, Dreher A, Dirr F, Reichel O, Patscheider M. [Pediatric OSAS and otitis media with effusion]. HNO. 2012 Mar;60(3):216-9
46. Gronau S, Fischer Y. [Tonsillotomy]. Laryngorhinootologie. 2005 Sep;84(9):685-90
47. Fischer Y, Gronau S. [Identification and evaluation of obstructive sleep apnea in children before adenotonsillectomy using evaluative surveys]. Laryngorhinootologie. 2005 Feb;84(2):121-35
48. Alavoine J, Graber A. [Extracapsular tonsillectomy under general anesthesia]. Rev Laryngol Otol Rhinol (Bord). 1968 Sep;89(9):568-79
49. Feinstein AR, Levitt M. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
50. Rapkin RH. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
51. Wannamaker LW. Tonsils, rheumatic fever and health delivery. N Engl J Med. 1970 Feb 5;282(6):336-7
52. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
53. van den Akker EH, Hoes AW, Burton MJ, Schilder AG. Large international differences in (adeno)tonsillectomy rates. Clin Otolaryngol Allied Sci. 2004 Apr;29(2):161-4
54. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
55. Koltai PJ, Solares CA, Mascha EJ, Xu M. Intracapsular partial tonsillectomy for tonsillar hypertrophy in children. Laryngoscope. 2002 Aug;112(8 Pt 2 Suppl 100):17-9
56. Reichel O, Mayr D, Winterhoff J, de la CR, Hagedorn H, Berghaus A. Tonsillotomy or tonsillectomy?--a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol. 2007 Mar;264(3):277-84
57. CHAMPEAU D. [Intracapsular tonsillectomy.]. Ann Otolaryngol Chir Cervicofac. 1961 Dec;78:866-9
58. FALCAO P. [Total intracapsular palatine tonsillectomy; systematization of technic.]. Rev Bras Otorrinolaringol. 1954 Jul;22(4-5):309-32
59. Anand A, Vilela RJ, Guarisco JL. Intracapsular versus standard tonsillectomy: review of literature. J La State Med Soc. 2005 Sep;157(5):259-61
60. Almqvist U. Cryosurgical treatment of tonsillar hypertrophy in children. J Laryngol Otol. 1986 Mar;100(3):311-4
61. Principato JJ. Cryosurgical treatment of the lymphoid tissue of Waldeyer's ring. Otolaryngol Clin North Am. 1987 May;20(2):365-70
62. Chatziavramidis A, Constantinidis J, Gennadiou D, Derwisis D, Sidiras T. [Volume reduction of tonsil hyperplasia in childhood with a surgical ultrasound device]. Laryngorhinootologie. 2007 Mar;86(3):177-83

63. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT.). Acta Otolaryngol. 2007 Nov;127(11):1176-81
64. Zhu X, Yang H, Chen X, Jin Y, Fan Y. [Temperature-controlled radiofrequency-assisted endoscopic tonsillectomy and adenoidectomy in children]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2011 Jun;25(12):551-3
65. Coticchia JM, Yun RD, Nelson L, Koempel J. Temperature-controlled radiofrequency treatment of tonsillar hypertrophy for reduction of upper airway obstruction in pediatric patients. Arch Otolaryngol Head Neck Surg. 2006 Apr;132(4):425-30
66. Feinstein AR, Levitt M. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
67. Rapkin RH. Tonsils and rheumatic fever. N Engl J Med. 1970 Apr 2;282(14):814
68. Wannamaker LW. Tonsils, rheumatic fever and health delivery. N Engl J Med. 1970 Feb 5;282(6):336-7
69. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
70. el Barbary Ae, Mohieddin O, Fouad HA, Khalifa MC. The tonsils and rheumatic fever. Ann Otol Rhinol Laryngol. 1969 Jun;78(3):648-56
71. Stryjecki J. [Tonsillectomy in the course of rheumatic fever in children]. Pediatr Pol. 1968 Dec;43(12):1531-4
72. Matanoski GM, Price WH, Ferencz C. Epidemiology of streptococcal infections in rheumatic and nonrheumatic families. II. The interrelationship of streptococcal infections to age, family transmission and type of group A. Am J Epidemiol. 1968 Jan;87(1):190-206
73. Alpert JJ, Peterson OL, Colton T. Tonsillectomy and adenoidectomy. Lancet. 1968 Jun 15;1(7555):1319
74. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Similar recovery rates of Fusobacterium necrophorum from recurrently infected and non-infected tonsils. Dan Med Bull. 2011 Jul;58(7):A4295
75. Klug TE, Henriksen JJ, Fuursted K, Ovesen T. Significant pathogens in peritonsillar abscesses. Eur J Clin Microbiol Infect Dis. 2011 May;30(5):619-27
76. Ramirez-Camacho R, Gonzalez-Tallon AI, Gomez D, et al. [Environmental scanning electron microscopy for biofilm detection in tonsils]. Acta Otorrinolaringol Esp. 2008 Jan;59(1):16-20
77. Mucke W, Huber HC, Ritter U. [The microbe colonization of the palatine tonsils of healthy school age children]. Zentralbl Hyg Umweltmed. 1994 Aug;196(1):70-4
78. Mitchelmore IJ, Reilly PG, Hay AJ, Tabaqchali S. Tonsil surface and core cultures in recurrent tonsillitis: prevalence of anaerobes and betalactamase producing organisms. Eur J Clin Microbiol Infect Dis. 1994 Jul;13(7):542-8
79. Schwaab M, Gurr A, Hansen S, et al. Human beta-Defensins in different states of diseases of the tonsilla palatina. Eur Arch Otorhinolaryngol. 2010 May;267(5):821-30
80. Brook I, Foote PA, Jr. Comparison of the microbiology of recurrent tonsillitis between children and adults. Laryngoscope. 1986 Dec;96(12):1385-8
81. Proenca-Modena JL, Pereira Valera FC, Jacob MG, et al. High rates of detection of respiratory viruses in tonsillar tissues from children with chronic adenotonsillar disease. PLoS One. 2012;7(8):e42136
82. Stuck BA, Gotte K, Windfuhr JP, Genzwurker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008 Dec;105(49):852-60
83. Österreichische Gesellschaften für HalsNasen-Ohren-Heilkunde KuH, Kinderund Jugendheilkunde. Gemeinsame Empfehlung zur Entfernung der Gaumenmandeln (Tonsillektomie). Monatsschr Kinderheilkd. 2008 Mar 7;3(156):268-71
84. Kaplan EL. The group A streptococcal upper respiratory tract carrier state: an enigma. J Pediatr. 1980 Sep;97(3):337- 45
85. Kaplan EL, Top FH, Jr., Dudding BA, Wannamaker LW. Diagnosis of streptococcal pharyngitis: differentiation of active infection from the carrier state in the symptomatic child. J Infect Dis. 1971 May;123(5):490-501
86. Tanz RR, Shulman ST. Chronic pharyngeal carriage of group A streptococci. Pediatr Infect Dis J. 2007 Feb;26(2):175-6
87. Tanz RR, Shulman ST. Streptococcal pharyngitis: the carrier state, definition, and management. Pediatr Ann. 1998 May;27(5):281-5
88. Wessels MR. Clinical practice. Streptococcal pharyngitis. N Engl J Med. 2011 Feb 17;364(7):648-55
89. Roberts AL, Connolly KL, Kirse DJ, et al. Detection of group A Streptococcus in tonsils from pediatric patients reveals high rate of asymptomatic streptococcal carriage. BMC Pediatr. 2012;12:3
90. Drago L, Esposito S, De VE, et al. Detection of respiratory viruses and atypical bacteria in children's tonsils and adenoids. J Clin Microbiol. 2008 Jan;46(1):369-70
91. Piacentini GL, Peroni DG, Blasi F, et al. Atypical bacteria in adenoids and tonsils of children requiring adenotonsillectomy. Acta Otolaryngol. 2010 May;130(5):620-5

92. Chiappini E, Regoli M, Bonsignori F, et al. Analysis of different recommendations from international guidelines for the management of acute pharyngitis in adults and children. Clin Ther. 2011 Jan;33(1):48-58
93. Chiappini E, Principi N, Mansi N, et al. Management of acute pharyngitis in children: summary of the Italian National Institute of Health guidelines. Clin Ther. 2012 Jun;34(6):1442-58
94. Al-Layla A, Mahafza TM. Antibiotics do not reduce post-tonsillectomy morbidity in children. Eur Arch Otorhinolaryngol. 2013 Jan;270(1):367-70
95. Dhiwakar M, Clement WA, Supriya M, McKerrow W. Antibiotics to reduce post-tonsillectomy morbidity. Cochrane Database Syst Rev. 2012;12:CD005607
96. Hayward G, Thompson MJ, Perera R, Glasziou PP, Del Mar CB, Heneghan CJ. Corticosteroids as standalone or addon treatment for sore throat. Cochrane Database Syst Rev. 2012;10:CD008268
97. Hayward G, Thompson MJ, Perera R, Del Mar CB, Glasziou PP, Heneghan CJ. Corticosteroids for the common cold. Cochrane Database Syst Rev. 2012;8:CD008116
98. Hayward G, Thompson M, Heneghan C, Perera R, Del MC, Glasziou P. Corticosteroids for pain relief in sore throat: systematic review and metaanalysis. BMJ. 2009;339:b2976
99. Moore N. Forty years of ibuprofen use. Int J Clin Pract Suppl. 2003 Apr;(135):28-31
100. van den Anker JN. Optimising the management of fever and pain in children. Int J Clin Pract Suppl. 2013 Jan;(178):26-32
101. Hay AD, Redmond NM, Costelloe C, et al. Paracetamol and ibuprofen for the treatment of fever in children: the PITCH randomised controlled trial. Health Technol Assess. 2009 May;13(27):iii-x,1
102. Hay AD, Costelloe C, Redmond NM, et al. Paracetamol plus ibuprofen for the treatment of fever in children (PITCH): randomised controlled trial. BMJ. 2008;337:a1302
103. Forrest JB, Heitlinger EL, Revell S. Ketorolac for postoperative pain management in children. Drug Saf. 1997 May;16(5):309-29
104. Romsing J, Ostergaard D, Drozdziewicz D, Schultz P, Ravn G. Diclofenac or acetaminophen for analgesia in paediatric tonsillectomy outpatients. Acta Anaesthesiol Scand. 2000 Mar;44(3):291-5
105. Romsing J, Ostergaard D, WaltherLarsen S, Valentin N. Analgesic efficacy and safety of preoperative versus postoperative ketorolac in paediatric tonsillectomy. Acta Anaesthesiol Scand. 1998 Aug;42(7):770-5
106. Barzaga AZ, Choonara I. Balancing the risks and benefits of the use of over-thecounter pain medications in children. Drug Saf. 2012 Dec 1;35(12):1119-25
107. Feinstein AR, Levitt M. The role of tonsils in predisposing to streptococcal infections and recurrences of rheumatic fever. N Engl J Med. 1970 Feb 5;282(6):285-91
108. Del Mar CB, Glasziou PP, Spinks AB. Antibiotics for sore throat. Cochrane Database Syst Rev. 2006;(4):CD000023
109. Lehnerdt G, Senska K, Fischer M, Jahnke K. Bilateral peritonsillar abscesses. Eur Arch Otorhinolaryngol. 2005 Jul;262(7):573-5
110. Segal N, El-Saied S, Puterman M. Peritonsillar abscess in children in the southern district of Israel. Int J Pediatr Otorhinolaryngol. 2009 Aug;73(8):1148-50
111. Powell EL, Powell J, Samuel JR, Wilson JA. A review of the pathogenesis of adult peritonsillar abscess: time for a reevaluation. J Antimicrob Chemother. 2013 Apr 23.
112. Segal N, El-Saied S, Puterman M. Peritonsillar abscess in children in the southern district of Israel. Int J Pediatr Otorhinolaryngol. 2009 Aug;73(8):1148-50
113. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
114. Herzon FS, Martin AD. Medical and surgical treatment of peritonsillar, retropharyngeal, and parapharyngeal abscesses. Curr Infect Dis Rep. 2006 May;8(3):196-202
115. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
116. Lehnerdt G, Senska K, Jahnke K, Fischer M. Post-tonsillectomy haemorrhage: a retrospective comparison of abscess- and elective tonsillectomy. Acta Otolaryngol. 2005 Dec;125(12):1312-7
117. Powell J, Wilson JA. An evidence-based review of peritonsillar abscess. Clin Otolaryngol. 2012 Apr;37(2):136-45
118. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
119. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
120. Paradise JL, Bluestone CD, Bachman RZ, et al. History of recurrent sore throat as an indication for tonsillectomy. Predictive limitations of histories that are undocumented. N Engl J Med. 1978 Feb 23;298(8):409-13

121. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med. 1984 Mar 15;310(11):674-83
122. Paradise JL, Bluestone CD, Colborn DK, Bernard BS, Rockette HE, KursLasky M. Tonsillectomy and adenotonsillectomy for recurrent throat infection in moderately affected children. Pediatrics. 2002 Jul;110(1 Pt 1):7-15
123. Kaygusuz I, Alpay HC, Godekmerdan A, et al. Evaluation of long-term impacts of tonsillectomy on immune functions of children: a follow-up study. Int J Pediatr Otorhinolaryngol. 2009 Mar;73(3):445-9
124. Windfuhr JP, Schloendorff G, Baburi D, Kremer B. Serious post-tonsillectomy hemorrhage with and without lethal outcome in children and adolescents. Int J Pediatr Otorhinolaryngol. 2008 Jul;72(7):1029-40
125. Stelter K, Ihrler S, Siedek V, Patscheider M, Braun T, Ledderose G. 1-year follow-up after radiofrequency tonsillotomy and laser tonsillotomy in children: a prospective, double-blind, clinical study. Eur Arch Otorhinolaryngol. 2012 Feb;269(2):679-84
126. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
127. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
128. Ericsson E, Graf J, Hultcrantz E. Pediatric tonsillotomy with radiofrequency technique: long-term follow-up. Laryngoscope. 2006 Oct;116(10):1851-7
129. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
130. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
131. Watson MG, Dawes PJ, Samuel PR, et al. A study of haemostasis following tonsillectomy comparing ligatures with diathermy. J Laryngol Otol. 1993 Aug;107(8):711-5
132. Kristensen S, Tveteras K. Posttonsillectomy haemorrhage. A retrospective study of 1150 operations. Clin Otolaryngol Allied Sci. 1984 Dec;9(6):347-50
133. Andrea M. Microsurgical bipolar cautery tonsillectomy. Laryngoscope. 1993 Oct;103(10):1177-8
134. Ewah B. An evaluation of pain, postoperative nausea and vomiting following the introduction of guidelines for tonsillectomy. Paediatr Anaesth. 2006 Oct;16(10):1100-1
135. Scherer H, Fuhrer A, Hopf J, et al. [Current status of laser surgery in the area of the soft palate and adjoining regions]. Laryngorhinootologie. 1994 Jan;73(1):14-20
136. Unkel C, Lehnerdt G, Schmitz KJ, Jahnke K. Laser-tonsillotomy for treatment of obstructive tonsillar hyperplasia in early childhood: a retrospective review. Int J Pediatr Otorhinolaryngol. 2005 Dec;69(12):1615-20
137. Davies J, Coatesworth AP. Double-blind randomized controlled study of coblation tonsillotomy versus coblation tonsillectomy on post-operative pain. Clin Otolaryngol. 2005 Dec;30(6):572-3
138. Haegner U, Handrock M, Schade H. ["Ultrasound tonsillectomy" in comparison with conventional tonsillectomy]. HNO. 2002 Sep;50(9):836-43
139. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT). Acta Otolaryngol. 2007 Apr 23;1-6
140. Isaacson G. Pediatric intracapsular tonsillectomy with bipolar electrosurgical scissors. Ear Nose Throat J. 2004 Oct;83(10):702, 704-702, 706
141. Huber K, Sadick H, Maurer JT, Hormann K, Hammerschmitt N. [Tonsillotomy with the argon-supported monopolar needle--first clinical results]. Laryngorhinootologie. 2005 Sep;84(9):671-5
142. Lister MT, Cunningham MJ, Benjamin B, et al. Microdebrider tonsillotomy vs electrosurgical tonsillectomy: a randomized, double-blind, paired control study of postoperative pain. Arch Otolaryngol Head Neck Surg. 2006 Jun;132(6):599-604
143. Stelter K, de la CR, Patscheider M, Olzowy B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol. 2010 Aug;124(8):880-5
144. Scherer H. [Tonsillotomy versus tonsillectomy]. Laryngorhinootologie. 2003 Nov;82(11):754-5
145. Windfuhr JP, Werner JA. Tonsillotomy: it's time to clarify the facts. Eur Arch Otorhinolaryngol. 2013 Aug 22
146. Sobol SE, Wetmore RF, Marsh RR, Stow J, Jacobs IN. Postoperative recovery after microdebrider intracapsular or monopolar electrocautery tonsillectomy: a prospective, randomized, single-blinded study. Arch Otolaryngol Head Neck Surg. 2006 Mar;132(3):270-4
147. Cantarella G, Viglione S, Forti S, Minetti A, Pignataro L. Comparing postoperative quality of life in children after microdebrider intracapsular tonsillotomy and tonsillectomy. Auris Nasus Larynx. 2012 Aug;39(4):407-10

148. Nguyen CV, Parikh SR, Bent JP. Comparison of intraoperative bleeding between microdebrider intracapsular tonsillectomy and electrocautery tonsillectomy. Ann Otol Rhinol Laryngol. 2009 Oct;118(10):698-702
149. Reilly BK, Levin J, Sheldon S, Harsanyi K, Gerber ME. Efficacy of microdebrider intracapsular adenotonsillectomy as validated by polysomnography. Laryngoscope. 2009 Jul;119(7):1391-3
150. Vaughan AH, Derkay CS. Microdebrider intracapsular tonsillectomy. ORL J Otorhinolaryngol Relat Spec. 2007;69(6):358-63
151. Sobol SE, Wetmore RF, Marsh RR, Stow J, Jacobs IN. Postoperative recovery after microdebrider intracapsular or monopolar electrocautery tonsillectomy: a prospective, randomized, single-blinded study. Arch Otolaryngol Head Neck Surg. 2006 Mar;132(3):270-4
152. Sorin A, Bent JP, April MM, Ward RF. Complications of microdebrider-assisted powered intracapsular tonsillectomy and adenoidectomy. Laryngoscope. 2004 Feb;114(2):297-300
153. Segal N, Puterman M, Rotem E, et al. A prospective randomized double-blind trial of fibrin glue for reducing pain and bleeding after tonsillectomy. Int J Pediatr Otorhinolaryngol. 2008 Apr;72(4):469-73
154. Sampaio AL, Pinheiro TG, Furtado PL, Araujo MF, Olivieira CA. Evaluation of early postoperative morbidity in pediatric tonsillectomy with the use of sucralfate. Int J Pediatr Otorhinolaryngol. 2007 Apr;71(4):645-51
155. Cantarella G, Viglione S, Forti S, Minetti A, Pignataro L. Comparing postoperative quality of life in children after microdebrider intracapsular tonsillotomy and tonsillectomy. Auris Nasus Larynx. 2012 Aug;39(4):407-10
156. Lavy JA. Post-tonsillectomy pain: the difference between younger and older patients. Int J Pediatr Otorhinolaryngol. 1997 Oct 18;42(1):11-5
157. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
158. Stelter K, Hiller J, Hempel JM, et al. Comparison of two different local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double blind, clinical trial. Eur Arch Otorhinolaryngol. 2010 Jul;267(7):1129-34
159. Sadhasivam S, Chidambaran V, Ngamprasertwong P, et al. Race and unequal burden of perioperative pain and opioid related adverse effects in children. Pediatrics. 2012 May;129(5):832-8
160. Tekelioglu UY, Apuhan T, Akkaya A, et al. Comparison of topical tramadol and ketamine in pain treatment after tonsillectomy. Paediatr Anaesth. 2013 Jun;23(6):496-501
161. Ozkiris M, Kapusuz Z, Saydam L. Comparison of ropivacaine, bupivacaine and lidocaine in the management of post-tonsillectomy pain. Int J Pediatr Otorhinolaryngol. 2012 Dec;76(12):1831-4
162. Stelter K, Hiller J, Hempel JM, et al. Comparison of two different local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double blind, clinical trial. Eur Arch Otorhinolaryngol. 2010 Jul;267(7):1129-34
163. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
164. Arikan OK, Ozcan S, Kazkayasi M, Akpinar S, Koc C. Preincisional infiltration of tonsils with ropivacaine in post-tonsillectomy pain relief: doubleblind, randomized, placebo-controlled intraindividual study. J Otolaryngol. 2006 Jun;35(3):167-72
165. Rotenberg BW, Wickens B, Parnes J. Intraoperative ice pack application for uvulopalatoplasty pain reduction: a randomized controlled trial. Laryngoscope. 2013 Feb;123(2):533-6
166. Sylvester DC, Rafferty A, Bew S, Knight LC. The use of ice-lollies for pain relief post-paediatric tonsillectomy. A single-blinded, randomised, controlled trial. Clin Otolaryngol. 2011 Dec;36(6):566-70
167. Steward DL, Grisel J, Meinzen-Derr J. Steroids for improving recovery following tonsillectomy in children. Cochrane Database Syst Rev. 2011;(8):CD003997
168. Windfuhr JP, Chen YS, Propst EJ, Guldner C. The effect of dexamethasone on post-tonsillectomy nausea, vomiting and bleeding. Braz J Otorhinolaryngol. 2011 Jun;77(3):373-9
169. Randel A. AAO-HNS Guidelines for Tonsillectomy in Children and Adolescents. Am Fam Physician. 2011 Sep 1;84(5):566-73
170. Baugh RF, Archer SM, Mitchell RB, et al. Clinical practice guideline: tonsillectomy in children. Otolaryngol Head Neck Surg. 2011 Jan;144(1 Suppl):S1- 30
171. Sutters KA, Miaskowski C, HoldridgeZeuner D, et al. A randomized clinical trial of the effectiveness of a scheduled oral analgesic dosing regimen for the management of postoperative pain in children following tonsillectomy. Pain. 2004 Jul;110(1-2):49-55

172. Lewis SR, Nicholson A, Cardwell ME, Siviter G, Smith AF. Nonsteroidal antiinflammatory drugs and perioperative bleeding in paediatric tonsillectomy. Cochrane Database Syst Rev. 2013 Jul 18;7:CD003591
173. Riggin L, Ramakrishna J, Sommer DD, Koren G. A 2013 updated systematic review & meta-analysis of 36 randomized controlled trials; no apparent effects of non steroidal antiinflammatory agents on the risk of bleeding after tonsillectomy. Clin Otolaryngol. 2013 Apr;38(2):115-29
174. Zernikow B, Smale H, Michel E, Hasan C, Jorch N, Andler W. Paediatric cancer pain management using the WHO analgesic ladder--results of a prospective analysis from 2265 treatment days during a quality improvement study. Eur J Pain. 2006 Oct;10(7):587-95
175. Hadden SM, Burke CN, Skotcher S, Voepel-Lewis T. Early postoperative outcomes in children after adenotonsillectomy. J Perianesth Nurs. 2011 Apr;26(2):89-95
176. Stelter K, Hempel JM, Berghaus A, Andratschke M, Luebbers CW, Hagedorn H. Application methods of local anaesthetic infiltrations for postoperative pain relief in tonsillectomy: a prospective, randomised, double-blind, clinical trial. Eur Arch Otorhinolaryngol. 2009 Jan 22
177. Kamarauskas A, Dahl MR, Hlidarsdottir T, Mainz J, Ovesen T. Need for better analgesic treatment after tonsillectomy in ear, nose and throat practices. Dan Med J. 2013 May;60(5):A4639
178. Stanko D, Bergesio R, Davies K, Hegarty M, von Ungern-Sternberg BS. Postoperative pain, nausea and vomiting following adeno-tonsillectomy - a longterm follow-up. Paediatr Anaesth. 2013 May 13
179. Chan CC, Chan YY, Tanweer F. Systematic review and meta-analysis of the use of tranexamic acid in tonsillectomy. Eur Arch Otorhinolaryngol. 2013 Feb;270(2):735-48
180. Sarny S, Habermann W, Ossimitz G, Stammberger H. Significant posttonsillectomy pain is associated with increased risk of hemorrhage. Ann Otol Rhinol Laryngol. 2012 Dec;121(12):776-81
181. Windfuhr JP, Schloendorff G, Baburi D, Kremer B. Serious post-tonsillectomy hemorrhage with and without lethal outcome in children and adolescents. Int J Pediatr Otorhinolaryngol. 2008 Jul;72(7):1029-40
182. Hessen Soderman AC, Ericsson E, Hemlin C, et al. Reduced risk of primary postoperative hemorrhage after tonsil surgery in Sweden: results from the National Tonsil Surgery Register in Sweden covering more than 10 years and 54,696 operations. Laryngoscope. 2011 Nov;121(11):2322-6
183. Krespi YP, Kizhner V. Laser tonsil cryptolysis: In-office 500 cases review. Am J Otolaryngol. 2013 Apr 10
184. Pfaar O, Spielhaupter M, Schirkowski A, et al. Treatment of hypertrophic palatine tonsils using bipolar radiofrequency-induced thermotherapy (RFITT.). Acta Otolaryngol. 2007 Nov;127(11):1176-81
185. Sarny S, Ossimitz G, Habermann W, Stammberger H. Hemorrhage following tonsil surgery: a multicenter prospective study. Laryngoscope. 2011 Dec;121(12):2553-60
186. Sarny S, Ossimitz G, Habermann W, Stammberger H. [Austrian tonsil study part 3: surgical technique and postoperative haemorrhage after tonsillectomy]. Laryngorhinootologie. 2013 Feb;92(2):92-6
187. Windfuhr JP, Wienke A, Chen YS. Electrosurgery as a risk factor for secondary post-tonsillectomy hemorrhage. Eur Arch Otorhinolaryngol. 2009 Jan;266(1):111-6

Authors

PD Dr. med. Klaus Stelter
Dep. of Otorhinolaryngology, Head and Neck Surgery
RoMed Clinic Bad Aibling
Harthauser Str. 16
83043 Bad Aibling
info@alpenpraxisklinik.de

Prof. Dr. med. Götz Lehnerdt
Dep. of Otorhinolaryngology, Head and Neck Surgery
St. Anna Clinic Wuppertal
Vogelsangstr. 106
42109 Wuppertal
Hno.kh-anna@cellitinnen.de

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.9: Pediatric Adenoidectomy Technique

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ADENOIDECTOMY SURGERY TECHNIQUE

Nico Jonas

Adenoidectomy may be done in isolation or combined with tonsillectomy. Adenoidectomy may be either ***total*** or ***partial***. ***Partial adenoidectomy*** involves leaving a ridge of adenoidal tissue inferiorly in the area of Passavant's ridge to enable apposition of the soft palate to the posterior pharyngeal wall during swallowing; it is indicated when there is concern about causing velopharyngeal insufficiency (VPI) e.g. with a submucous cleft palate.

Indications

Adenoidectomy is most frequently combined with tonsillectomy and/or insertion of grommets. Other indications include:

- Obstructive sleep apnoea
- Nasal obstruction
- Problematic rhinorrhea
- Recurrent upper respiratory tract infection
- Recurrent acute otitis media
- Recurrent otitis media with effusion
- For histological analysis

History and Clinical Examination

Adenoidal hypertrophy presents with nasal obstruction, mouth breathing, rhinorrhea, snoring and sleep apnea. ***Recurrent adenoiditis*** may manifest with otitis media with effusion (glue ear) with or without hearing loss, recurrent acute otitis media, rhinorrhea and recurrent upper respiratory tract infections.

Clinically adenoidal size can only be accurately determined in the awake patient by fibreoptic nasendoscopy. Occasionally enlarged adenoids can be seen extending below the soft palate, or at the back of a well-decongested nasal cavity using an otoscope. Nasal airflow can be determined by placing a metal spatula under the nose and looking for “misting” on expiration; enlarged adenoids are associated with reduced “misting”.

Before embarking on surgery, the following points need to be elicited on history and examination

- Bleeding diathesis
- Obstructive sleep apnea: avoid perioperative sedation and monitor carefully for apnea postoperatively
- Previous cleft palate repair: total adenoidectomy may cause velopharyngeal insufficiency

Surgical anatomy

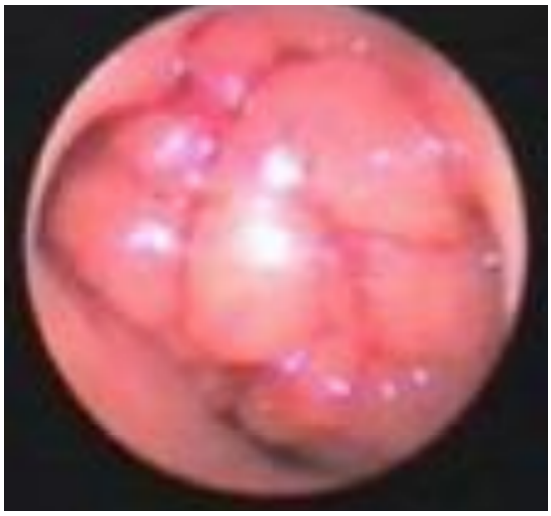


Figure 1: Enlarged adenoids obstructing posterior choana

The adenoid is situated in the midline of the posterior nasopharyngeal wall immediately below the rostrum of the sphenoid. It constitutes the superior portion of pharyngeal lymphoid tissue termed Waldeyer's ring. The nasopharynx communicates with the nasal cavity via the posterior choanae. The adenoids can enlarge to obstruct the choanae causing nasal obstruction and rhinorrhea (*Figure 1*).

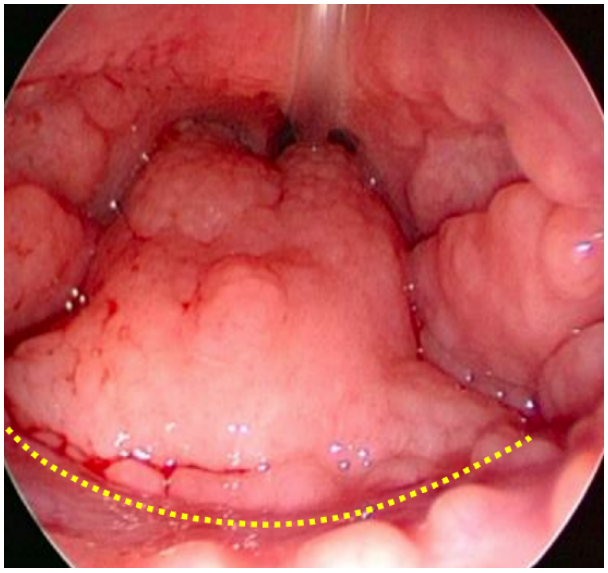


Figure 2: View from below of adenoids extending superiorly from Passavant's ridge (broken yellow line)

The space lateral to the adenoid and posteromedial to the orifice of the Eustachian tube is termed the fossa of Rosenmüller. Gerlach's tonsil refers to a collection of lymphoid tissue located within the lip of the fossa of Rosenmüller and can extend into the Eustachian tube. Inferiorly, the adenoids abut the upper margin of the superior constrictor or Passavant's ridge (*Figure 2*).

The ***arterial blood supply*** to the adenoid arises from branches of the external carotid artery i.e. ascending pharyngeal, ascending palatine, pharyngeal branch of maxillary artery, sphenopalatine, and artery of the pterygoid canal. ***Venous drainage*** is to the facial and internal jugular systems. ***Sensory innervation*** is provided by the glossopharyngeal (IX) and vagus (X) nerves; this explains the referred pain that patients experience to the ear and throat with adenoid infection and following adenoidectomy.

Grading of adenoidal size

Grade	Choanal obstruction
1	< 1/3
2	1/3 - 2/3

3	2/3 - 3/3

Table 1: Grading system for adenoid size

The percentage of choanal obstruction is often used to grade the size of adenoids (*Table 1*). This is best achieved by flexible nasendoscopy in an awake patient (if possible) or with a dental mirror placed in the postnasal space in an anesthetized patient.

Surgical equipment



Figure 3: Instruments used to perform curette adenoidectomy: curettes, BoyleDavis gag and tonsil swabs



Figure 4: Instruments used to perform adenoidectomy with suction diathermy: monopolar suction diathermy, Boyle-Davis gag, dental mirror, Burkitt straight forceps and suction catheter

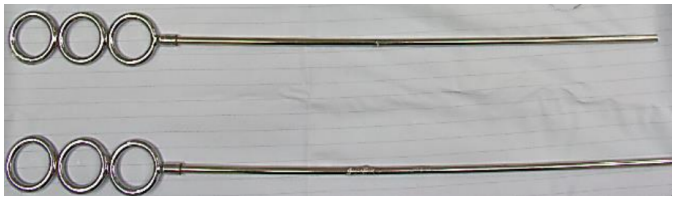


Figure 5: Drafton rods are used to suspend the Boyle Davis gag and stabilize the head

An adenoid curette and/or suction diathermy are commonly used to perform adenoidectomy. Advantages of suction diathermy include targeted, directed removal of the adenoids avoiding injury to adjacent structures, clearing choanal adenoidal tissue and

hemostasis. *Figures 3-5* illustrate the equipment required to perform adenoidectomy with a curette and with suction diathermy.

Preliminary steps

- General anesthesia with endotracheal intubation using an angled tube or with a laryngeal mask
- Patient is positioned supine with a shoulder roll to achieve extension of the neck

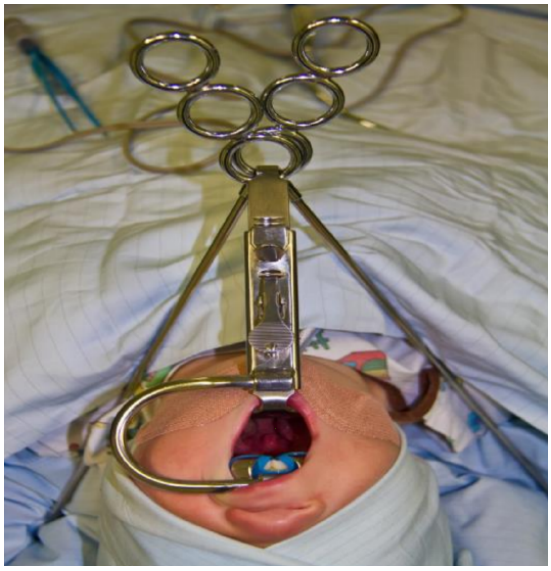


Figure 6: Boyle Davis gag in place suspended and held in place with Drafton rods

- A Boyle Davis mouth gag is inserted; ensure that the ventilation tube and tongue are in the midline (*Figures 3*, *4*, *6*)
- Open the gag to expose the oropharynx
- Stabilize the patient's head in the desired position by inserting Drafton suspension rods (*Figure 6*)



Figure 7: Note the nasal catheter retracting soft palate anteriorly

- To improve the view of the nasopharynx, insert a nasal catheter in one/both nostrils and bring it out through the mouth; secure both ends with an artery clip to retract the soft palate anteriorly (*Figure 7*)
- Assess the size of the adenoids and exclude an aberrant or dehiscent internal carotid artery by examining the nasopharynx with a dental mirror and/or by digital palpation
- Palpate the palate to exclude an occult submucous cleft palate; proceeding with adenoidectomy in such cases can cause rhinolalia aperta

Curette Adenoidectomy

- Use the largest adenoidectomy curette that will engage the adenoids
- Using a dental mirror aids the surgeon to place the curette under direct vision
- Stabilize the head with the non-dominant hand

- Remove the adenoids with a single firm scraping motion from superiorly to inferiorly
- Inspect the adenoid bed to assess whether removal is complete; if not, repeat the process until complete removal has been achieved
- Place swabs/sponges in the postnasal space while continuing with the tonsillectomy if indicated
- Remove the swabs after a few minutes
- Confirm hemostasis by inspecting the nasopharynx with a mirror
- Hemostasis can be achieved by using monopolar suction diathermy; it is absolutely essential that there is complete hemostasis
- Remove all clots from the nose and nasopharynx with a suction catheter passed through the nose
- Document in the operation notes that hemostasis has been achieved and clots cleared

Suction Diathermy Adenoidectomy

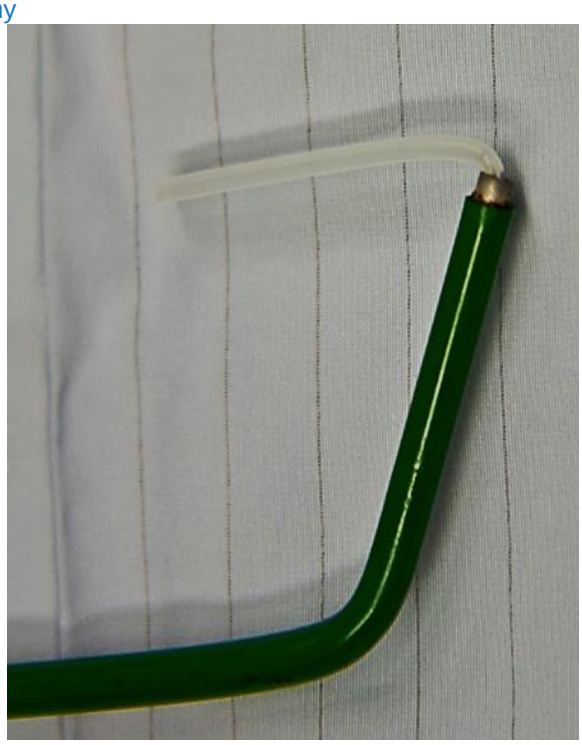


Figure 8: The suction diathermy tip is bent to 90 degrees with the introducer in place to prevent complete occlusion of the lumen at the bend

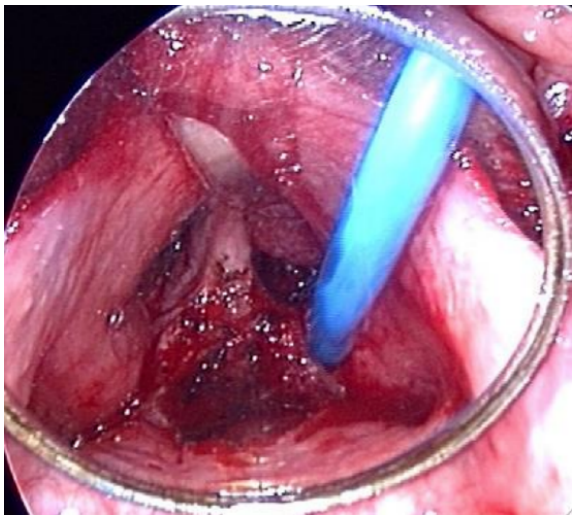


Figure 9: Suction diathermy adenoidectomy under direct vision using a mirror in the postnasal space.

- Bend the tip of the suction diathermy to 90 degrees with the introducer still in place to prevent kinking and occlusion of the lumen (*Figure 8*)
- Remove the introducer and connect continuous suction

- Set the monopolar diathermy at 38 Watts
- With a mirror held in the non-dominant hand, pass the suction diathermy behind the palate
- Using a combination of sweeping motions and localized "spot welding", remove or ablate the adenoids under direct vision until a clear view of the posterior choanae is obtained (*Figure 9*)

Postoperative Care

Adenoidectomy is commonly performed as a day case procedure. Paracetamol is usually sufficient to control postoperative pain. If suction diathermy was used, broad spectrum antibiotics (co-amoxiclav) is administered for a week postoperatively to treat the resulting nasal discharge. Patients are advised to miss school for 5 days and generally recover within a week.

Complications following adenoidectomy

Early

- Bleeding (more commonly with curette adenoidectomy)
- Aspiration of retained blood clot causing acute airway obstruction (Coronor's clot)

Late

- Nasal discharge (suction diathermy)
- Grisel syndrome (atlanto-axial instability)
- Scarring of Eustachian tube opening causing middle ear dysfunction
- Nasopharyngeal stenosis
- Velopharyngeal insufficiency
- Regrowth of adenoids

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SURGERY FOR NASAL DERMOIDS

Hiba Al-Reefy, Claire Hopkins, Nico Jonas

Midline masses are rare congenital anomalies, with an incidence reported to be between 1 in 20,000 to 1 in 40,000 live births. Nasal dermoid cysts are the most common of the congenital midline nasal masses, a group that also includes nasal gliomas and encephalocoeles, and much less frequently haemangiomas, lipomas, lymphangiomas and other very rare lesions. Cases are usually sporadic, but rare familial series have been reported. They are distinguished by the tissues of origin, with dermoids developing from trapped ectoderm and mesoderm; hence they may contain adnexal structures such as skin, hair follicles and sebaceous glands. By contrast, encephaloceles are herniations of the meninges, and may also contain brain tissue, while gliomas contain glial cells.

Clinical presentation



Figure 1: Dermoid cyst presenting as midline nasal mass



Figure 2: Nasofrontal sinus

Many dermoids present at birth, but some present later in childhood or even adulthood when they become symptomtic. They typically present as an isolated mass, a midline nasal deformity (*Figure 1*) or as a sinus tract opening onto the skin, (*Figure 2*). A midline nasal pit, fistula, or infected mass may be located anywhere from the glabella to the nasal columella. It usually terminates in a single subcutaneous tract which may have hair at its opening; this is said to be pathognomonic of a dermoid. It may secrete sebaceous material or pus, become intermittently inflamed, form an abscess, cause osteomyelitis, or present with nasal obstruction, or with broadening of the nasal root or bridge.

Occasionally it presents with intracranial complications such as meningitis or a cerebral abscess. Connection with the central nervous system has been variably reported to occur in 4-45%. Suspicion of in intracranial involvement should remain high, and

suspected lesions should not be biopsied before radiological evaluation has been undertaken.

Although there is no known syndromic association, associated congenital anomalies occur in 5-41%; this includes aural atresia, mental retardation, spinal column abnormalities, hydrocephalus, hypertelorism, hemifacial microsomia, albinism, corpus callosum agenesis, cerebral atrophy, lumbar lipoma, dermal cyst of the frontal lobe, cleft lip and palate, tracheoesophageal fistula, and coronary artery, cardiac, genital, and cerebral anomalies.

Embryology

The nose is formed from the frontonasal process and two nasal placodes which develop dorsal to the stomodaeum (primitive mouth) during the fourth week of embryological life. The nasal placodes consist of medial and lateral processes and become more prominent. The medial processes approach one another and eventually fuse in the midline. The lateral processes become less prominent as the maxillary process fuses with them. A deep groove in this region, called the nasal-maxillary groove becomes the nasolacrimal duct. As the external nose is develops, other neural crest cells migrate through the frontonasal process to form the posterior septum, ethmoid bone, and sphenoid. The nasal septum develops around week five from the frontonasal process, growing in an anterior-posterior direction.

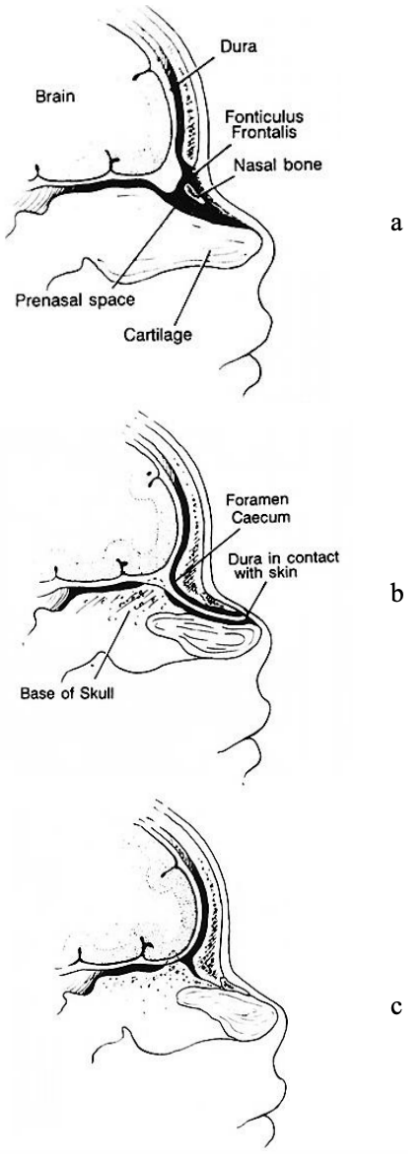


Figure 3: (a) Fonticulus nasofrontalis and prenasal space; (b) Fonticulus frontalis closes, foramen caecum is formed, and a projection of dural diverticulum contacts the tip of the nose; (c) Dural diverticulum retracts and prenasal space is obliterated. (From: Barkovich AJ, et al. Congenital nasal masses: CT and MR imaging features in 16 cases. Am J Neuroradiol 1991; 12:105-16)

During formation of the skull base and nose, mesenchymal structures are formed from several centers that eventually fuse and begin to ossify. ***Before they fuse there are recognized spaces between them that are important in the development of congenital midline nasal masses***. These include the fonticulus nasofrontalis, the prenasal space, and the foramen caecum (*Figures 3a-c*). The fonticulus frontalis is the space between the frontal and nasal bones. The prenasal space is located between the nasal bones and the nasal capsule (precursor of nasal septum and nasal cartilages). During fetal development these spaces are close by fusing and ossifying. Abnormal development of these structures is thought to be involved in the formation of nasal dermoids.

A widely accepted theory of dermoid sinus cyst development is the prenasal space theory. According to this theory, during normal development a projection of dura protrudes through the fonticulus frontalis or inferiorly into the prenasal space. This projection normally regresses but if it does not, the dura then remains attached to the epidermis and result in trapped ectodermal elements.

Pre-operative evaluation

Clinical evaluation

Encephalocoeles are pulsatile, compressible masses that expand on crying and on bilateral compression of the internal jugular veins (Furstenberg test); neither gliomas nor dermoids expand with crying or the Furstenberg test. However, a negative Furstenberg test does not exclude intracranial extension; hence imaging is essential.

Radiological Imaging

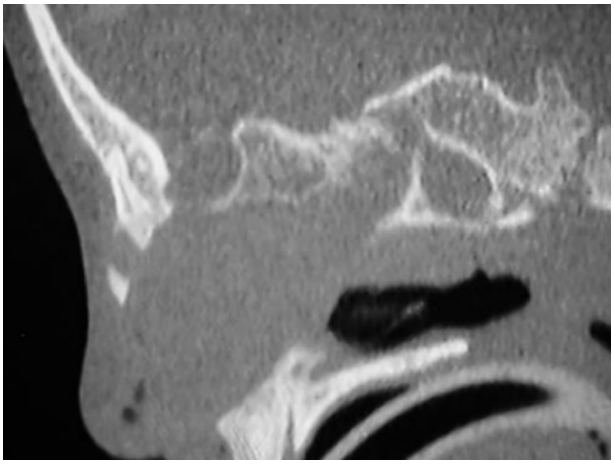


Figure 4: CT scan of nasal dermoid cyst

If a dermoid is suspected, imaging is mandatory to determine the extent of the cyst or tract, to exclude an intracranial connection and to plan surgery. A CT scan delineates the bony anatomy and may indicate an intracranial connection (*Figure 4*).

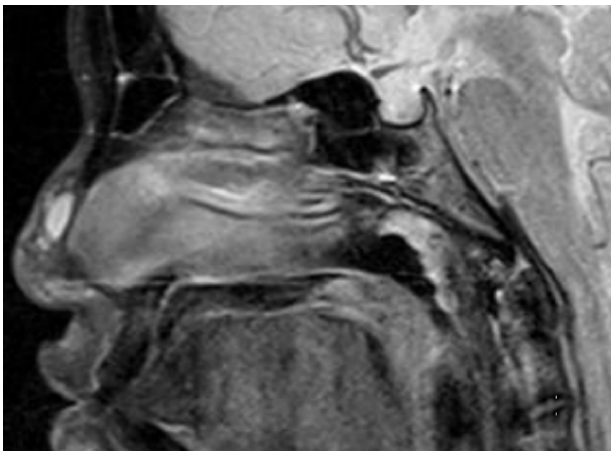


Figure 5: MRI scan of nasal dermoid cyst

Features such as an intracranial soft tissue mass, a bifid crista galli, orbital widening or a cribiform plate defect are indicators of intracranial extension. A normal crista galli makes an intracranial connection unlikely. However, in order to exclude this, MRI scanning is required and is becoming the imaging method of choice, as both false-positives and false-negatives for intracranial

involvement are found with CT. It is prudent in many cases (especially when a child requires general anesthesia or sedation for imaging) to either obtain both images at a single sitting or to proceed directly to MRI scan (*Figure 5*).

Surgery

Early surgical intervention is recommended to avoid further distortion of the nose or bony atrophy caused by growth of the mass or recurrent infection. Biopsy is contraindicated due to risk of CSF leakage in cases with intracranial connections. The surgical objective is complete surgical excision at the first operation. Two factors determine the surgical approach

- Is there an intracranial connection?
- What is the extent of the lesion?

The ideal surgical approach for extensive dermoid cysts and tracts should permit

- Access to the whole cyst/tract
- Medial and lateral osteotomies if required
- Rapid repair of cribriform defects and CSF rhinorrhoea
- Reconstruction of the nasal dorsum with a minimally visible scar

Several surgical approaches have been described; occasionally more than one incision is required especially in the presence of a nasal pit or skin breakdown

- ***Transverse rhinotomy***
- ***Septorhinoplasty approach***
- ***Vertical rhinotomy***
- ***Horizontal nasofrontal incision with eyebrow extensions***
- ***Endoscopic approaches***

Transverse rhinotomy: This can be used for small to moderate-sized lesions without intracranial extension. The sinus punctum is excised within a transversely oriented ellipse of skin and the tract is cannulated with a lacrimal probe and dissected. Medial or lateral osteotomies may be performed if necessary. If placed in a natural nasal skin crease it leaves a very favorable scar.



Figure 6: Stepped columella incision with open septorhinoplasty approach

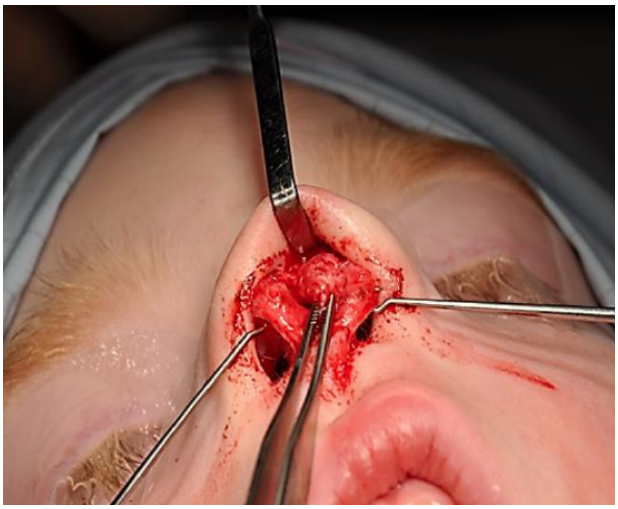


Figure 7: Full exposure of dermoid cyst

Open septorhinoplasty approach: This provides wide exposure, but with a concealed, aesthetically pleasing scar, for larger lesions and for patients with damaged bone and cartilage from prior surgery or recurrent infection or with intracranial extension. A separate excision of a sinus opening may be required; with intracranial extension a combined intracranial approach may be required. A stepped columella incision is made to release the columella followed by bilateral marginal incisions (*Figure 6*); the upper and lower lateral cartilages are delineated. A dermoid cyst may be adherent to the upper lateral cartilages, dorsal septum and nasal bones; full exposure is mandatory to ensure complete excision and to prevent recurrence (*Figure 7*). A nasal pit can be removed using a small elliptical skin incision on the nasal dorsum.

An endoscope or operating microscope may be used to facilitate more cephalad dissections and to achieve complete resection. The open septorhinoplasty approach allows for the lower lateral cartilages to be realigned if displaced laterally by a dermoid cyst extending to the nasal tip.

If a large defect remains after surgery, a dorsal graft can be placed to restore volume without the presence of an overlying incision line, thereby reducing risks of infection and extrusion. Grafts are however often not required as the defect fills with scar tissue.

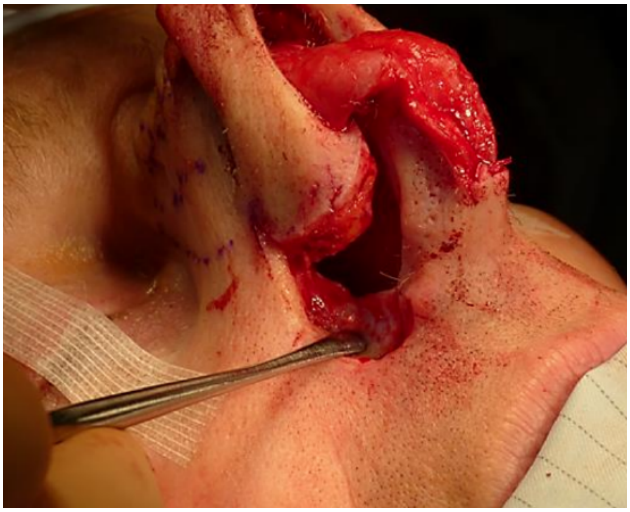


Figure 8: Extended alar base incision

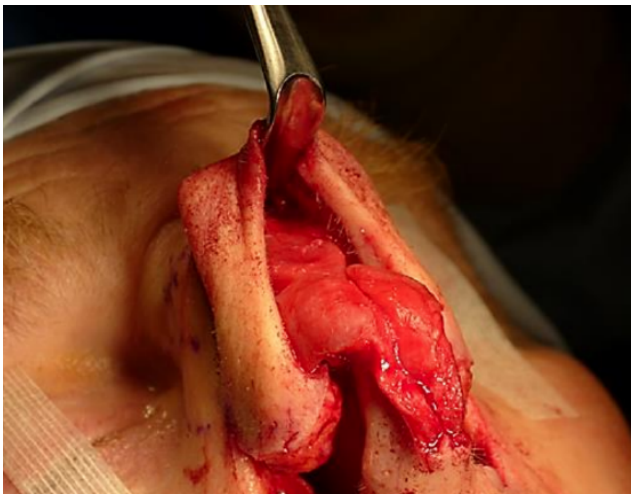


Figure 9a: Further exposure allows complete excision



Figure 9b: Excised dermoid cyst

Extension of this approach to involve the alar base allows for further exposure of the nasal dorsum as the skin envelope can be raised more cephalad (*Figures 8, 9a, 9b*).



Figure 10: Vertical midline incision

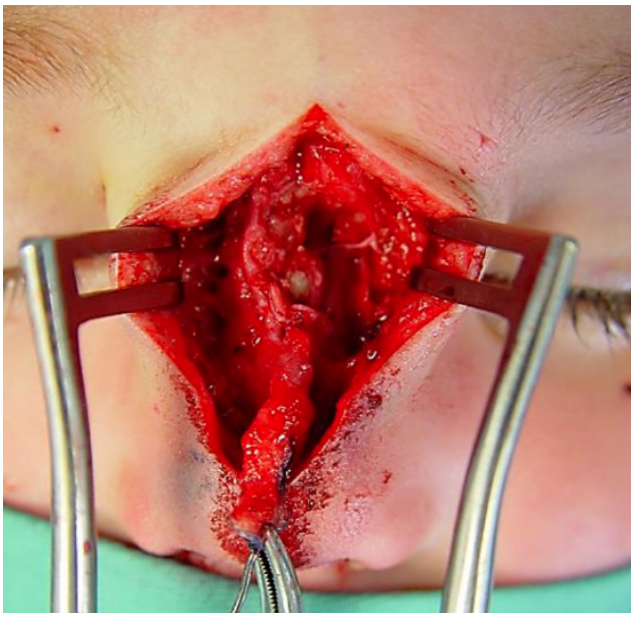


Figure 11: Nasal dermoid tract

Midline vertical incision: This provides excellent exposure as it can be extended to allow access to the skull base (*Figures 10*, *11*).



Figure 12: Horizontal nasofrontal incision with eyebrow extensions



Figure 13a: Dermoid cyst visible in wound

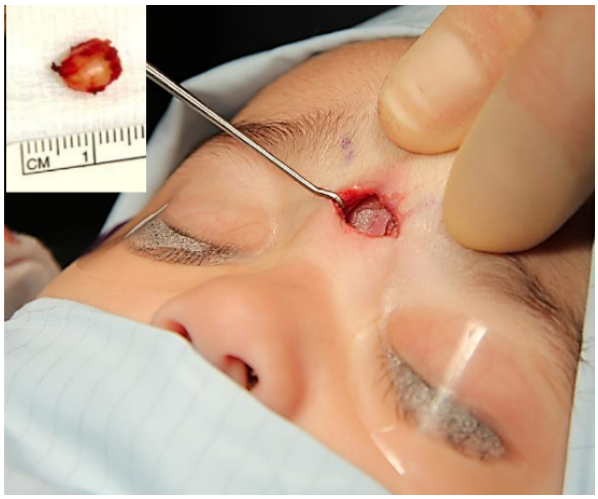
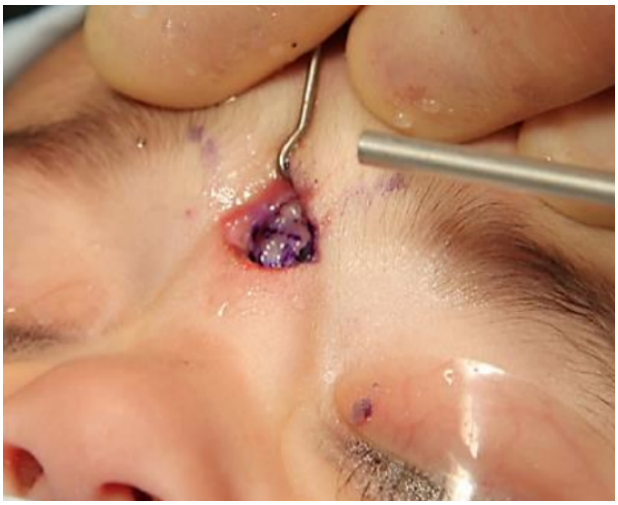
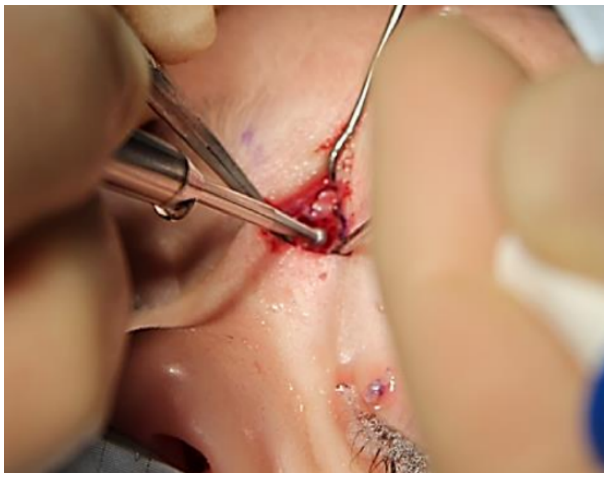


Figure 13b: Skull exposed following excision; specimen (inset)


Figure 14: Bony window marked on outer table of skull


Figure 15: Small cutting burr used to cut out bony window

Horizontal nasofrontal incision: This is reserved for cysts limited to the nasofrontal area or to facilitate a small craniotomy to remove the tract with intracranial extension. The incision can be extended along the eyebrows to allow additional exposure (*Figure 12*). Following removal of a cyst (*Figures 13a, b*) a bony window can be marked (*Figure 14*) to include the tract and allow access to the intracranial component. A small cutting bur can be used to cut out the bony window and allow direct access to the intracranial portion (*Figure 15*).



Figure 16: Closed horizontal nasofrontal incision

All facial incisions mentioned heal with excellent cosmesis (*Figure 16*); the choice of external surgical approach is therefore dictated principally by the size and site of the dermoid, presence of a pit, and experience of the surgeon.

Endoscopic approach: An endonasal endoscopic approach is recommended when a dermoid is located within the nasal cavity with little or no cutaneous involvement. It can be combined with a small external midline excision of the cutaneous punctum. Although there are reports of adequate visualization of the skull base through intercartilagenous incisions to allow passage of an endoscope and instruments, intracranial extension is a relative contraindication to endoscopic approaches.

Dermoids with intracanial extension

Midline masses with an intracranial connection usually require a combined approach with the help of a pediatric neurosurgeon. A frontal craniotomy is done via a bicoronal incision with elevation of a pericranial flap to facilitate reconstruction. A subcranial approach via transglabellar or nasofrontal incisions with eyebrow extensions and minicraniotomy as described above may be preferred to avoid frontal lobe retraction. Once the intracranial component has been excised, dural and bony defects are repaired. The extracranial mass may require a separate approach using the incisions described previously to permit complete removal.

Where intracranial communication has been neither excluded nor confirmed, an external approach is initially undertaken. The tract may be followed to its dural attachment at the foramen caecum where biopsies can be taken. If dermal or epidermal elements are identified in the biopsy, frontal craniotomy is indicated; if only fibrous tissue is present then excision is complete.

Postoperative complications

- ***Tissue defect***: Resecting a large dermoid may leave a significant soft tissue defect, as well as splayed nasal bones. Although osteotomies may be used to close the defect, there is often remarkable filling-in of the defect by scar tissue. It is therefore the authors' practice to splint the nose with plaster of Paris, as following rhinoplasty, and to delay reconstructive procedures. This has the advantage of having no graft material in situ should for revision surgery for recurrence be required.
- ***Complications associated with intracranial extension***
  - Meningitis
  - Cerebrospinal fluid leak
  - Cavernous sinus thrombosis
- ***Sepsis***: Soft tissue, osteomyelitis
- ***Anosmia***: With frontal craniotomy
- ***Recurrence***: This may occur as a delayed phenomenon if the cyst or the tract was not fully excised. Imaging should be repeated, paying particular attention to the most cephalic extension of the cyst. Rates of 4-12% in some larger series, and up to 100%, have been reported

Key Points

- The primary aim is complete surgical excision at the first operation
- Biopsy is contraindicated due to the risk of CSF leakage in cases with intracranial connections

- Early surgical intervention is recommended to avoid further nasal distortion and bony atrophy due to growth of the mass or recurrent infection
- The surgical approach is determined by the extent of the lesion and the presence of an intracranial connection

Authors

Hiba Al-Reefy MBChB, DOHNS, FRCS (ORL-HNS)
Specialist Registrar
Otolaryngology, Head and Neck Surgery
Guys and St. Thomas' Hospital
London, United Kingdom
drhibaalreefy@hotmail.com

Claire Hopkins BMBCh, MA (Oxon), FRCS (ORL-HNS), DM Rhinologist, Skull Base Surgeon
Guys and St. Thomas' Hospital
London, United Kingdom
clairehopkins@yahoo.com

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.11: Supraglottoplasty for Laryngomalacia

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LARYNGOMALACIA

Nico Jonas, Graeme van der Meer

Laryngomalacia is characterized by collapse of the supraglottic tissues on inspiration and is the most common cause of stridor in infancy. It generally becomes symptomatic 2-3 weeks after birth, and presents as characteristic high-pitched inspiratory, squeaking stridor. Classically symptoms are worse in the supine position, when the child cries, or is agitated. Males are affected twice as often as females. It usually resolves by the age of 2 years. Laryngomalacia may remain symptomatic beyond 2 years in patients with neuromascular disorders and should be considered in the differential diagnosis of inspiratory stridor even in older children. The etiology is not fully understood. There does appear to be a familial predisposition. Anatomically, redundant supraglottic soft tissues collapse on inspiration and cause supraglottic airway obstruction. Another theory is that of immature neuromuscular development causing supraglottic compromise. A common coexisting condition is that of acid reflux which may exacerbate laryngomalacia by causing posterior supraglottic edema.

Diagnosis

History

Diagnosis is usually suspected based on the history. The classic presentation is a neonate with inspiratory stridor starting 2-3 weeks after birth. Stridor is worse in the supine position and during feeding or with crying. The clinician should enquire about weight gain, cyanotic episodes, poor or prolonged feeding, aspiration and sleep disordered breathing. The voice should be unaffected, and the neonate should have a normal cry.

Clinical findings



Figure 1: Flexible laryngoscope with suction port

The diagnosis is confirmed by flexible fibreoptic laryngoscopy. This can be done in the awake, upright patient, using a flexible fibreoptic laryngoscope, ideally with a suction port (*Figure 1*).

Some clinicians prefer not to prepare the nose with local anesthetic as this permits feeding to comfort the neonate immediately following the procedure. The endoscope is passed via the nose or mouth. Limitations are that the subglottis and distal airway cannot be inspected.

Classic laryngoscopy findings

- Short aryepiglottic folds narrowing the supraglottis



Figure 2: Curled-up, omega-shaped epiglottis

- Omega or tubular shaped epiglottis (*Figure 2*)
- Anterior prolapse of the corniculate and cuneiform cartilages

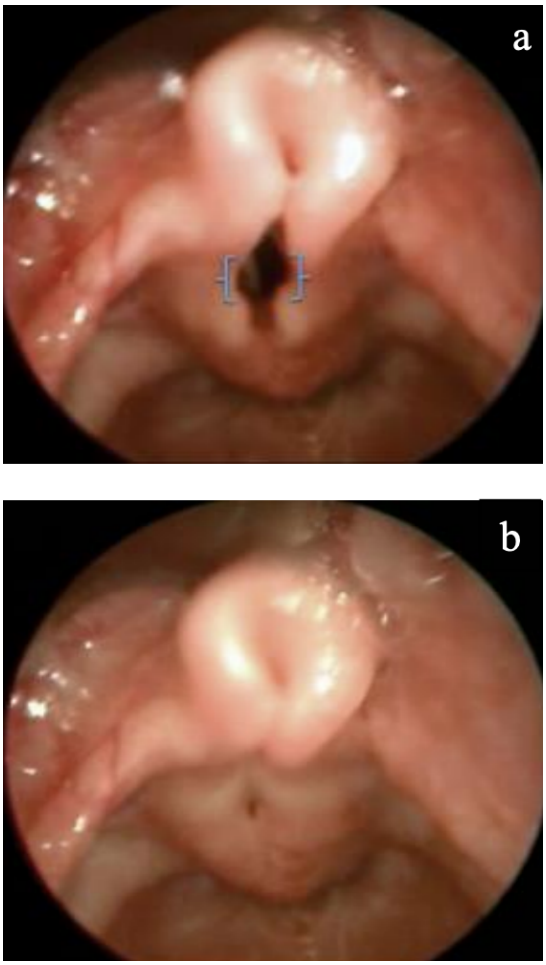


Figure 3: Omega-shaped epiglottis, short aryepiglottic folds (blue brackets) and prolapsing arytenoid mucosa (a: open during expiration, b: closed during inspiration)

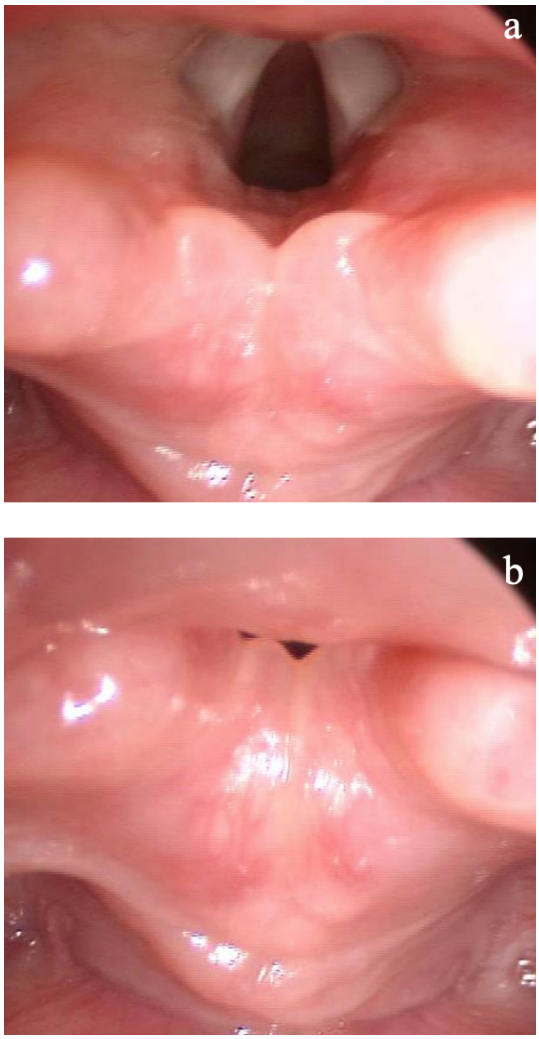


Figure 4: Laryngomalacia secondary to prolapsing arytenoids: (a: open during expiration, b: closed during inspiration)

- There may be redundant soft tissue around the arytenoids. (*Figures 3*, *4*)
- Intact vocal cord movement

Radiology is unnecessary unless concomitant pathology is suspected. Sleep studies or overnight saturation studies should be performed in patients when sleep disordered breathing and desaturations are suspected.

Direct laryngoscopy is occasionally required and indications include:

- Atypical history
- Suspicion of distal airway pathology
- Unable to make a diagnosis after flexible laryngoscopy

Classification

A variety of classification systems are used for laryngomalacia. The following system is pragmatic with specific treatments for each type:

Type 1: Foreshortened or taut aryepiglottic folds

Type 2: Presence of redundant supraglottic soft tissue

Type 3: Other underlying etiologies, such as neuromuscular disorders; this rarer type may present with the epiglottis prolapsing onto the vocal cords with inspiration

While these 3 types are not mutually exclusive, each should be considered as a separate pathological entity with a final common clinical presentation. Each type requires a specific surgical approach.

Non-surgical treatment

- Laryngomalacia usually resolves by the age of 2 years; no treatment other than parental reassurance is required in 99% of cases. Once the diagnosis is made the condition is explained to the parents. It is important to emphasize to parents that it is a self-limiting condition that will resolve in the majority of cases
- Patients are weighed every 2 weeks and the weight charted on a centile chart. They should be reviewed after 6 weeks to ensure adequate weight gain
- Patients are started on anti-reflux treatment (proton pump inhibitors or Histamine H2 receptor blockers); it is important that the dose of anti-reflux medication is adjusted whenever the body weight increases by 10% to ensure adequate dosage

Surgical treatment

Criteria that alert the clinician that surgical intervention may be required include:

- Dyspnea at rest
- Difficult and prolonged feeding (must stop feeding to catch his/her breath)
- Failure to thrive characterized by crossing two or more centiles on the growth chart
- Sleep disordered breathing/obstructive sleep apnea syndrome

Preoperative assessment

Once the decision has been made that surgery is required, a swallow assessment is done to exclude aspiration. Patients are also assessed to exclude underlying neurological conditions.

Anesthesia

- General anesthesia, preferably with spontaneous ventilation



Figure 5: Endotracheal tube used as nasopharyngeal airway

- Anesthetic can be delivered via an endotracheal tube, used as a nasopharyngeal airway (*Figure 5*)
- Endotracheal intubation or laryngeal mask ventilation is occasionally required prior to diagnostic endoscopy and the surgical procedure
- Total intravenous anesthesia is preferred to avoid exposing operating staff to inhalant anesthetic gases
- Once the appropriate depth of anesthesia has been reached, the anesthetist removes the tube or mask and the surgeon inserts a laryngeal suspension laryngoscope, taking care not to injure the patient's gums or teeth or to overextend the neck
- The patient may be allowed to breathe spontaneously with oxygen
- Anesthetic gases are delivered via a nasopharyngeal airway
- Dexamethasone (0.25 mg/kg) preoperatively minimizes postoperative inflammation and edema and may make the procedure more comfortable to the patient

Surgery: Diagnostic steps

- Diagnostic laryngoscopy, tracheoscopy and bronchoscopy are done to
  - Confirm the diagnosis
  - Exclude concomitant airway pathology

    - Confirm normal vocal cord movement
- Position the patient in the “sniffing position” to allow the larynx and trachea to be visualized; a headrest and cushion behind the shoulders or a shoulder roll facilitate the procedure
- Ensure that the shared airway is not compromised by either the surgeon or the anesthetist. Good communication between the anesthetist and surgeon is essential



Figure 6: Pediatric laryngoscope

- Select the appropriate laryngoscope (different sizes according to age) that allows ventilation via a side port (*Figure 6*)
- Once the larynx is visualized, anesthetize it with lignocaine sprayed onto the larynx (max dose: 4 mg/kg)
- With the laryngoscope correctly in place, thoroughly inspect the larynx, trachea and bronchi with a 4 mm 0° Hopkin’s rod looking specifically for concomitant pathology such as a laryngeal cleft, subglottic/tracheal stenosis or tracheal defects (present in up to 15% of patients)
- Then conduct a thorough inspection of larynx to confirm the diagnosis of laryngomalacia
- It is essential to assess vocal cord movement as well as cricoarytenoid mobility

Supraglottoplasty

Tracheostomy is reserved only for exceptional cases of severe laryngomalacia causing airway obstruction when supraglottoplasty is contraindicated.

The aim of surgery is to correct the anatomical cause with minimal tissue damage.

Cold steel technique is recommended. (Other instruments have been used including laser and microdebriders). An advantage of a cold steel technique is that it can be performed in the presence of an endotracheal tube which secures the airway and makes the anesthetic more manageable especially in the presence of severe gastroesophageal reflux or lung pathology. Furthermore, the required equipment is readily available in ENT units and there are no expensive consumables. The operating microscope allows the surgeon to use both hands when performing the supraglottic surgery.

After confirming the diagnosis, the following approach to treatment is implemented:

Laryngomalacia Type I (shortened aryepiglottic folds)

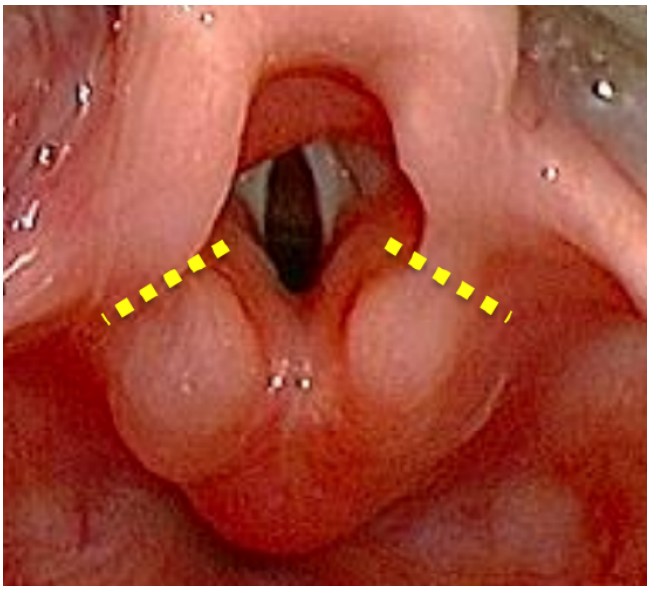


Figure 7: Short aryepiglottic folds; Yellow lines indicate where aryepiglottic cuts should be made



Figure 8: Endoscopic view illustrating improved supraglottic airway following cutting of shortened aryepiglottic folds

- Simple incision of the shortened aryepiglottic folds is the mainstay of treatment and has a success rate of 90% (*Figures 7, 8*)
- Apply adrenaline-soaked pledgets to the area to be incised with grasping forceps to provide tissue compression and diminish bleeding
- Tense the shortened aryepiglottic fold by grasping the mucosa at the back of the arytenoid and pulling it posteriorly
- Divide the shortened aryepiglottic fold with laryngeal microscissors down to the level of the false cord
- Control bleeding with adrenaline pledgets
- Repeat the procedure on the opposite side
- Some authors advocate excising a wedge, citing a slightly improved success rate

Laryngomalacia Type II (redundant supraglottic mucosa)

- Apply adrenaline-soaked pledgets to the area to be excised with grasping forceps to diminish bleeding
- Excise redundant mucosa using larynxgeal graspers and scissors
- Take care not to excise too much tissue
- It is very important to avoid traumatizing the mucosa on the medial surface of the arytenoid in order to prevent interarytenoid scarring and airway stenosis

Most cases are successfully treated by the above mentioned two procedures. Occasionally an ***epiglottopexy*** is required; this can be done using CO_2 laser to burn the base of the lingual surface of the epiglottis or by placing a suture between the lingual surface of the epiglottis and the tongue base.

Postoperative care

- Extubate and monitor overnight in a pediatric ICU or high care unit
- Adequate analgesia
- Humidified air
- As patients not uncommonly aspirate following supraglottoplasty, prescribe antireflux medication
- Dexamathasone is occasionally given to reduce postoperative swelling and edema

Contraindications to supraglottoplasty

- Underlying neurological condition
- Severe aspiration
- Abnormal vocal cord movement with aspiration

Complications

- Aspiration can be a major problem especially with neurological variants of laryngomalacia
- Persistent dyspnea, sleep apnea, and/ or failure to thrive
- Granulomas
- Edema

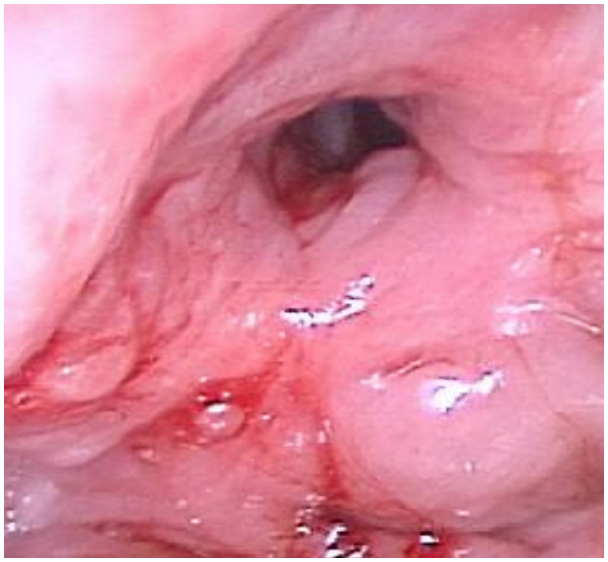


Figure 9: Severe supraglottic stenosis secondary to excessive lasering with supraglottic surgery

- Supraglottic scarring and fibrosis due to excessive removal of supraglottic tissues (*Figure 9*)

Complications are more frequent in children with associated congenital abnormalities; some surgeons recommend unilateral surgery in high risk cases to limit side effects. Most patients treated unilaterally have good outcomes although some patients do have to subsequently have a contralateral procedure done.

Important Tips

- Meticulous preparation and planning prior to surgery facilitates the procedure and minimizes complications
- Ensure correct patient positioning to achieve good surgical exposure
- Avoid excessive resection of supraglottic tissue
- Acid reflux disease control is important both pre- and postoperatively

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist

Addenbrooke's Hospital
Cambridge, United Kingdom
nico.jonas@gmail.com

Author

Graeme van der Meer MBChB MMed
Otolaryngologist
Netcare Settlers Hospital
Grahamstown, South Africa
graemevdm@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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TREATMENT OF EPISTAXIS IN CHILDREN

Simone Hadjisymeou, Nico Jonas

Epistaxis (bleeding from the nose) occurs commonly in children. They usually seek medical attention when it becomes a recurrent problem.

It can be classified by its anatomic location into anterior and posterior epistaxis; anterior epistaxis is far more common.

Etiology

- Idiopathic
- Traumatic: nose picking
- Coagulopathy e.g. hemophilia and von Willebrand's disease
- Juvenile nasopharyngeal angiofibroma (See chapter: Juvenile nasopharyngeal angiofibroma surgery)

Anatomy

The nose has a rich vascular supply with substantial contributions from arteries originating from both the internal (ICA) and the external (ECA) carotid arteries.

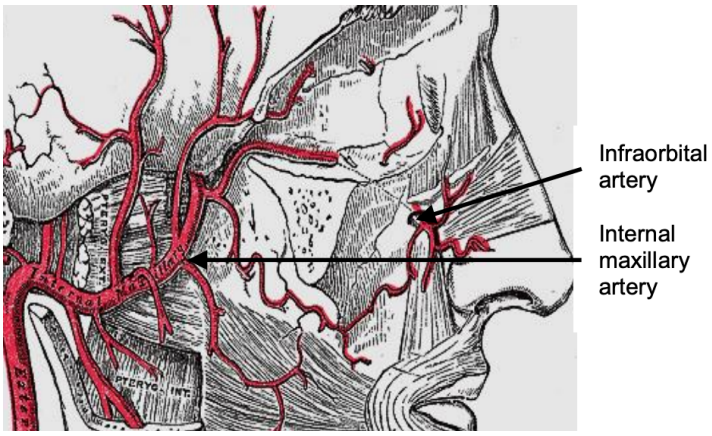


Figure 1: Internal maxillary artery entering pterygopalatine fossa through pterygomaxillary fissure (mandible removed)

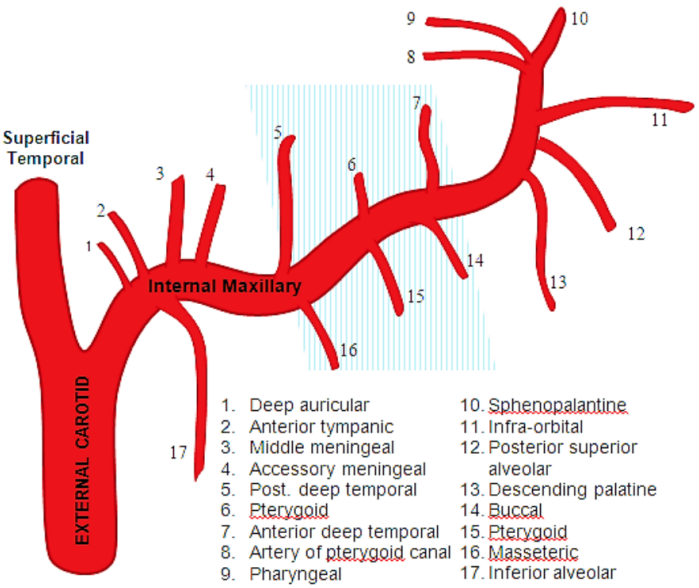


Figure 2: Branches of internal maxillary artery; blue shading denotes 2nd part of internal maxillary artery before it enters pterygopalatine fossa

The ECA system supplies blood to the nose via the facial and internal maxillary arteries. The superior labial artery is a terminal branch of the facial artery and contributes to the blood supply of the anterior nasal floor and anterior septum through its septal branch. The internal maxillary artery enters the pterygopalatine fossa where it divides into 6 branches: posterior superior alveolar, descending palatine, infraorbital, sphenopalatine, pterygoid canal, and pharyngeal (*Figures 1 & 2*). The descending palatine artery descends through the greater palatine canal and supplies the lateral nasal wall; a branch then returns to the nasal cavity via the incisive foramen to supply the anterior nasal septum. The sphenopalatine artery enters the nose near the posterior attachment of the middle turbinate to supply the lateral nasal wall; a branch also supplies the nasal septum.

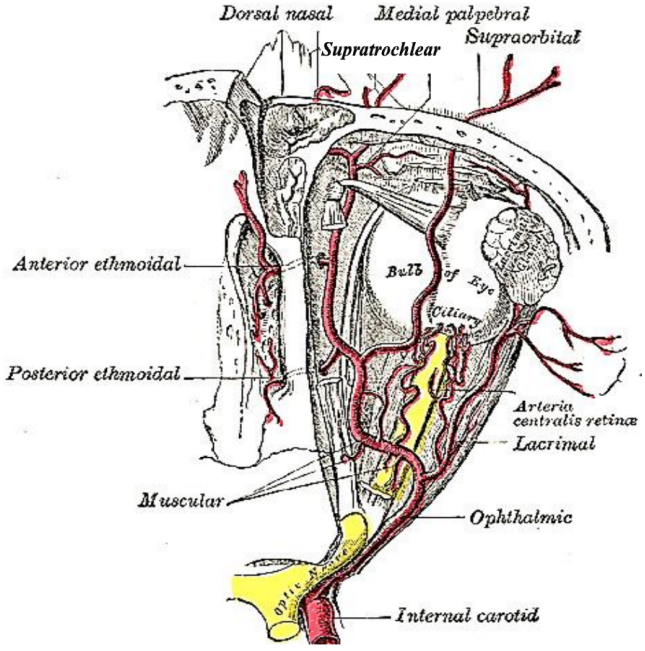


Figure 3: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries and the supratrochlear and supraorbital arteries

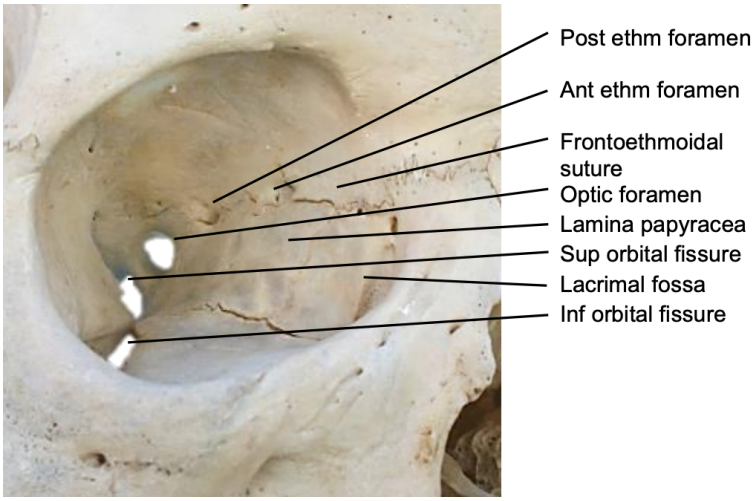


Figure 4: Right medial orbital wall illustrating the anterior and posterior ethmoidal foraminae

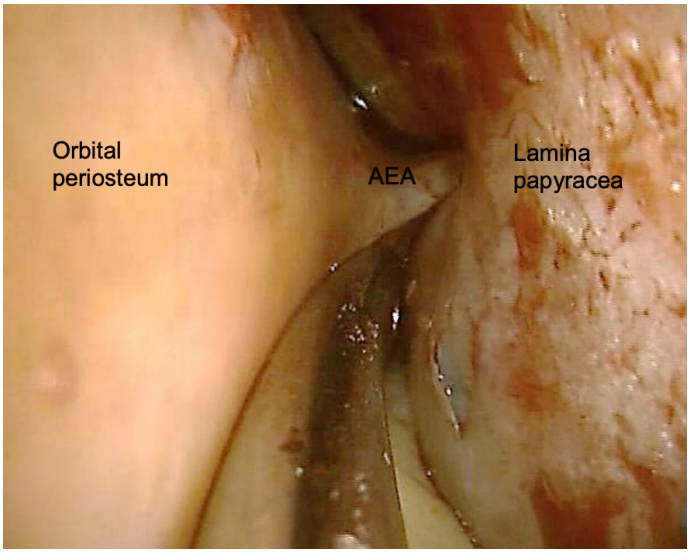


Figure 5: Anterior ethmoidal artery (AEA) exiting anterior ethmoidal foramen at level of frontoethmoidal suture line (right eye)

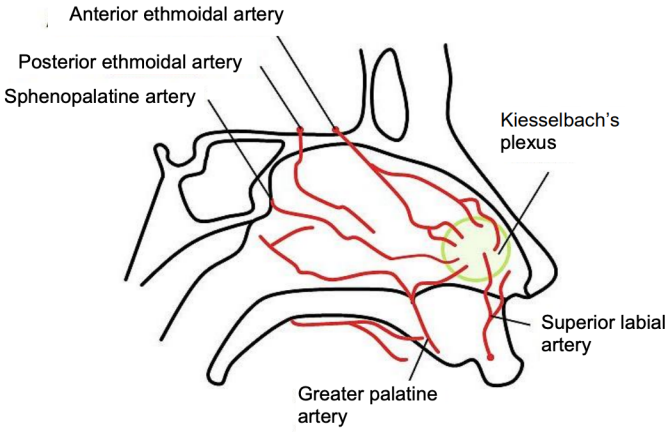


Figure 6: Arterial supply to nasal septum

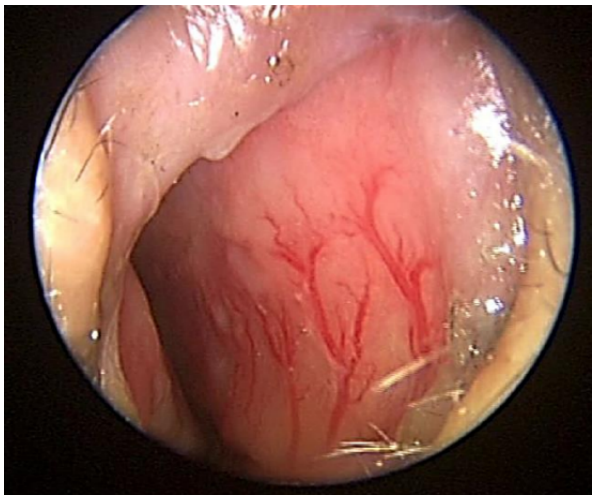


Figure 7: Prominent vessels located on the right anterior cartilaginous septum in Kiesselbach's plexus/Little's area

The ICA contributes through the ophthalmic artery which enters the bony orbit via the superior orbital fissure and divides into several branches (*Figure 3*). The posterior ethmoid artery exits the orbit through the posterior ethmoid foramen, located 2-9 mm anterior to the optic canal; the larger anterior ethmoid artery leaves the orbit through the anterior ethmoid foramen (*Figures 4, 5*). The anterior and posterior ethmoidal arteries cross the ethmoid roof to enter the anterior cranial fossa and then descend into the nasal cavity through the cribriform plate where they divide into lateral and septal branches to supply the lateral nasal wall and nasal septum (*Figure 3*). Kiesselbach's plexus or Little's area is located on the anterior cartilaginous nasal septum; it is an anastomotic network of vessels originating from both the ICA and the ECA (*Figures 6, 7*).

Assessment

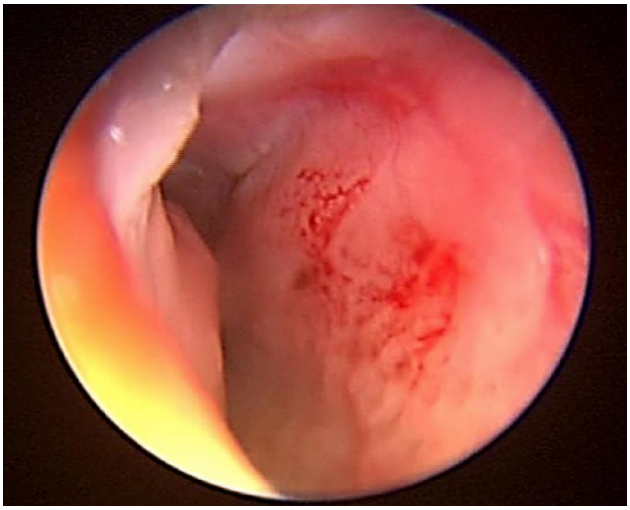


Figure 8: Ulceration of the right anterior nasal septum causing epistaxis

Anterior rhinoscopy usually reveals a bleeding point, prominent anterior septal vessels or ulceration (*Figure 8*). If a likely source of bleeding is not apparent, then nasendoscopy should be performed to exclude a posterior cause for the epistaxis.

First aid/Advice

While the nose is bleeding, sit the patient upright with the neck flexed and head forward. Pinch the anterior (soft) part of the nose between thumb and index finger for a few minutes to apply pressure to vessels in Little's area. Apply an ice pack to the forehead, to the bridge of the nose, or place a block of ice in the mouth to promote vasoconstriction and hence reduce blood flow to the nose[1, 2]. These measures stop most acute nosebleeds.

Cautery (chemical or electrocautery)



Figure 9: Headlight, local anesthetic / decongestant preparation, Thudicum nasal speculum, dressing forceps, cotton wool, silver nitrate cautery stick and antibiotic ointment

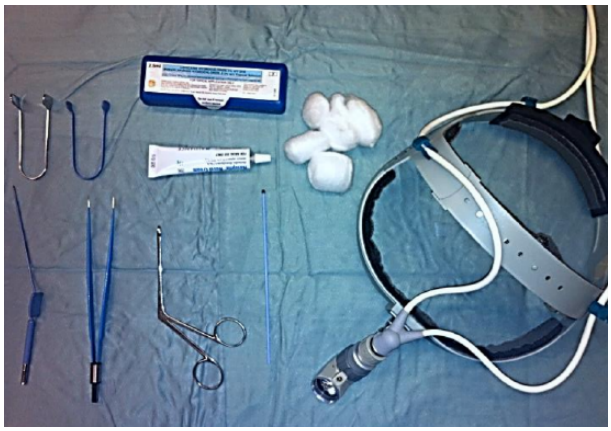


Figure 10: Headlight, local anesthetic / decongestant preparation, insulated and non-insulated nasal specula, insulated bipolar forceps, insulated monopolar needle, dressing forceps, cotton wool and antibiotic ointment

Anterior epistaxis originating from prominent vessels on the anterior septum can usually be controlled by applying antiseptic cream to the nasal vestibule, or by cauterization. The basic equipment required for nasal cautery with silver nitrate and for monopolar or bipolar electrocautery is outlined in *Figures 9 & 10*.

Chemical cautery



Figure 11: Silver nitrate sticks



Figure 12: Paraffin jelly has been applied to the upper lip to avoid a chemical burn and staining of the skin by silver nitrate

A cotton wool ball is soaked in a decongestant and local anesthetic and is placed in the anterior nasal cavity for 10 minutes. Cautery is done with a silver nitrate stick (*Figure 11*). When silver nitrate comes into contact with a wet surface it forms nitric acid which causes a chemical burn. Paraffin jelly is applied to the upper lip to prevent a chemical burn and staining from silver nitrate mixed with nasal mucus spills onto the upper lip (*Figure 12*).

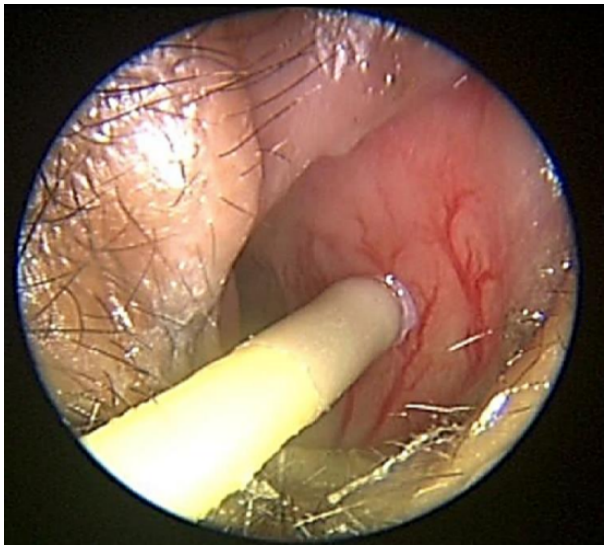


Figure 13: Cautery with silver nitrate to an anterior septal vessel

The patient is asked to blow and clear the nose. Initially cauterize the area surrounding the bleeding point to shrink vessels that supply it; then cauterize the bleeding point (*Figure 13*). Apply silver nitrate for 5-10 seconds to each location to avoid a deep burn which may cause necrosis and a septal perforation. The parent / caregiver is instructed to apply antibiotic cream to the cauterized area for a week following cauterization.

Electrocautery (Figure 14)



Figure 14: Cautery to anterior septal vessels using bipolar forceps

Bipolar or monopolar cautery may be used when chemical cautery fails to control anterior epistaxis on at least two occasions. It is generally done under general anesthesia in children.

Complications of cautery

These include nasal adhesions and septal perforation. Avoid cautery to opposing areas of the septum at the same sitting to reduce the chance of a septal perforation occurring. A chemical burn presenting as discoloration of the skin of the nasal vestibule and upper lip can persist for up to a week; hence the need to protect the skin by applying Vaseline to the upper lip.

Surgical intervention

This is considered if the former interventions fail to control anterior epistaxis, or with posterior epistaxis.

Examination of the nose under general anesthesia and electrocautery

- Prepare the nose with a topical decongestant and local anesthetic
- Examine the nose with a 4 mm Hopkin's rod or if not available, with a headlight and Killian's speculum
- Cauterize bleeding points with either an insulated monopolar needle or with bipolar forceps
- Occasionally cauterization cannot be performed or is unsuccessful and nasal packing must be inserted to control bleeding

Sphenopalatine artery ligation

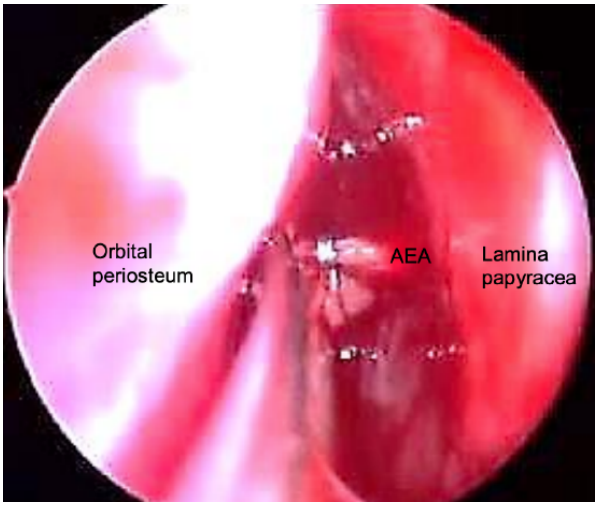


Figure 15: Liga clips being applied to the anterior ethmoidal artery (AEA)

If electrocautery fails to control the bleeding, the next step to consider is endoscopic sphenopalatine artery ligation. An incision is made in the middle meatal wall just anterior to the posterior attachment of the middle turbinate. A mucosal flap is carefully

elevated to identify the ethmoidal crest. The sphenopalatine artery is seen to enter the nasal cavity just posterior to the crest. The artery is clipped or cauterized using sphenopalatine bipolar forceps (*Figure 15*).

Other arterial ligations

Ethmoidal, internal maxillary or external carotid artery ligation is very rarely required in children (*Figure 15*). Internal maxillary and external carotid artery ligation have the added disadvantage that it precludes subsequent embolization should it be required.

Embolisation

Bleeding from the ECA system may be controlled with embolisation, either as a primary modality or when surgery has failed to control bleeding. Angiography is performed to check for the presence of unsafe communications between the ICA and ECA systems. Selective embolization of the internal maxillary artery and sometimes the facial artery may be performed. The most common reason for failure is continued bleeding from the ethmoid arteries.

Postoperative care

Employ measures to promote healing of the cauterized areas e.g. saline nasal spray and antiseptic nasal ointment.

Patient education

The following measures are advised during the 1st few days following cauterization

- Saline nasal spray
- Antiseptic nasal ointment
- Avoid blowing the nose hard
- Avoid digital nasal manipulation/picking the nose
- Avoid aspirin and non-steroidal anti-inflammatories (NSAIDs)

References

1. Porter MJ. A comparison between the effect of ice packs on the forehead and ice cubes in the mouth on nasal submucosal temperature. Rhinology. 1991; 29(1):11-5
2. Scheibe M, Wüstenberg EG, Hüttenbrink KB, Zahnert T, Hummel T. Studies on the effects of ice collars on nasal blood volume using optical rhinometry. Am J Rhinol. 2006; 20(4): 394-6

Authors

Simone Hadjisymeou MBBCh, BSc, MRCS (ENT)
ENT Registrar
Guys and St Thomas' Hospital
London, United Kingdom
simonehadji@gmail.com

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric ENT Consultant
Addenbrookes Hospital
Cambridge University Hospital NHS Foundation Trust
Cambridge, United Kingdom
nicojonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CHOANAL ATRESIA SURGERY

Neil Tan, Nico Jonas

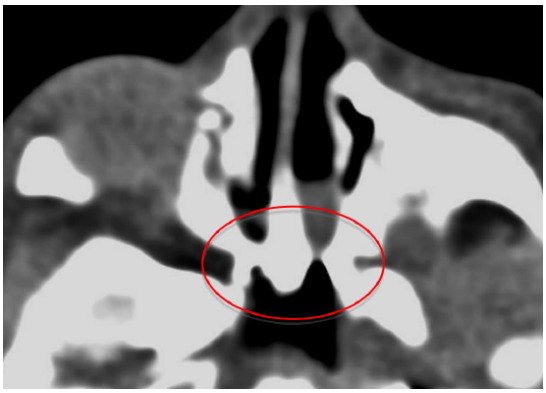


Figure 1: Axial CT demonstrating bilateral choanal atresia with left-sided mixed bony / membranous atresia and right-sided bony atresia

Choanal atresia is defined as a blockage of the posterior nasal openings. It is a rare condition and has an incidence of 1/7000 live births. It can be unilateral or bilateral. The blockage is purely bony in 30% of cases; in the remaining 70% it is a mixed bony and membranous obstruction (*Figure 1*). Complete total bony obstruction is extremely rare.

It is believed that membranous obstruction occurs due to failure of the bucconasal membrane to rupture sometime between the 5th and 6th weeks of foetal development. Bony obstruction occurs due to a combination of

- A narrow nasal cavity
- Medial thickening of the medial pterygoid plate
- Lateral thickening of the vomer

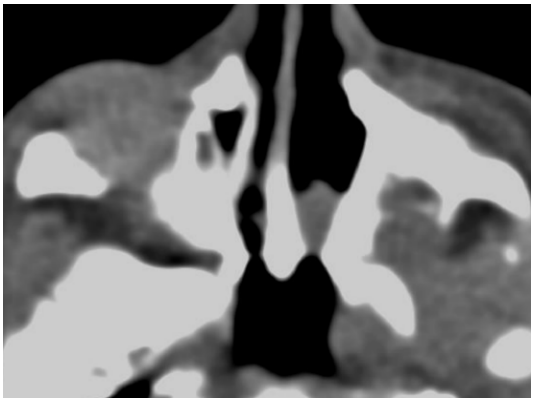


Figure 2: Axial CT scan demonstrating unilateral left-sided choanal atresia

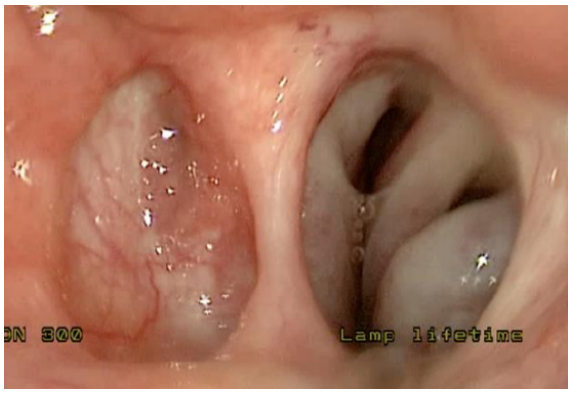
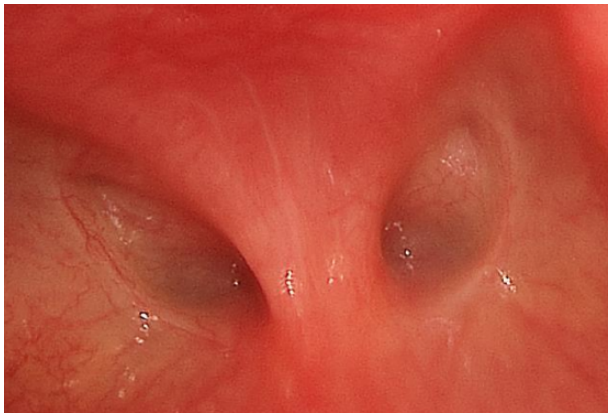


Figure 3: Retropalatal 700 endoscopic view demonstrating unilateral choanal atresia


Figure 4: Retropalatal endoscopic view demonstrating bilateral choanal atresia

Unilateral choanal atresia (*Figures 2, 3*) is most commonly an isolated problem. However 75% of bilateral cases (*Figure 4*) have associated syndromic or congenital abnormalities. These include CHARGE syndrome (coloboma, heart defects, choanal atresia, retardation of growth, genital abnormalities and ear abnormalities) and other syndromes that have associated craniofacial abnormalities such as Treacher Collins, Crouzon syndrome, velocardiofacial syndrome or craniosynostosis.

Differential diagnosis

The differential diagnosis of choanal atresia includes

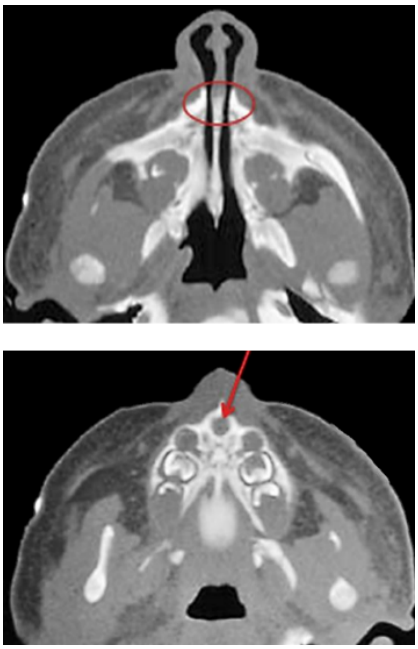


Figure 5: Axial CT scan in a patient with pyriform aperture stenosis and with a single central incisor (Red arrow)

- Nasal pyriform aperture stenosis (*Figure 5*)
- Deviated nasal septum
- Dislocated nasal septum
- Septal hematoma
- Neonatal rhinitis
- Mucosal swelling
- Turbinate hypertrophy
- Encephalocoele
- Nasal glioma
- Intranasal dermoid
- Chordoma
- Teratoma

Presentation

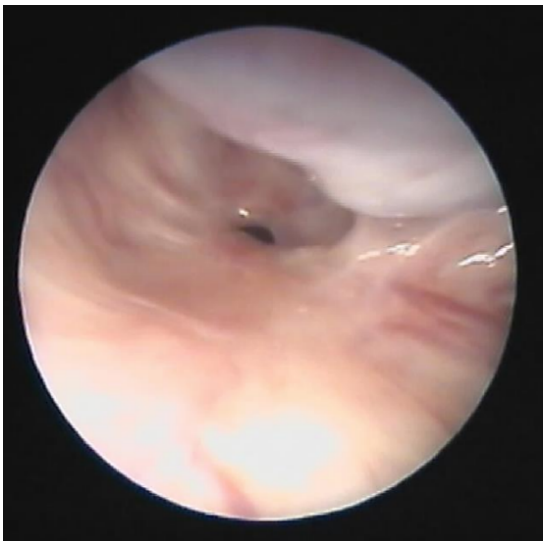


Figure 6: Previously undiagnosed membranous choanal stenosis in an adult

Unilateral choanal atresia may not present until later in life with complaints of a unilateral blocked nose or profuse unilateral nasal discharge (*Figure 6*).

On the contrary, ***bilateral choanal atresia presents as an acute emergency at birth*** as respiratory distress because newborns are obligate nasal breathers. A common feature of bilateral atresia is cyclical cyanosis whereby a newborn has respiratory distress with cyanotic episodes that improve on crying, and worsen on feeding.

Clinical evaluation

1. Two simple tests can be used to ***demonstrate airflow*** through the nose to exclude choanal atresia

- Movement of a thin piece of cotton wool held directly underneath the nares during inspiration and expiration
- A shiny metal tongue depressor held under the nares will reveal nasal misting in patients with patent nasal airways

2. ***Failure to pass an 8F (or smaller) suction catheter*** into the nasal cavity more than 5.5 cm from the alar rim can suggest the diagnosis

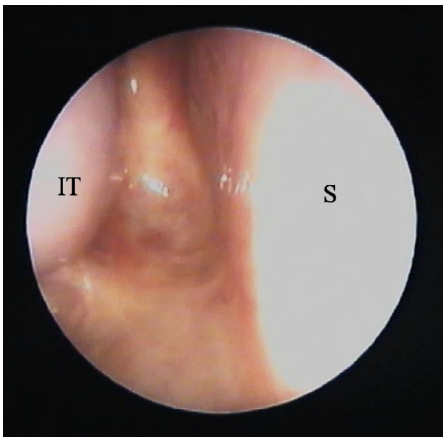


Figure 7: Transnasal endoscopic view of previously undiagnosed (R) unilateral choanal atresia in an adult (S = Septum; IT = inferior turbinate)

3. ***Direct visualization*** with a flexible nasendoscope after nasal suctioning will definitively diagnose the condition (*Figure 7*)

Radiological evaluation

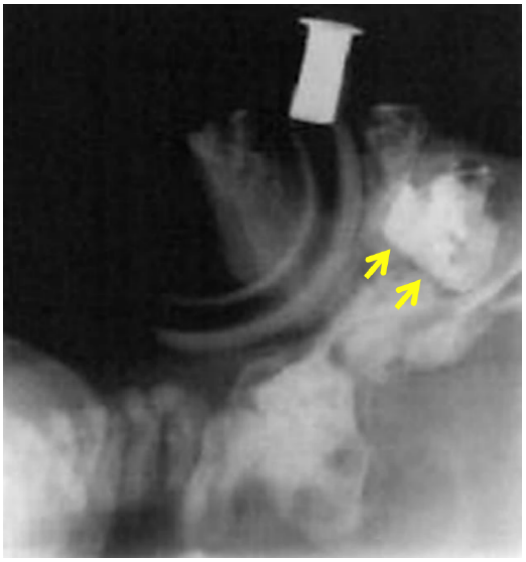


Figure 8: Lateral X-ray after filling the nose with radio-opaque dye demonstrates hold-up in the posterior nasal cavity (yellow arrows). Note oropharyngeal airway to maintain the airway

The diagnosis can be confirmed with a ***lateral skull X-ray*** after filling the nose with ***radiopaque dye*** and demonstrating hold-up of the dye in the posterior nasal cavity (*Figure 8*).

The atresia can be subclassified by ***CT scanning*** into bony or mixed bony membranous types (*Figure 1*). It is important to apply nasal decongestant (0.5% xylometazaline) 30 minutes prior to the CT scan and to suction the nose immediately before the CT scan to remove all nasal secretions in order to enable accurate radiological diagnosis.



Figure 9: Oral airway secured with tape

An ***oral airway*** is generally adequate to temporarily secure an airway in a newborn with bilateral choanal atresia and respiratory distress (*Figure 9*).



Figure 10: Standard dummy with the tip cut off



Figure 11: Guedel oropharyngeal airway

A ***McGovern nipple*** or a standard feeding ***bottle teat or dummy with the tip cut off*** (*Figure 10*) can also be used to facilitate oral breathing. In the short-term this has the effect of stenting the oral cavity open to allow mouth breathing; however it is not a long-term solution. Alternative options include a ***Guedel oropharyngeal airway*** (*Figure 11*). If an oral airway is not effective one has to proceed to ***endotracheal intubation***.

Feeding should be established via orogastric tube until surgical correction of the atresia is performed.

The patient should ideally be managed in a ***neonatal or pediatric intensive care*** unit with involvement of neonatologists, geneticists, pediatric ENT surgery and other specialties as required.

Timing of surgery

Surgery is urgently required for bilateral disease and symptomatic unilateral disease. Definitive surgery can often be delayed in patients with asymptomatic unilateral atresia. However, syndromic babies can have respiratory complications from unilateral atresia that require earlier surgery.

Preoperative Workup

All patients should undergo a full workup and evaluation once the airway has been secured, including for possible syndromic associations. The minimum investigations beyond the initial ***CT scan*** include ***ultrasonography of the cardiac and renal systems*** as well as ***ophthalmological*** and ***audiological*** assessment.

Genetic testing may be useful for patients with features of CHARGE syndrome; 67% are due to a recognized mutation in the chromodomain helicase DNA-binding protein-7 (CHD7) gene. The remainder are related to mutations in unrelated genes or other cytogenetic anomalies such as chromosome deletions.

Surgical management

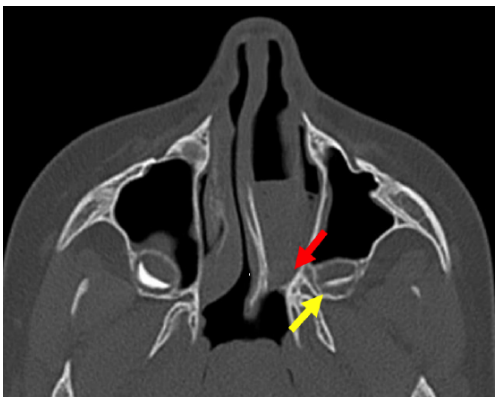


Figure 12: CT demonstrates need to thin the thickened vomer (red arrow) and widen the medialized medial pterygoid plate (yellow arrow)

The key to a successful outcome, regardless of surgical approach, is to create a large, 3-dimensional opening by a combination of (*Figure 12*)

1. Puncturing the membranous obstruction
2. Widening the medial bony thickening of the medial pterygoid plate
3. Thinning the thickened vomer

Traditionally the atresia was approached by transnasal / retropalatal, transseptal or transpalatal routes, but the last two are rarely used today. Transnasal punctures alone have high rates of restenosis.

Multiple procedures are often required to achieve a permanent opening in the posterior nares.

Retropalatal endoscopic approach

This endoscopic technique is currently favored by most pediatric otolaryngologists. The benefit of the retropalatal approach is that the newborn's nasal cavity is usually too small to accommodate both a 0° endoscope and a drill.

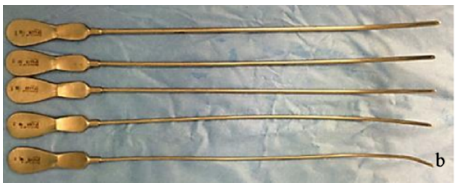
Transnasal instrumentation



Figure 13: 120 degree rigid endoscope

Visualization is achieved with a retropalatal 120° Hopkins rod (*Figure 13*).





Figures 14a, b: Urethral sounds used for initial perforation of the atresia



Figure 15: Powered drill (Choanal atresia bur)

Additional equipment includes curved urethral sounds and powered drills (*Figures 14*, *15*).

Surgical steps



Figure 16: Rae tube

- Surgery is done under general anesthesia with a downwards-facing Rae tube
- Tape the Rae tube to the lower lip in the midline as for a tonsillectomy
- Lay the patient supine with a shoulder roll in place
- Decongest the nose using 0.5% xylometazalone



Figure 17: Cleft palate / tonsil gag

- A cleft palate / tonsil gag is used to open the mouth and placed in suspension (*Figure 17*)
- Retract the soft palate
  - With unilateral atresia, insert a nasogastric tube on the unaffected side and pull it out of the mouth
  - With bilateral choanal atresia, place a suture in the soft palate to retract the palate until such time as a nasogastric tube can be inserted
- Insert the 120 degree rigid endoscope through the mouth and inspect the nasopharynx and the choanal atresia

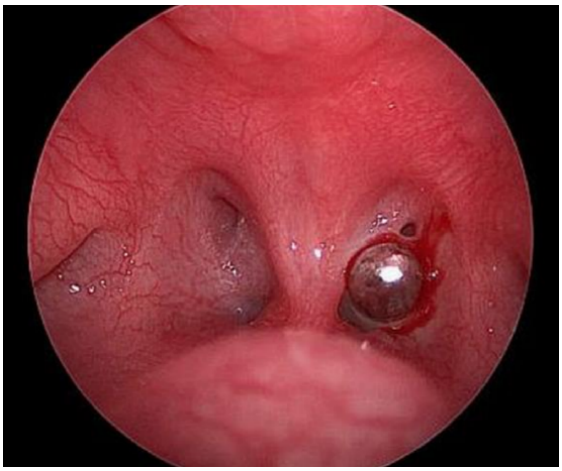


Figure 18: Transnasal puncture of membranous atresia with a urethral sound

- Insert a urethral sound into the nose and puncture the atretic plate under direct view with the 120 degree scope (*Figure 18*)
- The urethral sound may pass easily in a membranous obstruction or less easily in a purely bony atresia

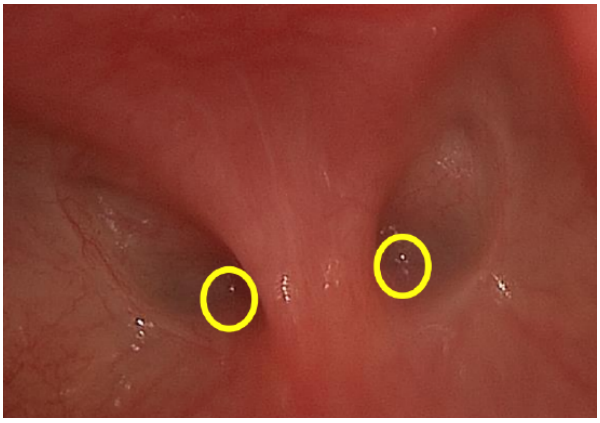


Figure 19: Junction of vomer and palate

- The most common position of the membranous section of an atresia is in the inferomedial corner at the junction of the vomer and the palate (*Figure 19*)
- Puncturing the atresia is however not sufficient to relieve the obstruction in the long-term, as rapid restenosis will occur without additional bone removal
- Insert the powered drill transnasally with a 4 mm choanal diamond burr



Figure 20: Bilaterally opened choanal atresias after laterally drilling the medial pterygoid plates; vomer intact

- Drill the medial pterygoid plate under direct vision taking care preserve as much mucosa as possible (*Figure 20*)
- If the vomer impinges on the choana, it can be resected
- If necessary a common posterior choanal opening can be created by removing the posterior few millimeters of the vomer

- Once again as much mucosa as possible is preserved in an attempt to leave as little exposed bone as possible at the end of the procedure
- Obtain hemostasis by using neurosurgical patties soaked in 1:10,000 adrenaline

To stent?

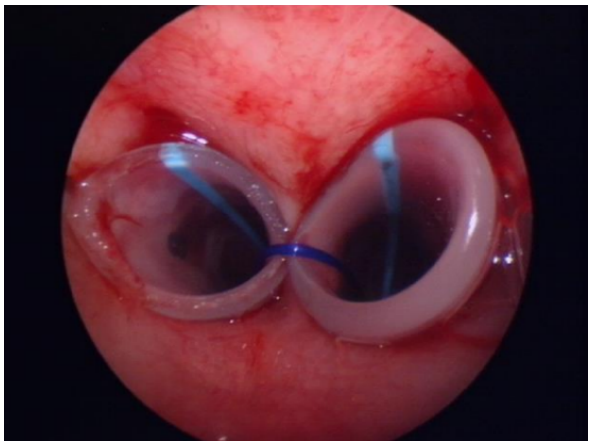


Figure 21: Retropalatal view of bilateral stents in position in the posterior choanae

Stents may be fashioned from cut endotracheal tubes, suction catheters, or custom made silicone stents can be used (*Figure 21*).

Traditionally almost all patients were stented. Currently stenting is however controversial as stents can cause granulations and scarring.

Stents are still preferred in very small babies that are surgically challenging. In such cases stenting preserves patency for the duration of the stent's placement and allows for weight gain to occur prior to revision surgery.

Mitomycin C

This is another contentious area with some evidence both for and against its use. It is believed to act topically to reduce mucosal restenosis by decreasing fibroblast mediated scarring.

Postoperative considerations

- After successful choanal atresia surgery the child should be extubated and can usually be managed on a general pediatric ward with regular nasal suctioning
- Oral feeding is established as soon as possible
- Postoperative nasal decongestant drops (0.5% xylometazalone) should be used for one week
- Saline and steroid drops should be used for 2 weeks to reduce postoperative inflammation and granulations

Alternative techniques

Transnasal drill-out with operating microscope

If the equipment required to perform a retropalatal endoscopic approach is not available, a standard operating microscope and a small bur can be used transnasally to open the stenosis. A standard ear speculum can be inserted in the nose after adequate decongestion and will allow for a view of the choanae with the use of a microscope.

Non-powered dilation techniques

If the above equipment is not available, transnasal opening and dilatation of the choanal atresia remains a viable and useful surgical option.

The safest way to achieve this is to use curved urethral sounds to perform an initial puncture of the membranous atresia followed by serial dilatation (*Figures 14, 18*).

- The surgical setup is identical, with the patient positioned supine with a shoulder roll in position, under general anesthetic with a down-facing Rae endotracheal tube
- Insert a cleft palate/tonsillectomy gag
- Retract the palate using the methods previously described

- A dental mirror and headlight can be used to obtain a view of the posterior choana in order to directly visualize the stenosis
- Prepare the nose with a decongestant
- Insert the smallest urethral sound with the curve pointing towards the floor of the nose and hug the septum to try and puncture the infero-medial corner of the choanal atresia (*Figure 18*). This avoids potential injury of the skull base during this "blind" procedure
- A finger can be placed on the soft palate or in the postnasal space to monitor when the atresia is punctured
- The opening can be further dilated by using serial urethral sounds until an adequate-sized stent (3.5 ET tube) can be passed





Figures 22a, b: Back-biting forceps used to remove bone from posterior septum

- Back-biting forceps introduced down the nose can be used to remove the posterior septum if necessary (*Figure 22*)

Author

Neil Tan FRCS, PhD
Pediatric ENT Registrar
Addenbrookes Hospital
Cambridge, United Kingdom
neil.tan@gmail.com

Author and Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric Otolaryngologist
Addenbrooke's Hospital
Cambridge, United Kingdom
nicojonas@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SURGERY FOR CONGENITAL NASAL PYRIFORM APERTURE STENOSIS (CNPAS)

John Wood, Graeme Van Der Meer



Figure 1: Axial CT demonstrates pyriform aperture stenosis (top) in contrast to bilateral choanal atresia (below)

Congenital nasal pyriform aperture stenosis (CNPAS) is a very rare condition of the newborn, in which the nasal pyriform aperture is narrowed by bony overgrowth of the nasal process of the maxilla (*Figure 1*). As the narrowest point of the nasal airway, a small change in its diameter may significantly increase nasal airway resistance. As infants are obligate nose breathers for the first three months of life (or longer if premature), such an increased airway resistance causes functional airway obstruction and respiratory distress.

While 1 in 5000 births has some form of congenital nasal airway obstruction, the majority is choanal atresia. The differential diagnosis includes nasal cavity masses, dacryocystocoeles, severe septal deviations and CNPAS.

Embryology

The palate develops from 3 structures: the primary palate that forms the hard palate anterior to the incisive fossa; and 2 lateral plates from outgrowths of the maxillary prominences. CNPAS can be explained by a deficiency of the fused medial nasal prominence, with subsequent faulty development of a small triangular primary palate, often abnormal incisors, and a narrow nasal cavity. During the 8 th week of gestation, maxillary ossification commences from the growth centers above the canine teeth. It has been suggested that over-ossification of the nasal process of the maxilla may be responsible, or it may be due to hypoplastic growth of the primary palate, suggesting that a local dysostosis of the maxilla with bony overgrowth is the abnormality, rather than “failed recanalization” of the nasal cavity.

Associated midline abnormalities can also occur, and may even be considered a minor form of holoprosencephaly (a spectrum of defects or malformations of the brain and face in which the forebrain fails to develop into 2 hemispheres). Abnormalities such as

microcephaly, hypoplasia of the corpus callosum or olfactory bulbs can occur. Facial anomalies may include ocular abnormalities, hypotelorism and dental anomalies. Most serious is the occurrence of pituitary dysfunction, which occurs in 15 to 25% of patients. After initial blood testing, clinical monitoring for at least 12 months is recommended, with poor or slowing growth at one year a positive predictor requiring further investigation.

Diagnosis

History and Examination

CNPAS presents like other causes of nasal airway obstruction with cyclical cyanosis, respiratory distress, feeding difficulties and failure to thrive. Failure to pass a nasogastric tube suggests choanal atresia or CNPAS, the difference being the level of obstruction. Obstruction within the 1st 1 cm is typical of CNPAS, while obstruction beyond 3 cm is more likely to signify choanal atresia. Bilateral choanal atresia is typically diagnosed very early, but the diagnosis of CNPAS may be delayed. Some craniofacial syndromes e.g. Crouzon syndrome may present with similar signs and symptoms, but have stenosis affecting the entire length of the nose. They are not amenable to surgical correction and a tracheostomy should be offered instead.

Examination of the nasal cavity with a nasendoscope should generate a high degree of suspicion, especially when unable to pass the scope into the nose. Examination of the oral cavity may reveal an absent frenulum of the upper lip and may indicate the presence of a solitary median maxillary central incisor (SMMCI) syndrome. As a manifestation of holoprosencephaly, it should prompt investigation of other midline abnormalities of the brain, cranial bones and maxilla. Consequently, failure to pass a 5 Fr catheter or 1.9mm endoscope through the anterior third of the nose should prompt further investigation.

Investigations

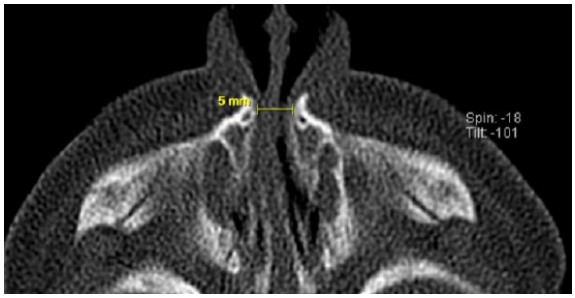


Figure 2: Axial CT scan demonstrating 5mm measurement of pyriform aperture stenosis

When CNPAS is suspected, a craniofacial CT scan with 2 mm slices will confirm the diagnosis. One study reported the average width of the pyriform aperture in CNPAS to be 8.5 mm, compared to 16.9 mm in a control group[1]. A pyriform aperture of >11 mm in a term infant is considered diagnostic of CNPAS (*Figures 1, 2*). This measurement however does not determine the need for surgical intervention, as this would depend on the clinical presentation.



Figure 3: Axial CT scan demonstrating solitary median maxillary central incisor



Figure 4: Median maxillary central incisor

Other radiological features should also be reviewed, including the presence of a midline bony ridge on the underside of the hard palate, and particularly the presence of a solitary median maxillary central incisor (*Figures 3, 4*). The presence of the latter is an indication for MRI scan and chromosomal analysis if available.

Management

Immediate



Figure 5: Oral airway secured with tape



Figure 6: Standard dummy with the tip cut off



Figure 7: Guedel oropharyngeal airway

The baby may present with varying degrees of respiratory distress. The patient should be admitted to a neonatal intensive care unit with continuous oxygen saturation monitoring. Significant distress may require an oral airway, as is used for newborns with bilateral choanal atresia (*Figure 5*). An oral airway is generally adequate to temporarily secure an airway. Other options include high flow oxygen administered via nasal prongs, a McGovern Nipple, a standard feeding bottle teat or dummy with the tip cut off (*Figure 6*), or a Guedel oropharyngeal airway (*Figure 7*).

Feeding can be established via an orogastric tube until nasal patency is achieved.

Neonatologists, geneticists, pediatric ENT and pediatricians should be consulted.

Conservative

Conservative management is the first line of treatment for CNPAS to allow the baby to grow beyond the 3 months' age of obligate nasal breathing and to potentially avoid surgery. Measures may include nasal irrigation with saline, nasal decongestants, short-term xylometazoline drops, or intranasal dexamethasone drops. Children that respond to conservative treatment should be closely monitored following discharge from hospital for apneic episodes, cyanosis, sleep disordered breathing, respiratory infections and poor growth.

Failed conservative management typically declares itself within the first 3 weeks of treatment. Such children require surgery by the end of the first month.

Indications for surgery

Surgery is indicated if conservative management fails. Indications for surgical intervention include

- apneic episodes
- cyanosis
- poor growth
- failure to thrive
- inability to wean from airway assistance

Predicting failure of conservative management is difficult. One study found a pyriform aperture measurement of <5.7 mm had an 88% sensitivity and specificity for predicting surgical intervention[2]. It is important to note that studies have suggested that there may often be no correlation with the circumference of the nasal inlet, emphasizing that every baby has a different ability to recover from airway obstruction.

Surgical options

A ***sublabial approach*** is most common used as it permits lateral drilling of the nasal process of the maxilla. This technique is described below. Postoperative nasal stenting is the norm, although the optimal duration for stenting is a matter of debate.

Balloon dilatation has also been used[3]. A 7 mm airway balloon is inflated to a pressure of 10 atmospheres for 5 minutes, with subsequent nasal stenting with a 14 Fr nasopharyngeal airway. This provided a satisfactory nasal airway at 1, 2 and 12 months without further procedures being required. Although only a case report, this technique may provide at worst a temporizing measure until further equipment and expertise is sought as required.

Surgical technique

- A sublabial approach is used
- The procedure is done under general anesthesia with the baby intubated transorally
- Secure the endotracheal tube in a position that allows good access to the oral cavity
- A head ring and shoulder roll can be used
- Drape to protect the eyes, leaving the nose, midface and mouth accessible
- Prepare the nose with neurosurgical pledgets soaked in nasal decongestant

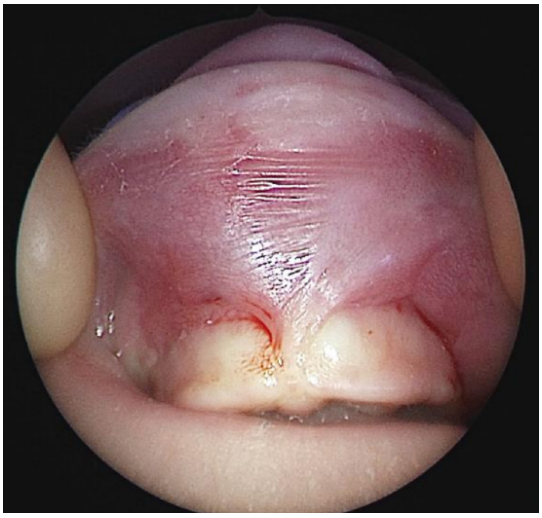


Figure 8: Blanching of alveolar mucosa following infiltration of local anesthetic

- Using a dental syringe, infiltrate local anesthetic (1% lidocaine with 1:100 000 adrenaline) into the upper gingival sulcus and pyriform aperture mucosa (*Figure 8*)

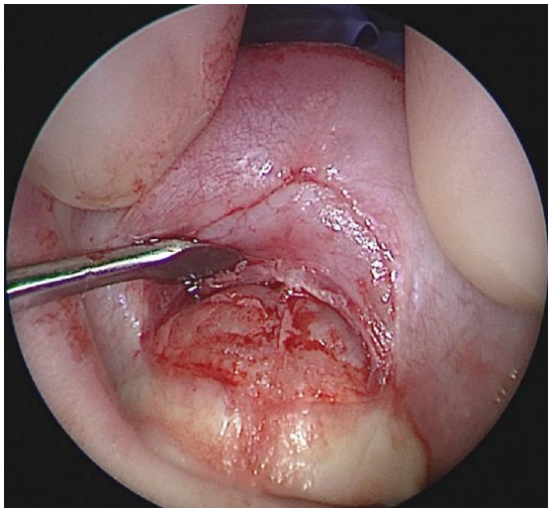


Figure 9: Sublabial incision and elevation of periosteum over maxilla with Cottle's elevator

- Make a 1.5 cm sublabial incision with a 15 blade down to bone, taking care not to damage the soft bone overlying the dental buds (*Figure 9*)

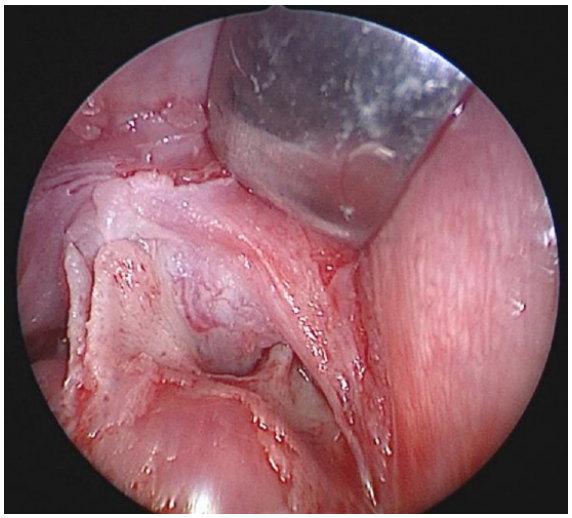


Figure 10: Identification of right pyriform aperture, the anterior nasal spine and the nasal process of the maxilla

- Dissect subperiosteally to expose the anterior nasal spine and the floor of each nostril, remaining anterior to the inferior turbinates to avoid injury to the nasolacrimal system (*Figures 9, 10*)

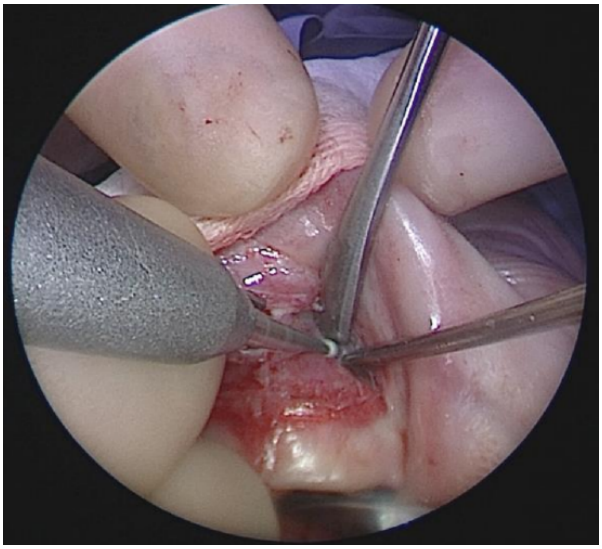


Figure 11: 2 mm coarse diamond drill used to remove bone from nasal process of maxilla

- Use a 2 mm coarse diamond drill to widen the pyriform aperture laterally (*Figure 11*)
- Avoid drilling inferiorly to avoid the tooth buds
- Use the CT scan as a guide and the inferior turbinate as a surgical landmark to obtain an optimal depth of drilling
- Continue drilling until the nasal cavity can accommodate a 3.5 endotracheal tube bilaterally
- Liston dilators can be used once the anterior drilling is complete

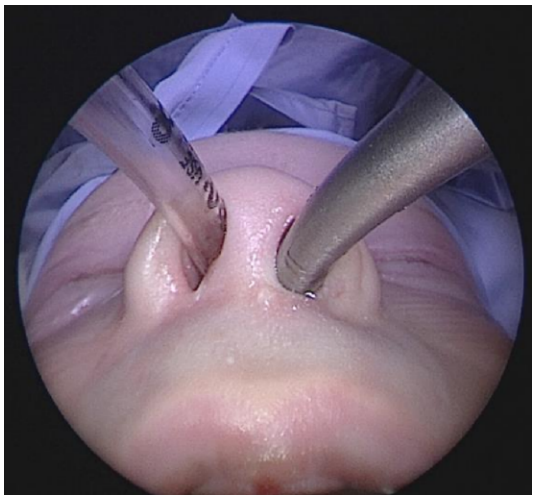
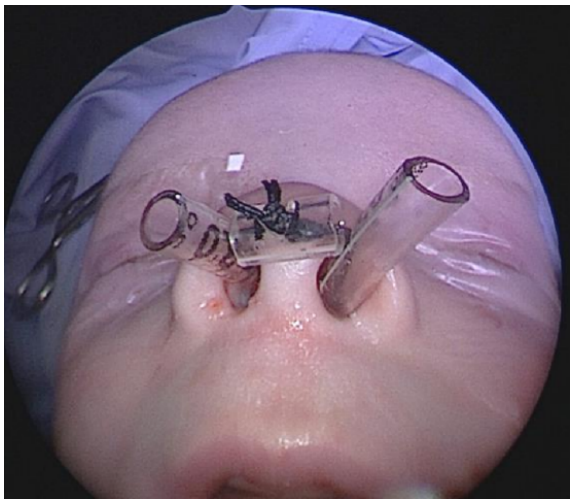


Figure 12: Endotracheal tube and Liston dilator (16 Fr) in opposing nostrils

- As in choanal atresia repair, while dilating it is important to keep a Liston dilator in the opposite nasal cavity to prevent the nasal septum from being displaced (*Figure 12*)
- Replace the nasal mucosa
- Some surgeons recommend making a releasing incision in the mucosa along the floor of the nose
- Create stents by trimming size 3.5 endotracheal tubes
- Insert each stent into the nose
- Ensure the tips of the stents are in the oropharynx just below the soft palate
- To prevent the stents becoming dislodged, a suture is passed between the tips of the tubes as follows:
  - Pass a small suction catheter down each tube so that the catheters protrude into the oropharynx
  - Grasp the ends of the catheters and advance them out of the mouth
  - Tie a single 3.0 silk suture to the end of each catheter
  - 
  - *Figure 13: Stent secured in each nasal cavity by a 3.0 silk suture looped around posterior end of the nasal septum*
  - Pull the catheters back along the endotracheal tubes and out of the nose, carrying the sutures with them (*Figure 13*)
  - This loops the 3.0 silk suture around posterior end of the nasal septum and secures the stents in each nasal cavity
  - It also obviates the need for posterior suturing of the tubes and allows for removal of the tubes in outpatients by simply cutting the anterior knot and pulling out the suture



- *Figure 14: Middle "bridge" formed from ETT to keep the stents from migrating and the suture from injuring the columella*
- Separate the anterior ends of the stents by using a piece of endotracheal tube as a bridge and passing the suture through small holes made in the sides of the stents (*Figure 14*)
- Trim the stents to facilitate feeding (especially if breastfeeding)
- It is important to measure the length of each stent to allow for accurate suctioning to maintain patency of the stents

- There is no consensus regarding the duration of stenting and varies from a few days to > 4 weeks. If removed too early, tissue dehiscence or restenosis may occur while longer durations are associated with a higher risk of pressure injury to the anterior nose and septum and formation of granulation tissue

Postoperative care

- Monitoring in an intensive care unit for 24-48 hours is recommended to ensure nasal airway patency
- Care of the stents is critical with regular irrigation with saline and suctioning to maintain patency
- Suctioning should be done to the ends of the tubes (measured) to ensure no trauma to the posterior pharyngeal wall occurs
- Use a suction catheter twice the size of the ETT e.g. 7 Fr catheter for a 3.5 ETT
- Once the stents have been removed, use nasal decongestants in conjunction with normal saline drops to minimize edema and crusting. Intranasal corticosteroids such as fluticasone can be used over the ensuing weeks

Complications

- Take care intraoperatively to prevent injury to the nasal mucosa, tooth buds, nasolacrimal ducts and inferior turbinates
- Inspect the nostril daily for signs of pressure areas from the stents
- Feeding difficulties are not uncommon, even with adequate nasal patency
- Restenosis of the pyriform aperture is not uncommon and should be checked for if symptoms recur

Long term follow-up

Long term care should involve a general pediatrician. Consider airway and feeding difficulties, particularly requiring hospital readmission. If signs of restenosis do occur and are symptomatic, then re-expansion may be required e.g. with a balloon or Liston dilator as it is mostly a soft tissue stenosis.

If pituitary deficiency has been noted, then long-term endocrinology follow-up is required.

References

1. Belden CJ, Mancuso AA, Schmalfuss I M. CT features of congenital nasal pyriform aperture stenosis: initial experience. Radiology 213, 1999; 495- 501
2. Wormald R, Hinton-Bayre A, Bumbak P et al. Congenital nasal pyriform aperture stenosis 5.7mm or less is associated with surgical intervention: A pooled case series. Int J Ped Otorhinolaryngol. 2015;79(11) 1802-5
3. Gungor AA, Reiersen DA. Balloon dilatation for congenital nasal piriform aperture stenosis (CNPAS): a novel conservative technique. Am J Otolaryngol. 2014; 35(3) 439-42

Authors

John Wood FRACS, MBBS, MSurg, BSocSci (Hons) BA(Hons)
Pediatric ORL Fellow
Starship Children's Health
Grafton, Auckland, New Zealand
drjmwood@gmail.com

Graeme Van Der Meer
MBChB MMed (ENT)
Pediatric ORL Consultant
Starship Children's Health
Grafton, Auckland, New Zealand
graemevdm@gmail.com

Pediatric Section Editor

Nico Jonas MBChB, FCORL, MMed
Pediatric ENT Consultant
Addenbrookes Hospital
Cambridge University Hospital NHS
Foundation Trust
Cambridge, United Kingdom
nicojonas@gmail.com

Editor

Johan Fagan MBChB, FCORL, MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CLEFT LIP AND PALATE SURGICAL TECHNIQUES: INTRODUCTION AND PHILOSOPHY

Kurt Butow and Roger Zwahlen

Facial cleft deformity comprises cleft lip and palate deformities, as well as clefts of facial structures not associated with a cleft lip or palate.

Cleft surgery requires a comprehensive knowledge of function (speech, occlusion, nasal airflow, middle ear function and facial muscles) and aesthetics, including racial specific features. The surgery comprises almost all types of cranio-maxillofacial and oral surgical interventions and involves both soft tissue (always 3-dimensional), and hard tissue (2- and 3-dimensional) corrective surgery. Appropriate treatment should be done at the best point in time i.e. neonatal period, toddler stage and childhood or during adolescence.

Multidisciplinary care

Optimal treatment can only be achieved in a multidisciplinary setting in which various specialties evaluate, examine, diagnose and treat patients according to treatment protocols. Patients, together with their parents/ caregivers, are reviewed yearly or two-yearly by all the multidisciplinary clinic specialties and disciplines e.g. during their birthday week. A multidisciplinary team typically comprises the following:

- Surgeon
- Orthodontist
- Speech and language pathologist
- Audiologist
- Pediatrician
- Community nurses
- Clinical psychologist
- Medical geneticist
- Pedodontist
- Oral hygienist
- Prosthodontist

Community nurses are the most important members of the clinic.

Surgeons should be able to treat every surgical aspect from childhood to adulthood, and should be familiar with primary, secondary and tertiary reconstructive procedures of facial soft tissue, facial hard tissue, and intraoral soft and hard tissue defects. Therefore, cleft surgeons need to be comprehensively trained in all aspects of cleft surgery and care, and be competent in primary, secondary and tertiary cleft treatment. Surgeons should be familiar with treating children with jaw-orthognathic suction and drinking plates (jaw-orthopedic devices) and know basic pediatric treatment regimens.

Whereas the optimal treatment for facial cleft deformity can only be offered in a multidisciplinary cleft clinic, solitary cleft lip deformities may be treated successfully in a non-multidisciplinary environment. During long-term follow-up, however, unpredictable abnormal tooth eruption overlying the cleft side and secondary deformities may occur. Secondary reconstruction due to cleft lip scarring, as well as cleft rhinoplasty at around 14 years of age might become necessary. This indicates the necessity that even patients suffering from minimal variations of cleft deformities need to be followed up in multidisciplinary clinics during their growth period.

Charity and mission surgery

Children in developing countries represent the most facial cleft deformities. However, most children with facial cleft deformities do not have access to multidisciplinary care and advanced treatment. The only hope for such children is nationally or internationally sponsored charity or mission surgical organizations. Cleft lips are the most obvious correctable facial deformity, and constitute an

important part of aesthetic appearance, and affect patients' personalities. It is estimated that about 90% of charity or mission surgeries only do cleft lip repairs, and do not address palatal repair which is very important for speech development and feeding. Continuous follow-up and interventions for secondary reconstructions, speech pathology, orthodontic and prosthodontic treatment also rarely exist for these unfortunate patients. Despite these shortcomings, it is important that the poorest of the poor, which represent most cleft patients, receive at least some type of basic treatment, even if only a cleft lip repair, in order to be accepted in their communities.

Requirements for best results

- Surgical protocols for facial cleft deformities, the sequence of surgical interventions, avoidance of revision surgery in the growing face, and continuous follow-up for about 16 years
- Alignment of dento-alveolar arches and nasal ala molding, where possible, and columella stretch-molding in bilateral cleft lip
- Selecting surgical procedures that cause the least long-term growth disturbances of facial hard and soft tissues and avoid occlusal disturbances and midfacial growth deficiency
- Selecting surgical procedures that provide the best aesthetic appearance
- Selecting surgical procedures that provide optimal results for soft palate function in terms of feeding and speech and that reduce middle ear effusions for better hearing

Initial cleft management

- Pediatric examination
- Community nurse consultation, especially for airway and feeding issues
- Speech therapy consultation for parents (if required)
- Surgical consultation and introduction of custom-made surgical protocol
- Psychological support for parents
- Functional jaw-orthognathic treatment or primary jaw-orthodontics immediately after birth (if required)
- Genetic counseling for parents and investigation of family history

Tessier Classification of Clefts

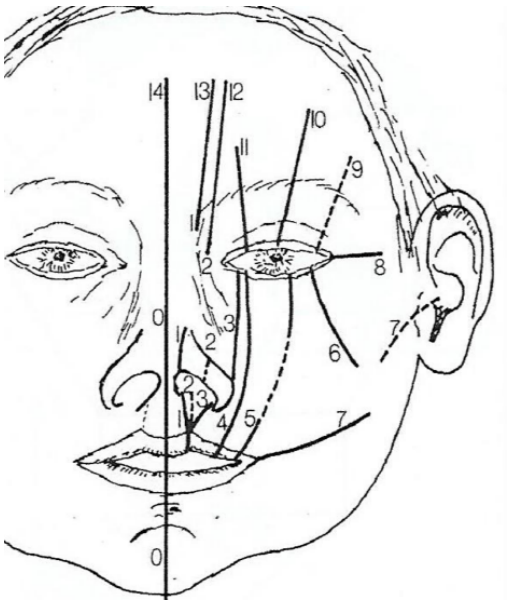


Figure 1: Tessier classification of cleft deformities

Figure 1 illustrates the Tessier classification of cleft deformities (1976) and is based on the anatomical position of the clefts.

The different types of ***Tessier clefts*** are numbered 0 to 14. These 15 different types of clefts can be put into 4 groups, based on their position: midline, paramedian, orbital and lateral clefts. The Tessier classification describes the clefts at soft tissue level as well as at bone level, because it appears that the soft tissue clefts can have a slightly different location on the face than the bony clefts.

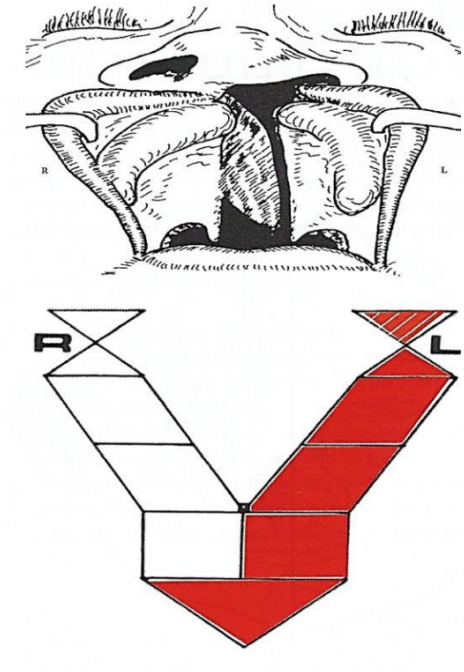
Midline clefts are Tessier number 0 ("median craniofacial dysplasia"), number 14 (frontonasal dysplasia), and number 30 ("lower midline facial cleft", also known as "median mandibular cleft"). These clefts bisect the face vertically through the midline. Tessier number 0 bisects the maxilla and the nose, Tessier number 14 comes between the nose and the frontal bone. The Tessier number 30

facial cleft is through the tongue, lower lip and mandible. The tongue may be absent, hypoplastic, bifid, or even duplicated. People with this condition may be tongue-tied.

Paramedian clefts are Tessier number 1, 2, 12 and 13. These clefts are quite similar to the midline clefts, but they are further away from the midline. Tessier number 1 and 2 both come through the maxilla and the nose, in which Tessier number 2 is further from the midline (lateral) than number 1. Tessier number 12 is in extent of number 2, positioned between nose and frontal bone, while Tessier number 13 is in extent of number 1, also running between nose and forehead. Both 12 and 13 runs between the midline and the orbit.

Orbital clefts are Tessier numbers 3, 4, 5, 9, 10 and 11 are orbital clefts. These clefts all involve the orbit. Tessier numbers 3, 4, and 5 are positioned through the maxilla and the orbital floor. Tessier numbers 9, 10 and 11 are positioned between the upper side of the orbit and the forehead or between the upper side of the orbit and the temple of the head. Like the other clefts, Tessier number 11 is in extent to number 3, number 10 is in extent to number 4 and number 9 is in extent to number 5.

Lateral clefts are positioned horizontally on the face. These are Tessier numbers 6, 7 and 8. Tessier number 6 runs from the orbit to the cheek bone. Tessier number 7 is positioned on the line between the corner of the mouth and the ear. A possible lateral cleft comes from the corner of the mouth towards the ear, which gives the impression that the mouth is bigger. It's also possible that the cleft begins at the ear and runs towards the mouth. Tessier number 8 runs from the outer corner of the eye towards the ear. The combination of a Tessier number 6-7-8 is seen in the Treacher Collins syndrome. Tessier number 7 is more related to hemifacial microsomia and number 8 is more related to Goldenhar syndrome.



R	Right side
L	Left side
Upper triangle	Nasal ala
Next triangle	Nasal floor
1st trapezius square	Lip
2nd trapezius square	Alveolus
Two squares	Hard palate
Lower triangle	Soft palate
Hatched	Partial
Filled	Complete

Example (shaded areas indicate cleft)

Left	CLAP
Left	Upper triangle deformed Nasal ala (subcutaneous)

Figure 2: Diagnostic key for cleft lip and palate

Figure 2 is a visual symbolic classification of cleft lip and palate cases. For documentation and classification purposes, clinical findings in cleft lip alveolus and palate patients are transferred into a "Y-scheme". It represents a quick visual guide both regarding

the anterior-posterior extension and regarding the distinction between partial and complete. The key in *Figure 2* explains the structure of the "Y-scheme" related to cleft extensions and its colouring related to cleft completeness.

Cleft lips can be classified as follows:

1. Micro-microform
2. Mini-microform
3. Microform
4. Minor-form
5. Total-/-Partial-incomplete (subcutaneous)
6. Total / Complete
7. Median facial dysgenesis

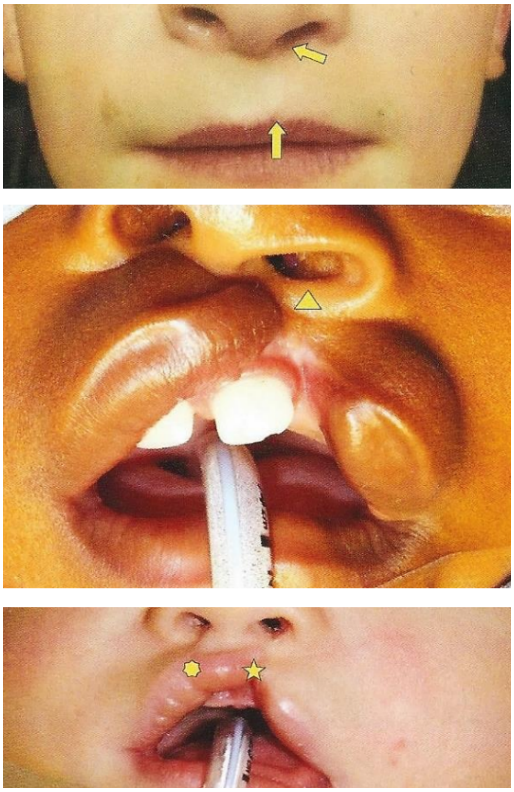
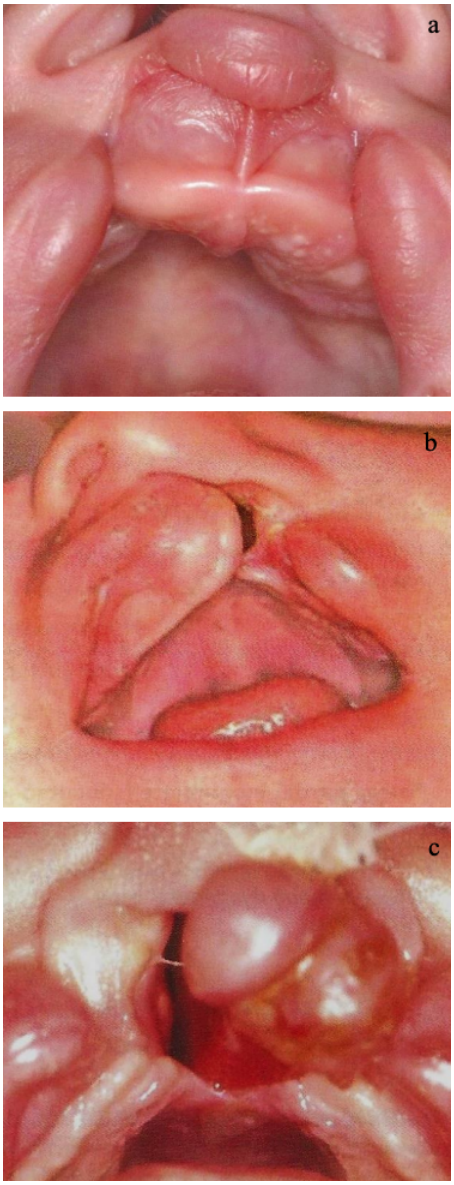


Figure 3a-c: Examples of types of cleft lips: Micro-microform ⇨; Mini-microform ✶; Minor-form ☆; Total / partial-incomplete (subcutaneous) △

Figure 3 illustrates examples of cleft lips (CL). The clinical picture of clefts may vary considerably, sometimes rendering their detection difficult. The pictures below highlight different cleft appearances, due to various degrees of cleft severity and its description under 1 to 7.

Clinical examples of cleft lips and palates

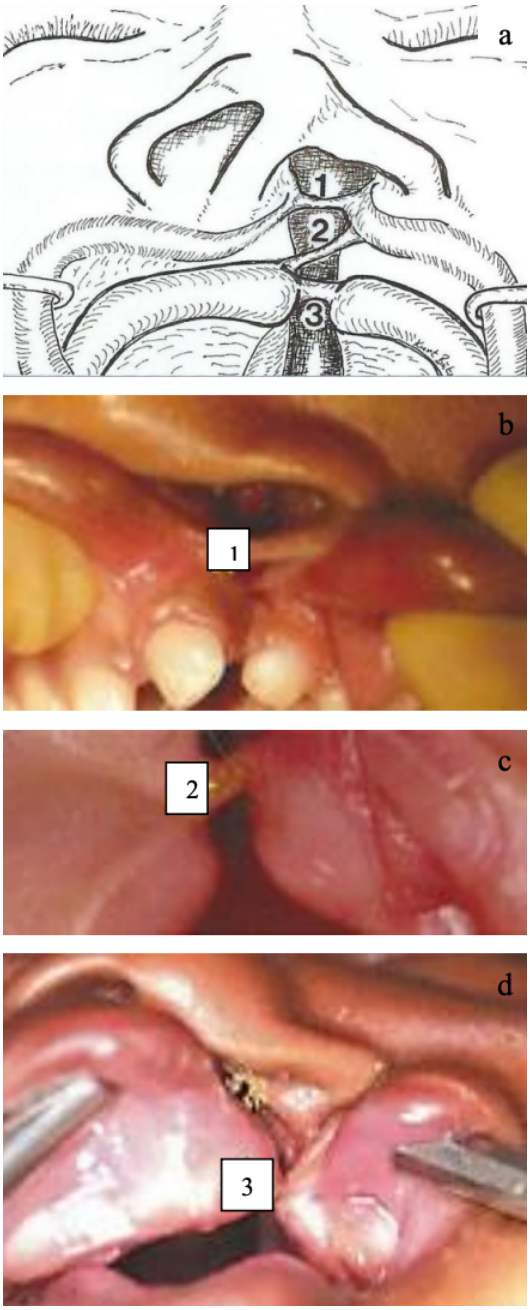
Cleft lip-alveolus (Figures 4a-c)



Figures 4a-c: Cleft lip-alveolus

The following three pictures show cases of cleft lip alveolus (abbreviated as CLA). No clefts can be found in the hard- and softpalate. *Figure 4a* depicts a bilateral atrophic cleft lip with a unilateral cleft alveolus, *Figure 4b* a wide left-sided cleft lip and cleft alveolus, and *Figure 4c* a very protrusive and rotated prolabium-premaxilla in a bilateral CLA.

Lip and/or alveolar bands

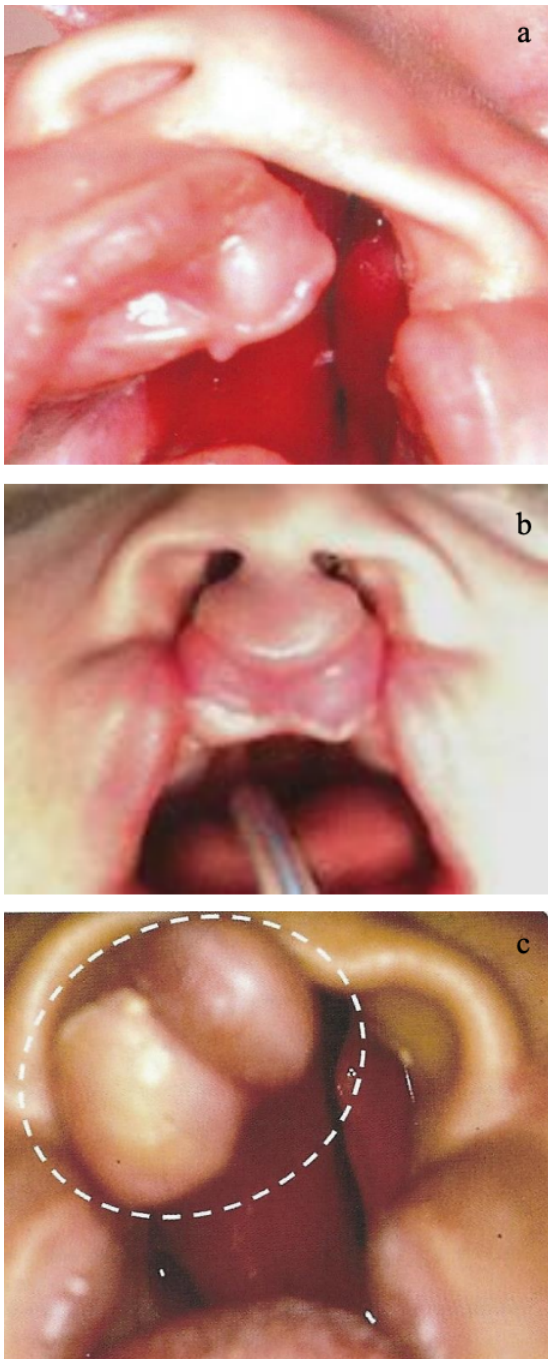


Figures 5a-d: Examples of lip-to-lip (Simonartz') bands (1), lip-to-alveolar bands (2), and alveolar-to-alveolar bands (3)

The scheme in *Figure 5a* highlights three different types of detectable soft tissue adhesions between lips and/or alveolar processes in cleft patients. *Figure 5b* represents the Simonart's Band, a lip to lip adhesion.

Figures 5c and 5d show clinical pictures of a lip to alveolus and an alveolus to alveolus adhesion, respectively.

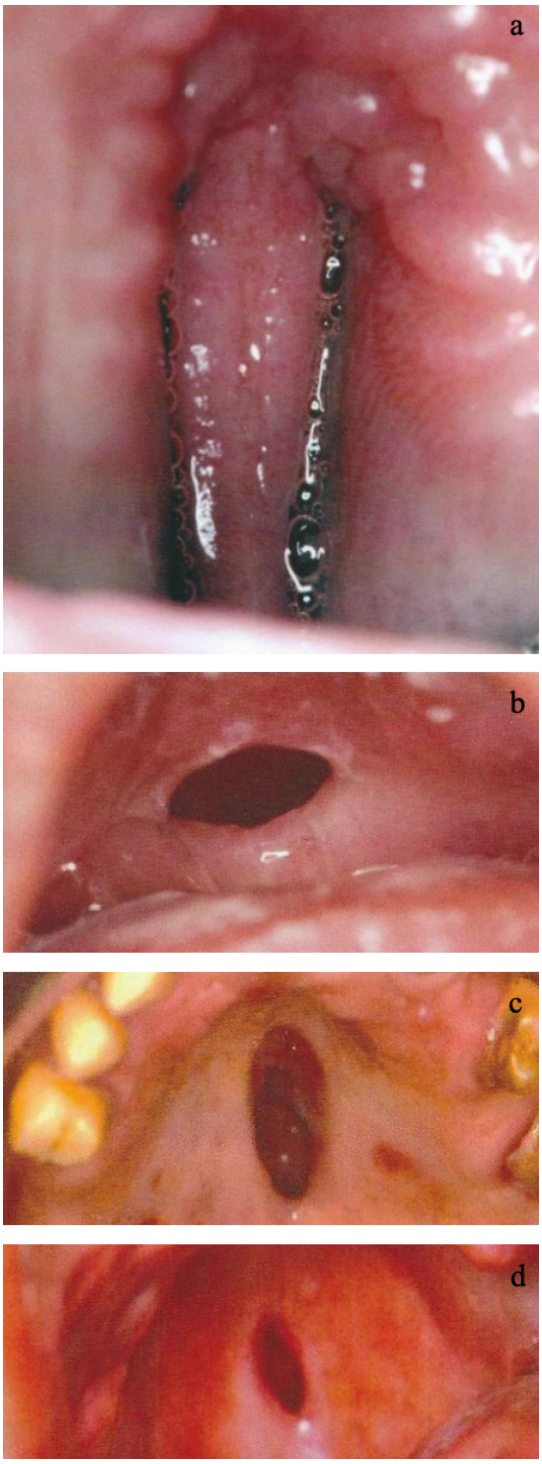
Cleft Lip-Alveolus and Palate (CLAP)



Figures 6a-c: Lip and/or alveolar bands

The following three pictures show cases of cleft lip-alveolus and palate (abbreviated as CLAP). *Figure 6a* depicts a left-sided unilateral complete CLAP. *Figures 6b and 6c* display cases with complete bilateral CLAP. Additionally, *Figure 6c* highlights a very much anteriorly displaced and laterally rotated prolabium-premaxilla (white dotted circle).

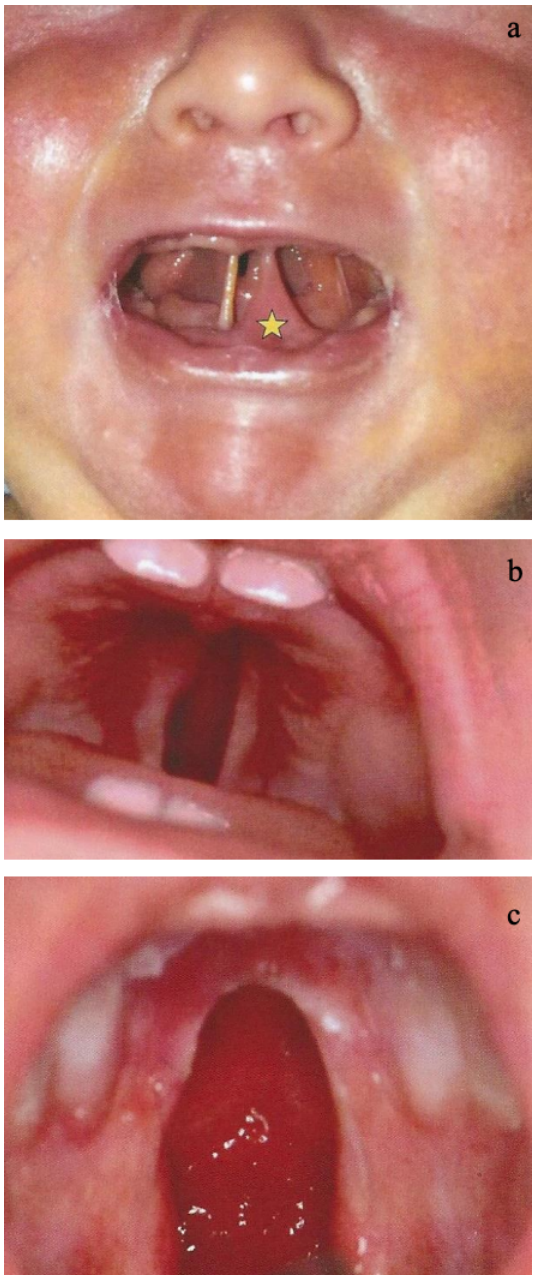
Hard palate (hP) clefts



Figures 7a-d: Hard palate (hP) clefts

Figures 7a-d show different extensions of isolated clefts of the hard palate. *Figure 7a* shows a full view of the nasal septum/ vomer.

Hard and soft palate (hPsP) clefts



Figures 8a-c: Hard and soft palate (hPsP) clefts (Synechia/oral band ☆)

Figures 8a-c demonstrate three different combined hard and soft palate clefts (abbreviated hPsP). *Figure 8a* additionally focuses on a specific soft tissue adhesion, a synechiae, between the alveolar process and the tongue. *Figures 8b and c* show various extensions of combined hPsP clefts.

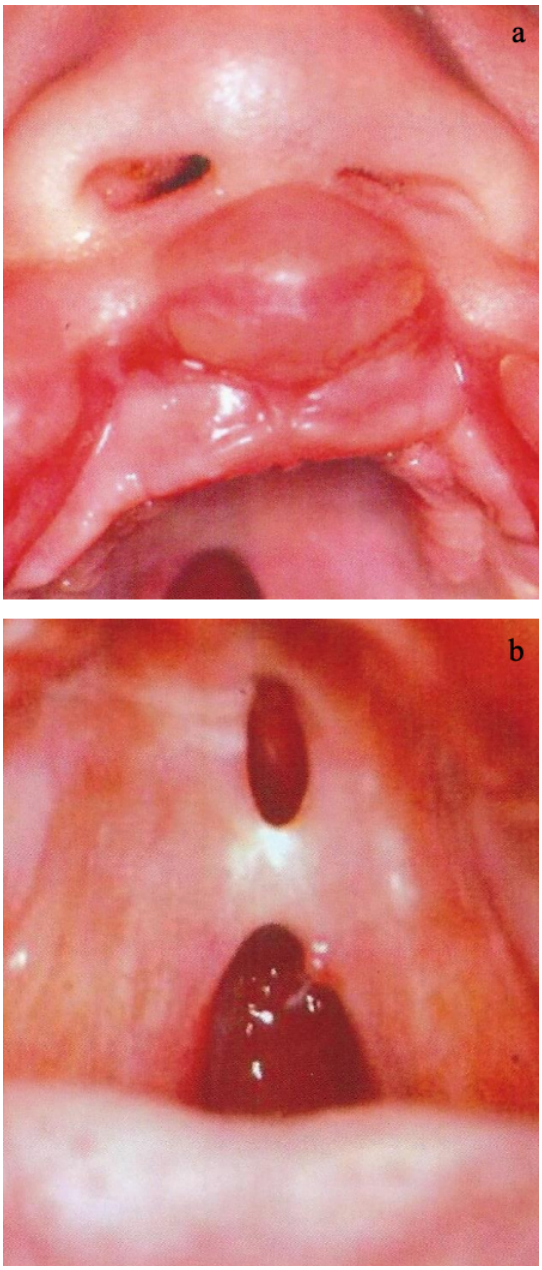
Soft palate (sP) clefts: Figures 9ab



Figures 9ab: Soft palate (sP) clefts

Figures 9a and b show soft palate clefts. As *Figure 9a* clearly shows a uvula on both sides of an asymmetric soft palate cleft, in *Figure 9b* the uvula is located entirely on the left side of the soft palate cleft.

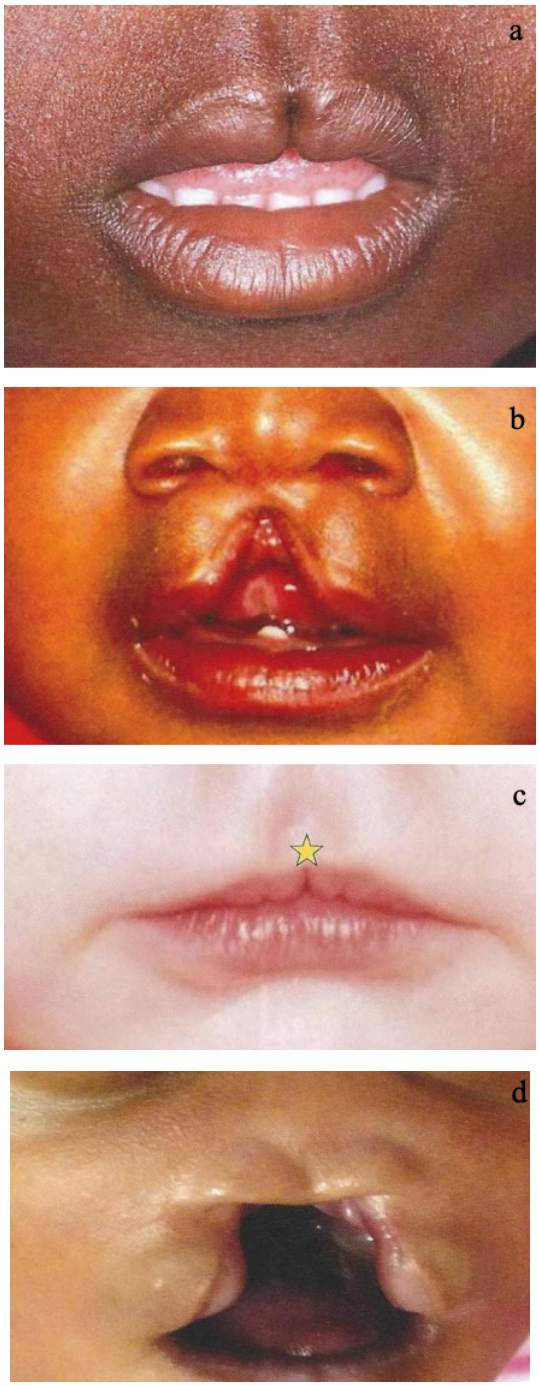
Combination of clefts (Combi) (Figures 10ab)



Figures 10ab: Combi clefts

Combi cleft cases may present with a cleft lip and cleft soft palate (CL+sP) without necessarily involving the alveolar bone and hard palate as a CLAP case.

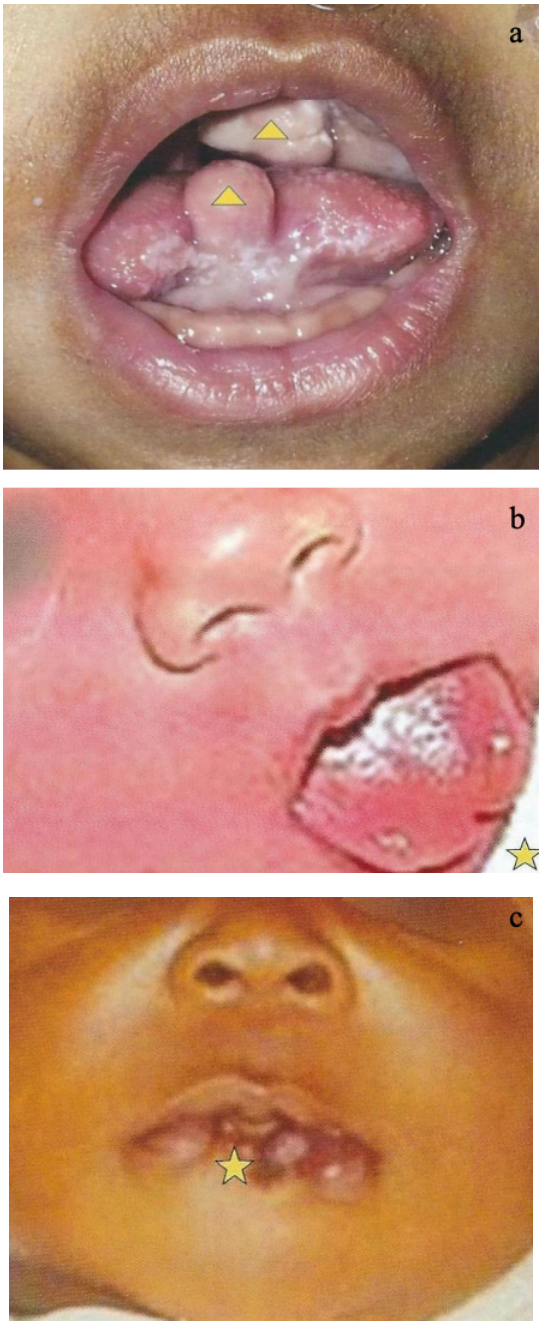
Median clefts (CL, CLA, CLAP)



Figures 11a-c: Median cleft – DeMyer II (a+c), DeMyer I (b+d) (d = holoprosencephaly)

Figures 11a-d highlight the vast variety of the clinical picture of median clefts. The anlage of various midline tissues might be missing, such as soft tissues like skin, muscle, but also alveolar and palatal bones. Whereas *Figures 11a & 11c* show a partial incomplete median cleft lip, a subcutaneous median cleft, respectively (DeMyer group II), *Figures 11b & 11d* demonstrate tissue deficiency due to a major non-anlage of midline structures (DeMyer group I).

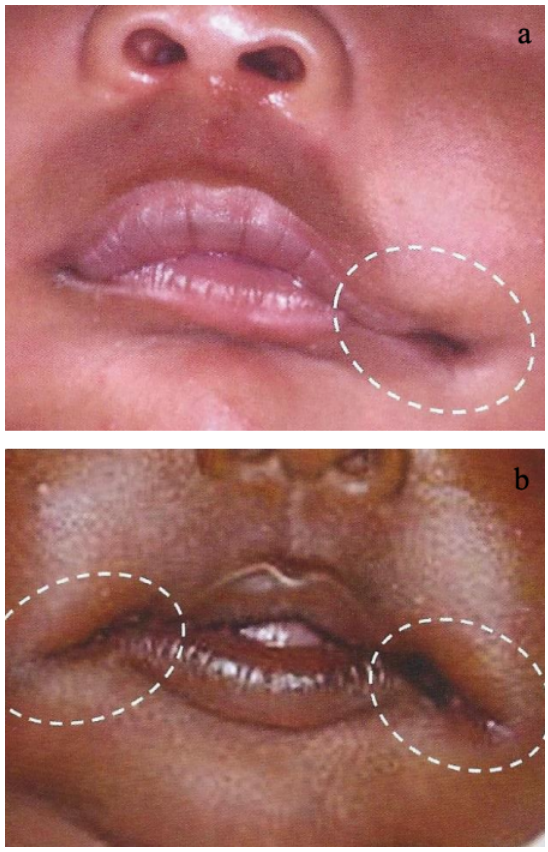
Median cleft (lower lip, tongue)



Figures 12a-c: Median clefts of tongue, palate and lower lip

Figures 12a-c highlight the vast clinical variety of median clefts. The anlage of various midline tissues might be involved, presenting clinical pictures such as cleft tongue with additional central tissue and the hard palate in *Figure 12a*, as minor median cleft tongue in *Figure 12b*, and as median incomplete lower cleft lip in *Figure 12c*.

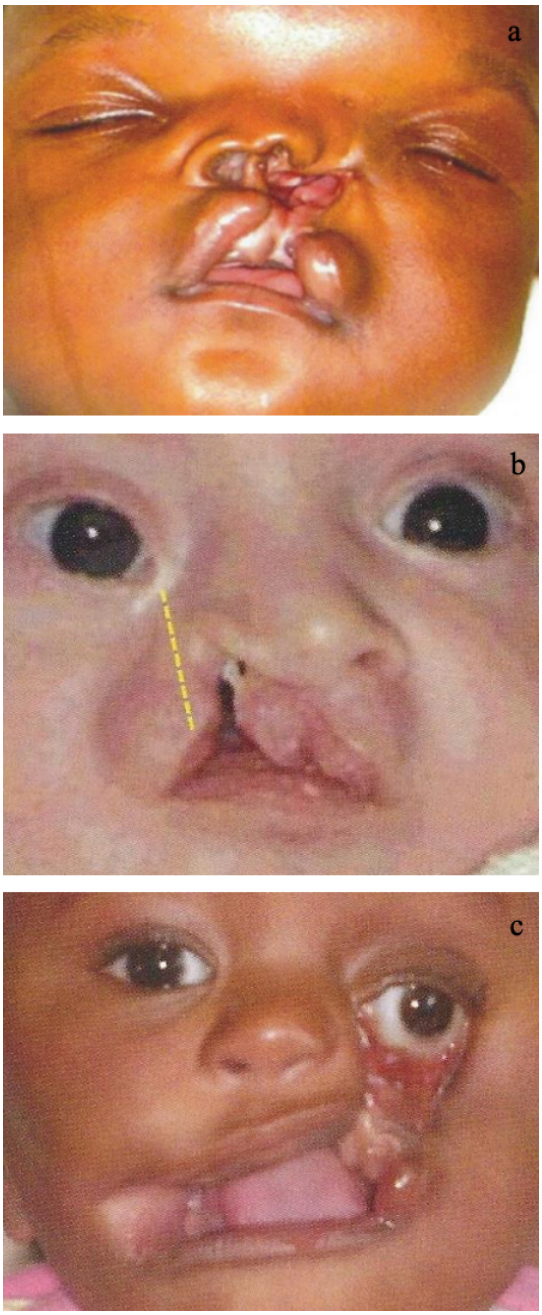
Lateral facial clefts = Tessier-7 cleft



Figures 13ab: Lateral clefts

Figure 13a displays a unilateral lateral facial cleft. A bilateral lateral facial cleft is shown in *Figure 13b*.

Oblique facial clefts (Figures 14a-c)



Figures 14a-c: Oblique facial clefts

Figures 14a-c show the clinical variety of oblique facial clefts, probably caused by amniotic bands during the intrauterine gestation (*Figure 1*). *Figure 14a* shows a left Tessier-3 cleft, *Figure 14b* Tessier-2 and Tessier-4 clefts on the right side, and *Figure 14c* a left Tessier-6 and a right Tessier-7 cleft.

Cleft Treatment Protocols from Neonate to Adult

Prior to initiation of treatment, a long-term strategy must be established: a so-called treatment/therapy protocol

1. General Treatment Protocol

Regular follow-ups

- Plate treatment for jaw-orthognathic or primary orthopedic reasons - 4 weekly
- Postoperative follow-up at week 2 and 8
- Annual follow-up during patient's birthday week (exception: for CL and sP, every 2 years, during patient's birthday week)

Other non-surgical specialists and involved disciplines

- Specialists e.g. orthodontist, community nurse, pediatrician and speech pathologist should attend every clinic
- If needed, attendance of other specialists, e.g. pedontist, prosthodontist and audiologist
- Others based on referral, such as anesthetist and pediatric neurologist

Pre-surgical examination

- Photographs
- Dental casts (if applicable)
- Blood tests (if applicable)

Non-surgical intervention

- Psychological support for parents with babies, for children and for adolescents

2. Nursing Protocol

Regular follow-up duties of community nurses

- Clinic management: arrange clinic times and patients' records, maintain photo-documentation, liaise with auxiliary disciplines related to social and family problems
- Check patients' attendance during normal and outside clinic hours, such as newborn consultation, appointments for plate manufacturing
- Help and support with feeding problems
- Organize preoperative visits of patients at their homes
- Advise re preoperative hospital admission and on inward period
- Call other hospitals to consult parents with newborn cleft babies
- Arrange surgical bookings for cleft babies
- Gather statistical data on new arrivals and on surgical interventions of cleft patients
- Reachable by phone for parents' nursing questions
- Involved in research

Pediatric nursing in surgical ward

- Implement pediatric nursing protocol re medication, nasogastric feeding, oral cavity cleaning, prevention of vomiting
- Assistance with suture removal

3. Pediatric pharmacological protocol

Medication and care

4. Surgical Protocol

a. Timing of surgery

Pathology	**Timing**
CL	5 mnths
CLA	5 mnths
sP (CLAP)	5 mnths
sPhP: Mirror-image protocol: hP closed before lip and ant nasal floor)	7 mnths
CLAP	7 mnths
Bilat CLA/CLAP: Columella lengthening	12 mnths
hPsP: Hard palate cleft	18 mnths
CLAP, hPsP, sP CLAP requires speech therapy	2-4 yrs
CLAP, hPsP, sP CLAP requires fluorography exam	4 yrs

CLAP, hPsP, sP: Velopharyngeal flap	4 yrs
CLA, CLAP: Secondary osteoplasty (Ideal age: 9 years, but this depends on completeness of orthodontic presurgical treatment)	9-13 yrs
Any cleft type: Orthognathic surgery	14-18 yrs
CL, CLA, CLAP: Revision cleft lip and/or cleft nose. The ideal age is around 14 years. However, it depends on eventual orthognathic surgical reconstruction of midface or mandible	14-18 yrs

Table 1: Timing of surgery: CL (Cleft lip); sP (Soft palate); hP (Hard palate), CLAP (Cleft lip, anterior nasal floor + hard palate)

b. Cleft surgery: Mirror Image Protocol

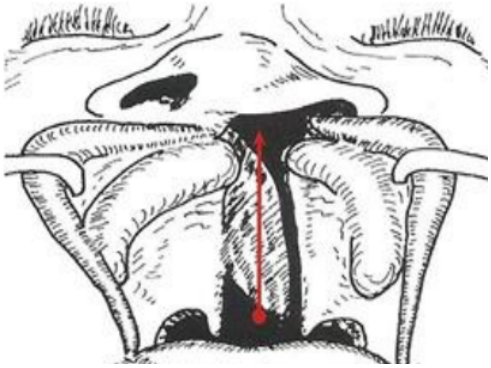


Figure 15: surgical protocol or "reverse" surgical protocol or “Principle: from inside to outside”

A "mirror-image" protocol (*Figure 15*) is used to completely close primary cleft lips and palates for the following reasons:

Watertight closure of the entire cleft can only be achieved by perfect closure of the lip, anterior nasal floor, area between the dentoalveolar arches, from the anterior nasal floor to the hard palate and from the hard palate to the soft palate, with the surgical closure starting with the soft palate and working towards the lip. On the contrary, primary closure of cleft lip preceding the hard palate cleft closure will always lead to an anterior or a buccal oronasal fistula.

Closure of the soft palate should be considered between 5 and 7 months of age, as the phonetic age of babies begins around this time.

Closure of the hard palate should be done after the soft palate closure. This avoids babies experiencing compromised breathing during the recovery period. During the reconstructed soft pal-ate healing period, the hard palate is still open toward the nasal cavity i.e. breathing is not restricted. This is of utmost importance particularly in combined hard and soft palate clefts and especially in patients suffering from a FairbairnRobin triad, a subdivision of a Pierre Robin sequence.

c. Reasons for a surgical protocol

1. Achieve optimal closure and avoid oronasal fistula

- Close from inside-to-out-side
- Use mirror-image protocol

2. Use best predictable surgical techniques for complete closure (*Table 2*)

	Surgical techniques
sP	Intravelar veloplasty with tensor stitch to activate Eustachian tube Sommerlad's levator & palatoglossopharyngeal muscle repositioning and reconstruction, and an Ivanov's uvula reconstruction

hP	Inferior or caudally based vomer flap or Superior or cranially based vomer flap with Polylactic acid resorbable sheet to cover vertical triangular defect for maintaining the blood clot and to achieve flat palatal healing
CA	Anterior nasal floor flap in cranial part of cleft
CL	Anatomical lip-plasty [unilateral type] and a Broadbent's modification or NoordhoffTrott [bilateral] type technique

Table 2: Best predictable surgical techniques for complete closure

3. Achieve optimal speech development and occlusal function

4. Avoid midfacial growth disturbances (dysgnathia) by selecting the optimal primary surgical techniques

5. Avoid revision surgeries and excessive orthodontic treatment

Note about above surgical protocol

- These techniques are the authors' preferred techniques, based on research and clinical observations
- It helps to achieve complete closure using minimally invasive surgery, and to minimize long-term growth disturbances

Recommended online text

Authors

Professor Kurt-W Bütow MChD (MFO Surg), DrMedDent, PhD, DSc, FCMFOS, Maxillo-Facial Surgery; Fellowship in Cleft Facial Deformities
University of Pretoria Cleft Palate Deformities Clinic
Pretoria, South Africa
kurt@butow.co.za

Roger Zwahlen DipMedDent, DipMed, DrMed, DrMedDent, Private Docent
FMHMKG, FEBOMFS, FIBCSOMS
Specialist in Oral and Maxillofacial Surgery
Practice Verdeja
Fribourg, Switzerland
rozwahlen@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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3.16: Primary Presurgical Treatment for Cleft Nose, Lip, Dentoalveolar Arches and Palate

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CLEFT LIP AND PALATE SURGICAL TECHNIQUES: PRIMARY PRESURGICAL TREATMENT FOR CLEFT NOSE, LIP, DENTOALVEOLAR ARCHES & PALATE

Kurt Bütow and Roger Zwahlen

Functional jaw-orthognathic (FJO) suction and drinking plates are important elements in the management of cleft lip and palate (CLAP) deformities. They allow patients to eat and drink while awaiting surgical repair, and actively rotate smaller dentoalveolar segments prior to surgical intervention.

This chapter focuses on indications, contraindications, timing and methodology of functional jaw-orthognathic suction and drinking plates for patients with CLAP deformities.

Description and variations

Various devices are employed for primary treatment of cleft patients according to the type of cleft deformity:

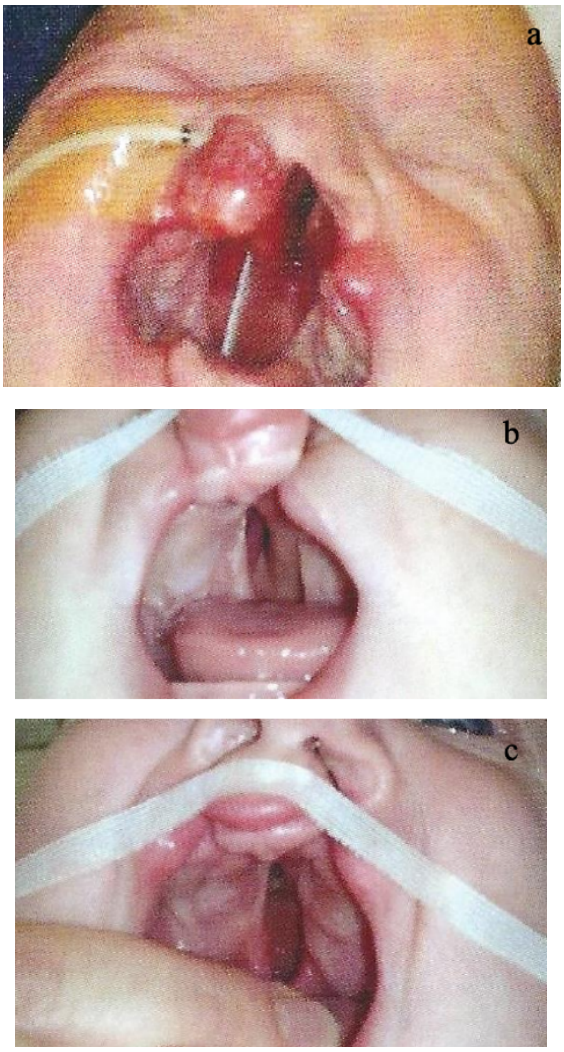


Figure 1: Lip bandage and FJO used to reposition the premaxilla with bilateral CLAP (a); at 2¾ months (b) at 5 months (c)



Figure 2a: Action of FJO

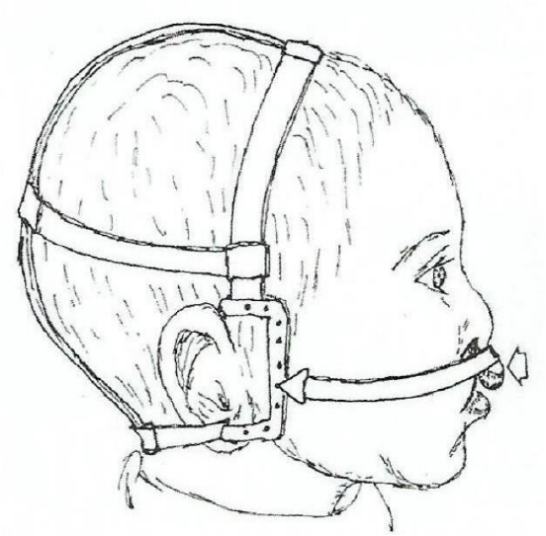


Figure 2b: Headgear for bilateral CLAP premaxilla repositioning

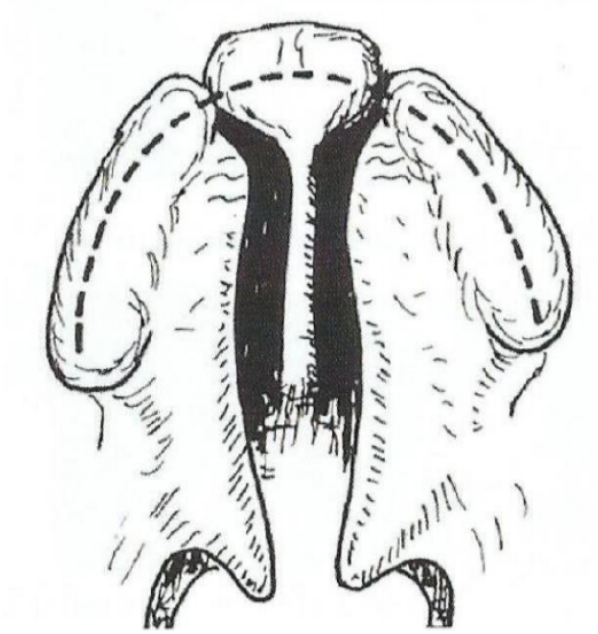


Figure 2c: Final reduction of CLAP prior to surgical intervention



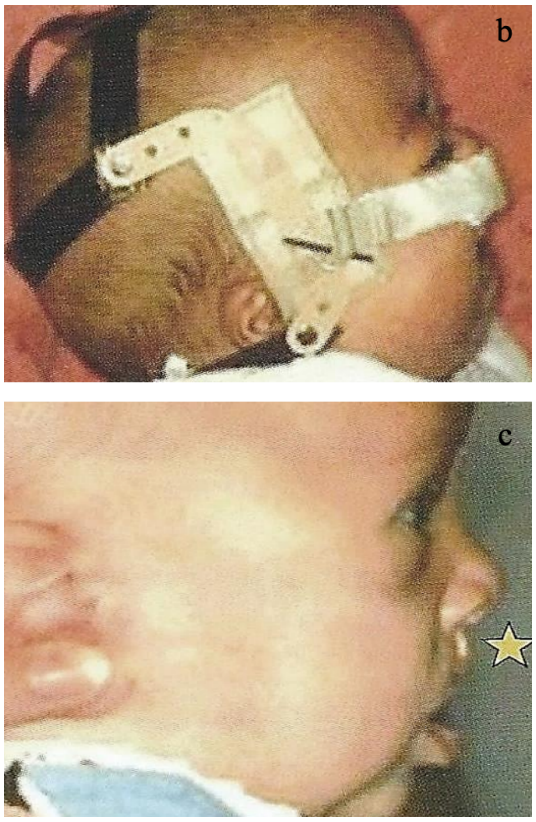
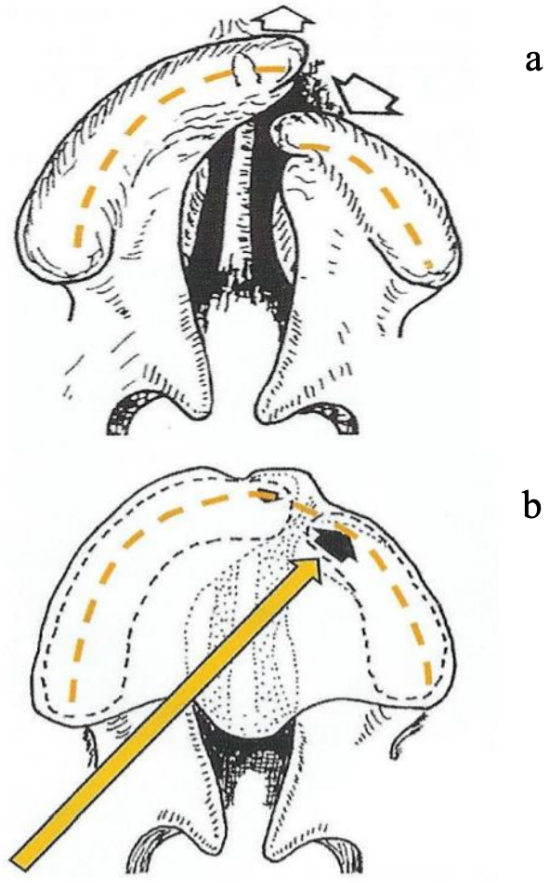


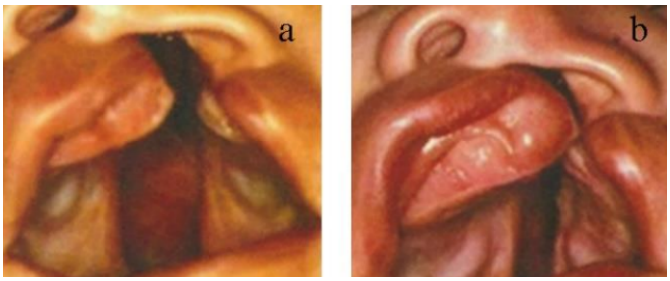
Figure 3: Protruded premaxilla-prolabium (a); headgear for bilateral CLAP premaxilla repositioning (b); result of conservative premaxilla repositioning achieved prior to surgery (c)



Figure 4: Example of orthopedic device (drinking plate)



Figures 5a,b: Functional jaw-orthognathic suction and drinking (FJO) plate



Figures 6a,b: Functional jaw-orthognathic movement after 5 months of treatment with a FJO



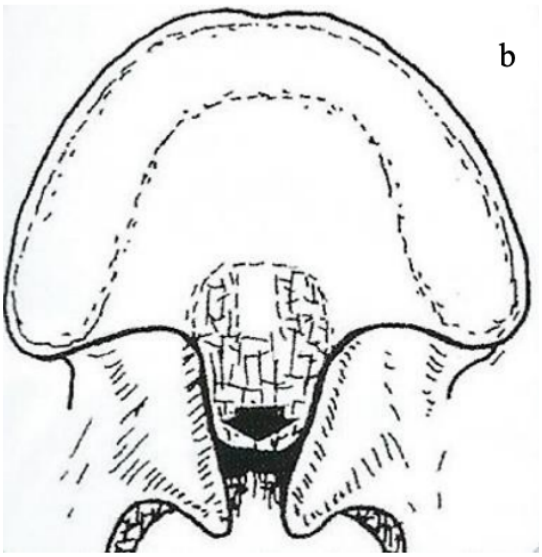


Figures 7ab: Example of an orthopedic devices (drinking plates) in situ



Figure 8: Suction and drinking plate (obturator with dorsal extension)







Figures 9a-c: Suction and drinking plate with posterior extension for hPsP cleft



Figure 10: Nasal alar cartilage molding achieved after initial repair of the soft palate, prior to repair of the hard palate, anterior nasal floor and lip

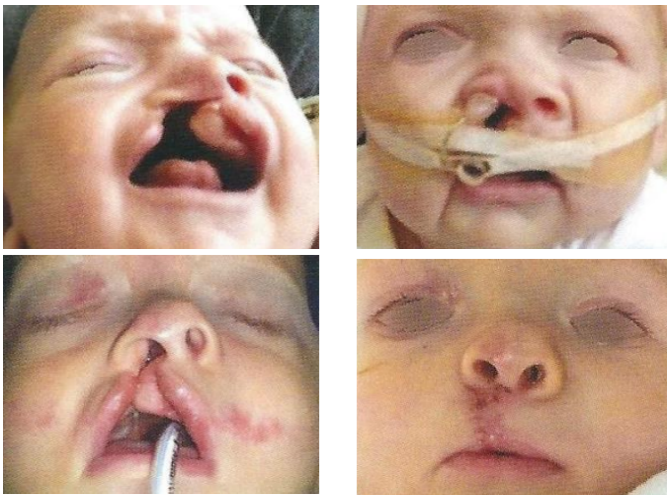


Figure 11: Improvement of cleft alar cartilage architecture following 5 months' alar cartilage moulding (NAM) and 6 days postoperative (Courtesy Dr Emad Ghabrial)

1. ***Lip bandage ("taping")*** to narrow a wide unilateral cleft lip deformity
2. ***Lip bandage ("taping")*** both to narrow a wide bilateral cleft lip deformity as well as to reposition a protrusive premaxilla in bilateral cleft lip-alveolus and bilateral cleft lip-alveolus-palate deformities (*Figures 1a-c*)
3. ***Headgear device*** to reposition a protrusive premaxilla in bilateral cleft lipalveolus and cleft lip-alveolus-palate deformities (*Figures 2*, *3*)
4. ***Functional jaw-orthognathic suction and drinking plate (FJO)*** (*Figure 4*) that further molds the displaced and rotated dentoalveolar arches (*Figures 5*, *6*). Moreover, this device, like an obturator in tumor surgery, separates the nasal from the oral cavity in uni- and bilateral cleft lip-alveolus-palate deformities, allowing sucking, drinking and breathing
5. ***Suction and drinking plate (Bolton plate)*** for patients with clefts at the hardsoft palate. These plates may be manufactured with or without additional dorsal extension to serve for breathing as an anti-apnoea device as well as an obturator for suction and drinking (*Figures 7*, *8*, *9*)
6. ***Nasal alar molding (NAM 1) and nasal alveolar molding (NAM 2) devices***
    1. ***NAM 1*** to improve the deformed alar cartilage pre-surgically that often presents with an anti-convex deformity at the cleft side. Additionally, this device can be used to continuously mold the alar cartilage during the post-surgical healing phase (*Figure 10*)
    2. ***NAM 2*** to improve the deformed alar cartilage, to mold displaced and rotated dentoalveolar arches, being further useful as an obturator for suction, drinking and breathing (*Figure 11*)

Indications

In neonates with any type of cleft lip, alveolus or palatal deformity, primary treatment immediately after birth is of paramount importance to ensure:

1. ***Breathing*** by separating the oral cavity from the nasal cavity
2. ***Feeding*** to thrive and gain weight during the pre-surgical period
3. ***Molding*** displaced-rotated dentoalveolar arches to facilitate planned surgical procedures
4. ***Posterior positioning*** of a protrusive premaxilla with bilateral cleft lip-alveolus and cleft lip-alveolus-palate, and to ease the tension of reunited muscle and soft tissue during surgery
5. ***Narrowing*** unilateral and bilateral cleft lip width by presurgical lip bandaging ("taping") for easier cleft lip reconstruction and a more pleasing outcome
6. Nasal alar molding on the cleft side to achieve a more acceptable aesthetic result of the nasal ala and the anterior nasal passage on the cleft side both in the short and long term

Contraindications

Only a few contraindications exist regarding appliances used for primary treatment:

1. ***Skin rash*** due to taping of lip bandages
2. ***Parents' compliance***: Parents must be committed to clean the devises daily to avoid infection and pressure sores

3. Patients with isolated cleft soft palates only very seldom ***tolerate*** an obturator plate
4. In patients with Pierre Robin sequence who present with a hard-soft cleft palate, the Bolton plate with its dorsal extension ***may not be tolerated*** as a breathing (27%) or as a feeding aid (36%)

Timing

1. Lip bandaging is commenced shortly after birth with cleft lip and cleft lipalveolus deformities
2. In patients with a cleft lip-alveolus palate and cleft hard-soft palate, treatment commences as soon as an impression of the palate with rubber-like material can be made to manufacture the functional jaw-orthognathic suction and drinking plate (FJO), preferably in the 1st week after birth (*Figure 4*)

Duration

Presurgical treatment of primary cleft lip palates is commenced shortly after birth and continues until the first surgical intervention.

Patients with lip bandages and intra-oral devices need to be reevaluated at least monthly for:

1. ***Plate adjustment*** due to changes from palatal/oral cavity growth
2. Controlling the ***molding*** of dentoalveolar arches to achieve the best possible presurgical dentoalveolar arch configuration
3. ***Advice*** to parents about pressure marks and device tidiness as well as feedback regarding breathing and feeding

Expected results

Primary treatment in cleft lip-palate patients is key to achieving substantially better long term functional (breathing, occlusion, swallowing) as well as aesthetic results of the nose and lip.

Manufacturing of devices

The two important devices for the primary treatment are

1. Functional jaw-orthognathic suction and drinking plate (FJO) in cleft lipalveolus-palate patients
2. Extended suction and drinking plate, Bolton plate) that can also be dorsally extended in patients with hard-soft palate clefts

Both are essential for breathing and feeding. The FJO is also important to mold the dentoalveolar arches in preparation for surgery.



Figure 12: Bolton type device

Jaw impressions are made using a dental ‘rubber’ compound (*Figure 12*), ± a silicone material, as is normally used to take impressions for dental crowns and bridge reconstruction. ***Under NO circumstances, should “alginate” material be used*** to create jaw impressions due to the risk of the alginate being displaced into the nasal and/or pharyngeal/laryngeal spaces. This dental ‘rubber’ component is loaded onto a custom-made infant impression tray or ‘spoon’ (*Figure 12*), as every infant presents with unique oral anatomical dimensions related to the size and width of the alveolar arches and the depth of the palate.



Figure 13: Jaw impressions are done with a dental ‘rubber’ component of a CLAP



Figure 14: Plaster-of-Paris model on which plates are manufactured

The impression serves as a cast to create a Plaster-of-Paris model (*Figures 13, 14*) on which the plates are manufactured with Acrylic material of around 0.7–1.0 mm thickness.



Figure 15: Acrylic material of around 0.7-1.0 mm thickness with soft denture-lining material that has been molded on the Plaster of Paris model for CLAP defect

The plate is equipped with a soft denture lining material that is molded in the oral cavity and the dentoalveolar arches and the palate (*Figure 15*). The FJO-plate needs to fit well. Should it be loose-fitting, adhesion powders or creams used for dentures may improve its retention.

Examples



Figure 16: A bilateral cleft palate and lip (CLAP)

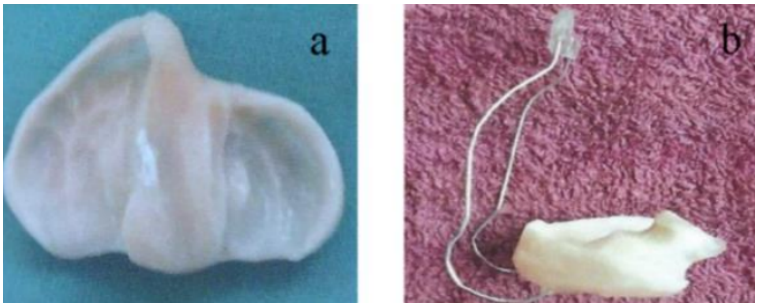
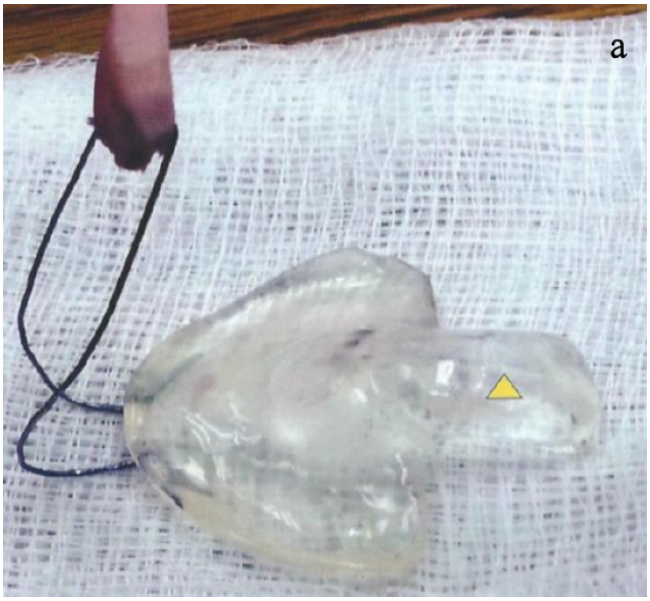


Figure 17a: Orthopedic device (drinking plate); 17b: Suction and drinking plate (SDP) with external facial stabilizer for hPsP cleft



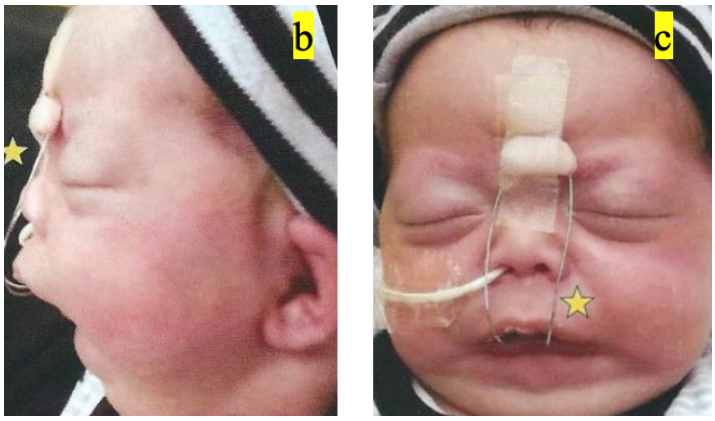


Figure 18a-c: To avoid glossoptosis in a patient with hPsP and Pierre Robin syndrome, a special suction plate (Bolton plate) is used with an additional posterior extension and external facial retention

Other cleft palate and lip chapters

Cleft lip & palate surgical techniques: introduction and philosophy

Recommended online text

Cleft: Ultimate Treatment. Bütow KW, Zwahlen R.

Authors

Professor Kurt-W Bütow MChD (MFO Surg), DrMedDent, PhD, DSc, FCMFOS, Maxillo-Facial Surgery; Fellowship in Cleft Facial Deformities
University of Pretoria Cleft Palate Deformities Clinic
Pretoria, South Africa
kurt@butow.co.za

Roger Zwahlen DipMedDent, DipMed, DrMed, DrMedDent, Private Docent
FMHMKG, FEBOMFS, FIBCSOMS
Specialist in Oral and Maxillofacial Surgery
Practice Verdeja
Fribourg, Switzerland
rozwahlen@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SURGICAL TREATMENT OF PEDIATRIC DROOLING

Katherine Pollaers, Shyan Vijayasekaran

Drooling is normal in children until 4 years of age. However, simple drooling can have negative social consequences, and chronic posterior drooling can have serious clinical sequelae.

Anterior drooling is characterized by unintentional saliva loss from the mouth, which has social and cosmetic consequences.

Posterior drooling is when saliva spills over the tongue into the hypopharynx, which leads to chronic pulmonary aspiration (CPA) of saliva. Chronic pulmonary aspiration results in recurrent lower respiratory tract infections, antibiotics use, medical consultations, interventions, and hospitalizations. The severity and complications of aspiration depend on the quantity and quality of the aspirated material, the patients defense mechanisms and pulmonary status[1].

Assessment (Figures 1, 2)

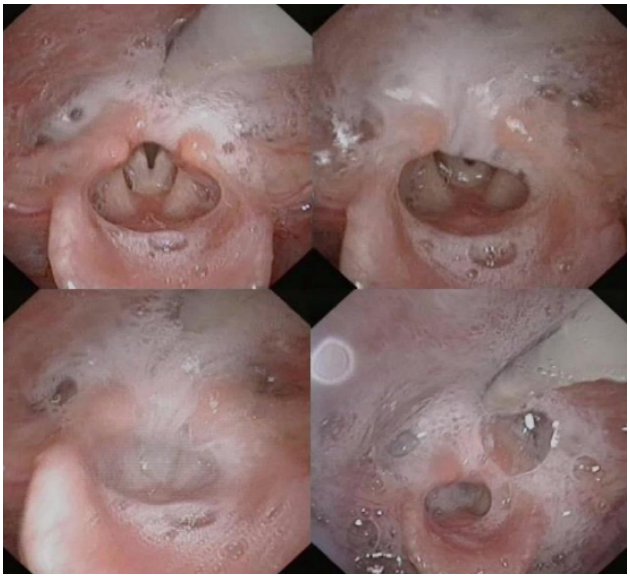


Figure 1: Serial flexible nasendoscopy images show salivary penetration through glottic inlet

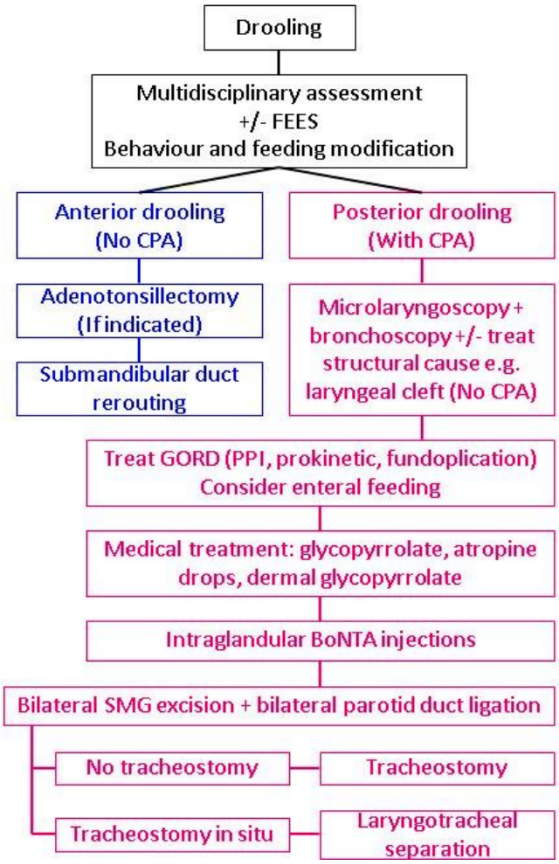


Figure 2: Management of drooling

Children are best evaluated by a multidisciplinary feeding team. The assessment of drooling and aspiration initially involves a history and examination and bedside tests which includes flexible nasendoscopy (*Figure 1*) and in selected cases a Functional Endoscopic Evaluation of Swallow (FEES).

Anterior drooling does not usually require extensive assessment. Most patients have adenotonsillar hypertrophy or delayed oromotor skills associated with neurodevelopmental pathology.

Posterior drooling may require investigation including imaging of the chest and a contrast swallow assessment. Patient with a tracheostomy may have a dye test.

Diagnostic microlaryngoscopy and biopsy are the investigations of choice for anatomical causes of CPA. Any structural abnormality that is identified, for example a laryngeal cleft, is then appropriately managed. Bronchial washings and brushings for microbiological assessment and histology for lipid laden macrophages may be performed.

Assessment and treatment of gastro-esophageal disease should be considered, particularly in complex children, to reduce the risk of aspiration of gastric contents. Management is with proton pump inhibitors, prokinetic agents or thickened oral fluids. In severe cases fundoplication may be considered.

Management of Anterior Drooling

Patients with anterior drooling can be managed efficiently by correcting the upper airway obstruction (adenoidectomy or adenotonsillectomy) required for treatment of coexistent sleep disordered breathing.

Patients with delayed oromotor skills and those with complex medical conditions are managed in a similar manner to the posterior drooling cohort.

Some patients with resistant anterior drooling without posterior drooling may be managed with submandibular salivary duct diversion. However, this group of patients needs to be carefully assessed to exclude salivary aspiration before doing surgery, as the submandibular salivary duct diversion is likely to exacerbate aspiration.

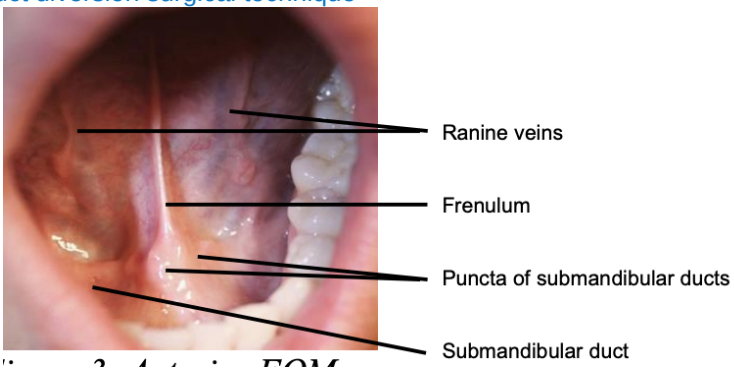


Figure 3: Anterior FOM

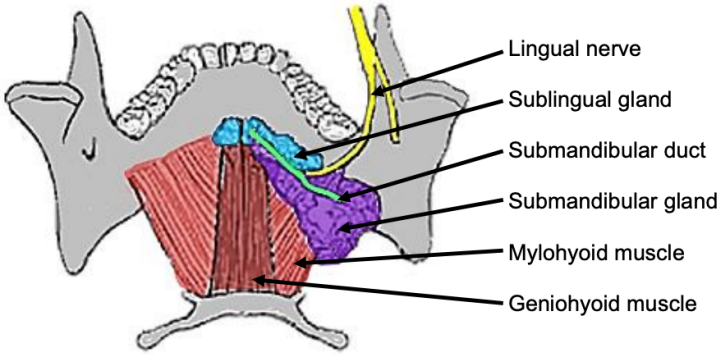


Figure 4: Superior, intraoral view of SMG, duct, lingual nerve and mylohyoid and geniohyoid muscles

The submandibular duct is located immediately deep to the mucosa of the anterior and lateral floor of mouth and opens into the oral cavity to either side of the frenulum via a puctum (*Figures 3 & 4*). Posteriorly the duct enters the superficial portion of the gland near the posterior border of mylohyoid muscle. The frenulum is a mucosal fold that extends between the floor of mouth and the ventral oral tongue, in the midline, between the openings of the submandibular ducts (*Figure 3*).

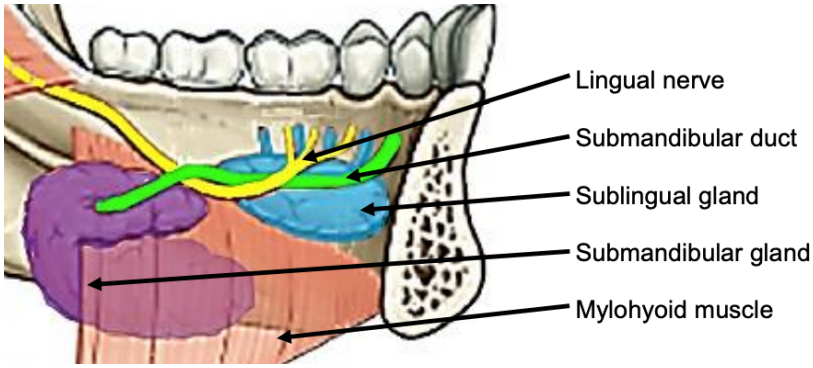


Figure 5: Intraoral view of left sublingual gland with ducts of Rivinus, SMG and duct, lingual nerve, and mylohyoid muscles

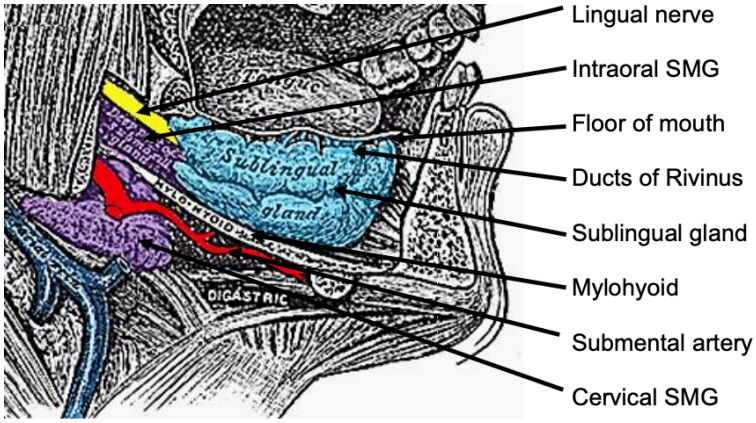


Figure 6: View of right sublingual gland

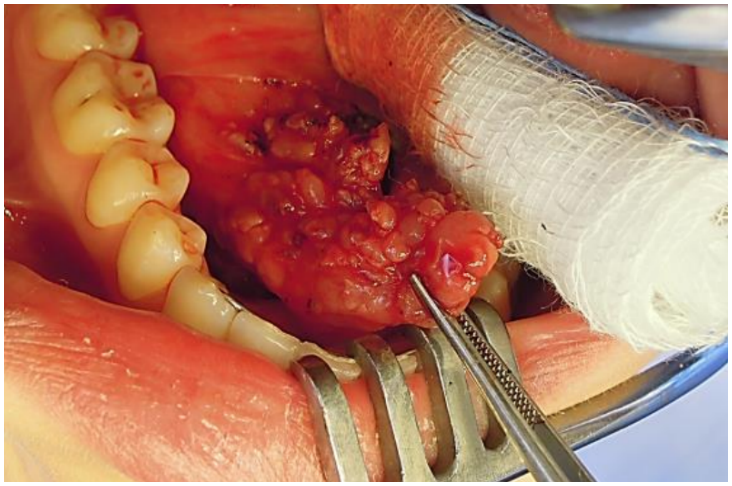


Figure 7: Right sublingual salivary gland

The paired sublingual salivary glands are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles (*Figures 4, 5, 6, 7*). The glands drain via 8-20 excretory ducts of Rivinus into the SMG duct and also directly into the mouth on an elevated crest of mucous membrane called the plica fimbriata which is formed by the gland and is located to either side of the frenulum of the tongue (*Figures 4 & 5*).

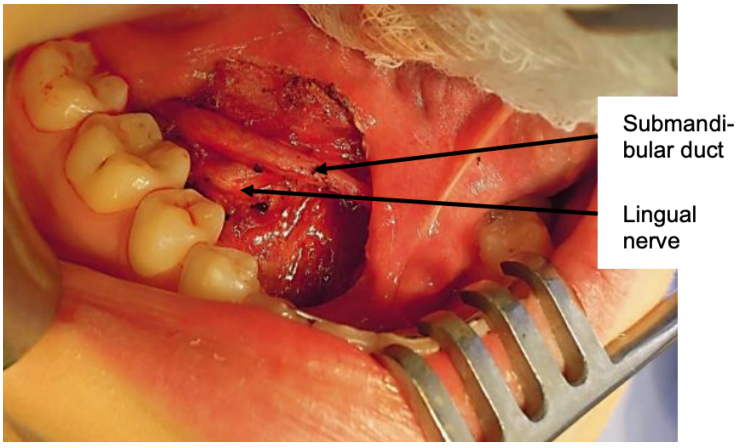


Figure 8: Lingual nerve and submandibular duct after removal of sublingual gland in operation done for a ranula

The lingual nerve lies on the surface of the mylohyoid muscle, then crosses deep to the submandibular duct in the posterolateral floor of mouth. It then runs on the surface of the hyoglossus, above the level of the duct, and is then distributed to the mucous membrane of the oral tongue (*Figures 4, 5, 8*).

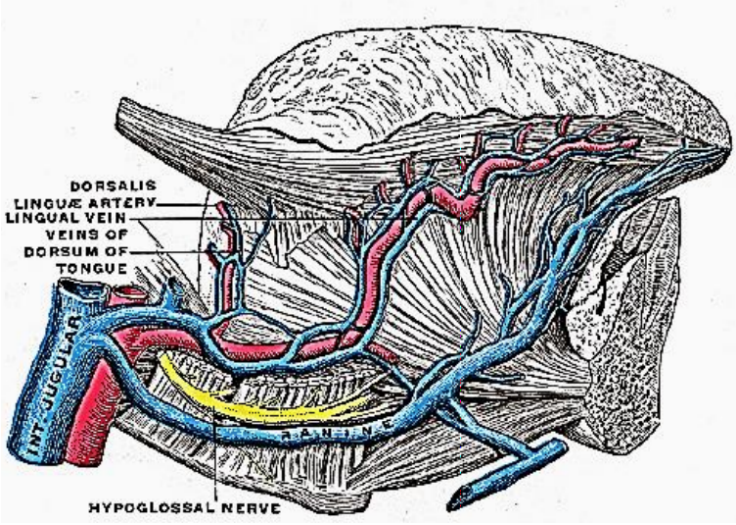


Figure 9: XIIn accompanied by ranine veins

Therefore, the entire length of the duct can be exposed from above without injuring the nerve. Ranine veins are visible on the ventral surface of the tongue and accompany the hypoglossal nerve (*Figures 3 & 9*).

Surgical steps

- General anesthesia is administered, the patient is intubated transnasally and positioned supine with a head ring
- The jaw is held open with a bite-block and a stay suture is used to retract the tongue
- The submandibular duct orifice is identified and cannulated with a lacrimal probe
- The cuff of mucosa surrounding the duct orifice is infiltrated with local anesthetic (xylocaine 1% with adrenaline)
- The mucosa around the duct is incised and the incision continued in a linear fashion, posterolaterally, for 1 cm
- The cannula remains inside the duct, and the duct is dissected free from the surrounding soft tissue, over a length of approximately 3 cm
- A tunnel is made just deep to mucosa from the posterior limit of the incision to posterior to the glossopharyngeus muscle (anterior tonsillar pillar)
- A mucosal incision is made posterior to the glossopharyngeal muscle, in the mucosa of the tonsillar fossa (NB. Children with anterior drooling would usually have undergone previous adenotonsillectomy, as first-line treatment)
- The duct with the surrounding cuff of tissue is rerouted through the tunnel to emerge from the mucosal defect in the tonsillar fossa, secured using 4-0 vicryl
- The floor of mouth incision is closed
- The stay suture is removed
- Postoperative broad-spectrum oral antibiotics are administered

Management of Posterior Drooling

Children with posterior drooling without structural upper aerodigestive tract abnormality and CPA require a ***stepwise approach*** to management in a multidisciplinary team setting. The treatment goals are to reduce the incidence of lower respiratory tract infection, decrease hospitalization, nursing care requirements and to improve quality of life. Management options for posterior drooling are nonsurgical or surgical.

1. Non-surgical management

Behavioral modification and feeding programs

Initial conservative management involves allied health interventions which aim to improve oromotor function. Oral intake textures are modified, and positioning and feeding strategies are employed to reduce risk of aspiration. In children where oral intake is deemed unsafe, a feeding gastrostomy or jejunostomy tube are introduced.

Medications

Anticholinergic agents are the mainstay of systemic medical treatment for drooling. Glycopyrrolate is the first-line oral anticholinergic. At our institution, this is available as a liquid or crushable tablet. It is commenced at a low dose of 0.01mg/kg/dose

twice a day, and increased to effect, with a maximum dose of 0.04mg/kg three times per day[2]. Oral atropine drops onto the tongue is another option. Dermal glycopyrrolate (scopolamine) patches are a well tolerated option; patches can be trimmed to tailor the dose. Adverse effects of anticholinergic medications include irritability, restlessness, sedation, delirium, blurred vision, urinary retention, constipation and skin flushing. Side-effects limit their use in 20% of children.

Botulinum toxin injection

Intraglandular botulinum toxin type A (BoNTA) injections into the major salivary glands have proven very useful. Injections are administered to the major salivary glands, usually under ultrasound guidance to avoid intravascular injection. BoNTA blocks the release of acetylcholine at parasympathetic synapses, blocking parasympathetic innervation of the salivary glands and hence saliva secretion. The dose at our institution is 2 units/kg total, given in divided doses amongst all the glands. Adverse effects are very rare. Salivary gland Botox is well-suited to children who are also having injections to their limbs under the same anesthetic - in such cases the dose to the salivary glands is reduced. An uncommon but severe complication is spread of BoNTA to the pharyngeal musculature which can cause severe dysphagia[3]. The procedure is repeated at 3-6 monthly intervals.

Steps for Botulinum toxin injection

- General anesthesia is administered
- The patient is positioned supine with a head ring
- The skin overlying both necks and the parotid regions are prepared and draped with sterile drapes
- The ultrasound probe is draped
- Botulinum toxin, type A purified neurotoxin complex powder is reconstituted, according to the manufacturer’s instructions.
- Local guidelines should be consulted for the maximum cumulative dose in the pediatric patient. The maximum dose is divided amongst the four glands.

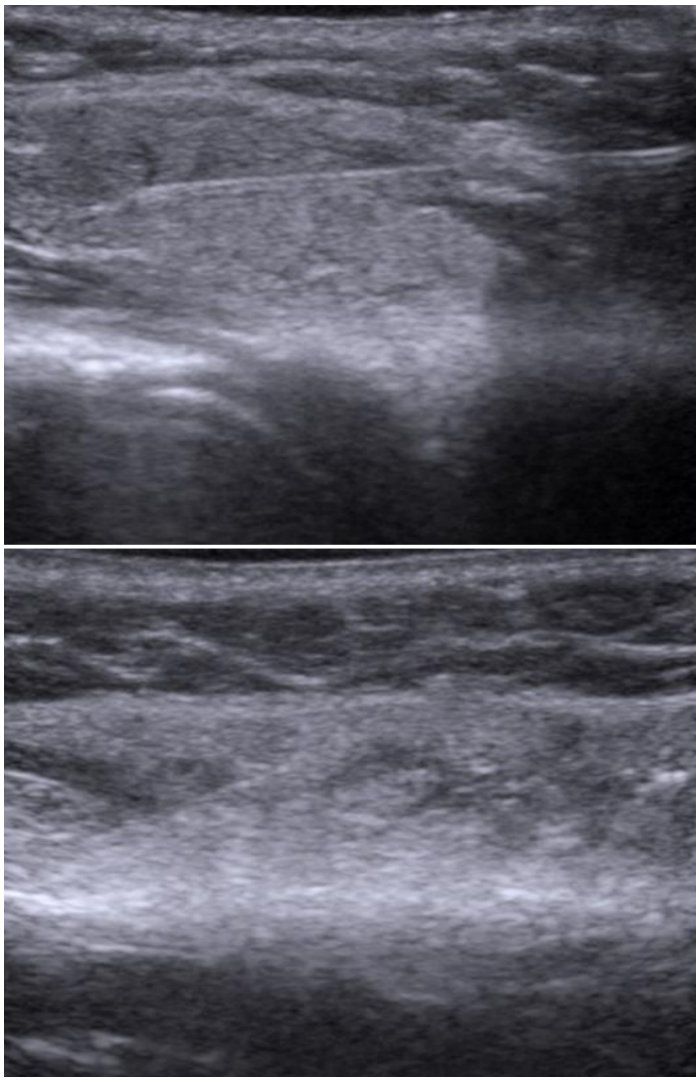


Figure 10: Ultrasound guided intraparotid Botulinum Toxin A injection. The parenchyma is infiltrated, avoiding vascular structures

- Using a 25-gauge needle, under ultrasound guidance, Botulinum toxin is infiltrated into the parenchyma of both parotid and submandibular glands (*Figure 10*)
- Post-procedure antibiotics are not required

2. Surgical management

Patients with drooling that has not responded to medical therapy and have chronic pulmonary aspiration (CPA) of saliva are considered for surgical management. Most of these children have neurological impairments. Surgical management addresses either salivary flow or definitively separates the trachea from the larynx, or tracheostomy alone.

Procedures to reduce salivary flow include:
1) Salivary duct ligation
2) Submandibular gland excision
3) Tympanic neurectomy: not recommended as it is ineffective, risks hearing loss and results in loss of taste[5]

Airway procedures include
1) Tracheostomy
2) Laryngotracheal separation

At our institution, children who fail medical therapy are offered bilateral submandibular gland excision and bilateral parotid duct ligation. Long-term side effects are rare, xerostomia being the most commonly encountered complication. This procedure has been shown to reduce readmission rates for children with chronic salivary aspiration[6,7].

Procedures to reduce salivary flow

1) Salivary duct ligation

- The salivary ducts of the submandibular (SMG) and parotid glands are amenable to ligation. Short-term morbidity includes sialadenitis and discomfort which is managed supportively as an inpatient, until symptoms have improved. Parotid duct ligation reduces salivary gland secretions in response to food stimulation,[4] as the parotid produces more saliva in response to food than the other salivary glands. Ducts are ligated using a transoral approach. All four ducts can be ligated in the same procedure ('4-duct ligation').

Surgical steps

- General anesthesia is administered
- The patient is intubated transnasally and positioned supine with a head ring
- Intraoperative cephazolin and metronidazole are administered
- The jaw is held open with a bite-block
- A stay suture is used for tongue retraction
- The parotid duct orifice is identified and cannulated with a lacrimal probe
- The mucosa surrounding the orifice is infiltrated with local anesthetic (xylocaine 1% with adrenaline)
- The mucosa around the duct orifice is incised in an elliptical fashion
- The terminal duct is dissected free from the surrounding soft tissues
- The duct is ligated with a 3-0 silk suture
- The terminal duct and surrounding mucosa are amputated
- The duct is buried in the soft tissues
- The elliptical mucosal defect is closed with 4-0 vicryl
- The same is repeated on the contralateral side
- Attention then turns to the SMG duct orifice, which is identified and cannulated
- The mucosa surrounding the orifice is infiltrated with local anesthetic (xylocaine 1% with adrenaline)
- The mucosa around the orifice is incised in an elliptical fashion (along the direction of the duct)
- The duct is dissected free over a length of <1 cm
- The duct is ligated with a 3-0 silk suture
- The terminal duct and surrounding mucosa are amputated
- The duct is buried
- The elliptical mucosal defect is closed with 4-0 vicryl
- Postoperative broad-spectrum oral antibiotics are administered, and low dose amoxicillin is administered for 2 weeks postoperatively.

Wiatrak BJ. Salivary gland 4-duct ligation for the management of chronic sialorrhea in children. Oper Tech Otolaryngol - Head Neck Surg. 2002;13(1):68–70

Varma SK, Henderson HP, Cotton BR. Treatment of drooling by parotid duct ligation and submandibular duct diversion. Br J Plast Surg. 1991;44(6):415–7.

2) Submandibular gland excision

Transcervical submandibular gland excision is utilised to treat drooling. It eliminates saliva production in the resting state, as 70% of resting state saliva production occurs from the SMG glands. (See *Figure 2*) This procedure results in 2-3 cm unilateral or bilateral cervical scars. Complications are the same as with routine SMG excision. A detailed description of SMG excision can be read in the Open Access Atlas.

Airway procedures

1) Tracheostomy

Children with neurological impairment often have tracheostomy placement for pulmonary toilet and to manage multiple medical comorbidities. In some cases, tracheostomy alone can be used to manage CPA secondary to drooling. This option requires intensive nursing care with regimented, very frequent tracheostomy tube suctioning.

2) Laryngotracheal separation/diversion

These are definitive surgical procedures for CPA cases that have proven to be unresponsive to all other management. They are offered to patients who are tracheostomy dependent, gastrostomy tube fed and non-verbal, and who continue to have CPA. These procedures completely separate the lower respiratory tract from the upper aerodigestive tract and eliminate any risk of aspiration. Children have a permanent tracheostomy tube and phonation is no longer possible. Both these procedures are potentially reversible, but it is best not to consider either option unless the need to reverse was considered only a remote possibility.

Laryngotracheal separation technique

- General anesthesia is administered
- The patient is positioned supine with a head ring
- The skin overlying both necks are prepared and draped with sterile drapes
- Administer perioperative broad spectrum antibiotics
- Make transverse cervical skin incision
- Elevate subplatysmal flaps superiorly and inferiorly
- Separate the infrahyoid strap muscles
- Expose and divide thyroid isthmus
- Expose and bluntly mobilize the trachea with finger dissection or a blunt hemostat to the upper mediastinum
- Avoid injury to recurrent laryngeal nerves in the tracheo-oesophageal grooves
- Horizontally incise the trachea distal to 1st of 2nd tracheal rings; depending on the length of the neck the incision may be made lower between 2nd and 3rd rings or even more inferiorly
- Angle the tracheal incision superiorly to create a beveled tracheostoma
- Carefully separate the posterior tracheal wall from esophagus, taking care not to enter the esophageal lumen

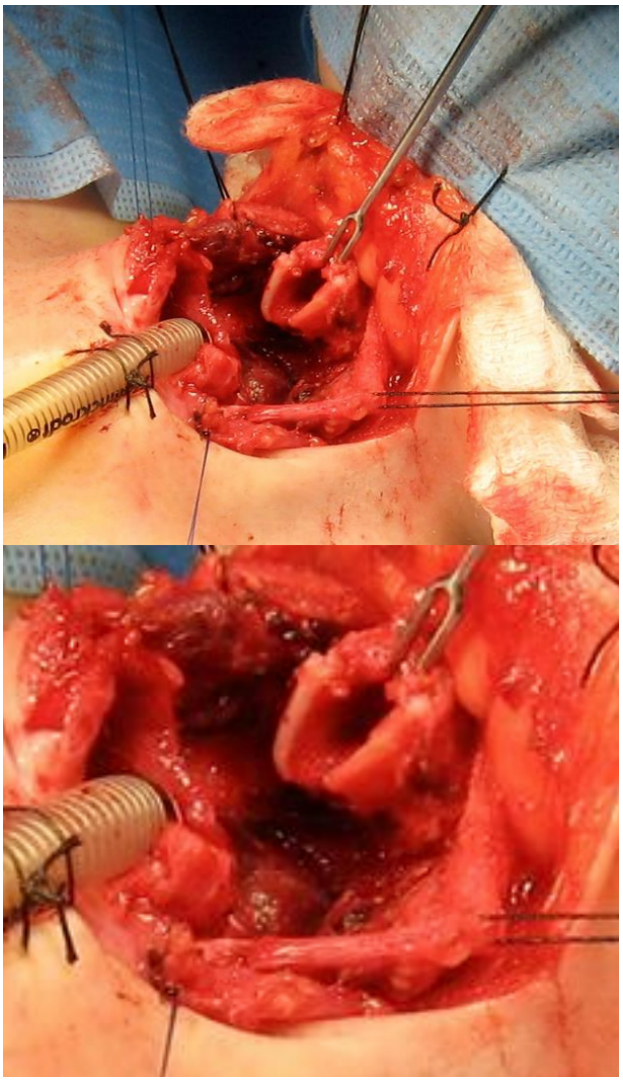
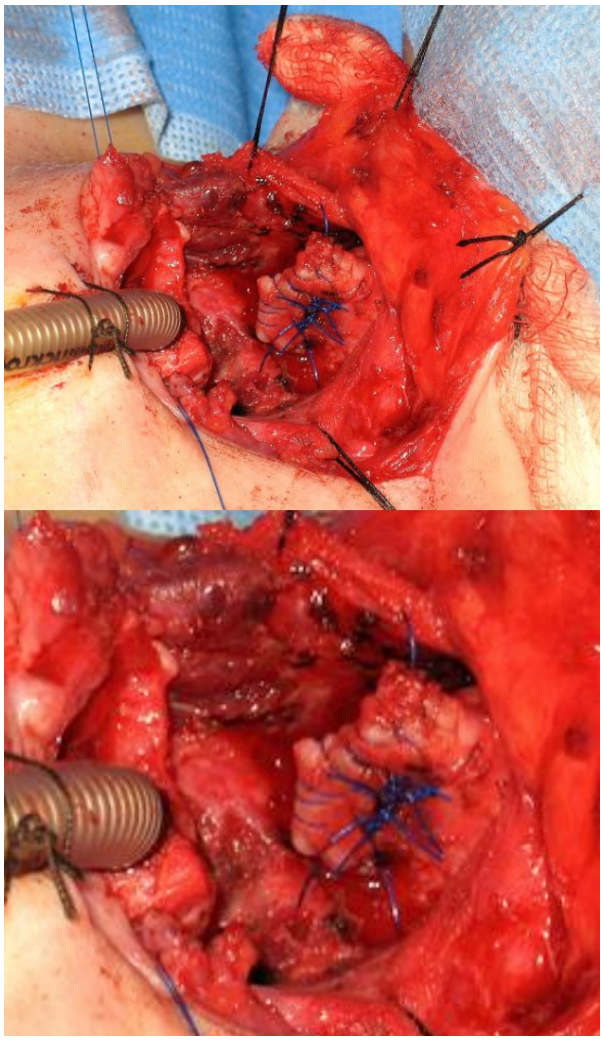


Figure 11: The trachea is separated, and the distal segment is intubated

- Place a small anesthetic tube through skin incision into the trachea to reroute gas administration from transoral to the stoma (*Figure 11*)
- Make a circular skin incision in the anterior neck above the suprasternal notch
- Formalize the tracheostomy by suturing the distal trachea circumferentially to the lower circular skin incision using 3-0 vicryl deep and 4-0 chromic running in 4 separate quadrants in a similar fashion to a laryngectomy stoma
- Create a blind pouch of the superior tracheal end:
  - Remove the 2nd tracheal ring Invert the underlying subglottic mucosa with interrupted 4-0 vicryl



- *Figure 12: A blind pouch is created by removing 2nd tracheal ring, the subglottic mucosa is inverted and closed with interrupted 4-0 vicryl and oversewn with running 3-0 vicryl*
- Oversew with running 3-0 vicryl (*Figure 12*)
- Reinforce the subglottic pouch with strap muscles and fibrin glue

- Insert a corrugated drain
- Close the skin is closed in layers.

Laryngeal diversion

The trachea is separated, and a cervical stoma is created as with laryngotracheal separation. However, the distal end of the proximal segment of trachea is anastomosed to an anterior esophagostomy in an end-to-end fashion. Saliva is therefore diverted into the esophagus. The risk of surgical complications is higher with diversion, due to the anastomosis between the proximal trachea and esophagus.

Laryngectomy

Laryngectomy results in permanent separation of the trachea from the upper aerodigestive tract and is very rarely performed in children with CPA secondary to drooling. It is not reversible, and children are rendered aphonic.

References

1. Terry P, Fuller S. Pulmonary consequences of aspiration. Dysphagia. 1989; 3(4):179–83
2. The Royal Children's Hospital Melbourne. Saliva Control in Children [Internet]. 2017 [cited 2020 May 9]. https://www.rch.org.au/uploadedFiles...salivabook.pdf

3. Patterson A, Almeida L et al. Occurrence of Dysphagia Following Botulinum Toxin Injection in Parkinsonismrelated Cervical Dystonia: A Retrospective Study. Tremor Other Hyper kinet Mov (N Y). 2016;6:379
4. Khan WU, Islam A, Fu A, Blonski DC, Zaheer S, McCann CA, et al. Four-duct ligation for the treatment of sialorrhea in children. JAMA Otolaryngol - Head Neck Surg. 2016;142(3):278–83
5. Gallagher TQ, Hartnick CJ. Bilateral submandibular gland excision and parotid duct ligation. Adv Otorhinolaryngol. 2012;73:70–5
6. Noonan K, Prunty S, Ha JF, Vijaya - sekaran S. Surgical management of chronic salivary aspiration. Int J Pediatr Otorhinolaryngol [Internet]. 2014;78 (12):2079 –82
7. Manrique D, Sato J. Salivary gland surgery for control of chronic pulmonary aspiration in children with cerebral palsy. Int J Pediatr Otorhinolaryngol. 2009;73(9):1192 –4

Authors

Katherine Pollaers
MBBS M Surg
Perth Children's Hospital
Western Australia
Australia
katherine.pollaers@health.wa.gov.au

Shyan Vijayasekaran
MBBS FRACS
Perth Children's Hospital
Western Australia
Australia
Shyan.vijayasekaran@health.wa.gov.au

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CHAPTER OVERVIEW

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ENDOSCOPIC TRANSORBITAL SURGERY: MEDIAL ORBITAL (PRECARUNCULAR) APPROACH

Darlene Lubbe

The precaruncular approach is indicated for the following clinical situations:

1. Ligation of anterior and posterior ethmoidal arteries
2. Multiportal surgery for optic nerve decompression. The precaruncular portal is especially useful to retract herniating fat and muscle laterally to allow for both posterior orbital and optic nerve decompression
3. Minimally invasive surgery for removal of medial orbital lesions – cavernous hemangiomas, pseudotumors and to biopsy medially located lesions
4. Access to lacrimal sac
5. To address blow-out fractures of the medial orbit and to reconstruct the medial orbital wall
6. Access to lateral aspect of ipsilateral sphenoid sinus
7. Access to contralateral sphenoid sinus for Sternberg canal defects
8. Access to medial cavernous sinus
9. Access to ipsilateral anterior cranial fossa / cribriform area / olfactory fossa
10. Drainage of medially located subperiosteal abscesses secondary to complicated sinusitis

Precaruncular approach compared to Lynch-Howarth incision

Access to the ethmoidal arteries is required to ligate the vessels with nasoethmoid traumatic fractures or to assist with hemostasis prior to resection of the sinonasal tumors. The Lynch-Howarth incision has been the gold standard to approach these arteries, with the frontoethmoidal suture line said to be the optimal way of finding these arteries. However, this external approach should be replaced by the precaruncular approach to access these arteries for the following reasons:

Lynch-Howarth incision

- External facial incision that can cause cosmetically unacceptable scars
- Dissection through skin, subcutaneous tissue, orbicularis oculi muscle is required with suturing of the incision
- Bleeding can be encountered from the angular vessels

Precaruncular approach

- Provides access to
  - Ethmoidal arteries
  - Medial orbit
  - Lamina papyracea
  - Ethmoid and sphenoid sinuses
  - Optic nerve
  - Medial cavernous sinus
- Direct access without breaching facial skin
- Easy, quick, direct access without dissecting uninvolved tissue (skin, muscle, lacrimal system, sinuses)
- No suturing of skin incision required

Surgical Anatomy

It is important to understand the anatomy of the medial canthus, lacrimal system and the attachments of the medial orbital wall structures to the bony orbit prior to utilizing this medial portal.

Medial canthus

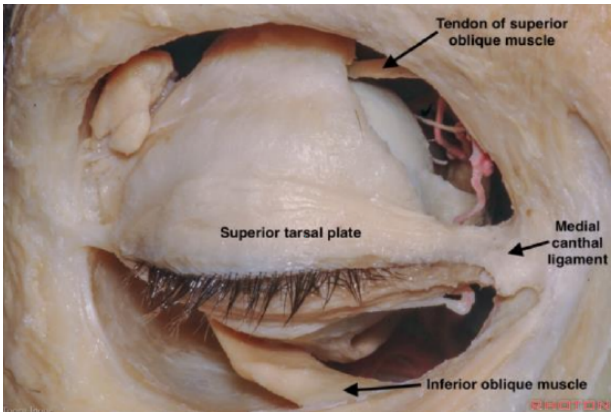


Figure 1: Right eye medial canthus

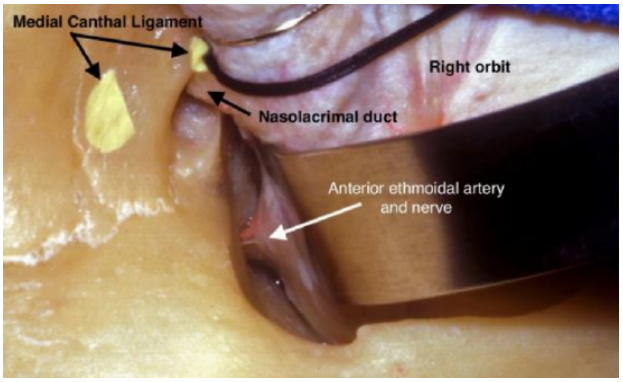


Figure 2: Right eye as seen from above with retractor retracting orbit laterally to show the anterior ethmoidal artery

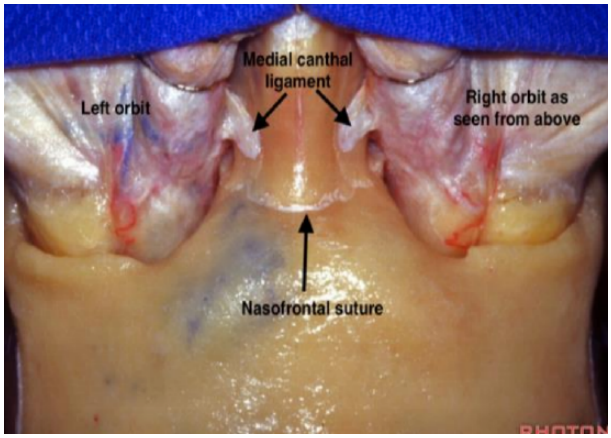


Figure 3: Medial canthal ligaments demonstrated from above

The medial canthus is where the upper and lower eyelids meet. It includes the canthal tendon and lacrimal canaliculi. The canaliculi and tendon are superficial to the area of dissection and should be preserved if the dissection is done within the correct surgical plane (*Figures 1-3*).

As the medial canthus is difficult to reconstruct, great care should be taken to avoid injury to these structures.

Lacrimal system



Figure 4: Lacrimal dilator, probes and irrigation



Figure 5: Probing and syringing of lacrimal system

The lacrimal canaliculi run in a plane superficial to the plane of dissection of the precaruncular approach. The surgeon can cannulate the canaliculi after dilating the superior and inferior puncta to ensure that these structures are not injured during the surgery. If familiar with dacryocystorhinostomy (DCR) surgery, this is usually unnecessary (*Figures 4 & 5*) (Chapter on DCR).

The lacrimal sac and nasolacrimal duct lie below the frontoethmoidal suture line (*Figure 2*) and dissection of this area is unnecessary if doing an anterior and posterior ethmoidal artery ligation, accessing the medial orbit for orbital tumors, decompressive surgery or during multiportal surgery.

Attachments of medial orbital structures to bony orbit

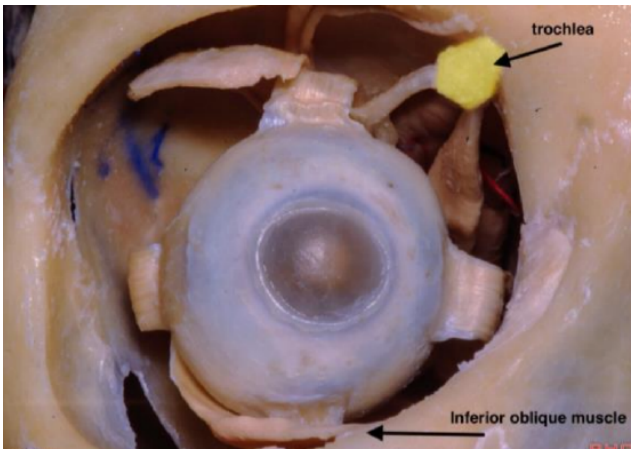


Figure 6: Right eye showing the medial portal located between the trochlea and the insertion of the inferior oblique muscle

The medial (precaruncular) portal is located between the attachment of the trochlea to the superior-medial wall of the orbit and the attachment of the inferior oblique muscle to the inferior orbit (*Figures 1 & 6*).

It is important to remember that because these structures attach to the periorbital fascia, dissecting in the subperiosteal plane (between bone and periorbital fascia) is essential to avoid damage to these structures. It is usually unnecessary to dissect close to these structures unless an extended approach is required where the medial portal is combined with superior or inferior portals.

The ***trochlea*** is a cartilaginous sling that acts as a pulley for the superior oblique muscle. It is located approximately 1.5 cm superior to the lacrimal caruncle[1] (*Figures 1, 6*). The trochlear fossa is about 4 mm from the orbital margin. This is where the pulley is attached.

The ***inferior oblique*** arises from the orbital surface of the maxilla, lateral to the lacrimal groove. It is the only muscle that ***does not*** originate from the common tendinous ring (annulus of Zinn). The muscle passes laterally, posteriorly and superiorly (*Figure 6*) and runs between the inferior rectus and the floor of the orbit and passes just underneath the lateral rectus muscle. It inserts onto the sclera between the inferior and lateral rectus muscles. Once again, one should ***avoid trying to identify this muscle*** during a pure medial approach and always remain in a subperiosteal plane when dissecting the periorbital fascia off the bony orbital wall.

Structures encountered during the medial precaruncular approach

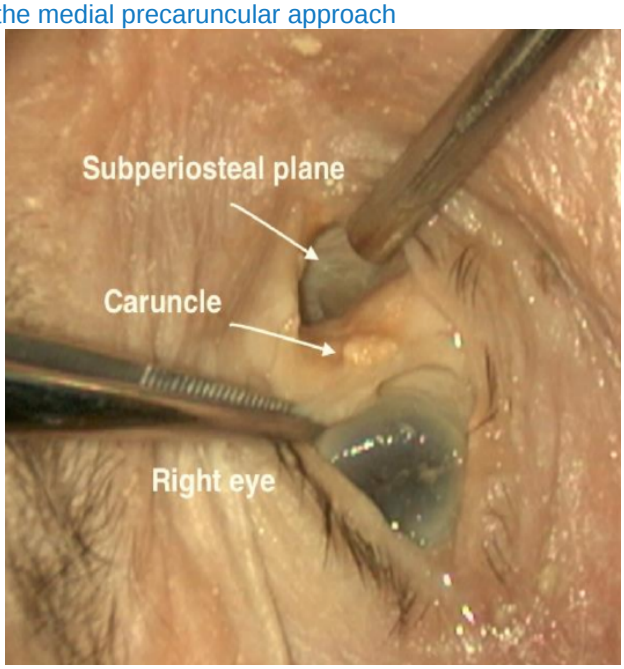


Figure 7: Caruncle of right eye

Caruncle: The caruncle is a small mound of tissue that located at the medial aspect of the eye (*Figure 7*). Its function is most likely related to directing the flow of tears to the lacrimal puncti.

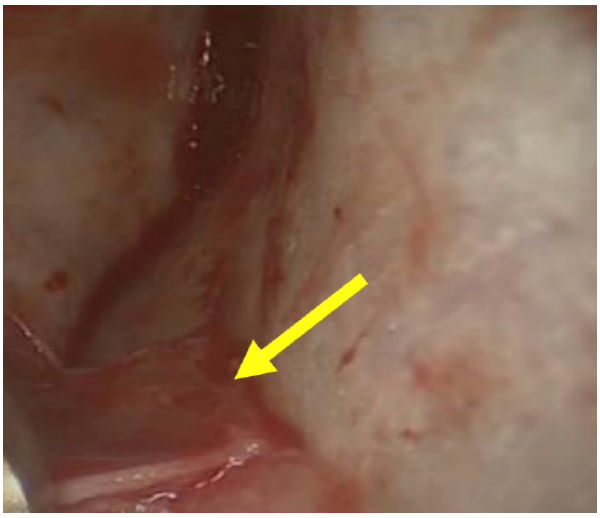


Figure 8: Horner's muscle identified in the right eye. The anterior ethmoidal artery lies 12 mm posterior to this muscle

Horner's muscle: This is a small muscle that can be identified in the most anterior part of the medial orbit. It is one of the first structures encountered once the incision is made through the conjunctiva between the caruncle and the medial canthal skin (*Figure 8*). Its function is not quite clear, but it most likely also assists with drainage of tears through the lacrimal system.

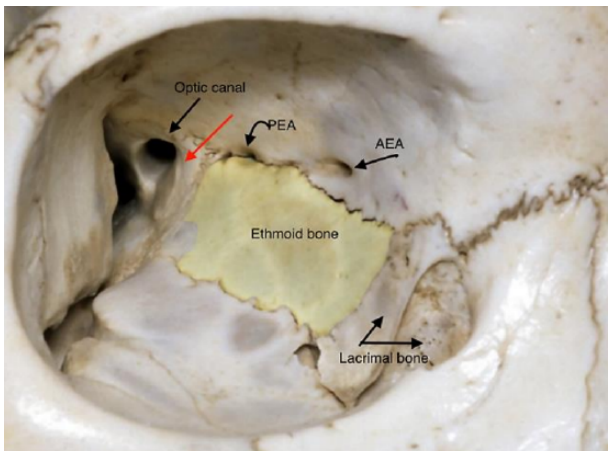


Figure 9: Right eye showing the frontoethmoidal suture line above the ethmoid bone (yellow) with the anterior ethmoidal artery (AEA) and the posterior ethmoidal artery (PEA) close to this suture line. Red arrow = bone of sphenoid body

Frontoethmoidal suture line: This is only clearly visible in 50% of patients[2] and is therefore not a great landmark for the ethmoidal arteries. If visible, the ethmoidal vessels and nerves are found within the suture line or just above it (*Figure 9*).

If it is not clearly identifiable, then the nasion should be used as a landmark for the ethmoidal vessels as the ethmoidal arteries are at the same level as the nasion[2].

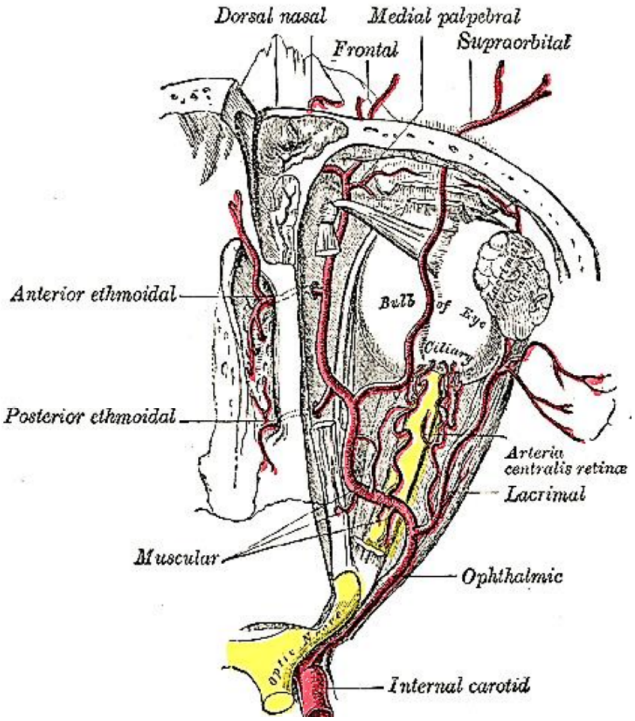


Figure 10: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries

Anterior and posterior ethmoidal arteries: These are branches of the ophthalmic artery and are therefore branches of the internal carotid artery system (*Figure 10*). The arteries run from the orbit to the nasal cavity (lateral-to-medial).

There are numerous ways to find the arteries using their relationships to other structures:

1. The arteries are at the ***level of the nasion*** [2] or nasofrontal suture line (*Figures 2*,*3*,*9*)
2. Close to (within or above) the ***frontoethmoidal suture line***, which is only clearly visible in 50% (*Figure 9*)
3. 12 mm posterior to ***Horner's muscle*** [2]
4. ***"24-12-6 rule"***: The anterior ethmoidal artery can be found 24 mm from the anterior lacrimal crest; the posterior ethmoidal foramen is 12 mm posterior to this; and the optic canal 6 mm posterior to the posterior ethmoidal artery.

Note: When the precaruncular approach is used to ligate the ethmoidal vessels, the lacrimal crest does not have to be exposed.

Accessory ethmoidal arteries: These are often encountered between the anterior and posterior ethmoidal arteries. They usually are very small and are easily transected during elevation of the periosteal layer.

It is important to remember that the posterior ethmoidal artery can be absent. Great care should therefore be taken before cauterizing or ligating a structure that could possibly be the optic nerve. If there is any doubt, it is safer to not cauterize the 2nd artery as any trauma to the optic nerve would lead to blindness.

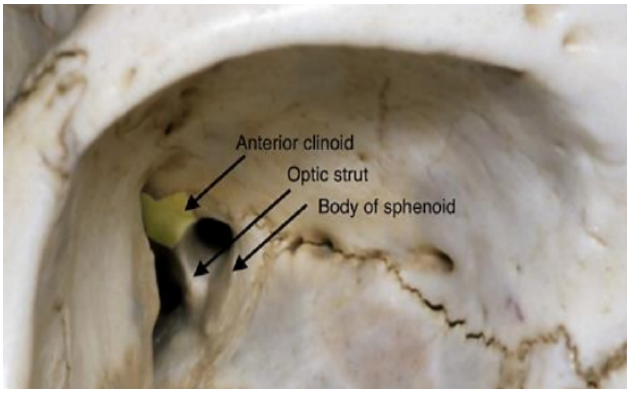


Figure 11: Right optic canal formed by the body and the lesser wing of the sphenoid See optic strut (inferiorly) and anterior clinoid (posteriorly)

Optic canal: The optic canal is found 6 mm posterior to the posterior ethmoidal artery in the most posterior-medial aspect of the bony orbit (*Figure 11*).

It is located within the sphenoid bone and is bound medially by the body of the sphenoid and laterally by its lesser wing (optic strut) (*Figure 11*).

Indications for Precaruncular Approach

Preoperative planning

The need for imaging depends on the indication for surgery. For any ***surgery other than ethmoidal artery ligation, preoperative imaging is mandatory***. For simple ligation of the ethmoidal vessels, preoperative CT imaging is not required. If a patient has proptosis secondary to an intra- or extraconal lesion (space within the orbit outside the musculofascial cone), then preoperative CT and MRI is useful to assess the location of the lesion relative to the rectus muscles and optic nerve. Navigation is also useful to locate any pathology other than the ethmoidal arteries.

Ophthalmological examination is indicated for any patient who has orbital pathology, proptosis or visual abnormalities. It is important to document the visual acuity, visual fields if indicated, degree of proptosis and intraocular pressure prior to performing any surgery. The only indication for not performing these tests would be for ligation of the ethmoidal arteries in a patient with no orbital pathology or visual problems.

Preoperative counselling includes mentioning all the possible complications that could occur if any important structures are injured during this approach. It is important to explain to patients that this approach has been used since 2010 with very few if any complications reported in the literature. Injury of the lacrimal system can cause epiphora; injury to the ethmoidal vessels can cause an orbital hematoma or intracranial hemorrhage if there is any backflow of blood; medial rectus muscle injury will cause diplopia; and optic nerve injury will cause blindness. Entering the medial cavernous sinus can injure cranial nerves III, IV, VI and the internal carotid artery causing a stroke or death.

It needs to be stressed that the precaruncular approach is minimally invasive, requires minimal dissection of uninvolved tissue (sinuses, lamina papyracea, rectus muscles), with little pain because of the little disruption of normal tissues, requires no suturing and with early discharge from the hospital (often the same day and minimal if any morbidity.

Surgical technique

1. Anesthesia and positioning
2. Preoperative preparation & instruments
3. Surgical steps
4. Postoperative management

1. Anesthesia and positioning

- Surgery is as for routine FESS surgery with the patient supine with the head flat or flexed 15 degrees (See Chapter on FESS)
- The head is turned slightly to the side of the surgeon
- The surgeon always stands on the left of the patient (when facing the patient) for a left-handed surgeon, regardless of which eye needs to be addressed
- The author prefers total intravenous anesthesia (TIVA), but it is essential to have a slow heart rate and normotensive patient to assist with hemostasis
- 1 Gram of IV Kefzol is given at induction because multiportal surgery is often performed – this means the eye could possibly be contaminated with nasal organisms if a transnasal approach is combined with a transorbital approach

2. Preoperative preparation and instruments

- If the endonasal route is to be used, standard packing techniques are used, using 2 mL of 1:1000 Adrenaline topically on neurosurgical patties (See Chapter on FESS)
- Clean the eye prior to draping with either normal saline or diluted Betadine solution (unless allergic to iodine). It is important to instruct the scrub nurse not to clean the eye with any products that could potentially damage the cornea or irritate the sclera (e.g. Chlorhexidine solution)

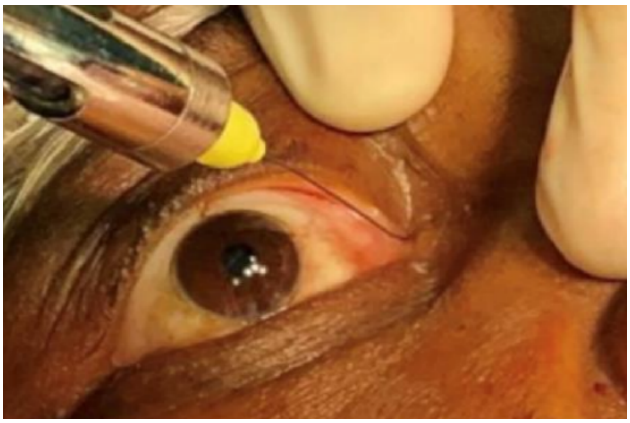


Figure 12: Injecting 1:80 000 Adrenaline with Lidocaine into the medial canthus

- Inject 0.2 mL local anesthetic (1:80,000 Adrenaline with 2% Lidocaine) at the start of surgery, between the caruncle and the skin edge of the eye (*Figure 12*) for hemostasis during the initial dissection of the precaruncular portal
- It is important to keep the cornea moist or to protect it with a corneal protector throughout the procedure to prevent any corneal trauma, as drying of the cornea can cause corneal ulceration or keratitis

Instrument requirements

- Camera system
- Zero-degree 4 mm standard 18 cm endoscope (sinuscope)
- Standard FESS tray
- Additional essential instruments
  - Ribbon retractors / Dural retractors (on neurosurgery tray): Ensure that a variety of sizes (8 mm, 10 mm, 15 mm) of retractors are available
  - Small cat's paw retractor
  - Suction Freer
  - Freer elevator
  - Bipolar forceps (as used with tonsillectomy)
  - Ligaclip applicator

3. Surgical steps

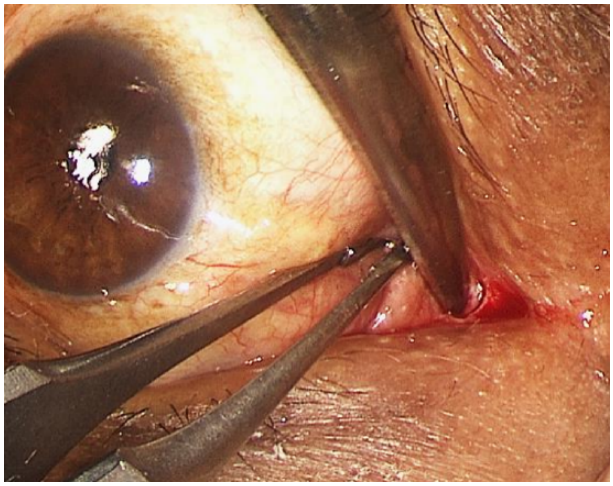


Figure 13: Right eye; retracting the caruncle laterally to incise between the caruncle and the medial canthal skin

- Identify the caruncle of the eye, grasp it with toothed forceps and retract it laterally (*Figure 13*)
- Incise the conjunctiva between the caruncle and the medial canthal skin with sharp iris scissors

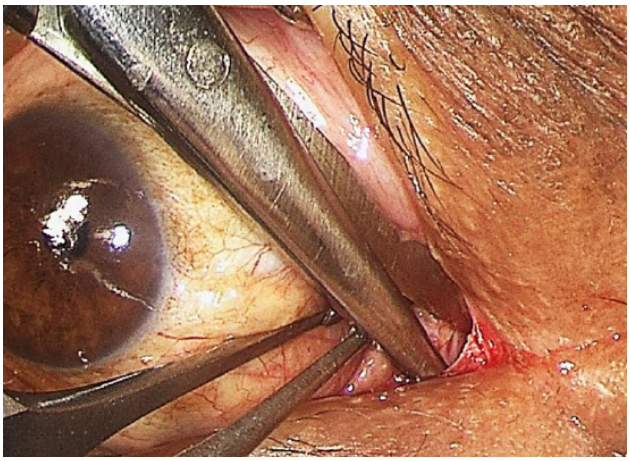


Figure 14: Right eye; precaruncular incision. Scissors inserted between caruncle and medial canthal skin, spreading tissues as soon as the bone is felt

- Aim the tip of the scissors towards the bone of the medial wall of the orbit, and dissect deep to the lacrimal canaliculi to prevent traumatizing them (*Figure 14*)
- Surgeons not familiar with lacrimal anatomy should ask their ophthalmology colleagues to help dilate both puncti and insert probes into the canaliculi to ensure that the dissection is deep to these structures. Damaging the canaliculi could lead to epiphora (*Figures 4,5*)
- Once the tip of the scissors hits the bony orbital wall, the scissors is opened to 'spread' the orbital tissues to identify the bony orbital wall (*Figure 14*)

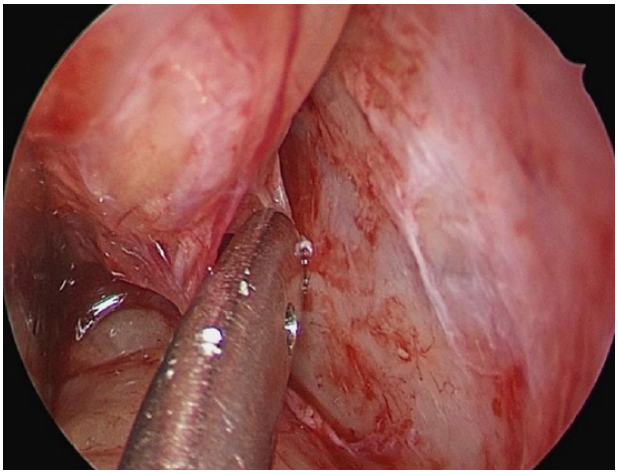


Figure 15a: Right eye; precaruncular incision with suction Freer elevator used to dissect in subperiosteal plane towards ethmoidal arteries

- Once bone is exposed, use a suction elevator, Cottle elevator or Freer's elevator to dissect in the ***subperiosteal plane*** between bone and periorbital fascia (*Figure 15a*)
- As with septoplasty surgery, it is important to be in the correct plane to avoid breaching the periorbital fascia, as this would cause orbital fat to herniate into the surgical corridor and make further surgery difficult



Figure 15b: A ribbon retractor is used to retract the orbit laterally (a retractor to retract the eyelids, as seen in this picture, is not routinely required)

- Use ribbon retractors to retract the orbital contents laterally (*Figure 15b*). Ensure that a variety of sizes (8 mm, 10 mm, 15 mm) of ribbon retractors are available
- Take great care with the amount of traction applied to the eye by the surgical assistant, especially at the posterior aspect of the orbit where excessive pressure with the retractor can cause damage to the optic nerve or the medial rectus muscle
- Insert the endoscope into the surgical portal as soon as the subperiosteal plane can be visualized – usually within 1 cm of the initial incision
- It is easier to find the exact plane using the endoscope
- The endoscope initially rests on the ribbon retractor for stability
- The author uses a standard 4 mm 18 cm sinus endoscope, but a 3 mm wide angled scope will give good visualization with a bit more space for manipulating instruments within the surgical corridor
- The rest of the procedure is performed using the endoscope
- Check the pupil for any changes in size or shape every 5 minutes while retracting as pupillary changes indicate raised intraocular pressure which can cause visual loss
- A small cat's paw retractor can be used to retract the medial canthus medially to 'open up' the surgical portal between the ribbon retractor and the cat's paw
- Continue the dissection in the subperiosteal plane, dissecting more superiorly towards the level of the nasion with the suction Freer elevator
- The first structure encountered is ***Horner's muscle***
- The dissection may well be more posterior to Horner's muscle, so if it is not easily identified then proceed to find the next landmark
- Try to identify the ***frontoethmoidal suture line***
- If this is not possible, then determine the level of the ***nasion*** – this is the level at which the ethmoidal vessels will be found

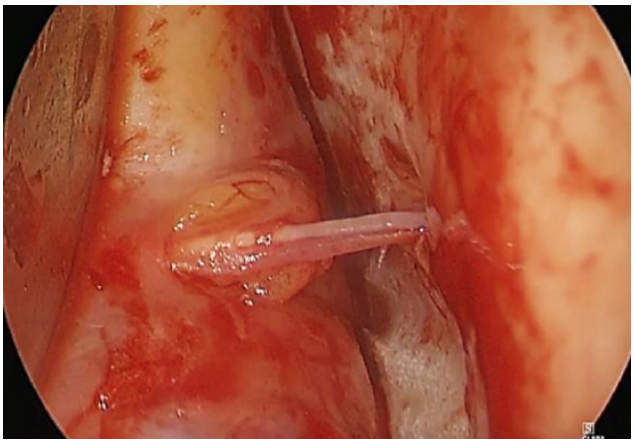


Figure 16: Right eye; anterior ethmoidal artery with a bit of fat herniating through the periorbital fascia

- Find the ***anterior ethmoidal artery***; it is easily identified as a 'tenting structure' as the suction elevator elevates the periosteum off the bony orbital wall (*Figure 16*)
- A bit of ***orbital fat*** often herniates through the periorbital fascia where the artery exits the orbit (Video). This fat can also be used as a landmark to find the artery. In about 50% of females this fat is a constant landmark for the artery (*Figure 16*)

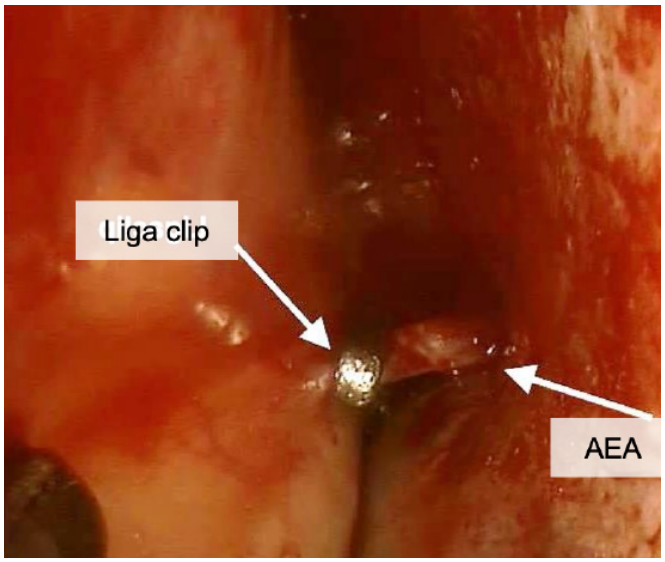


Figure 17: Right eye; anterior ethmoidal artery (AEA) has been clipped as the artery leaves the orbit

- Use a standard tonsil ***bipolar*** forceps to ***cauterize*** the ***anterior ethmoidal artery*** or apply a ***ligaclip*** (*Figure 17*)

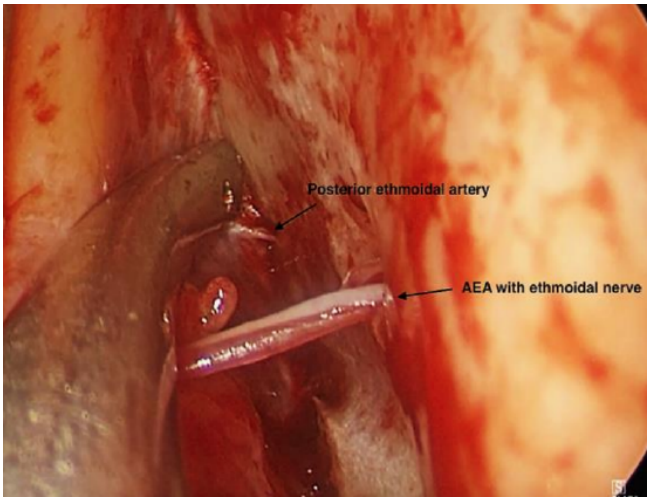


Figure 18a: Posterior ethmoidal artery 12 mm posterior to AEA

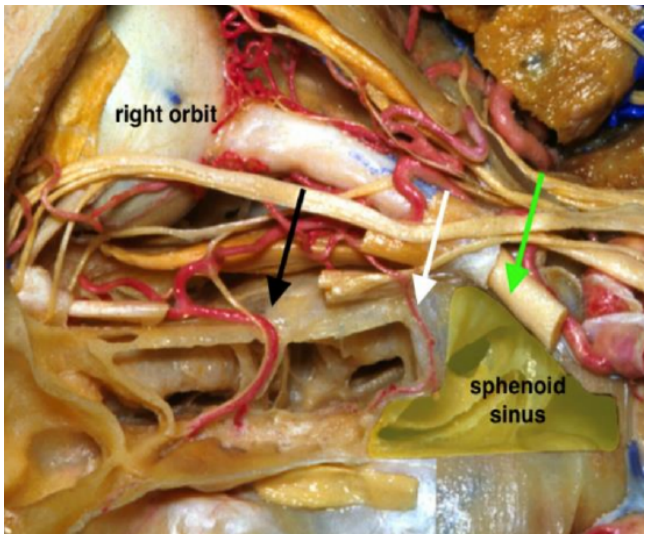


Figure 18b: Note close proximity between the AEA (black arrow), PEA (white arrow), and optic nerve in optic canal (green arrow)

- Find the ***posterior ethmoidal artery*** 12 mm behind the anterior ethmoidal artery (Video) (*Figures 18ab*)
- It is important to remember that there are often ***small accessory ethmoidal arteries*** and that the ***posterior ethmoidal artery may be absent***
- It is imperative to ***ensure that the optic nerve is not confused for the posterior ethmoidal artery***. Therefore contemplate carefully before ligating what you think is the posterior ethmoidal artery

Deciding how to proceed at this point depends on the indication for using the precaruncular approach

- If the aim of the surgery was to ligate the vessels, the surgical portal is irrigated with saline and nasal endoscopy is done to check that hemostasis has been achieved
- There is no need to suture the precaruncular incision

Precaruncular approach as extra portal during multiportal surgery for access to posterior orbit and for optic nerve decompression



Figure 19: Multiportal surgery using combined precaruncular and binostril approaches for optic nerve decompression

These procedures require retraction of the orbital contents. They may be combined with an ipsilateral endonasal approach, or a binostril approach (*Figure 19*, video). However, a precaruncular approach can be used on its own without an endonasal approach, thereby preserving the normal sinus anatomy.

Indications for precaruncular approach to decompress the orbit include

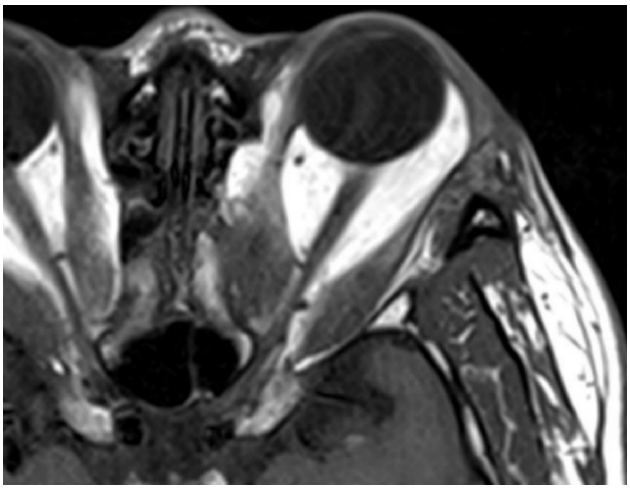


Figure 20: Previous medial decompression for thyroid eye disease with prolapse of orbital fat, making access to the posterior orbit and optic nerve difficult using a purely endonasal approach

- Thyroid orbitopathy (*Figure 20*)
- Severe proptosis
- Previous medial decompression has been performed and further decompression is required (*Figure 20*)

Optic nerve decompression involves the following steps



Figure 21: Optic nerve (blue arrow) within optic canal. Single red arrow shows where lamina is removed during optic nerve decompression. Double red arrow shows extent of decompression needed

- Remove the posterior 1/3 of the lamina papyracea by fracturing the lamina towards the ethmoid sinuses and away from the periorbita (*Figure 21*)
- Keep the nasal mucosa intact if an endonasal approach is not required

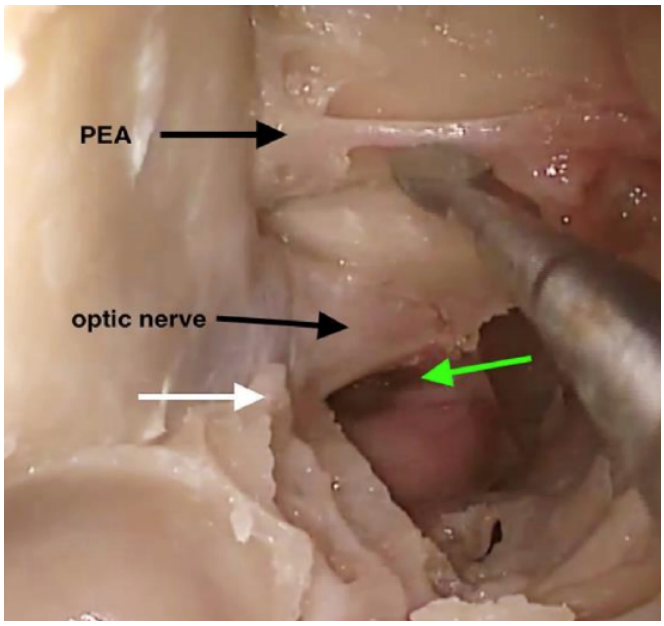


Figure 22: Right optic nerve decompression from the optic protuberance (white arrow) to the opticocarotid recess (green arrow)

- The optic canal is found just below the level of the ethmoidal arteries (*Figures 11, 17ab, 22*). Therefore, ensure that dissection is carried out at this level
- Once the anterior face of the sphenoid is identified, the posterior ethmoidal artery can be visualized at the angle where the superior aspect of the sphenoid sinus face meets the skull base (*Figure 22*)
- Decompress the optic canal for a distance of 1 cm from the optic protuberance to the opticocarotid recess (OCR) (*Figure 22*)

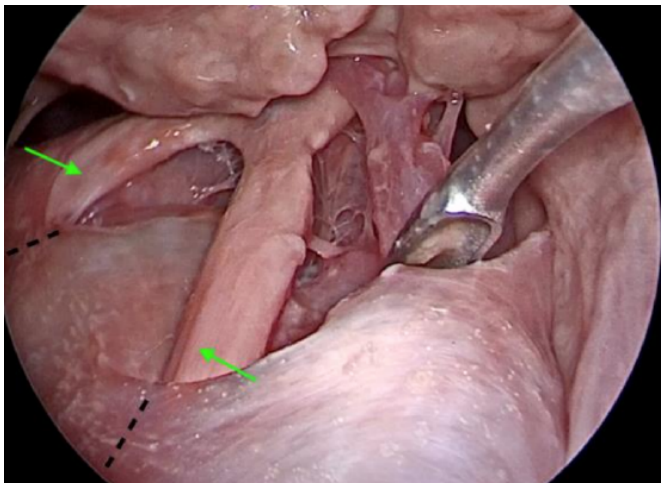


Figure 23: Optic nerves as seen from above through a lateral transorbital approach with 70-degree endoscope. Image shows the intracranial component of the optic nerves (green arrows) as it leaves the optic canal (black interrupted lines)

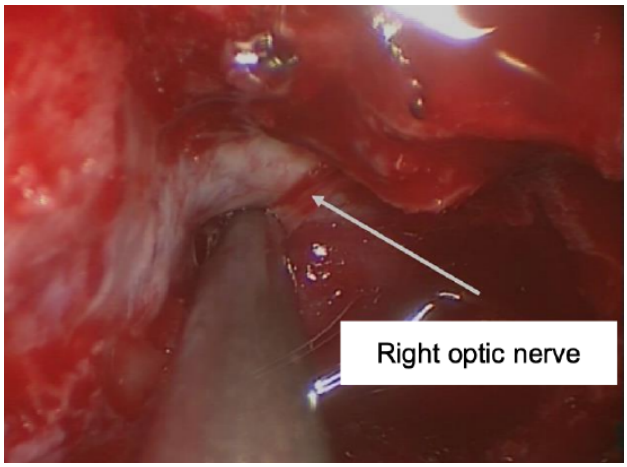


Figure 24: Right optic nerve decompression from the optic protuberance to the OCR

- Beyond the opticocarotid recess the optic nerve runs intracranially. Decompression beyond this point is unnecessary unless the optic chiasm itself needs to be decompressed (*Figures 23, 24*)
- It is not the author's practice to fenestrate the optic nerve sheath during optic nerve decompression

Precaruncular approach to medial orbital tumors

The precaruncular approach can be used to access ***intra- or extraconal lesions*** involving the medial orbit. ***Cavernous hemangioma*** is one of the most common pathologies encountered within the orbit and the precaruncular portal is the most minimally invasive approach to remove these lesions. It is important to study the ***imaging (CT and MRI) preoperatively*** and to assess the location of the lesion in relation to important orbital structures – the rectus muscles and the respective nerves that innervate them and vessels that supply them. An ***ophthalmological examination*** is essential, and all cases should be done in conjunction with an ophthalmologist.

- Incise the periorbital fascia

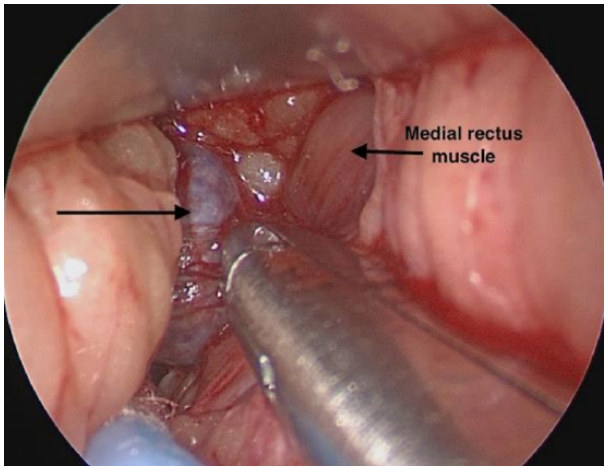


Figure 25: Right eye; precaruncular approach to intraconal cavernous hemangioma (black arrow)

- Dissect bluntly to the lesion as previously described (*Figure 25*)
- Neurosurgical patties can be used to help retract fat during dissection
- No reconstruction is required as the medial wall of the orbit is not breached during surgery

Postoperative management

- At conclusion of the surgery, irrigate the surgical portal with normal saline
- It is important to ensure that adequate hemostasis has been achieved and that the ethmoidal arteries have been cauterized or ligated

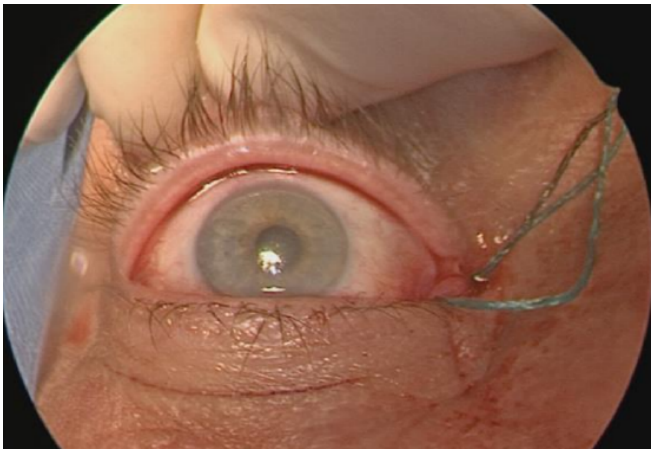


Figure 26: There is no need to suture the precaruncular incision. It is important to examine the pupil for asymmetry. Green threads are from neuropattie that is still in situ for hemostasis, and will be removed before end of surgery

- The surgical incision site is not sutured (*Figure 26*)
- It is important to check the patient's vision and eye movements immediately after surgery
- A cold pack can be applied over the eye for a few minutes every hour in the first 24 hours to prevent bruising in the medial canthal area
- Topical chloromycetin ointment is applied in the corner of the eye for 3-5 days following surgery

References

1. Shin HJ, Gil YC, Shin KJ, et al. Identification of the trochlea with reference to the lacrimal caruncle, and its significance as a landmark in orbitofacial surgery. J Plast Reconstr Aesthet Surg. 2015 Mar;68(3):351-5
2. Cornelis M, Lubbe DE. Clin Otolaryngol. Pre-caruncular approach to the medial orbit and landmarks for anterior ethmoidal artery ligation: a cadaveric study. 2016 Dec;41(6):777-81

Author

Darlene Lubbe MBChB, FCORL
Associate Professor
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
doclubbe@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ENDOSCOPIC TRANSSPHENOIDAL (ETSS) PITUITARY SURGERY TECHNIQUE

Moses Penduka, Patrick Semple, Darlene Lubbe

Endoscopic transsphenoidal pituitary surgery (ETSS) is generally indicated for patients with symptomatic pituitary micro and macroadenomas causing symptoms such as visual loss, headaches or hormone associated problems. It has become the standard approach, surpassing traditional microscopic approaches, although the literature does not conclusively prove which approach is superior with regards to complications and outcomes. The superiority of the endoscopic approach lies with better light penetration at the target area, improved visualization provided by angled telescopes, minimal collateral tissue damage with quicker recovery than with an open approach and preservation of intranasal anatomy and function. Access to the pituitary fossa in revision endoscopic transsphenoidal surgery is much quicker and less invasive than other approaches because the bony surgical corridor has already been made.

Endoscopic Anatomy

The transnasal transsphenoidal approach to the pituitary implies that the surgical corridor is created by working medial to the middle turbinates. A single nostril or bilateral approach can be used depending on whether one or two surgeons are working simultaneously and whether multiple instruments need to be manipulated at the target area. For small microadenomas, some surgeons use a single nostril approach. This usually means the mucoperichondrium of the septum from one side can be preserved. For a bilateral approach, a partial posterior septectomy is required.

ETSS is divided into 3 stages

1. Nasal stage
2. Sphenoid stage
3. Sellar stage

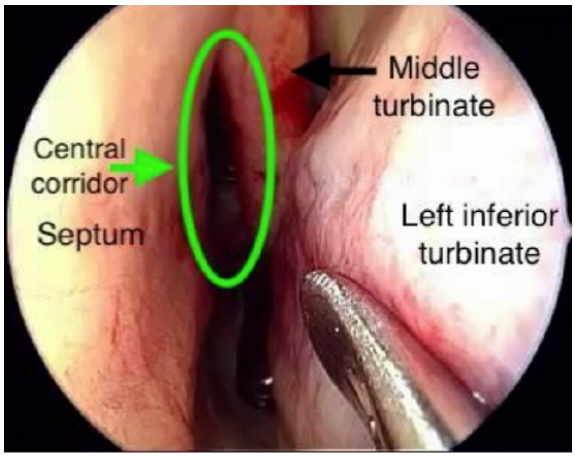


Figure 1: Initial view during nasal stage

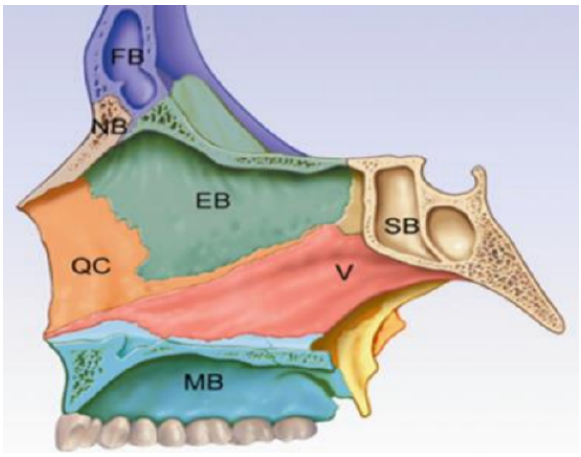


Figure 2: Nasal septum. QC: Quadrangular cartilage, EB: Ethmoid bone, V: Vomer, SB: Sphenoid bone, MB: Maxillary bone


Figure 3: Right-sided septal spur

During the ***nasal stage***, it is important to identify the anatomy of the related structures and to identify any anomalies that may hamper access to the pituitary fossa (*Figures 1-3*)

- Nasal septum: septal deviations, perforations, or a septal turbinate
- Inferior turbinates: hypertrophied turbinates
- Middle turbinates: concha bullosa, paradoxical turbinate
- Structures lateral to middle turbinate: uncinate process, ethmoid bullae - signs of infection draining from the maxillary sinus, nasal polyps
- At level of skull base: attachment of septum to cribriform plate. Olfactory mucosa at 1 cm superior aspect of septum to be preserved

The Open Access Atlas chapters on Endoscopic ethmoidectomy and Sphenopalatine artery ligation provide further detail of the anatomy of these structures.

Nasal septum

Anatomical anomalies are common and that these may affect access and hinder the creation of an adequate surgical corridor for manipulation of multiple instruments using a binasal approach. It is important to perform anterior rhinoscopy at the initial ENT consultation to assess the need for a septoplasty. Performing a septoplasty may lengthen the time of the procedure and it is important to plan for this beforehand. Septal anomalies may include:



Figure 4: CT radiograph showing right sided septal spur

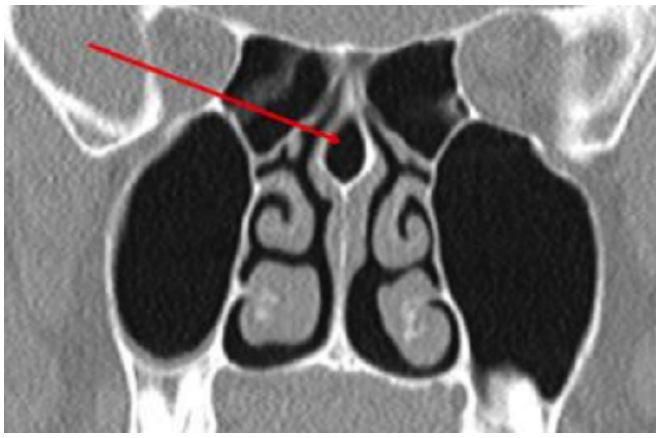
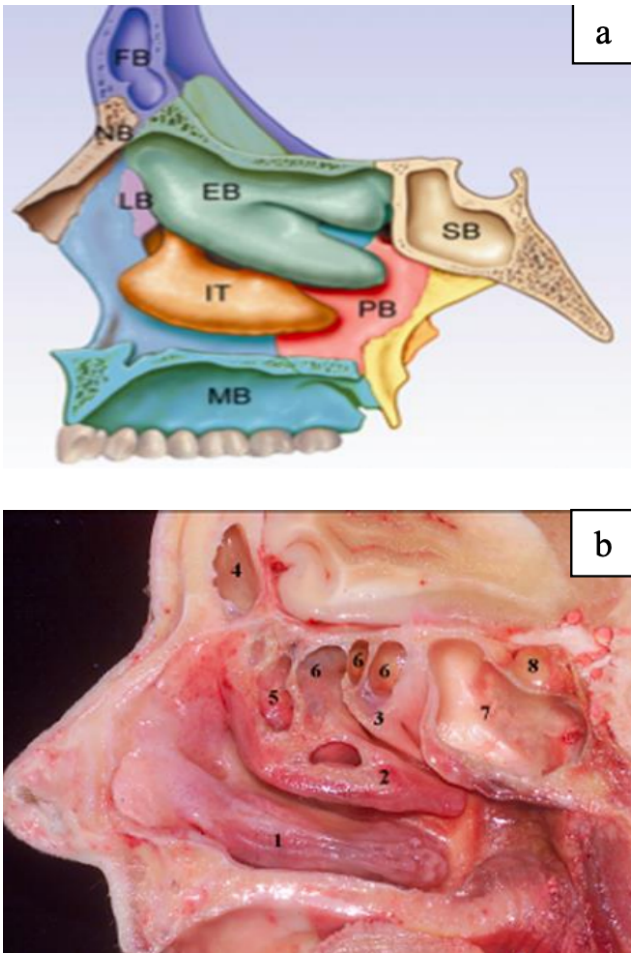


Figure 5: CT radiograph showing a septal turbinate

- ***Septal spurs*** can be removed with a simple Killian's incision placed anterior to the spur (*Figures 3, 4*; Video clip)
- ***Septal deviations*** may require a formal septoplasty via a hemitransfixion incision before creating the surgical corridor. Harvesting a ***septal mucoperichondrial flap*** needs to be kept in mind since it is easier to elevate the flap with the perpendicular plate of the ethmoid and vomer still intact. Therefore, elevate the flap before a septoplasty is done
- ***Septal turbinates***: It is important to recognize the presence of a ***pneumatized posterior septum*** since entering this 'cavity' can be misleading and an inexperienced surgeon may think the sphenoid sinus has been entered (*Figure 5*)

Lateral wall of nasal cavity



Figures 6a, b: Anatomy of the lateral wall. The top figure illustrates the various bones that form the lateral wall; IT (inferior turbinate), EB (ethmoid bone), SB (sphenoid bone), PB (palatine bone), LB (lacrimal bone). The lower figure illustrates the inferior, middle and superior turbinates (1, 2 & 3) and related air cells; frontal (4), agger nasi (5), ethmoid cells (6) and sphenoid sinus (7). The superior turbinate is an important landmark for the sphenoid sinus ostium



Figure 7: Attachment of middle turbinate to the skull base

Figures 6ab illustrate the anatomy of the lateral nasal wall of the nose. It is important to remember that the middle turbinate attaches to the skull base and that undue manipulation of the middle turbinate could lead to a fracture at the point where the middle turbinate attaches to the lateral lamella of the cribiform plate (*Figure 7*). This may cause a CSF leak.

Anatomical anomalies involving the turbinates are also common and include

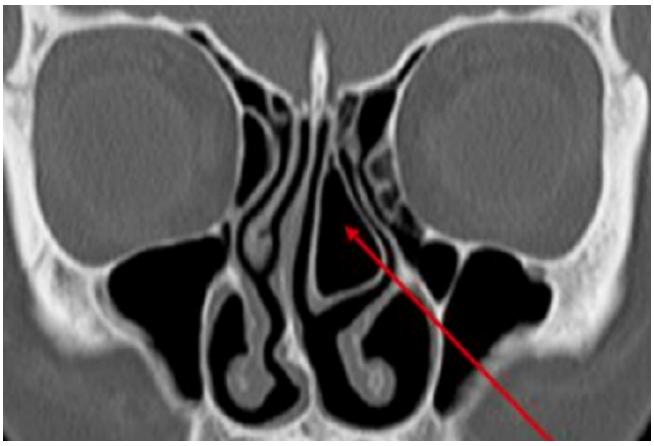
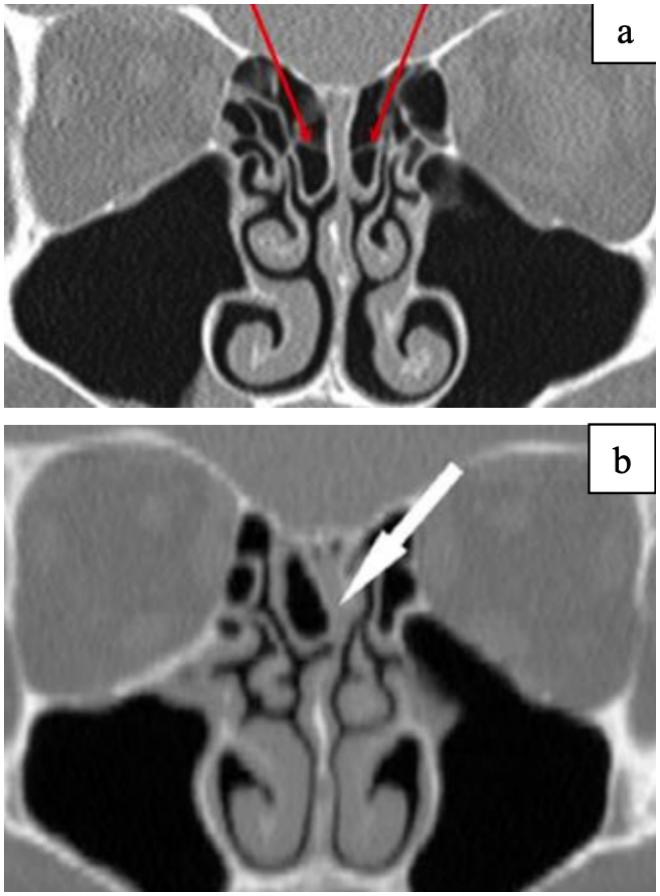


Figure 8: Concha bullosa of middle turbinate



Figures 9ab: Superior turbinate conchae

- Inferior turbinate hypertrophy
- Turbinate conchae (concha bullosa) (*Figures 7, 8, 9ab*)
- Paradoxical/duplex middle turbinates

It is important that the olfactory epithelium be protected when working on these structures. Olfactory mucosa should be preserved in the following areas:

- Mucosa of superior-medial aspect of the middle turbinate
- Superior aspect of superior turbinate
- Superior aspect of the septal mucosa (superior ½ in relation to the height of the middle turbinate)

Sphenoid sinus

The sphenoid sinus must be approached after carefully reviewing the preoperative radiographs as anatomical variations are common. The ostium should be located prior to elevating the mucoperichondrial septal flap.

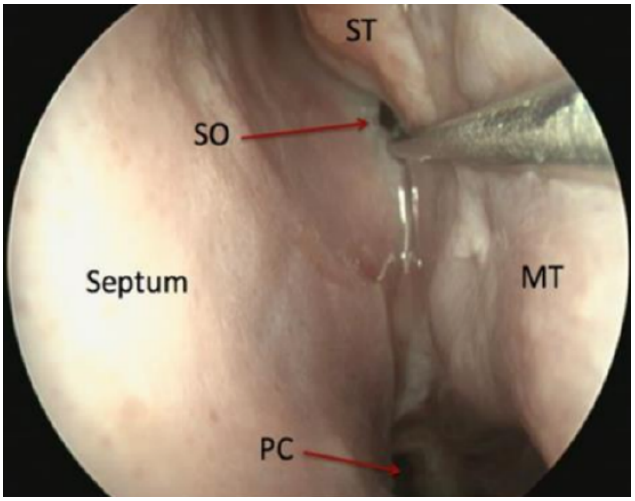


Figure 10: View of the sphenoid sinus ostium (SO) in sphenoethmoidal recess; this ostium is 2½ sucker tips above the posterior choana (PC)

The ***sphenoid ostium*** is located medial to the superior turbinate in about 85% of individuals at a ***level horizontal to the superior border of the natural ostium of the maxillary sinus*** (*Figure 10*).

It ***can also be easily located by counting about 2½ sucker tips above the posterior choana***.

- Pass the endoscope to the posterior aspect of the nasal cavity
- Locate the posterior aspect of the middle turbinate
- Then gently lateralize the posterior aspect of the middle turbinate
- Slide the 0-degree endoscope into the area between the middle turbinate and the nasal septum
- Identify the superior turbinate
- Use a Freer suction elevator to gently palpate the sphenoid face just medial to where the mid-1/3 of the superior turbinate meets the lower 2/3 of the turbinate
- The Freer should easily slide into the natural ostium
- Turn the Freer sideways to open the membranous part of the sphenoid ostium
- Commence the mucoperichondrial septal flap at this level to avoid injury to the posterior septal artery which lies just below the ostium

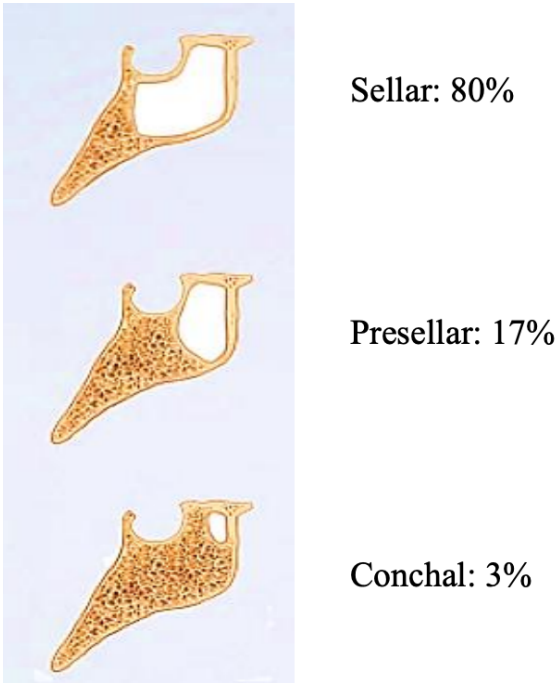


Figure 11: Variations in the sellar configurations



Figure 12: Variety of sphenoid intersinus septum configurations

In a study by Ossama et al variations of the sphenoid sinus include pneumatization, sellar configuration (*Figure 11*) and septation (*Figure 12*).

Pneumatisation affects access to the sella especially if the sellar bulge is ill-defined. Intersphenoid and accessory septa may attach laterally to the carotid prominence (*Figure 12*). As a rule, one should assume that any septa may attach to the carotid canal and assess this risk carefully on imaging before ETSS.

The posterior branch of the sphenopalatine artery (posterior septal artery) must be preserved as it is the basis of the Hadad Bassagastagy flap. It runs across the face of the sphenoid below the sphenoid ostium to supply the posterior septum. This blood vessel can be sacrificed on the opposite side, but care must always be taken with this vessel since it is the most common reason for significant postoperative bleeding requiring further surgery to arrest the bleeding.

Preoperative consent

A team approach to the workup of a patient is of utmost importance and should include the neurosurgeon and rhinologist. The patient must be informed of both the medical and surgical complications that may follow pituitary surgery that include:

- Diabetes insipidus
- Endocrine abnormalities and remission outcomes

- Visual outcomes
- Postoperative CSF leaks and their management, including meningitis
- Rhinologic complications such as adhesions, perforations, sinusitis, mucocoele formation
- Carotid artery injury
- Postoperative sellar hematoma
- Mortality

Anesthesia, positioning and draping

- The authors administer intravenous Cefazolin 1 gm at commencement at induction of anesthesia
- The surgical setup is similar to most endoscopic sinonasal procedures (see chapter on Endoscopic ethmoidectomy)
- General anesthesia with total intravenous anesthesia (TIVA) is preferred to achieve a normotensive state with low pulse rate
- A throat pack is not routinely used in our unit due to subsequent throat discomfort and the risk of patients swallowing the pack during the end of anesthesia. Others insert a throat pack to minimize risk of aspiration and swallowing of blood which may cause gastritis with postoperative nausea and vomiting
- The patient is placed supine with the head slightly flexed, elevated and turned towards the operating surgeon who usually stands on the right of the patient (right-handed surgeon)
- Cover the eyes with transparent adhesive plastic sheeting



Figure 13: Pituitary preparation with the eyes and nose visible after draping

- Drapes are placed so that both eyes and the nasal cavity are visible (*Figure 13*)

Surgical steps

Numerous surgical steps must be followed to ensure an uneventful surgical exposure and pituitary resection:

1. Field preparation: preoperative packing and infiltration
2. Optimizing access: septoplasty, turbinate surgery
3. Identifying sphenoid ostium
4. Raising mucoperiosteal flap
5. Posterior septectomy and sphenoidectomy
6. Reducing sphenoid septations and exposing the sella
7. Sellar stage of endoscopic pituitary surgery
8. Closure of surgical corridor
9. Postoperative care

1. Field preparation

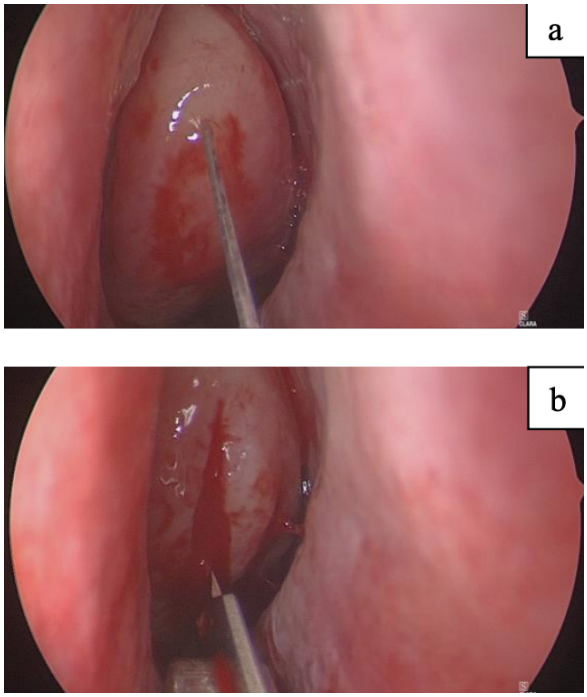
Topical decongestion is achieved as described in the chapter on Endoscopic Ethmoidectomy.

- Neuropatties soaked with a mixture of 2 ampoules of 1:1000 adrenaline diluted with 1 mL oxymetazoline, achieve optimum decongestion
- Place the patties between the septum and the inferior and middle turbinates

- If possible, place a pattie between the septum and the middle turbinate. This makes elevation of the sphenoid ostium easier
- Allow at least 10 minutes of decongestion by packing the nasal cavity before the scrub nurse preps and drapes the patient
- Further decongestion is achieved at the start of the surgical procedure by submucosal injection with Xylotox into the inferior turbinate, middle turbinate and septum. This gives the added advantage of hydro-dissection for the Hadad flap that will be elevated off the septum. Be careful not to inject too rapidly as this may cause a rapid rise in blood pressure which may be detrimental especially in the elderly hypertensive patient. Very little (0.1 mL) Xylotox is injected into the inferior turbinate, and very slowly, as this structure is extremely vascular

2. Optimizing access

- ***Inspect the nose*** with the endoscope using the traditional 2-pass strategy. This is important in order to appreciate the anatomy and characteristics of any abnormalities that might be present
- ***Out-fracture the inferior turbinates*** using a Freer's dissector to improve access. Placed in the inferior meatus, the Freer's dissector is used to first infracture the inferior turbinate then placed medially to out-fracture



Figures 14 ab: Incising a concha bullosa

- If a ***concha bullosa*** has been identified it is ***reduced on its medial aspect*** to widen the transnasal corridor (vs lateral reduction required during FESS surgery). First confirm its presence by entering the concha using the needle of a dental syringe. A "give" is easily felt and is confirmed by unrestricted flow when injecting into this space. Enter the concha with a 12-scalpel blade and divide it along its length anteriorly and inferiorly (*Figure 14*). A through-biting instrument is then used to remove the medial aspect of the concha
- ***Septoplasty*** may not be required if a concha bullosa has been reduced. It will however be required if a septal spur compromises access. The technique for septoplasty is described in the chapter on septoplasty. It is important to remember that the Hadad flap will be raised and caution should be taken not to compromise the blood supply to the flap when doing the septoplasty. It is important to stay above the level of the sphenoid ostium when making the superior cut of the mucoperichondrial septal flap. A posterior septectomy is required for the binasal approach after the mucoperichondrial flap has been elevated on one side. The perpendicular plate of the ethmoid and the vomer and the opposite septal mucosa can be removed to create the posterior septectomy and corridor to the sphenoid sinus.

3. Identifying the sphenoid ostium

The sphenoid sinus ostium can be easily identified using the transethmoidal or transnasal corridors. However, in this instance, a middle meatal antrostomy and ethmoidectomy are hardly indicated. The only indication for doing a middle meatal antrostomy and ethmoidectomy would be for patients with concomitant sinus disease to avoid postoperative infection from these infected sinuses.

- Using the transnasal midline corridor between middle turbinate and nasal septum (*Figure 1*), the ostium is identified medial to the lower 1/3 of the superior turbinate
- The distance between the sphenoid sinus ostium and the posterior choana is gauged by counting 2½ sucker tips from the choana superiorly, staying medial to the superior turbinate (between superior turbinate and septum) (*Figure 10*)
- Once the ostium is located it is initially widened superiorly and medially
- Inferiorly, the posterior septal artery will be encountered
- On the side that the mucoperichondrial flap has been elevated, the artery must be preserved
- On the opposite side it can be sacrificed to drill the rostrum down to the floor of the sphenoid sinus
- The sphenoidotomy is widened using mushroom punch forceps, a Kerrison punch or endonasal drill

4. Raising mucoperiosteal flap

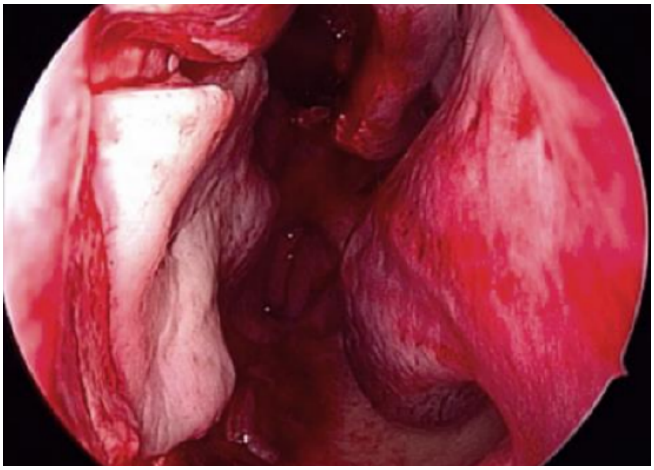


Figure 15: Harvesting the Hadad flap from the left nasal septum

The Hadad flap is important to repair CSF leaks, a known complication of skull base surgery (*Figure 15*). It is a robust, vascularized flap based on the posterior septal artery. ***Remember the anatomical relationships of the posterior septal artery to the sphenoid sinus ostium and the olfactory epithelium to preserve the blood supply to the flap***.

- The authors prefer to create the flap on the left side to avoid neurosurgical instruments damaging the flap. The endoscope is usually held on the same side as the flap by the ENT surgeon while the neurosurgeon works on the opposite side, thereby avoiding damage to the flap
- The boundaries of the flap are
  - Medial aspect of sphenoid sinus ostium
  - Anteriorly, to just in front of the anterior end of the middle turbinate at a level of the midpoint of its height
  - If additional length is required for a large CSF leak, the flap can be extended via a hemitransfixion incision onto the floor of the nose, lateral to the inferior turbinate
- Outline the flap using suction diathermy to ensure minimal bleeding
- Cut the mucoperiosteum down to the bone/cartilage along the boundaries described above, using a 15-blade or a Cottle dissector
- Elevate the flap in a submucoperiosteal plane as during a septoplasty
- Dissect from anterior-to-posterior up to the rostrum
- Once the anterior cut has been made and mucosa lifted, a turbinectomy scissors can be used to make the superior cut
- The inferior cut is only made if the flap is to be used for repair of a CSF leak
- If only a superior cut was made, then the flap is rolled inferiorly and out of the way of the surgical corridor
- If no CSF leak occurs, the flap is replaced to close the posterior septectomy defect
- Suture the middle turbinates on either side of the flap (Videoclip)

5. Posterior septectomy and sphenoidectomy

- A posterior septectomy is required to fully expose the anterior face of the sphenoid sinus (Videoclip)
- Once the flap has been raised, parts of the sphenoid face and bony septum are exposed
- The bony posterior septum is quite thin

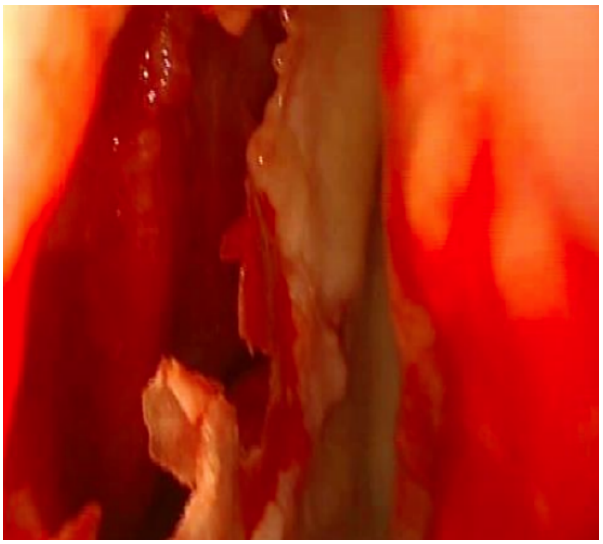


Figure 16: Posterior septectomy. Note the contralateral septal mucoperiosteum which may be sacrificed using back-biting forceps or a microdebrider

- Therefore, a posterior septectomy is performed by simply fracturing the perpendicular plate of the ethmoid with a Freer's elevator and with back-biting forceps. Remove bone using Blakesley forceps (*Figure 16*)
- Elevate mucosa off the contralateral sphenoid sinus ostium using a Freer's elevator
- Cauterize the mucosa of the sphenoid ostia using monopolar suction cautery



Figure 17: Kerrison punch (above) and tip of mushroom punch

- Remove the bone between the ostia with a Kerrison punch, mushroom punch (*Figure 17*), endonasal drill or hammer and chisel
- Lower the sphenoid face to the floor of the sphenoid sinus to allow instrumentation of the pituitary fossa
- Fully expose the sella

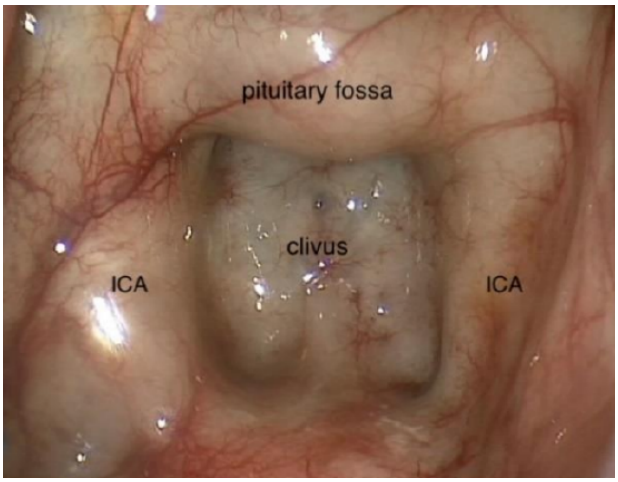


Figure 18: Sella, clivus, and internal carotid arteries (ICA)

- Identify the internal carotid arteries within the sphenoid sinuses (*Figure 18*)

6. Reducing sphenoid septations and exposing sella

- All sphenoid septations attached to the pituitary fossa are drilled down to expose the entire pituitary fossa
- ***Be extremely careful when reducing the sphenoidal septations*** as they may be attached to the internal carotid arteries (*Figure 12*). Therefore, sphenoidal septations must be reduced using through-biting instruments or a diamond drill
- Drill down the anterior wall of the pituitary fossa until only a thin eggshell of bone is left over the pituitary tumor or gland

7. Sellar stage of endoscopic pituitary surgery

The neurosurgeon performs the 2nd part of the surgery i.e. resection of the pituitary tumor. The ENT surgeon therefore moves to the opposite side of the table or to the head to manipulate the zero-degree 30 cm endoscope for the neurosurgeon.

- It is our practice for the otolaryngologist to hold the endoscope while the neurosurgeon uses two instruments in both hands to resect the pituitary tumor
- Both nostrils are used for access (binasal approach)
- With experience, the two surgeons become accustomed to working as a team and the movement of the endoscope and instruments become well-coordinated
- With the floor of the sella exposed, the neurosurgeon identifies the planum, optic prominences, opticocarotid recesses, carotid prominences and can identify the entry point to start the pituitary dissection (*Figure 18*)
- Use neuronavigation to confirm bony structures and the trajectory of the proposed opening in the floor of the sella
- The floor is usually very thin with macroadenomas
- Open the floor of the sella initially using a dissector and then a Kerrison upcutting forceps (*Figure 17*)
- If the floor is thicker it can safely be thinned using a drill prior to opening it
- The size of the opening is dependent on the size of the sella and the distance between the two carotid arteries, but should be large enough for insertion of instruments and to present an adequate view of the adenoma for its removal
- Neuronavigation provides added safety by using it to define the size of the opening, particularly relating to the internal carotid arteries, optic nerves and anterior fossa floor
- If neuronavigation is not available, then fluoroscopy can be used although it is limited to a lateral view
- Once an adequate opening in the floor of the sella has been made then the dura is incised
- Prior to incising dura, our practice is to use a Doppler at the proposed incision site to ensure that the carotid artery is not underlying and where it may be injured
- Open the dura with a cruciate incision or as an inferiorly based dural flap
- The tumor/adenoma now becomes visible, prolapsing through the opening
- Obtain a biopsy with a rongeur
- Most pituitary adenomas are soft; using an endoscopic approach is dependent on this characteristic
- If the pituitary adenoma is hard and firm and cannot be removed by a combination of curettage and suction, then this approach should be abandoned as there is an extremely high risk of injury to surrounding structures when the tumor is forcibly delivered
- Ideally, use 2 suction cannulae to methodically remove the tumor from the sella until the posterior capsule is seen

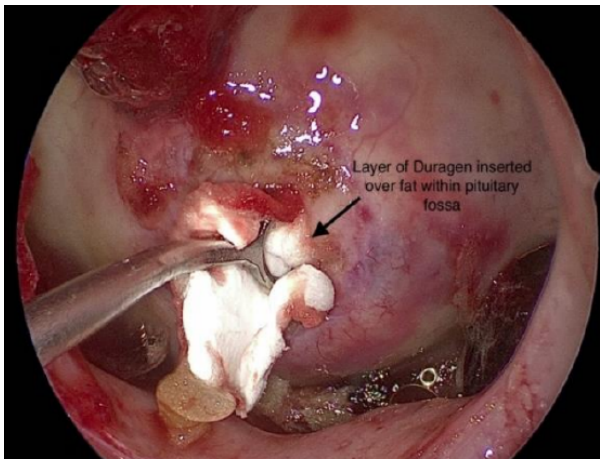
- Then proceed to remove tumor laterally up to the wall of the cavernous sinus
- A curette is used in conjunction with the 2 suction cannulae to remove tumor that is difficult to suck away
- The aim is to completely empty the sella of tumor and to allow suprasellar tumor to descend into the sellar field and to be removed
- Most of the surgery is done with a 0- degree endoscope, but a 30-degree endoscope can used to view and remove suprasellar and lateral tumor
- Neuronavigation can also be used at this stage to confirm the position of the instruments with regard to the image of the tumor as well as the position of other bony and neurological structures. However, it is important to realize that the navigation is not in real time and as the tumor is removed the position on the image is no longer accurate, except for the bony landmarks
- When working laterally in the region of the cavernous sinuses, a Doppler may again be useful to locate the internal carotid arteries and to protect them from injury
- Once the majority of the tumor has been removed, the capsule/arachnoid will often descend into the operative field/sella. This is inspected and any residual pockets of tumor identified and gently removed
- It is important to realize if the tumor is soft, it may rapidly be removed, and the capsule may come into view very early in the procedure – so the operator must be aware of this to prevent an arachnoid tear and an unnecessary cerebrospinal fluid (CSF) leak
- Obtain hemostasis by gentle irrigation
- If the tumor has been completely removed, then bleeding is generally minimal
- More time may be required to ensure hemostasis when there is residual tumor
- Inspect the surgical field for a CSF leak
- The anesthetist can provide positive end-expiratory pressure (PEEP) to assist the descent of suprasellar adenoma and to ensure there is no CSF leak
- If a CSF leak is identified, then a repair needs to be done
- We generally do not reconstruct the defect in the floor of the sella, but usually fill the sphenoid sinus with fat or Surgiflo

8. Closure of surgical corridor

- The ENT surgeon now resumes control of the surgery to repair and reconstruct nasal structures as required
- If no CSF leak has occurred during the surgery, the Hadad flap is laid back over the septal defect. A suture is placed anteriorly to anchor the flap where the anterior incision was made and to secure it to the nasal septum, similar to septoplasty surgery. A suture can also be placed through the middle turbinate and septum to secure the flap
- Nasal plugging is not used, but a simple dressing is applied to the external nose

9. Postoperative care

- Postoperative antibiotics are not routinely given
- Patients are transferred to the neurosurgical intensive care unit for observation, specifically to monitor for a CSF leak, level of consciousness (GCS), signs of visual compromise and inappropriate antidiuretic hormone secretion (SIADH)
- Patients usually stay in ICU for 3-5 days post-surgery to monitor for SIADH. SIADH is the most important reason for postoperative monitoring in ICU. Electrolytes and fluid must be replaced if SIADH occurs
- Topical Oxymetazoline and a saline nasal spray are commenced on Day 1 following surgery for a period of 5 days
- ***If a postoperative CSF leak is noticed***
    - ***Immediate repair*** is required using fat harvested from the abdomen



- *Figure 19: Repair of a CSF leak*
- This can be followed by a layer of fascia lata or Duragen (*Figure 19*)
- A Hadad flap is used if needed
- Lumbar drains are not routinely used

- Patients are followed up at a combined pituitary clinic where the neurosurgeon, endocrinologist and oncologist make decisions regarding need for hormone replacement, radiotherapy and long term follow-up
- Patients see an endocrinologist regularly to discuss hormone replacement therapy
- A follow-up MRI is done at 3 months
- It is usually not necessary for ENT follow-up if the surgical corridor has been closed. However, if turbinectomies or a posterior septectomy has been performed, regular debridement will be necessary. This can be avoided by careful creation and closure of the surgical corridor (Video taking down adhesions)

Authors

Moses Penduka MBChB, FCORL
University of Cape Town Karl Storz Rhinology Fellow
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
mfpenduka@yahoo.co.uk

Patrick Semple MMed, FCS (Neurosurg), PhD
Professor
Division of Neurosurgery
University of Cape Town
Cape Town, South Africa
patrick.semple@uct.ac.za

Darlene Lubbe MBChB, FCORL
Associate Professor
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
doclubbe@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

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EXTERNAL ETHMOIDECTOMY & FRONTAL SINUSOTOMY/TREPHINE

Johan Fagan, Neil Sutherland, Eric Holbrook

External approaches to the frontal, ethmoid and maxillary sinuses are seldom used nowadays other than in centers in the developing world where endoscopic sinus surgery expertise and instrumentation are not available; CT scans are also often not available in such centers to permit endoscopic sinus surgery to be properly planned and safely executed.

Some indications for open approaches

- ***Drainage of an orbital abscess***
- ***Ethmoid artery ligation for epistaxis***
- ***External ethmoidectomy***
  - Sinus pathology when endoscopic surgery expertise and instrumentation not available
  - Biopsy of tumors
  - Transethmoidal sphenoidotomy
- ***External frontal sinusotomy/trephination***
  - Complicated acute frontal sinusitis
  - Pott's puffy tumor
  - Lateral frontal sinus mucocele
  - Repair of frontal sinus CSF leak
  - Biopsy of tumors
  - Removal of osteomata
  - Frontal sinus obliteration

The ***classic external frontoethmoidectomy*** operation entailed removing the lamina papyracea, opening and stripping the mucosa from the ethmoid sinuses up to cribriform plate, nibbling away the lateral wall of the frontonasal duct and floor of the frontal sinus, and stripping the mucosa from the frontal sinus.

This classic external frontoethmoidectomy operation is however contrary to modern principles of endoscopic sinus surgery which include:

- Limiting surgery to diseased sinuses
- Sparing mucosa
- Avoiding surgery to the frontal recess and frontonasal duct
- Preserving the middle turbinate
- Limiting resection of lamina papyricea to avoid medial prolapse of orbital soft tissues

This chapter focuses on the relevant surgical anatomy and techniques of external ethmoid and frontal sinus surgery, and incorporates principles borrowed from our current understanding of sinus anatomy, pathophysiology, and endoscopic sinus surgical techniques.

Anatomy of ethmoid & frontal sinuses

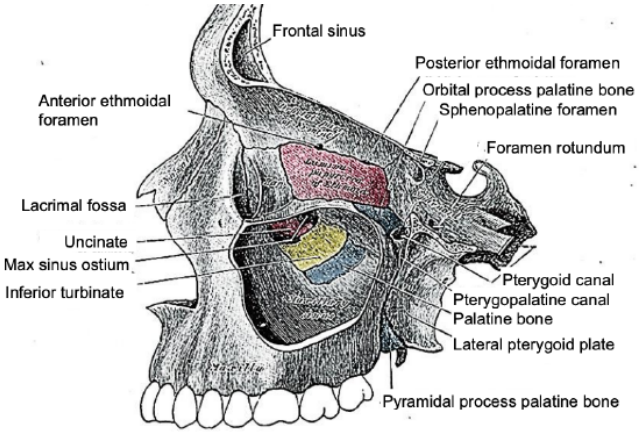


Figure 1: Lateral view of maxilla with windows cut in lateral and medial walls of left maxillary sinus

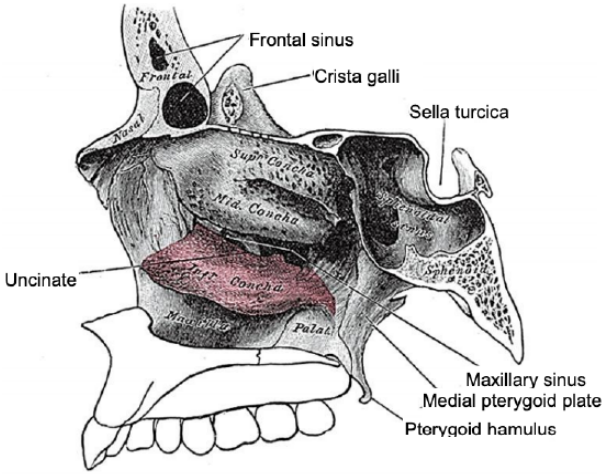


Figure 2: Bony anatomy of the lateral wall of the right nose

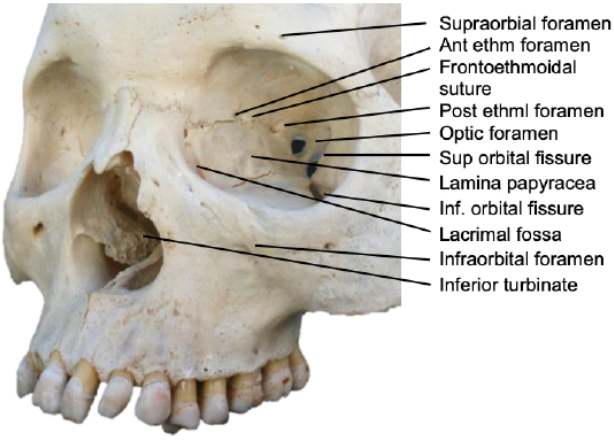


Figure 3: Bony anatomy in cadaver

Figures 1-3 illustrate the detailed bony anatomy relevant to external ethmoidectomy. *Figure 2* illustrates the bony anatomy of the lateral wall of the nose.

Figure 3 demonstrates the anatomy of the medial wall of the orbit in a cadaveric skull; note in particular the thin lamina papyracea, the lacrimal fossa, the frontoethmoidal suture line and the anterior and posterior ethmoidal foramina and the infraorbital foramen.

Key bony surgical landmarks include:

- The floor of the anterior cranial fossa (cribriform plate) corresponds with the frontoethmoidal suture line
- The anterior and posterior ethmoidal foramina are located along the frontoethmoidal suture line

- The proximity (5-11 mm) of the posterior ethmoidal foramen and artery to the optic nerve in the optic foramen

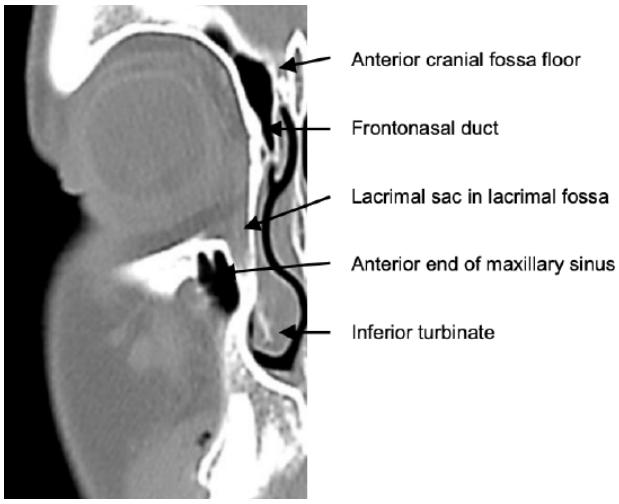


Figure 4: Coronal CT slice through lacrimal fossa and frontonasal duct

Figure 4 demonstrates the coronal anatomy at the level of the anterior limit of an external ethmoidectomy. Specifically note the lacrimal sac in the lacrimal fossa, which is preserved at surgery, and the relative heights of the floors of the antrum and the nasal cavity.

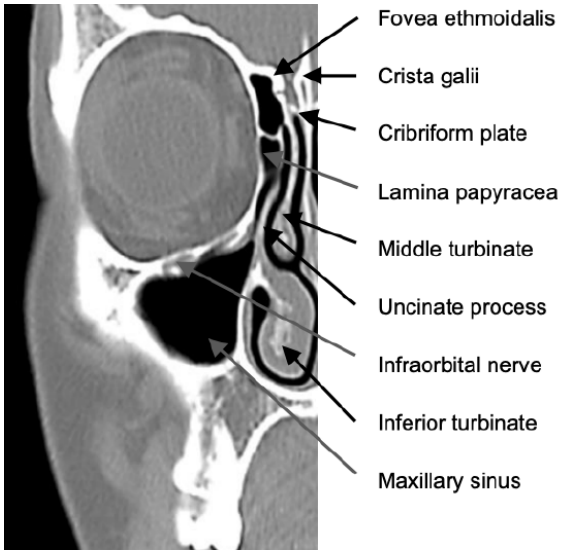


Figure 5: Coronal CT slice anterior to ethmoidal bulla

Figure 5 demonstrates the coronal anatomy anterior to the ethmoidal bulla. Specifically note the uncinate process, the vertical middle turbinate that attaches to the paperthin cribriform plate, and the thin lamina papyracea.

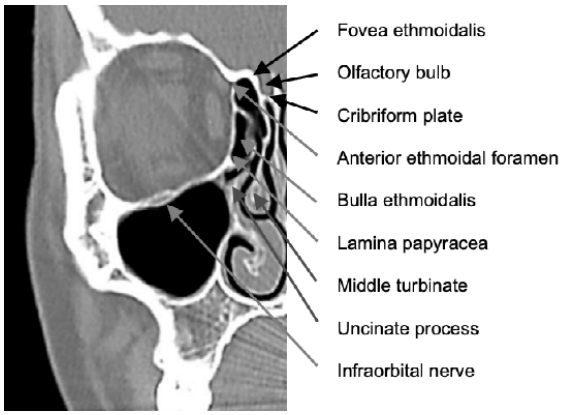


Figure 6: Note the position of the anterior ethmoidal artery where it passes through its foramen which is located in the frontoethmoidal suture line, and the anterior ethmoidal cells and it relationship to the middle turbinate and lamina papyracea

Figure 6 demonstrates the coronal anatomy through the ethmoidal bulla. It also illustrates the value of using the anterior ethmoidal artery and frontoethmoidal suture line to gauge the level of the floor of the anterior cranial fossa when opening the lamina papyracea from the orbital side e.g. for sepsis or tumor resection. Note the following relating to the anterior ethmoid sinus: the lamina papyracea constitutes its lateral wall; how small it is in the adult patient (24 mm high, 11 mm wide and 23 mm in length); and its relationships to the middle turbinate and uncinate process.

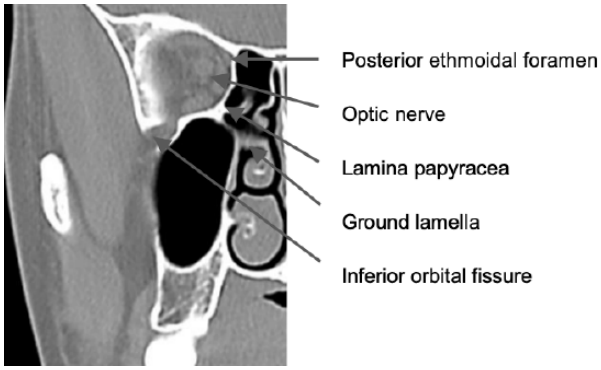


Figure 7: Coronal slice through posterior ethmoids demonstrating posterior ethmoidal foramen and optic nerve

Figure 7 is a coronal cut through the posterior ethmoids. Note the horizontally orientated ground lamella that divides the anterior from the posterior ethmoid sinuses, and how it attaches to the middle turbinate. It also illustrates the value of using the posterior ethmoidal artery and frontoethmoidal suture line to determine the level of the floor of the anterior cranial fossa when opening the lamina papyracea from the orbital side.

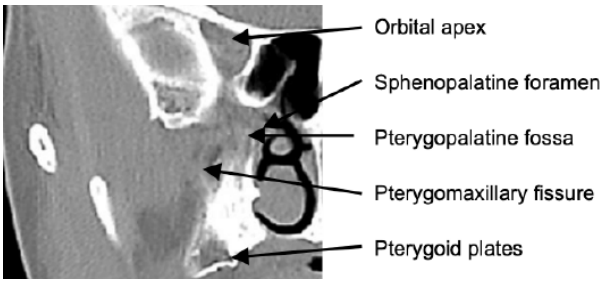


Figure 8: Coronal cut immediately behind maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa

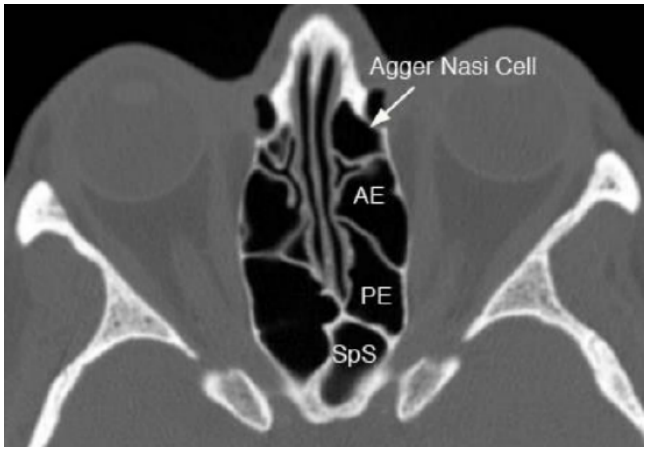


Figure 9: Axial view

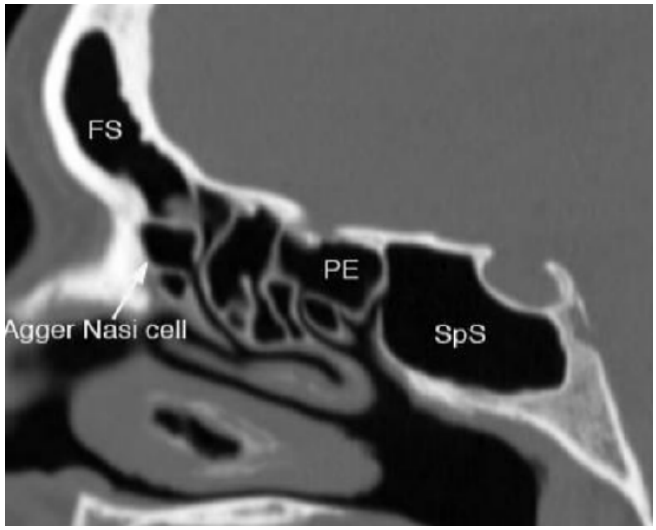


Figure 10: Sagittal view: Note relationship of frontal sinus to agger nasi and bulla

Figure 8 demonstrates the coronal anatomy immediately posterior to the maxillary sinus in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure; and medially with the nasal cavity via the sphenopalatine foramen. *Figures 9 & 10* show axial and sagittal views of the sinus anatomy.

Vasculature

The paranasal sinuses are supplied by both the internal and external carotid artery systems.

Branches of the internal carotid artery of surgical significance include:

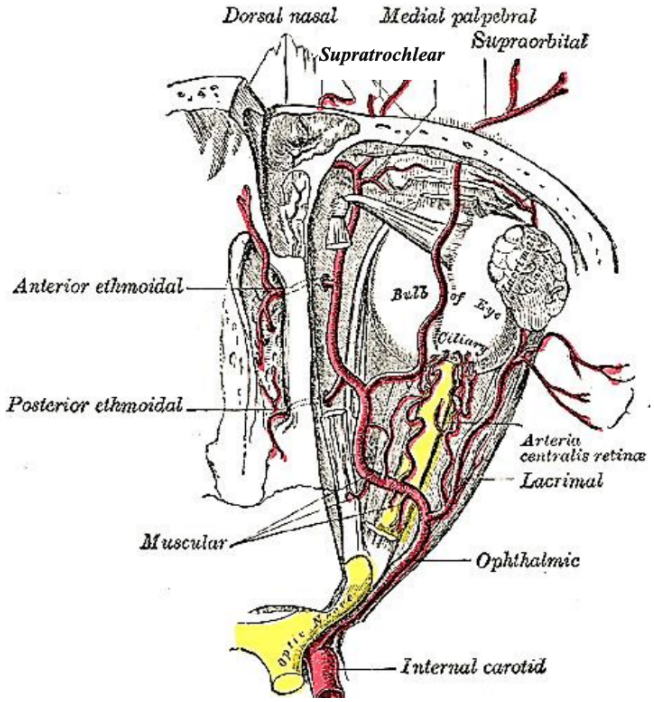


Figure 11: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries and the supratrochlear and supraorbital arteries

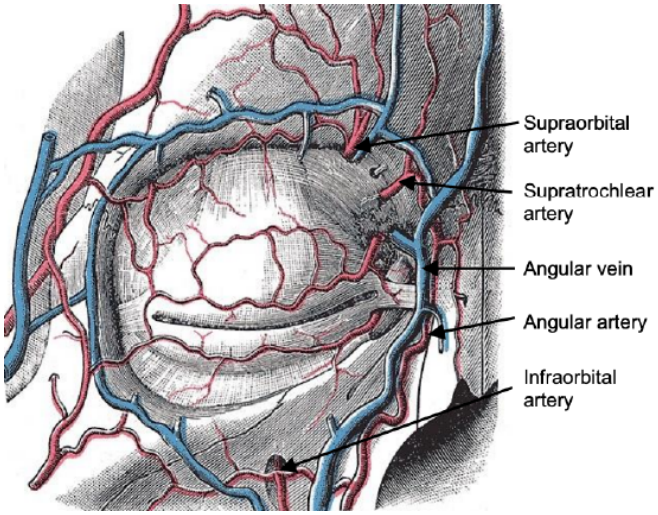


Figure 12: Vasculature around the orbit

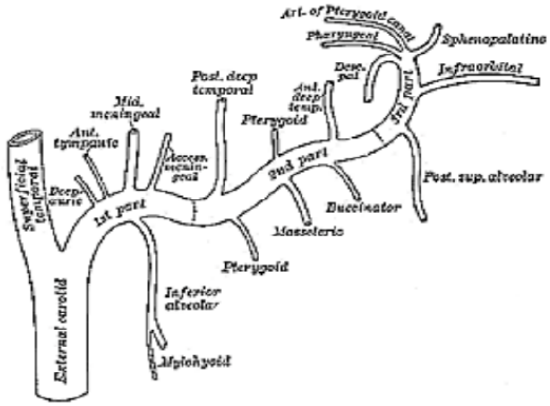


Figure 13: Branches of internal maxillary artery

- ***Ophthalmic artery*** (*Figures 3, 11*): It emerges with the optic nerve from the optic canal, 44 mm from the anterior lacrimal crest and approximately 6 mm (5-11 mm) from the posterior ethmoidal foramen
- ***Posterior ethmoidal artery*** (*Figures 1, 3, 7, 11*): It originates from the ophthalmic artery and enters the orbit through the posterior ethmoidal foramen which is located approximately 36 mm from the anterior lacrimal crest, and 12 mm (8-19 mm) from the anterior ethmoidal foramen. The vessel then courses through the posterior ethmoids near the anterior face of the sphenoid sinus close to the skull base to supply the posterior ethmoidal cells, the posterosuperior nasal septum, and parts of the superior and middle turbinates
- ***Anterior ethmoidal artery*** (*Figures 1, 3, 6, 11*): It originates from the ophthalmic artery and enters the orbit through the anterior ethmoidal foramen which is located 25 mm from the anterior lacrimal crest. It then courses across the fovea ethmoidalis before branching and supplying the cribriform plate and anterior and superior parts of the nasal septum. Although the vessel usually is flush with the skull base, ***it may be suspended in a mesentery; this places it at risk of injury during surgery***
- ***Supraorbital artery*** (*Figure 11, 12, 13*): It originates from the ophthalmic artery and passes along the medial borders of the superior rectus and levator palpebrae superioris muscles, and then joins the supraorbital nerve between the roof of the orbit and levator palpebrae superioris; it exits the orbit via the supraorbital notch/foramen to supply levator palpebrae superioris, the frontal bone, frontal sinus, upper eyelid, and the skin of the forehead and scalp. It is absent in up to 20% of patients
- ***Supratrochlear artery*** (*Figures 11, 12*): It leaves the ophthalmic artery just behind the trochlea. It exits the orbit superomedially with the supratrochlear nerve, ascends on the forehead and supplies skin, muscle, and pericranium, anastomosing with the supraorbital artery and with the contralateral supratrochlear artery

Branches of the external carotid artery of surgical significance include:

- ***Internal maxillary artery***: A branch of the external carotid artery (*Figure 13*), it passes through the pterygomaxillary fissure to enter the pterygopalatine fossa
- ***Sphenopalatine artery*** (*Figure 13*): This is the terminal end of the internal maxillary artery and enters the nasal cavity through sphenopalatine foramen at the back of the superior meatus where it gives origin to posterior lateral nasal branches. It supplies the posterior nasal cavity, as well as the maxillary, ethmoid, and sphenoid sinuses
- ***Posterior septal artery***: This is a branch of the sphenopalatine artery and crosses the posterior nasal cavity just above the posterior choana to terminate on the nasal septum; one branch descends in a groove in the vomer to enter the incisive canal and to anastomose with the greater palatine artery
- ***Facial/external maxillary artery***: A branch of the external carotid artery, it courses in the soft tissues of the face and past the medial canthus as the angular artery (*Figure 12*)

Veins of surgical significance: The only vein encountered during external frontoethmoidectomy is the angular vein which is situated medial to the medial canthus of the eye (*Figure 12*).

Nerves of surgical significance

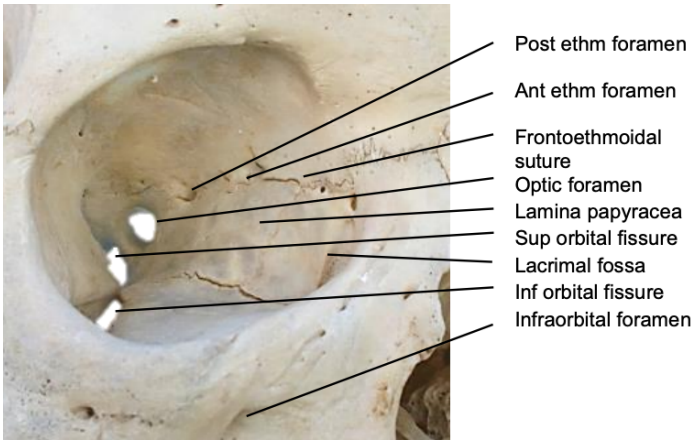


Figure 14: Right medial orbital wall

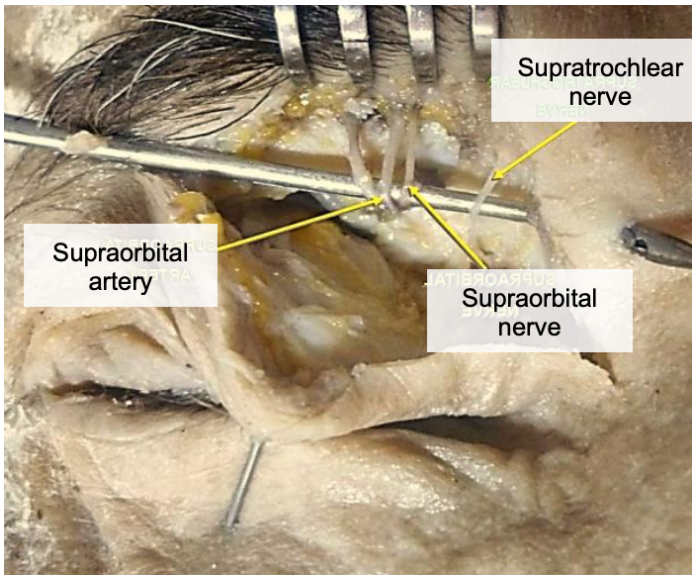


Figure 15: Supraorbital and supratrochlear nerves (Right eye)

- ***Optic nerve***: The optic nerve enters the orbit via the optic foramen, 5-11 mm posterior to the posterior ethmoidal foramen (*Figure 14*)
- ***Supraorbital nerve*** (*Figure 15*): This is a terminal branch of the ophthalmic division (V1) of the trigeminal nerve. If it is injured where it passes through the supraorbital foramen or notch, the patient has sensory loss of the skin of the forehead extending to the vertex
- ***Supratrochlear nerve*** (*Figure 15*): This is also a terminal branch of the ophthalmic division (V1) of the trigeminal nerve. It exits the orbit between the pulley of the superior oblique muscle and the supraorbital foramen/notch and ascends onto the forehead to provide sensory innervation to the skin of the lower part of the forehead close to the midline, conjunctiva and upper eyelid

Orbital structures of surgical significance

Figure 14 shows the detailed bony anatomy of the orbit. During dissection medially along the orbital wall, the following structures are encountered: medial palpebral ligament, orbital septum, lacrimal sac, periosteum, and anterior and posterior ethmoidal arteries

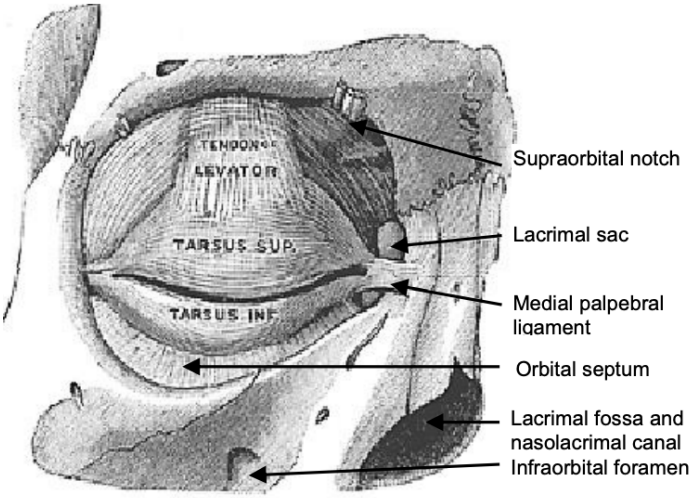


Figure 16: Right orbit: medial palpebral ligament, orbital septum, lacrimal sac and lacrimal fossa

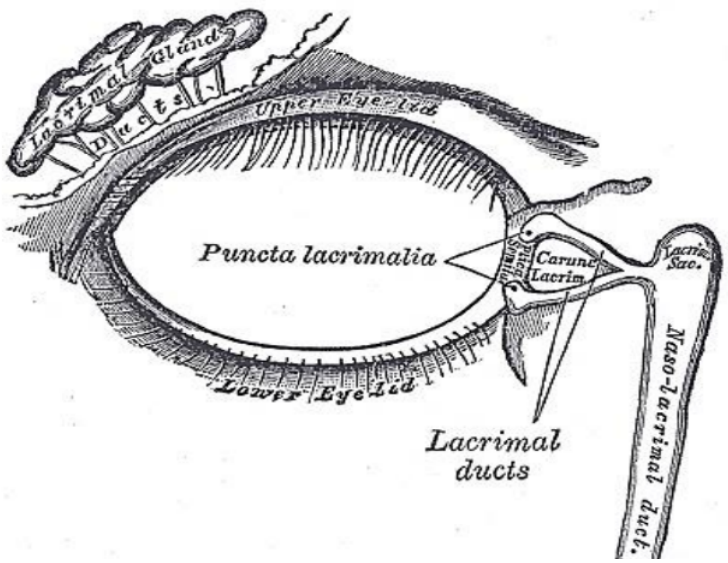


Figure 17: Right lacrimal system

- ***Orbital septum*** (*Figure 16*): This connective tissue structure attaches peripherally to the periosteum of the orbital margin and acts as a diaphragm that retains the orbital contents. Late-rally, it is attached to the orbital margin 1.5 mm anterior to the attachment of the lateral palpebral ligament to the lateral orbital tubercle. The septum continues along the superior orbital rim. Superomedially it crosses the supraorbital groove, passes inferomedially anterior to the trochlea, and follows the posterior lacrimal crest behind the lacrimal sac.

It then crosses the lacrimal sac to reach the anterior lacrimal crest, passes inferiorly along the anterior lacrimal crest and then laterally along the inferior orbital rim

- ***Medial palpebral ligament (medial canthal tendon)*** (*Figure 16*): This is a fibrous band that fixes the tarsi to the medial orbital wall. It is intimately related to the lacrimal drainage system. It lies anterior to the canaliculi, but a deep head inserts into the posterior lacrimal crest and onto the fascia of the lacrimal sac
- ***Lacrimal sac*** (*Figures 14, 16, 17*): It is located in the lacrimal fossa, which is bound medially by the lacrimal bone and the frontal process of the maxilla. It is related anteriorly, laterally, and posteriorly to the medial palpebral ligament

External ethmoidectomy

As was mentioned in the introductory paragraphs, the classic external frontoethmoidectomy operation entailed removing lamina papyracea, opening and stripping the mucosa from the ethmoid sinuses up to the cribriform plate, nibbling away the lateral wall of the frontonasal duct and floor of the frontal sinus, stripping the mucosa from the frontal sinus, and attempting to preserve the middle turbinate.

However, the classic external frontoethmoidectomy operation is contrary to the modern principles of endoscopic sinus surgery which include:

- Limiting surgery to extent of disease
- Sparing mucosa
- Avoiding unnecessary surgery to the frontal recess and frontonasal duct
- Preserving middle turbinate
- Limiting resection of lamina papyricea to avoid medial prolapse of orbit soft tissues

Principles that should be applied to modern day external (fronto)ethmoidectomy include:

- Obtain CT imaging (if possible) to assess the extent of disease, and as a roadmap for surgery, especially to evaluate the anatomy of the skull base
- Make as small a defect as is possible in the lamina papyracea to avoid medial prolapse of orbital soft tissues
- Do a minimum surgical drainage procedure of the ethmoids and limit it to the extent of disease
- Spare mucosa
- Preserve the middle turbinate to avoid adhesions to the nasal septum affecting olfaction, and to keep it as a surgical landmark

- ***Handle the middle turbinate extremely gently*** to avoid fracturing the cribriform plate and causing a CSF leak
- If concern exists about frontal sinus drainage
  - Avoid surgery to the frontonasal duct if possible; rather do a frontal sinusotomy and irrigate the frontal sinus
  - If one elects to open the frontonasal duct, avoid stripping mucosa circumferentially to avoid ductal stenosis; remove only a lateral strip of mucosa and handle the remaining mucosa atraumatically

Surgical steps

- ***Preoperative consent*** includes discussing the facial incision, injury to the optic, supraorbital and supratrochlear nerves, diplopia, epiphora, enophthalmos, telecanthus, and CSF leak
- The operation is done under ***general anesthesia***, with orotracheal intubation
- Perioperative broad spectrum ***antibiotics*** are administered for 24 hours
- The nasal cavity is decongested with a topical ***vasoconstrictor***
- The ***eyelids*** may be sutured together with 6/0 silk taking care not to invert the eyelashes to avoid corneal abrasions, or a protective contact lens is inserted
- ***Local anesthetic with vasoconstrictor*** is injected in the planned skin incision

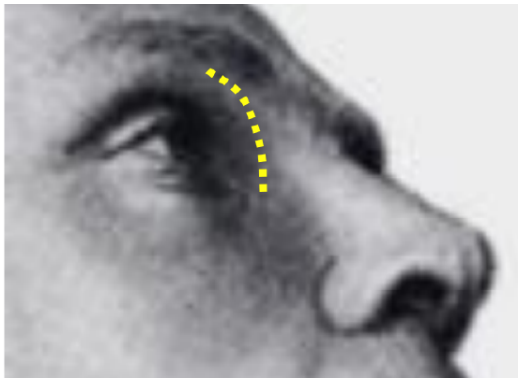


Figure 18: Lynch incision

- A 2.5-3 cm long curvilinear incision is made midway between the medial canthus and nasal dorsum taking care not to transect the supratrochlear and supraorbital nerves (*Figure 18*). A Z-plasty may be included to reduce the risk of bowstringing of the scar
- The remainder of the soft tissue dissection is done with electrocautery onto the nasal bone and frontal process of maxilla; the ***angular vessels*** are cauterized or ligated adjacent to the medial canthus of the eye (*Figure 12*)
- The incision is made through ***periosteum*** which is then elevated off ***lamina papyracea*** and floor of the frontal sinus
- Retract the orbital contents laterally taking care not to breach the periorbitum as fat then spills into the wound
- Sequentially identify the ***attachment of the medial palpebral ligament, anterior lacrimal crest, the lacrimal sac in the lacrimal fossa, and the posterior lacrimal crest***. Displace the ***lacrimal sac*** laterally from the fossa but take care to limit dissection inferiorly to avoid avulsion of the medial ligament
- Identify the ***frontoethmoidal suture line***; this is a crucial surgical landmark as it corresponds with the level of the cribriform plate and the anterior and posterior ethmoidal foramina

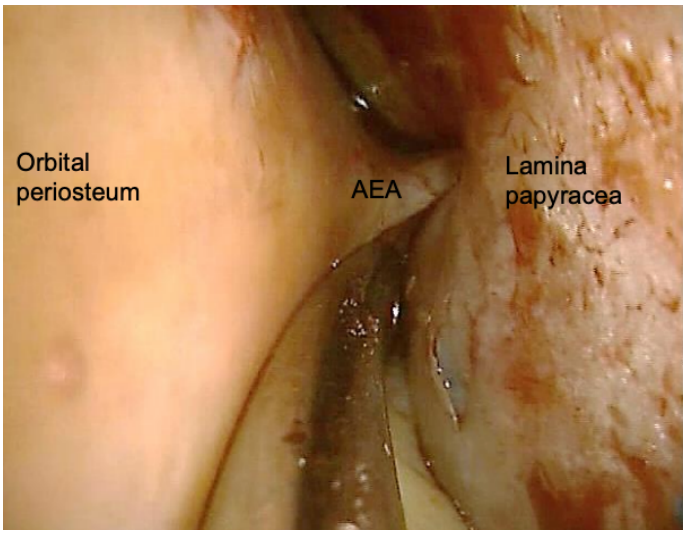


Figure 19: Anterior ethmoidal artery (AEA) exiting foramen at level of frontoethmoidal suture line (right eye)

- Identify the ***anterior ethmoidal artery*** as it bridges the divide between the ***anterior ethmoidal foramen*** and the periorbita (*Figure 19*)

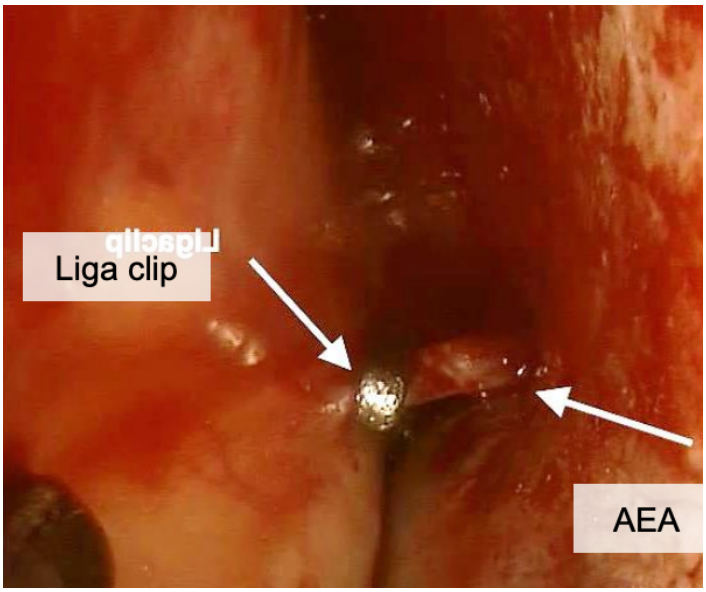


Figure 20: Liga clips being applied to anterior ethmoidal artery (AEA)

- Ligate/clip/bipolar the anterior ethmoidal artery, and divide it to reduce bleeding during ethmoidectomy (*Figure 20*); Blood flow courses from the direction of the orbit to the nasal cavity, so division of the artery should be medial to the clip if only one clip is placed
- This provides access to the ***posterior ethmoidal artery***; it is generally not necessary to divide this vessel, and stopping short of the posterior ethmoidal artery safeguards the optic nerve
- Proceed to ***external ethmoidectomy***

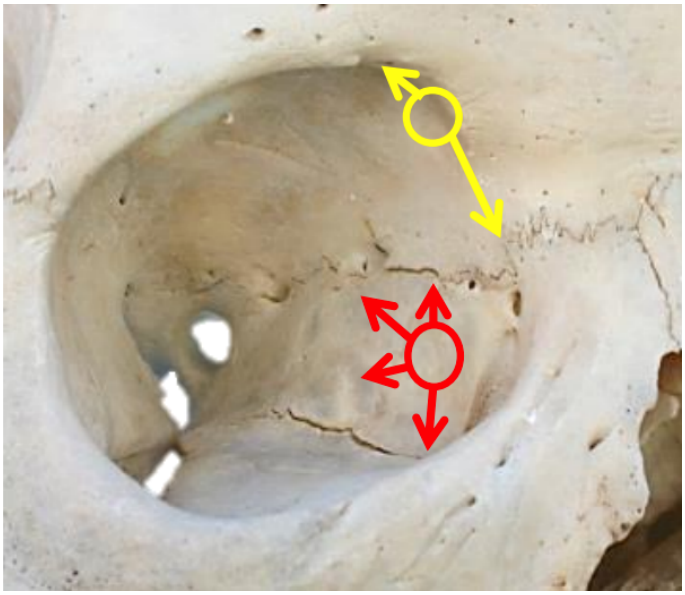


Figure 21: Ethmoidotomy (red) and frontal trephine (yellow) with subsequent directions of dissection

- Use a hammer and gouge to ***perforate the thin lamina papyracea*** immediately behind the posterior lacrimal crest, keeping well below the frontoethmoidal suture; this ethmoidotomy provides direct access to the anterior ethmoids (*Figure 21*)
- An alternative approach is to do a ***frontoethmoidectomy***, initially entering the frontal sinus and using a Kerrison rongeur to carefully remove only the lateral wall of the frontonasal duct, sparing the remaining mucosa of the duct to avoid ductal stenosis (*Figure 21*). ***The bulla ethmoidalis is immediately posterior, and the agger nasi cells immediately anterior, to the termination of the frontonasal duct*** (*Figures 9, 10*)



Figure 22: Kerrison's rongeur (top) and Blakesley forceps

- Use a Kerrison's rongeur or Blakesley forceps to enlarge the ***ethmoidotomy***, keeping the defect as small as possible to prevent herniation of orbital soft tissue to a minimum (*Figure 22*)



Figure 23: Direction of dissection of anterior ethmoidectomy

- Before proceeding with the ethmoidectomy, recall how small the anterior (24 mm high, 11 mm wide, 23 mm long) and posterior (21 mm high, 12 mm wide and 21 mm in length) ethmoids are (*Figure 23*)
- Remove the floor of the ***ethmoidal bulla*** by directing the Blakesley forceps anteroinferiorly (*Figure 23*)
- Keep middle turbinate intact taking care not to move it and fracture the cribriform plate
- To open the ***posterior ethmoids***, direct the Blakesley forceps posteriorly (*Figures 9, 10*)
- An external ethmoidectomy may safely be completed ***up to the cribriform plate*** if necessary
- To do a ***sphenoidotomy***, continue even further posteromedially keeping below the level of the frontoethmoidal suture (*Figures 9, 10*)
- Avoid disturbing the frontonasal duct

Key points: External frontoethmoidectomy

- Apply principles learned from endoscopic sinus surgery to open approaches
- Be aware of the positions of the supratrochlear and supraorbital nerves when making a Lynch incision
- Detailed knowledge of 3-dimensional anatomy of the paranasal sinuses, anterior skull base and orbit is essential
- Carefully follow the surgical steps in a well controlled surgical field in order to sequentially identify anatomical structures
- Know the anatomic landmarks of the cribriform plate
- The point at which the vertical lamella of the middle turbinate attaches to the lateral aspect of the cribriform plate and lateral lamella of the olfactory fossa may fracture with manipulation of the middle turbinate causing a CSF leak
- The lateral attachment of the posterior part of the middle turbinate to the lamina papyracea is called the ground lamella; it has a downward sloping orientation as one moves posteriorly
- The height of the fovea ethmoidalis and its attachment to the lateral lamella of the olfactory fossa is variable
- The anatomy of the anterior ethmoidal artery is variable; it may be suspended in a mesentery below the skull base
- The anatomical relations of the frontonasal duct are: agger nasi cells (anteriorly); bulla ethmoidalis (posteriorly); nasal septum (medially); and lamina papyracea (laterally) (*Figures 9, 10*)
- Prevent cicatrical scarring of the frontonasal duct by avoiding circumferential mucosal trauma
- Be aware of the location of the sphenopalatine artery where it emerges on the lateral nasal wall just behind the crista ethmoidalis; bleeding can be controlled with liga clips or bipolar cautery

External frontal sinusotomy/trephine



Figure 24: Frontal sinusotomy



Figure 25: Position of external frontal sinusotomy/trephine

- Examine the sinus x-rays and/or CT scan to determine the extent of pneumatization of the frontal sinuses (*Figure 24*)
- Make a Lynch incision if the surgery is combined with an external ethmoidectomy, or a 1 cm incision just below/ within the medial eyebrow
- Avoid injury to the supraorbital and supratrochlear nerves
- The thinnest bone is in the medial floor of the sinus: open the frontal sinus medially in the orbital roof with a burr, chisel or currette (*Figure 25*)

Closure

- Hemostasis is achieved with topical hemostatic agents; it is only rarely necessary to pack the nose
- Avoid cautery near the cribriform plate as perforate the paper-thin bone and cause a CSF leak
- Suture any tears in the periorbita to avoid herniation of orbital fat
- The skin is carefully repaired to optimize the cosmetic results
- Patients are instructed about regular nasal douching with saltwater, and are recalled for nasal toilette

Frontal sinus mini-trephination



Figure 26: Position of frontal sinus mini-trephination

This technique is used to delineate the position of the frontonasal duct during endoscopic sinus surgery, or to irrigate an infected frontal sinus. Unlike formal frontal sinus trephine, the sinusotomy is placed above the orbital rim (*Figure 26*). It is therefore critical that it first be radiologically confirmed that the frontal sinus extends high enough above the orbital rim to permit this approach to avoid intracranial penetration by the drill

- Mark the position of the mini-trephine 1 cm from midline at the level of the medial end of the eyebrows
- Infiltrate skin and subcutaneous tissue with local anesthetic & adrenaline
- Make a stab incision in a skin crease (vertical or transverse) with a scalpel onto bone
- Spread the soft tissues with sharp ended scissors down to bone
- While distracting the skin edges, insert the drill guide firmly against the bone
- Pass the drill through the guide and drill the hole through the anterior table into the sinus
- While keeping the guide firmly in place, immediately remove the drill and irrigate the guide to avoid burning the skin and soft tissues
- Feed the wire stilette through the guide into the sinus
- Pass the cannula over the stilette through the mini-trephine into the sinus

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Authors

Neil Sutherland MBChB, FCORL
Otolaryngologist
Cape Town, South Africa
nsquared@ctonline.co.za

Eric H Holbrook MD
Co-Director of Sinus Center
Massachusetts Eye and Ear Infirmary
Boston, MA, USA
Eric_Holbrook@meei.harvard.edu

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

JUVENILE NASOPHARYNGEAL ANGIOFIBROMA SURGERY

Derek Rogers, Christopher Hartnick, Johan Fagan

Juvenile nasopharyngeal angiofibroma (JNA) is a rare tumor representing only about 0.05% of head and neck tumors.[1] The most common presentation is a prepubescent or adolescent male with severe, recurrent epistaxis and nasal obstruction. The epistaxis may even require a blood transfusion. Since JNAs occur exclusively in males, a hormonal theory has been implicated.

As these tumors are quite rare, many patients may have been treated conservatively by a primary care provider before being referred to an otolaryngologist. Patients may have undergone a trial of nasal steroids and antihistamines or been mistaken for having simple anterior epistaxis. An adolescent male with recurrent epistaxis and chronic nasal obstruction is highly suspicious for a JNA. The epistaxis and nasal obstruction progressively worsen. Unilateral nasal obstruction may progress to bilateral obstruction as the tumor grows to fill the nasopharynx. Other common symptoms include headache, facial swelling, unilateral rhinorrhea, hyposmia, and ipsilateral conductive hearing loss due to Eustachian tube dysfunction.

JNAs originate from the sphenopalatine artery near the sphenopalatine foramen, an anatomic area usually readily accessible via endoscopic technique. Hence most of these tumors are now removed via an endoscopic approach by surgeons skilled in endoscopic surgery working in properly equipped centers. Compared to open approaches, the endoscopic approach results in less intraoperative blood loss, fewer complications, lower rates of recurrence, and shorter hospital stays.[2] Due to the vascularity of these tumors, preoperative embolization of major feeding vessels by interventional radiology leads to significantly less blood loss and facilitates endoscopic resection.[3]

Traditionally, several open approaches are employed, including lateral rhinotomy, midfacial degloving, transmaxillary (Caldwell-Luc), transpalatal, Le Fort 1 and infratemporal fossa approaches. Extensive tumors, such as those with lateral infratemporal fossa involvement or significant optic canal or intracranial extension may necessitate an open or a combined open and endoscopic approach. Radiotherapy and anti-androgen therapy are reserved for tumors deemed inoperable.[4]

Pertinent Anatomy

It is essential that a surgeon be familiar with the detailed vascular anatomy of the maxillary artery and its terminal branches, and that of the maxilla, paranasal sinuses, pterygoplatine fossa, orbit and anterior skull base. Studying a cadaver skull and having it available in the operating room is of great value.

Vascular anatomy

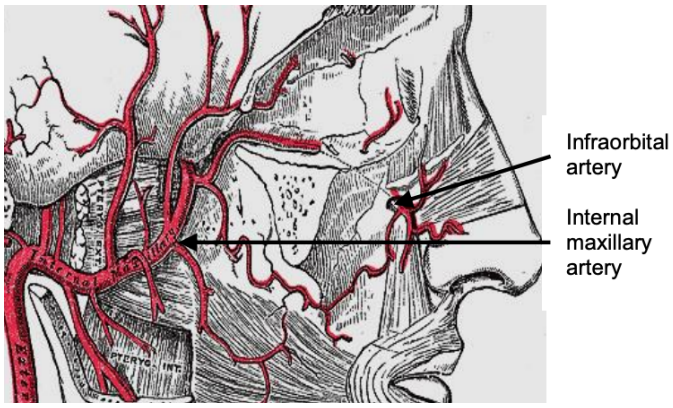


Figure 1: Internal maxillary artery entering pterygopalatine fossa through pterygomaxillary fissure (mandible removed)

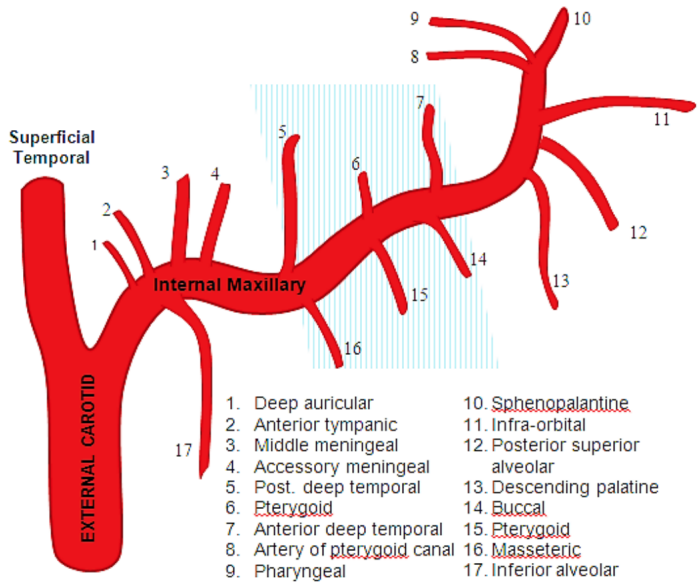


Figure 2: Branches of internal maxillary artery; blue shading denotes 2nd part of internal maxillary artery before it enters pterygopalatine fossa

JNAs typically arise from the sphenopalatine artery, which is a terminal branch of the internal maxillary artery. The internal maxillary artery branches off the external carotid artery (*Figures 1, 2*). The sphenopalatine artery usually contains two or more branches. Larger tumors can however have arterial supply from the ascending pharyngeal, contralateral internal maxillary artery, and be supplied by the cavernous portion of the internal carotid artery at the lateral wall of sphenoid sinus.

Bony anatomy (Figures 3, 4)

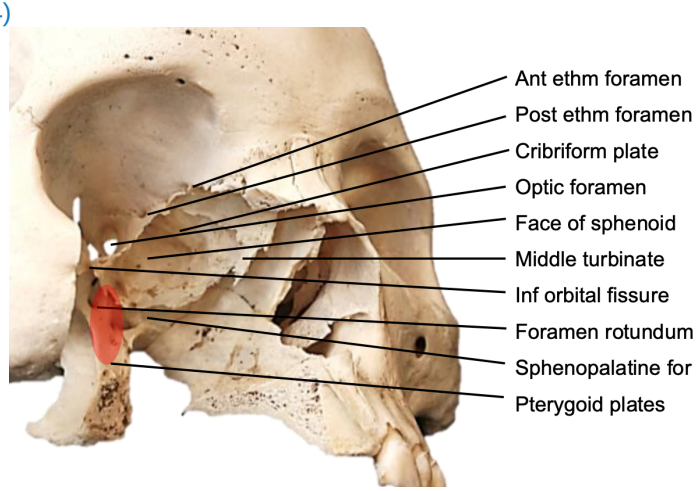


Figure 3: Total maxillectomy defect illustrating the relations of the pterygopalatine fossa (Red)



Figure 4: Close-up of Figure 3

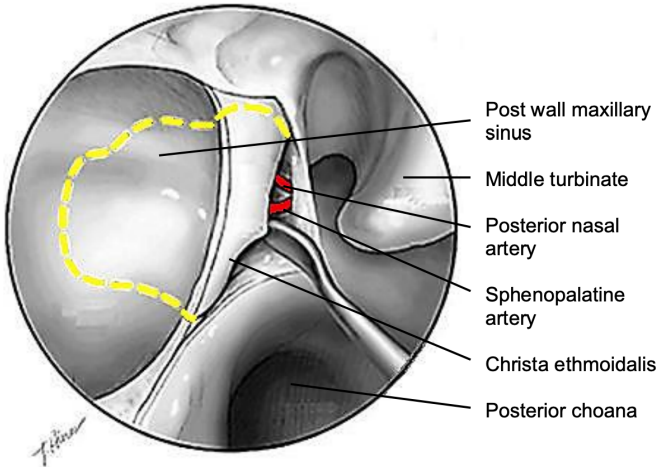


Figure 5: Endoscopic view of posterior wall of (R) maxillary antrum through a large middle meatal antrostomy: sphenopalatine artery is located directly posterior to crista ethmoidalis; posterior nasal artery is superior to sphenopalatine arter

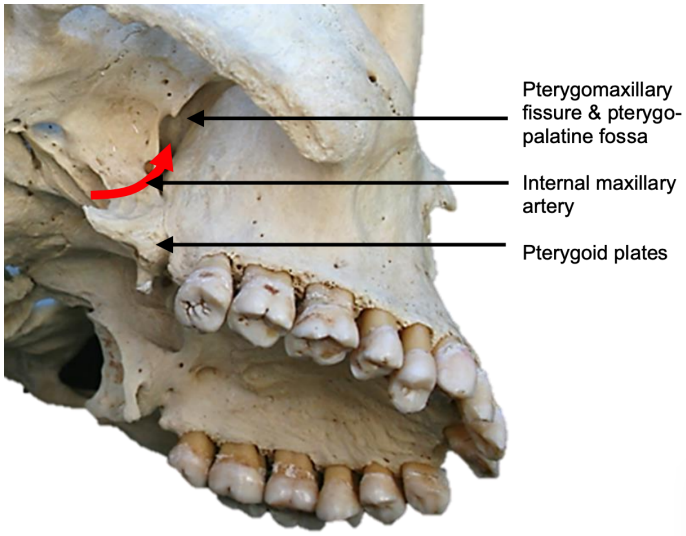


Figure 6: Internal maxillary artery (red arrow) traverses the pterygomaxillary fissure to enter the pterygopalatine fossa

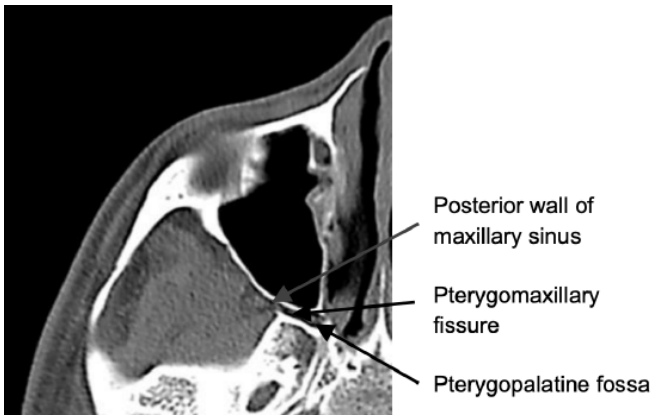


Figure 7: Axial cut at level of infraorbital nerve and orbital floor

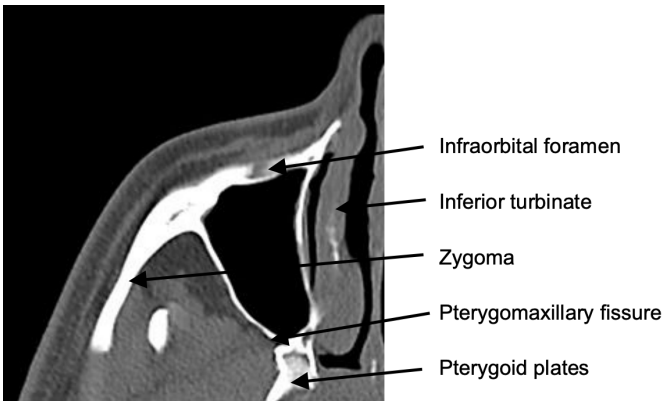


Figure 8: Axial cut at level of infraorbital foramen and pterygoid plates

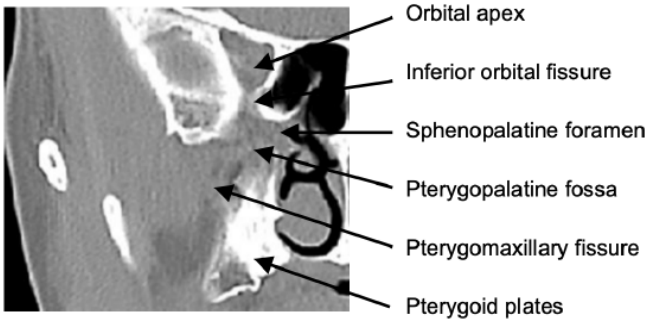


Figure 9: Coronal cut immediately behind the maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa

JNAs typically arise from the lateral nasal wall at the ***sphenopalatine foramen*** and generally involve the pterygopalatine fossa. The sphenopalatine foramen is located along the lateral nasal wall immediately posterior to the crista ethmoidalis and opens into the middle and superior meati (*Figures 3-5*). The ***pterygopalatine fossa*** is located immediately behind the thin posterior wall of the maxillary sinus (*Figures 3, 4*). It serves as a gateway to the nasal and oral cavities, infratemporal fossa, orbit, pharynx, and middle cranial fossa through eight foramina.[5] It communicates laterally with the infratemporal fossa via the pterygomaxillary fissure, and medially with the nasal cavity via the sphenopalatine foramen (*Figures 3, 4*). Immediately posterior are the pterygoid plates (*Figures 3-9*). *Figures 7 & 8* show axial views of the anatomy of the pterygopalatine fossa, pterygomaxillary fissure, and maxillary sinus.

Figures 3, 4 & 9 demonstrate the coronal anatomy immediately posterior to the maxillary sinus in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. It also illustrates how a JNA may extend superiorly though the inferior orbital fissure into the orbit, medially into the nasal cavity and sphenoid, and laterally into the infratemporal fossa.

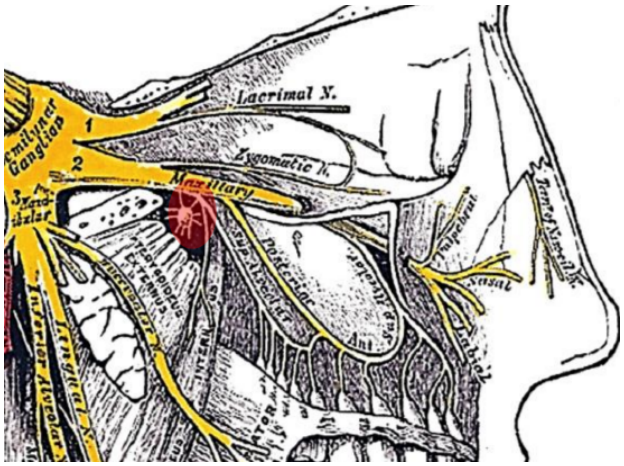


Figure 10: V2, pterygopalatine ganglion and infraorbital nerve (pterygopalatine fossa in red)

The ***maxillary division of trigeminal*** (V2) enters the pterygopalatine fossa via for amen rotundum (*Figures 7, 10*). The ***infraorbital nerve*** is a terminal branch of V2 and runs in the floor of the orbit/roof of the antrum to exit the infraorbital foramen.

Preoperative Evaluation

Clinical Evaluation

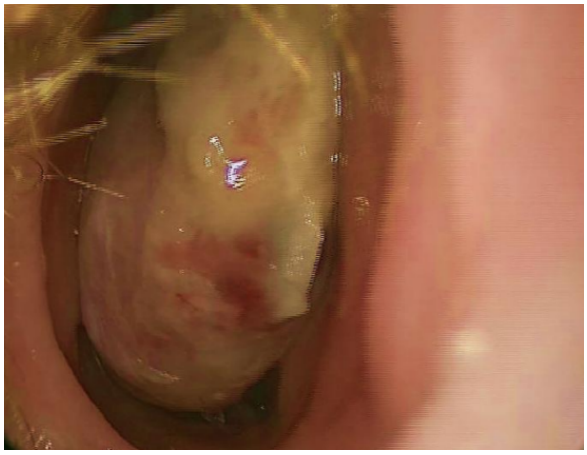


Figure 11: View of right nasal cavity showing large, vascular mass

A thorough history and physical are performed. The history should focus on the aforementioned nasal symptoms as well as any orbital symptoms. The initial head and neck physical examination notes any proptosis, vision changes, facial swelling, or otitis media with effusion. Fiberoptic nasopharyngoscopy is performed which typically reveals a vascular mass emanating from the posterior aspect of the middle and/or superior meatus, possibly filling the nasopharynx (*Figure 11*). ***The mass must not be biopsied*** due to the risk of causing significant epistaxis and as it may represent an encephalocoele or other nasal mass with an intracranial component.

Radiologic Evaluation

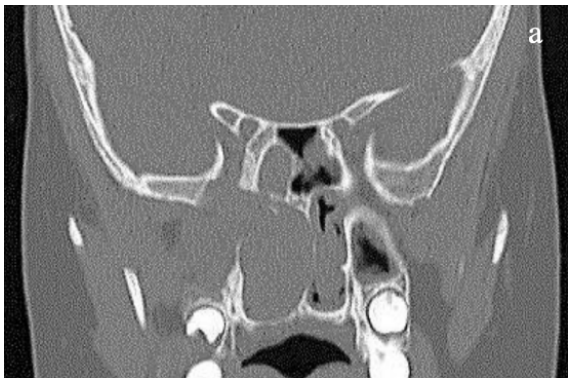


Figure 12a: CT scan: Widening of the sphenopalatine foramen and nasal cavity



Figure 12b: CT scan: Anterior bowing of posterior wall of maxillary sinus (HolmanMiller sign) and nasal mass

CT and MRI scans with contrast should be obtained to evaluate the extent of the tumor. CT scan helps delineate the bony anatomy (*Figures 12a, b*). JNAs usually cause widening of the sphenopalatine foramen and may cause anterior bowing of the posterior wall of the maxillary sinus, also known as the Holman-Miller sign (*Figure 12b*).

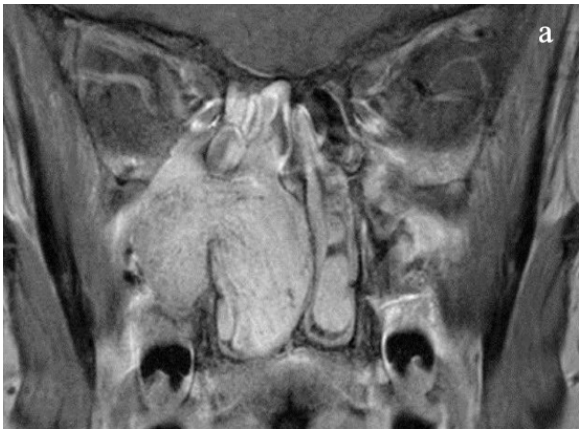


Figure 13a: MRI: No orbital or intracranial extension

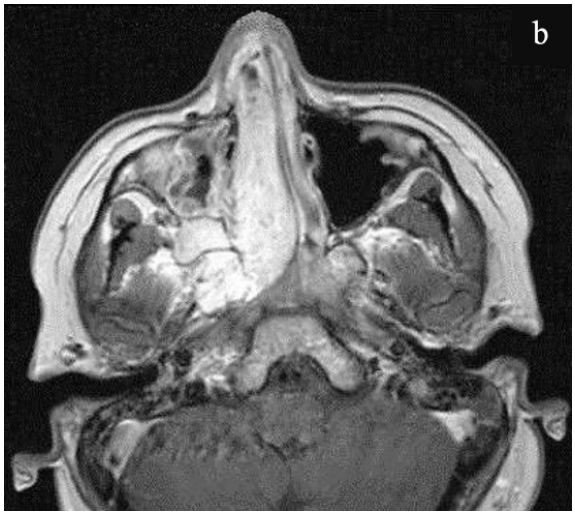


Figure 13b: MRI: Extension to medial infratemporal fossa

MRI provides essential information regarding soft tissue structures including the tumor, orbital structures, and intracranial components (*Figures 13a, b*). It also permits a distinction to be made between retained sinus secretions and mucosal edema vs. tumor.

Staging systems

Several staging systems have been proposed based on the radiologic appearance of JNAs. Two commonly used systems were developed by Fisch [6] (*Table 1*) and Radkowski[7] (*Table 2*). More recently a staging system was proposed based primarily on prognostic factors for endoscopic resection (*Table 3*). [8]

Stage	Description of Tumor Involvement
I	Limited to nasopharynx, bone destruction negligible or limited to sphenopalatine foramen
II	Invades pterygopalatine fossa or maxillary, ethmoid, or sphenoid sinus with bone destruction
III	Invades infratemporal fossa or orbital region IIIA: No intracranial involvement IIIB: Extradural, parasellar involvement
IV	Invades dura IVA: Without cavernous sinus, pituitary, or optic chiasm involvement IVB: With the above

Table 1: Fisch Staging for JNA

Stage	Description of Tumor Involvement
I	IA: Limited to nose or nasopharynx IB: Same as above but involving ≥ 1 sinus
II	IIA: Minimal extension through sphenopalatine foramen and into medial pterygomaxillary fossa IIB: Full occupation of pterygomaxillary fossa displacing posterior wall of maxillary sinus forward, orbit erosion, displacement of maxillary artery branches IIC: Involvement of infratemporal fossa or cheek, or posterior to pterygoid plates

III	Erosion of skull base IIIA: Minimal intracranial involvement IIIB: Extensive intracranial involvement or any cavernous sinus extension

Table 2: Radkowski Staging for JNA

Stage	Description of Tumor Involvement
I	Nasal cavity, medial pterygopalatine fossa
II	Paranasal sinuses, lateral pterygopalatine fossa, no residual vascularity
III	Skull base erosion, orbit, infratemporal fossa, no residual vascularity
IV	Skull base erosion, orbit, infratemporal fossa, with residual vascularity
V	Intracranial extension, residual vascularity Medial (M): Medial cavernous sinus Lateral (L): Middle cranial fossa

Table 3: University of Pittsburgh Medical Center (UPMC) Staging for JNA

Angiography

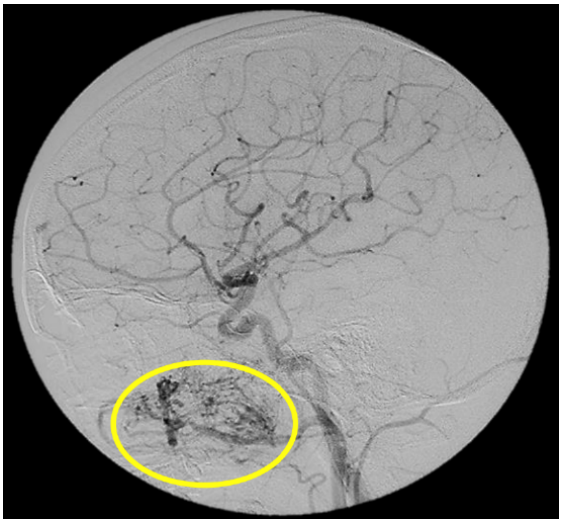


Figure 14a: JNA (circled) supplied by internal maxillary and ascending pharyngeal arteries



Figure 14b: JNA following embolization with persistent supply from ascending pharyngeal artery

Angiography is both diagnostic and therapeutic; it is performed 24-72 hours before surgery to determine the precise blood supply to the tumor and to embolize feeding vessels. Flooding the tumor with small particles is preferred, as coiling major vessels proximally precludes subsequent embolization should the tumor recur. By thrombosing the tumor with microparticles, smaller supply vessels from e.g. the internal carotid artery system also thrombose; hence bleeding from the internal carotid artery generally does not present a problem when delivering tumor from the sphenoid sinus. It is important that the surgeon discusses the outcome of the embolization with the interventional radiologist to determine how successful the embolization had been, and what vessels need to be surgically ligated or clipped (*Figures 14a, b*).

Should interventional angiography not be available, then surgery must be planned in such a way as to gain proximal vascular control of the internal maxillary artery and/or external carotid artery prior to attempting resection.

General surgical principles

- JNAs may be resected by endoscopic, open or combined (endoscopic & open) techniques
- The surgical approach is dependent on
  - Tumor location and extent
  - Pattern of vascular supply
  - Effectiveness of embolization
  - Facial skeletal maturity
  - Experience of the surgical team
- Carefully plan surgical approach(es) according to the imaging studies
- In expert hands and with effective preoperative embolization, most JNAs can be removed endoscopically with reduced morbidity
- ***Complete all bone work and ensure good access to the tumor before attempting resection, because once bleeding is encountered, the surgery may become very difficult and hazardous, and hemostasis may only be possible after completing the tumor resection***
- In young patients, avoid excessive soft tissue and bone dissection of the midface to minimize the risk of causing growth abnormalities [9]

Anesthesia considerations

- Patients are placed supine in reverse Trendelenburg position
- Oral RAE® endotracheal tube permits unobstructed access to the nose
- Hypotensive general anesthesia
- Type and crossmatch 2 units of blood as rapid blood loss can occur; consider banking 2 units of autologous blood one week before surgery
- Intraoperative blood salvage (autologous blood transfusion/cell salvage/cell saver technique) can be employed to recover blood lost during surgery which is reinfused into the patient

Endoscopic resection

Indications

- Tumors involving nasal cavity, paranasal sinuses, and nasopharynx
- Tumors with only medial infratemporal fossa involvement or extradural parasellar involvement with limited intracranial extension
- Facilitation of open approaches

Relative contraindications

Lateral infratemporal fossa involvement, extensive parasellar extension, encasement of the optic nerve, intradural spread, or cavernous sinus involvement. Note that cavernous sinus involvement is often overestimated on MRI scan due to hypervascularity of the tumor bed.

Intraoperative considerations

- Self-cleaning endoscope such as EndoScrub®
- Suction bipolar electrocautery, suction Freer elevator, suction Blakesley forceps or Kerrison rongeur, and hemoclip applier
- Intraoperative image guidance (if available)

Procedure

- Inject Lidocaine with epinephrine into the greater palatine foramina, septum, uncinate and middle turbinate on the side with the tumor
- Pack both nasal cavities for 10 minutes with cottonoid pledgets soaked in oxymetazoline

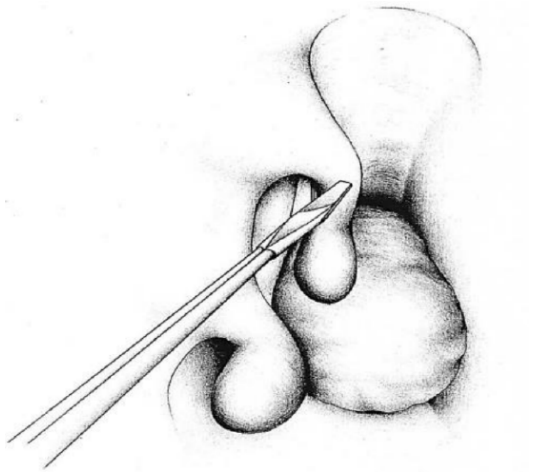


Figure 15: The middle turbinate is amputated to provide access to the tumor

- On the side with the tumor, amputate the inferior aspect of the middle turbinate with scissors (*Figure 15*)
- The tumor may initially need to be partially debulked to identify landmarks (only if well embolized)
- Perform an uncinectomy and wide middle meatal antrostomy

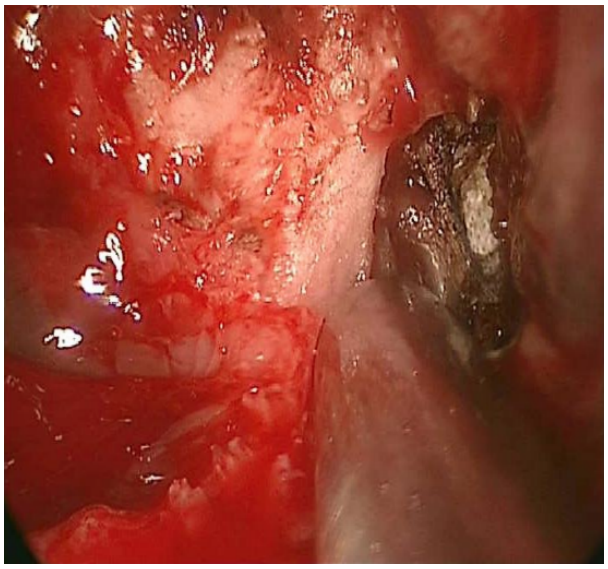


Figure 16: Intraoperative photo (right nose) following middle meatal antrostomy, showing crista ethmoidalis and posterior maxillary sinus wall

- Enlarge the middle meatal antrostomy until the posterior wall of the maxillary sinus is clearly visible (*Figures 5, 16*)
- Consider doing a posterior septectomy to allow better visualization and access from the opposite nasal cavity
- Perform a total ethmoidectomy and identify the sphenoid rostrum
- Completed a sphenoidotomy to ensure that tumor does not extend into the sphenoid

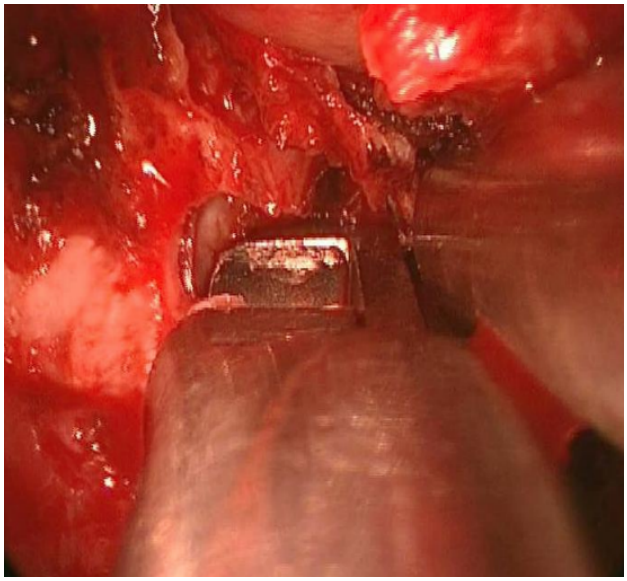


Figure 17: Intraoperative photo showing Kerrison rongeur used to remove posterior maxillary sinus wall

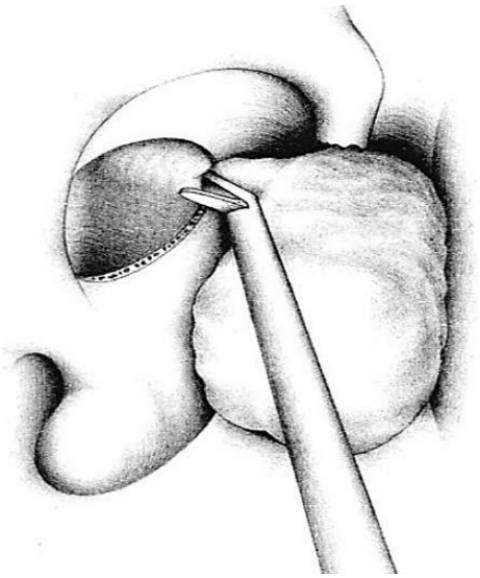


Figure 18: The posterior wall of the maxillary sinus is removed along the sphenopalatine artery

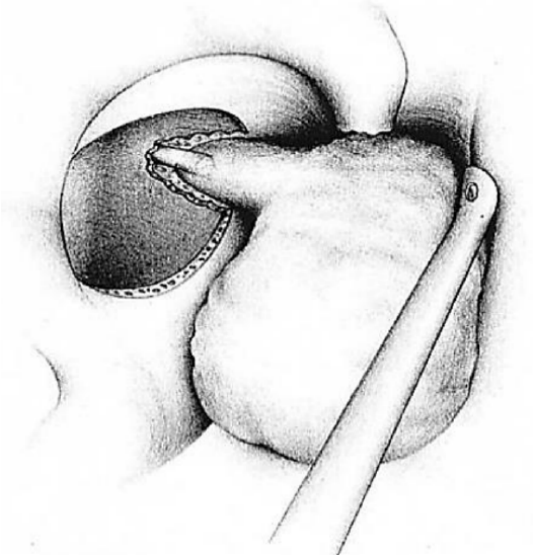


Figure 19: The tumor is dissected to its vascular pedicle

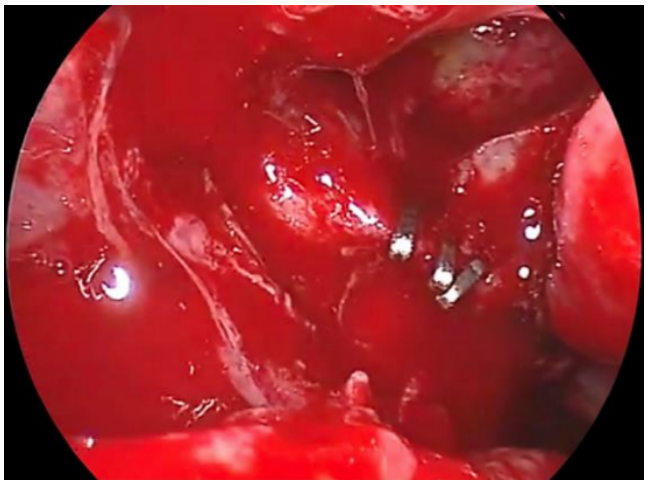


Figure 20: Sphenopalatine artery has been clipped in the pterygopalatine fossa

- Expose the sphenopalatine artery and tumor pedicle by removing the posterior wall of the maxillary sinus (*Figures 17-19*)
- Isolate and clip/ligate the sphenopalatine artery lateral to the tumor, ***even if it has been embolized*** (*Figure 20*)

- If tumor extends beyond the limits of the endoscopic instruments e.g. beyond the pterygopalatine fossa into the infratemporal fossa, then a Caldwell-Luc approach or open procedure may be needed for access
- Dissect tumor off adjacent structures; often it is adherent to septum, sphenoid rostrum, skull base, and nasopharynx
- Suction bipolar electrocautery is first used to ablate feeding vessels along the surface of the tumor; a suction Freer elevator or knife is used to release adhesions
- The tumor is dissected free until all that remains is the pedicle
- If it has not yet been done, apply hemoclips to branches of sphenopalatine artery, divide the artery, and deliver the tumor via the nasopharynx and out the mouth
- Inspect the entire mucosal area that was involved with tumor
- Biopsies may be sent to clear the margins
- Obtain meticulous hemostasis
- Apply hemostatic sinus material, such as Arista™ powder, Stammberger Sinufoam™, or Surgicel to bleeding surfaces

Postoperative Care

- The patient is admitted to the ward for overnight observation
- If intraoperative blood loss was significant, a full blood count is obtained and the patient is transfused if needed
- Oxymetazoline is used for minor epistaxis
- Nasal saline irrigations are started on the 1st postoperative day, at least twice daily, for nasal toilet
- The patient is instructed not to blow the nose
- The 1st postoperative visit is scheduled at 1 week

Complications

- Standard risks of endoscopic sinus surgery apply including pain, bleeding, infection, hyposmia, synechiae, orbital injury, loss of vision, cerebrospinal fluid leak, and intracranial injury
- Bleeding requiring transfusion
- Tumor recidivism if margins are not cleared

Key Points

- Tumor removal and postoperative recovery are greatly facilitated by preoperative embolization
- Intraoperative navigation may aid the surgeon
- Special endoscopic instruments with suction capacity are helpful to dissect these vascular tumors
- First complete all bone work to gain good access before attempting to resect tumor
- Be prepared to convert to an open approach if tumor involves the lateral infratemporal fossa or parasellar region

Open approaches

Open approaches are employed for tumors that extend to the lateral infratemporal fossa, tumors with intradural extension, and in centers that lack endoscopic expertise. Open approaches may also be used in conjunction with endoscopic resection e.g. anterior antrostomy may be employed to gain access to and clip the internal maxillary artery lateral to a large tumor or to access the infratemporal fossa. Conversely, the endoscope can be used at the conclusion of an open resection to inspect the tumor bed to ensure complete resection and to obtain haemostasis. Open approaches include the following:

- Medial maxillectomy
- Le Fort 1 osteotomy
- Transpalatal
- Maxillary swing
- Infratemporal fossa
- Facial translocation

	Endosc	Transpal	Le Fort 1	Medial maxillect	ITF	Facial transloc
Nasopharynx	■	■	■	■	■	■
Intranasal	■	■	■	■		■
Ethmoids	■		■	■		■
Sphenoid	■	■	■	■	■	■
Pt Pal Fossa	■		■	■	■	■
Medial ITF	■		■	■	■	■
Lateral ITF					■	■
Medial cav sinus			■	■		■
Lateral cav sinus					■	■
Middle cranial fossa					■	■

Table 4: Access provided by different surgical approaches[9]

An approach or combinations of approaches is carefully selected according to the location of the tumor and its extensions (*Table 4*)[9]. Readers are referred to chapters on Total Maxillectomy, Inferior Maxillectomy, Medial Maxillectomy, and Maxillary Swing approaches for additional detail about these approaches.

Medial maxillectomy

Medial maxillectomy is suited to tumors limited to the nose, nasopharynx, sphenoid, pterygopalatine fossa, medial infratemporal fossa and medial cavernous sinus (*Table 4*). Unless an ethmoidectomy is required, the medial maxillectomy is more limited than that described in the chapter on medial maxillectomy.



Figure 21: Midfacial degloving approach with right medial maxillectomy

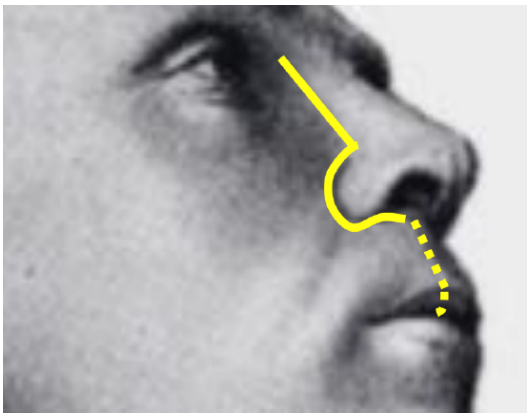


Figure 22: Lateral rhinotomy incision. Very rarely is a lip split extension required for access



Figure 23: Medial maxillectomy: typical bony removal for access to a JNA



Figure 24a: Anterior coronal CT slice demonstrating resected lateral nasal wall, and transected lacrimal sac



Figure 24b: Coronal CT through midantrum demonstrates resected lateral nasal wall including inferior turbinate, uncinate process and trimmed middle turbinate



Figure 24c: Coronal CT through posterior antrum demonstrating resected lateral nasal wall and inferior turbinate

- Soft tissue elevation is generally done by midfacial degloving approach (*Figure 21*); lateral rhinotomy is only required when the superior parts of the ethmoids are to be dissected (*Figure 22*)
- Inspect the antrum to determine the tumor extent and to plan the subsequent bony cuts
- The extent of the subsequent bony resection is tailored to the JNA
- A medial maxillectomy can now been done (*Figure 23*); *Figures 24a-c* illustrate the extent of the bone resection with the limited medial maxillectomy generally required for JNAs
- ***The sequence of the osteotomies*** is planned to reserve troublesome bleeding to the end

1. ***Osteotomy below inferior orbital rim***: A sharp osteotome/power saw/bone nibbler is used to cut along the thick inferior orbital rim just medial to the infraorbital nerve (*Figures 23, 24*)
2. ***Osteotomy connecting antrostomy with nasal vestibule***: A sharp osteotome is used to connect the anterior antrostomy with the floor of the nasal vestibule (*Figures 23, 24*)
3. ***Osteotomy across frontal process of maxilla***: This part of the dissection is often best done with a Kerrison's rongeur or oscillating saw. There is often persistent minor bleeding from the bone that may be controlled with bone wax or cautery (*Figure 23*)

4. ***Osteotomy along floor of nose***: A sharp osteotome or heavy scissors is used to divide the lateral wall of the nose/medial wall of the antrum along the floor of the nasal cavity up to the posterior wall of the antrum. When doing this dissection with an osteotome, the dissection is halted when the osteotome hits up against the solid pterygoid bone (signaled by change in the sound)
5. ***Osteotomy through lacrimal bone, and anterior ethmoids***: This osteotomy is made at the level of the roof of the antrum (*Figures 24b, c*). The osteotomy is done by gently tapping on an osteotome or with heavy curved scissors with tips pointed inferiorly. The osteotomy stops at the posterior wall of the antrum
6. ***Vertical posterior osteotomy through posterior end of medial wall of antrum anterior to pterygopalatine fossa***: The final posterior vertical cut is made with heavy curved (Mayo) scissors as a downward continuation of the osteotomy in Point 5. It runs through the medial wall of the maxillary sinus, starting superiorly at the posterior end of the previous osteotomy, and ending at the level of the nasal floor

- The ***medial maxillectomy specimen is then removed*** by gently levering it inferiorly and laterally with the Mayo scissors while completing the posterior osteotomy, remaining lateral to and preserving middle turbinate
- An ***external ethmoidectomy*** may now safely be completed under direct vision up to cribriform plate if required
- Carefully remove the paper-thin posterior wall of the maxillary antrum to expose the JNA and the sphenopalatine and/or internal maxillary artery
- Clip/ligate/bipolar the sphenopalatine / internal maxillary artery even if it has been embolized
- Proceed with the resection using blunt and bipolar dissection; suction bipolar electrocautery is first used to ablate feeding vessels along the surface of the tumor; a suction Freer elevator or knife is used to release adhesions
- Dissect tumor off adjacent structures; often it is adherent to septum, sphenoid rostrum, skull base, and nasopharynx
- If tumor extends laterally beyond the pterygopalatine fossa into the infratemporal fossa, then remove the posterolateral antral wall for additional exposure
- Inspect the entire area that was involved with tumor; this may be aided by use of an endoscope
- Obtain meticulous hemostasis
- Apply hemostatic sinus material, such as Surgicel to bleeding surfaces
- At the conclusion of surgery, the transected lacrimal sac (*Figure 24a*) is slit along its longitudinal axis and the edges are sutured to the surrounding tissues or stented to avoid epiphora

Le Fort 1 osteotomy



Figure 25: Le Fort 1 osteotomy; posteriorly it passes through the pterygomaxillary fissure

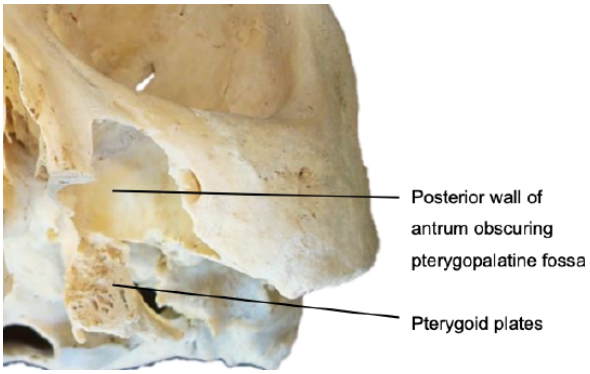


Figure 26: Exposure following downfracturing of hard palate

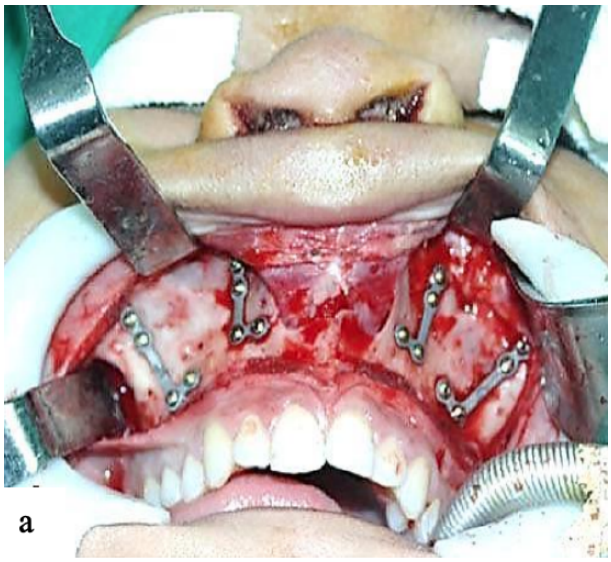


Figure 27a: Maxilla preplated [11]

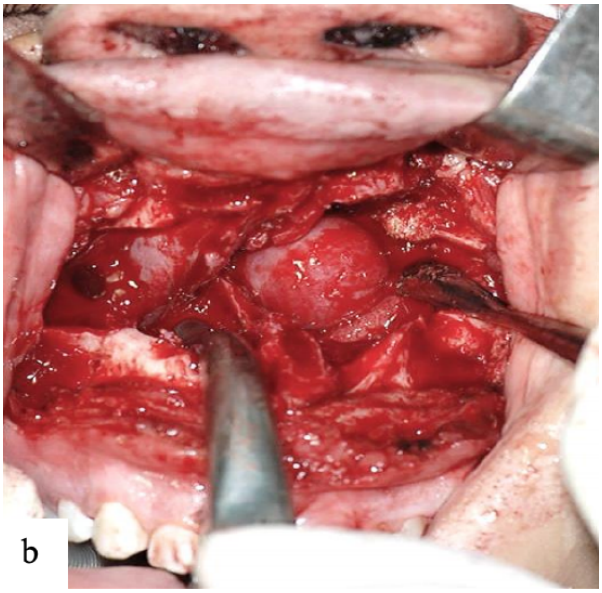


Figure 27b: Maxilla down fractured to expose JNA [11]



Figure 27c: JNA being delivered [11]

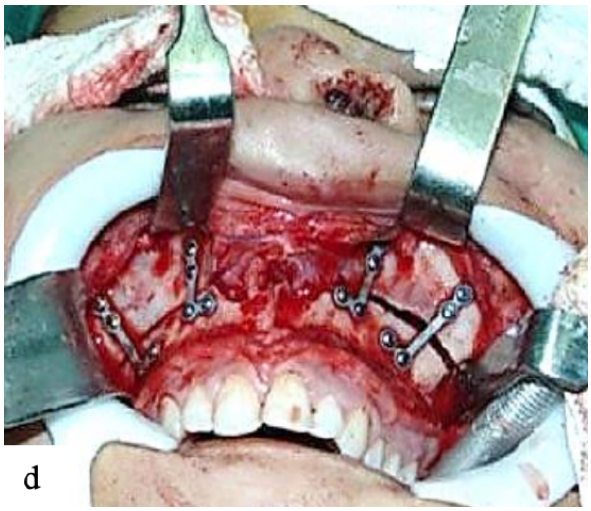


Figure 27d: Plated osteotomy [11]

Le Fort 1 osteotomy with down-fracturing of the palate is suited to tumors limited to the nose, nasopharynx, sphenoid, pterygopalatine fossa, medial infratemporal fossa and medial cavernous sinus (*Figures 25, 26, Table 4*). (See chapter on Inferior Maxillectomy) As with other transfacial approaches, effects on facial growth are a concern; Le Fort 1 osteotomy has been reported to result in 30% of predicted vertical growth of the anterior maxilla, though it does not affect horizontal growth and does not cause dental malocclusion. It also causes dental denervation.[10] The maxilla is pre-plated with miniplates along the line of the osteotomy to ensure an accurate repair (*Figure 27a*).

Transpalatal approach

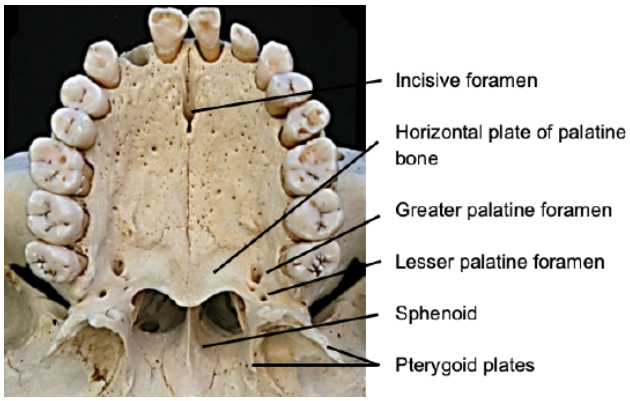


Figure 28: Anatomy of relevant to transpalatal approach

This approach can be used for JNAs confined to the nasopharynx, sphenoid and nasal cavity (*Table 4*). The bony anatomy of the hard palate is illustrated in *Figure 28*.

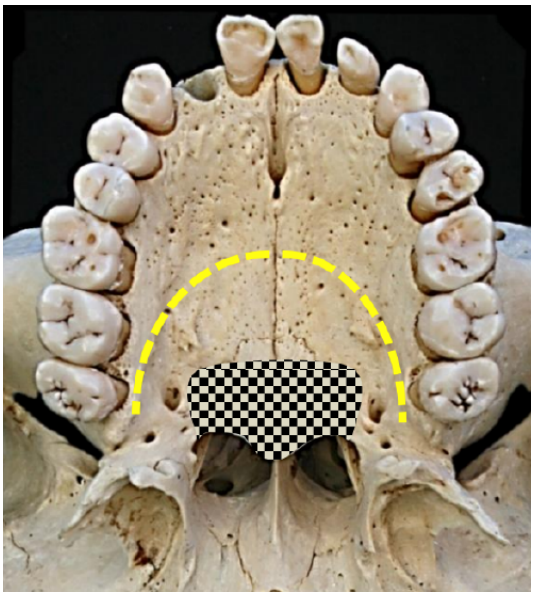


Figure 29: Mucosal incision in hard palate (yellow line) to elevate palatal flap; bone removal to expose tumor (chequered area)

An incision is made in the mucosa of the hard palate, and the thick mucosa is stripped off the hard palate, leaving it attached to the soft palate posteriorly (*Figure 29*). The soft palate is freed from the posterior edge of the hard palate to access the nasopharynx. The horizontal plate of the palatine bone is removed using a strong backbiter/Kerrison's rongeur /drill to expose the JNA (*Figure 29*).

Maxillary swing approach (Figure 30)

This is described in detail in the chapter on Maxillary Swing approaches.

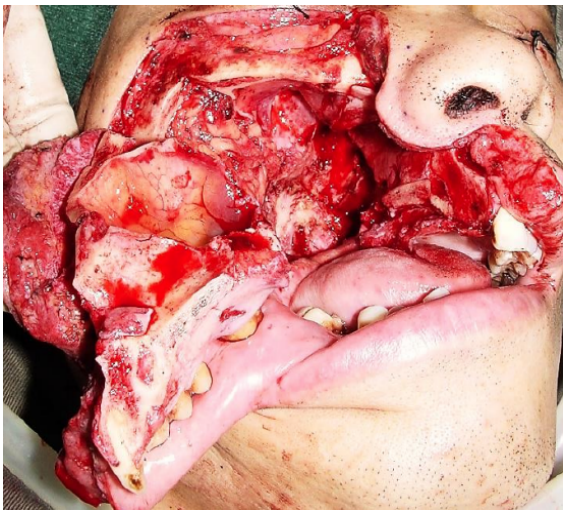


Figure 30: Maxilla has been fully swung laterally exposing nasopharynx; maxilla remains based on soft tissues of cheek

Infratemporal fossa approach

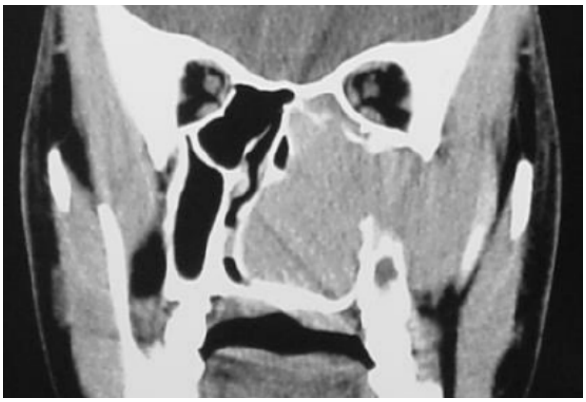


Figure 31: JNA extending to infratemporal fossa

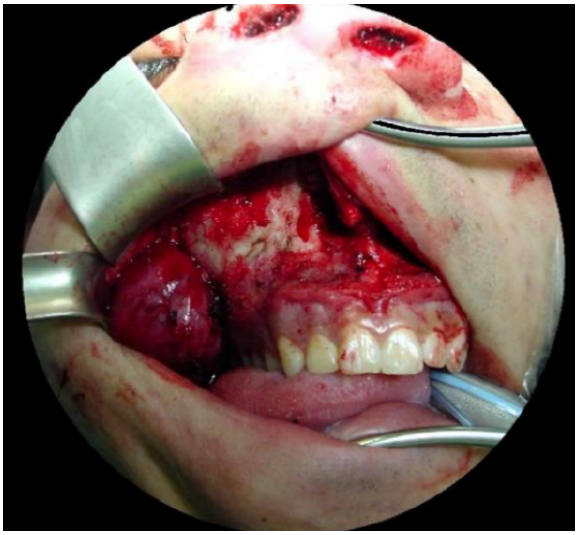


Figure 32: JNA protruding anteriorly from infratemporal fossa

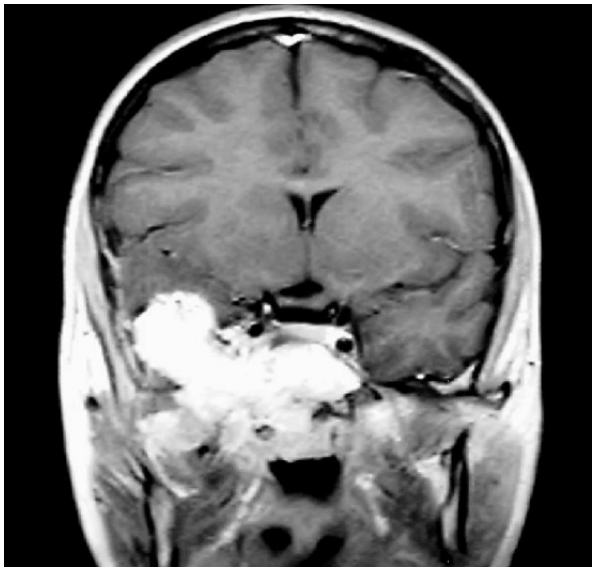


Figure 33: JNA extending to lateral cavernous sinus and middle cranial fossa

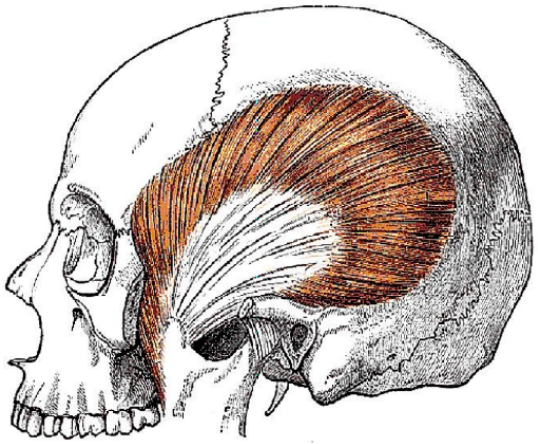


Figure 34: Infratemporal fossa is deep to zygoma (removed) and temporalis muscle

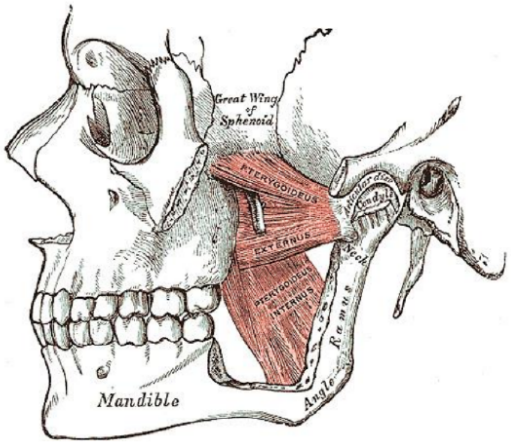


Figure 35: Internal maxillary artery is seen passing between bellies of lateral pterygoid to reach the pterygomaxillary fissure

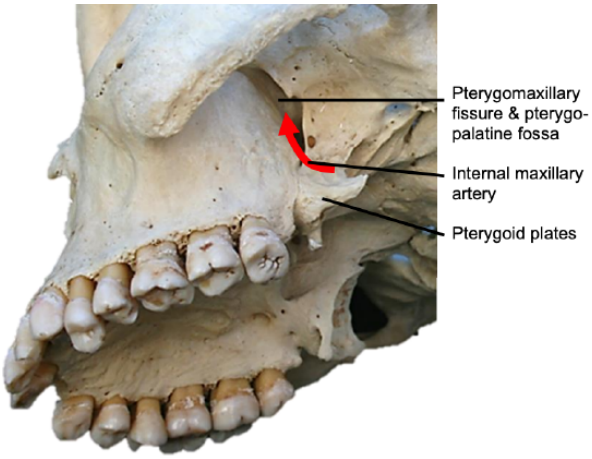


Figure 36: View of infratemporal fossa, internal maxillary artery and pterygomaxillary fissure

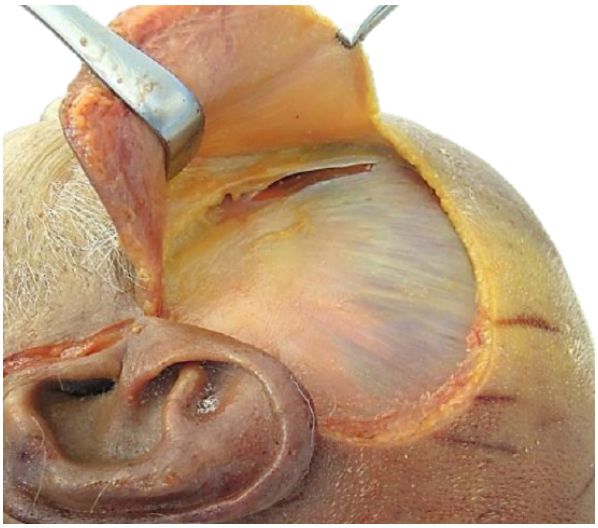


Figure 37: Exposed temporalis fascia and fat pad

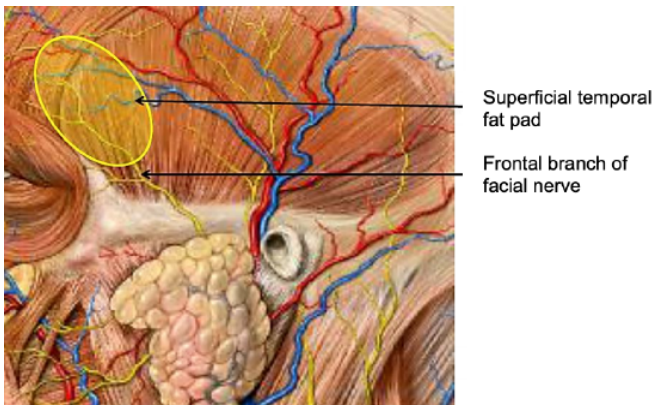


Figure 38: Facial nerve and fat pad

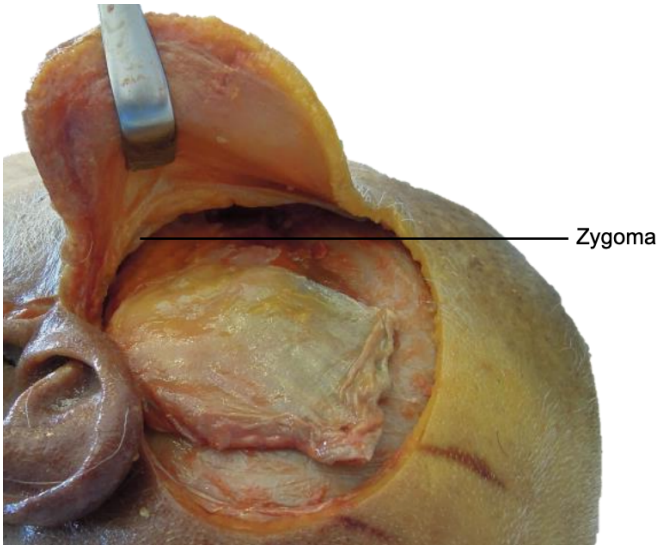


Figure 39: Mobilization of temporalis muscle and exposure of zygomatic arch

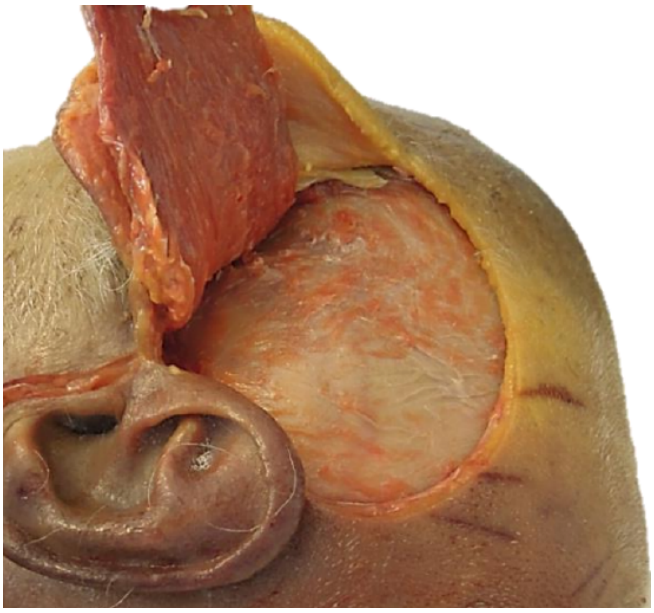


Figure 40: Flap completely elevated from temporal fossa

Significant involvement of the infratemporal fossa (*Figures 31, 32*), cavernous sinus, or middle cranial fossa (*Figure 33*) requires infratemporal fossa or subtemporal approaches, often combined with an anterior approach. In order to reach the infratemporal fossa, one has to remove the zygoma, and reflect the temporalis muscle (*Figures 33-36*).

- The surgery is done via a hemicoronal incision commencing in a preauricular skin crease just below the level of the zygoma and placed behind the hairline for cosmetic reasons (*Figure 37*)
- Extend the incision to the temporalis fascia and elevate skin and subcutaneous tissue in the plane on the temporalis fascia (*Figure 37*)
- Elevation in this plane is stopped anteriorly when the superficial temporal fat pad with the facial/temporal branches of the facial nerve are encountered (*Figures 37, 38*)
- Incise the deep layer of deep temporalis fascia in a vertical direction at this point to expose the temporalis muscle
- Dissect anteriorly in a subfascial plane, deep to the fat pad up to the lateral orbital bony rim (anterior margin of temporal fossa)
- Next incise the temporalis fascia about 1 cm below the superior temporal line and from the posterior margin of the muscle, down onto the bone (leaving a cuff of fascia on bone permits subsequent suturing of muscle back to its original position)
- Identify the superior aspect of the zygomatic arch along its full length. This may require forceful inferior retraction of the soft tissues with a Langenbeck retractor (*Figure 39*)
- Incise the two layers of deep temporal fascia along the superior margin of the zygoma, and free the zygoma from the insertion of the masseter muscle
- Osteotomize and remove the zygomatic arch, and preserve it in saline so that it can be plated/wired back later in the procedure
- Elevate the temporalis muscle from the bone of the temporal fossa using either diathermy or a periosteal elevator while remaining hard on the bone (*Figure 40*)
- Extend the dissection medial to the coronoid process of the mandible that is now readily palpable; the coronoid process of the mandible can be divided and reflected inferiorly for additional exposure

References

1. Herman P, Lot G, Chapot R, Salvan D, Huy PT. Long-term follow-up of juvenile nasopharyngeal angiofibromas: analysis of recurrences. Laryngoscope 1999; 109:140-7
2. Pryor SG, Moore EJ, Kasperbauer JL. Endoscopic versus traditional approaches for excision of juvenile nasopharyngeal angiofibroma. Laryngoscope 2005; 115: 1201-7
3. Schroth G, Haldemann AR, Mariani L, Remonda L, Raveh J. Preoperative embolization of paragangliomas and angiofibromas. Measurement of intratumoral arteriovenous shunts. Arch Otolaryngol Head Neck Surg 1996; 122:1320-5
4. Lee JT, Chen P, Safa A, Juillard G, Calcaterra TC. The role of radiation in the treatment of advanced juvenile angiofibroma. Laryngoscope 2002; 112:1213-20
5. Osborn AG. Radiology of the pterygoid plates and pterygopalatine fossa. AJR Am J Roentgenol 1979; 132:389-94

6. Andrews JC, Fisch U, Valavanis A, Aeppli U, Makek MS. The surgical management of extensive nasopharyngeal angiofibromas with the infratemporal fossa approach. Laryngoscope 1989; 99:429-37
7. Radkowski D, McGill T, Healy GB, Ohlms L, Jones DT. Angiofibroma. Changes in staging and treatment. Arch Otolaryngol Head Neck Surg 1996; 122:122-9
8. Snyderman CH, Pant H, Carrau RL, Gardner P. A new endoscopic staging system for angiofibromas. Arch Otolaryngol Head Neck Surg 2010; 136:588-94
9. Fagan JJ, Snyderman CH, Carrau RL, Janecka IP. Nasopharyngeal angiofibromas: selecting a surgical approach. Head Neck. 1997 Aug;19(5):391-9
10. Lowlicht RA, Jassin B, Kim M, Sasaki CT. Long-term Effects of Le Fort I Osteotomy for Resection of Juvenile Nasopharyngeal Angiofibroma on Maxillary Growth and Dental Sensation. Arch Otolaryngol Head Neck Surg. 2002;128 (8):923-7
11. Avelar RL, de Santana Santos T, Antunes AA, Dourado E Filho JRL. Horizontal Maxillary Osteotomy Approach for Resection of Juvenile Nasopharyngeal Angiofibroma. J Craniofac Surg 2011;22: 1027-30

Suggested video

Author

Derek J. Rogers, MD
Pediatric Otolaryngology
Harvard Medical School
Massachusetts Eye and Ear Infirmary, Boston, MA, USA
Derek_Rogers@meei.harvard.edu

Christopher J. Hartnick, MD, MS Epi, Professor
Department of Otolaryngology Division
Director, Pediatric Otolaryngology
Harvard Medical School Massachusetts Eye and Ear Infirmary
Boston, MA, USA
Christopher_Hartnick@meei.harvard.edu

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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REPAIR OF NASAL SEPTAL PERFORATIONS

Ahmad Sedaghat, Benjamin Bleier

The most common causes of nasal septal perforations are trauma, iatrogenic e.g. septoplasty, and pharmacologic e.g. intranasal corticosteroids and cocaine abuse. Other etiologies such as vasculitis, malignancy and infection should be considered when investigating a patient when a cause is not apparent.

Most septal perforations go unnoticed. The most troublesome signs and symptoms include a whistling sound, crusting and epistaxis; these are consequences of disruption of laminar airflow and its desiccating effect on the nasal tissues. In some cases with e.g. vasculitis or chronic picking at nasal crusts, septal perforations may grow in size and cause collapse of the dorsal or caudal supports leading to nasal deformity

Despite its varied aetiology, the common mechanism for developing a septal perforation is disruption of blood flow and devitalization of the septum. Despite its rich blood supply in the form of Kiesselbach's plexus, perforations most commonly involve the anterior septum; this plexus is comprised of the terminal branches of the superior labial, greater palatine and anterior ethmoidal arteries and does not tolerate vascular insults well.

Indications for septal surgery

Because septal perforations are not life threatening, many may be treated conservatively by moisturizing the nasal mucosa with saline irrigation and topical ointments. This may control symptoms and reduce the risk of enlargement of the perforation. Surgery is warranted only for patients who fail conservative treatment and are symptomatic. When septal perforations are related to an active disease e.g. vasculitis, malignancy or infection, treatment should be directed at the underlying disease process. Only once the etiology is controlled can treatment be tailored to the extent of the symptomatology.

Indications for surgery include:

- Symptomatic perforations
  - Crusting
  - Whistling
  - Recurrent epistaxis
  - Nasal congestion
- Perforations refractory to conservative management
  - Nasal moisturizers
  - Septal button

Contraindications to surgery include:

- Active underlying cause
  - Vasculitis
  - Malignancy
  - Infection
- Diameter/location precluding harvesting of adequate tissue for reconstruction (approximately >3 cm)

Surgical anatomy

Bony & cartilaginous anatomy (Figures 1, 2)

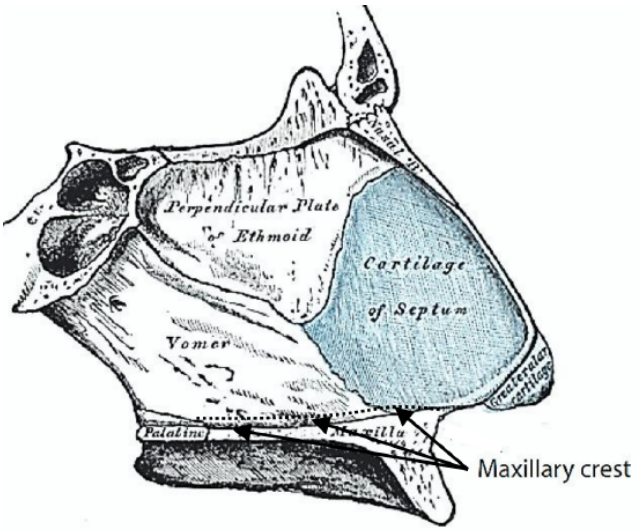


Figure 1: Bony and cartilaginous anatomy



Figure 2: Perpendicular plate of ethmoid attaches to cribriform plate

The nasal septum has both bony and cartilaginous components. Anteriorly the septum is composed of the quadrangular cartilage. Posteriorly the septum consists of bone of the perpendicular plate of the ethmoid superiorly and the vomer inferiorly. The most inferior part of the septum is the maxillary crest which is a bony projection from the maxilla and palatine bone along the full length of the septum. The maxillary crest articulates with quadrangular cartilage anteriorly and the vomer posteriorly. Superiorly the perpendicular plate of the ethmoid attaches to the delicate cribriform plate (*Figure 2*). This has clinical relevance as rough handling or twisting of the perpendicular plate can cause a fracture of the skull base, a cerebrospinal fluid leak and meningitis. The bony and cartilaginous components of the septum are covered by periosteum and perichondrium from which they receive their blood supply. Superficially it has a covering of respiratory mucosa.

Vascular supply (Figures 3-5)

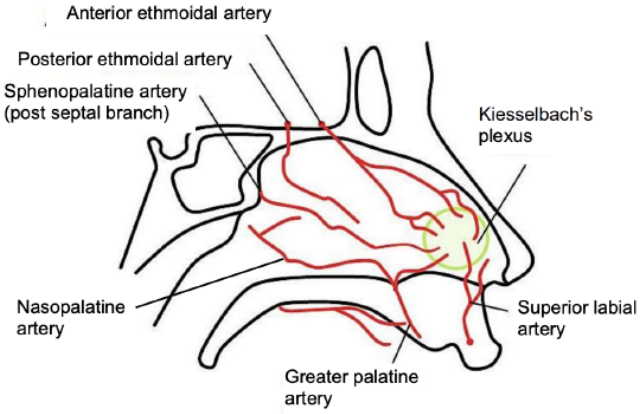


Figure 3: Arterial supply to nasal septum

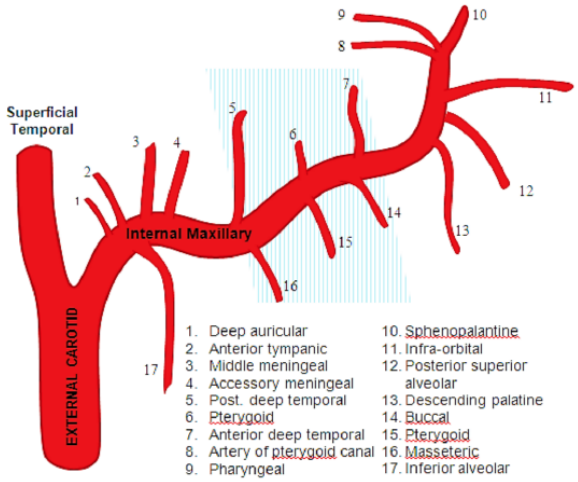


Figure 4: Branches of internal maxillary artery; blue shading denotes 2nd part of internal maxillary artery before it enters pterygopalatine fossa

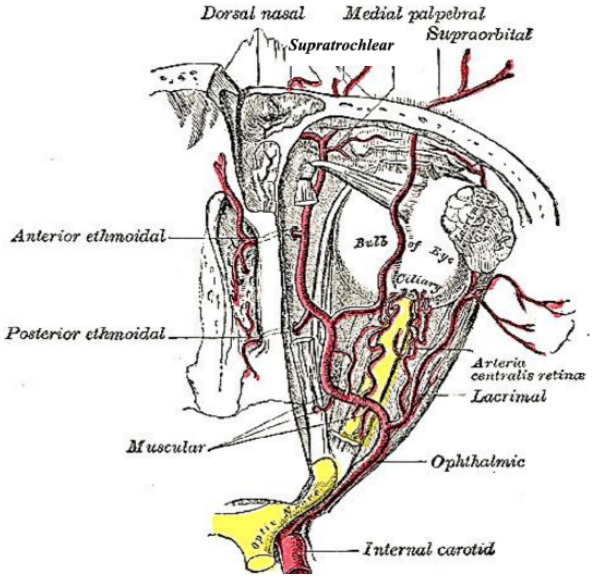


Figure 5: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries

An understanding of the vascular supply is important if large mucoperiosteal flaps are to be used to repair a septal perforation (*Figure 3*). Venous outflow generally follows the arterial blood supply.

The nasal septum has both internal (ICA) and external carotid (ECA) artery supply. The ***anteroinferior septum*** is supplied by the septal branch of the superior labial artery, and the greater palatine artery (*Figure 3*). The former arises from the facial artery, a branch of the ECA; the latter is a proximal branch of the internal maxillary artery, also a branch of the ECA.

The ***anterosuperior septum*** is supplied by the anterior ethmoidal artery; this arises from the ophthalmic artery, a branch of the ICA (*Figure 5*). These 3 vessels converge at the anterior septum to form Kiesselbach's plexus, a common origin of epistaxis.

Posterosuperiorly the septum receives its blood supply from the posterior ethmoidal artery, a branch of the ophthalmic artery (ICA) and the posterior septal branch of the sphenopalatine artery, a terminal branch of the internal maxillary artery (ECA) (*Figures 5, 3*).

Surgical approaches

Unless an endoscopic technique is used, access to the nasal septum can be very restricted. It is the authors' preference to do the surgery endoscopically due to the excellent visibility it affords. However surgery may also be achieved with an operating microscope or with a headlight and nasal speculum. Non-endoscopic surgical approaches may include endonasal (+/- microscope), external rhinoplasty, alar release and midfacial degloving techniques.

Surgical techniques

A variety of techniques may be used to repair septal perforations [1, 2]

- *Intranasal mucosal flaps*: Inferior turbinate flaps, quadrangular cartilage flap and a variety of mucoperiosteal flaps
- *Combinations of intranasal mucosal flaps and interposition grafts*: Graft materials that have been reported to have been used include temporalis fascia, mastoid periosteum, nasal septal tissues, acellular human dermal grafts, conchal cartilage and porcine small intestine mucosa [1]
- *Superiorly based buccinator myomucosal flap* (See chapter on Buccinator myomucosal flap)

The authors favor using a ***bipedicled anterior septal (BAS) flap***. This is the septal repair that will be described. The BAS is pedicled on the septal branches of the superior labial and greater palatine arteries (*Figure 3*). The greater palatine artery anastomoses via the incisive canal with the nasopalatine branch of the sphenopalatine artery. These vessels form an anastomotic network that extends as far as the mucosa of the posterosuperior septum.

Surgical Steps for Bipedicled Anterior Septal (BAS) flap

- Decongest both sides of the nose using pledgets soaked in 1:1000 epinephrine, or alternatively pseudoephedrine. After several minutes, inject lidocaine with epinephrine in submucoperichondrial planes bilaterally
- Clear the perforation of crusts

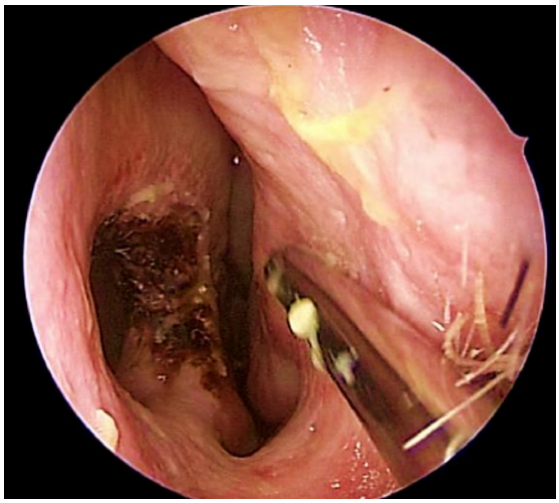


Figure 6: Septal perforation viewed from left nasal cavity before clearing crusts

- Examine both sides of the septum and determine the side more amenable to elevation and rotation of a BAS flap (*Figure 6*)

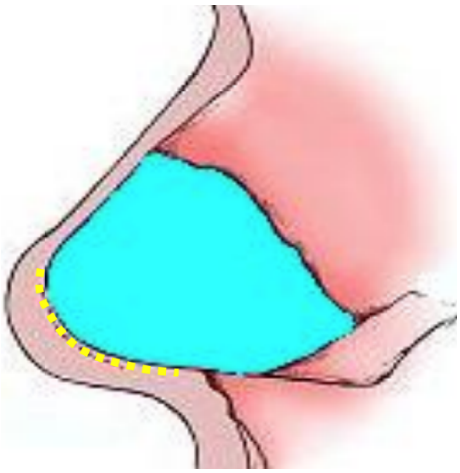


Figure 7: Hemitransfixion incision (Yellow line)

- Make a hemitransfixion incision in the skin of the nasal vestibule to expose the septal cartilage on the side contralateral to the planned flap so as not to disrupt the blood supply to the BAS flap (*Figure 7*)
- Carefully elevate a mucoperichondrial flap in an anterior-to-posterior direction using a Cottle elevator up to the anterior edge of the perforation

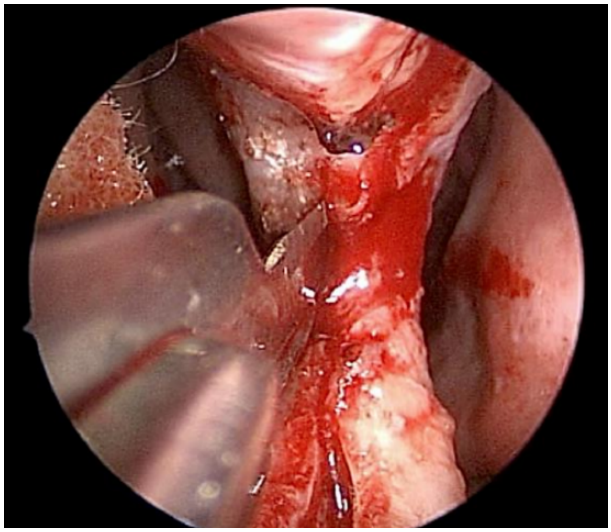


Figure 8: Establishing a subperichondrial dissection plane around the perforation

- Use a #15 blade to incise the rim of the perforation circumferentially and establish a subperichondrial dissection plane (*Figure 8*)

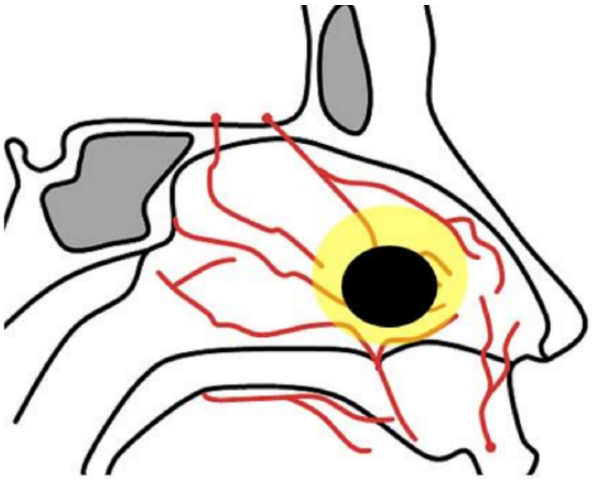


Figure 9: Elevated subperichondrial flap (yellow) around entire perforation (black)

- Elevate a subperichondrial flap around the entire perforation; this circumferential pocket will house the alloderm/ fascial graft (*Figure 9*)

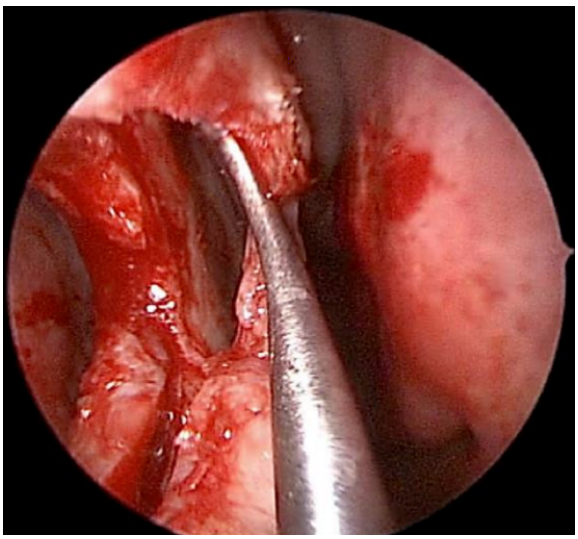


Figure 10: Elevating the submucoperichondrial flap

- Move to the opposite nose and elevate the BAS flap posteriorly and superiorly to the perforation up to the face of the sphenoid in anticipation of creating the bipedicled rotation flap (*Figure 10*)

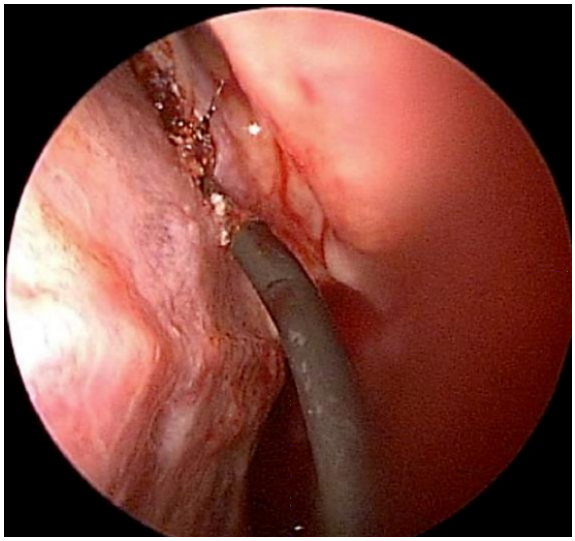


Figure 11: Elevation of flap up to the face of the sphenoid

- Leave the mucosa intact anteriorly and inferiorly to preserve blood supply to the flap from the septal branches of the superior labial and greater palatine arteries (*Figure 11*)

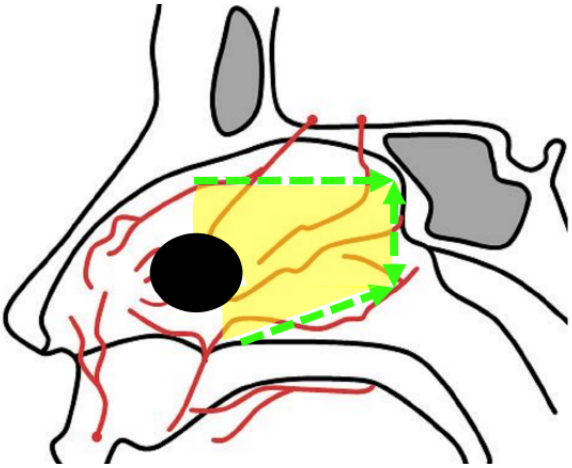


Figure 12: BAS flap (yellow) receives its blood supply from the septal branch of the superior labial artery; perforation (black); mucosal incision lines (green)

- Once the flap has been elevated off the septal cartilage and bone, incise the flap along the skull base from a line drawn vertically through the midpoint of the perforation up to the face of the sphenoid (*Figure 12*)
- Make a 2nd incision inferiorly to the face of the sphenoid at the level of the choanal arch, preserving the mucosal vascular pedicle inferiorly (*Figure 12*)
- Join these 2 incisions by a vertical incision along the sphenoid face (*Figure 12*)

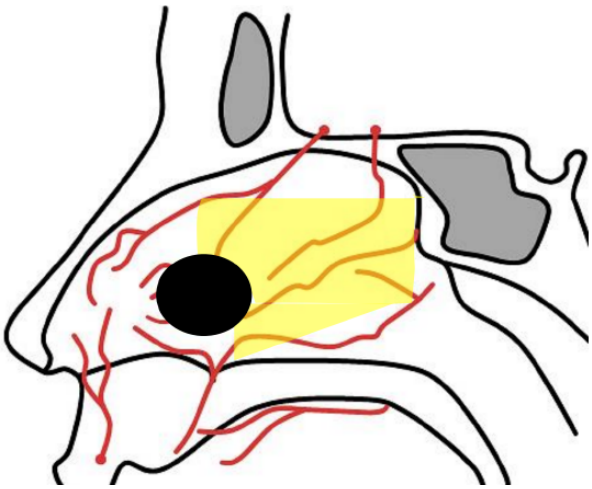


Figure 13: BAS flap (yellow) receives its blood supply anteroinferiorly from the septal branch of the superior labial and greater palatine arteries

- This creates a large mucosal flap which is pedicled anteroinferiorly (*Figure 13*)
- Once the flap has been elevated, attention is turned to closing the perforation
- This is performed in a multilayered fashion to minimize the risk of failure
- Cut alloderm or temporalis fascia in an ovoid shape, 1 cm larger than the diameter of the perforation

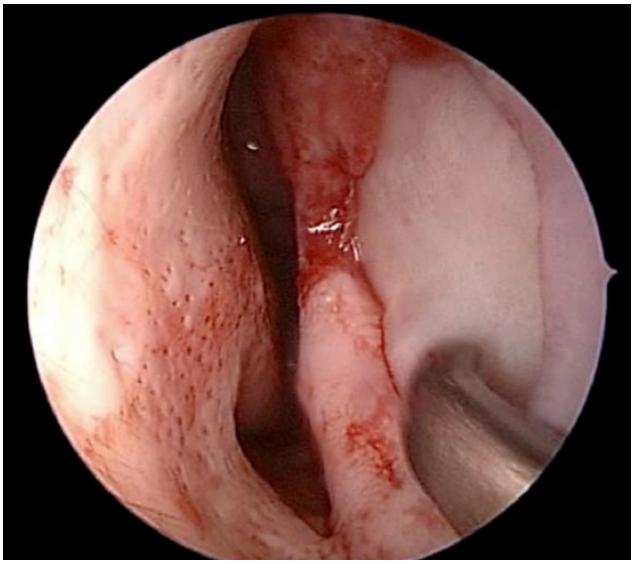


Figure 14: Interposition of graft (alloderm or fascia) in submucoperichondrial plane

- Insert the alloderm or fascia through the hemitransfixion incision to cover the perforation as seen in *Figure 14*

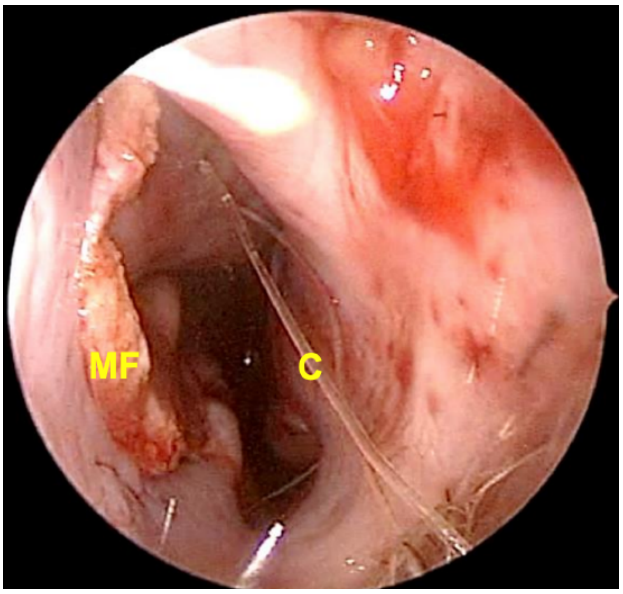


Figure 15: Note the mucosal flap (MF) covering the perforation and the catgut suture through the posterior edge of the flap (C)

- Tack it to the caudal septal cartilage with a 4-0 plain catgut suture and then tuck it into the submucoperichondrial pocket taking care to fully overlap the entire perimeter of the perforation (*Figure 15*)

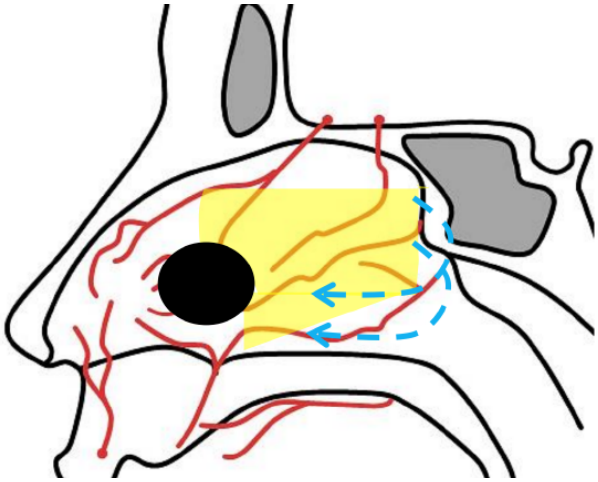


Figure 16: The posterior edge of the flap is rotated and advanced (blue arrows) to cover the perforation

- Rotate the posterior edge of the mucosal flap anteriorly to completely cover the perforation (*Figures 15, 16*)
- Insert a tacking suture through the posterior end of the alloderm/fascia to maintain its position
- Fix the flap with a single 4-0 plain catgut suture tacking stitch (*Figure 15*)
- Leave the knot loosely tied to prevent tissue necrosis as this portion of the flap has the most tenuous blood supply
- Place additional tacking sutures around the flap to keep it in position
- Insert splints (e.g. Doyle splints) bilaterally, held in place with a single 2-0 prolene U-stitch traversing the splints and the septum. The splints are left in place for 2-3 weeks

Comments

- Patient selection is critical as closure of septal perforations is notoriously difficult
- Subtotal perforations or perforations with no surrounding cartilage may not be good candidates for repair
- Some authors advocate use of bilateral flaps. This however incurs considerable risk of expanding the size of the perforation and uses up all septal reconstructive options should the surgery fail
- Good endoscopic suturing technique is critical to this repair; consequently, it should be undertaken only after these skills have been adequately practiced during routine endoscopic septoplasty

Complications

- Recurrence/persistence/increase in size of perforation
  - >2 cm diameter is an independent risk factor for failure
  - Devitalized flap
- Epistaxis from raw mucosal edges produced during surgery
- Infection
- Crusting due to persistent turbulent airflow around the reconstruction

References

1. Cogswell LK, Goodacre TE. The management of nasoseptal perforation. Br J Plast Surg. 2000 Mar;53(2):117-20
2. Goh AY, Hussain SS. Different surgical treatments for nasal septal perforation and their outcomes. J Laryngol Otol. 2007 May;121(5):419-26

Authors

Ahmad R. Sedaghat, MD, PhD
Chief Resident
Department of Otolaryngology - Head and Neck Surgery
Massachusetts Eye and Ear Infirmary
Harvard Medical School
Boston, USA
ahmad_sedaghat@meei.harvard.edu

Benjamin S. Bleier, MD
Assistant Professor
Department of Otology and Laryngology
Massachusetts Eye and Ear Infirmary
Harvard Medical School
Boston, USA
benjamin_bleier@meei.harvard.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SEPTOPLASTY FOR DEVIATION OF THE NASAL SEPTUM

Ahmad Sedaghat, Benjamin Bleier

Septoplasty refers to surgical manipulation and/or removal of deviated septal cartilage and/or bone to correct a nasal septal deformity.

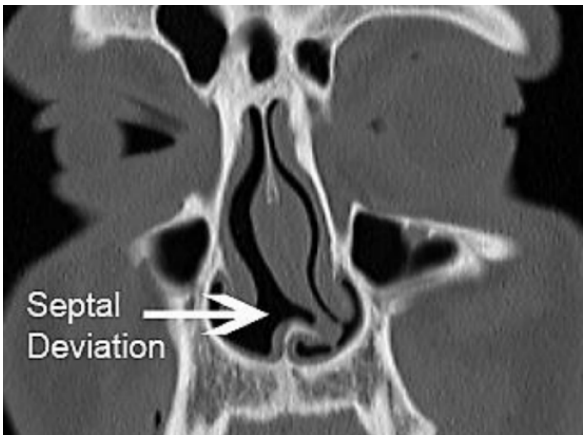


Figure 1: Example of a septal deviation

Up to 90% of people have nasal septal deviations (*Figure 1*), but the majority is asymptomatic. Septal deviation may cause nasal obstruction only when the nasal mucosa is swollen due to e.g. inflammation, allergic rhinitis, pharmacologic factors such as rhinitis medicamentosa or hormonal changes during pregnancy; in such cases obstruction may resolve either spontaneously or with medical therapy e.g. intranasal or systemic steroids, antihistamines and decongestants.

Indications for septoplasty

Septoplasty may be required to correct a deviated nasal septum for

- Irreversible symptomatic nasal obstruction
- Improving access for endoscopic sinus or skull base surgery
- Septal spurs causing epistaxis

Surgical anatomy

Bone and cartilage

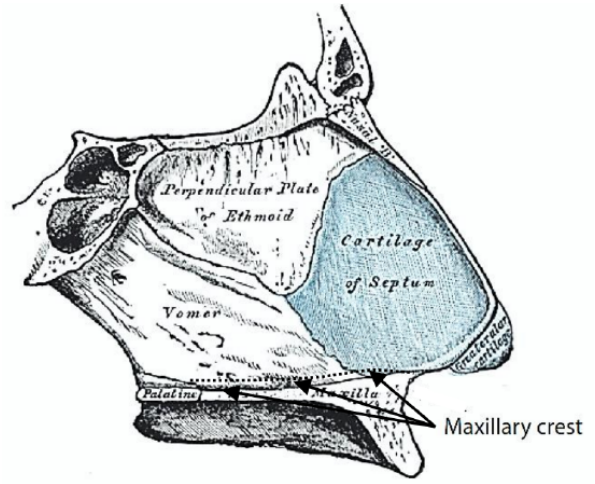


Figure 2: Bony and cartilaginous anatomy

The nasal septum has both bony and cartilaginous components (*Figure 2*). Anteriorly the septum is composed of the quadrangular cartilage. The posterior septum consists of bone of the perpendicular plate of the ethmoid superiorly and the vomer inferiorly. The most inferior strip of the septum is the maxillary crest, a bony projecttion from the maxilla and palatine bone along the full length of the septum. The maxillary crest articulates with quadrangular cartilage anteriorly and the vomer posteriorly.

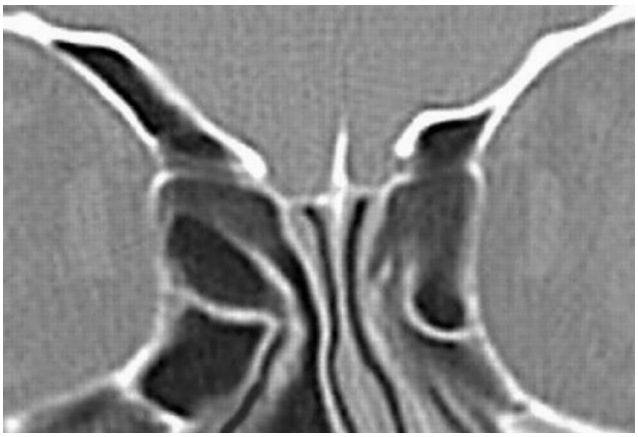


Figure 3: Perpendicular plate of ethmoid attaches to delicate cribriform plate

Superiorly the perpendicular plate of the ethmoid attaches to the delicate cribriform plate (*Figure 3*). This has clinical relevance as rough handling or twisting of the perpendicular plate can cause a fracture of the skull base, a cerebrospinal fluid leak and meningitis. The bony and cartilaginous septum is covered with periosteum and perichondrium from which it receives its blood supply. Superficially it is lined by respiratory mucosa.

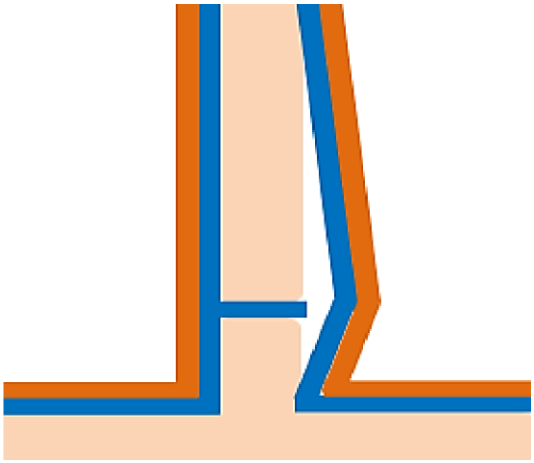


Figure 4: One has to cut across the fibrous attachments to join the superior and inferior subperiosteal tunnels

The perichondrium of the quadrangular cartilage and periosteum of the perpendicular plate of the ethmoid and vomer are in continuity because of their common embryologic origin from the frontonasal prominence. However the periosteum of the maxillary crest is separate from the periosteum of the vomer and perichondrium of the quadrangular cartilage due to its origin from the maxillary processes. This has clinical relevance as one has to cut across these fibrous attachments in order to join subperichondrial and subperiosteal dissection planes over the quadrangular cartilage or vomer with the subperiosteal plane over the maxillary crest (*Figure 4*).

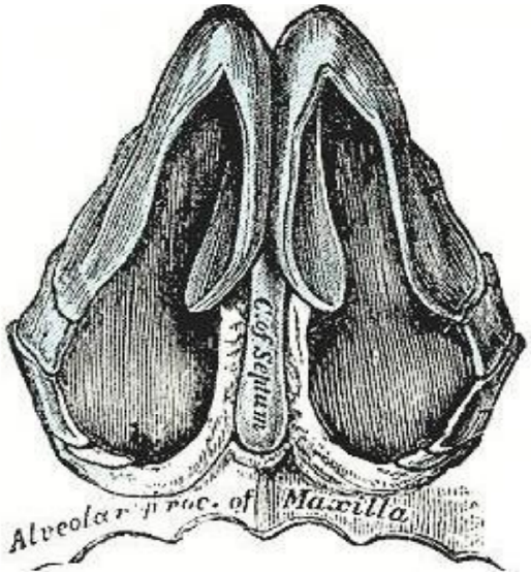


Figure 5: Nasal valve

The internal nasal valve is the narrowest part of the nasal airway and is formed by the septum, the anterior end of the inferior turbinate, the caudal aspect of the upper lateral cartilage and the floor of the piriform aperture (*Figure 5*). Deviation of the septum at the nasal valve is therefore likely to contribute to symptomatic obstruction. The quadrangular cartilage attaches to the columella by a membranous septum at the anterior and caudal aspect of the septum.

Vascular supply (Figures 6-8)

An understanding of the vascular supply is important if large mucoperiosteal flaps are to be used. Venous outflow generally follows the arterial blood supply.

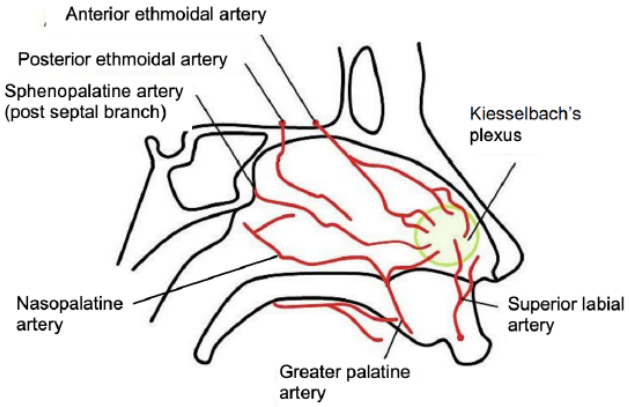


Figure 6: Arterial supply to nasal septum

The nasal septum has both internal (ICA) and external carotid (ECA) artery supply. The ***anteroinferior septum*** is supplied by the septal branch of the superior labial artery, and the greater palatine artery (*Figure 6*). The former arises from the facial artery, a branch of the ECA; the latter is a proximal branch of the internal maxillary artery, also a branch of the ECA.

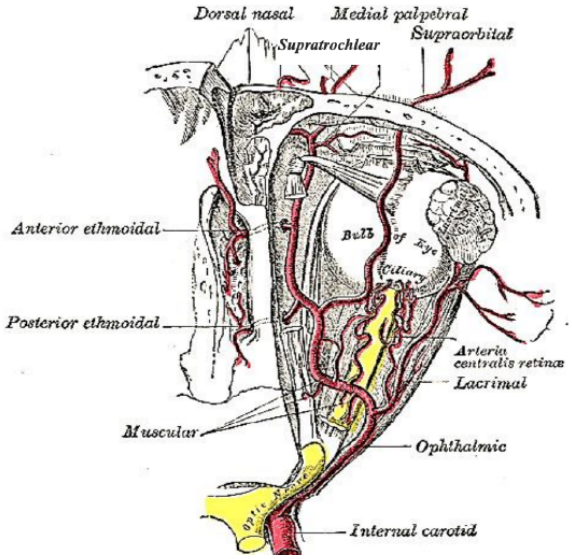


Figure 7: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries

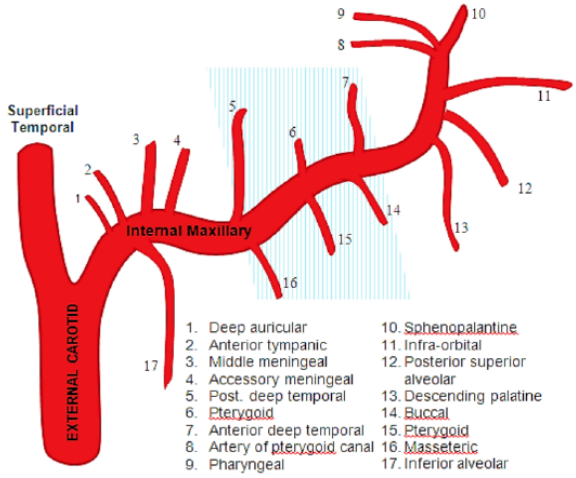


Figure 8: Branches of internal maxillary artery; blue shading denotes 2nd part of internal maxillary artery before it enters pterygopalatine fossa

The ***anterosuperior septum*** is supplied by the anterior ethmoidal artery; this arises from the ophthalmic artery, a branch of the ICA (*Figure 7*). These 3 vessels converge at the anterior septum to form Kiesselbach's plexus, a common origin of epistaxis. ***Posterosuperiorly the septum*** receives its blood supply from the posterior ethmoidal artery, a branch of the ophthalmic artery (ICA) and the posterior septal branch of the sphenopalatine artery, a terminal branch of the internal maxillary artery (ECA) (*Figures 6, 8*).

Innervation

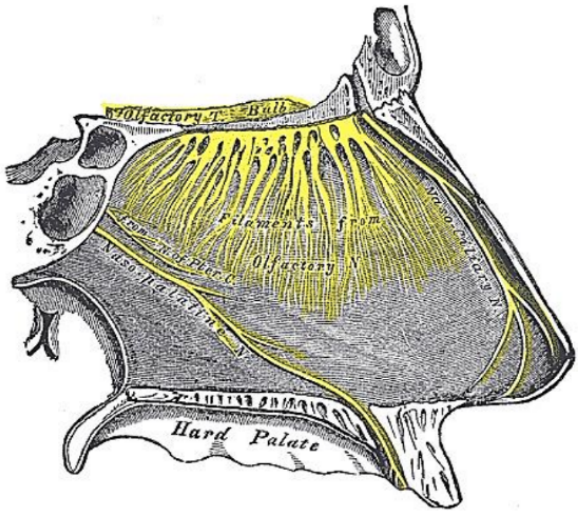


Figure 9: Nasopalatine nerve

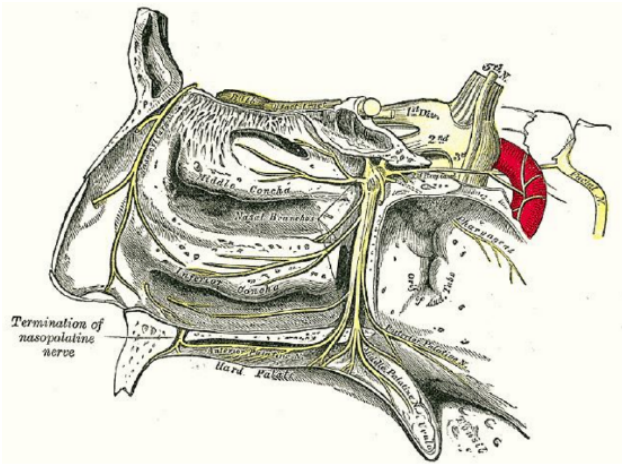


Figure 10: The nasopalatine nerve joins the greater palatine nerve via incisive foramen

The septum is innervated principally by the ophthalmic division (V1) of the trigeminal nerve. The anterior and posterior ethmoid dal nerves (branches of nasociliary nerve) are branches of V1 and provide sensory innervation to most of the septum. Only the nasopalatine nerve has its origin from the maxillary division (V2) of the trigeminal nerve (*Figure 9*); it arises from the pterygopalatine ganglion and innervates the anterior and caudal septum, primarily in the region of the maxillary crest. It enters the nasal cavity through the sphenopalatine foramen, passes medially below the ostium of the sphenoid sinus to reach the septum, and runs obliquely downward and forward between the periosteum and mucous membrane to reach the inferior septum. It then enters the roof of the mouth through the incisive canal and communicates with the corresponding nerve of the opposite side and with the greater palatine nerve (*Figure 10*). This has clinical relevance as surgical removal of the maxillary crest during septoplasty may injure the nasopalatine nerve and cause numbness of the maxillary incisors (often transient).

Surgical technique

Septoplasty must achieve separation of the left and right nasal cavities, adequate nasal air flow, as well as preserve dorsal and tip support of the nose. The authors favour submucosal resection of deviated septal cartilage and/or bone as was first reported and popularized by Freer and Killian.

Surgical approaches

It is the authors' preference to do the surgery endoscopically due to the excellent visibility it affords. Surgery may also be achieved with an operating microscope or with a headlight and nasal speculum. Nonendoscopic surgical approaches may include endonasal (+/-microscope), external rhinoplasty, alar release and midfacial degloving techniques. If an endoscopic technique is not used, access to the nasal septum can be restricted.

Surgical Steps

- Decongest both sides of the nose with pledgets soaked in 1:1000 epinephrine, or alternatively, pseudoephedrine. After several minutes, inject lidocaine with epinephrine in submucoperichondrial planes bilaterally

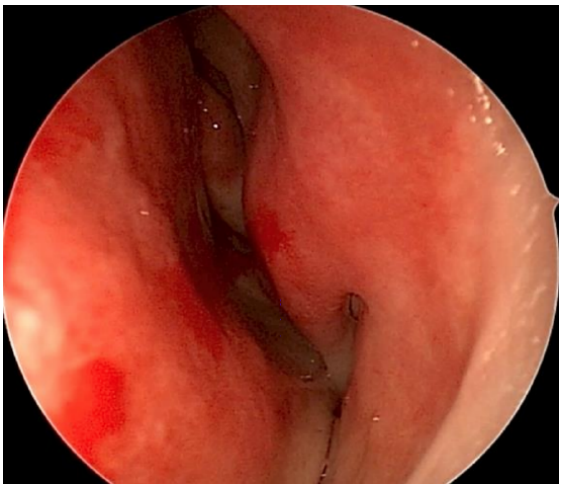


Figure 11: Deviated nasal septum (left nose)

- Examine both sides of the septum (*Figure 11*)
- Determine the side with a prominent septal convexity for the surgical approach as the mucosa is more likely to tear during elevation of the septal flap
- Incise the mucosa approximately 5 mm anterior to the intended transcartilaginous incision; the authors prefer to make the incision with an angled blade in order to cut perpendicular to the mucosa
- Extend the incision up to the mucoperichondrial junction taking care not to score the underlying cartilage
- Extend the incision as superiorly as possible; if an endoscope is used, use its shaft to retract the upper lateral cartilage to enhance the dorsal exposure

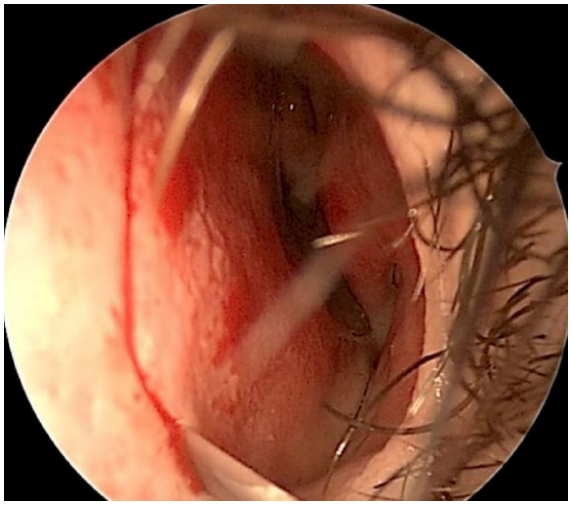


Figure 12: Incision up to the nasal floor where a back cut is added to enhance exposure

- Extend the incision to the nasal floor where a 5 mm back cut may be added to further enhance exposure (*Figure 12*)
- Use a Cottle elevator to develop a submucoperichondrial flap via the incision

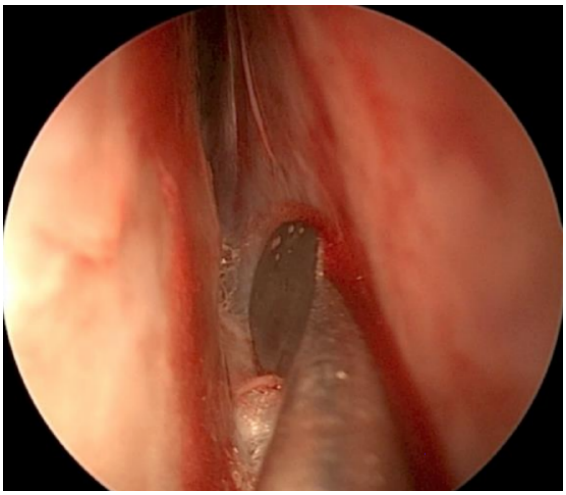


Figure 13: Mucoperichondrial and mucoperiosteal flaps have been elevated down to the maxillary crest

- Elevate a flap while stripping in a semicircular fashion starting in a posterosuperior direction, then down towards the nasal floor and finally sweeping from posterior to anterior inferiorly (*Figure 13*)
- Take care to remain within the welldefined subperichodrial / subperiosteal plane until you encounter the dense fibrous attachments to the maxillary crest (*Figure 4*); in order to extend elevation of the flap onto the maxillary crest and nasal floor the surgeon has to divide these fibers sharply using either a Cottle elevator or the belly of a #15 scalpel blade. Scrape along the underlying bone with a sweeping motion from the vertical limb of the maxillary crest inferiorly towards the nasal floor to divide these fibers
- The nasopalatine neurovascular bundle is often seen anteriorly during this step; take care to preserve it (*Figures 6, 9*)
- Continue to elevate the flap from the convexity of the septal deviation under direct vision until the “horizon” point is reached where one can no longer see the junction between the flap and the underlying cartilage/bone
- If the junction between the flap and the cartilage can no longer be seen, elevation should cease until later in the procedure

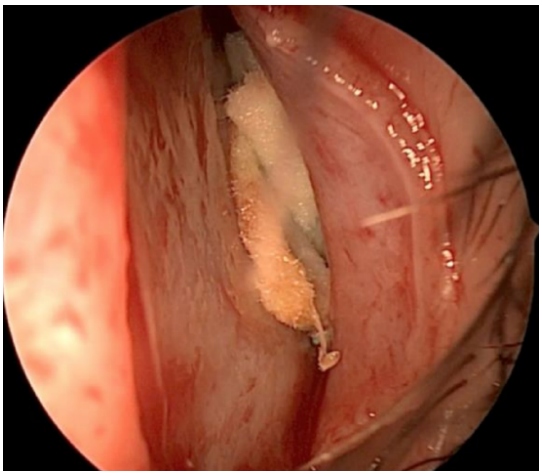


Figure 14: Flap elevated off the septal convexity with an epinephrine soaked pledget used for haemostasis

- Control bleeding with intermittent suction and epinephrine-soaked pledgets (*Figure 14*)

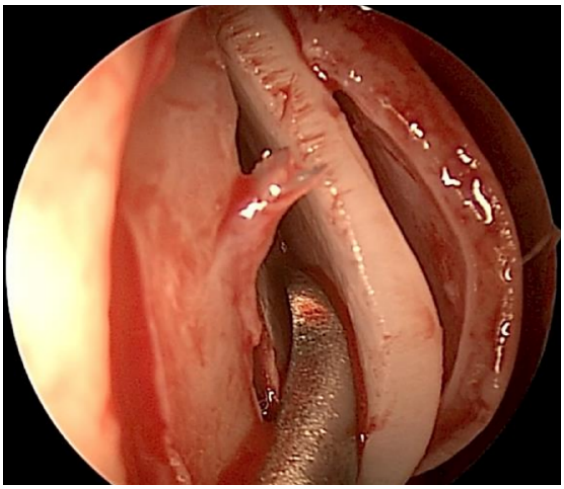


Figure 15: Cottle elevator used to complete the cartilage incision and to create a contralateral submucoperichondrial flap

- With the ipsilateral flap elevated beyond the septal deviation, make a transcartilaginous incision 1-2 mm posterior to the original mucosal incision with an angled blade or by scoring the cartilage with the blade and then using a Cottle elevator to complete the cartilage incision (*Figure 15*)

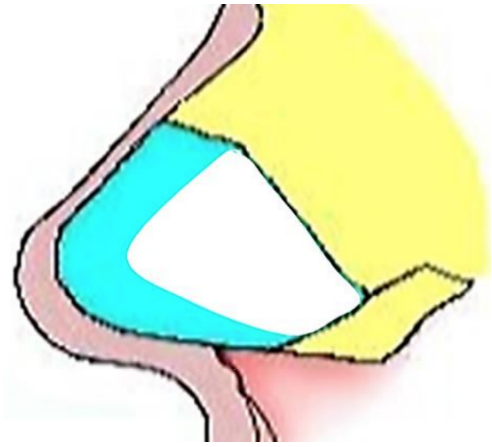


Figure 16: Dorsal and caudal cartilage struts of >1 cm are preserved for support

- Preserve dorsal and caudal cartilage struts of >1 cm for nasal and tip support (*Figure 16*)
- Elevate a contralateral flap (*Figure 15*); stop elevating the flap when the junction between the flap and cartilage cannot be seen

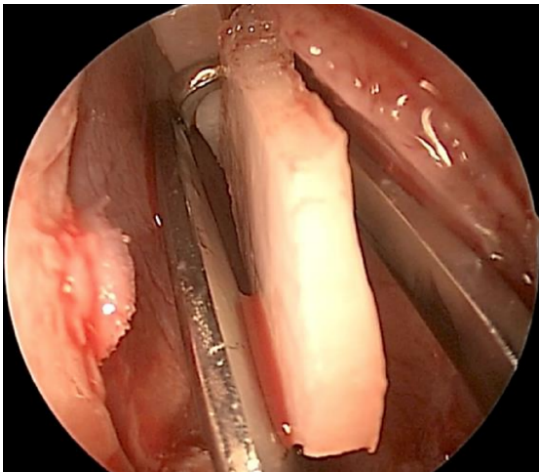


Figure 17: A swivel knife is being used to excise the deviated cartilage

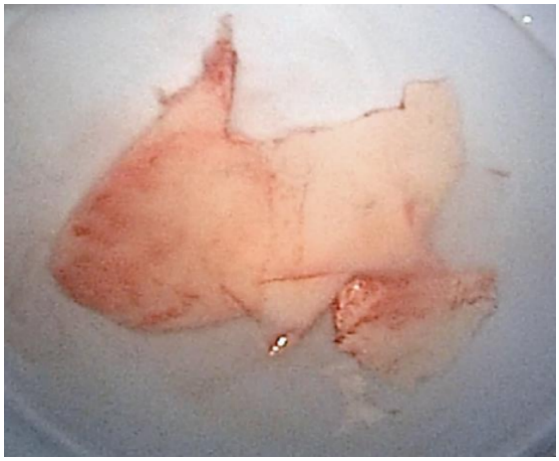


Figure 18: Cartilage is preserved to be replaced at later in the procedure

- Once both flaps have been fully elevated, use a swivel knife or scissors to remove part of the quadrangular cartilage (*Figure 17*); save the cartilage to later replace it (*Figure 18*)

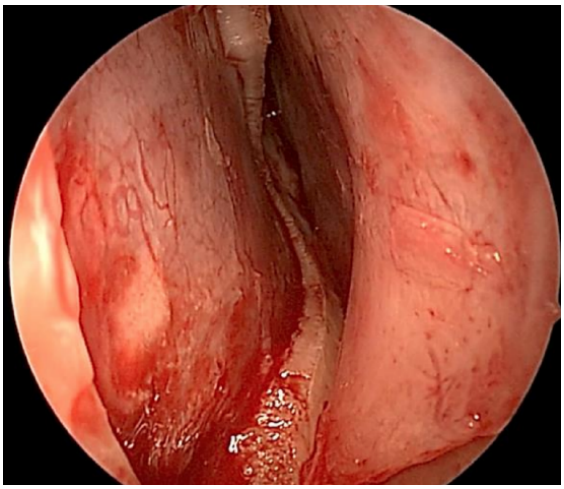


Figure 19: Improved access after removal of cartilage

- Removing cartilage improves the view of remaining septal deflections and affords better access to the “horizon points” which previously limited elevating the flaps (*Figure 19*)
- Further elevate the flaps to fully expose the septal deflections
- Use a through-biting punch to remove bone above the deflection to separate the deflection from its attachment to the skull base taking care not to twist the vertical plate of the ethmoid to avoid inadvertently fracturing of the cribriform plate
- Once the deflection has been separated from the skull base, reflect remaining mucosal attachments around the deflection and carefully fracture and re-move remaining bony deflections with grasping forceps

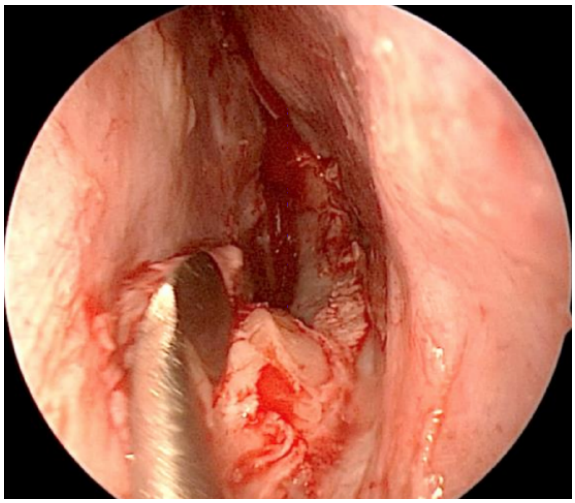


Figure 20: Exposing the maxillary crest

- If a deflection involves the maxillary crest, elevate the mucosa along the floor of the nose in a posterior to anterior direction (*Figures 1, 20*)

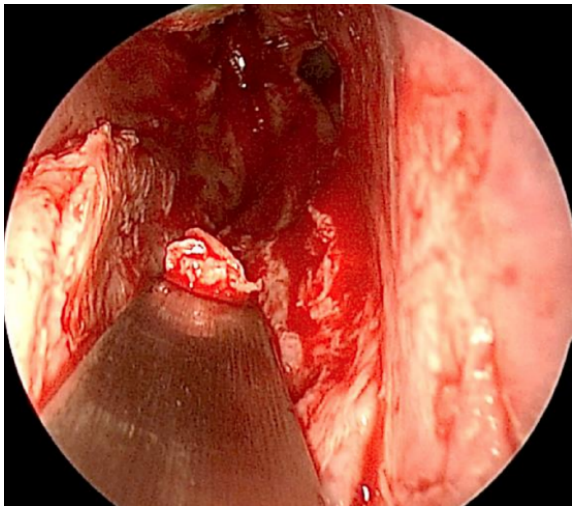


Figure 21: A 4 mm chisel is used to remove crest projecting into the airway

- Remove the crest which projects into the airway with a 4 mm chisel (*Figure 21*); do not completely transect the crest if possible as this may injure the nasopalatine nerve and precipitate troublesome bleeding from the greater palatine artery Once the entire deflection has been removed it is recommended that the cartilage that had been removed is replaced, particularly if a large portion of the quadrangular cartilage was excised; curved areas of the cartilage are first flattened with a mallet

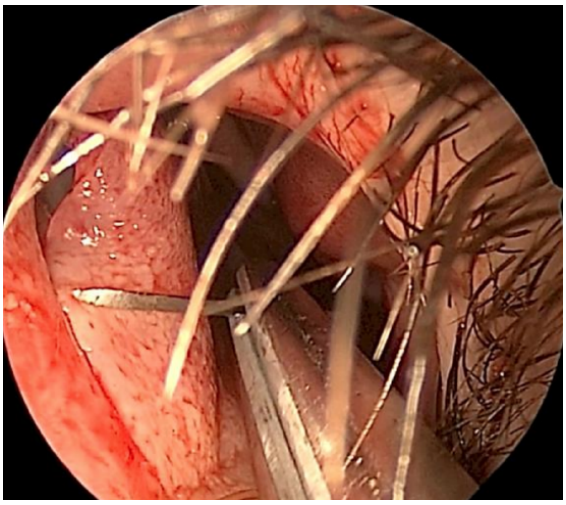


Figure 22: Coapting the mucoperichondrial flaps

- The mucoperichondrial flaps are closed; use a 4-0 plain catgut suture on a a Keith needle to close both the incision and to coapt the mucoperichondrial flaps with a quilting stitch
- Pass the needle posterior and then anterior to the incision; tie the 2 knots to tack down the mucosa (*Figure 22*) Take care with this initial stitch to fully approximate the mucosal edges leaving a long tail

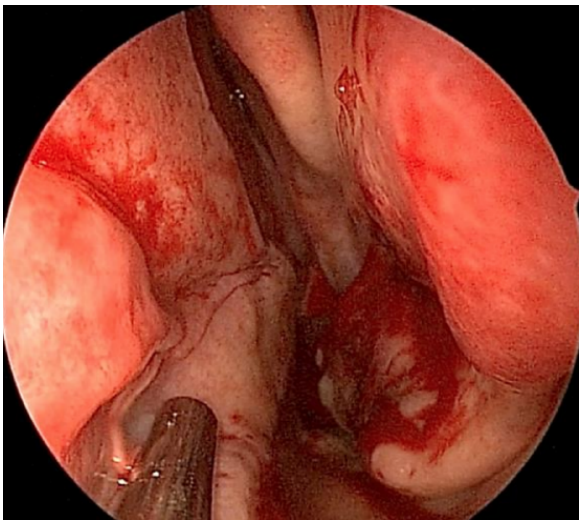


Figure 23: Coapting the mucoperichondrial flaps

- Use the same stitch to close the incision using a similar back-and-forth technique. It may be carried posteriorly to coapt the mucoperichondrial flaps using 3 to 4 passes (*Figure 23*). Finally the stitch may be brought anteriorly and tied to the long tail of the initial tacking stitch
- Splints are optional following quilting although it may promote healing and reduce the risk of a septal hematoma; the senior author uses Doyle splints which are sutured through the membranous septum and left in place for approximately 1 week

Complications

- Septal hematoma
- Epistaxis from raw mucosal edges
- Septal perforation
  - Bilateral, opposing mucosal tears
  - Excessive packing
  - Septal hematoma
- Nasal obstruction
  - Inadequate correction of septal deformity
  - Synechiae from opposing, traumatized septal and inferior turbinate mucosal surfaces

- Nasal deformity from excessive removal of cartilage and preserving too little dorsal or caudal cartilage struts



Figure 24: Septal hematoma

Septal hematomas (*Figure 24*) are rare, particularly with the use of quilting stitches and splints. The surgeon should be vigilant for this complication as it requires immediate intervention. Many hematomas may be managed in a clinic setting by incising the mucosa under local anesthesia and evacuating the clot. Bilateral packing to exert pressure on the site of the hematoma is recommended to avoid reaccumulation. If an obvious cause is not evident, the surgeon should rule out a coagulopathy.

Septal perforations may be very symptomtic and should be avoided at all costs. The key to avoiding perforations is to avoid opposing mucosal perforations. While a perforation ipsilateral to the deviation may be unavoidable and generally does not have consequence, great care should be taken to preserve the integrity of the contralateral mucosal flap. If opposing perforations are noted, then an interposition graft should be placed between the flaps such as autologous cartilage/fascia or an alloplastic graft. The authors do not recommend attempting to primarily approximate the edges of a perforation as tension on the mucosa from the suture may cause further tears, compromise blood supply, and enlarge the mucosal defect.

Authors

Ahmad R. Sedaghat, MD, PhD
Chief Resident
Department of Otolaryngology - Head and Neck Surgery
Massachusetts Eye and Ear Infirmary
Harvard Medical School
Boston, USA
ahmad_sedaghat@meei.harvard.edu

Benjamin S. Bleier, MD
Assistant Professor
Department of Otology and Laryngology
Massachusetts Eye and Ear Infirmary
Harvard Medical School
Boston, USA
benjamin_bleier@meei.harvard.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SPHENOPALATINE ARTERY (SPA) LIGATION

Darlene Lubbe

SPA ligation is generally indicated for intractable posterior epistaxis that does not settle following 24 hours of adequate anterior and posterior nasal packing, and for recurrent unilateral epistaxis unrelated to an underlying systemic disease or a drug related blood dyscrasia.

Anatomy of the sphenopalatine artery

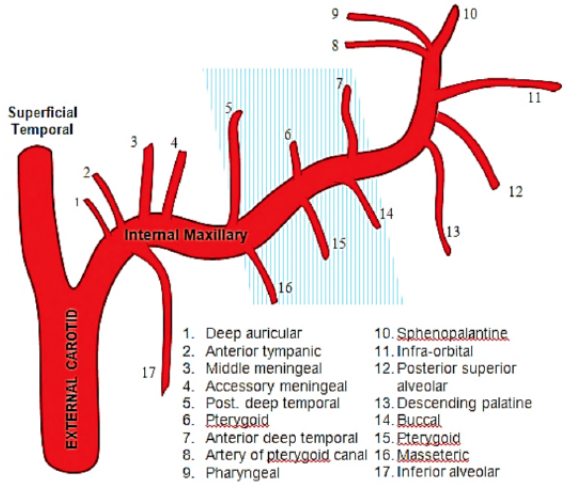


Figure 1: Branches of internal maxillary artery

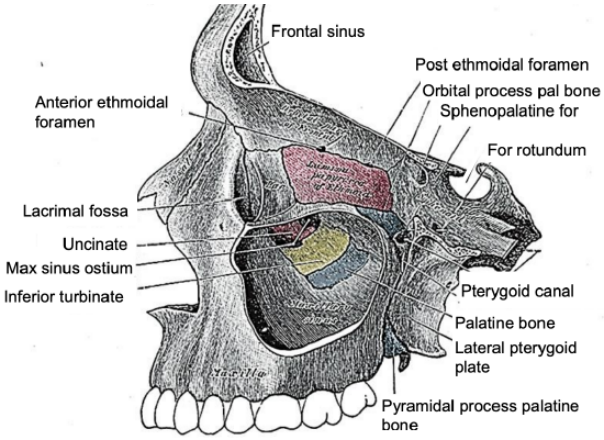


Figure 2: Picture showing the left maxillary sinus and the sphenopalatine foramen located behind the posterior wall of the maxillary sinus

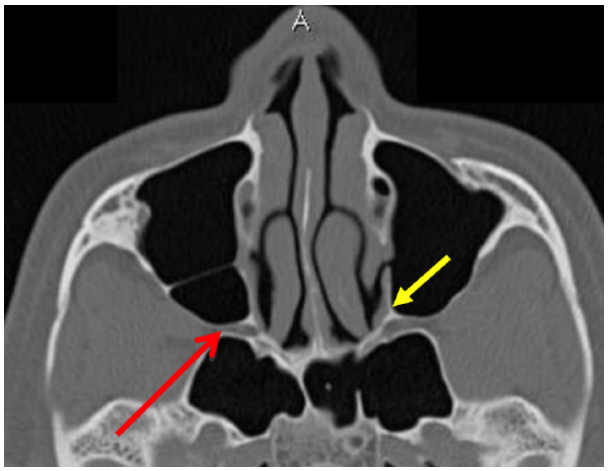


Figure 3: Axial CT scan of sinuses with red arrow pointing to the SPA and pterygopalatine fossa, and the yellow arrow pointing to the christa ethmoidalis

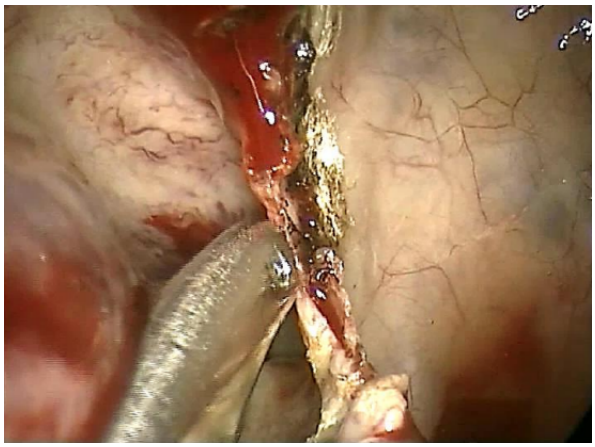


Figure 4: Endoscopic view showing the posterior wall of the left maxillary sinus; the instrument is just anterior to where the crista ethmoidalis would be located

The sphenopalatine artery (SPA) is one of the terminal branches of the internal maxillary artery (IMA) which originates from the external carotid artery system. It provides 90% of the blood supply to the nasal cavity i.e. the lateral nasal wall, the turbinates and most of the nasal septum. The anterior and superior nasal septum is supplied by the anterior and posterior ethmoidal arteries which originate from the ophthalmic artery (internal carotid artery system). The sphenopalatine artery is one of six terminal branches of the 3rd or pterygomaxillary portion of the internal maxillary artery (*Figure 1*). These 6 branches all originate in the ptergyopalatine fossa which is located behind the medial part of the posterior wall of the maxillary sinus (*Figures 2, 3 & 4*).

The sphenopalatine artery may have 1-10 branches, with 97% of patients having >2 branches and 67% having >3 branches. All branches arise from the SPA in the pterygomaxillary fissure and enter the nasal cavity as separate blood vessels. The most anterior branch is the largest and exits through the sphenopalatine foramen. This branch needs to clipped or cauterized and cut to be able to determine the presence of more posteriorly located vessels. Other branches of the SPA may exit posterior to the main branch or superior or inferior to the SPA foramen.

Preoperative consent

Patients need to be informed that

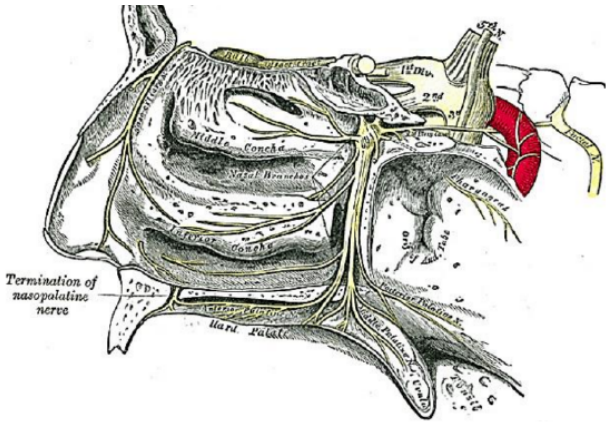


Figure 5: Diagram showing the right sphenopalatine foramen with the nasopalatine nerve which can be injured during SPA ligation, exiting the foramen

- The procedure might fail following which angiography and embolization could be required to control bleeding
- Cauterizing the SPA too vigorously can injure the nasopalatine nerve or its branches and cause palatal numbness (*Figure 5*)

Anesthesia, Positioning and Draping

1. SPA ligation is usually performed under general anesthesia with a cuffed endotracheal tube to protect the airway
2. Local anesthesia is not advisable since patients with epistaxis will have blood running down the pharynx causing coughing and possible aspiration of blood
3. The anesthetist should optimize the surgical field by keeping the patient normotensive with a slow heart rate
4. Total intravenous anesthesia (TIVA) is the author's preference
5. Insert a throat pack if there is significant bleeding or if it is anticipated, to avoid aspiration of blood and to avoid blood entering the stomach and causing post-operative nausea and vomiting
6. Place the patient supine with the head level or slightly flexed to 15 degrees and slightly rotated towards the surgeon
7. Close the eyes and cover them with see-through adhesive plastic sheeting; the drapes should not obscure the eyes

Initial surgical steps

1. Remove all nasal packing
2. Irrigate the nasal cavity with warm saline
3. Apply topical anesthesia by inserting ribbon gauze or neurosurgical patties soaked in 2 mL of 1:1000 adrenaline between the inferior turbinate and the nasal septum and in the middle meatus if possible.
4. Oxymetazoline can be used instead of adrenaline in patients with cardiac disease

SPA ligation: Surgical steps (Left side)

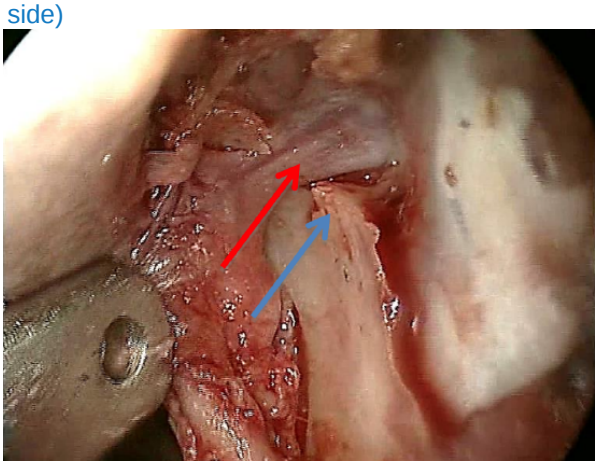


Figure 6: Blue arrow points to crista ethmoidalis; SPA is visible behind it (red arrow)

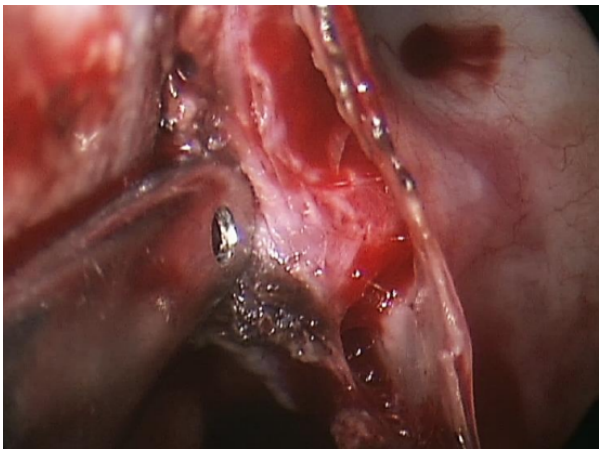


Figure 7: SPA as it exits the SP-foramen

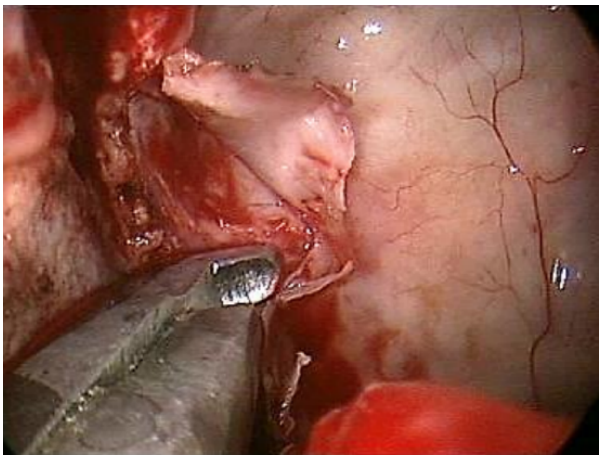


Figure 8: Removing crista ethmoidalis with a Kerrison upcut punch to expose pterygopalatine fossa behind maxillary sinus

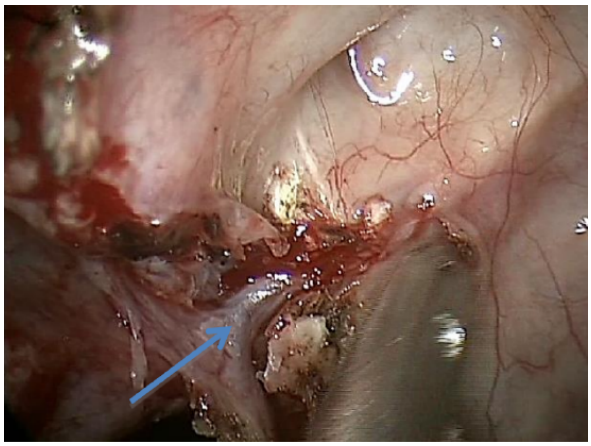


Figure 9: The most anterior or main branch of the SPA is identified (blue arrow) and followed into the pterygopalatine fossa for a few millimeters

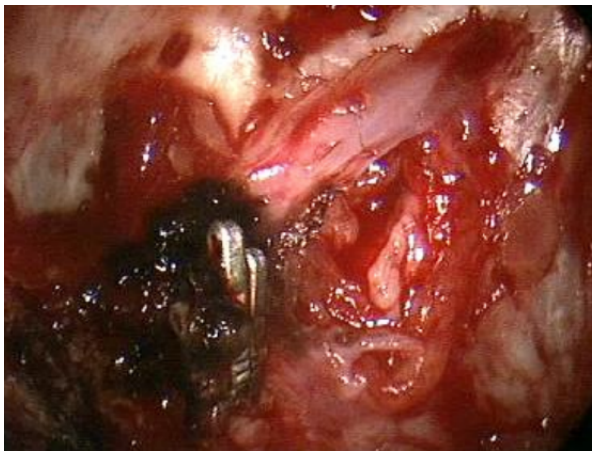


Figure 10: Two ligaclips applied to the proximal end of the SPA. The artery was the cut to find posteriorly-located branches

1. Endoscopically inspect the nasal cavity, nasopharynx, entire nasal septum, turbinates and lateral wall of the nose
2. If an obvious bleeder is found, bipolar cautery is applied to the area and a decision is made whether to proceed with an SPA ligation or not. If any doubt exists whether the cauterized vessel was responsible for the bleeding, proceed to SPA ligation
3. Irrigate the maxillary sinus by means of a proof puncture via the inferior meatus to clear blood from the sinus
4. Inject 0.5-1ml of 1:80 000 adrenaline with lignocaine into the axilla of the middle turbinate and into the posterior insertion of the middle turbinate to the lateral nasal wall. It is essential to inject slowly to avoid sudden increases in blood pressure
5. Advance a 0 degree, 18 cm rigid endoscope into the posterior nasal cavity by guiding the endoscope between the inferior and middle turbinates
6. Once the nasopharynx is reached, the endoscope is retracted slightly into the posterior end of the middle meatus, just lateral to the most posterior part of the middle turbinate where it inserts into the lateral nasal wall
7. Gently medialize the posterior part of the middle turbinate taking care not to fracture the middle turbinate at its attachment to the cribriform plate as this may cause a CSF leak. There is no need to medialise the anterior portion of the middle turbinate
8. Palpate the lateral nasal wall to locate the posterior fontanelle. The fontanelle is a mucosa-covered ‘ostium’ and is located posterior to the uncinate process, under the bullae ethmoidalis and about 1 cm anterior to where the middle turbinate attaches to the lateral nasal wall posteriorly. This defect in the bony medial wall of the maxilla can be clearly palpated
9. Make a vertical mucoperiosteal incision immediately behind the posterior fontanelle. This is about 1 cm anterior to the posterior insertion of the middle turbinate. The incision should be about 1 cm in length and should extend from high up in the middle meatus (at the level of the basal lamella) to the inferior turbinate
10. Dissect submucosally in a posterior direction from the vertical incision behind the posterior fontanelle
11. The first structure to be encountered is the crista ethmoidalis (*Figure 6*). It is an important landmark as the SPA is located just posterior to it. Take care when dissecting around this area not to accidentally disrupt the SPA as this can cause significant bleeding
12. Elevate a mucoperiosteal flap to expose the SPA as it exits its foramen (*Figure 7*)
13. Use a Kerrison punch or upcut to remove the crista ethmoidalis and to follow the SPA laterally into the pterygopalatine fossa (*Figure 8*)
14. Identify the main or anterior branch of the SPA (*Figure 9*)
15. Either cauterize the vessel with bipolar cautery or apply a Ligaclip (*Figure 10*) The author prefers bipolar cautery as Ligaclips often are dislodged
16. Transect the artery to provide access to determine the presence of more arterial branches posteriorly, superiorly and inferiorly (*Figure 10*)
17. Replace the mucosal flap and place a small piece of Surgicel over the mucosal flap; no additional nasal packing is required
18. Observe the patient in hospital overnight

Alternative technique in the event that the SPA is not found

It may be difficult to locate the SPA especially in the following circumstances:

- An edematous nose secondary to nasal packing
- Anatomical anomalies e.g. deviated nasal septum, large concha bullosa etc.
- Limited space in the nasal cavity due to a combination of the above factors and/or large turbinates

If the tip of the endoscope cannot be positioned in the posterior part of the middle meatus and limited space prevents one from making the mucosal incision, the following should be done:

1. Do a standard uncinectomy, preserving the superior part of the uncinate
2. Enlarge the maxillary sinus ostium posteriorly using a through-cutting Blakesley forceps until the posterior wall of the maxillary sinus is encountered (*Figure 4*)
3. This provides sufficient access so that the mucoperiosteal flap can be raised from the level of the posterior wall of the maxillary sinus (*Figure 7*)
4. Occasionally a limited septoplasty or reduction of a concha bullosa is required to gain adequate access to the posterior middle meatus

Postoperative instructions

1. The patient is discharged the following day with topical Oxymetazoline nasal spray for 5 days
2. Instruct the patient not to blow the nose for at least 48 hours and only gently thereafter
3. Oral antibiotics are not routinely required; neither is nasal douching
4. The patient is seen after 2 weeks to ensure that no further bleeding has occurred

Author

Darlene Lubbe MBChB, FCS (ORL)
Associate Professor
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
doclubbe@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ENDOSCOPIC TRANSNASAL OPTIC NERVE DECOMPRESSION

Boštjan Lanišnik, Janez Ravnik

This chapter focuses on the indications, decision making and surgical technique of endoscopic transnasal optic nerve decompression and presents some controversies relating to decompression for traumatic optic neuropathy. Endoscopic optic nerve decompression can be performed with little or no morbidity. It is done mainly for traumatic optic neuropathy. Other indications include skull base tumors e.g. meningiomas growing into the optic canal. or fibroosseous lesions of the skull base. Endoscopic optic nerve decompression is most suited to pathology located medial to the optic nerve. Lateral fractures of the sphenoid wing e.g. of the clinoid, are more easily accessed through a pterional approach.

Surgical Anatomy

Optic canal

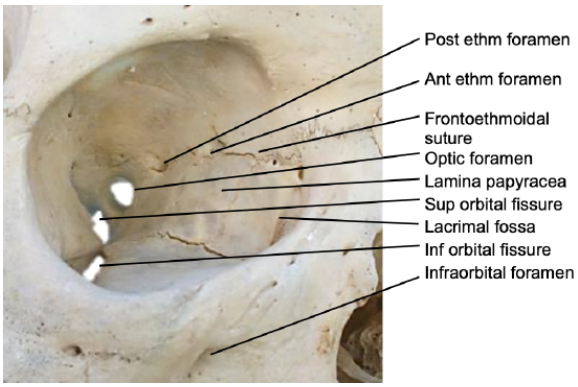


Figure 1: Right medial orbital wall



Figure 2: Close-up of right orbit demonstrating the position of the optic canal relative to the posterior ethmoidal foramen, superior orbital fissure and optic strut

The optic nerve enters the optic canal at the superomedial corner of the orbital apex. The canal is about 10 mm in length and contains the optic nerve, ophthalmic artery and sympathetic plexus. Laterally it is separated from the superior orbital fissure by a bony bridge called the optic strut (*Figures 1, 2*).

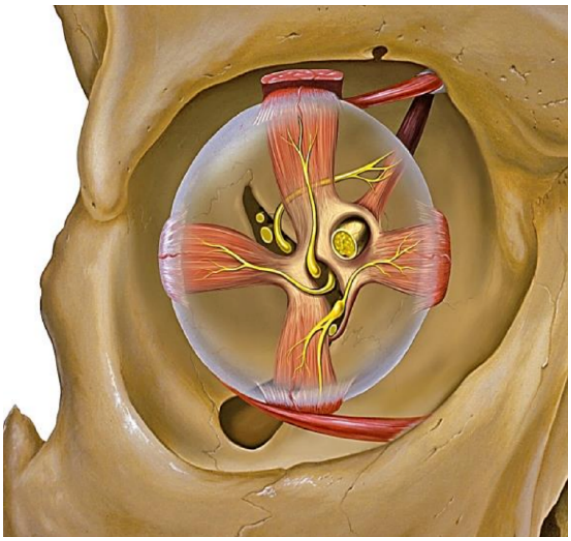


Figure 3: Eye muscles attach to Annulus of Zin [1]

The tendinous Annulus of Zinn is attached at the upper, medial and lower margins of the optic canal (12 to 6 o'clock). It is the insertion for the extraocular muscles i.e. superior, medial, inferior and lateral rectus (*Figure 3*).

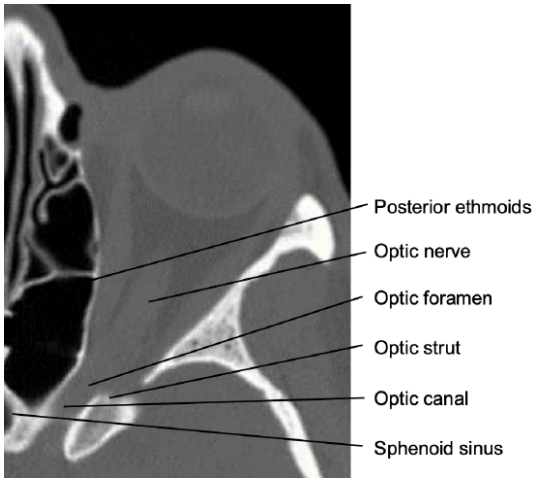


Figure 4: Note the posteromedial course of the optic canal

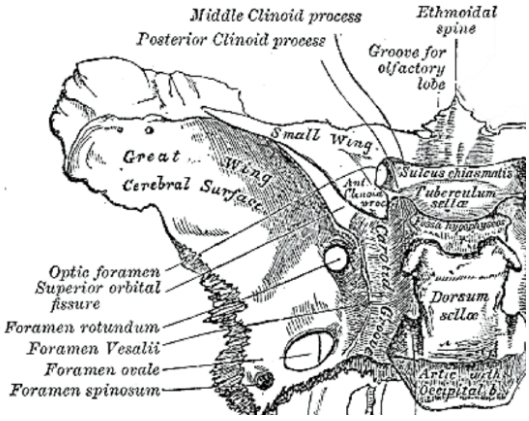


Figure 5: Relationships of optic canal to sphenoid and clinoid

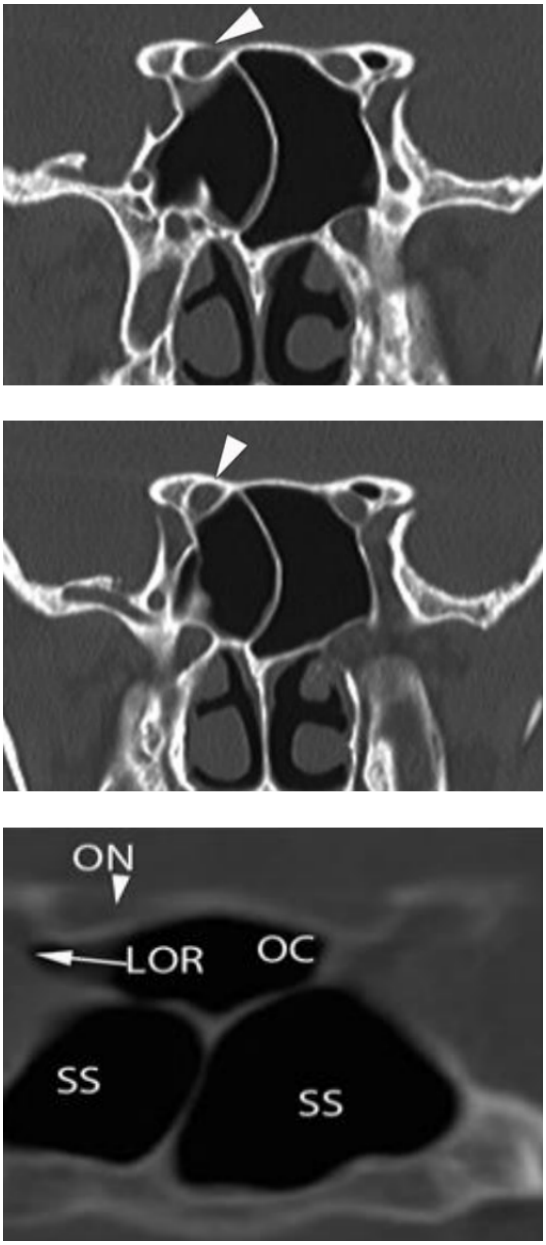


Figure 6: Coronal CTs and intraoperative photograph demonstrating the relations of the optic (ON) to the lesser wing of the sphenoid bone, the sphenoid bone, and the sphenoid sinus (SS) or alternatively into the Onodi cell (OC) of the posterior ethmoid

The optic canal courses in a posteromedial direction (*Figure 4*). The walls are formed by the body of the sphenoid and the lesser sphenoid wing. At the intracranial end it is shielded laterally by the anterior clinoid. The lateral wall of the optic canal is formed by the optic strut that blends superolaterally into anterior clinoid (*Figures 4, 5, 6*). The superior wall is formed by the anterior root of the lesser wing of the sphenoid bone; the medial wall is formed by the sphenoid bone (*Figure 5*).

This wall projects into the upper lateral wall of the sphenoid sinus or alternatively into the Onodi cell of the posterior ethmoid (*Figure 6*).

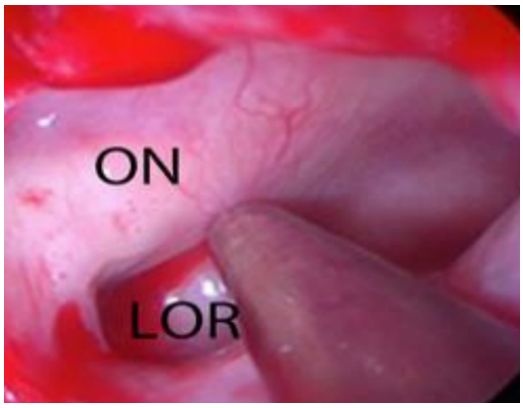


Figure 7: Left Optic nerve (ON) and lateral optico-carotid recess (LOR)

Ophthalmic artery (Figure 8)

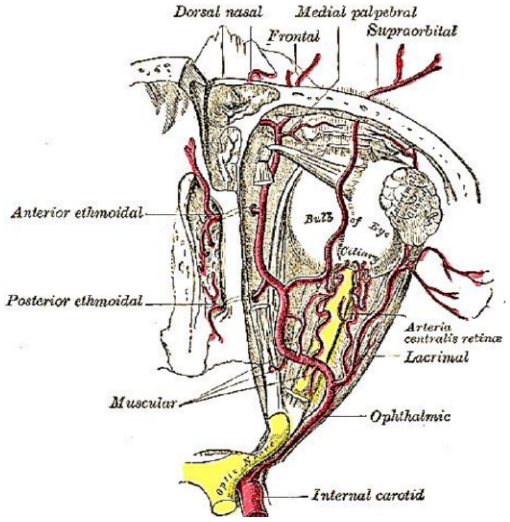


Figure 8: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries and the supratrochlear and supraorbital arteries

The ophthalmic artery arises from the medial aspect of the anterior loop of the internal carotid artery (ICA) just above the cavernous sinus. Intracranially it is located medially and below the optic nerve. In the optic canal the artery passes within the optic nerve sheath and below the optic nerve.

There are variations of the position of the ophthalmic artery within the canal. It can be found anywhere between 3 and 6 o'clock, so caution must be exercised when incising the optic nerve sheath.

Optic nerve

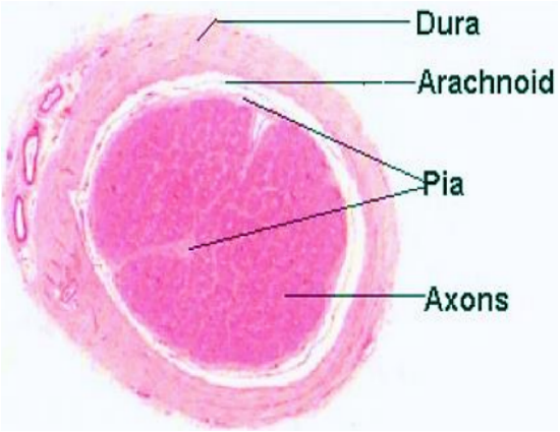


Figure 9: Cross-section of optic nerve

The optic nerve exits the orbit via the optic canal and courses posteromedially to the optic chiasm where there is a partial decussation (crossing over) of its fibers from the temporal visual fields of both eyes (*Figure 9*). Unlike peripheral nerves that contain epi-, peri- and endoneurium, the optic nerve is ensheathed in all three meningeal layers i.e. dura, arachnoid, and pia mater (*Figure 9*). The reason for this different structure is that the optic nerves are part of the central nervous system as they are outpouchings of the diencephalon (optic stalks) during embryonic development. Because fiber tracts of the central, as opposed to the peripheral nervous system are incapable of regeneration, optic nerve damage produces irreversible blindness.

Traumatic optic neuropathy (TON): classification and terminology

TON refers to injury to the optic nerve due to craniofacial trauma. Injury may be direct e.g. penetrating trauma and physical disruption of optic nerve continuity, or indirect when trauma forces are transmitted to the optic nerve with no/minimal disruption of the surrounding structures.

TON can be classified according to the location of the injury: head of optic nerve, intraorbital segment, intracanalicular segment or intracranial segments. The two most common sites of indirect TON are the intracanalicular segment (optic nerve sheath is adherent to the periosteum) and intracranial segment (in close proximity to the dural rings).

The optic nerve can be decompressed at other levels as well, e.g. the intracranial segment and the optic chiasm. Compressive symptoms at these levels are predominantly caused by tumors such as meningiomas and pituitary adenomas. Decompression of these segments requires transplanum and transsellar approaches that are not discussed in this chapter.

Controversies relating to optic nerve decompression in TON

Nerve decompression is a ***controversial procedure when performed for TON***. It is ***performed only for indirect TON***, since direct TON with optic nerve disruption is by definition an irreversible injury. There is a close association between initial visual acuity and final results. Patients who are blind and have no light perception when first examined have extremely poor or no chance of benefiting from decompression. Fractures of the optic canal as well as fragment impingement also carry a worse prognosis in some studies, although not in all.

Despite there being no scientific evidence that decompressing the optic nerve for indirect TON improves visual outcomes it is still performed in selected cases. The International Optic Nerve Trauma Study was intended to be a randomized control trial, but because of failure to recruit enough patients it was converted into an observational study. There was no statistically significant difference in visual acuity outcomes between the observational, steroid and surgical groups.

Role of corticosteroids in TON

Steroids have been used for spinal cord injury since the 1990s after the NASCIS 2 and 3 studies which demonstrated some benefits relating to neurological symptoms if methylprednisolone (MP) was administered within 8 hours of a spinal cord injury with initial a bolus of 30 mg/kg of MP, followed by infusion of 5.4 mg/kg/hr for the next 23 hours. Both studies were heavily criticized for their designs and questionable benefit of MP on improvement of the neurological deficits. Revised recommendations by the American Association of Neurological Surgeons (AANS) recommended against the use of steroids in the first 24 to 48 hours after spinal cord injury.

After publishing the results of the MRC CRASH study showing potential harmful effects of steroids in craniofacial trauma patients, the use of steroids for TON has become more limited, since most patients with TON have some form of concomitant intracranial injury.

A Cochrane Review by Yu-Wai-Man and Griffiths in 2011 compared 31 eligible double-blinded placebo-controlled, randomized trials of high-dose intravenous steroids in patients with indirect TON. The authors concluded that there is a high rate of spontaneous visual recovery and that there is no convincing data that would suggest any added benefit of steroids over observation alone. Nevertheless, many practitioners still use steroids as conservative management of the TON, but the decision must made on a case-by-case basis.

Indications & contraindications for optic nerve decompression

Optic nerve decompression is generally always indicated if continuity of the optic nerve is not disrupted and there is evidence of worsening of visual acuity.

Indications for optic nerve decompression include (from Palmer JN, Chiu AG)

- Traumatic optic neuropathy
- Graves' ophthalmopathy associated with optic neuropathy
- Idiopathic intracranial hypertension
- Fibro-osseous lesions
- Neoplasms (sinonasal tumor, meningioma, orbital apex tumor)

Contraindications for optic nerve decompression include

- Complete disruption of the nerve or chiasm
- Complete atrophy of the nerve
- Carotid-cavernous fistula
- Medical comorbidities precluding general anesthesia

TON is one of the most frequent indications for optic nerve decompression. Because of the poor chance of a blind patient regaining useful vision after decompression we consider decompression only in cases where there is a displaced fracture of the canal, but there is no evidence that the nerve was severed. In patients with preserved light perception we always consider surgical decompression with/or without steroids.

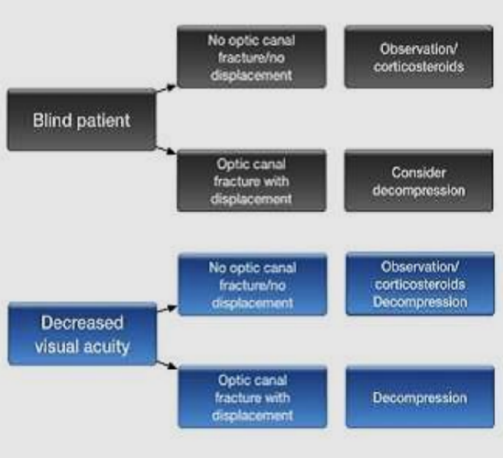


Table 1: Management algorithm for TON

With all the controversies of the surgical procedure as well as corticosteroids, we ***use the following algorithm for TON (Table 1)***.

Timing of intervention is also controversial, but logic dictates that decompression should be done as soon as possible after optic neuropathy is diagnosed, especially if it is of sudden onset. In patients with TON and fractures of the sphenoid wing and anterior clinoid that are displaced, lateral decompression via pterional approach must be considered.

Clinical presentation of optic neuropathy

A patient's history will reveal the etiology of an optic neuropathy e.g. trauma, tumor, or surgery. Patients will also report how quickly the vision has deteriorated e.g. slowly over months with skull base tumors, and rapidly following trauma. In comatose patients it is difficult to establish whether a patient has TON, since there are no reliable electrophysiological tests that can be used.

Technique of transnasal optic nerve decompression

Standard instruments used for endoscopic sinus surgery are required e.g. through-cut, dissecting instruments as well as powered instrumentation. One can use a regular high-speed diamond drill usually with a 4 mm fine diamond burr, or special powered instruments with a hand piece that allows simultaneous irrigation and suction. It is important to use abundant irrigation during drilling to avoid thermal damage to the nerve.

Surgical technique

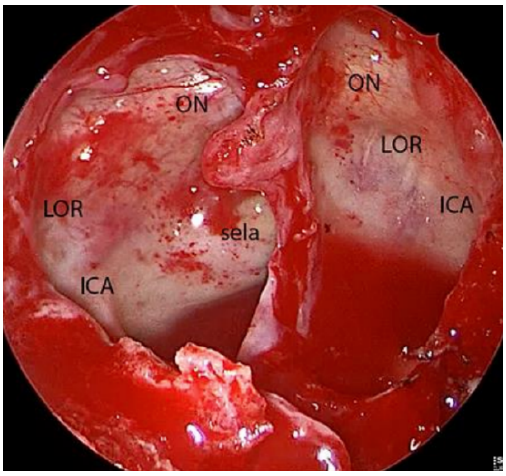


Figure 10: Lamina papyracea exposed up to face of sphenoid

1. Perform a ***posterior ethmoidectomy*** with a wide antrostomy; for less experienced surgeons it is best to perform a complete ethmoidectomy and expose the lamina papyracea (*Figure 10*)
2. Perform a ***wide sphenoidotomy*** with the anterior sphenoid wall resected to the skull base and to the lamina papyracea; this helps one to identify the orbital axis and orbital apex
3. Identify the orbital apex and optic canal

- The easiest and safest way to achieve this is to resect the lamina papyracea posteriorly, starting 10-15 mm anterior to the face of the sphenoid
- One can sometimes remove the lamina papyracea with a Freer elevator, but if it is too thick, then a high-speed drill is first used to thin it to an egg-shell thickness
- Take care not to injure the periorbita and the underlying extraocular muscles; if the periorbita are injured, fat protrudes into the field of view; it is safe to carefully bipolar small pieces of fat

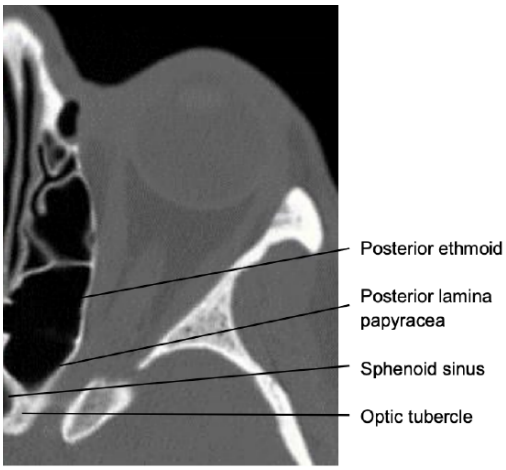


Figure 11: Note the posteromedial course of the optic canal

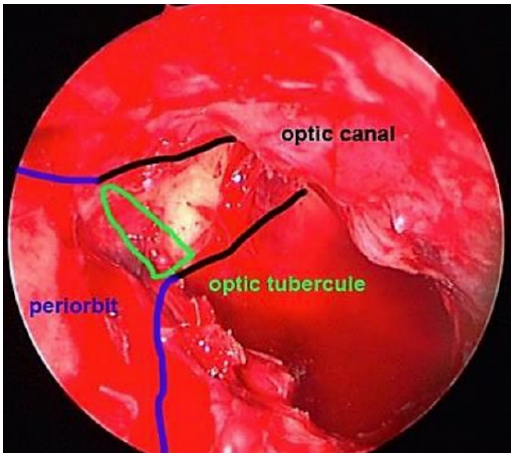


Figure 12: Lamina papyracea has been removed; periorbita exposed; wide sphenoidotomy; optic tubercle visible

4. After the posterior lamina papyracea has been removed, follow the periorbita posteriorly to where they converge at the orbital apex; the thick bone between posterior ethmoid and sphenoid is known as the optic tubercle (*Figures 11, 12*)

5. The Annulus of Zinn (*Figure 3*) is attached to the superior, inferior and medial margins of the orbital junction with the optic canal and can be identified after complete resection of the lamina papyracea at the level of the optic tubercle

6. The Annulus of Zinn (*Figure 3*) is attached to the superior, inferior and medial margins of the orbital junction with the optic canal and can be identified after complete resection of the lamina papyracea at the level of the optic tubercle

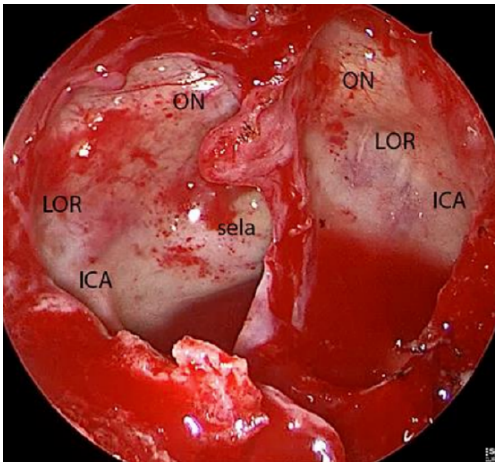


Figure 13: Endoscopic view of right and left sphenoid sinuses demonstrating the optic nerve (ON), internal carotid artery (ICA) and lateral optic-carotid recess (LOR)

7. Identify the bony protrusion of the optic canal in the sphenoid sinus; it is a continuation of the optic tubercle (*Figure 13*)

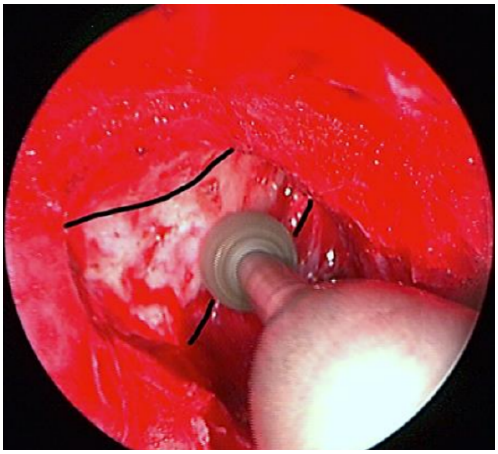


Figure 14: Thinning the bone down to an eggshell thickness with a high-speed drill

8. Use a diamond burr attached to a high speed drill or a powered endonasal hand piece to thin the bone down to an egg-shell thickness (*Figure 14*)

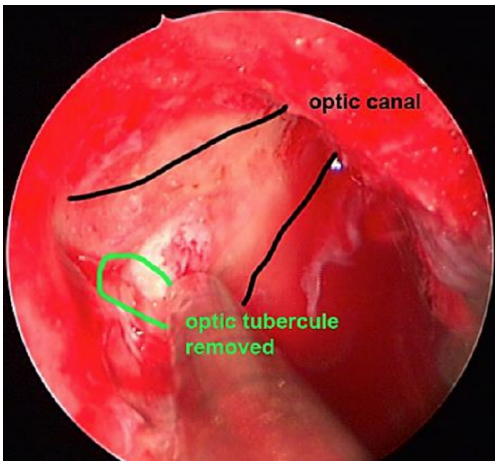


Figure 15: Thinning the bone down to an eggshell thickness with a high-speed drill

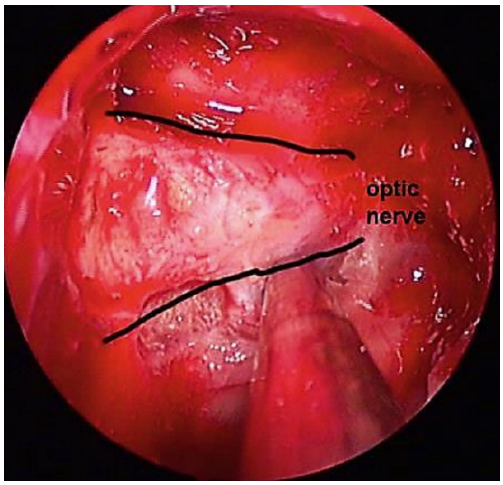


Figure 16: Optic nerve exposed

9. Remove the thinned bone with a Freer or Beale elevator and expose the optic nerve sheath (*Figures 15, 16*)

10. Incise the optic nerve sheath along the optic nerve and through the Annulus of Zinn. Place the incision(s) at the superomedial quadrant, as the ophthalmic artery is located in the inferomedial quadrant of the optic canal

11. Pack the nose and surgical cavity with hemostatic material; in case of bleeding, lightly pack the nose with sponges. Remove the packing on Day 1 or 2

12. Postoperative care: Instruct the patient to irrigate the nose with saline and corticosteroid drops. The authors advocate systemic antibiotics while the packing is in place (in the absence of a CSF leak)

References

1. "Eye orbit anterior" by Patrick J. Lynch, medical illustrator. Licensed under CC By 2.5 via Wikimedia Commons - http://commons.wikimedia.org/wiki/Fi...t_anterior.jpg

Authors

Boštjan Lanišnik, MD, PhD
Dept. for ENT-Head and Neck Surgery
University Medical Center Maribor Ljubljanska 5
SI-2000 Maribor, Slovenia
blanisnik@me.com

Janez Ravnik, MD,PhD
Department of Neurosurgery
University Medical Center Maribor
Slovenia
jravnik@planet.si

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ENDOSCOPIC ETHMOIDECTOMY (FESS) SURGICAL TECHNIQUE

Pedro Monteiro, Darlene Lubbe

Endoscopic ethmoidectomy refers to exenteration of the anterior +/- posterior ethmoid cells.

The ethmoids are in close proximity to the orbit and its contents, the optic nerve, the sphenoid sinus, the paper-thin cribriform plate with meninges above, the ethmoidal arteries and the olfactory nerves. Like all endoscopic sinus surgery, the anatomy and surgical technique are best learned on a cadaver, followed by surgery under direct supervision of an experienced endoscopic sinus surgeon. Ethmoidectomy done by a surgeon unfamiliar with the detailed anatomy of the nose and paranasal sinuses, especially in the absence of a CT scan or when unable to properly interpret a CT scan, or by a surgeon untrained in endoscopic sinus surgery, is high-risk.

This chapter presents the relevant anatomy, indications for surgery, preoperative workup, surgical instrumentation, anesthesia, surgical technique, postoperative care and pitfalls of endoscopic ethmoidectomy.

Relevant Anatomy

Ethmoid Bone

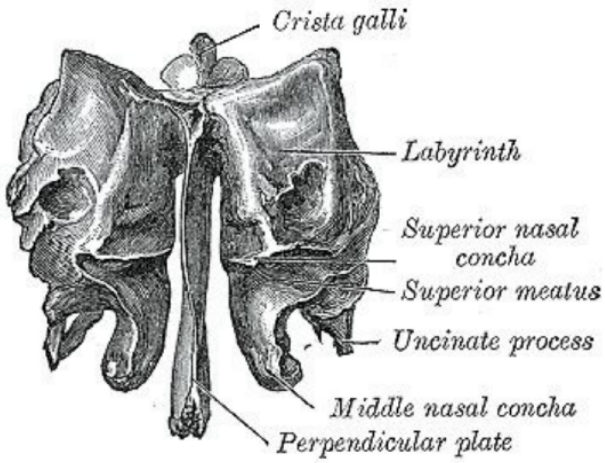


Figure 1: Anterior view of ethmoid bone demonstrating cribriform plate, crista galli, perpendicular plate, and labyrinths

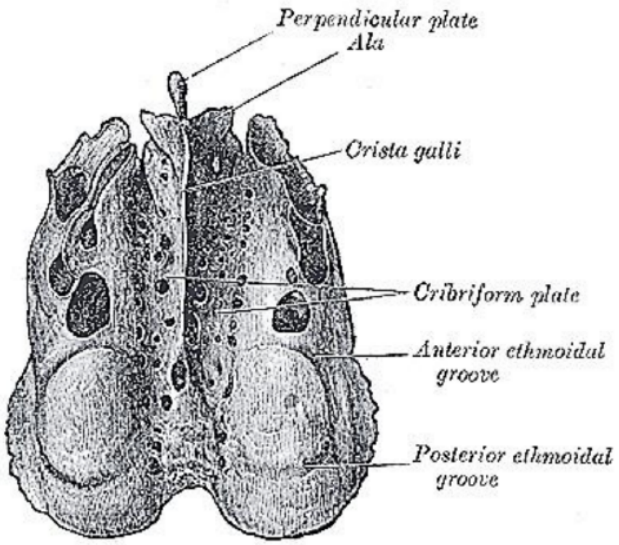


Figure 2: Superior view of ethmoid bone

The ethmoid has 3 parts: ***cribriform plate; perpendicular plate; and labyrinths/ lateral masses*** (*Figures 1, 2*).

Cribriform plate

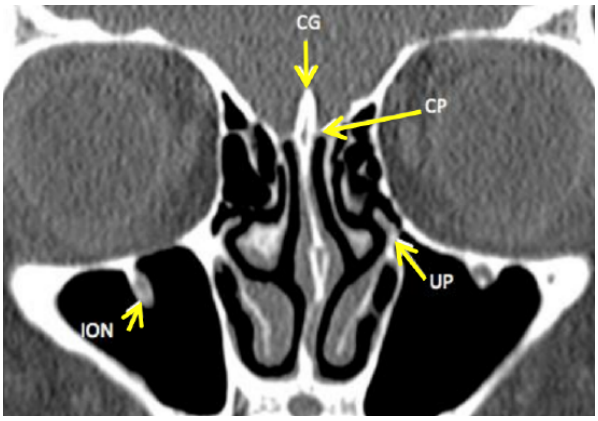


Figure 3: Coronal CT scan through the anterior ethmoids demonstrates the cribriform plate (CG = crista galli, CP = cribriform plate, UP = uncinate process, ION = inferior orbital nerve (V2))

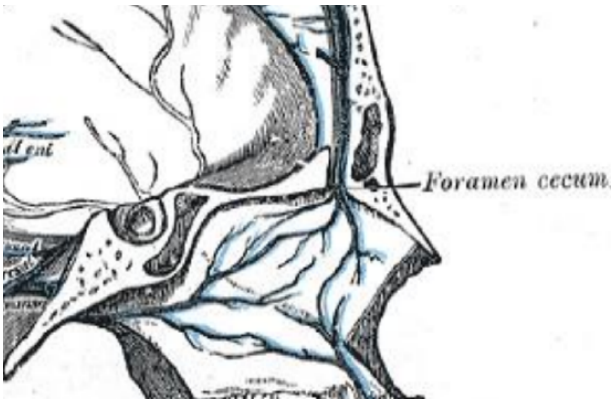


Figure 4: Falx cerebri attaches to crista galli, and foramen caecum contains the emissary vein

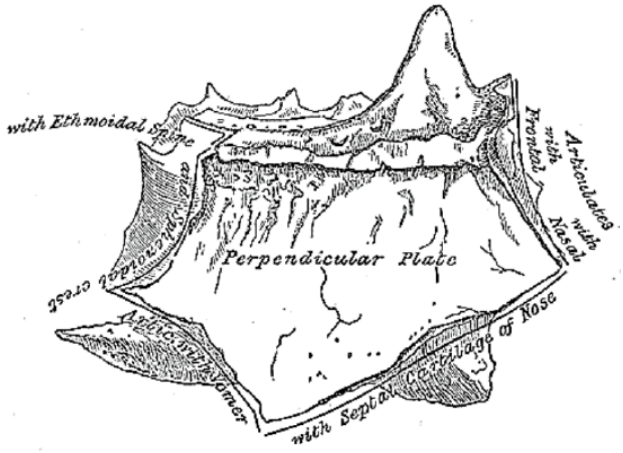


Figure 5: Ethmoid bone, lateral view

The cribriform plate is a paper-thin bone that forms the roof of the nasal cavity and the medial roof of the ethmoids (*Figures 2*, *3*). It articulates with the ethmoidal notch of the frontal bone anteriorly (*Figure 2*). The crista galli projects superiorly from the cribriform plate in the midline and is in contact with the falx cerebri along its posterior border (*Figure 4*). Two projecting alae (*Figures 2*, *5*) help complete the foramen caecum which contains the emissary vein that drains to the superior sagittal sinus (*Figure 4*).

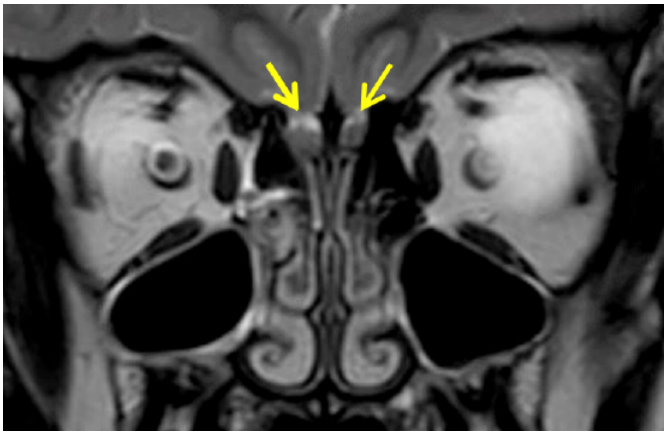


Figure 6: Coronal MRI demonstrating the olfactory bulbs (arrows) to either side of the crista galli

The cribriform plate is narrow and deeply grooved on either side of the crista galli where it contains the olfactory bulbs (*Figures 3*, *6*) from which olfactory fibers pass through multiple foramina in the cribriform plate to the superior turbinate, upper nasal septum and middle turbinate.

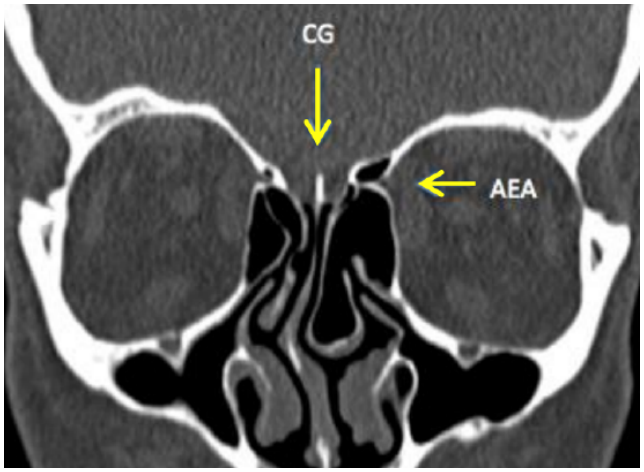


Figure 7: Coronal CT scan of fissure to either side of crista galli (CG) and a foramen transmitting the nasociliary nerve and anterior ethmoidal artery (AEA)

In the anterior cribriform plate is a fissure to either side of the crista galli that is occupied by a process of dura mater. Lateral to this fissure, a foramen transmits the nasociliary nerve and anterior ethmoidal artery (*Figure 7*).

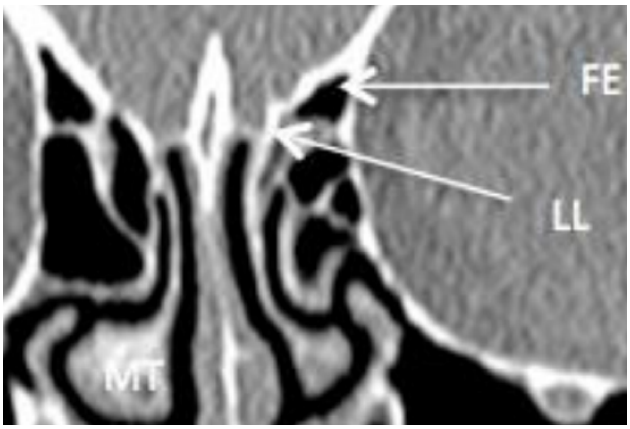


Figure 8: Coronal CT scan demonstrating the fovea ethmoidalis (FE), lateral lamella of the cribriform plate (LL) and middle turbinate (MT)

The ***roof of the ethmoids is a high-risk surgical area*** due to its proximity to dura and brain, the risk of causing a CSF leak and meningitis, and its relations to the anterior ethmoidal artery. Laterally it is formed by a thicker horizontal portion (***fovea ethmoidalis***), and medially by a thinner vertical portion (***lateral lamella of cribriform plate***) (*Figure 8*). The superior/vertical attachment of the ***vertical lamella of the middle turbinate*** divides the anterior skull base into the cribriform plate medially and the fovea ethmoidalis laterally.

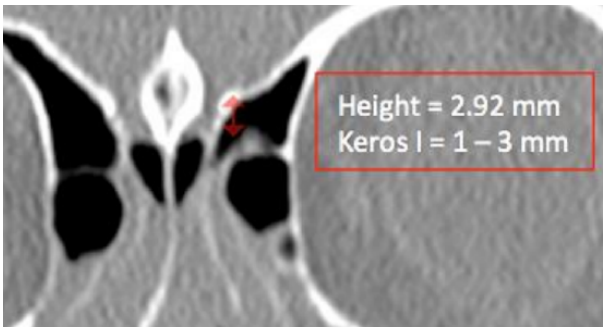


Figure 9a: Keros classification: Type I = 1-3 mm (15%)

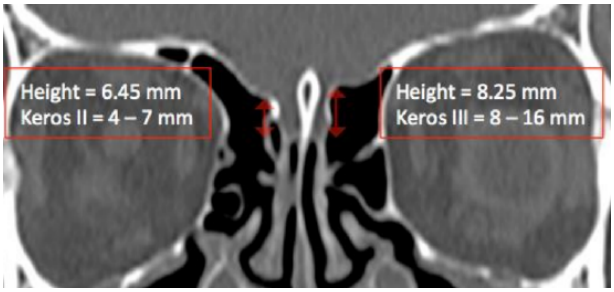


Figure 9b: Keros classification: Type II = 4-7 mm (70%), Type III = 8-16 mm (15%). Note that Keros classification can be different on either side

The ***lateral lamella*** of the cribriform plate is only 0.05 - 0.2 mm thick and is at high risk of injury during surgery. The ***Keros classification*** describes the depth of the olfactory fossae (*Figures 9a, b*). It is a measurement of the height of the lateral lamella at its highest point and is measured from the fovea ethmoidalis to the cribriform plate. This measurement is asymmetrical in up to 15% of patients. A higher value is associated with increased risk of cribriform plate injury, CSF leaks and injury to the anterior ethmoidal artery.

Perpendicular plate of ethmoid

The perpendicular plate of the ethmoid is an inferior vertical projection below cribriform plate of the crista galli and forms the upper part of the posterior bony septum (*Figures 1, 5*). Anterosuperiorly it articulates with the spines of the frontal and nasal bones;

posteriorly it articulates with the sphenoidal crest and vomer; and anteroinferiorly with the quadrangular cartilage of the nasal septum (*Figure 5*).

Labyrinths / lateral masses

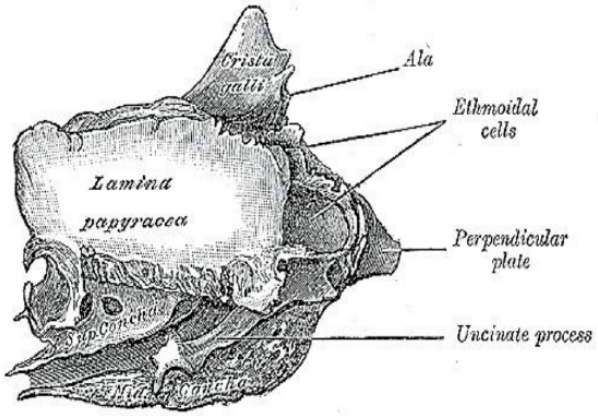


Figure 10: Lateral view of the right lamina papyracea which constitutes the lateral wall of the ethmoid sinuses

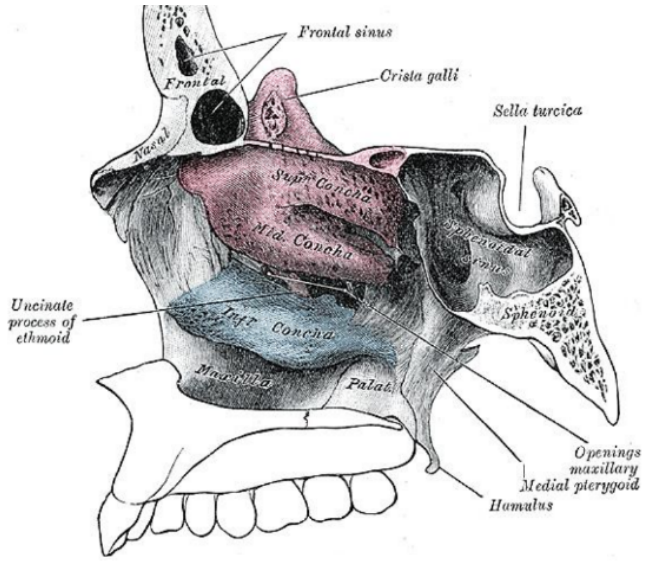


Figure 11: Medial view of the ethmoid bone and the ethmoid sinuses

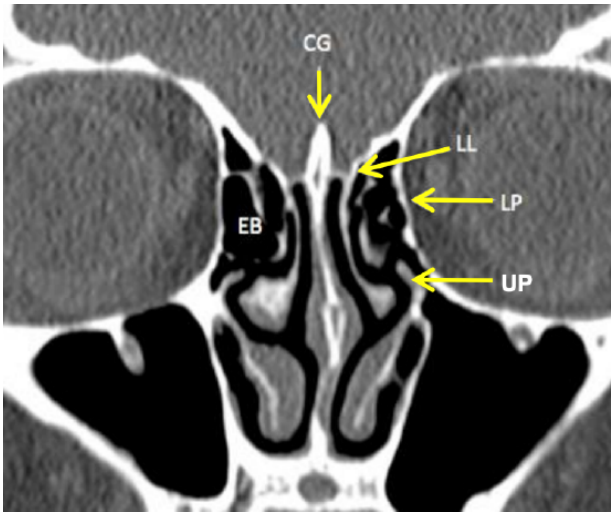


Figure 12: Coronal CT scan of ethmoid sinuses demonstrating the lamina papyricea and the vertical lamella of the middle turbinate (LL = lateral lamella of cribriform plate, LP = lamina papyracea, EB = ethmoidal bulla, UP = Uncinate process)

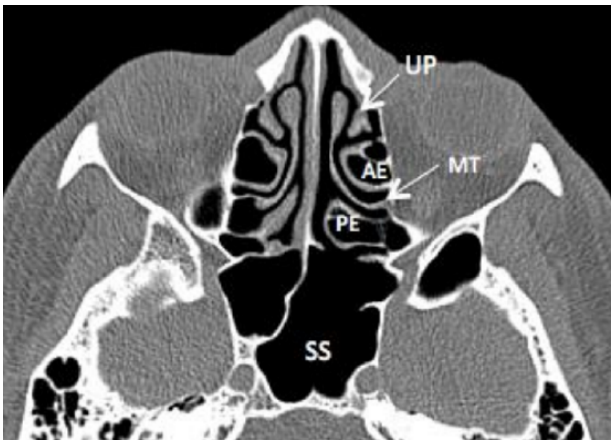


Figure 13: Axial CT demonstrating uncinate process (UP), anterior ethmoids (AE), basal (ground) lamella of middle turbinate (MT), posterior ethmoids (PE) and sphenoid sinus (SS)

The labyrinths (lateral masses) contain the ethmoid cells that are exenterated during ethmoidectomy. They consist of numerous thin-walled cavities known as ethmoidal cells or ethmoid sinuses and lie between two vertical bony plates i.e. the orbital plate (lamina papyracea) laterally and the basal or vertical lamella of the middle turbinate medially (*Figures 10, 11, 12, 13*).

It is crucial to carefully study the CT scans preoperatively to detect aberrations of sinus anatomy and to avoid losing your way while traversing the sinuses; hence the need to understand variations of ethmoid anatomy.

Recognised groups of ethmoid cells are:

- Anterior ethmoidal cells
  - Agger nasi
  - Haller cells
  - Frontal / frontoethmoidal cells
  - Suprabullar cells
    - Frontal bullar cell
    - Supraorbital ethmoidal cell
- Posterior ethmoidal cells
  - Onodi cell

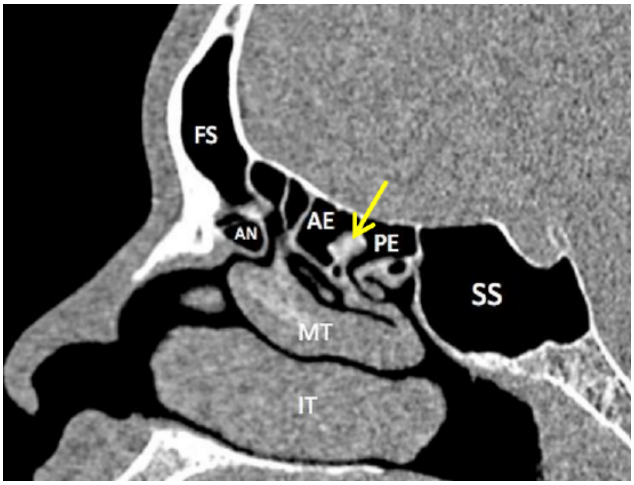


Figure 14: Sagittal view through ethmoids to demonstrate frontal sinus (FS), agger nasi (AN), anterior ethmoids (AE), basal/ ground lamella (yellow arrow), posterior ethmoids (PE) and sphenoid sinus (SS)

The anterior ethmoidal cells are separated from the posterior ethmoidal cells by the basal/ground lamella, which is the lateral extension of the middle turbinate at its posterior end (*Figure 14*). The anterior ethmoidal cells drain into the middle meatus.

The ***posterior ethmoidal cells*** are situated posterior to the basal lamella of the middle turbinate. They drain into the superior meatus.

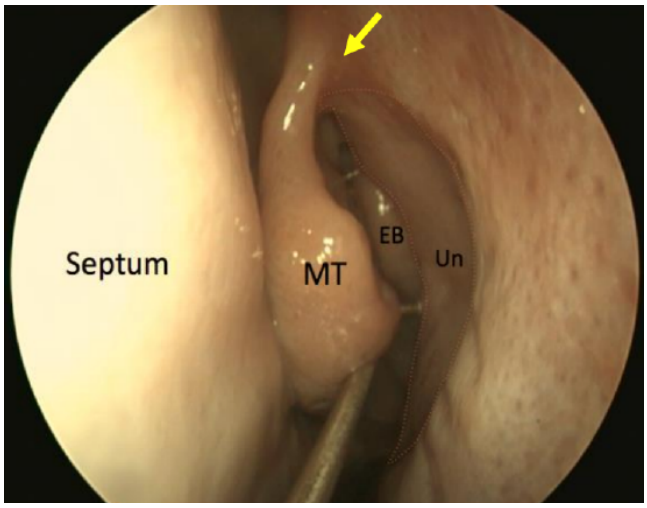


Figure 15: Endoscopic view of left ethmoid bulla (EB) in the middle meatus, behind the sickle shaped uncinate process (Un). Arrow points to "axilla"

The ***ethmoidal bulla (bulla ethmoidalis)*** is a constant landmark during ethmoid surgery and is the largest anterior ethmoid air cell. It lies posterior to the uncinate process (*Figures 15*).

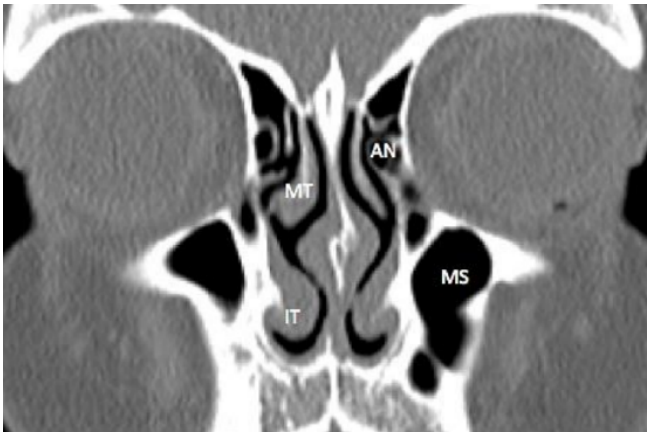
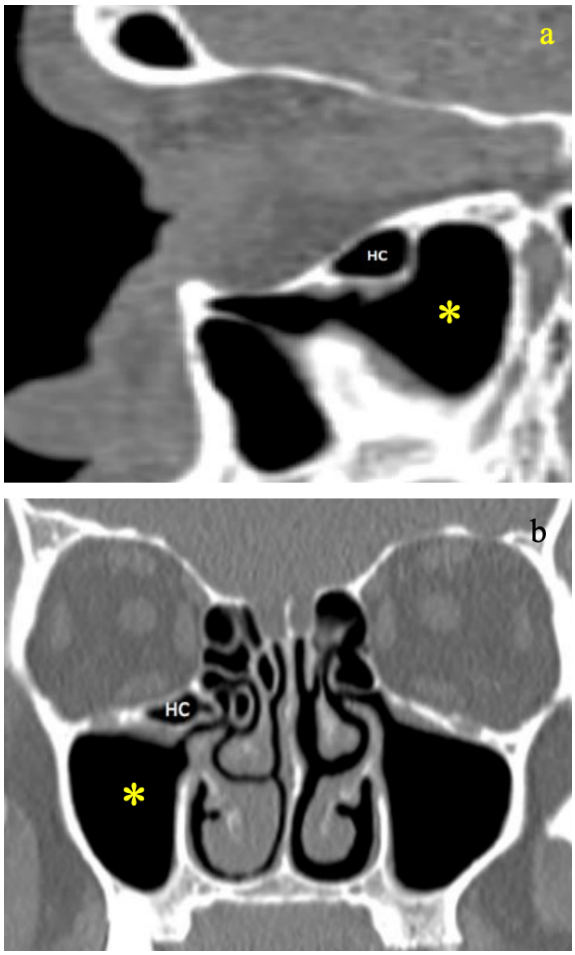


Figure 16: Coronal CT shows agger nasi cell (AN), inferior (IT) and middle turbinates (MT), and maxillary sinus (MS)

The ***agger nasi*** is the most anterior ethmoid air cell (*Figures 14, 16*). It is located in the lacrimal bone anterior and superior to the axilla, which is the attachment to the lateral nasal wall of the middle turbinate (*Figure 15*). The agger nasi is present in 90% of CT scans, and is the 1st anterior ethmoidal cell to become pneumatized. It is seen just superior to the lacrimal sac on coronal CT scan (*Figure 16*). The posterior wall of the agger nasi forms the anterior boundary of frontal recess (*Figure 14*), and its medial wall is closely related to the vertical lamella of middle turbinate (*Figure 16*). The superior part of the uncinate process forms the medial wall of the agger nasi. Laterally it is bounded by the lamina papyracea (*Figure 16*).

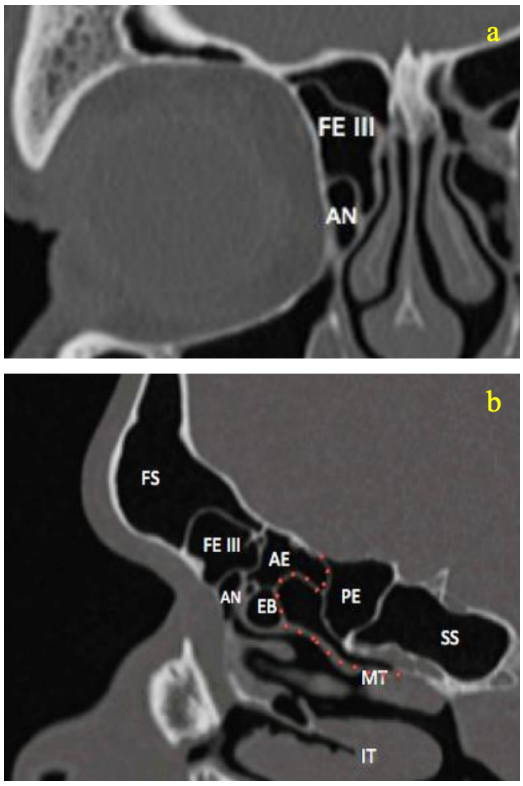


Figures 17a, b: Sagittal (above) and coronal (below) CTs demonstrating Haller cell (HC) extending into maxillary sinus *

Haller cells are anterior ethmoid air cells extending into the maxillary sinus (*Figure 17*). They can obstruct the outflow tract of the maxillary sinus and must be removed when there is pathology within the maxillary sinus. These cells are important to identify preoperatively on CT scan if surgery to the maxillary sinus is anticipated.

Frontal cells, also referred to as ***frontoethmoidal cells***, are anterior ethmoid cells that pneumatise the frontal recess/sinus above the agger nasi. ***Bent & Kuhn*** classified these frontal cells into ***4 types***:

- ***Type I***: Single cell above agger nasi not extending into frontal sinus (25%)
- ***Type II***: Group of cells (>2) above agger nasi cell but below orbital roof (5%)



Figures 18a, b: Coronal and sagittal CTs demonstrate Type III Kuhn cell: extension into frontal recess (FE III), agger nasi (AN), ethmoid bulla (EB), anterior ethmoid cell (AE), posterior ethmoid cell (PE), sigmoid sinus (SS), inferior turbinate (IT) and middle turbinate (MT) with basal lamella (red dotted line)

- ***Type III***: Single cell extending from agger nasi into frontal sinus (3%) (*Figure 18*)

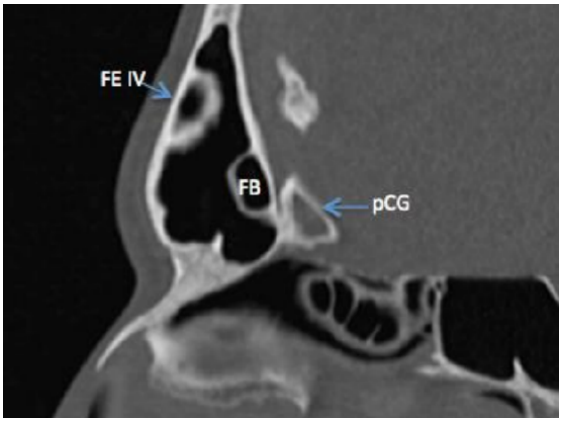


Figure 19: Sagittal CT demonstrating a Type IV Kuhn cell (isolated cell within the frontal sinus) as well as frontal bullar cell (pneumatizes along skull base within the frontal sinus)

- ***Type IV***: Isolated cell within frontal sinus, not contiguous with agger nasi (<1%) (*Figure 19*)

Excessive pneumatization of these cells (especially Types III and IV) may obstruct the frontal recess and predispose to frontal sinus disease.

Suprabullar cells are anterior ethmoidal air cells located above the bulla ethmoidalis and extend towards the frontal recess, but not into the frontal sinus.

A ***frontal bullar cell*** is a suprabullar cell that pneumatizes from the posterior frontal recess and pneumatizes along the skull base into the frontal sinus (*Figure 19*).

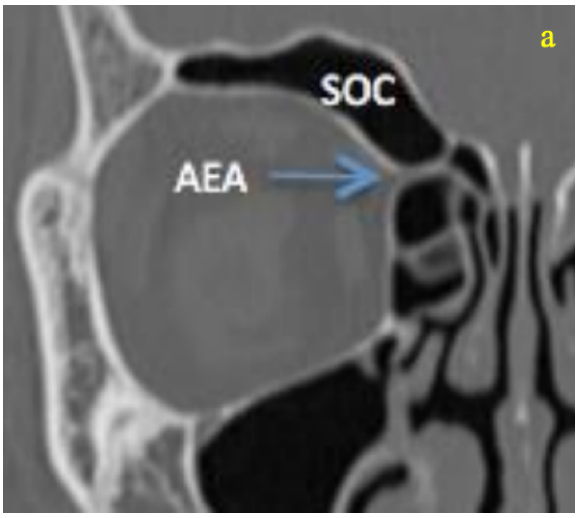


Figure 20a: Coronal CTs demonstrating a supraorbital ethmoid air cell (SOC). It can be distinguished from the frontal sinus by pneumatization posterior to the anterior ethmoidal artery (AEA)

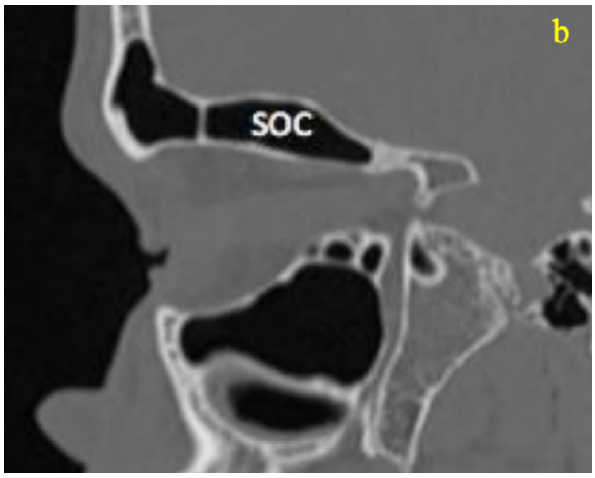


Figure 20b: Sagittal CTs demonstrating a supraorbital ethmoid air cell (SOC) with pneumatization seen posterior to the anterior ethmoidal artery

A ***supraorbital ethmoidal cell*** is a suprabullar anterior ethmoidal air cell that arises behind the frontal recess and extends over the orbit by pneumatizing the orbital plate of the frontal bone (*Figures 20a*, *b*). When it is large, it may be mistaken for the frontal sinus and it may obstruct the frontal recess.

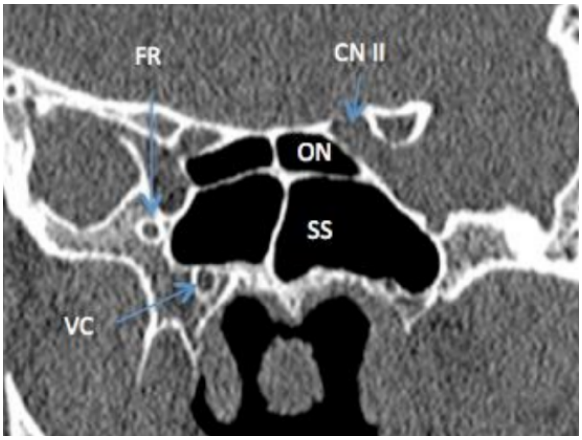


Figure 21: Coronal CT demonstrating proximity of Onodi cell (ON) to optic nerve (CN II)

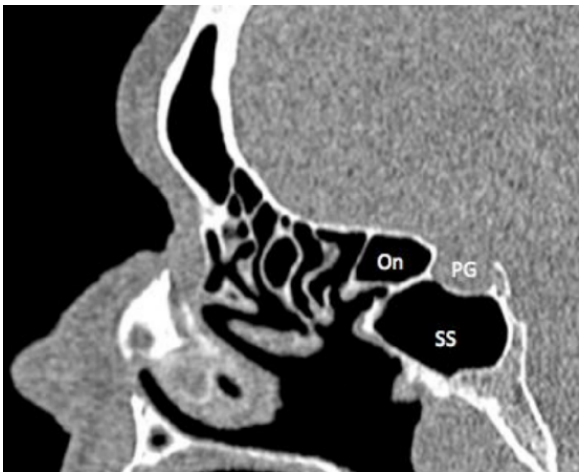


Figure 22: Sagittal CT demonstrating Onodi cell (On), pituitary gland (PG) and sphenoid sinus (SS)

An ***Onodi cell*** is a posterior ethmoid (sphenoethmoidal) cell that extends superior and often lateral to the sphenoid sinus (*Figures 21*, *22*).

Horizontal septations within the sphenoid sinus seen on CT represent an Onodi cell, with the Onodi cell being the posterolateral cell at the level where the horizontal septation is seen (*Figures 21*, *22*). It is found in up to 25% of patients, and is important to identify on a preoperative CT scan because if there is no sphenoid sinus behind it (because the sphenoid sinus is below the Onodi cell), then the middle cranial fossa is immediately behind the Onodi cell. It is often closely related to the optic nerve and the nerve is therefore at great risk during posterior ethmoid surgery. There is an increased risk of optic nerve injury (15% dehiscent in Onodi cell), carotid artery injury (20% dehiscent in Onodi cell) or brain injury.

Anatomy of turbinates, uncinate process, lamina papyracea and lateral nasal wall

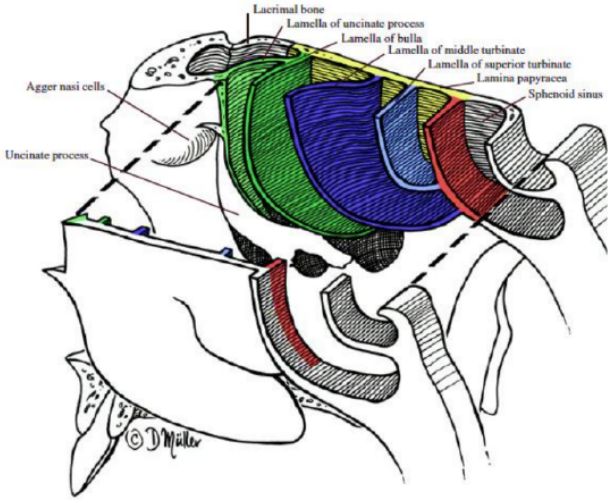


Figure 23: Messerklinger's 5 lamellae

Messerklinger described ***5 lamellae*** (bony structures) that traverse the ethmoids and extend from the lamina papyracea laterally to the cribriform plate superiorly and between fovea ethmoidalis and the frontal bone (*Figure 23*).

1st Lamella: Uncinate process (incompletely developed lamella)

2nd Lamella: Bulla lamella (pneumatization of this lamella forms the ethmoidal bulla)

3rd Lamella: Ground / basal lamella of the middle turbinate (most constant and completely formed lamella)

4th Lamella: Superior turbinate

5th Lamella: Supreme turbinate (only occasionally present)

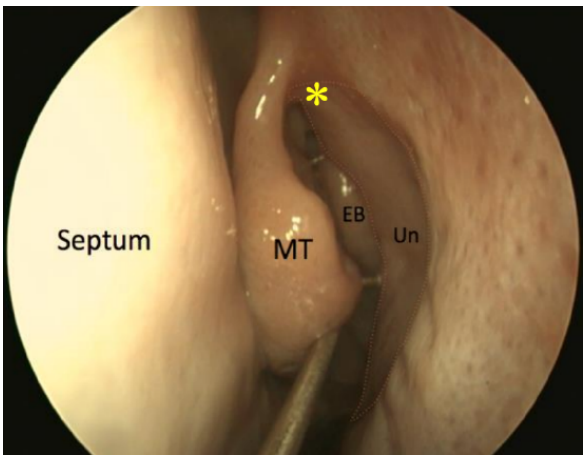


Figure 24: Endoscopic view of (L) ethmoid bulla (EB) in the middle meatus, behind the uncinate process (Un), and the axilla (*)

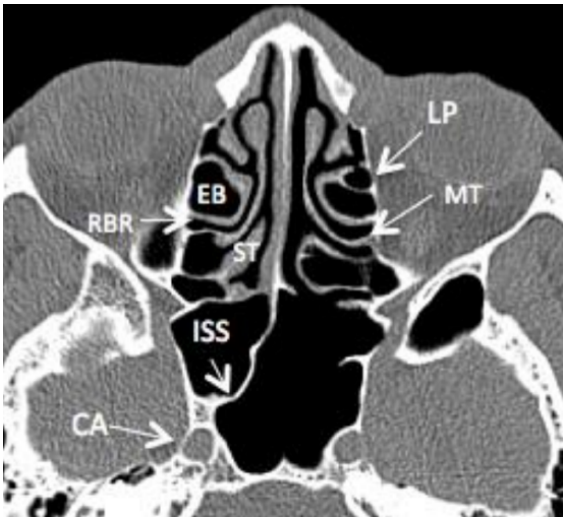


Figure 25: Axial CT scan of ethmoid sinuses demonstrates the lamina papyracea (LP), the basal or ground lamella of the middle turbinate (MT), ethmoidal bulla (EB), retrobullar recess (RBR), superior turbinate (ST), intersinus septum of sphenoid (ISS), and its relation to carotid artery (CA)

Because it is a key anatomical landmark during sinus surgery, the middle turbinate should always be preserved. The middle turbinate is part of the ethmoid bone. It comprises vascular, erectile glandular tissue on spongy bone and is lined by pseudostratified columnar ciliated respiratory epithelium. Anteriorly it fuses with the agger nasi to form the axilla (*Figure 24*). Superiorly it attaches to the lateral lamella of the cribriform plate in a sagittal plane. Posteriorly it rotates to lie in a coronal plane (basal lamella) and attaches to the lamina papyracea, thereby separating the anterior from the posterior ethmoid cells (*Figure 25*). Posterior to the sphenopalatine foramen it attaches to the perpendicular plate of the palate in a horizontal plane.

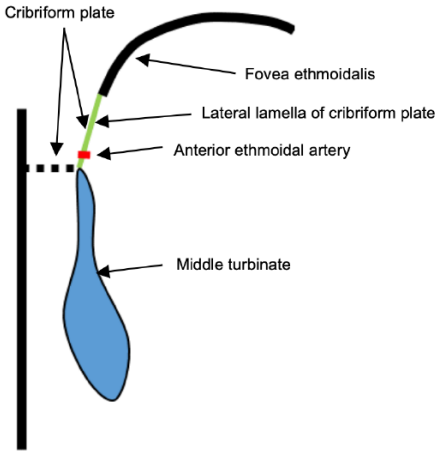


Figure 26a: Anatomy of middle turbinate: Coronal cut through anterior ethmoids demonstrating paper-thin cribriform plate, thicker fovea ethmoidalis, and point where anterior ethmoidal artery traverses the lateral lamella of the cribriform plate

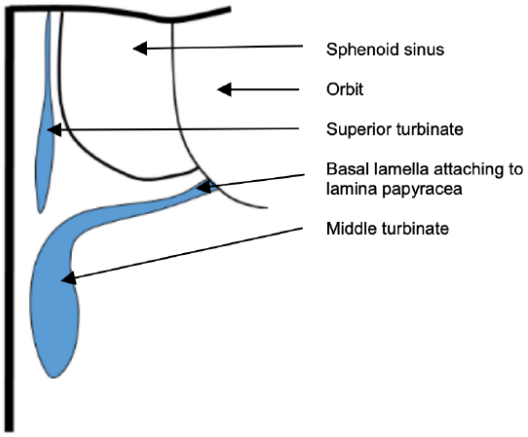


Figure 26b: Anatomy of middle turbinate: Coronal view to illustrate the ground lamella running horizontally and attaching to lamina papyracia to separate the anterior and the posterior ethmoids

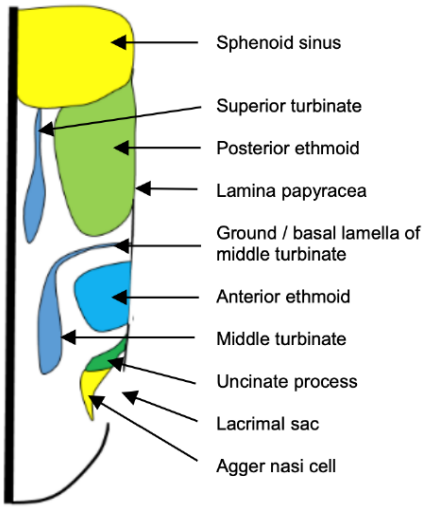


Figure 26c: Anatomy of middle turbinate: Axial view to illustrate the ground lamella separating the anterior and posterior ethmoids

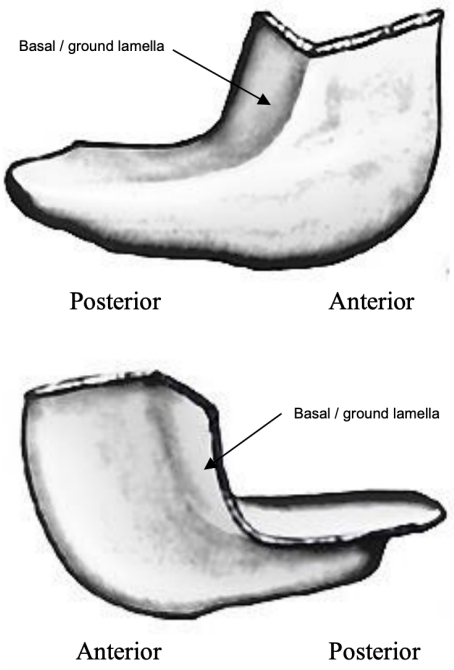


Figure 27: Shape of (L) middle turbinate

The ***basal (ground) lamella*** is the lateral extension of the middle turbinate that attaches to the lamina papyracea. It is an important surgical landmark to identify during surgery as it separates the ***anterior*** from the ***posterior ethmoid cells*** (*Figures 25, 26, 27*).

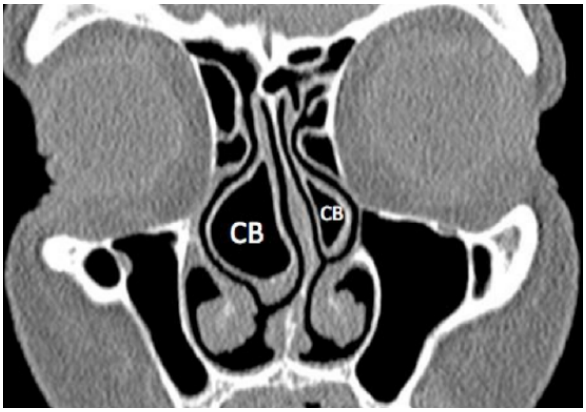


Figure 28: Concha bullosa (CB)

A ***concha bullosa*** is a pneumatized middle turbinate and is present in up to 50% of people (*Figure 28*).

Even though it may obstruct the ostiomeatal complex and predispose to acute or chronic rhinosinusitis, most people with concha bullosae are asymptomatic. A concha may impede access to the middle meatus and need to be reduced prior to uncinectomy or ethmoidectomy.

The middle turbinate must be handled with great care for the following reasons:



Figure 29: Middle turbinate (MT) attaches to paper-thin cribriform plate above, which is especially thin medially. Note the then lamina papyracea (LP)



Figure 30: Paradoxical middle turbinate curving away from the middle meatus

- It is attached to the paper-thin cribriform plate above; excessive manipulation of the turbinate can fracture the cribriform plate and cause a CSF leak (*Figure 29*)
- The cribriform plate is very thin medial to the turbinate; hence surgeons should avoid this area during surgery (*Figure 29*)
- The olfactory area of the nose is located between the turbinate and the septum; hence surgery and consequently adhesions occurring medial to the turbinate can cause anosmia
- The lateral extension of the middle turbinate called the basal/ground lamella, divides the anterior from the posterior ethmoid air cells and should be identified at surgery as an anatomical landmark
- The free edge of the middle turbinate typically faces medially towards the middle meatus, but can also paradoxically face laterally (*Figure 30*)

Uncinate process

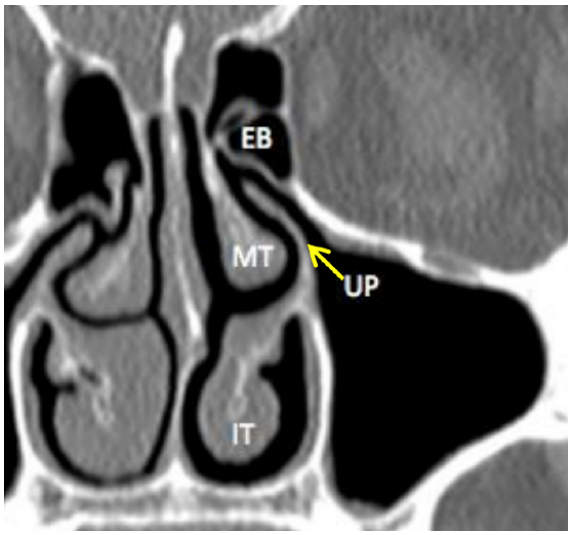


Figure 31: Coronal CT scan demonstrating the uncinate process (UP), ethmoidal bulla (EB), middle turbinate (MT), inferior turbinate (IT). Note close proximity of uncinate process to orbital wall

The ***uncinate process*** is a thin, sickle-shaped projection of ethmoid bone that is encountered anteriorly in the lateral nasal wall (*Figures 10, 11, 12, 13, 23, 24, 30, and 31*). Removing the uncinate provides access to the hiatus semilunaris and the ethmoidal bulla. It has a free posterior edge which lies anterior to the ethmoidal bulla (*Figure 23*). The uncinate attaches to the posterior edge of the lacrimal bone anteriorly and to the superior edge of the inferior turbinate inferiorly, and has a free edge posteriorly covered by mucosa. Superiorly it has a variable attachment to the lamina papyricea, fovea ethmoidalis or middle turbinate. This superior attachment influences the frontal sinus drainage pathway (either medial to, or directly into superior ethmoid infundibulum). Note its close proximity to the orbital wall (*Figure 31*), which may be injured should surgeon use poor surgical technique. The uncinate process may be pneumatized and cause obstruction to the infundibulum or have more than one attachment superiorly.

Lamina papyracea (Figures 26, 32)

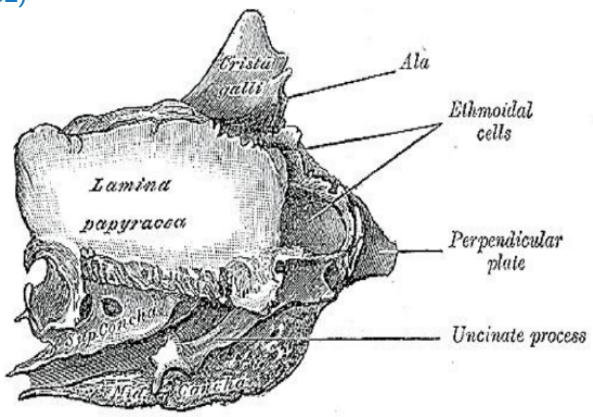


Figure 32: Lateral view of the right lamina papyracea which constitutes the lateral wall of the ethmoid sinuses

The lateral wall of the labyrinth is formed by the orbital plate of the ethmoid (***lamina papyracea***). It articulates with the orbital plate of the frontal bone superiorly, the maxillary and orbital processes of the palatine inferiorly, the lacrimal bone anteriorly and the sphenoid posteriorly (*Figure 29*).

Maxillary sinus ostium (Figure 33)

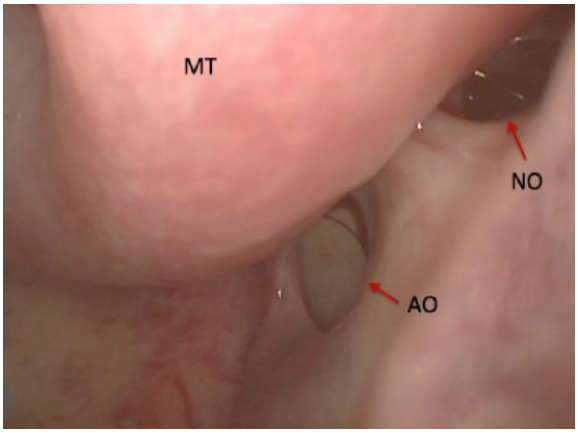


Figure 33: Left natural maxillary sinus ostium (NO) and accessory ostium (AO)

The maxillary sinus ostium is located on the supermedial aspect of the maxillary sinus. It opens into the ethmoidal infundibulum. The natural ostium is typically oval shaped and orientated obliquely. The natural ostium is not visible under endoscopic visualization unless the uncinate process has been removed.

Anterior and posterior fontanelles and accessory ostia (Figure 33)

The anterior and posterior fontanelles are bony defects in the medial wall of the maxillary sinus above the inferior turbinate. The fontanelles are covered only by mucosa and connective tissue. Defects in the fontanelles are called accessory ostia (*Figure 33*). They are more commonly located posteriorly and are spherical with the long axis in a horizontal plane.

Anatomy of ostiomeatal complex, meati and recesses

Ostiomeatal complex (Figure 34)

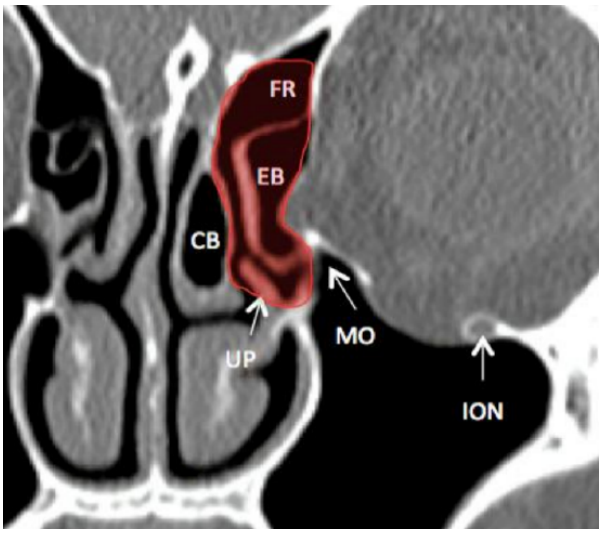


Figure 34: Coronal CT demonstrating the ostiomeatal complex (shaded red) and how a pneumatised middle turbinate (concha bullosa) may impede access to the middle meatus. Frontal recess (FR), ethmoidal bulla (EB), concha bullosa (CB), uncinate process (UP), natural maxillary ostium (MO), inferior orbital nerve (ION)

This is a functional unit which is the common drainage pathway for the frontal, maxillary and ethmoid sinuses. It includes the ethmoidal infundibulum, middle turbinate, ethmoidal bulla, uncinate process, hiatus semilunaris and frontal recess.

Middle meatus (Figure 35)

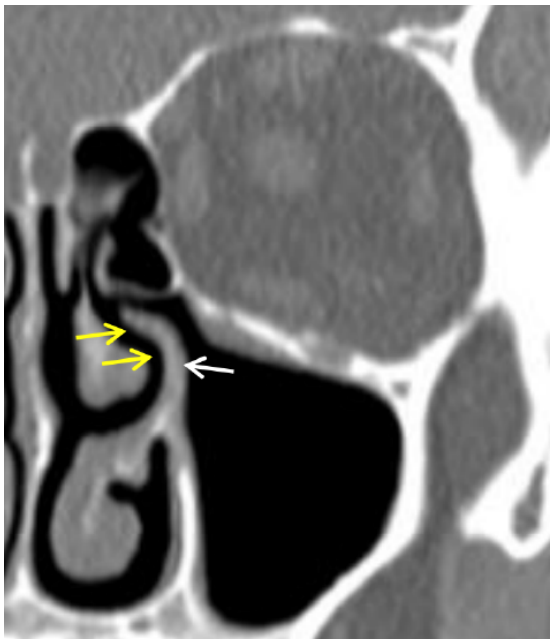


Figure 35: Yellow arrows point to middle meatus between middle turbinate and lateral wall of nose, and uncinate process (white arrow)

The middle meatus is the curved anteroposterior passage above the superior border of the inferior turbinate, between the middle turbinate and lateral nasal wall.

Hiatus semilunaris (Figures 36, 37)

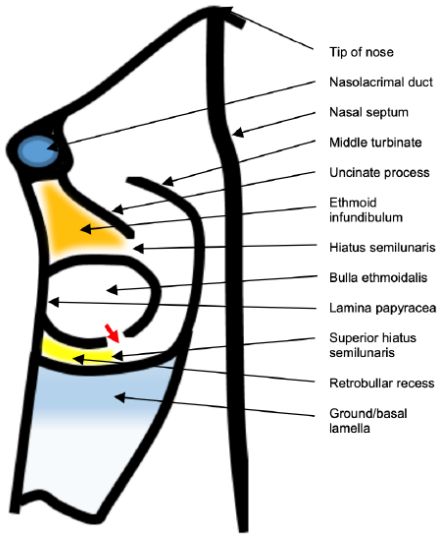


Figure 36: Superior axial view of hiatus semilunaris, ethmoidal infundibulum, superior hiatus semilunaris, retrobullar recess, ethmoidal bulla; nasolacrimal duct, uncinate process, lamina papyracea; ground/ basal lamella, and middle turbinate

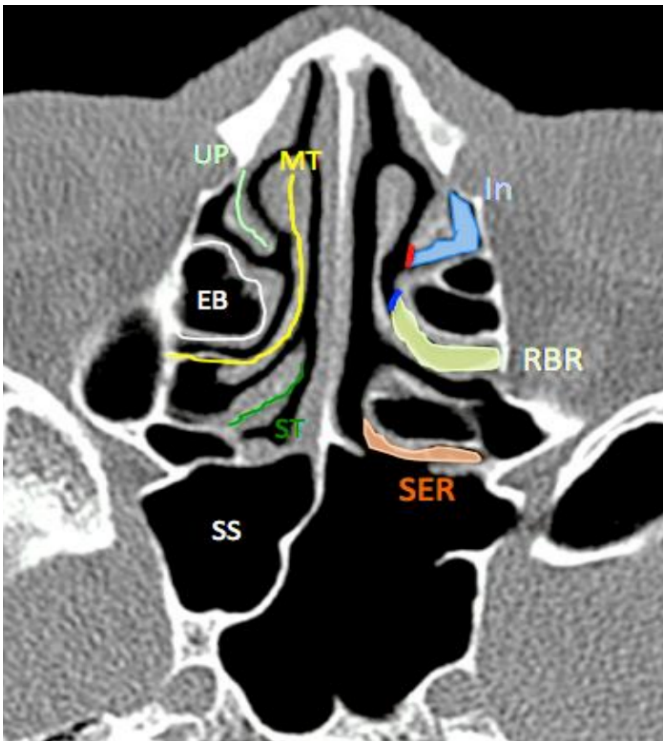


Figure 37: Axial CT demonstrating the relationships of various structures, clefts and spaces. Hiatus semilunaris (red line), uncinate process (UP), middle turbinate (MT), ethmoidal bulla (EB), superior turbinate (ST), sphenoid sinus (SS), ethmoidal infundibulum (In), retrobullar recess (RBR), sphenoethmoidal recess (SER)

The hiatus semilunaris is the 'entrance' to the ethmoidal infundibulum. It is a 2-dimensional opening between the free posterior edge of the uncinate process and the anterior face of the bulla ethmoidalis.

Ethmoidal infundibulum (Figures 36, 37)

This is a 3-dimensional space bound by the uncinate process medially, maxillary sinus ostium inferiorly, lamina papyracea and frontal process of maxilla (+/- lacrimal bone) laterally and the ethmoidal bulla posteriorly. Anteriorly it ends blindly in an acute angle where the uncinate process attaches to the lateral nasal wall and has a variable superior configuration depending on the attachment of the uncinate process (either ending blindly in the ***recessus terminalis*** if the attachment is to lamina papyracea, or into the frontal recess if attached to the skull base or middle turbinate)

Retrobulbar recess (Figures 36, 37)

The ***retrobullar recess*** is a space that may be present between the posterior surface of the bulla ethmoidalis and the basal lamella.

Suprabullar recess

The ***suprabullar recess*** may be present between the superior surface of the bulla and the fovea ethmoidalis.

Sphenoethmoidal recess (Figures 37, 38)

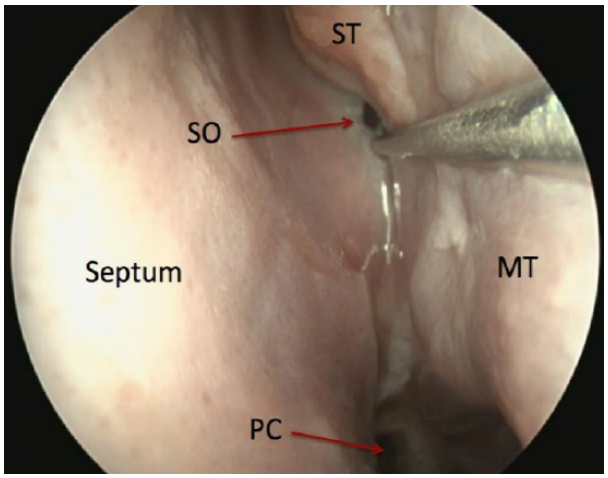


Figure 38: View of the sphenoid sinus ostium (SO) in sphenoethmoidal recess; this ostium is 3 sucker tips above the posterior choana (PC)

The sphenoethmoidal recess lies anterior to the sphenoid face (anterior wall of sphenoid) and medial to the superior turbinate. The ***sphenoid ostium*** is located medial to the superior turbinate (85%) at a level horizontal to the superior border of the natural maxillary ostium.

Anatomy of arteries

Anterior ethmoidal artery

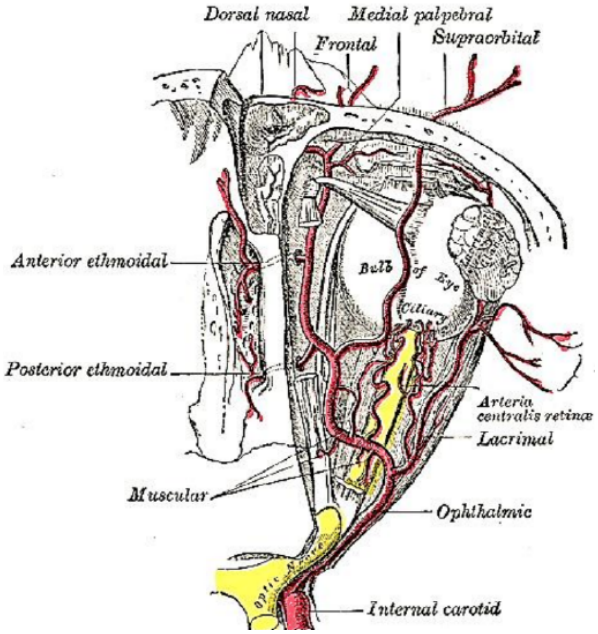


Figure 39: Ophthalmic artery gives rise to anterior and posterior ethmoidal arteries

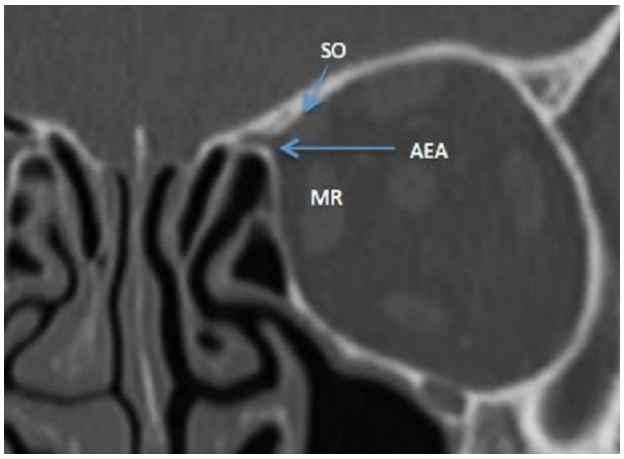


Figure 40: Coronal CT of anterior ethmoidal artery (AEA) as it exits the orbit at anterior ethmoid foramina (between superior oblique (SO) and medial rectus (MR) muscles)

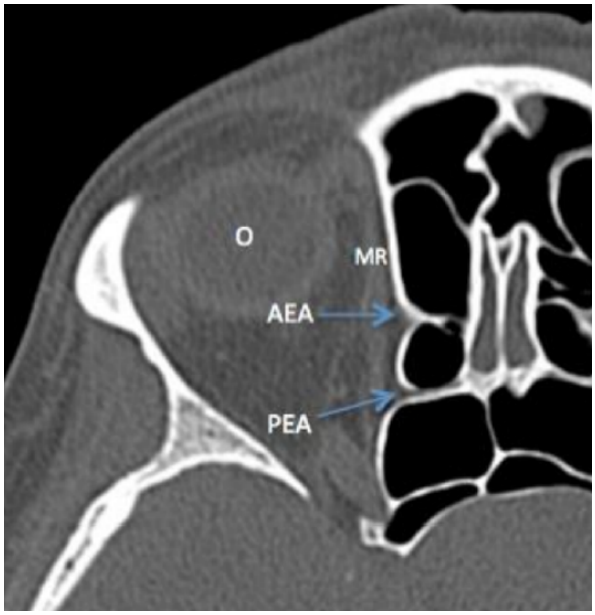


Figure 41: Axial CT shows anterior (AEA) and posterior ethmoidal arteries (PEA), and medial rectus (MR) and orbit (O)

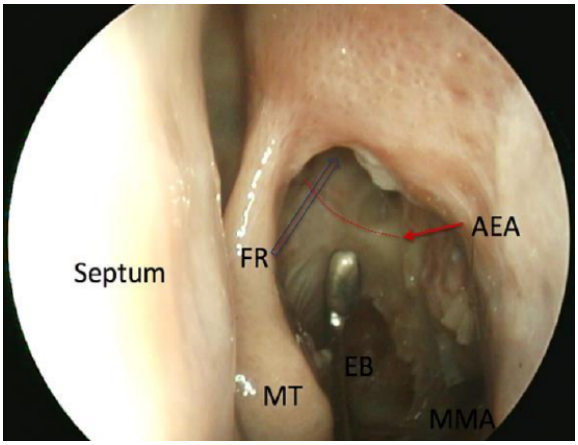


Figure 42: Position of the anterior ethmoidal artery (AEA) with lamina papyracea removed and its relation to the frontal recess (FR) indicated by blue arrow. Middle turbinate (MT), opened ethmoidal bulla (EB), middle meatal antrostomy (MMA)

The anterior ethmoidal artery is a branch of the ophthalmic artery, which is a branch of the internal carotid artery (*Figure 39*). In the orbit it passes between the medial rectus and superior oblique muscles to exit via the anterior ethmoidal foramen where it forms

a “beak” as it traverses the lamina papyracea (*Figures 40, 41*). It traverses the ethmoid roof obliquely from posterolateral to anteromedial (*Figure 42*).

Its relation to skull base is important as it may be covered by bone or be suspended in a mesentery up to 5 mm below skull base which puts it at increased risk of injury intraoperatively, especially during anterior ethmoidectomy or during surgery in the frontal recess. It is important to note that its position may vary on each side. Injury to the artery can cause it to retract into the orbit resulting in a rapidly expanding orbital hematoma. This can cause traction on the optic nerve and blindness. It is therefore important to know how to perform a lateral canthotomy and decompression (medial and /or lateral) in the event of injury to the artery to prevent visual impairment.

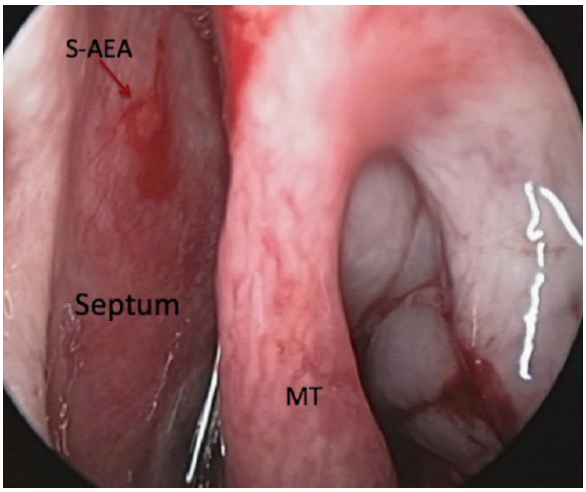


Figure 43: Septal branch of anterior septal artery (S-AEA)

The anterior ethmoidal artery enters the anterior cranial fossa through the lateral lamella of the cribriform after traversing the anterior ethmoids and then turns anteriorly in the anterior ethmoidal sulcus before reentering the nose to supply the superior septum and middle turbinate (*Figures 39, 43*). The anterior ethmoidal sulcus is the thinnest part of the skull base and is a common site of a CSF leak, both spontaneous and acquired. The septal branch (*Figure 39*) of anterior ethmoidal artery is a common site of epistaxis and should be carefully looked for in patients presenting with intractable epistaxis. Nasal packing often does not compress this branch of the anterior ethmoidal artery, which lies about 1 cm below the level of the cribriform plate and just posterior to the anterior aspect of the middle turbinate, on the superior septum (*Figure 43*).

Posterior ethmoidal artery

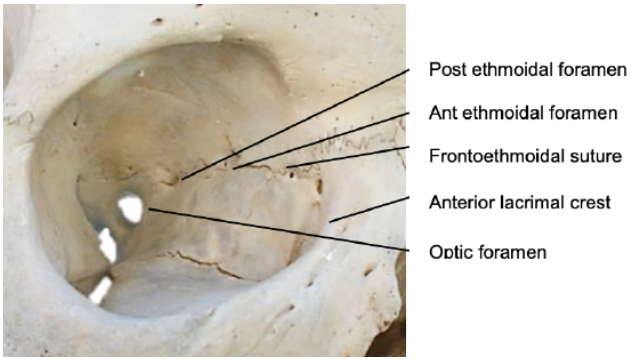


Figure 44: Right medial orbital wall

The posterior ethmoidal artery is also a branch of the ophthalmic artery (*Figure 39*). It exits the orbit via the posterior ethmoidal canal (*Figures 41, 44*). The distances between anterior lacrimal crest, the anterior ethmoidal foramen, and the posterior ethmoidal foramen, and the optic canal are approximately 24 mm, 12 mm and 6 mm (*Figure 44*).

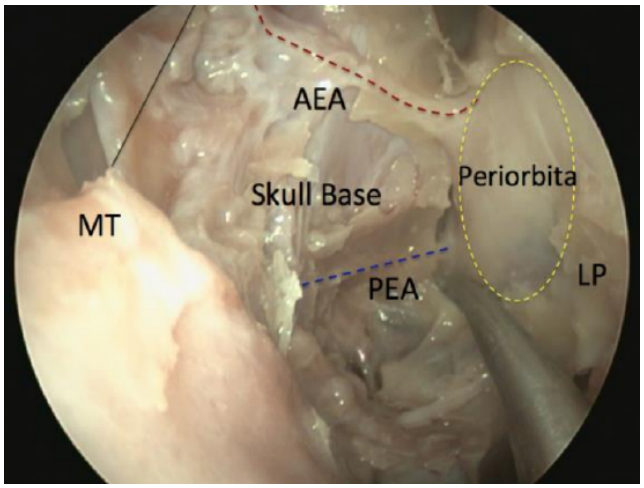


Figure 45: Left anterior (AEA) and posterior ethmoidal arteries (PEA), viewed with a 30° endoscope as they traverse the anterior skull base (skull base, superior attachment of middle turbinate (MT) and lamina papyracea (LP) have been removed)

The posterior ethmoidal artery crosses the anterior skull base anterior to sphenoid face and is usually covered by bone, making it less vulnerable to surgical injury (*Figure 45*). The artery can often be seen at the junction between skull base (fovea ethmoidalis) and the sphenoid face.

Sphenopalatine artery (Figure 46)

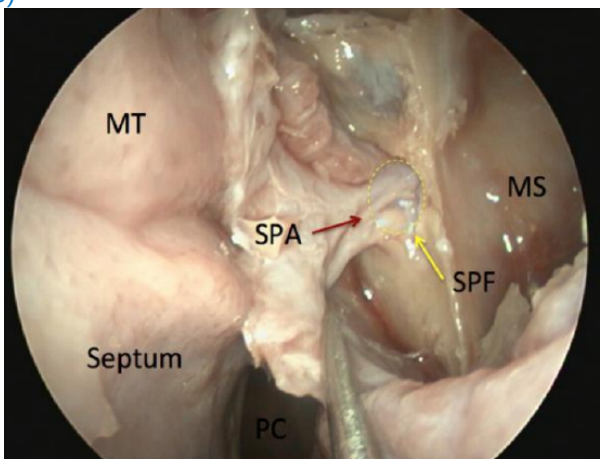


Figure 46: The sphenopalatine artery (SPA) and its branches as they exit the sphenopalatine foramen (SPF) behind the posterior wall of left maxillary sinus (MS)

The sphenopalatine artery is a branch of the internal maxillary artery (IMA), which is a branch of external carotid artery. It accounts for up to 90% of the blood supply to the nasal cavity (lateral nasal wall, turbinates and septum). The IMA runs behind the posterior wall of the maxillary sinus in the pterygopalatine fossa and exits as the sphenopalatine artery via the sphenopalatine foramen, which is formed by the body of the sphenoid posteriorly and the orbital process of palatine bone anteriorly. The sphenopalatine artery may have as many as 10 branches, and these may divide before (40%) or after the sphenopalatine foramen.

The ***posterior septal branch ofsphenopalatine artery*** runs across the face of the sphenoid below the sphenoid ostium to supply the posterior septum. The ***Hadad-Bassagasteguy vascularized nasoseptal pedicled flap*** is based on this artery. Intranasally, a projection of palatine bone, called the ethmoidal crest, is the most reliable landmark to find the sphenopalatine artery; the artery runs immediately behind this crest.

CT scan: Preoperative checklist

CT scans of the paranasal sinuses are essential before embarking on any form of endoscopic sinus surgery to

- Plan the best surgical approach (endoscopic/open/combined)
- Detect anatomical anomalies
- Assess risks to vital structures
- Assist with diagnosis

- Determine extent of surgery required

CT scans are generally indicated for

- Chronic rhinosinusitis (CRS) that persists despite 6-12 weeks' medical treatment
- Complicated sinusitis (with contrast)
- Unilateral nasal signs/symptoms
- Suspected tumor (with contrast; consider MRI)

Before embarking on endoscopic ethmoidectomy it is essential to assess the following on the CTs

1. Are all sinuses present?
2. What is the degree of pneumatization, particularly of the frontal and sphenoid sinuses, and the depth of the maxillary sinuses in younger patients? Well pneumatized sinuses pose a bigger risk to vital structures
3. Septum and turbinates; is there a choncha bullosa?...Important for access
4. Lamina papyracea intact?
5. Ethmoidal air cells: Agger nasi, ethmoidal bulla, suprabullar, supraorbital, Onodi, Haller, Khun cells?
6. Basal lamellae: indicate transition between anterior and posterior ethmoids
7. Relations of posterior ethmoids to internal carotid artery and sphenoid
8. Keros classification
9. Anatomy of anterior ethmoid artery
10. Sphenoid sinus and surrounds, and relation of septae to internal carotid artery
11. Foramina…rotundum, vidian canal
12. Outside the sinuses: Internal carotid artery, optic nerve

Ethmoidectomy: Surgical approaches

Ethmoidectomy can be done by ***external, endoscopic or combined*** approaches. Readers are referred to the Open Access Atlas chapter on External ethmoidectomy.

External ethmoidectomy is now rarely performed but can be indicated for:

- Complicated sinusitis or acute infection not responding to antibiotics when endoscopic visualization may be severely restricted by bleeding from inflamed mucosa
- Massive facial trauma
- Ligation of anterior and posterior ethmoidal arteries
- Laterally placed mucoceles
- External DCR
- CSF leaks
- Orbital decompression
- Tumors
- Unavailability of endoscopes

Endoscopic Ethmoidectomy

Important considerations when taking consent

- Is a septoplasty indicated for access? This may be difficult to determine preoperatively with Grade 3 polyps
- Is there a possibility that frontal sinus trephination is required (especially if neuronavigation is not available)?
- All risks must be mentioned but address high-risk areas according to the patient's specific pathology and CT findings; make the patient aware that you will be cautious in these areas
- Is there a risk to the extraocular muscles i.e. superior oblique/ or medial rectus muscle injury causing diplopia?
- CSF leak if working close to skull base
- Meningitis if CSF leak occurs
- Blindness if damage to the optic nerve; inform the patient if work in this area is planned or not

Preoperative optimization

- Anticoagulant medication including aspirin is stopped 5-10 days prior to surgery
- The authors do not routinely prescribe steroids, antibiotics or nasal decongestants

Operating room setup



Figure 47: Positioning the patient: head is in a neutral position with endotracheal tube taped to the left corner of the mouth and the camera stack is positioned directly opposite the surgeon

CT scans must be displayed as they may need to be reviewed during surgery. Because endoscopic sinus surgery causes back, neck and knee strain for surgeons, it is important to position the camera so that it is most ergonomic for the surgeon. Our preference is for the camera stack to be placed opposite to the surgeon, and not at the head of the bed, so that the surgeon operates without having to twist his/her body to view the screen (*Figure 47*).

Anesthesia

- Surgery is done under general anesthesia
- Secure the endotracheal tube at the left corner of mouth for a right-handed surgeon standing on the right side of the bed
- The endotracheal tube and filter should be out of the way of the endoscope or instruments
- The patient is placed supine, either flat or slightly flexed to 15 degrees, or slightly rotated towards the surgeon
- Lubricate the corneas, close the eyes and cover them with clear adhesive tape; the drapes should not obscure the eyes
- The anesthetist should optimize the surgical field by keeping the patient normotensive with a slow heart rate
- The authors prefer total intravenous anesthesia (TIVA)
- Throat packs are not routinely used, unless significant bleeding is anticipated
- Cefazolin is administered at induction

Surgical equipment



Figure 48: Septoplasty: Killian's nasal speculum (1), dental syringe and needle (2), Adson tissue forceps (3), 15 blade (4), iris sharp scissors (5), Freer suction elevator (6), Freer elevator (7), Cottle elevator (8), Blakesley forceps (9), gouge (10), straight chisel (11), mallet (12), 0° 4 mm x 18 cm endoscope

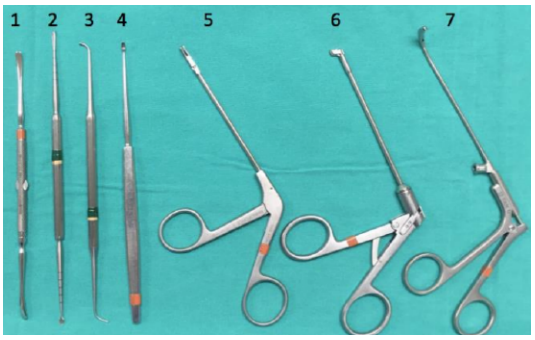


Figure 49: Middle meatal antrostomy, ethmoidectomy: Freer elevator (1), Cottle elevator (2), ball probe (3), straight curette (4), 45° backbiter (5), downbiter (6), maxillary antrum forceps (7)

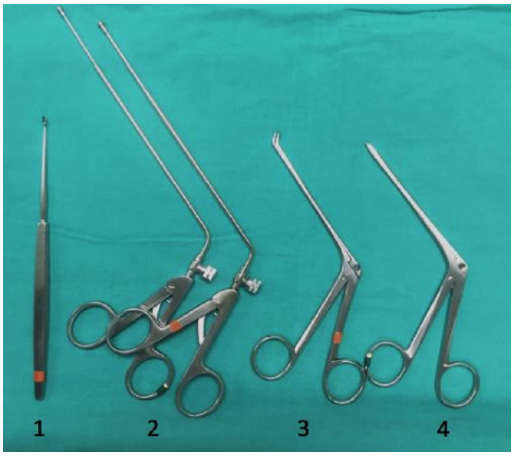


Figure 50: Sphenoidotomy: straight curette (1), mushroom punches (2), 45° Blakesley (3), straight Blakesley (4)

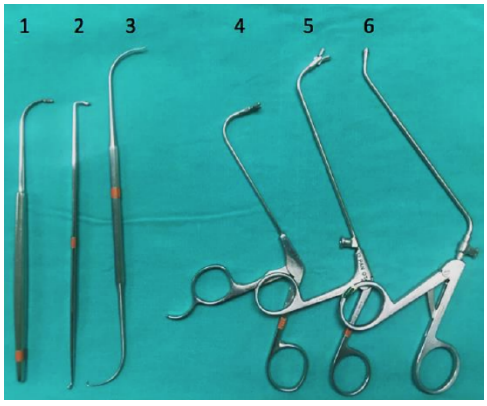


Figure 51: Frontal sinus: frontal sinus curette (1), 90° frontal sinus curette (2), frontal sinus probe (3), frontal sinus giraffe forceps horizontal jaws (4), frontal sinus giraffe forceps vertical jaws (5), frontal sinus mushroom punch (6)

Surgical instruments are illustrated in *Figures 48-51*. Neuronavigation is not routinely employed but can be helpful in revision surgery and with difficult frontal sinus surgery.

Surgical steps

Preparation & Inspection

- Achieve topical decongestion by inserting ribbon gauze or neurosurgical patties soaked in 2 mL of 1:1000 adrenaline between the inferior turbinate and the nasal septum and in the middle meatus if possible
- Oxymetazoline can be used instead of adrenaline in patients with cardiac disease
- Carefully ***inspect the nose*** with the endoscope; this is an essential step before beginning any procedure

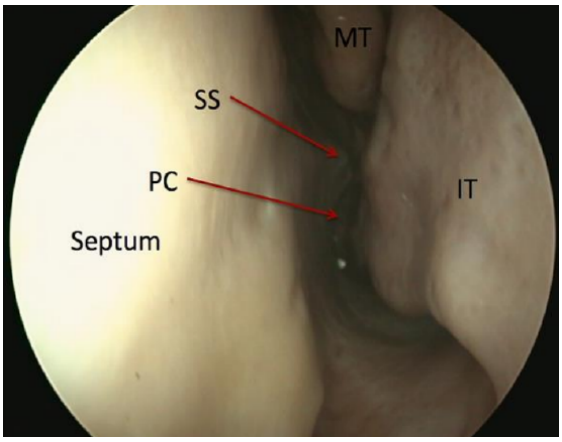


Figure 52: 1st pass along left nasal floor / inferior meatus up to posterior choana (PC); note septal spur (SS), middle turbinate (MT), and inferior turbinate (IT)

- ***1st pass***: Inferior meatus/nasal floor to postnasal space. Always examine the postnasal space for lesions or adenoidal tissue (*Figure 52*)

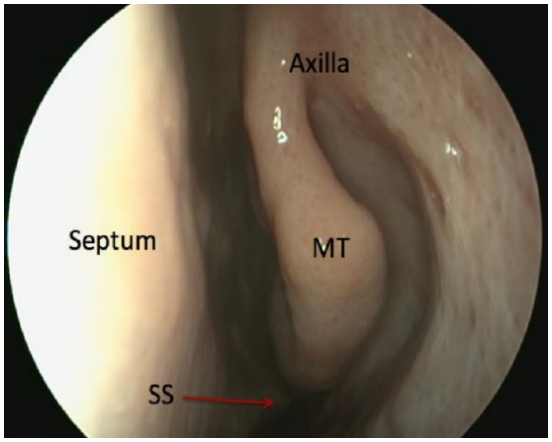


Figure 53: 2nd pass along middle meatus. Middle turbinate and axilla should be visible. Note posterior septal spur (SS) not obstructing access to middle meatus

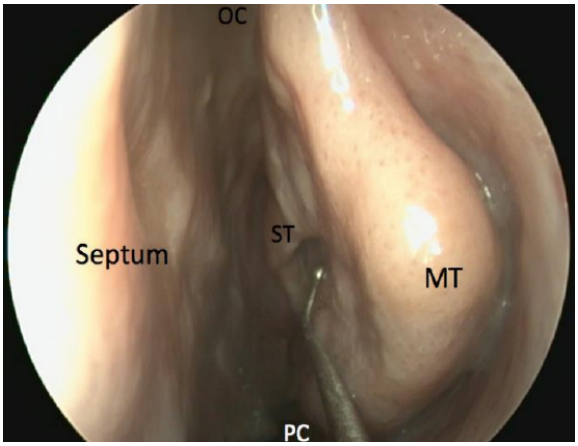


Figure 54: Inspection medial to middle turbinate shows superior turbinate (ST). This is not always possible in live patients, and care must be taken not to manipulate the middle turbinate too vigorously as this might cause a CSF leak. It is important to only mobilise the middle turbinate at its posterior aspect where it is more mobile and not anteriorly. Olfactory cleft (OC)

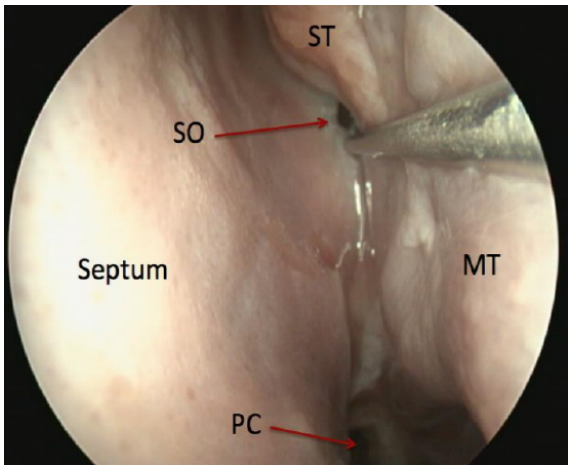


Figure 55: View of the sphenoid sinus ostium (SO) in sphenoethmoidal recess; this ostium is 3 sucker tips above the posterior choana (PC)

- ***2nd pass***: Middle meatus – retract the endoscope from the posterior nasal cavity into the middle meatus, keeping lateral to the posterior aspect of the middle turbinate; pay careful attention to the inferior and middle turbinates including the axilla of the middle turbinate (conchae, hypertrophy, paradoxical turbinates), the nasal septum (deviation, spurs which may impede surgical access to middle meatus), uncinate process (may be everted) and ethmoidal bulla (most constant landmark) (*Figures 53, 54, 55*)
- ***Inject local anesthetic and adrenaline*** using a dental syringe (Authors use 2% lignocaine/1:80,000 adrenaline preparation) into the nasal septum (if septoplasty required, middle turbinate, axilla of middle turbinate, and inferior turbinate (very slow injection into turbinates). There is a risk of a hypertensive episode if adrenaline is injected too quickly or if too large a volume is injected. This can cause brain hemorrhage, especially in the elderly with vascular problems

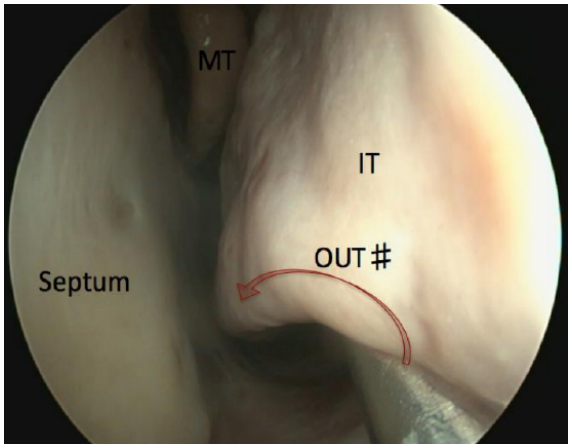


Figure 56: Outfracturing of the inferior turbinate (IT) using a Freer dissector. The instrument is placed under the turbinate and medialized

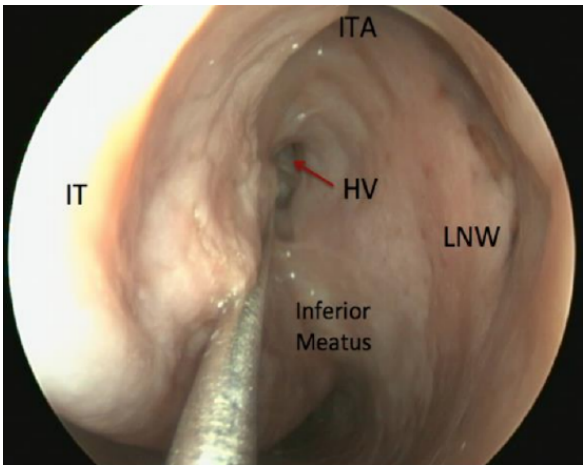


Figure 57: View of Hasner's valve (HV) in inferior meatus. Inferior turbinate axilla (ITA), lateral nasal wall (LNW)

- ***In- and out-fracture the inferior turbinate*** to improve access to the uncinate process and middle meatus (*Figures 56, 57*).
- This is performed with the blunt end or shaft of the Freer dissector to minimize mucosal injury and troublesome bleeding. Insert the instrument under the inferior turbinate and use it to medialize (in-fracture) the turbinate, starting at the axilla and moving posteriorly. The turbinate is then lateralized (outfractured) under direct vision, starting posteriorly and moving anteriorly

Retrograde uncinectomy

- The uncinate process represents the 1st lamella as described by Messerklinger (*Figure 23*)
- Identify the free posterior edge of the uncinate in front of the ethmoidal bulla
- The uncinate process always lies posterior to the anterior aspect of the middle turbinate
- Do not confuse the uncinate process with the maxillary line (frontal process of maxilla)

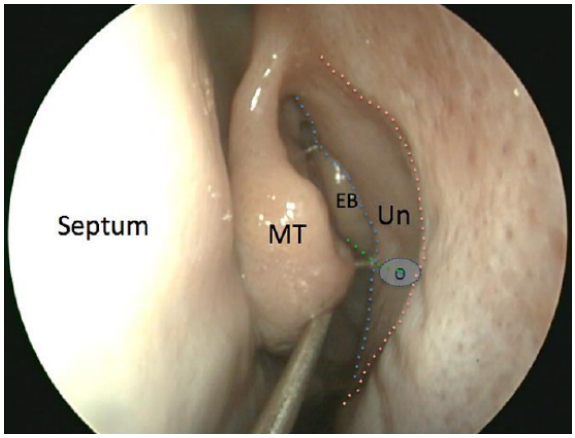


Figure 58: Insert a ball probe behind the free edge of the uncinate process (Un) (blue line). This must not be mistaken for the frontal process of maxilla (red line). The natural ostium of the maxillary sinus (O) lies at the level where the inferior edge ethmoidal bulla (green line) intersects with the free posterior edge of uncinate process (green line).

- Insert a ball probe through the hiatus semilunaris behind this free edge (*Figure 58*)
- Always insert the ball probe where two lines transect each other – a line at the lower border of the ethmoidal bulla and a line at the inferior aspect of the uncinate (*Figure 58*)
- Gently elevate the uncinate anteriorly thus creating some space behind it; the ball probe is now in the infundibulum
- Take care not to over-manipulate or over-medialize the middle turbinate, as fracturing the superior attachment of the middle turbinate at the lateral lamella of the cribriform plate may cause a CSF leak

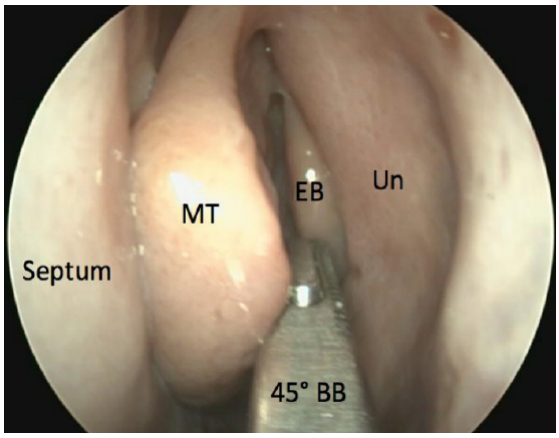


Figure 59: Insert a closed 45° backbiter (BB) up to face of ethmoidal bulla (EB) in middle meatus. Uncinate process (Un)

- Use a 45° backbiter / side-biter to complete the uncinectomy; insert the closed instrument, then open it on the face of the ethmoidal bulla, so that the open blade can be manipulated behind the free edge of the uncinate (*Figure 59*)

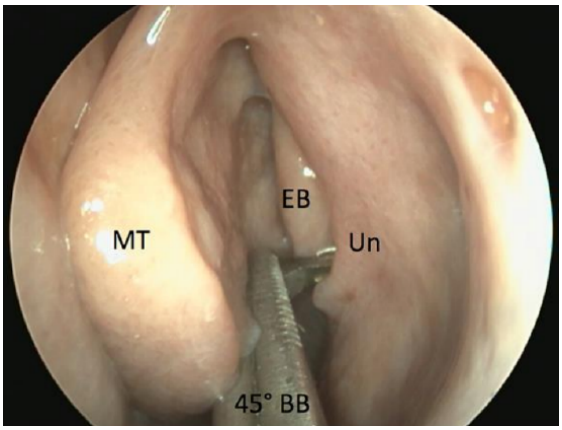


Figure 60: Open 45° backbiter (BB) and insert open blade behind free edge of uncinate process (Un)

- Close the instrument working anteriorly in a safe manner away from lamina papyracea thus minimizing the risk to the eye (*Figure 60*)
- It is important to resect the uncinate with all 3 its layers (mucosa/bone/ mucosa)

Anterograde Uncinectomy

- Uncinectomy can also be performed anterogradely with a sickle knife or Freer dissector
- Identify the anterior attachment of the uncinate
- Make an incision with a sickle knife or Freer dissector to release it from its anterior attachment to the lacrimal bone
- All 3 layers must once again be incised (mucosa/bone/mucosa)
- Remove the uncinate with a through cutting instrument

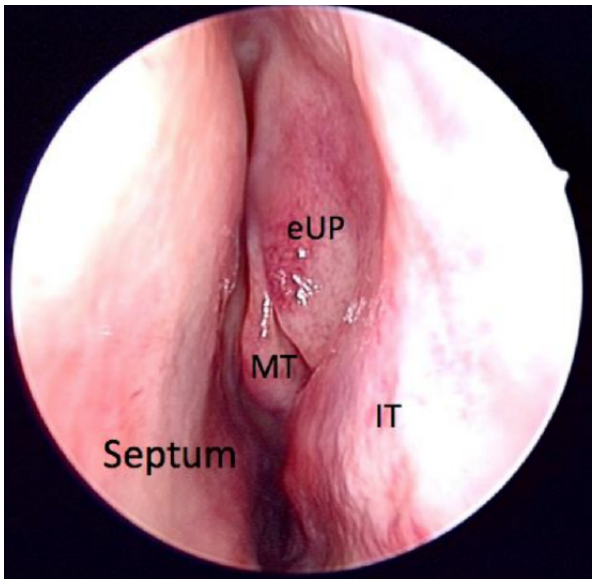


Figure 61: Everted uninate process (eUP)

- The anterograde technique carries a greater risk of injury to the lamina papyracea and the eye, but may be necessary with a ***very everted uncinate*** when it is not possible to get an instrument behind its free edge (*Figure 61*)

Middle meatal antrostomy

- Proceed to middle meatal antrostomy

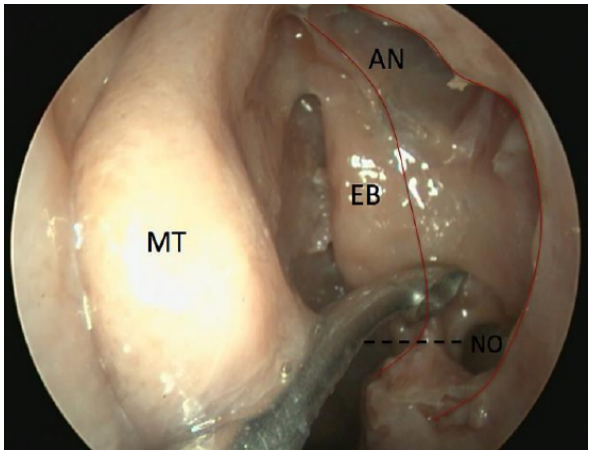


Figure 62: Identifying the maxillary sinus natural ostium (NO). Uncinate process has been removed (red lines). Agger nasi (AN), ethmoidal bulla (EB). Black dashed line shows how the natural maxillary ostium is at the same level as where ethmoidal bulla intersects with free edge of uncinate process (inferiorly)

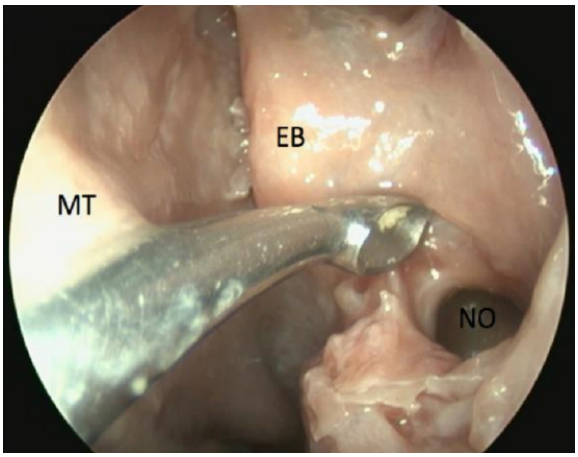


Figure 63: Close-up view of natural ostium of maxillary sinus (NO), ethmoidal bulla (EB)

- Identify the natural maxillary ostium at the same level as the inferior edge of the middle turbinate (*Figures 62, 63*)
- Insert a curved ball probe into the maxillary antrum via its natural ostium
- Widen the opening of the natural ostium posteriorly and inferiorly by removing mucosa with through cutting or back/ side biting instruments
- If accessory ostia have previously been identified, then these ostia should be interconnected to avoid a subsequent recirculation phenomenon
- The ***size of the maxillary sinusotomy*** depends on the disease process. For severe nasal polyposis a large (type III) middle meatal antrostomy is required. For minimal disease, an infundibulotomy (uncinate window) may be all that is required
- Take a pus swab from the maxillary sinus

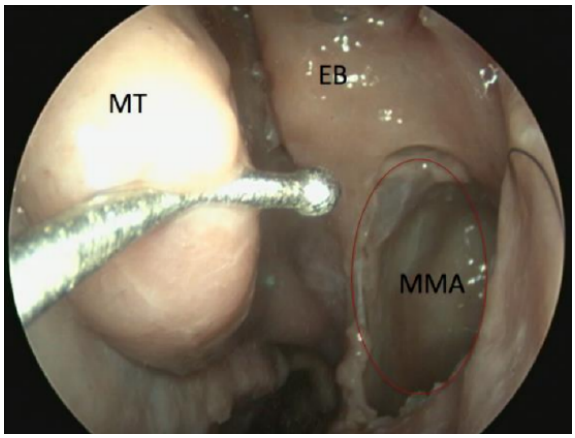


Figure 64: Type III middle meatal antrostomy (MMA)

- ***Simmens classifies maxillary sinusotomy as follows:***
  - ***Infundibulotomy (uncinectomy)***: Removal of uncinate process, preserving the mucosa of the natural maxillary ostium. The superior attachment of the uncinate can be left intact, particularly if attached to the skull base or middle turbinate to avoid potential complications e.g. adhesions around the frontal recess and CSF leaks
  - ***Type I maxillary sinusotomy***: Enlarging the natural maxillary ostium posteriorly by <1 cm. If an accessory ostium is present, this should be combined with the natural ostium to avoid a recirculation phenomenon
  - ***Type II maxillary sinusotomy***: Antrostomy is opened 2 cm posteriorly and inferiorly
  - ***Type III maxillary sinusotomy*** (*Figure 64*): Antrostomy is opened up to posterior wall of maxillary antrum, anteriorly to the lacrimal sac and inferiorly to the base of the inferior turbinate

Anterior ethmoidectomy

- The lateral attachment of the ethmoidal bulla represents the ***2nd lamella*** as described by Messerklinger (*Figure 23*)
- The straight curette and 45° Blakesley are the most important instruments for ethmoidectomy; the curette is used to break the bony lamellae and the 45° Blakesley is used to remove the cells

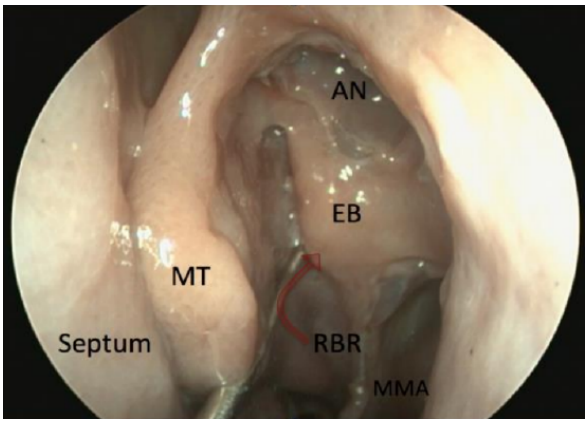


Figure 65: Retrobullar recess (RBR) is between ethmoidal bulla (EB) and middle turbinate (MT) basal lamella. It is not always present

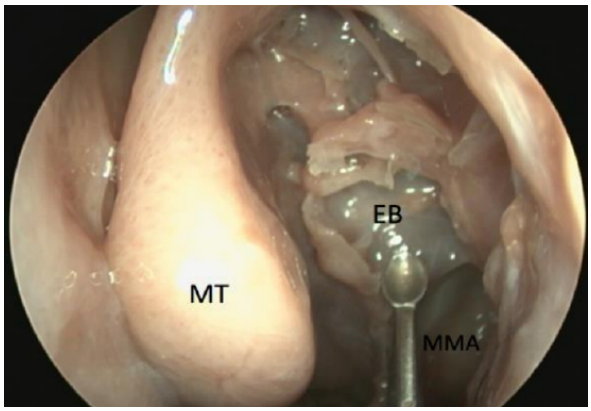


Figure 66: Face of ethmoidal bulla (EB) removed

- First open the bulla ethmoidalis by placing a straight curette behind the ethmoidal bulla into the retrobullar recess or into the bulla from below and breaking the bulla down by moving the instrument towards yourself (*Figures 65, 66*)
- Other anterior ethmoidal air cells are similarly opened
- Once the cell walls are fractured, remove them with a 45° Blakesley (*Figure 50*)
- Loose tissue can be removed by grasping and rotating medially
- Remember ***never to pull on any tissue***;

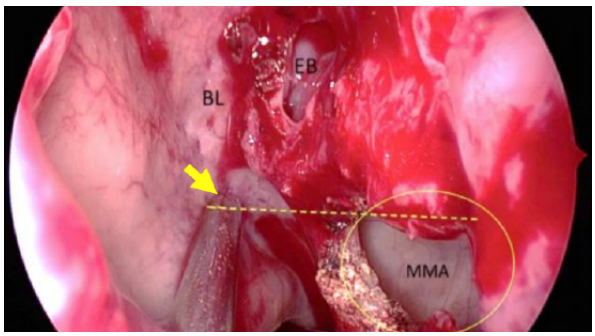


Figure 67a: Close-up view of middle meatus after middle meatal antrostomy (MMA) showing basal lamella (BL) of middle turbinate, ethmoidal bulla (EB) face removed. The suction tip (yellow arrow) indicates level at which basal lamella is to be perforated

- The basal lamella of the middle turbinate now comes into view (*Figure 67a*)

Basal/ground lamella

- The lateral insertion of the middle turbinate to the lamina papyracea is called the basal lamella. It is posterior to the bulla ethmoidalis and separates the anterior from posterior ethmoid air cells, and represents the ***3rd lamella*** as described by Messerklinger (*Figure 23*)

- Open the basal lamella at the level of the superior aspect of the maxillary sinus ostium, pointing the sucker medially towards the septum. This will be in line with the sphenoid ostium (*Figures 67a*)

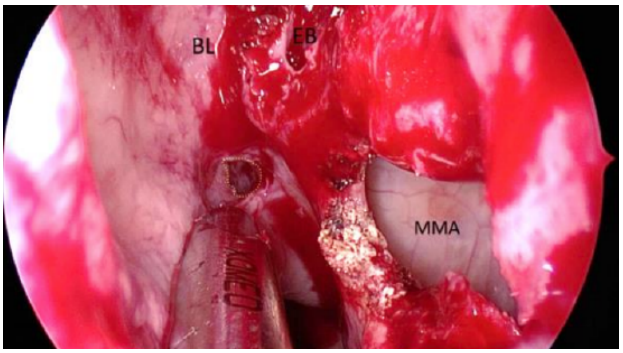


Figure 67b: Perforating the basal lamella (BL) of middle turbinate. This initial perforation is subsequently enlarged using a shaver or Kerrison punch

- Use a thin straight sucker to break through the basal lamella to enter the posterior ethmoidal cells (*Figures 67b*)
- Pass a straight curette through this opening in the basal lamella and enlarge the opening, first superiorly, and then laterally towards the lamina papyracea
- Remove the medial aspect of the basal lamella with a sphenoid or Kerrison punch
- ***Be careful not to pull on this area*** as the middle turbinate may be avulsed or fractured during this part of the procedure

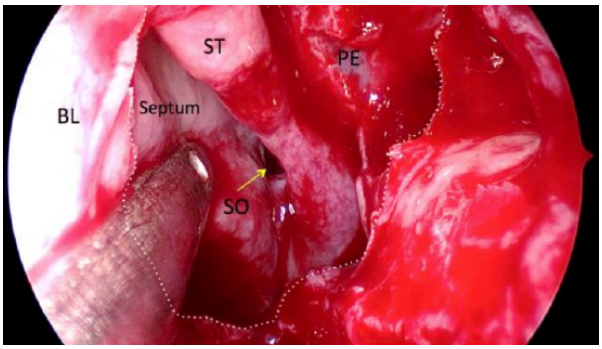
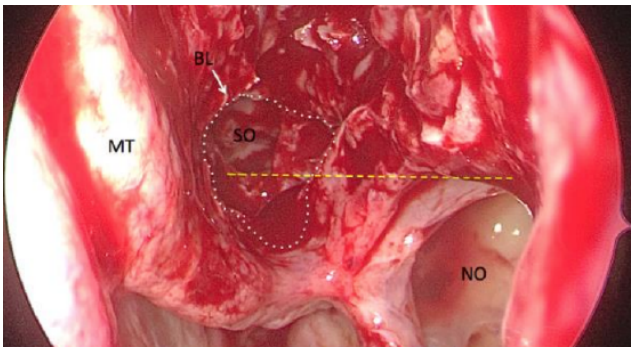


Figure 68: Dashed line indicates opening of basal lamella (BL) of middle turbinate. Entire edge of superior turbinate (ST), sphenoid ostium (SO) and posterior ethmoidal air cell (PE) are now visible

- Open the basal lamella until the entire free edge of the superior turbinate is visible (*Figure 68*)

Posterior ethmoidectomy

- Proceed to posterior ethmoidectomy in a similar anterior-to-posterior stepwise fashion, working up to the sphenoid face and skull base
- To identify these structures, it is often good to first locate the sphenoid ostium
- This is done after medially breaking through the basal lamella of the middle turbinate (*Figure 68*)



Figures 69: The sphenoid ostium can be located by perforating the basal lamella of the middle turbinate (BL). The window in the basal lamella is demonstrated by dashed line. The inferior margin of sphenoid ostium (SO) is at the same level as the superior margin of maxillary sinus natural ostium (NO) demonstrated by yellow dashed line.

- The inferior border of the sphenoid ostium is seen at a level approximately horizontal to the superior border of the maxillary ostium, medial to superior turbinate (*Figure 69*)
- Once the ostium has been identified, you know where the sphenoid face is; this represents the posterior limit of the ethmoidectomy dissection

Onodi cell

- ***Horizontal septations seen on CT within the sphenoid sinus represent an Onodi cell***
- An Onodi cell is associated with an increased risk of ***optic nerve injury*** (15% dehiscent in Onodi cell) as it is often closely related to the optic nerve and care needs to be taken not to injure the optic nerve within this cell. It is also associated with carotid artery (20% dehiscent in Onodi cell) or brain injury

Completing the ethmoidectomy

- Once the sphenoid ostium has been identified, the posterior and superior limits of the dissection can easily be determined
- The authors now break through the lamella of the superior turbinate (preserving the superior turbinate) using a small straight sucker and 1 mm 45-degree Kerrison punch so that the sphenoid ostium can be directly visualized from the middle meatus via the ethmoidectomy
- Use a straight curette to break down the posterior ethmoidal cells, working from posteriorly to anteriorly and away from the skull base

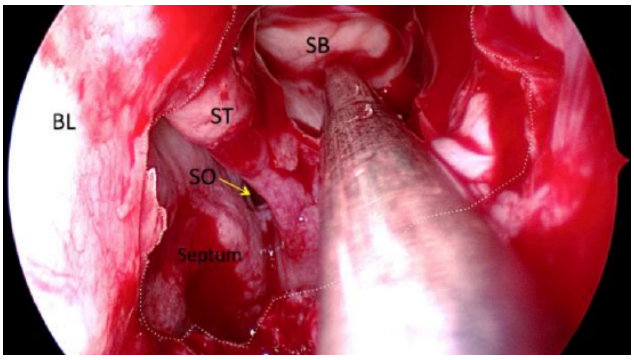


Figure 70: Fovea ethmoidalis (skull base) now clearly visible

- The fovea ethmoidalis (skull base) can now be clearly seen (*Figure 70*)

Frontal recess and frontal sinus drainage pathway

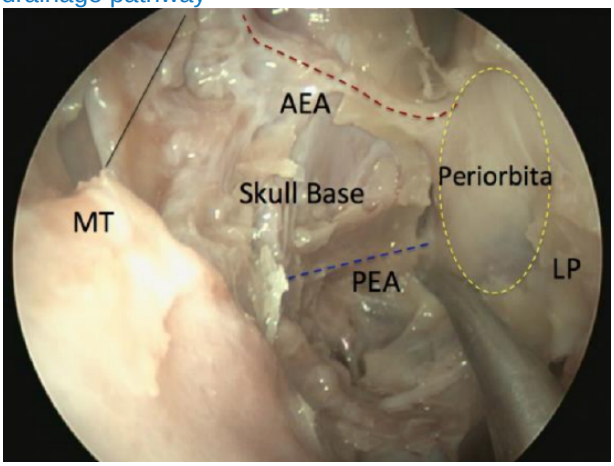


Figure 71: Anterior (AEA) and posterior ethmoidal arteries (PEA), viewed by 30° endoscope as they traverse anterior skull base (skull base, superior attachment of middle turbinate (MT) and lamina papyracea (LP) all removed)

- Continue the dissection from posterior-to-anterior with the skull base kept in full view during the dissection (*Figure 71*)

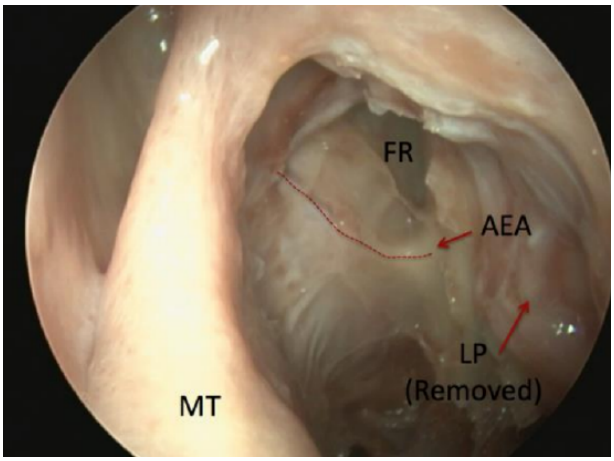


Figure 72: The anterior ethmoidal artery (AEA) is closely associated with the posterior boundary of the frontal recess (FR). It runs from posterolateral to anteromedial on the skull base (above) or occasionally in a mesentry below skull base which is more vulnerable to injury

- Once the frontal recess area is reached, care needs to be taken to avoid injury to the anterior ethmoidal artery (*Figure 72*)
- It is the authors' preference to first identify the frontal sinus drainage pathway before removing the remaining cells around the area of the anterior ethmoidal artery or posterior aspect of the frontal recess
- These cells are left undisturbed until last as the highest risk of an anterior ethmoidal artery bleed and CSF leak is during this part of the procedure

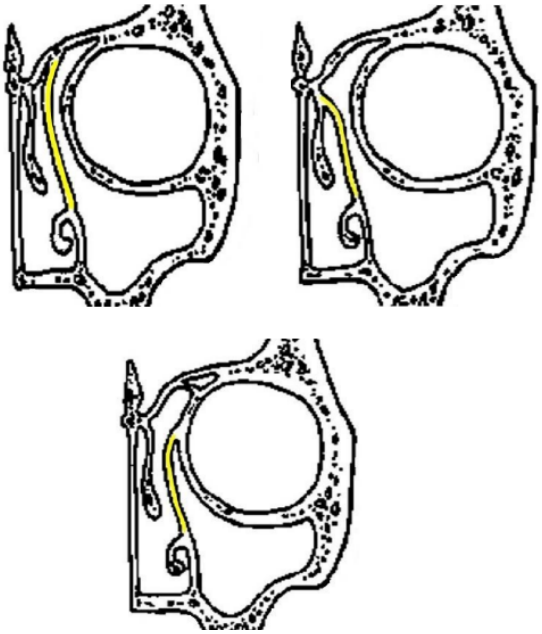


Figure 73: Frontal sinus drainage pathway is determined by insertion of the uncinate process to the: roof of ethmoid centrally; middle turbinate; and lamina papyracea laterally

- Review the frontal sinus drainage pathway on the CT scan; it is important to examine the insertion of the uncinate process and the anatomy of the agger nasi cell and bulla ethmoidalis to determine the frontal sinus drainage pathway (*Figure 73*)
- A ball probe can usually be carefully inserted into the drainage pathway

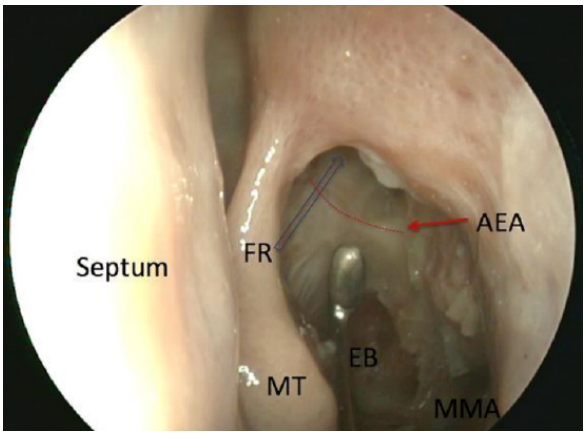


Figure 74: Anterior ethmoidal artery (AEA) with lamina papyracea (LP) removed. Frontal recess (FR) indicated by blue arrow

- Once the frontal sinus has been entered and the posterior border of the frontal sinus has been identified, the remaining cells around the anterior ethmoidal artery can be safely removed (*Figure 74*)

Nasal Packing

- Packing may be used to control bleeding, prevent adhesions or provide compression to avoid a septal hematoma if septoplasty has been done
- The authors commonly use topical hemostatic powder (Nexstat®) for hemostasis and to avoid packing
- If the middle turbinate needs to be medialized to prevent adhesions, dissolvable packing such as Nasopore is favored as a temporary spacer

Postoperative in hospital care

- Regular analgesia
- Pulse, blood pressure and Glasgow coma scale are carefully monitored
- Observe for epistaxis, headaches, orbital swelling, diplopia, reduced visual acuity and clear rhinorrhea
- Remove nasal packs the following day

Postoperative ambulatory care

- Antibiotics are ***not routinely*** prescribed
- Instruct patient not to blow the nose hard for at least 48 hours and only gently thereafter
- Day 1: Commence topical decongestants for 5 days and a saline spray or douche for 6 weeks
- Day 2: Check intraoperative pus swab results; if a specific organism has been isolated, prescribe appropriate antibiotics
- Day 4: Suction-toilet the nose, check for septal hematoma or infection
- 1 week: Recommence long-term nasal steroids with nasal polyposis
- 6 weeks: Decrust the nose with a rigid endoscope in the clinic if necessary

Pearls and Pitfalls

Excessive intraoperative bleeding

- Pack with adrenaline or oxymetazoline soaked gauze
- Work on the opposite side of the nose and return to complete surgery once hemostasis has been achieved
- Sphenopalatine artery ligation may be required
- Staged surgery is often better to reduce the risk of serious complications; therefore abandon surgery if there is uncontrollable bleeding or poor visibility

Frontal sinus surgery

- Surgery to the frontal sinus is often easier to perform once infection and inflammation have settled

Anterior ethmoidal artery injury

- Preoperative CT evaluation of the location of the ethmoidal arteries relative to the skull base is essential
- Injury to the anterior or posterior ethmoidal arteries causes them to retract into the orbit and cause an orbital hematoma
- Proptosis and orbital hematoma increases intraocular pressure causing blindness

- Intraoperative signs: Orbital hematoma, proptosis, periorbital swelling
- Therefore, it is essential that eyes remain visible during surgery through a clear adhesive dressing
- Attempt to control bleeding in the nose with bipolar cautery
- Never use monopolar cautery due to the risk of blowing a hole in the thin bone of the skull base and causing a CSF leak
- Orbital hematoma and proptosis either intra- or postoperatively requires urgent lateral canthotomy
- As lateral canthotomy is only a temporary solution and should be followed by a full medial orbital decompression

Breach of lamina papyracea

- Generally, has no consequences if it is recognized
- Be aware of possible risk of injury to the periorbita
- Does not required repair
- Avoid blowing nose for 10 days as at risk of pneumo-orbit

Exposed orbital fat

- Medial rectus muscle is at risk
- Stop surgery for a moment, and carefully assess the area
- Confirm that it is fat by placing tissue in normal saline or water; if it floats, it is fat
- If comfortable with the situation, then proceed with the surgery
- Avoid the microdebrider in this area
- No repair required
- Avoid blowing nose for 10 days as at risk of pneumo-orbit

Diplopia due to medial rectus injury

- Urgently consult an ophthalmologist
- Medial rectus injury causes diplopia
- Cannot easily be corrected
- Is a life altering complication and hard to legally defend

CSF leak

- If noticed intraoperatively, repair immediately
- Depending on the location of the leak, this can be done with bipolar cautery, local mucosal flaps, facial underlay grafts and/or Duraseal
- Lumbar drains not indicated

How to prepare and administer a saline douche

Nasal irrigation is a safe and natural way to help wash crusts and mucus from the nose. Although there are many over-the-counter saline solutions, patients can make their own:

Saline solution

- ¼ teaspoon of bicarbonate (baking) soda
- ¼ teaspoon of salt (non-iodised)
- 1 cup of boiled then cooled water

Method

- Fill a large syringe (10 or 20 mL) or a sinus rinse bottle (available from many pharmacies) with the saline solution
- Stand over a basin
- Keep the head straight
- Put the nozzle towards the back of the nose
- Squirt into one nostril and then repeat on the other side Or
- Pour some of the solution into the palm of the hand and sniff it into each nostril
- The mixture should run into the mouth – spit this out
- Swallowing the solution is harmless
- Repeat two times per day
- If a medicated nasal spray has been prescribed, the douching solution should be used before using the nasal

Authors

Pedro Monteiro MBBCh, MMed, FCORL
University of Cape Town
Karl Storz Rhinology Fellow
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
mail@pmonterio.com

Darlene Lubbe MBChB, FCORL
Associate Professor
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
doclubbe@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

RHINOPLASTY: BASIC APPROACHES AND TECHNIQUES IN NASAL TIP SURGERY

GJ Nolst Trenité

The variety of procedures for nasal tip surgery and the individual differences in tip anatomy are complicated by the confusing terminology in the international literature. It was Tardy who advocated a systematic rational approach to the nasal tip. With this framework in mind, the inexperienced nasal surgeon can use the appropriate incisions, approaches and techniques more easily. The basic philosophy is to operate as atraumatically as possible and to preserve tip support, which is very important in getting good long term postoperative results.

There are ***three basic surgical approaches*** to the tip of the nose:

1. Non-delivery approach

- Cartilage-splitting
- Retrograde eversion

2. Delivery approach

3. External approach

Indications for each of these approaches depend on the specific anatomy of the nose and the proposed changes:

- Volume reduction
- Reconstruction
- Rotation
- Change of projection

Surgical Procedures

1. Non-delivery approach The non-delivery approach is very appropriate for:

- Small volume reduction of the lateral crus
- Slight cephalic rotation of the tip

Volume reduction can easily be done using a transcartilaginous incision, in which only slight surgical trauma occurs.



Figure 1: Drawing of the skeletal landmarks and the planned resection on the skin

The operative procedure for the ***cartilage splitting non-delivery approach*** is as follows: after drawing the skeletal landmarks and boundaries on the skin of the nose, the most cephalic part of the lateral crus to be resected is outlined with a marking pen on the external skin (*Figure 1*).



Figure 2a: Imprint of the vestibular skin with a suction tube to mark the planned site of the transcartilaginous incision



Figure 2b: Suction tube imprint of the vestibular skin (arrow)

It is helpful to indicate on the vestibular skin where the transcartilaginous incision should be made. This can be done either by a through-and-through needle from the outside or, more elegantly, by using the imprint of a surgical instrument on the vestibular skin (*Figures 2a,b*).

Care should be taken to preserve at least 5 mm of uninterrupted cartilage (in a vertical dimension) of the lateral crus.



Figure 3: Vestibular skin incision





Figures 4a,b: The vestibular skin is dissected free from the cephalic part of the lateral crus to be resected

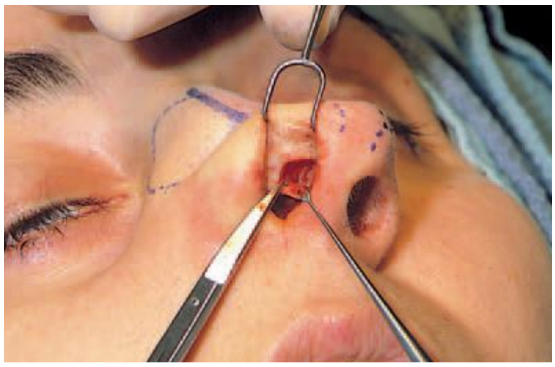




Figure 5a,b: Dissection at the nonvestibular site after splitting the cartilage



Figures 5c,d: Resection of cephalic parts of the lateral crura

Although many surgeons make their incisions through the vestibular skin and cartilage at once, it facilitates the dissection of the vestibular skin to do this in two stages. A vestibular skin incision with a No. 15 blade (*Figure 3*) is followed by dissecting the vestibular skin free from the proposed resection of the cephalic part of the lower lateral cartilage with a pair of sharp pointed curved scissors (*Figures 4a,b*). After splitting the cartilage (No. 15 blade), the nonvestibular side of the cephalic part to be resected is dissected free from the overlying soft tissue and removed (*Figures 5a-d*). Pressure of the middle finger of the operator's hand (holding the double-hooked ala retractor) on the lateral crus will give excellent exposure and control during surgery.

After sufficient and symmetric volume reduction, the vestibular skin should be sutured carefully with 5/0 atraumatic absorbable suture material. This simple tip refinement procedure gives minimal surgical trauma, leaving the integrity of the lower lateral intact ensuring the best chances for uncomplicated healing process.

Nowadays, the ***retrogade-eversion approach*** is performed less often. Instead of a transcartilaginous incision, an ***intercartilaginous incision*** is made followed by retrograde dissection over the lateral crus at the non-vestibular side, eversion of the lateral crus and resection of the planned cephalic portion of the cartilage.

2. Delivery approach

The ***delivery approach***, although more traumatic, is indicated when the planned changes to the nasal tip are more than just a small volume reduction.

The indications for this approach are:

- Asymmetry
- Bifidity
- Extra cephalic tip rotation
- Diminishing of the tip projection

With this approach, it is possible to modify the alar cartilages under direct vision up to the dome and interdomal area. Different operative techniques can be applied:

- Precise excision of cartilage to achieve good symmetry
- Remodeling the alar cartilages by scoring and morcellation
- Interdomal suturing to correct bifidity

- Interruption of the continuity of the alar cartilage to reduce an extremely overprojected tip (‘pinocchio’ nose) or to enhance cephalic tip rotation.



Figure 6: Intercartilaginous incision caudal to the valve area and around the anterior septal angle

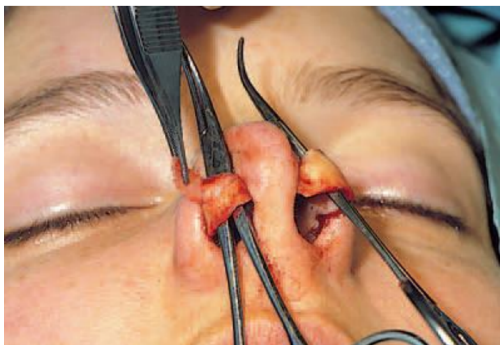
The surgical procedure to deliver the alar cartilages starts with an intercartilaginous incision with a No. 15 blade. It is important to make this incision caudally to the valve area to prevent unnecessary scarring in the valve area. This intercartilaginous incision should be carried well around the anterior septal angle (*Figure 6*). If not, delivery could be stagnated.



Figure 7: Marginal incision

The next step is to make a marginal incision (No. 15 blade), hugging the caudal edge of the lower lateral to prevent surgical damage to ‘the soft triangle’. The incision starts at the upper part of the caudal edge of the medial crus, then goes around the dome and follows the caudal edge of the lateral crus as far as necessary (*Figure 7*).





Figures 8a,b: Precise dissection and excision of a cephalic portion of the lateral crus

After these two incisions, the non-vestibular side of the lateral crus is freed from the soft tissue by dissection with a pair of sharp pointed curved scissors. To deliver the bipedicled chondrocutaneous flaps, small hemostats are very handy. Precise excision of cartilage is now possible under direct vision (*Figures 8a,b*).

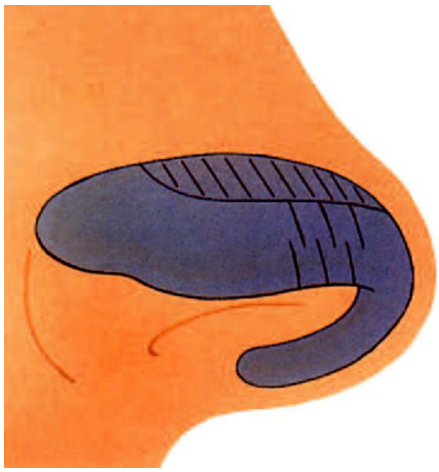


Figure 9a: Weakening procedure of the lateral crus by scoring the cartilage

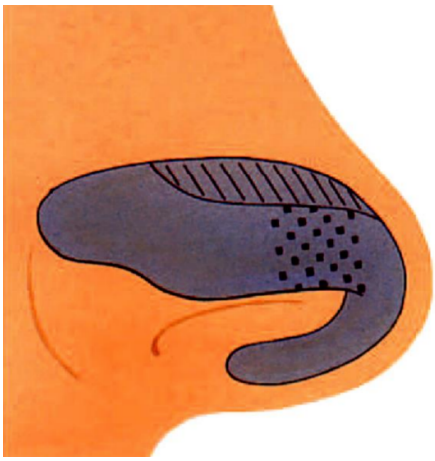
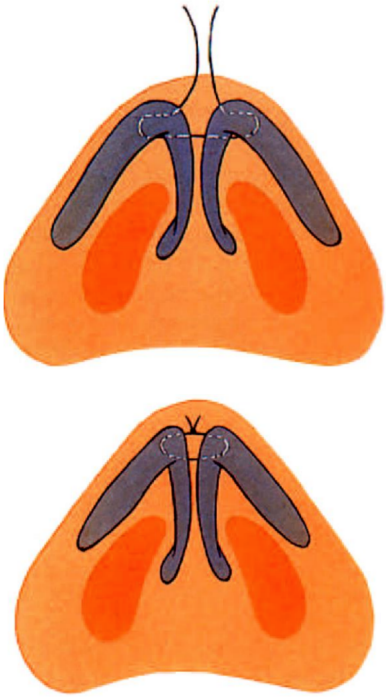
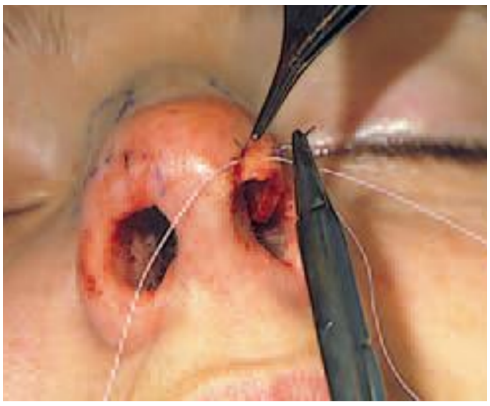


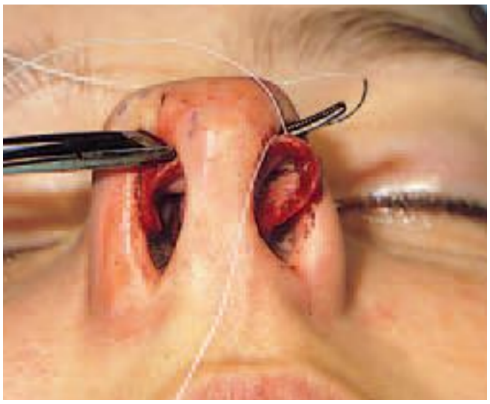
Figure 9b: Weakening procedure of the lateral crus by morcellation

In the case of bulging of the lateral crus, the weakening procedure (scoring or morcellation) is performed, if indicated in combination with resection of a cephalic portion of the lateral crus (*Figures 9a,b*).



Figures 10a, b: Horizontal mattress suture technique to correct bifidity of the tip





Figures 10 c,d: Mattress suture with 6/0 Goretex of left lower lateral followed by transportation of the needle with a mosquito clamp to the right side for the same procedure



Figure 10e: Direct postoperative result after advancing the domes with horizontal mattress suture technique

The delivery approach is also appropriate in the case of bifidity of the nasal tip, in which the horizontal mattress suture technique can be performed to advance the domes with a non-absorbable (Goretex) or a slow absorbable (PDS) atraumatic suture (*Figures 10a-e*).

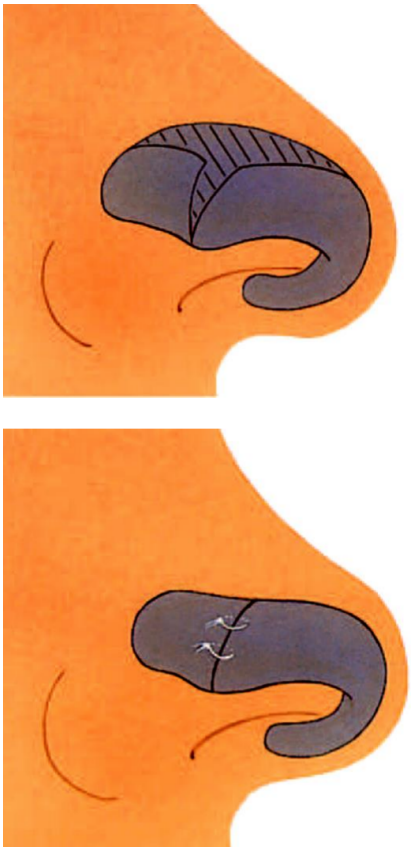


Figure 11a: Dome amputation



Figure 11b: Sutured lower laterals with an onlay tip graft to hide possible postoperative irregularities

Interrupting the continuity of the alar cartilage can give some unpredictable scarring, especially visible in thin-skinned noses. In the case of dome amputation to reduce a ‘pinocchio’ nose, an onlay tip graft will hide possible irregularities in the healing process (*Figures 11a,b*).



Figures 12a,b: Interrupted strip technique to obtain adequate cephalic tip rotation in case of a tension nose

To reduce tip projection and to obtain sufficient cephalic tip rotation, as is indicated in correcting a tension nose, the continuity of the alar cartilage is interrupted by transection of the lateral crus at the junction of its middle and lateral third, followed by resection of the cartilage segment of the lateral third and cephalic part (*Figures 12a,b*).

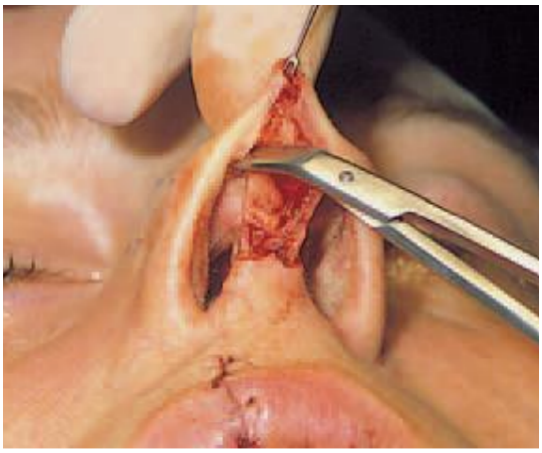
A supplementary procedure to enhance tip rotation is resection of a caudal strip of cartilage in the septum. The surgeon should be aware that the healing process is less predictable, with more chance of postoperative asymmetries, with the delivery approach than with the non-delivery approach.

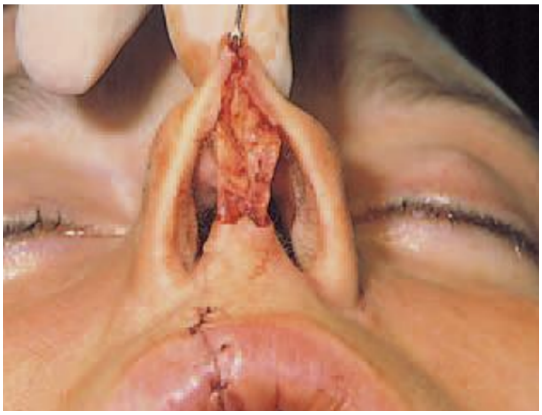
3. External approach

The external approach, although even more traumatic and time consuming, gives the best exposure of the three approaches. This approach enables the surgeon to perform bimanual surgery, and it makes judgement of the specific deformities much easier. Therefore, it is especially indicated in the case of:

- Congenital deformities such as cleft, lip nose
- Extensive revision surgery
- Severe nasal trauma
- Elaborate reduction and augmentation procedures

Nevertheless, there is a tendency to use the external approach routinely, especially by less experienced nasal surgeons. This is justified as long as the surgeon weighs the surgical trauma of the chosen approach against the possibilities of a satisfying postoperative result in each individual case.





Figures 13a,b: External approach after careful preparation of the columella skin flap avoiding injury to the underlying cartilage of the medial crura



Figure 14: Meticulous suturing of the midcolumellar incision with 6/0 nylon

Careful preparation of the columella skin flap (*Figures 13a,b*), without disturbing the underlying cartilage of the medial crura, and meticulous suturing of the midcolumellar skin incision (*Figure 14*), to prevent skin necrosis and visible scarring, are prerequisites.

Clinical examples

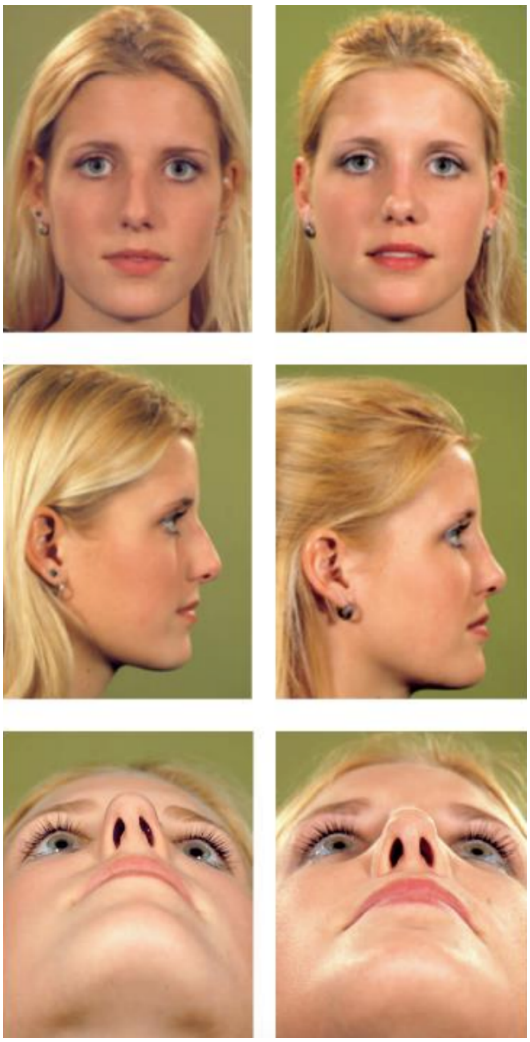


Figure 15: Pre- (left) and postoperative (right) views of a patient who underwent a rhinoplasty by the non-delivery approach. First a septoplasty was performed to correct a caudal septal deviation to the left followed by a cephalic resection of the lower laterals. Then a cartilaginous bony hump was removed followed by medial oblique, lateral micro-osteotomies and infracture of the nasal bones



Figure 16: Pre- (left) and postoperative (right) views of rhinoplasty by the delivery approach, to narrow the broad trapezoid tip with transdomal and interdomal suturing followed by a bilateral cephalic resection of the lower laterals and a small resection of the cartilaginous dorsum. The asymmetry of the nostrils due to a caudal septal deviation to the left was corrected by a septoplasty through a hemitransfixion incision

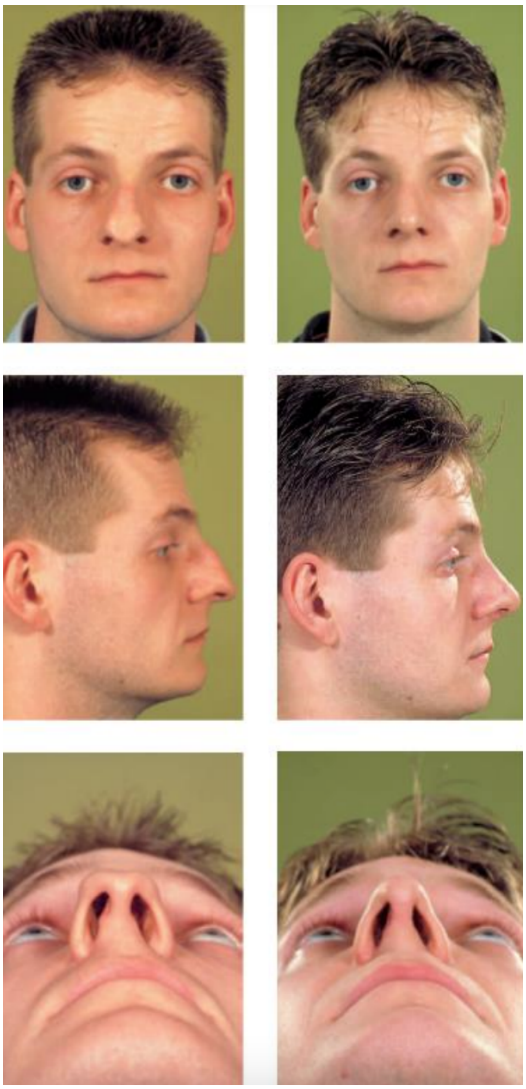


Figure 17: Pre- (left) and postoperative (right) views of a patient with a congenital deformity of the nose with agenesis of the nasal bones, overdevelopment of the cartilaginous vault and an extreme trapezoid deformity of the nasal tip. Narrowing of the tip with inter- and transdomal suturing and adequate cephalic tip rotation was performed with an interrupted strip technique through an external approach. Finally alar base wedge resections were performed to correct alar flaring



Figure 18: Pre- (left) and postoperative (right) views of a patient with a bulbous tip with lack of projection. An external rhinoplasty was performed for more tip projection and refinement with the use of autogenous grafts (columella strut and shield graft) from septal cartilage

In *Figures 15-18* clinical cases of nondelivery, delivery and external approaches are shown.

The material in this chapter originates from the textbook **"Rhinoplasty: A practical guide to functional and aesthetic surgery of the nose"** G.J. Nolst Trenité (ed) ISBN 978-90-6299-206-5 https://www.rhinoplasty.nl/store/

Author

Gilbert Nolst Trenité MD, PhD
Professor of Otorhinolaryngology
Former President of European Academy of Plastic Surgery
Amsterdam, Netherlands
nolsttrenite@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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4.11: Grafts in Rhinoplasty Surgery

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GRAFTS IN RHINOPLASTY SURGERY

GJ Nolst Trenité

In the last century all kinds of biological and nonbiological materials were used for augmentation of the nasal dorsum and to correct tip deformities. Nonbiological implants have a high risk of local infection and extrusion of the implant, compared to biological grafts. Although the common use of new biocompatible synthetic materials (teflon, mersilene, goretex, etc) give very good results in other parts of the body, this is not so for the nose due to its vulnerability for trauma inducing an antigenic reaction in the tissue surrounding the implant. Allogeneic (homologous) and xenogeneic (heterologous) materials still have some extended resorption of the graft. Up until now, autogenous (autogeneic, autologous) material has always been regarded as the graft material of choice in nasal surgery, despite the additional harvesting procedure. In most cases there is a preference for autogenous cartilage over bone, because of the lack of flexibility of bone and its tendency to be resorbed.

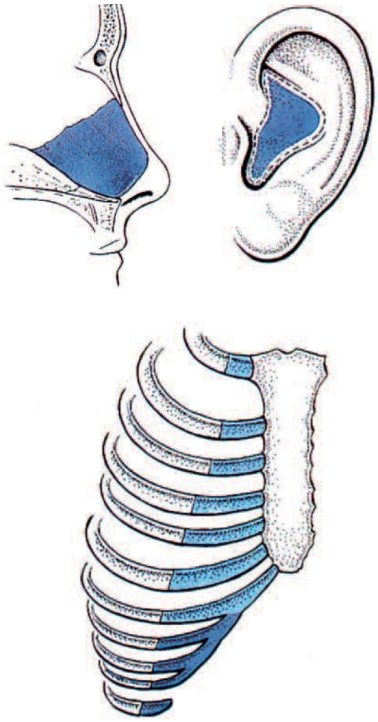
Autogenous graft materials

As autogenous graft material for the nose, one can use single or composite grafts:

Single grafts	**Composite grafts**
Cartilage	Double layer graft (skin, cartilage)
Bone	Triple layer graft (skin, cartilage, skin)
Skin	

Donor sites

Most donor sites for autogenous grafts are easily accessible during nasal surgery. There are, however, two exceptions: costal cartilage and iliac crest bone. The most frequently used donor sites are:



Figures 1a,b,c: Donor sites for autogenous cartilage grafts – dark blue areas

- For cartilage (*Figure 1a,b,c*)
  - Nasal septum
  - Auricle
  - Costal cartilage

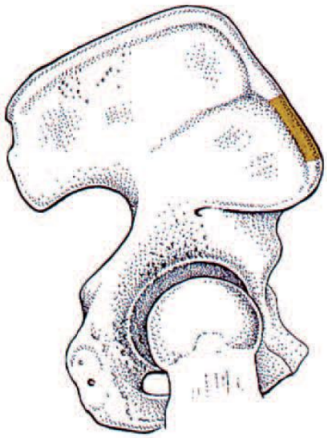


Figure 2: Iliac crest with brown area as donor site for bone

- For bone (*Figure 2*)
  - Iliac crest
  - Cranium

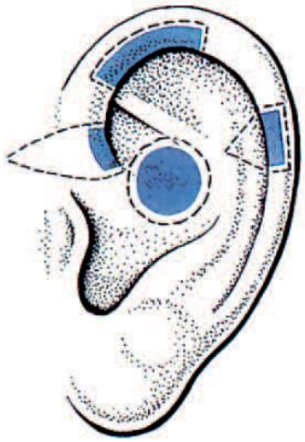


Figure 3: Different areas of the auricle for harvesting composite grafts

- Full skin & composite grafts (*Figure 3*)
  - Auricle

Recipient sites

The recipient site for bone is usually confined to the dorsum. Single full thickness skin grafts have a tendency to retract and are therefore only suitable for small skin defects over the cartilaginous and bony nasal skeleton. Double and triple layer composite grafts are indicated for defects with tissue loss of the tip, ala or columella.

Autogenous cartilage is generally used in most recipient sites. The main recipient sites for grafts in nasal surgery are:

- radix
- septum
- dorsum
- nasal side wall
- tip
- ala
- columella
- nasolabial groove

Indications

Radix

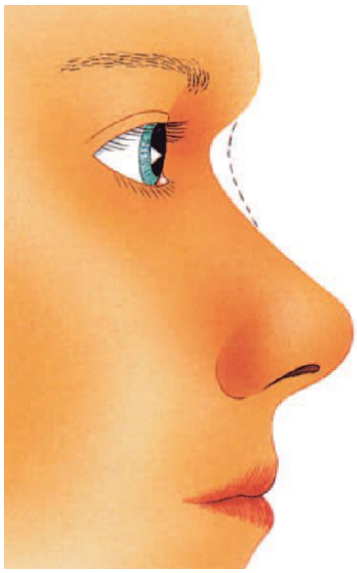


Figure 4a: A too deep nasofrontal groove resulting in an apparent overprojection of the nose

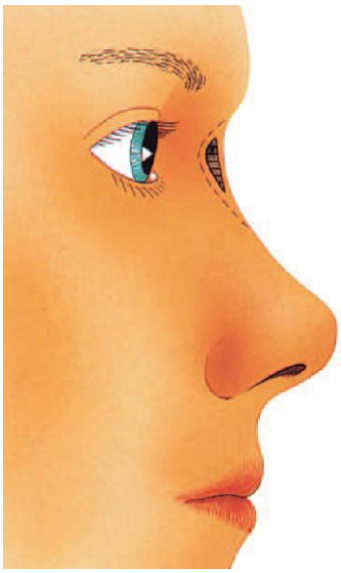


Figure 4b: Autogenous cartilage graft (blue striped area) to lengthen the nose and to correct the apparent overprojection

By changing the horizontal and vertical positions of the deepest depression of the root of the nose using a small cartilaginous graft, will result in lengthening of the nose and diminishing an apparent over-projection of the nasal tip (*Figures 4a,b*).

Septum



Figure 5a: Sagging of the cartilaginous dorsum, diminished tip support and retraction of the columella due to overresection of the caudal part of the septum

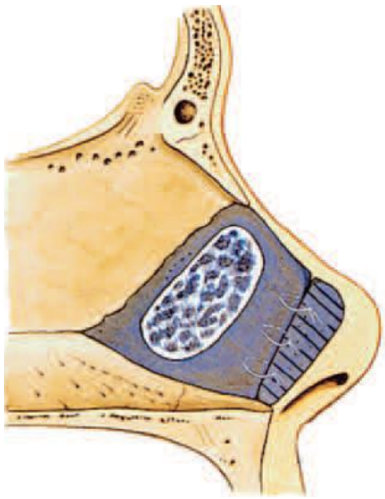


Figure 5b: Rebuilding the septum with autogenous septal cartilage (blue striped area). Reimplantation of crushed left-over cartilage in the donor site to prevent a septal perforation

The choice of graft for augmentation of the nasal dorsum depends on the etiology and extent of the correction needed. Postoperative sagging of the cartilaginous dorsum after septal surgery is best treated with rebuilding or repositioning of the cartilaginous septum (*Figures 5a,b*). For rebuilding the septum autogenous cartilage from the posterior portion of the septum (if still available), conchal cartilage or costal cartilage (less accessible) is suitable. In case of a septal abscess with excessive loss of septal cartilage, immediate rebuilding with autogenous costal cartilage or allogeneic 'bank' cartilage is indicated, to prevent saddling and, if it concerns a growing child, additional midfacial growth disturbances.

Dorsum

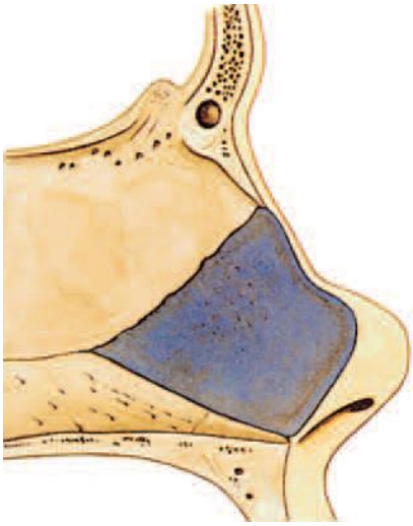


Figure 6a: Saddle nose caused by a too low cartilaginous dorsum with normal tip support

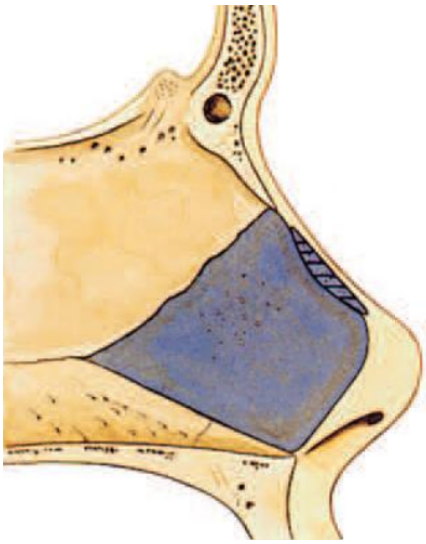


Figure 6b: Autogenous septal or conchal cartilage (blue striped area) to rebuild a sagging cartilaginous dorsum

In a saddle nose caused by a too low cartilaginous dorsum with normal tip support, a cartilaginous septal or conchal graft is appropriate (*Figures 6a,b*).

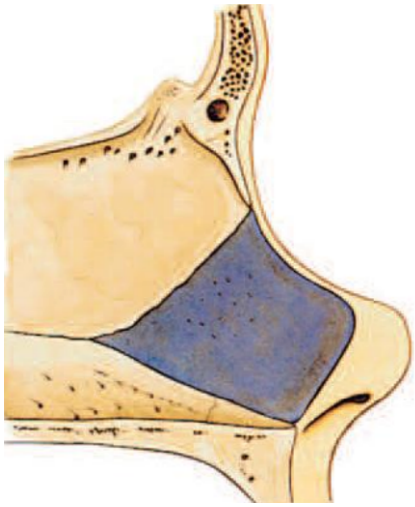


Figure 7a: Severe saddling involving the whole osseocartilaginous vault

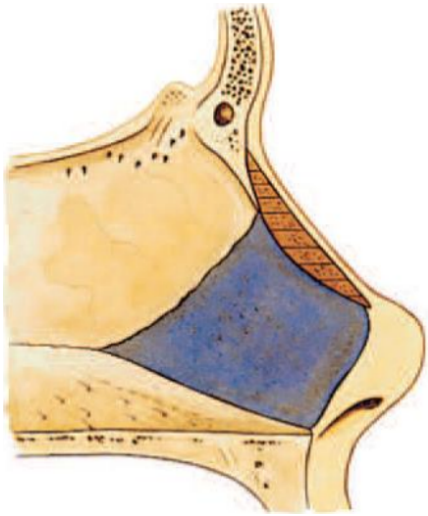


Figure 7b: Autogenous bone graft – brown striped area – to augment the nasal (bony and cartilaginous) dorsum

A nose with severe saddling involving the whole osseocartilaginous vault could be a good candidate for a bone graft (*Figures 7a,b*).

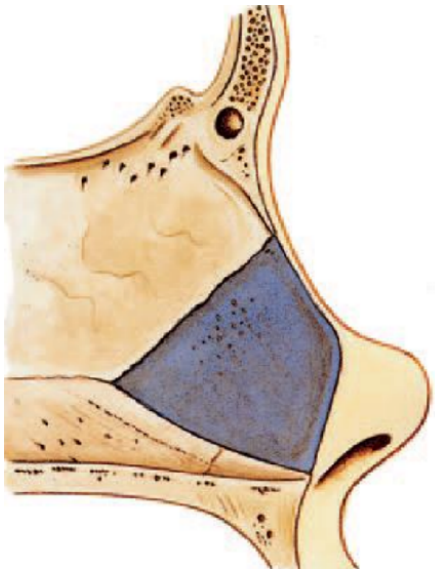


Figure 8a: A combination of severe saddling and diminished tip support

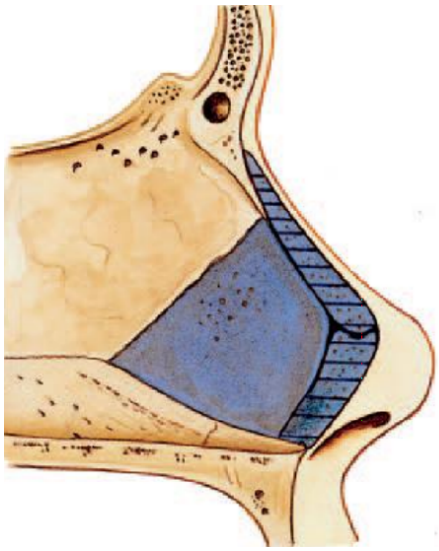


Figure 8b: A two piece autogenous costal cartilage graft (blue striped areas) to reconstruct the normal projection of the nose

Due to the tendency of iliac crest bone to be resorbed, cranial bone or costal cartilage grafts are now more popular. When this severe saddling is combined with loss of tip support, a (two piece) costal cartilage graft is very suitable (*Figures 8a,b*).

Nasal side wall

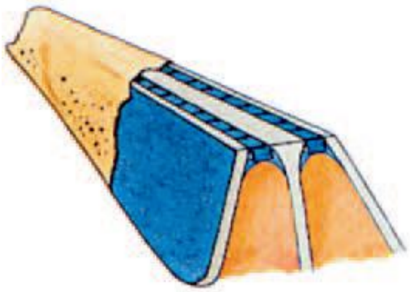


Figure 9a: Spreader grafts of autogenous septal cartilage (blue striped areas) to restore a too narrow nasal valve and an aesthetically too narrow mid-nose



Figure 9b: Autogenous septal onlay graft (blue striped area) to camouflage avulsion of the upper lateral from the nasal bone

Mid-nose collapse due to excessive resection of the upper lateral or avulsion of the upper lateral from the nasal bone (K-area) can be treated with a septal cartilage graft (*Figures 9a,b*).

Tip, ala and columella

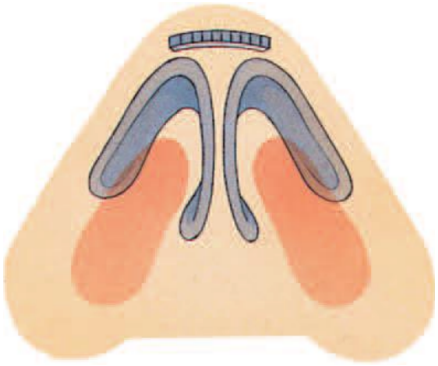


Figure 10: Onlay tip graft of autogenous cartilage of the concha, which is very suitable due to its natural bending

For tip augmentation, cartilaginous grafts from the concha, septum, or a combination of these, can be used depending on the operative technique and extent of the correction. Conchal cartilage is very suitable as an onlay tip graft because of its natural bending properties (*Figure 10*).

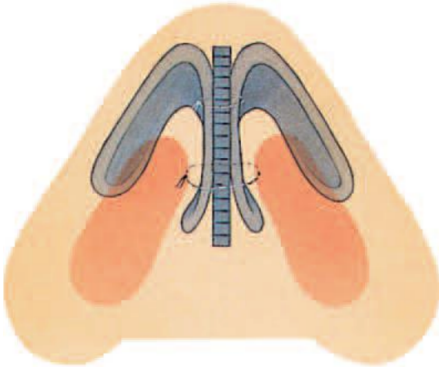


Figure 11a: Columella strut of autogenous septal cartilage for extra tip support fixed by mattress sutures to the medial crura

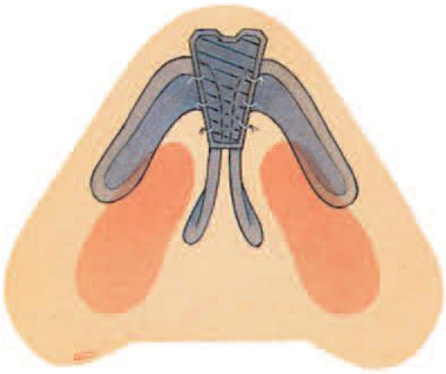


Figure 11b: Shield-type tip graft sculptured from autogenous septal cartilage to gain extra tip projection and definition

Septal cartilage is the material of choice for a columella strut for extra tip support, and for a shield-type tip graft for extra tip definition and projection (*Figures 11a,b*).

In certain cases of alar rim defects, resulting in alar collapse, a conchal cartilage graft with its concave side towards the vestibulum can be very effective. When there are not very large alar, tip or columellar defects with cartilage and soft tissue loss, and in cases of vestibular stenosis, composite grafts are indicated.

Nasolabial angle



Figure 12: Small pieces of autogenous cartilage to correct an acute nasolabial angle

To correct an acute nasolabial angle, due to some retraction of the columellar base, small pieces of available septal or conchal cartilage in a subcutaneous pocket are appropriate (*Figure 12*).

Harvesting technique

The harvesting technique described in this chapter is restricted to only the most frequently used autogenous grafts in nasal surgery.

Septal cartilage

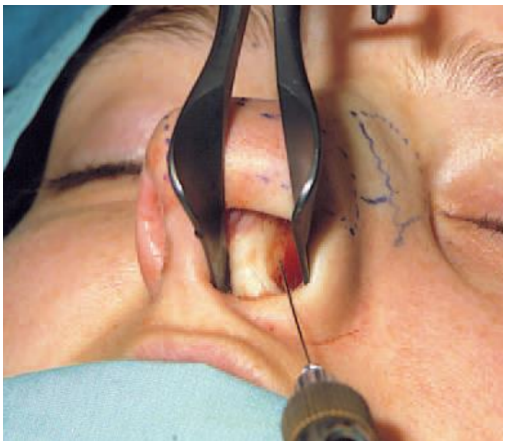


Figure 13a: Hydraulic dissection with local anesthetic

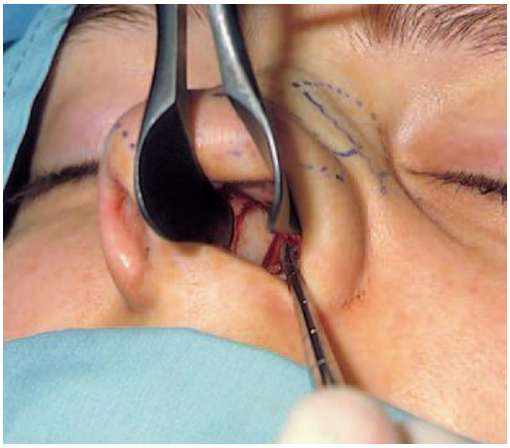


Figure 13b: Freeing the mucoperichondrium from the septal cartilage after a Killian incision



Figure 13c: Vertical transcartilaginous incision followed by freeing the mucoperichondrium at the opposite side

Hydraulic dissection with a local anesthetic will facilitate this procedure (*Figure 13a*). When there is no indication for correction of a deviated septum, the hemitransfixion incision should be replaced by a Killian incision (blade No. 15), so as not to disturb the septocolumellar junction (*Figure 13b*). The initial incision through the mucoperichondrium can be made at either side of the septum. With a sharp, pointed, curved pair of scissors, dissection is started in the subperichondrial plane and continued with a Cottle or Joseph elevator to free the mucoperichondrium over the area of septal cartilage to be resected (*Figure 13b*). After incising the cartilage, a subperichondrial tunnel is made over the corresponding area at the opposite side of the cartilage (*Figure 13c*). Care should be taken not to damage the mucoperichondrium to prevent perforation of the septum.

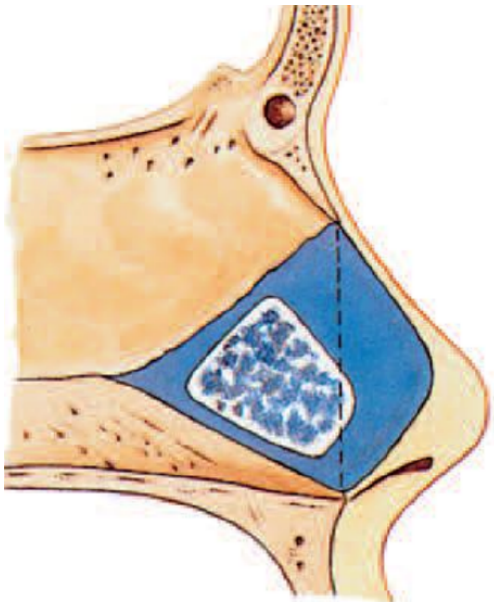


Figure 14a: Donor site of septal cartilage, posterior to the dotted line to guarantee septal support of the nasal dorsum with reimplantation of crushed cartilage



Figure 14b: Harvested septal cartilage for sculpturing columella strut and shield tip graft

After additional horizontal and vertical chondrotomies with a beaver knife, the planned amount of septal cartilage can be harvested. In choosing the cartilage harvesting area, care should be taken not to disturb the continuity of that part of the quadrangular cartilage anteriorly to the imaginary line between the most caudal point of the nasal bones (rhinion) and the anterior nasal spine, to prevent sagging of the cartilaginous nasal dorsum (*Figures 14a,b*). A blunt forceps should be used to remove the graft material in order not to damage the cartilage. After the sculpturing procedure, the left-over cartilage should be used as a crushed implant in the area of the previously resected cartilage to prevent the mucoperichondrium from sticking together. This procedure diminishes the chance of a septal perforation and stimulates the growth of new septal cartilage.

Ear cartilage



Figure 15: Retro-auricular skin incision

For small cartilage onlay grafts for the nasal tip, a retro-auricular skin incision is made over the concha (*Figure 15*).



Figure 16: Two parallel incisions through cartilage and ‘post-auricular’ perichondrium



Figure 17: Resection of the first onlay tip graf

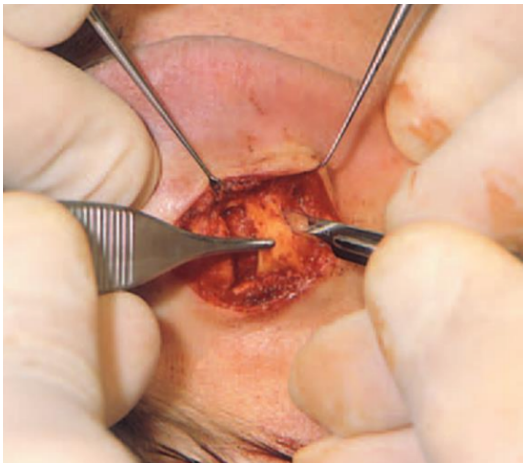


Figure 18a: Harvesting a second graft

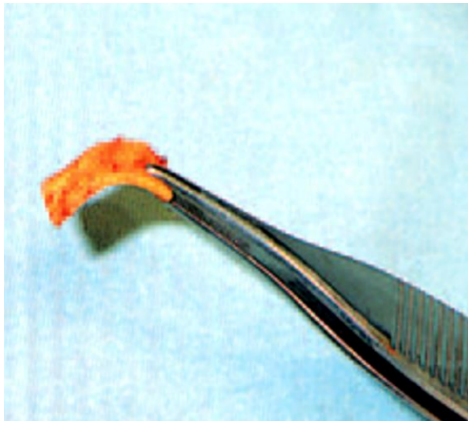


Figure 18b: Natural bending of the conchal cartilage graft



Figure 18c: Skin closure with 5/0 atraumatic nylon ‘running’ suture

Generally, pieces measuring 5–10 mm are suitable. The cartilage grafts can be harvested from the cymba conchae (cranial to the radix helices) or cavum conchae (caudal to the radix helicis), depending on the appropriate degree of bending which is needed. After freeing the soft tissue by blunt dissection over the area to be resected, two transcartilaginous incisions (No. 15 blade) are made through the cartilage and ‘postauricular’ perichondrium (*Figure 16*), followed by subperichondrial dissection on the preauricular side with a sharp, pointed, curved pair of scissors, and finally by resection of the cartilage graft (*Figure 17*). If necessary this can be followed by harvesting of a second piece of conchal cartilage (*Figures 18a,b*). The skin can easily be closed with a 5/0 atraumatic nylon ‘running’ suture (*Figure 18c*).

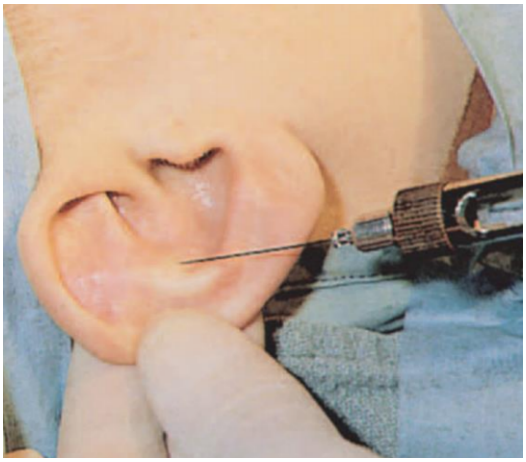


Figure 19a: Application of local anesthesia: anterior side in subperichondrial plane



Figure 19b: Application of local anesthesia: posterior side in supraperichondrial plane



Figure 20: Three through-and-through needles to mark the postauricular skin and cartilage incisions



Figure 21: Skin incision along the landmark of the needles



Figure 22: Transcartilaginous incision leaving the preauricular perichondrium intact

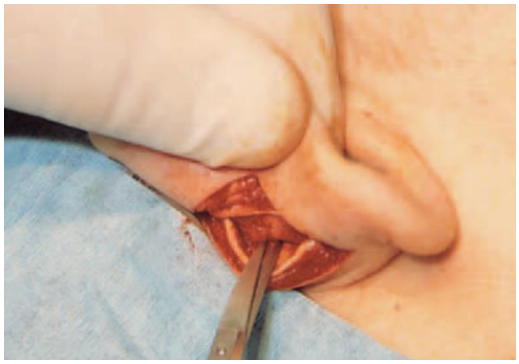


Figure 23: Subperichondrial tunnelling over the cavum and cymba conchae

To harvest a large piece of conchal cartilage, the preauricular approach is technically easier than the postauricular approach but is less elegant as it leaves a preauricular scar. After infiltration of a local anesthetic solution (2% lidocaine with 1:100,000 epinephrine) at the anterior side of the concha into the subperichondrial surgical plane, to facilitate the dissection, the posterior side is infiltrated, but now in the supraperichondrial plane (*Figures 19a,b*). To outline the postauricular semicircular skin and cartilage incision, three needles are used, stabbed through the auricle from the anterior side just medial to the antihelix, following the lateral border of the cavum and cymba conchae (*Figure 20*). After incising the skin along the line indicated by the needles (*Figure 21*), the postauricular perichondrium and conchal cartilage are incised, leaving the perichondrium intact on the anterior side (*Figure 22*). With a sharp, pointed, curved pair of scissors, subperichondrial tunneling is then carried out over the cavum and cymba conchae (*Figure 23*).

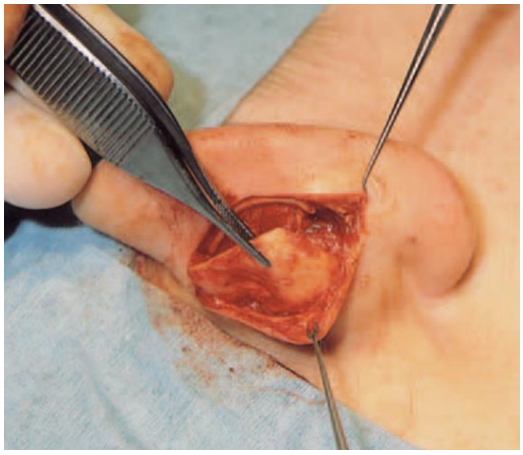
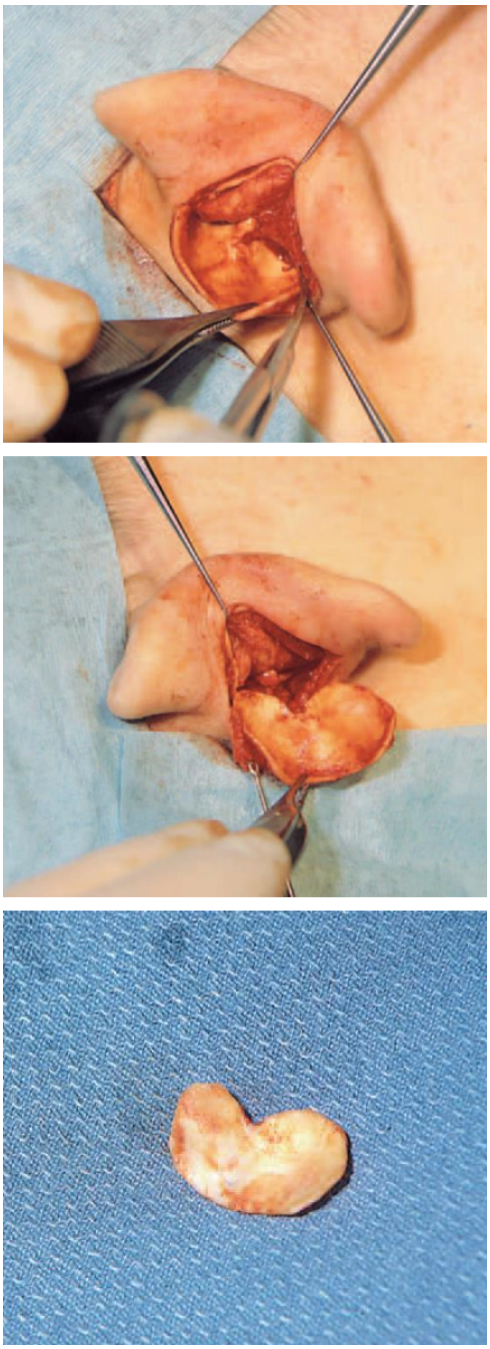


Figure 24: Supraperichondrial dissection at the posterior side



Figures 25 a,b,c: Resection of the cartilage graft leaving the radix helicis intact



Figure 26: Conchal packing fixed with through-and-through mattress sutures

The next step is to free the cartilage at the posterior side by blunt dissection in a supraperichondrial plane (*Figure 24*). The cartilage is now incised just lateral of the ear canal, leaving the radix helicis intact for structural support and finally resected (*Figures 25a,b*). After meticulous hemotasis, the skin incision is closed with a 5/0 atraumatic running suture. Carefully applied conchal packing, secured with through-and-through mattress sutures (*Figure 26*), and a light compression ear bandage will prevent the formation of hematoma.

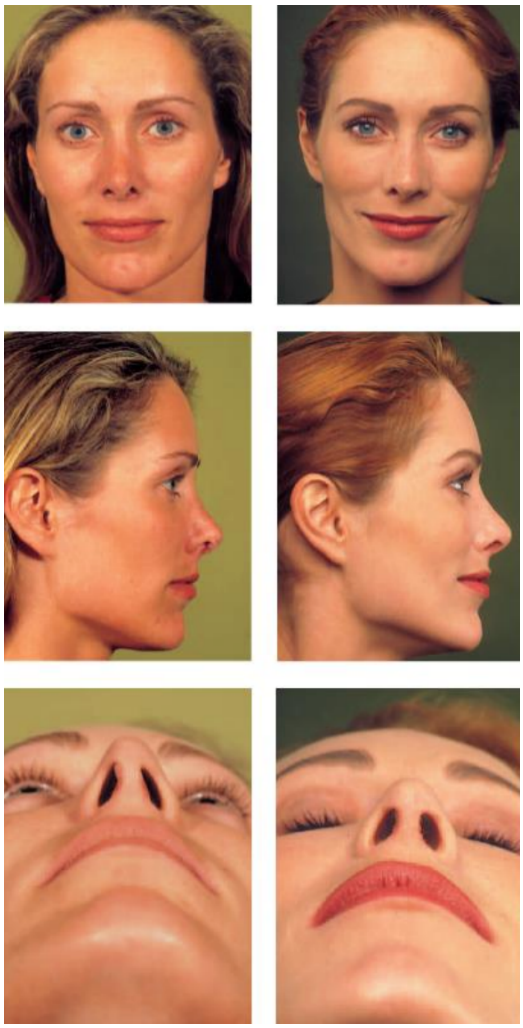


Figure 27: Pre- (Left) & postoperative (Right) views

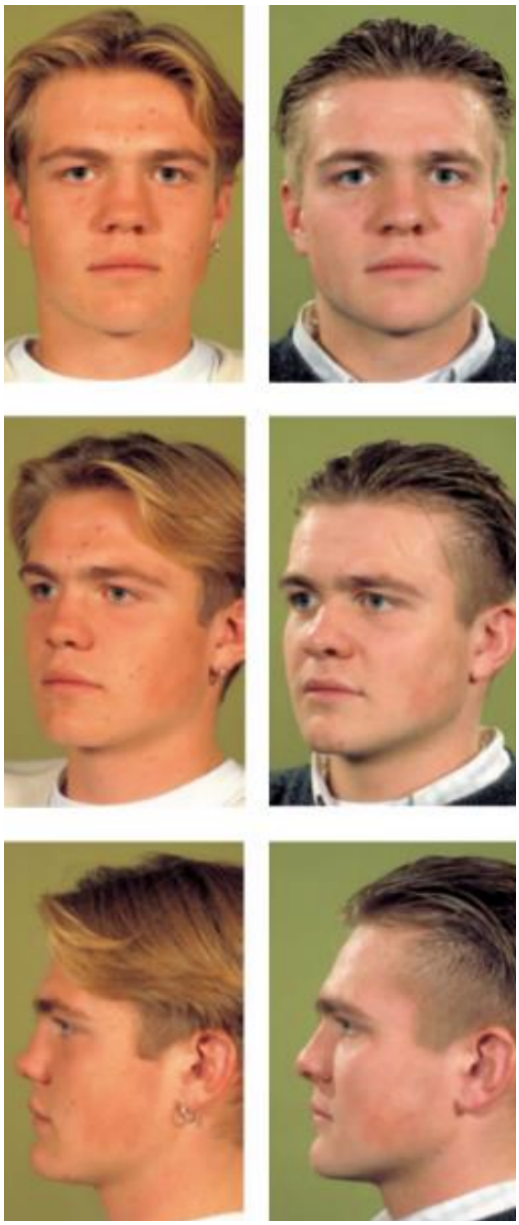


Figure 28: Pre- (Left) and postoperative (Right) views of a rhinoplasty in case of severe trauma. Through an external approach the fractured septum was rebuilt which, in combination with a dorsal conchal cartilage onlay graft, resulted in a normal profile



Figure 29: Pre- (Left) and postoperative (Right) views of a patient with functional problems due to a too narrow nasal valve (right more than left), who underwent an external rhinoplasty. After a moderate reduction of the dorsal height, spreader grafts were harvested from the cartilaginous septum and placed between septum and upper laterals through an external approach. Due to widening of the nasal valve area forced inspiration did not result in alar collapse anymore

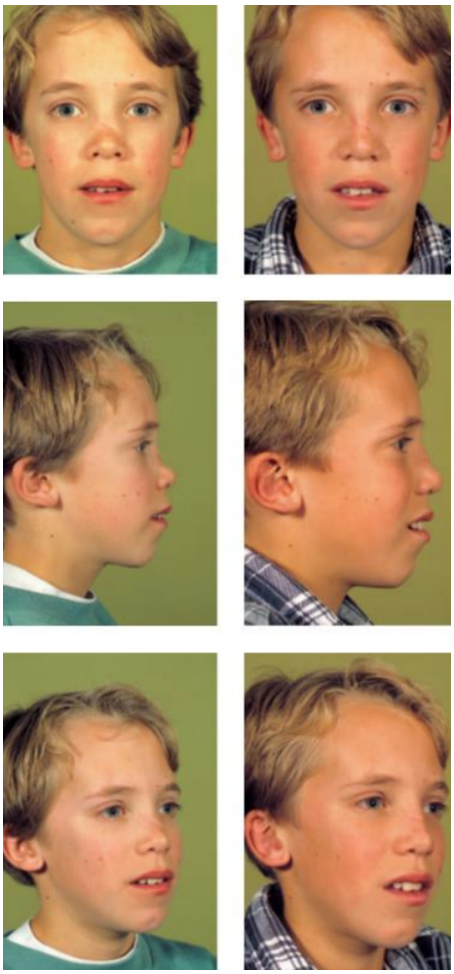


Figure 30: Pre- (Left) and postoperative (Right) views of an 11-year-old boy with a saddle deformity following severe nasal trauma

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Figures 31: Pre- (Left) and postoperative (Right) views of patient after multiple nasal trauma with loss of most of s cartilaginous framework. An external rhinoplasty was performed. Instead of a broken columella incision a V-incision was made at the base of the columella to perform a V-Y procedure to lengthen the columella. To rebuild the nose, autogenous rib cartilage was used

In *Figures 27-31* pre- and postoperative views are shown of patients who underwent a rhinoplasty with autogenous cartilage grafting procedures.

Figure 27 shows pre- (Left) and postoperative (Right) views of a patient who underwent a revision rhinoplasty, with the use of autogenous septal cartilage to lengthen the caudal septum with a batten and to augment the nasal dorsum with a septal cartilage onlay graft.

Figure 28 shows pre- (Left) and postoperative (Right) views of a patient who underwent rhinoplasty following severe trauma: Through an external approach the fractured septum was rebuilt which, in combination with a dorsal conchal cartilage onlay graft, resulted in a normal profile.

Figure 29 shows pre- (Left) and postoperative (Right) views of a patient with functional problems due to a too narrow nasal valve (right worse than left), who underwent external rhinoplasty. After a moderate reduction of the dorsal height, spreader grafts were harvested from the cartilaginous septum and placed between septum and upper laterals through an external approach. Due to widening of the nasal valve area forced inspiration did not result in alar collapse anymore.

Figure 30 shows pre- (Left) and postoperative (Right) views of an 11-year-old boy with severe psychological problems with his facial appearance, due to a severe nasal trauma resulting in a saddle deformity. He underwent an endonasal septorhinoplasty to

straighten the deformed septum, to narrow the bony pyramid with micro-osteotomies and to augment the nasal dorsum with a conchal cartilage onlay graft.



Figure 32a: Incision over 8th rib cartilage



Figure 32b: 8th rib cartilage exposed

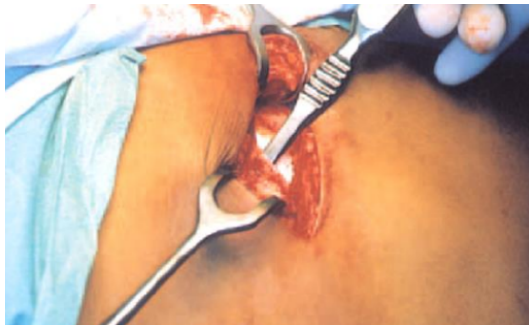


Figure 32c: Incising rib cartilage

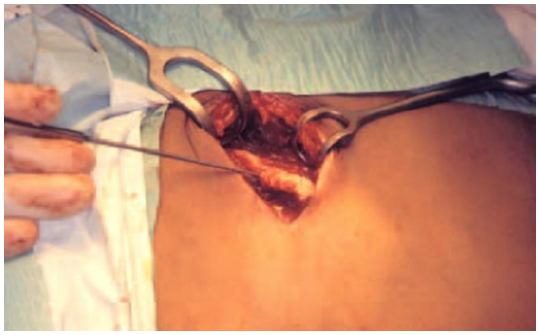


Figure 32d: Harvesting rib cartilage

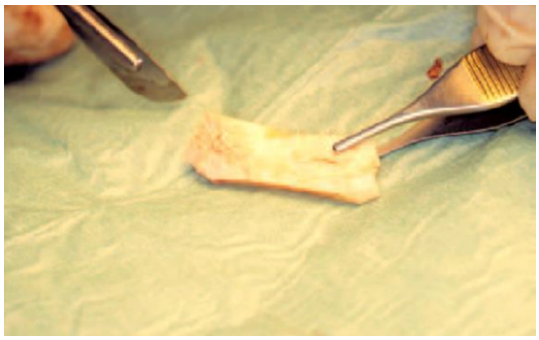


Figure 32e: Rib cartilage



Figure 32f: External approach



Figure 32g: Columella strut



Figure 32h: Columella strut in situ



Figure 32i: Dorsal onlay graft



Figure 32j: Tip onlay graft



Figure 32k: Skin closure

Figures 32a-k show the harvesting of rib cartilage and the reconstruction of the nasal framework. The cartilage was harvested from the eighth rib which was sculpted into two pieces, a columella strut and a dorsal onlay graft. To prevent warping the superficial part of the rib cartilage was removed. Through an external approach, airway and dorsal profile were restored by a two-piece reconstruction in combination with a tip onlay graft to restore tip definition.

The material in this chapter originates from the textbook **"Rhinoplasty: A practical guide to functional and aesthetic surgery of the nose"** G.J. Nolst Trenité (ed) ISBN 978-90-6299-206-5 https://www.rhinoplasty.nl/store/

Author

Gilbert Nolst Trenité MD, PhD
Professor of Otorhinolaryngology
Former President of European Academy of Plastic Surgery
Amsterdam, Netherlands
nolsttrenite@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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RHINOPLASTY: SURGERY OF THE OSSEOCARTILAGINOUS VAULT

GJ Nolst Trenité

Looking at the sequence of operative steps, most rhinoplastic surgeons prefer to perform surgery of the osseocartilaginous vault after tip surgery. One of the main reasons for this is that, by applying an external nasal dressing immediately after osteotomy, edema and ecchymosis can be prevented or at least diminished. Another reason is that, in order to obtain an aesthetic balance, in certain cases it is easier to adapt the form of the osseocartilaginous vault to the form of the tip, rather than vice versa.

In this chapter, surgery of the osseocartilaginous vault is divided into five sections:

- Hump resection
- Osteotomies
- Management of special bony pyramid problems
- Radix nasi surgery
- Cartilaginous vault surgery

Hump resection

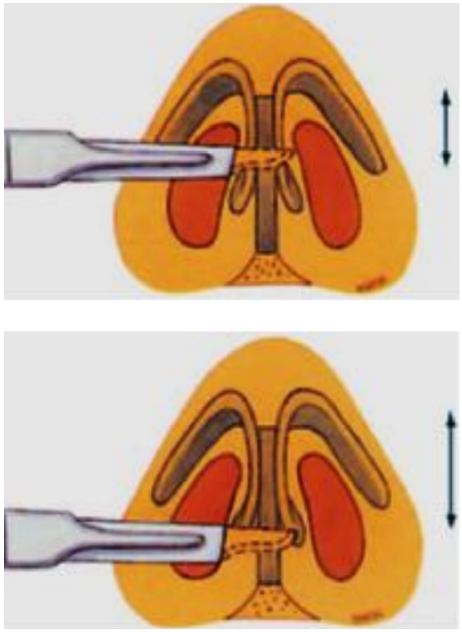


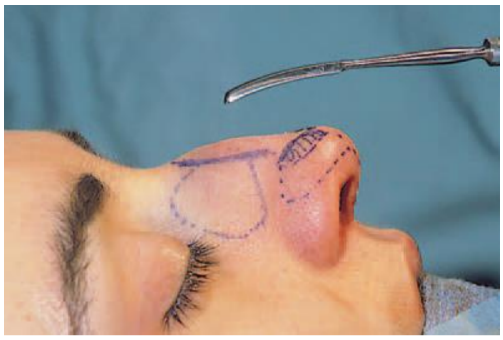
Figure 1a: partial transfixion incision; b: complete transfixion incision

The nasal hump consists of a cartilaginous and a bony part. In most cases, the bony part of the hump is much smaller than the cartilaginous part. With the endonasal approach, intercartilaginous incisions are connected by a transfixion incision to obtain ample access to the hump. It is important to dissect carefully between the upper and lower lateral cartilage in order to prevent postoperative irregularities of the lateral nasal wall. The intercartilaginous incision from lateral to medial, just caudal of the nasal valve, must be carried around the anterior septal angle. The two intercartilaginous incisions will then be connected by a partial transfixion incision, unless there is a specific indication for a complete transfixion incision. With a complete transfixion incision an important support of the tip in its connection between the medial crura and the anterior edge of the nasal septum will be disturbed (*Figures 1a,b*).



Figure 2: Sharp dissection in the surgical plane (close to the perichondrium) to free the cartilaginous dorsum from the overlying soft tissue

The next step is to free the cartilaginous part of the hump from the overlying soft tissues. With careful and sharp dissection (No. 15 blade) in the supraperichondrial surgical plane, damage to the musculus transversus nasi, together with unnecessary scarring and bleeding, will be prevented (*Figure 2*).





Figures 3a,b: Elevation of the periosteum of the nasal bone (only of the hump area) with a Joseph elevator

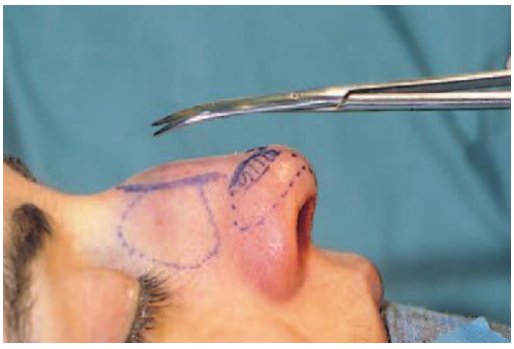
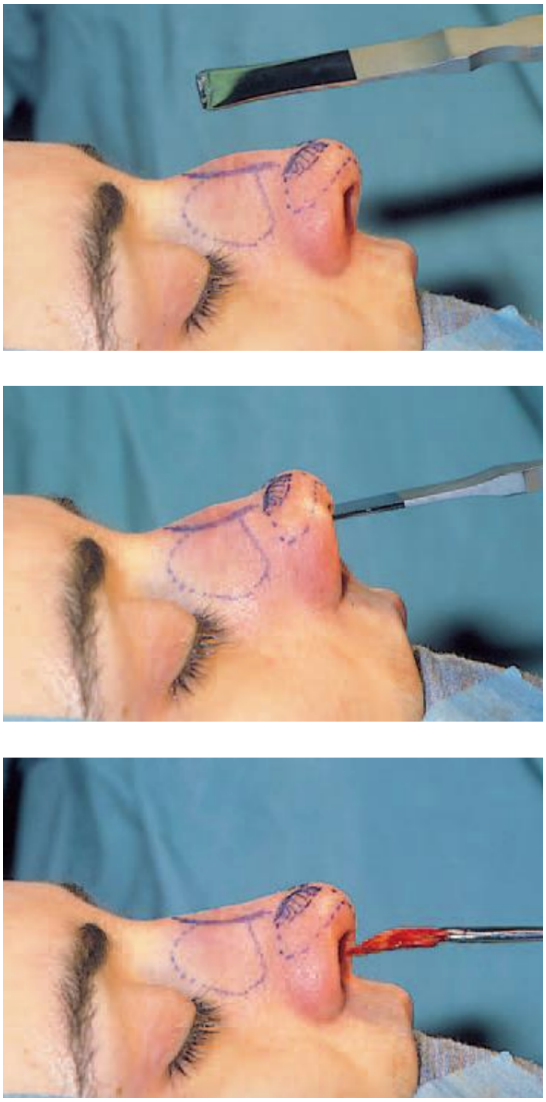


Figure 4: Dissection of the periosteum attached to the sutura intranasalis



Figure 5: Incising the cartilaginous vault under direct vision at the ‘planned’ resection line

After freeing the cartilaginous vault from the overlying soft tissues, the periosteum is incised at the caudal end of the nasal bone and elevated with a Joseph elevator (*Figures 3a,b*). There is no need to elevate the periosteum very far laterally. The procedure should be limited to the area of the hump to be resected. Periosteum attached to the sutura intranasalis can simply be cut from the bony vault with a long pair of scissors (*Figure 4*). With an ‘Aufricht’ retractor in place, the cartilaginous vault can now be incised by a through-and-through incision (No. 15 blade) from cephalic to caudal at the ‘planned’ resection line (*Figure 5*).



Figures 6a,b,c: Resection of the osseocartilaginous hump with a 14 mm hump osteotome

Using this cartilaginous cutting face as a guideline, the hump osteotome is introduced to loosen the bony part at the hump, followed by the removal of the osseocartilaginous hump ‘en bloc’ (*Figures 6a,b,c*).

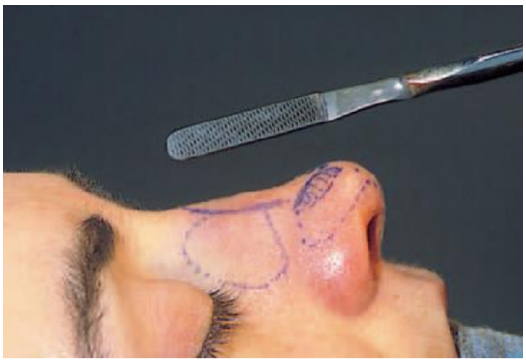


Figure 7: Smoothing of the bony surface after hump resection with a medium-fine (tungsten-carbide) rasp

A (medium-fine) tungsten-carbide or diamond rasp is now used to smoothen the bony surface (*Figure 7*) and, if necessary, some extra shaving of the cartilaginous dorsum is carried out to obtain the desired supratip-tip relation.

In case of a small hump, it is easier to start shaving off small pieces of the cartilaginous hump to the desired level and then to use a down-cutting rasp to lower the bony dorsum.

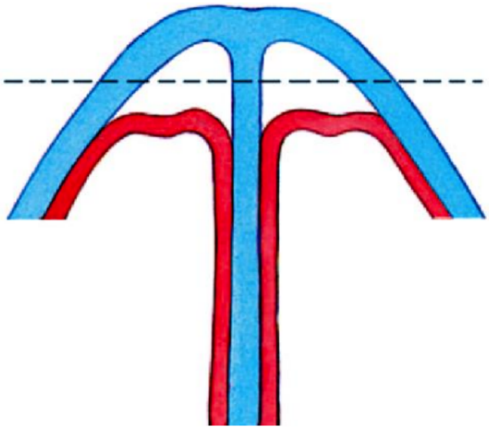


Figure 8: Stripping of the mucoperichondrium at first on the posterior side of the cartilaginous vault in case of a large hump

When a small bony hump is removed with a rasp, it is certainly less important to elevate the periosteum, the more so as this kind of bony hump resection guarantees a smooth contour of the bony pyramid. When removing the cartilaginous part of a very large hump, stripping off the mucoperichondrium at first on the posterior side of the cartilaginous vault (extramucosal technique), will prevent postoperative irregularities of the dorsum due to damage to the mucoperichondrium (*Figure 8*).

There are various additional important points to consider in hump resection:

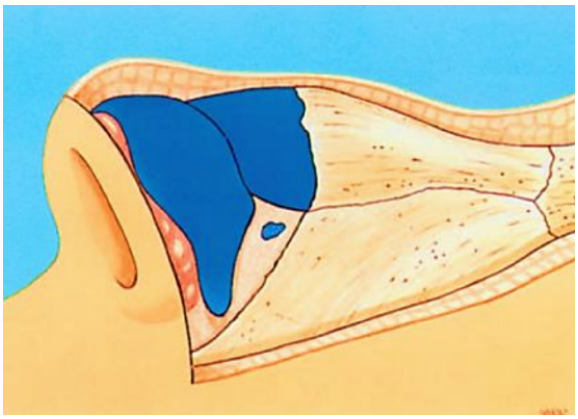


Figure 9: Illustration of the difference in thickness of the soft tissue lying over the osseocartilaginous vault

- Pay attention to the difference in thickness of the overlying soft tissue, which is at its thinnest at the rhinion (the caudal point of the ossa nasalia) (*Figure 9*)

- Check whether the nose dorsum shows any small irregularities after hump resection, which should be meticulously smoothed over
- Check whether enough cartilage has been resected from the anterior edge of the upper lateral
- Remove all loose bone particles, especially after rasping
- Correct over-resection by replacing the excised hump after trimming to the appropriate size (Skoog's method), or use an autogenous septal cartilage graft

A frequently occurring postoperative complication is the 'polly beak', which can be divided into:

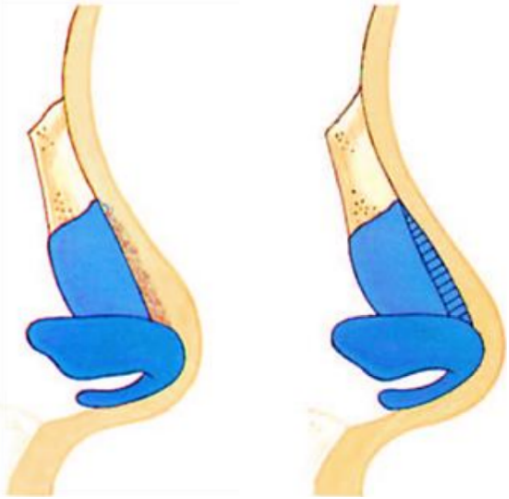


Figure 10a: Soft tissue 'polly beak'; b: Cartilaginous 'polly beak'

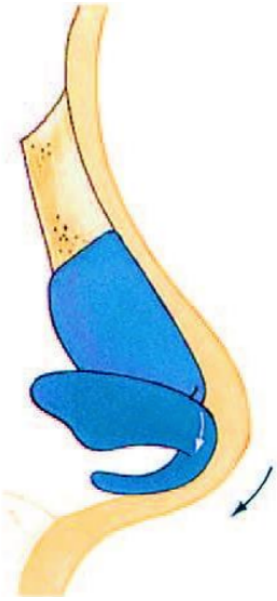


Figure 10c: Relative 'polly beak'

- The soft-tissue 'polly beak' (*Figure 10a*). This arises when dissection in the surgical plane is not made carefully enough, resulting in scarring of the overlying soft tissues
- The cartilaginous 'polly beak' (*Figure 10b*). This is caused by too little resection of the cartilaginous part, or by a relatively excessive resection of the bony part of the hump
- The relative 'polly beak'. This is the result of the tip drooping, due to tip surgery in which the tip support was insufficiently guaranteed (*Figure 10c*)

Osteotomies

Osteotomies are required to mobilize the bony pyramid for in-fracture, out-fracture or realignment. With traditional techniques and instruments, mobilization of the bony pyramids results in significant edema and ecchymosis.

The technical refinements of the last decade have produced a considerable reduction in ecchymosis and edema, resulting in quicker and better healing. The most important factors are:

- Precise placement of local vasoconstrictive and anesthetic solution
- Use of micro-osteotomes
- Preservation of periosteal attachment
- Medial-oblique osteotomy to eliminate transverse osteotomy

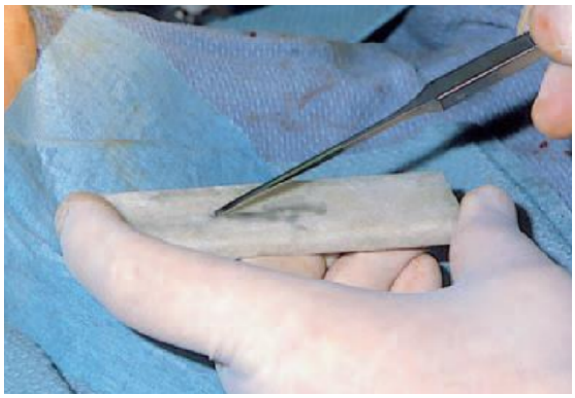


Figure 11: Sharpening of the microosteotome ‘durante operationem’

Well-placed local anesthesia at least 15 minutes prior to the surgery (on the bony pyramid) is very helpful in reducing bleeding. With the microosteotome if necessary sharpened during surgery (*Figure 11*), it is not necessary to elevate the periosteum. This gives less surgical trauma and leaves the periosteum intact to a large extent in which way it can act as an internal splint.



Figure 12: Medial-oblique osteotomy

When a medial-oblique osteotomy is combined with a slightly curved lateral osteotomy, there is no need for the traditional transverse osteotomy (*Figure 12*).

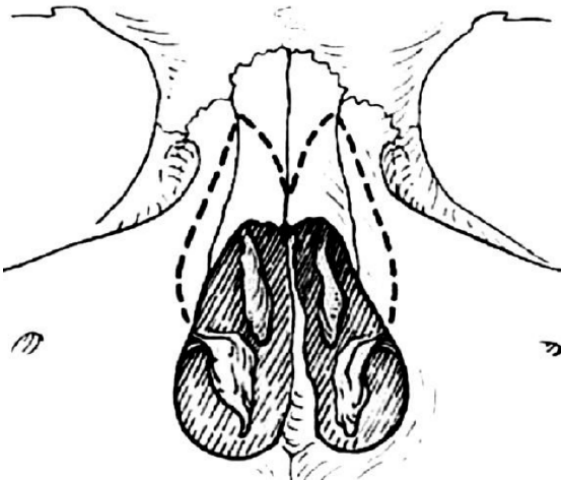


Figure 13: Osteotomy pathway (dotted line) of medial-oblique and lateral osteotomies

The crossover point of both osteotomies should not be (and aesthetically there is no need) more cephalic than the intercanthal line, thereby avoiding the thick bone of the radix nasi (*Figure 13*). It is important to leave the (external) periosteal and (internal) mucoperiosteal lining intact as far as possible.

Lateral osteotomies can be performed percutaneously as well as intranasally.



Figure 14: Low lateral osteotomy



Figure 15: Dorsum of the nose after hump resection and micro-osteotomies

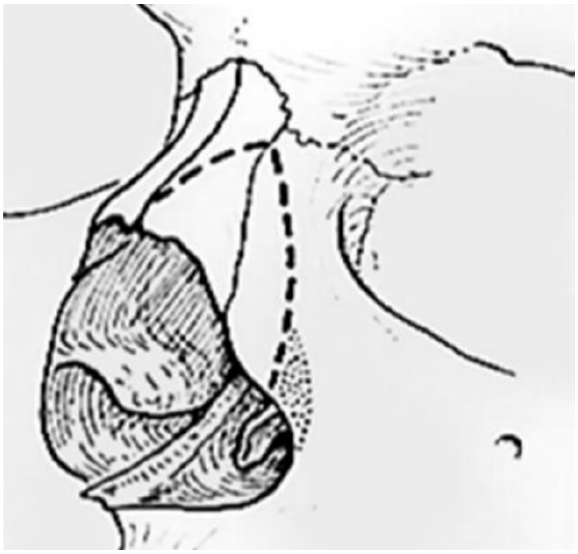


Figure 16: Bony ridge at base of lateral wall of piriform aperture (dotted area) to be preserved in performing a low lateral osteotome followed by in-fracture of nasal bone



Figure 17: Readjusted bony vault after infracture of the nasal bones

The micro-osteotome is inserted through the soft tissue of the lateral wall of the piriform aperture, starting at the ascending process of the maxilla at the superior margin of the inferior turbinate. For a low lateral osteotomy, it should then proceed laterally, preserving a bony ridge at the base of the lateral wall of the piriform aperture (*Figures 14-17*). In this way, any possible narrowing of the airway by in-fracture of the os nasale can be prevented (*Figure 17*).

It should then proceed, slowly bending from lateral to medial, as far as the intercanthal line where the medial-oblique osteotomy is carried out. Readjustment of the osteotome after sliding off the bone, prevents unnecessary lesions of the periosteum. A 2 mm osteotome is often sufficient. When the bone is thicker than normal, a 3-mm osteotome is indicated.

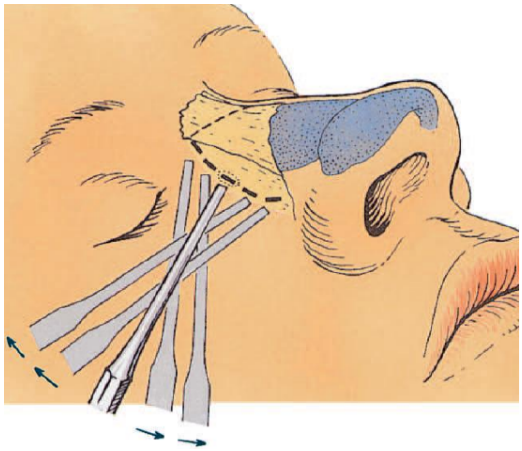


Figure 18a: Percutaneous lateral osteotomy making small point osteotomies along the planned osteotomy line



Figure 18b: Percutaneous lateral osteotomy through a skin incision halfway along the planned osteotomy line

In ***percutaneous lateral osteotomy***, a skin incision of 23 mm is made halfway along the planned osteotomy line, after which small point-osteotomies are made cephaliccally and caudally along the osteotomy line (*Figures 18a,b*). Although the percutaneous technique is rather more traumatic than the intranasal one, it gives excellent control.

In order to prevent a hematoma, it is wise to put pressure paranasally on both sides at the level of the skin incision after the procedure for 3-5 minutes.

Additional intermediate osteotomies are indicated in an asymmetric bony pyramid.

If the traditional transverse osteotomy is indicated, this can either be done percutaneously via a small incision at the level of nasion or an incision in the eyebrow with a micro-osteotome, or intranasally via the lateral osteotomy line, with a special transversely curved osteotome.

Complications which can occur in osteotomies of the bony pyramid are the following:

- An osteotomy carried out insufficiently, after which the bony part springs back into its original position

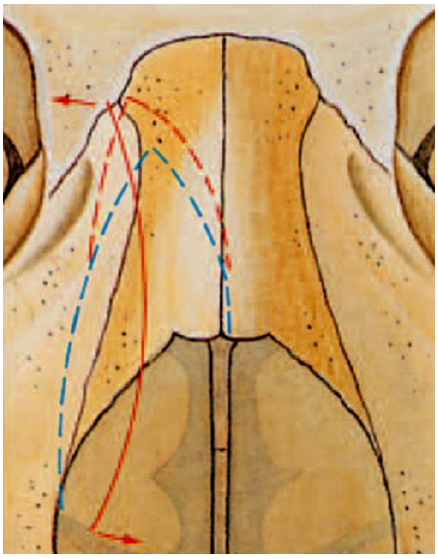


Figure 19: “Rocker phenomenon” due to too far cephalically performed osteotomies (red dotted lines)

- ‘Rocker phenomenon’ which can occur in osteotomies carried out too far cephalically. When the concave bony part, now curved medially, is repositioned on the caudal or cephalic side, the other part will project (*Figure 19*)

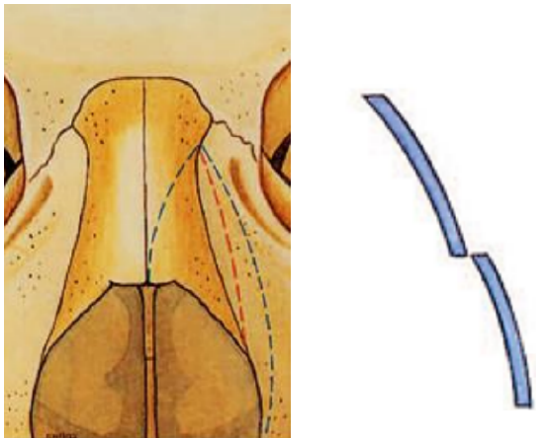


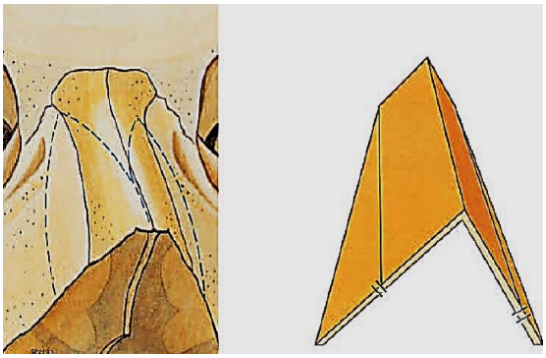
Figure 20: Staircase phenomenon due to a too medially-placed osteotomy (red dotted line)

- Lateral osteotomies carried out too far medially, in which a “staircase phenomenon” arises (*Figure 20*)
- Callosus (which often disappears spontaneously)

Management of special bony pyramid problems

Asymmetric bony pyramid due to lateral deviation

In a strong deviation of the nose, there may be a large difference between the size of the left and right os nasale, in which case exact repositioning in the midline after standard osteotomies is not possible.



Figures 21: More medially placed lateral osteotomy (green dotted line) to correct moderate asymmetry of bony pyramid

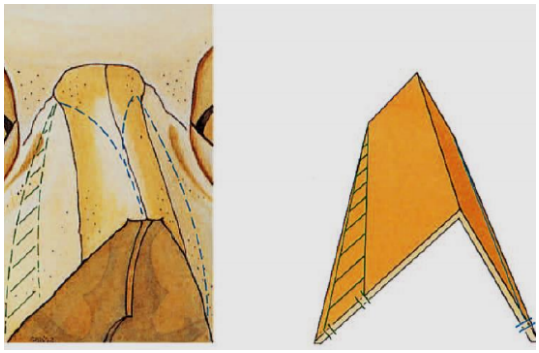


Figure 22: Resection of bony wedge (green striped area) in case of severe asymmetry of bony pyramid

If these asymmetries are not too large, a lateral osteotomy, placed more medially on the long side, is often sufficient (*Figure 21*). In a very seriously asymmetric bony pyramid, a wedge resection is indicated, whereby a bony wedge is removed on the lateral side of the longest side wall (*Figure 22*). When removing a bony wedge, the periosteum will have to be stripped off both sides of the wedge in order to be removed. To obtain adequate repositioning, the septum will also have to be mobilized and corrected, otherwise the chance of the deviation reappearing postoperatively is high.

Abnormally curved nasal bones



Figure 23: Supplementary intermediate osteotomies (green dotted lines) to remodel concave and convex bony side walls

In case of a concavity or convexity of a side wall, it is necessary to perform one or more intermediate osteotomies to remodel the bony pyramid (*Figure 23*).

Broad trapezoid bony pyramid

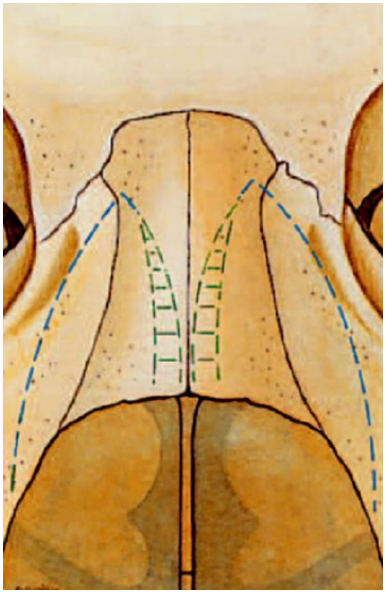


Figure 24: Resection of medial wedges (green striped areas) to correct a broad trapezoid bony pyramid

With this type of bony pyramid, in-fracture is not possible by medial-oblique and lateral osteotomies alone. Therefore a medial wedge resection is mandatory on both medial parts of the nasal bones (*Figure 24*).

Radix nasi surgery

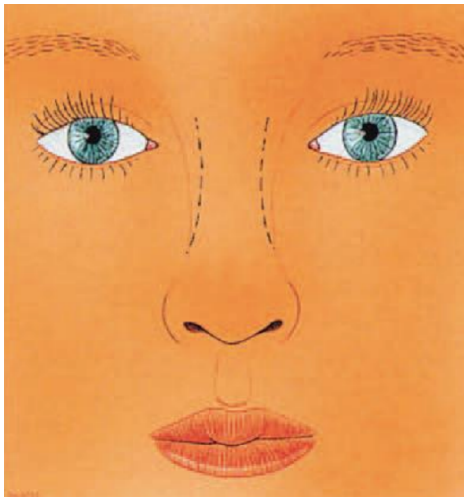


Figure 25: Proposed correction (dotted lines) of too wide a radix nasi

The role of the radix nasi is often underestimated in the aesthetic balance of the facial complex. In frontal view, the width of the radix nasi should be in good alignment with the natural curve from eyebrow to lateral nasal bone. Too wide radix nasi is very uncommon and can be corrected by infracture, after osteotomies have been placed more cephalically (above the intercanthal line) (*Figure 25*). In particular after rhinoplasty, when osteotomies have been placed too cephalically and after too much in-fracture of the bony pyramid, the radix nasi often becomes too narrow. This can be corrected with out-fracture after re-osteotomies. In profile, the radix nasi also plays a role in the aesthetic balance of the face and is characterized by the nasofrontal and nasofacial angles. A change in the horizontal or vertical position of the deepest depression of the root of the nose (nasion) has a direct effect on the apparent projection and length of the nose. A change in the position of the radix nasi, which is a relatively small surgical procedure, will have a great impact on the appearance of the nose. A dorsal onlay graft gives the nose a longer appearance and the (unchanged) nasal tip a shorter one. Deepening of the naso-facial groove using a chisel or glabella rasp has the opposite effect.

Cartilaginous vault surgery

Resection of the caudal border of the upper laterals

This is indicated as an additional procedure after a considerable shortening of the nose, due to which the caudal parts of the upper laterals protrude into the vestibulum.



Figure 26: The resected cartilaginous part of caudal border of the upper laterals and caudal septum in a nose shortening procedure should be approximately of equal length

Care should be taken not to over-shorten the upper lateral cartilages, as this may lead to unnatural narrowing of the middle third of the nose. Besides an unaesthetic appearance, over-resection of the upper lateral cartilages may result in functional problems due to inspiratory collapse of the weakened lateral nasal wall. When shortening the nose, it is a good rule not to resect more from the caudal end of the upper lateral than from the septum (*Figure 26*).

Other indications for caudal resection of the upper laterals are internal valve problems caused by pathological returning of the caudal end of the upper lateral, which interfere with normal internal valve functioning.

Narrowing the cartilaginous vault

In some cases, the cartilaginous vault is trapezoid in shape, due to the flat anterior part of the upper laterals. Resection of a small paraseptal strip of cartilage on both sides will narrow the cartilaginous vault. The technique used for adequate exposure of the cartilaginous dorsum in combination with extramucosal dissection is the same as the one used for resection of a large hump.

Widening the cartilaginous vault

Spreader grafts to widen the cartilaginous vault are indicated for aesthetic reasons when there is a very narrow mid-nose or because of functional problems caused by too sharp an angle (smaller than 10 degrees) of the internal valve. Small strips of autogenic septal cartilage are the first choice as graft material. Using the intranasal approach, they should be placed in an extramucosal pocket between the septum and the lateral cartilages. However, the external approach gives far better control.

Clinical examples of osseocartilaginous vault surgery



Figure 27: A patient who underwent a hump resection followed by medial oblique, (endonasal) lateral micro-osteotomies and infracture with moderate edema and ecchymosis two days postoperatively (top); and already resolving ecchymosis six days postoperatively (bottom) just before removal of the Denver splint

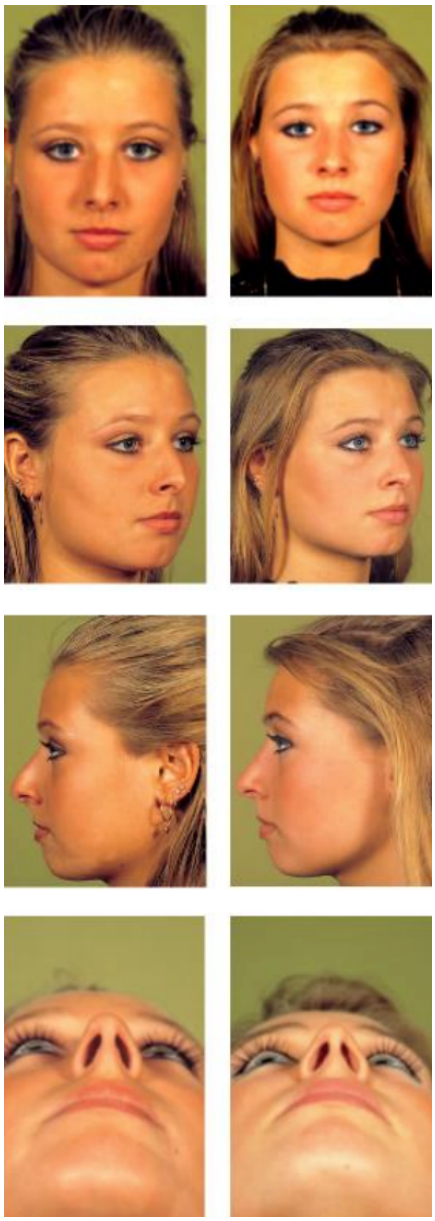


Figure 28: Pre- (L) and longterm (R) postoperative views after hump resection followed by predialoblique (endonasal) lateral view-osteotomies and in-fracture of the nasal bones



Figure 29: Pre- and postoperative views of a patient who underwent revision rhinoplasty to correct a cartilaginous polly beak



Figure 30: Pre- and postoperative views of a patient with a tension nose due to overdevelopment of the cartilaginous septum who underwent a rhinoplasty by the endonasal approach to reduce the osseocartilaginous vault and to correct a slight downward rotation of the tip with resection of a caudal strip of septal cartilage



Figure 31: Pre- and postoperative views of a ten-year-old girl who underwent endonasal septorhinoplasty due to posttraumatic septal deviation with nasal airway impairment and a gradually increasing deviation of the nasal dorsum. Realignment of the dorsum was performed with medial oblique and (endonasal) lateral osteotomies. When performing rhinoplasties in children, the surgeon should be aware that operating on a growing nose can interfere with midfacial growth. He/she has to weigh up the possible advantages (psychological and growth directional) against possible disadvantages (growth inhibition). From the experimental work of the Verwoerd group, we know that, in contrast to surgery of the cartilaginous vault, mobilization of the nasal bones does not lead to specific morphological anomalies in further growth

In *Figures 27-31*, pre- and postoperative views of patients are shown who underwent osseocartilaginous vault surgery.

The material in this chapter originates from the textbook "**Rhinoplasty: A practical guide to functional and aesthetic surgery of the nose**" G.J. Nolst Trenité (ed) https://www.rhinoplasty.nl/store/

Author

Gilbert Nolst Trenité MD, PhD
Professor of Otorhinolaryngology
Former President of European Academy of Plastic Surgery
Amsterdam, Netherlands
nolsttrenite@gmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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4.13: Septoplasty in Rhinoplasty Surgery

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

THE NASAL SEPTUM IN RHINOPLASTY: BASIC SEPTOPLASTY TECHNIQUES

FWA Otten

Septal corrections form an important step in rhinoplastic surgery. Not only for functional, but also for aesthetic surgery the septum deserves attention. In the past the septum has been submitted to resection of bone and cartilage with sometimes even negative functional and cosmetic consequences. Nowadays, because of its supporting function, one tries in a septoplasty to operate as conservative as possible by preserving and reconstructing the septum.

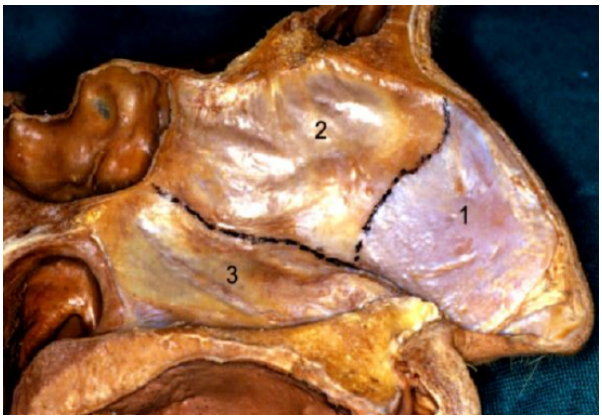


Figure 1: The nasal septum exists of the quadrangular cartilage or anterior cartilaginous septum (1), the perpendicular plate of the ethmoid (2) and the vomer (3)

The nasal septum consists of a posterior bony and an anterior cartilaginous part. *Figure 1* shows a cadaver dissection specimen of the septum. The bony septum has two components: the vomer and the perpendicular plate.



Figure 2a: The cartilaginous septum and the upper laterals form one cartilaginous structure

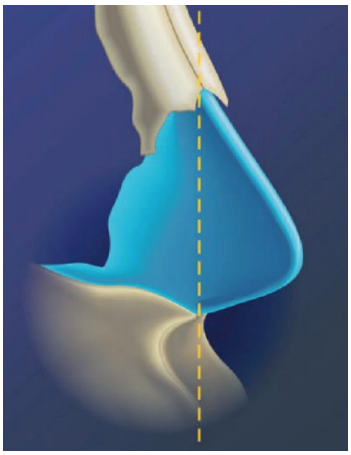


Figure 2b: The septal cartilage right of the dotted line forms the most important supporting component of the septum, determines the contours of the external cartilaginous nose and is important for a patent nasal airway

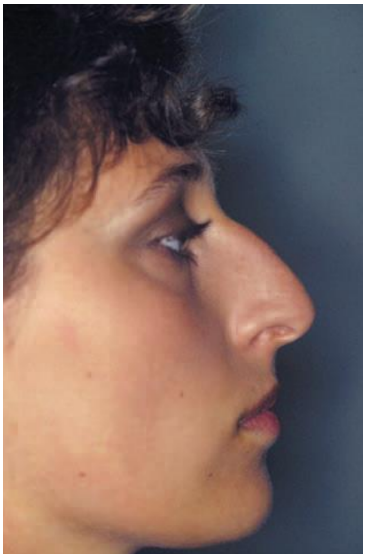


Figure 3a: Strong nasal profile because of a ‘high’ anterior cartilaginous septum

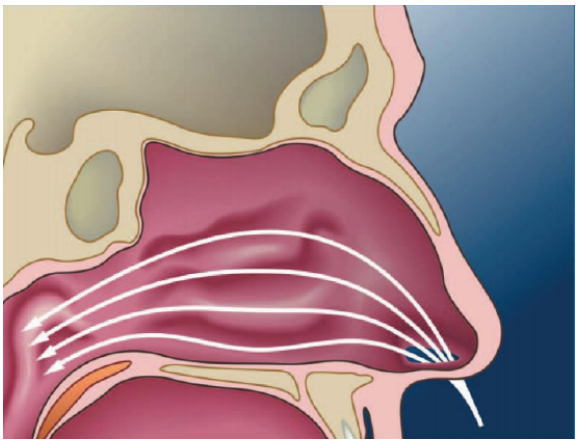


Figure 3b: Cross-section of the nasal cavity to indicate the narrowness of the anterior nose in relation to the posterior nose

The anterior cartilaginous part, consisting of a quadrangular cartilage and two upper lateral cartilages, is a very important supporting structure of the nose (*Figures 2a,b*). A straight and firm cartilaginous septum contributes to the contours of the external cartilaginous nose and an efficient airway (*Figures 3a,b*). This means that anatomic malformations of the cartilaginous septum can cause functional and aesthetic complaints.

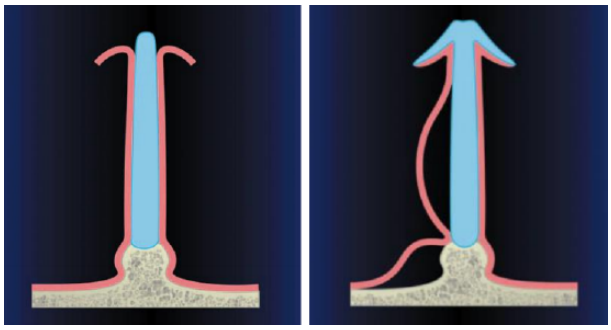
Functional complaints are often the result of cartilaginous septal deviations in the anterior nose. This area is the narrowest part of the nose (*Figure 3b*). Small anatomical abnormalities give immediately rise to nasal airway obstruction.

Aesthetic complaints are seen in 'high' and anterior cartilaginous septal deviations resulting in a twisted cartilaginous nasal dorsum, an asymmetric columella or nasal tip (*Figures 19a and 28a*). A cartilaginous septal defect results in a depression of the nasal dorsum (*Figure 38a*), while an overdeveloped dorsal or caudal part of the septum can result respectively in a cartilaginous dorsal hump, a blunt nasolabial angle or a 'hanging columella' (*Figures 25a, 33a*).

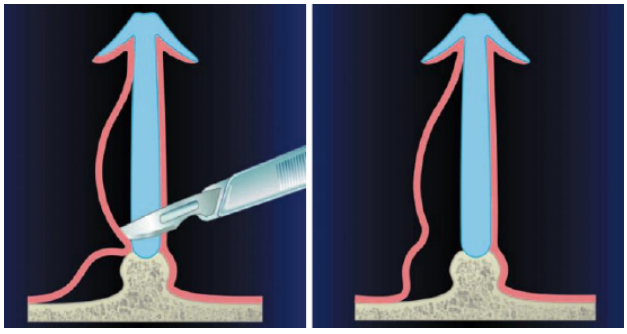
The bony septum has less supporting function than the cartilaginous septum and causes less functional problems as the nose is posteriorly much wider (*Figure 3b*). As a result, the bony septum is easier to handle. Septoplasty frequently is the initial step in rhinoplasty because realignment of the septum as the midline supporting structure of the nose, is essential for successful functional results, nasal tip and bony pyramid surgery.

The standard approach to the septum

As the cartilaginous septum is an important supporting structure, it must be operated on as conservatively as possible. By dissecting as little as possible, most of the mutual connections of this supporting structure can be left intact with the rest of the nasal skeleton. This goal can be achieved in most of the cases by tunneling the anterior septum only on one side, leaving the contralateral mucoperichondrium intact. The tunnel is made on the side where one has space for handling the instruments. If one has to deal with an inferior deviation of the septum, a lower tunnel is also created on the same side in order to visualize that part of the septum that has to be corrected. After dissecting the cross-fibers of the covering connective tissue at the base of the septum, the anterior and lower tunnel become one compartment, which gives a good view of the septum and its underlying premaxilla.



Figures 4a,b: The standard approach to the septum: (a) schematic cross-section of the anterior cartilaginous septum; (b) anterior and lower tunnel



Figures 4c,d: (c) Dissection of the basal cross fibers; (d) Anterior and lower tunnels form one compartment for a better view of the nasal septum and supporting premaxilla

The above mentioned procedure is schematically seen in *Figures 4a-d*. Subsequently the septal tunnel is enlarged in a posterior direction by elevating the mucoperiosteal flap of the bony septum on the same side.

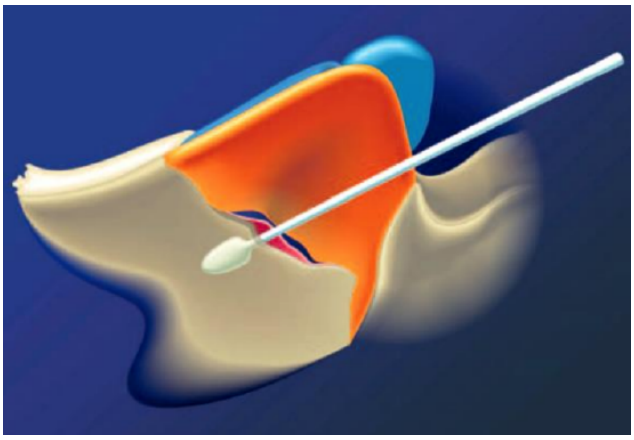


Figure 4e: Posterior chondrotomy with formation of the contralateral posterior septal tunnel along the bony septum. The contralateral anterior mucoperichondrium stays attached to the cartilaginous septum for a better stability



Figure 5a: One-sided septum tunneling

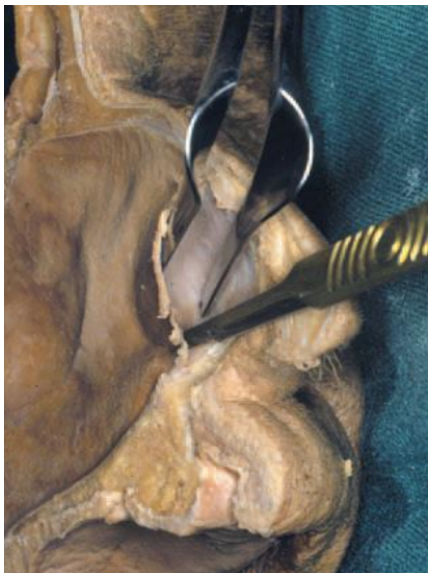


Figure 5b: Dissection of basal cross-fibers

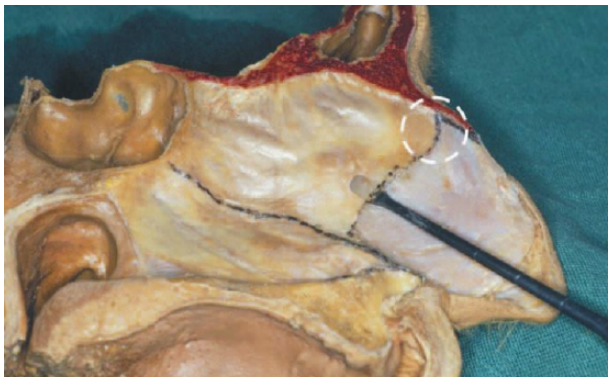


Figure 5c: Posterior chondrotomy; white dotted circle indicates the K(stone) – area

By blunt division of the junction between the cartilaginous and bony septum, the mucoperiosteal flap on the contralateral side of the bony septum can also be elevated (*Figure 4e*). By this standard approach the whole septum can be reached. A cadaver dissection illustrates this procedure in *Figures 5a-c*.

Blunt division of the cartilaginous and bony septum ('posterior chondrotomy') must not be carried out too high because then the cartilaginous septum completely loses the support of the bony septum and pyramid in the important so called 'K(eystone)-area', the highest point of connection between the bony and cartilaginous septum (*Figure 5c*).

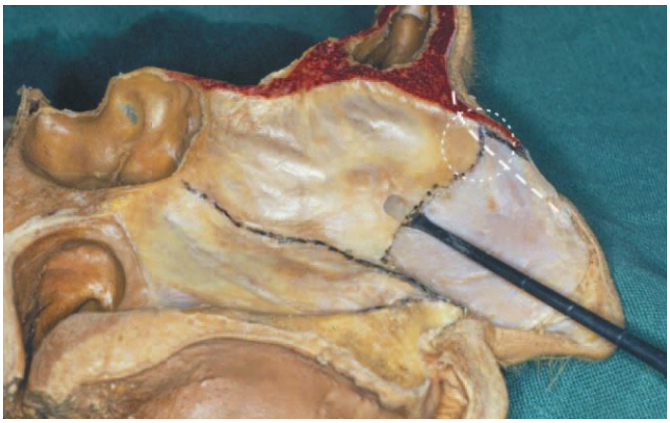


Figure 5d: Relationship between K-area and dorsal hump resection

This is especially the case when hump removal also has to be done, as with this latter procedure the 'K-area' is also weakened and reduced from above (*Figure 5d*).



Figure 5e: Area where normally deviated bony parts of the septum are removed

If the 'K-area' is destroyed it results in a so-called 'saddle nose' (*Figure 38a*). By leaving the mucoperichondrium attached to the septum on one side one creates in this situation more stability for this supporting structure. After luxating the cartilaginous septum to one side, bony septal deviations can be removed with a biting forceps, leaving the anterosuperior bony septum intact in order to preserve the 'K-area'. *Figure 5e* shows this.

The rest of the bony septum does not have an important supportive function. If necessary, crushed pieces of septal bone can be put back at the end of the operation, preventing mucosal atrophy in the long run.

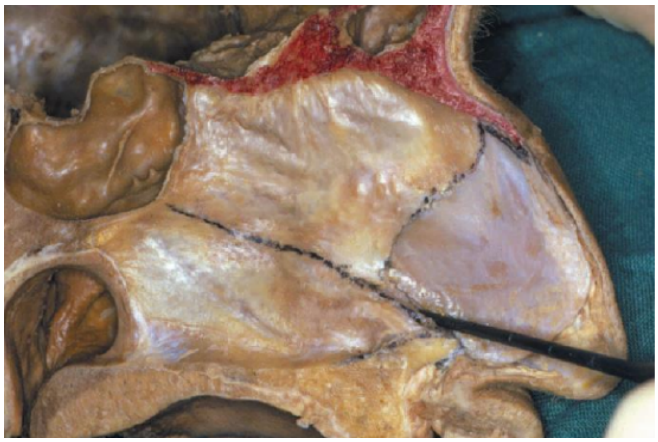


Figure 5f: Luxation of the caudal border of the cartilaginous septum to the one-sided tunnel

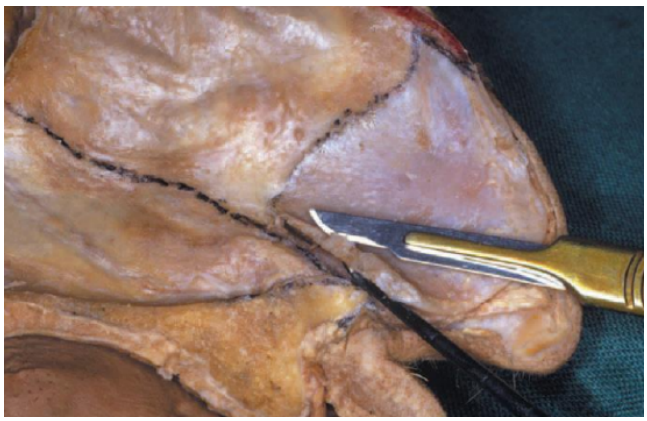


Figure 5g: Resection of a basal strip in cases of a too high and/or luxated septum

Before or after this correction of the bony septum, the cartilaginous septum can be realigned from the one-sided anterior tunnel in about 90% of cases. Resect as conservatively as possible and reconstruct the cartilage in the midline in order to preserve its supportive function (*Figures 5f,g*).

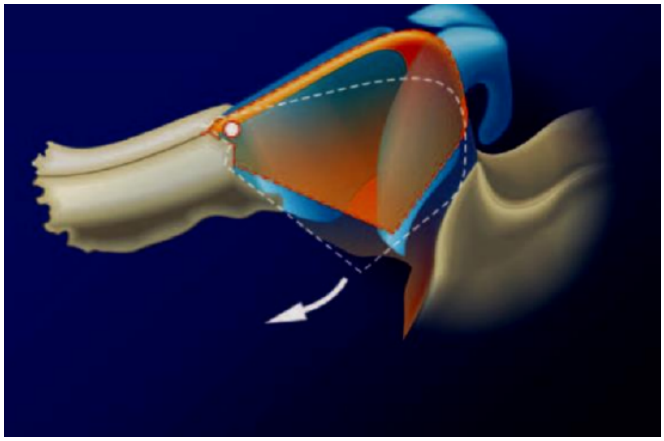


Figure 6a: Schematic illustration of deprojection of the nose as a result of loss of septum support. This can happen after tunneling the septum on both sides, resection of anterior parts of the bony septum and caudal parts of the cartilaginous septum



Figures 6b,c: Patient before septum surgery and postoperative view of the same patient with deprojection of nose as result of loss of septum support after septum surgery

Tunneling on both sides with resection of bony and cartilaginous parts of the septum creates the risk that the septum falls into the nose, pivoting around the 'K-area' (*Figure 6a*). This results in a less supporting function of the septum and consequently deprojection of the nasal tip (*Figures 6b,c*).



Figure 7a: Hemitransfixion incision line



Figure 7b: Anterior septum tunnel

However, one could use this phenomenon in certain cases on purpose as a procedure to deproject the nose. In general, a long hemitransfixion is made (*Figure 7a*). In the subperichondrial plane an anterior tunnel is made on the same side (*Figure 7b*). Spreading the mucoperichondrial flap of the anterior tunnel from the septum with a nasal speculum gives a good view of the cartilaginous septum.



Figure 7c: Exposure of caudal septum and premaxilla region using a small hook



Figure 7d: Dissection of the covering basal connective tissue



Figure 7e: Exposure of anterior and lower tunnel as one compartment

However, by subsequently pulling down the inferior corner of the long hemitransfixion incision with a small hook one creates in practice a much better exposure of the septum (*Figure 7a*), particularly when the cross-fibers of the connective tissue between the anterior and bottom tunnel are also dissected with a knife under clear and direct vision (*Figures 7d,e*).

Functional corrections of the septum

Convex deviated high anterior septum

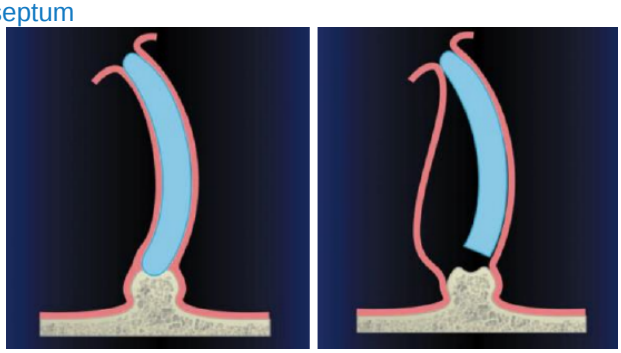


Figure 8a: Convex deviated too high cartilaginous septum; b: Anterior septum tunnel with resection of a basal strip of the too high anterior cartilaginous septum

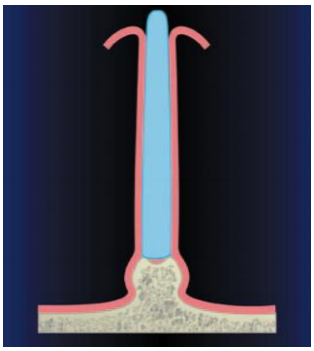
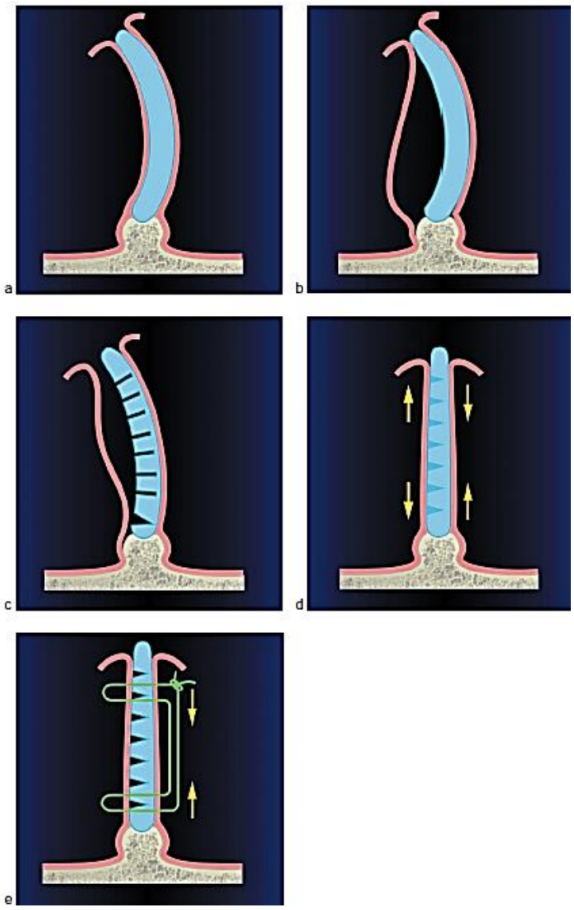


Figure 8c: Spontaneous straightening of the cartilaginous septum after resection of the basal strip

In this case the too high septum is still in place on the maxillary crest. After creating an anterior septal tunnel with a blunt elevator on the concave side, the firm basal attachments of the mucosa to the caudal septum and maxillary crest are dissected with a knife. After freeing the caudal edge of the cartilaginous septum and the maxillary crest from their overlying mucosa, the two structures are separated bluntly from each other so that a caudal sliver can be resected from the oversized cartilaginous septum. The mucoperichondrium on the contralateral side of the septum is left in place. Care must be taken not to resect too much in order to preserve the supporting function of the septum (*Figures 5f,g* and *8a,b,c*).

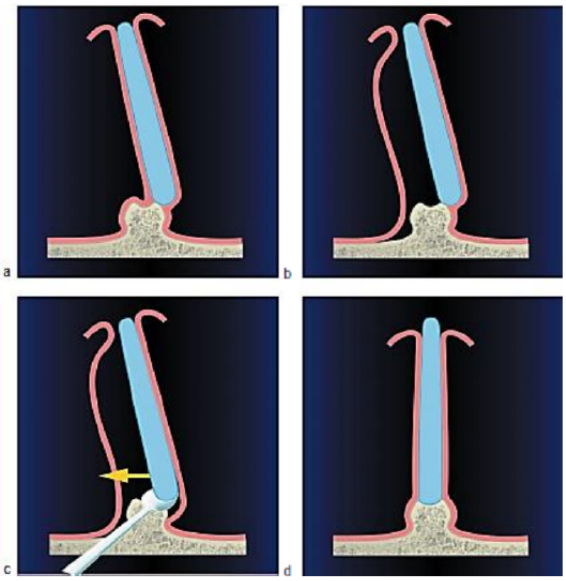


Figures 9a: Curved anterior cartilaginous septum; b: Anterior septum tunnel without spontaneous straightening of septum; c: Scoring of the concave side of septum; d: Straightening of septum as a result of (1) broken interlocked stress in cartilage, and (2) elasticity of contralateral mucoperichondrium

The cartilaginous septum can now be realigned with the midline, stabilized by the attached contralateral mucoperichondrium. There are situations where the septum will hold its curved position (*Figures 9a,b*). In such cases one can straighten the cartilage by scoring on the concave side, breaking the interlocked stress of the cartilage. Simultaneously the elasticity of the contralateral mucoperichondrium helps to realign the septum (*Figures 9c,d*).

The attached mucoperichondrium on the convex side gives stability to the scored cartilaginous pieces, even if the cartilage has been cut through completely. This situation can be further strengthened by a 4x0 Vicryl through-and-through suture, situated above and beneath the deflection, whilst being knotted on the convex side (*Figure 9e*).

Luxated anterior septum



Figures 10a: Luxated anterior cartilaginous septum; b: Anterior and lower tunnel; c: Freeing and lifting of the anterior septum from the maxillary crest; d: Repositioned septum in the midline

In this scenario the septum stands beside the maxillary crest (*Figure 10a*). Consequently the anterior septal tunnel is for handling best when made on the contralateral side. Through the junction between the cartilaginous septum and the maxillary crest, the nasal floor on the other side of the nose can be reached by lifting the luxated septum (*Figures 5f* and *10b,c*). With this maneuver, the luxated septum is freed on the caudal side. After elevating the mucoperiosteum from a part of the contralateral nasal floor, the luxated septum can be pulled back and repositioned in the midline on the maxillary crest (*Figure 10d*).

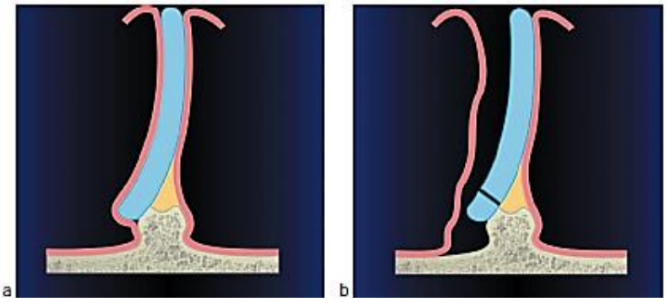


Figure 11a: Luxated too high anterior cartilaginous septum; b: Anterior and lower tunnel

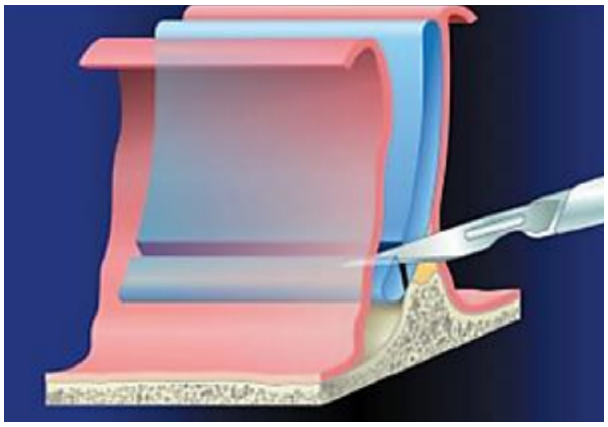


Figure 11c: Dissection of basal strip of septum

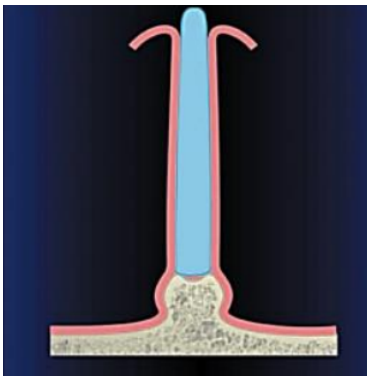


Figure 11d: Realignment of septum

In cases of an oversized luxated cartilaginous septum, the caudal border can be reduced in the same way as the previously mentioned resecting procedure, leaving the mucosa as a stabilizing factor on the contralateral side intact (*Figures 11a-d*).

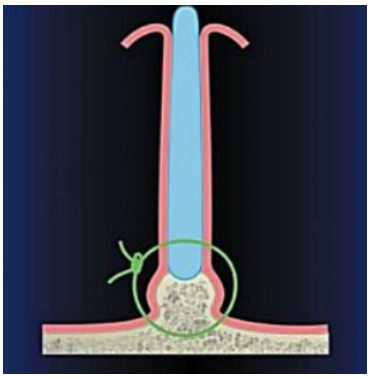


Figure 12: Stabilization of the cartilaginous septum by suturing the basal septum to the nasal spine

The septum can be secured in the midline with a suture around the anterior nasal spine as illustrated in *Figure 12*.

Septal ridge and spur

Most of the time, a septal ridge is situated along the border of the cartilaginous septum and vomer. A ridge often tapers to a spur or spine. This malformation can best be reached and corrected from the contralateral side like in the luxated septum. After resecting the deviated part of the cartilaginous septum, the bony part of the ridge and spur are freed from the mucosa on the contralateral side, according to the standard approach, and taken out with a biting forceps or fractured into the midline.

Fracture lines of the septum

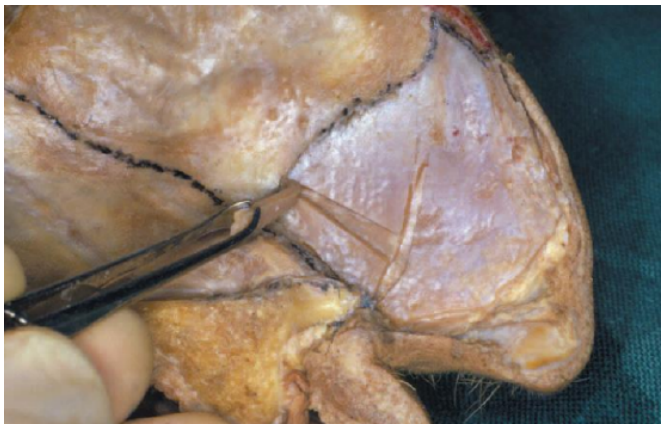


Figure 13: Resection of surplus cartilage in a vertical and horizontal fracture line

Fracture lines in the cartilaginous septum can run horizontally or vertically. In most cases the surplus or overlap of cartilage around the fracture lines must be resected to realize realignment of the septum. This procedure is shown in a cadaver dissection in *Figure 13*.

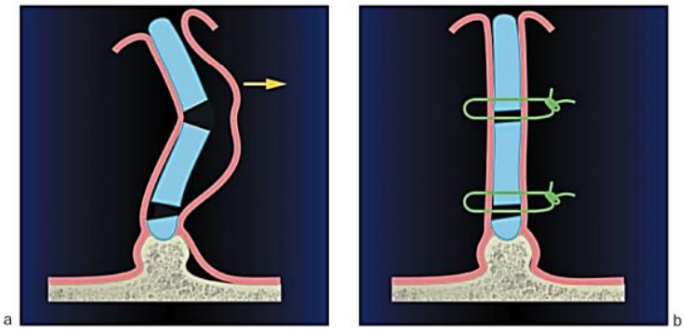
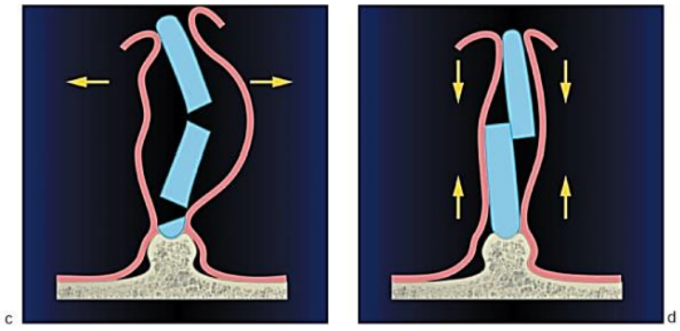


Figure 14a: Resection of fracture lines through a left-sided septum tunnel. Stabilization of the fracture pieces by means of the connected contralateral mucoperichondrium; b: Realignment of the septum and fixation with through-and-through sutures



Figures 14c,d: Destabilization of fractured cartilaginous septum after tunneling on both sides

The resection is best executed by using a hooked knife through a one-sided anterior septal tunnel, leaving the opposite mucosa intact to serve as a stabilizing structure (*Figure 14a*). The new situation can be further fixed by putting mattress sutures through the area of excision and the fractured pieces of the cartilaginous septum (*Figure 14b*). In this situation the overlying contralateral mucosa is of great help in realigning this anterior septum and prevents overlap of the fractured pieces. An indication of what could occur after tunneling on both sides is shown in *Figures 14c,d*.

High septal deviations

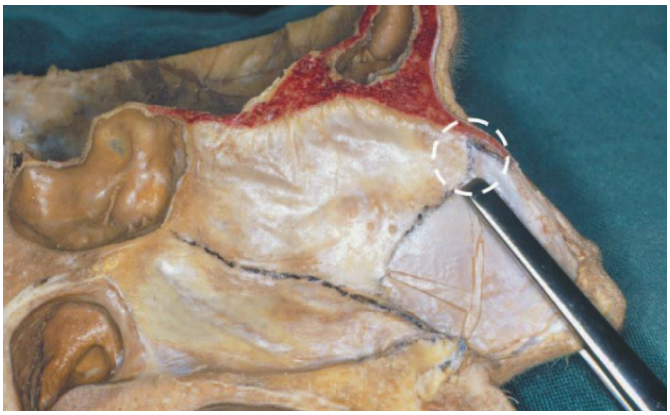


Figure 15a: Crushing of high septal deviation in the K-area

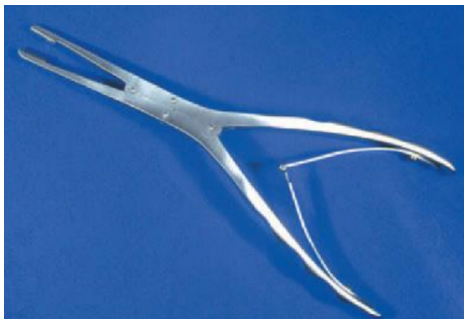


Figure 15b: Cartilage crusher

Very high cartilaginous septal deviations are difficult to correct when they belong to the important supporting K-stone area of the septum (*Figure 5c*). Resection of these malformations bear the risk of destroying this supporting area. A high deviation of the septum can be carefully realigned with a cartilage crusher (*Figures 15a,b*). Crushing weakens and straightens the cartilage in this area but leaves its supporting function intact.

Anterior septal defect

An anterior cartilaginous septal defect caused by trauma or previous surgery, results in loss of support of the cartilaginous nose. This results in functional and also cosmetic complaints. The septum has to be reconstructed with a columellar strut.



Figure 16: Creating a columella pocket with curved scissors

Via a relatively posterior performed hemitransfixion incision a pocket is created in the membranous part of the septum and the columella, between the medial crura of the alar cartilages (*Figure 16*). Be sure to cut all the bridges of scar tissue in this pocket in order to be able to introduce the new columellar strut properly.

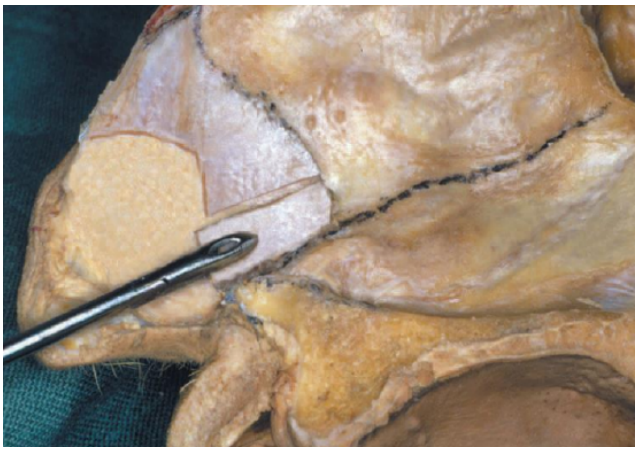


Figure 17a: Harvesting cartilage from posterior cartilaginous septum

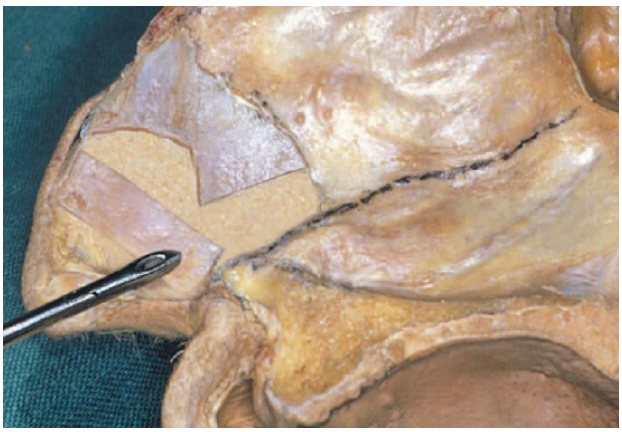


Figure 17b: Reconstruction of anterior cartilaginous septum with columellar strut

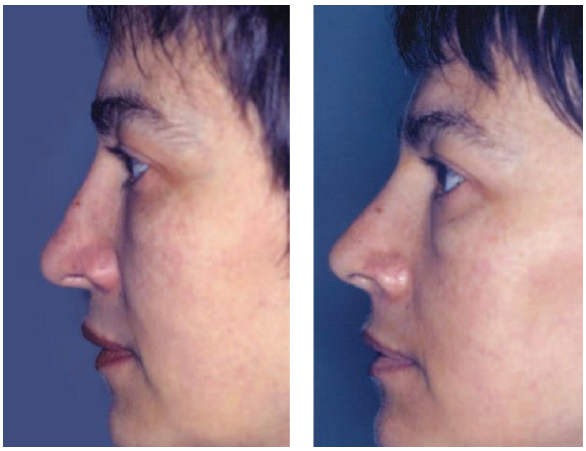


Figure 18a: Preoperative view of a patient with loss of support of the septum as a result of an anterior cartilaginous septal defect; b: Postoperative view of the same patient after reconstruction of the septum, as illustrated in Figures 17a,b

This strut is made of posterior septal or ear cartilage, placed on the anterior nasal spine and fixed with mattress-sutures upon introduction in the columellar pocket (*Figures 17a,b*). The new support of the strut opens the anterior nose in the valve area. *Figures 18a,b* show the effect of this manoeuvre on the appearance of the external nose.

Aesthetic corrections of the septum

In rhinoplasty, cosmetic goals can regularly be achieved by corrections of the nasal septum. By looking in greater detail at the septum, one can analyze which part has to be corrected in order to reach a certain aesthetic goal. Some of these situations are described below.

The twisted cartilaginous nasal dorsum

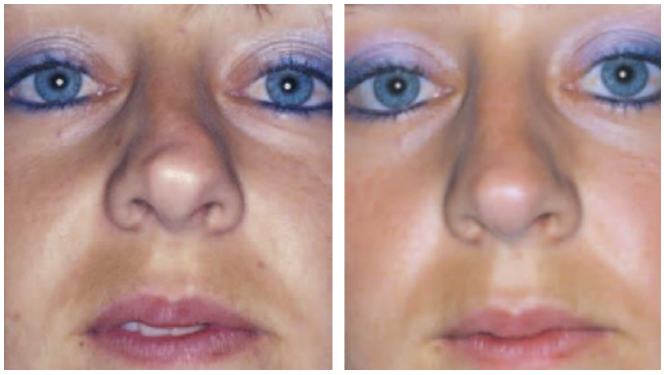


Figure 19: Twisted cartilaginous dorsum as a result of high cartilaginous septal deviation and postoperative view after correction of septum and upper laterals

A high deviation of the cartilaginous nasal septum can result in a twisted cartilaginous nasal dorsum on the outside (*Figure 19*).

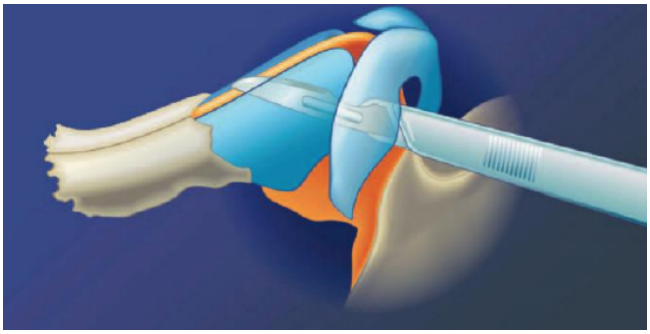


Figure 20a: Separation of the right upper lateral cartilage from the septum, directly through the nasal cavity

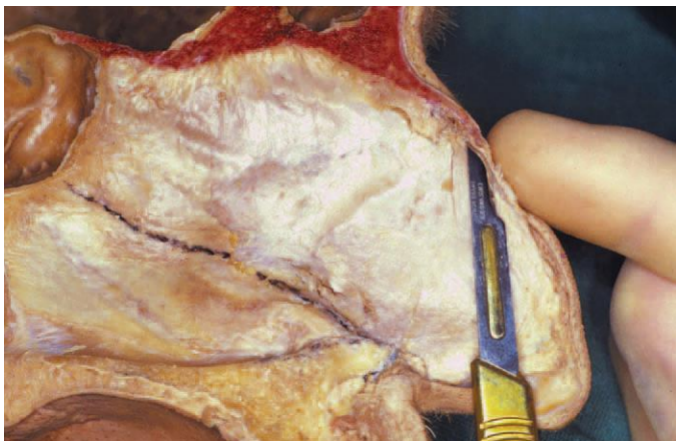


Figure 20b: Palpating with a finger on the dorsum of the nose to feel the knife coming through the upper lateral cartilage underneath the nasal skin

In these circumstances the upper lateral cartilages are often asymmetric. Besides a routine septal correction, realignment of the dorsal side of the septum can best be acquired after separating one (on the convex side of the septum) or both of the upper lateral cartilages from the nasal septum. This can carefully be done through the nasal cavity and cranial nasal mucosa with a knife (*Figure 20a*). The nasal dorsum is palpated at the same time with a forefinger, feeling the knife coming through the cartilage underneath the nasal skin (*Figure 20b*).

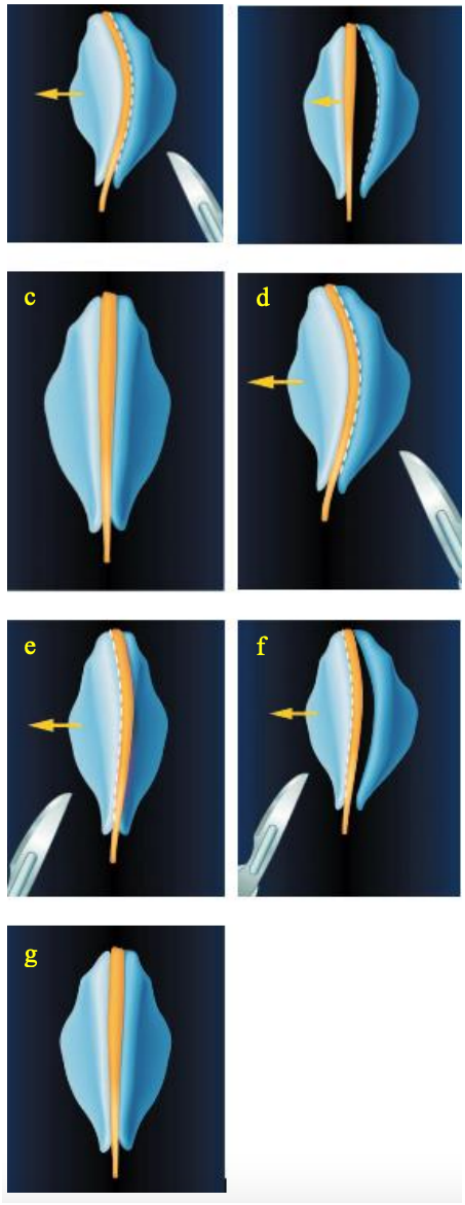
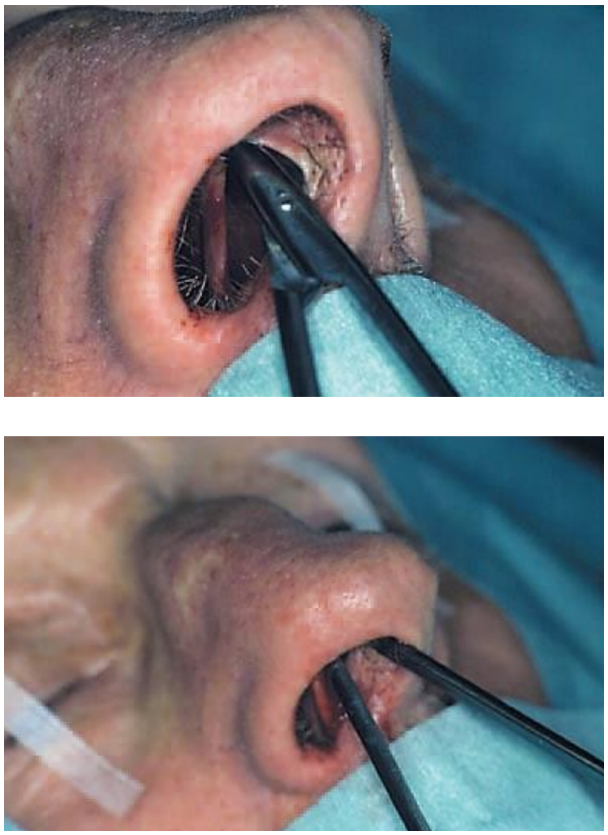


Figure 21a: Twisted dorsal septum and asymmetric upper laterals; b,c: Realignment of the septum after separating the left upper lateral from the septum; d-g: Sometimes both upper laterals have to be separated to realign the dorsal septum

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Figures 22a,b: Undermining of the dorsal nasal skin through the hemitransfixion incision in order to straighten the dorsal septum

The upper laterals realign automatically along the straightened septum. Suturing is not necessary. The effect of this procedure is outlined in *Figures 21a-g*. If necessary, the skin of the nasal dorsum can be elevated through a hemitransfixion incision (with scissors over the anterior septal angle) in order to free the dorsal side of the septum from its restrictive attachments to the skin (*Figures 22a, b*).

These manoeuvres help to straighten the cartilaginous dorsum of the nose, as can be seen in *Figure 19b*. An alternative is introducing spreader grafts between the septum and the upper laterals by means of an open approach.

Nasal tip rotation



Figure 23a: Patient with prominent anterior septal angle and adjacent caudal edge of cartilaginous septum (and hump); b: Postoperative view after resecting anterior septal angle (and hump). Notice upward rotation of the nasal tip by this procedure

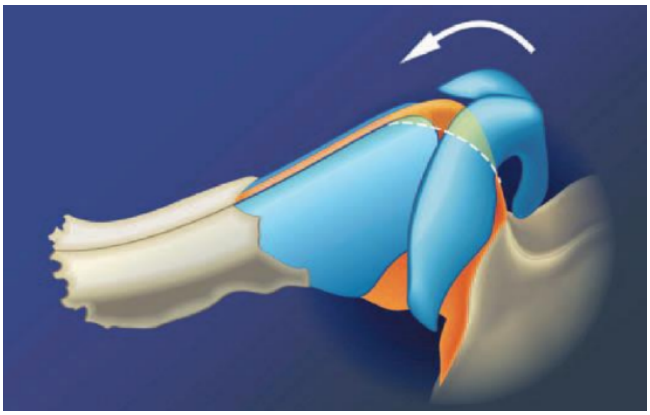


Figure 24a: Area of anterior septal angle resection. This resection results in an upward rotation of the nasal tip

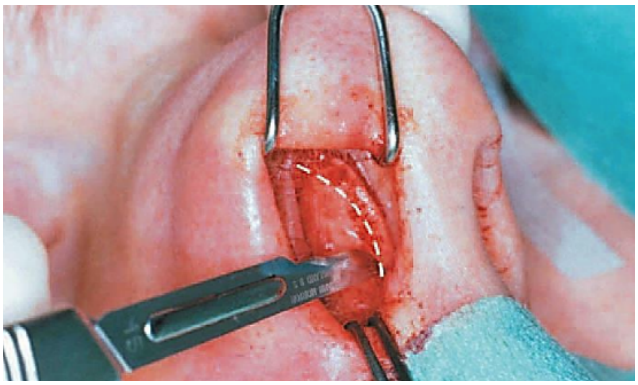


Figure 24b: Resection of anterior septal angle. The overlying mucosa is resected in the same amount as the cartilage

In case of downward rotation of the nasal tip, this is frequently the result of a too prominent anterior septal angle and adjacent caudal edge of the cartilaginous septum (*Figure 23a*). Palpating with thumb and forefinger helps to diagnose this variation of septal anatomy. It can be corrected by merely resecting cartilage and overlying mucosa of the anterior septal angle and the adjacent caudal edge (*Figures 24a,b*). After this simple procedure the nasal tip automatically rotates upwards as a result of the elasticity of the dorsal skin (*Figure 23b*). Then the defect is closed primarily with resorbable sutures.

Correction of the nasolabial angle



Figure 25a: Preoperative view of patient with blunt nasolabial angle as a result of a too prominent caudal border of the septum and nasal spine; b: Postoperative view after resection of caudal border of septum and nasal spine, as well as frontal angle reconstruction

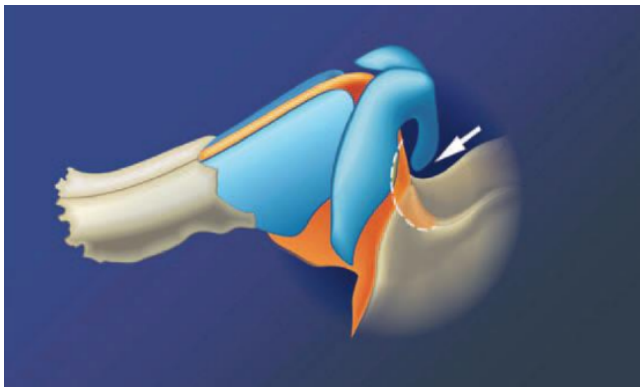


Figure 26a: Area of septum and nasal spine resection for correction of blunt nasolabial angle

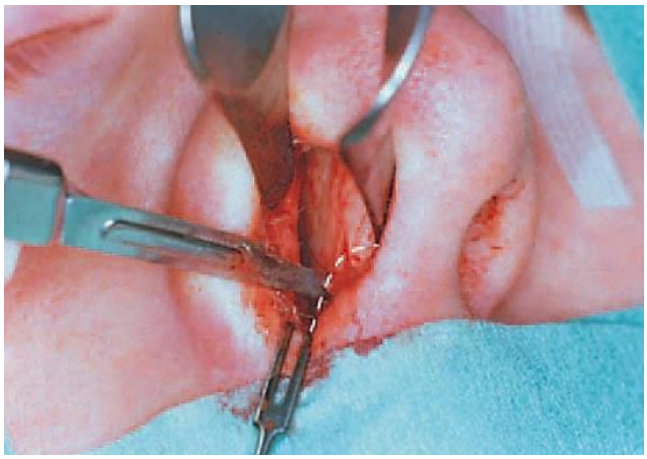


Figure 26b: Resection of septum, as illustrated in Figure 26a, during surgery. The overlying mucosa is resected in the same amount as the cartilage

A prominent caudal border of the septum near the nasal spine often forms a blunt nasolabial angle (*Figure 25a*). As above, palpation helps to discover the underlying anatomy. By resecting this part of the caudal border with the overlying mucosa, in combination with a nasal spine reduction (if necessary), the nasolabial angle can be reduced (*Figures 26a,b*). *Figure 25b* shows the result of this procedure.

Overdeveloped ‘hanging’ columella

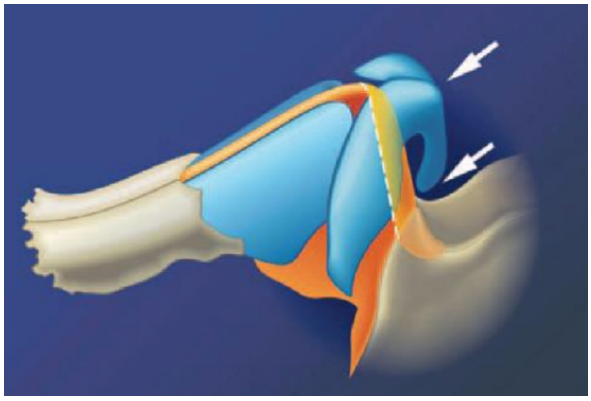


Figure 27a: Resection of the total caudal edge of the septum in case of an overdeveloped ‘hanging’ columella

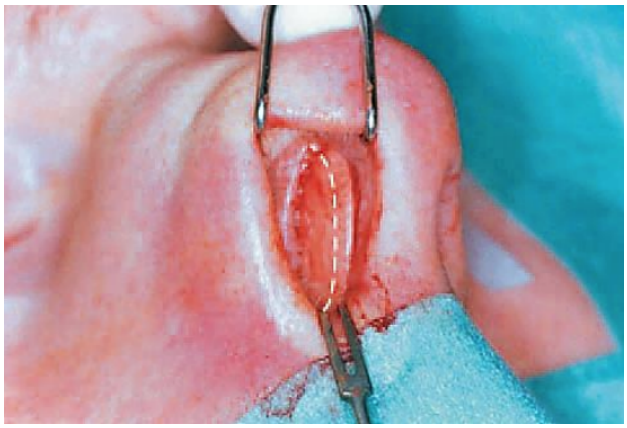


Figure 27b: The same situation as in Figure 27a during surgery. The overlying mucosa is resected in the same amount as the cartilage

In this situation (sometimes in combination with large medial crura of the alar cartilages) the whole caudal septal edge is often too prominent. This malformation can be corrected by means of a complete transfixion incision. This way, the whole caudal edge of the cartilaginous septum can be trimmed together with the overlying mucoperichondrium (*Figures 27a,b*). By suturing the defect primarily, the too prominent columella can retract in the desired position.

Deviation of caudal edge of septum

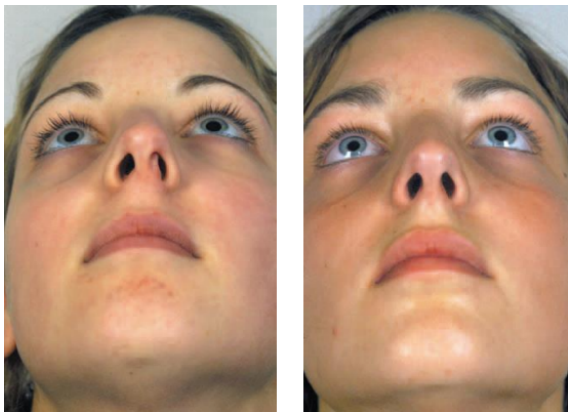


Figure 28a: Preoperative view of a patient with a deviation of the caudal edge of the cartilaginous septum. Notice the partly obstructed left nostril; b: Postoperative view of the same patient after correction of the caudal septum

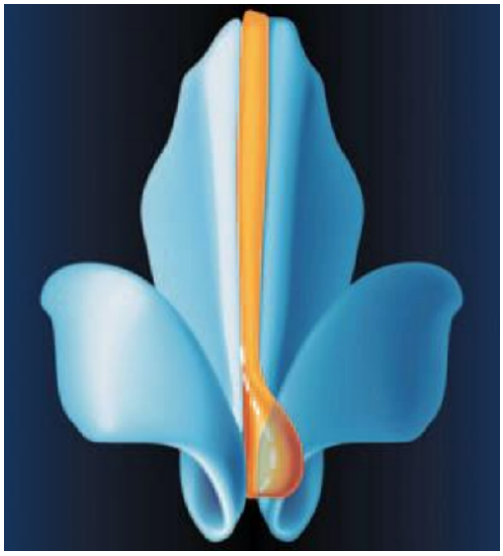


Figure 29: Area of resection or scoring of the septum in case of a caudal septal deviation, as illustrated in Figures 28a, b.

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When a deviation of the caudal edge of the septum is present, the result is a distorted columella and occasionally an obstructed nostril on the deviated side (*Figure 28a*). If the caudal septum is too long, the deviated rim is simply resected with its overlying mucosa (*Figure 29*). Having a normal length, the septal cartilage will have to be scored on the concave side in order to reposition it in the midline, after creating a columellar pocket (*Figure 28b*). See The anterior septal defect for creating a columellar pocket (*Figure 16*).



Figure 30a: Preoperative view of patient with a nasal tip asymmetry as a result of severe deviation of anterior cartilaginous septum. b: Postoperative view after reconstruction of the septum. No nasal tip surgery was performed

In an exceptional situation even the nasal tip can be asymmetric as a result of a strong deviation of the caudal septum. In these circumstances the whole cartilaginous septum is freed from overlying mucosa on both sides, resected, reconstructed and put back, fixing it with mattress sutures, in order to prevent columellar retraction (*Figures 30a,b*).

Deviation of the nasal base



Figure 31a: Patient with deviated caudal septum and an asymmetric nasal base; b: Patient after septal correction and undermining of the nasal base or ‘magic plane’ (see Figures 32a, b)





Figure 32a: Introduction of scissors into the nasal base or ‘magic plane’ via the caudal part of the hemitransfixion; b: The dotted line indicates the ‘magic plane’. This is the area that must be undermined during a septum correction, to realign an asymmetric nasal base

When the septum is strongly deviated and luxated at its caudal edge, complete realignment of the septum is not always possible. This because the whole nasal base is occasionally asymmetric (*Figure 31a*). In these circumstances the area between the skin of the nasal base (and part of the upper lip) and the musculus orbicularis oris must be undermined to completely straighten the septum and the base of the nose. Undermining of this so-called ‘magic plain’ is easily realized by spreading the tissue bluntly with slightly curved scissors through the hemitransfixion incision (*Figures 32a,b*). The result of this maneuver is illustrated in *Figure 31b*.

Cartilaginous nasal hump



Figure 33a: Preoperative view of patient with bony and cartilaginous hump. The cartilaginous part of the hump comprises of septum cartilage; b: Postoperative polly beak (yellow arrow) after hump removal. This is the result of too little dorsal cartilaginous septum reduction

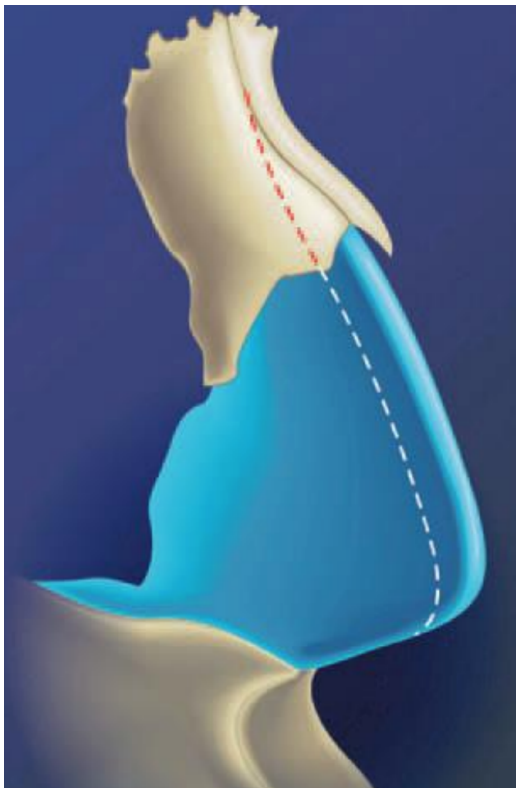


Figure 34: The dotted line indicates the correct area of dorsal (cartilaginous septum) reduction that should have been done in the patient of Figure 33a. Notice that also the anterior septal angle must be resected

A cartilaginous nasal hump is the result of an overdeveloped cartilaginous dorsal septum (*Figure 33a*). To correct this situation the dorsal side of the quadrangular cartilage must be resected (*Figure 34*). This in itself is a correction of the septum. It is difficult to judge the precise amount and place of reduction. Frequently also the anterior septal angle must be trimmed to prevent a so-called 'polly beak' (*Figure 33b*).



Figure 35: Resection of the anterior septal angle in case of a cartilaginous hump removal during surgery. Precise judgement of cartilage resection is essential for a good result of hump removal



Figure 36a: Preoperative view of a patient with a bony cartilaginous dorsal hump (‘tension nose’); b: Postoperative view of the same patient of Figure 36a after correct resection of the hump (with the anterior septal angle). Note the indirect change of the ala, the nostril and the nasal tip (reduction) as a result of this maneuver

In an endonasal procedure the best approach to reach this goal is a transfixion incision in combination with an intercartilaginous incision on both sides. After freeing the anterior septal angle and cartilaginous dorsum the exact amount of dorsal cartilage that has to be reduced can be estimated (*Figure 35*). This is essential for a good aesthetic result of the nasal profile (*Figures 36a,b*).

Cartilaginous nasal dorsal defect, ‘the saddle nose’



Figure 37a: Patient with a small defect of the dorsum of the cartilaginous septum. Preoperative view; b: Postoperative view of the same patient after filling the defect with the patient’s own cartilage



Figure 38: Patient with a severe ‘saddle nose’ after over-resection of septal cartilage during surgery (left); Postoperative view after septum reconstruction with patient’s own ear cartilage. Note also that otoplasty on both sides has been done

Small defects of the cartilaginous dorsum can be reconstructed with small layers of patients’ own cartilage in the defect of the dorsum (*Figures 37a,b*). Through an endonasal incision the graft is introduced in the area of the defect into a small pocket, to prevent displacement of the graft on the dorsum. In case of a collapse of the cartilaginous nasal dorsum (*Figure 38*), the total septum must be reconstructed. For this correction, an external approach is often indicated.

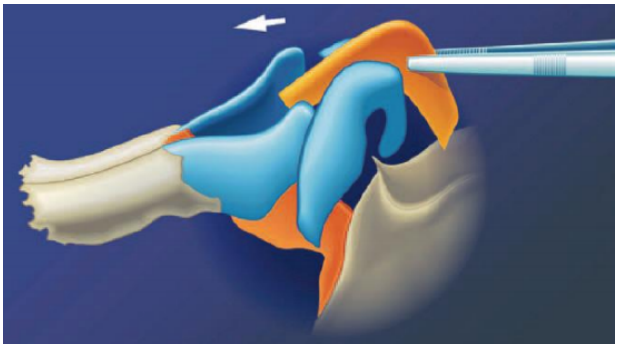


Figure 39a: Schematic reconstruction of anterior cartilaginous septum with cartilage transplant

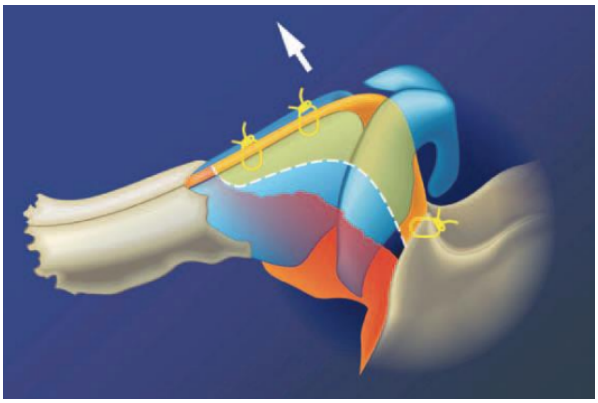


Figure 39b: Fixed cartilage transplant; note the change of the dorsal profile of the nose

The procedure is schematically seen in *Figures 39a,b*. Posterior septal cartilage, bony septum, ear- or rib-cartilage are the materials one can choose from. Reconstruction gives a strong aesthetic change of the nose and face as a whole. *Figure 38* shows the result of this procedure in a patient's nose that has been reconstructed with cartilage taken from his protruding ears. In the same operation an otoplasty has been performed on both sides.

Postoperative management

If necessary, after one of these procedures the anterior cartilaginous septum can be sutured to the nasal spine (*Figure 12*) to accomplish secure realignment of the anterior septum. Optionally, the elevated mucoperichondrial flap can be reattached to the septum by through-and-through sutures in the cartilaginous septum. This prevents septal hematoma and creates stability. Nasal tampons can stay in situ for 24-48 hours. Routine antibiotic treatment is not necessary.

The material in this chapter originates from the textbook "**Rhinoplasty: A practical guide to functional and aesthetic surgery of the nose**" G.J. Nolst Trenité (ed) ISBN 978-90-6299-206-5 https://www.rhinoplasty.nl/store/

Author

FWA Otten MD, PhD
Department of Otorhinolaryngology, Diaconessenhuis
Houtlaan 55
2334 CK
Leiden, Netherlands

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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CALDWELL-LUC (RADICAL ANTROSTOMY), INFERIOR MEATAL ANTROSTOMY & CANINE FOSSA AND INFERIOR MEATUS PUNCTURES

Johan Fagan

The ***Caldwell-Luc operation*** involves creating an opening into the maxillary antrum through the canine fossa via a sublabial approach.

Canine fossa (CFP) & inferior meatal puncture are used to obtain samples of pus from the antrum, to irrigate the antrum ("antral washout"), or as an adjunct to endoscopic ethmoidectomy.

Surgical anatomy

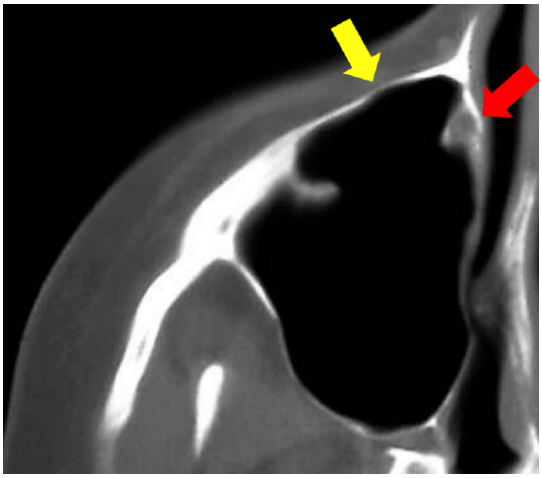


Figure 1: Thin bone of canine fossa (yellow arrow); nasolacrimal duct (red arrow)

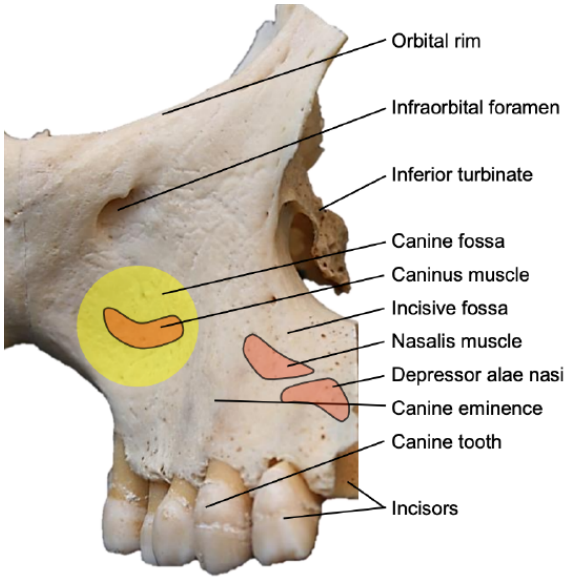


Figure 2: Right canine fossa (yellow), incisive fossa and canine eminence

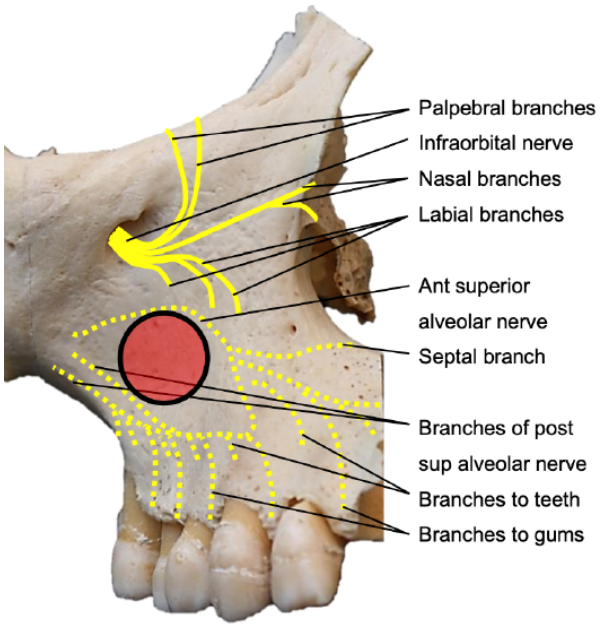


Figure 3: Infraorbital nerve and branches of the anterior superior alveolar and posterior superior alveolar nerves; antrostomy in canine fossa (red circle); stippled lines indicate nerves within the bone

The Caldwell-Luc operation involves entering the maxillary sinus via an opening in the thin bone of the ***canine fossa*** (*Figures 1-3*).

A ***series of eminences*** overlie the roots of the teeth on the inferior part of the face of the maxilla (*Figures 2, 3*). Just above the eminences of the incisor teeth is a depression called the ***incisive fossa***; it gives origin to the depressor alae nasi. The nasalis muscle arises just lateral to it (*Figure 2*).

The ***canine fossa*** is a depression on the anterior surface of the maxilla below the infraorbital foramen and lateral to the ***canine eminence*** and the ***incisive fossa*** (*Figures 2, 3*). It is larger and deeper than the incisive fossa, and is separated from it by the ***canine eminence***, a vertical mound overlying the socket of the canine tooth. The caninus muscle arises from the canine fossa.

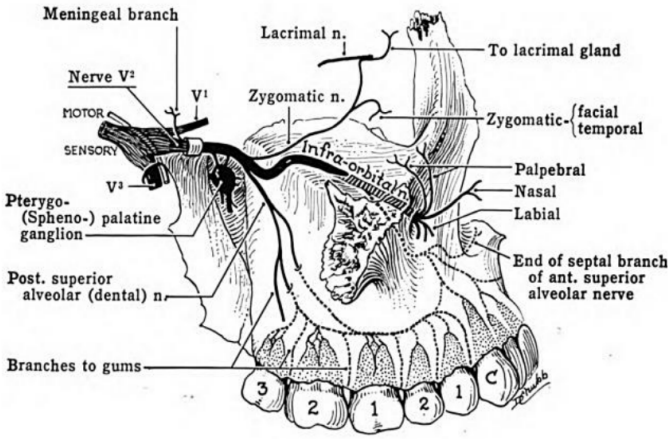


Figure 4: Branches of V2 (An Atlas of Anatomy, by regions; 1962: Grant)

The ***infraorbital foramen*** transmits the ***infraorbital nerve***, artery, and vein. The infraorbital neurovascular bundle traverses a groove in the orbital floor/roof of the sinus which can be dehiscent. It exits through the infraorbital foramen, located approximately 5 mm below the midportion of the inferior orbital rim to enter the soft tissues of the cheek. Branches of the nerve supply the lower eyelid, nose, cheek and upper lip (*Figures 3, 4*). Care must be taken when elevating the periosteum from the anterior wall of the sinus to avoid injury to the infraorbital nerve where it exits the canal. Branches of the ***anterior and posterior superior alveolar nerves*** travel through bone to supply the upper teeth and gums (*Figures 3, 4*). These nerves may be injured when extending the antrostomy too low and cause loss of sensation to the teeth and gums.

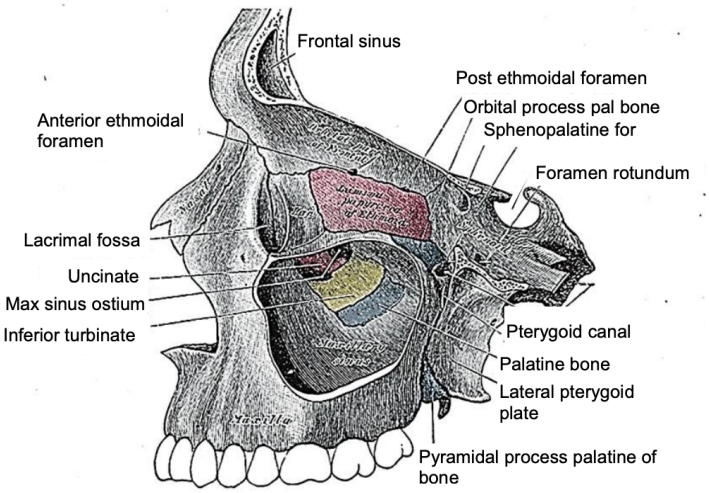


Figure 5: Lateral view with windows cut in lateral and medial walls of maxillary sinus

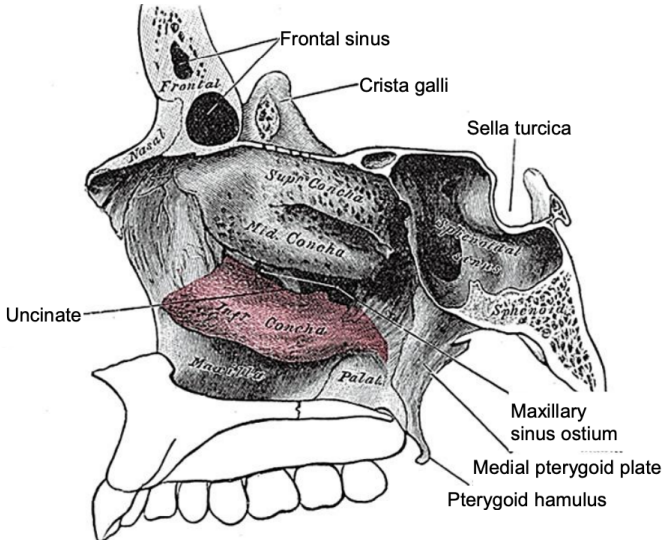


Figure 6: Bony anatomy of the lateral wall of the nose

The ***maxillary sinus*** is lined by ***ciliated columnar epithelium***. The cilia move secretions toward the natural sinus ostium; this explains the limited efficacy of an inferior meatal antrostomy. The adult maxillary sinus is 25-35 mm wide, 36-45 mm high, and 38-45 mm long, and has an average volume of 15 mL. The ***superior wall*** is formed by the orbital floor which is thin and often dehiscent. The infraorbital nerve is in the roof of the sinus. Medially and posteriorly the roof is composed of the floor of the ethmoid sinuses (*Figure 10*). The ***anterior wall*** contains the nerves and vessels that supply the upper teeth. It is thinner anteriorly and thickens posterolaterally where it joins the zygomatic process (*Figure 1*). Septae are present in about a third of cases, mainly anteriorly (*Figure 1*). The ***medial wall*** of the maxillary sinus separates it from the nasal cavity (*Figures 5, 6*).

The inferior turbinate is attached along the nasal wall below the level of the maxillary sinus ostium (*Figure 6*). The nasolacrimal duct traverses the thicker bone at the junction of the medial and anterior walls before opening into the nose below the inferior turbinate (*Figures 1, 12*). The sinus communicates with the nasal cavity via the maxillary sinus ostium in the hiatus semilunaris of the middle meatus (*Figures 8, 9*). The ***posterior wall*** is the infratemporal surface of the maxilla and separates the sinus from the pterygomaxillary fissure and the pterygopalatine fossa which contains the internal maxillary artery and its branches and the pterygopalatine ganglion and its branches (*Figure 4*).

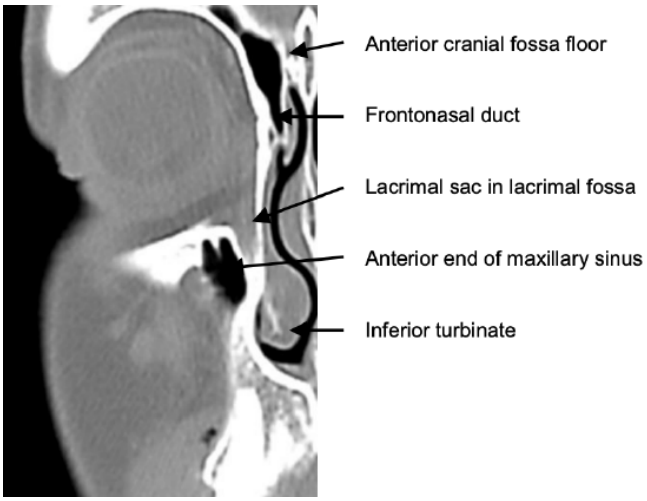


Figure 7: Coronal CT slice through lacrimal fossa

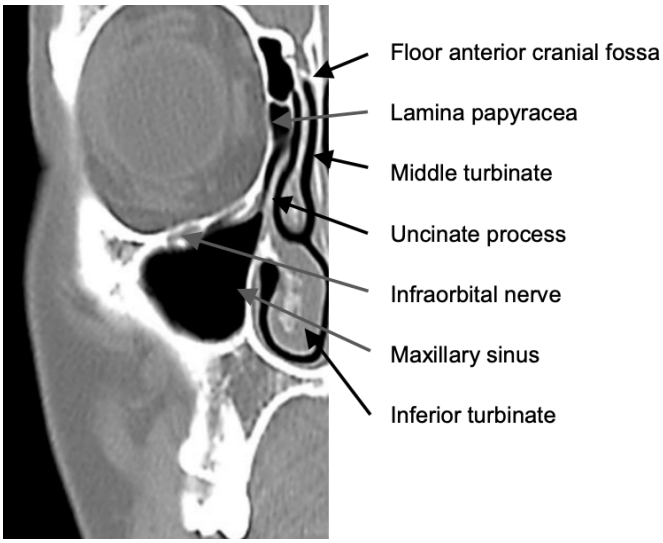


Figure 8: Coronal plane through anterior ethmoids midway along the maxillary sinus

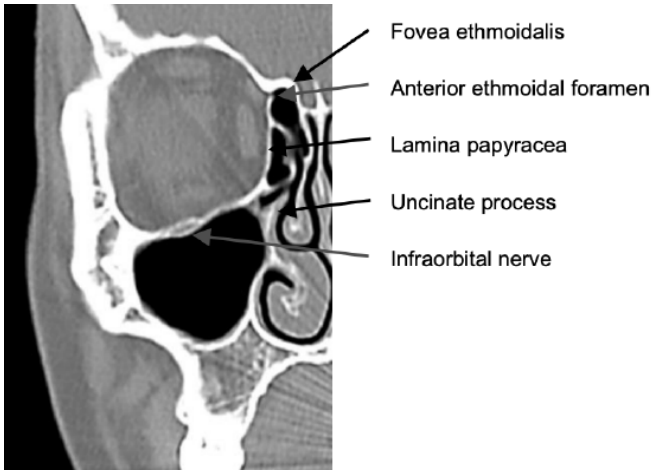


Figure 9: Anatomy at uncinate process

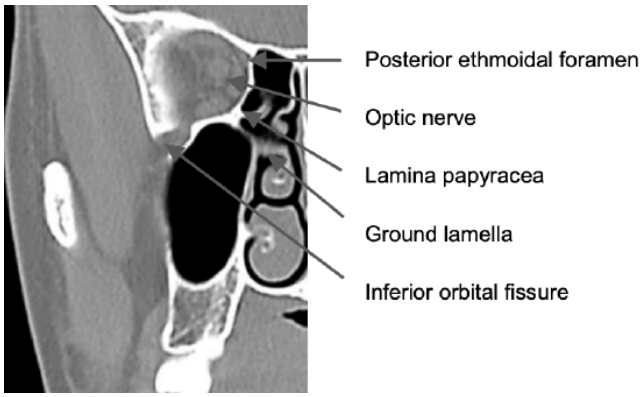


Figure 10: Coronal slice through posterior maxillary sinus; note its relationship to the ethmoids

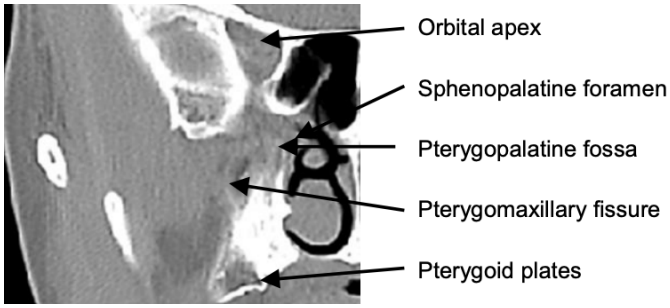


Figure 11: Coronal cut immediately behind the maxillary sinus

The ***radiological anatomy*** of the maxillary sinus is assessed on plain X-rays or by coronal and axial CT scans and is essential to do prior to a Caldwell-Luc procedure (*Figures 1, 7-13*). *Figures 7-10* demonstrate the coronal anatomy at the anterior, midand posterior maxillary sinus. *Figure 11* is a slice immediately behind the maxillary sinus in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure and medially with the nasal cavity via the sphenopalatine foramen.

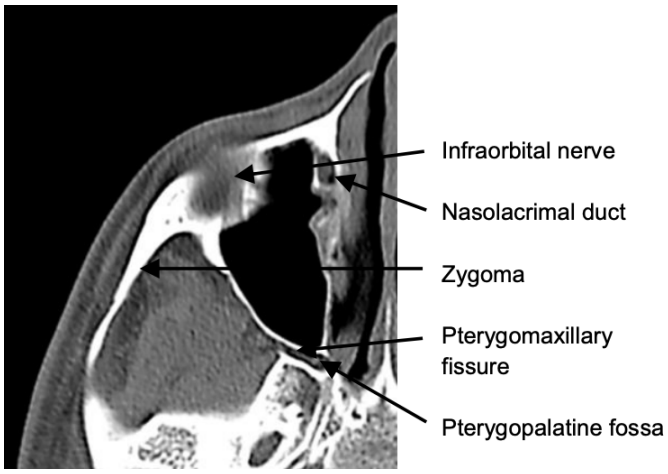


Figure 12: Axial cut at level of infraorbital nerve and orbital floor

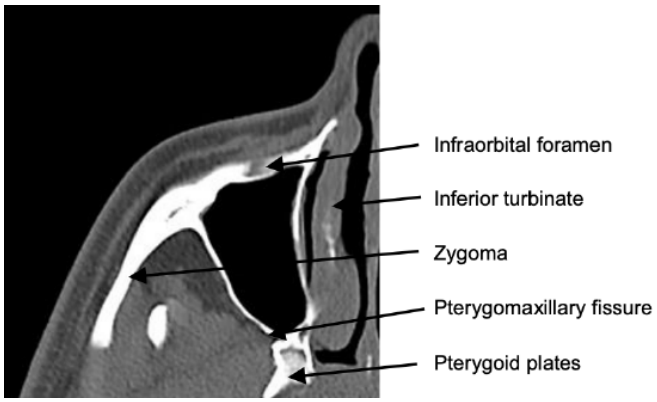
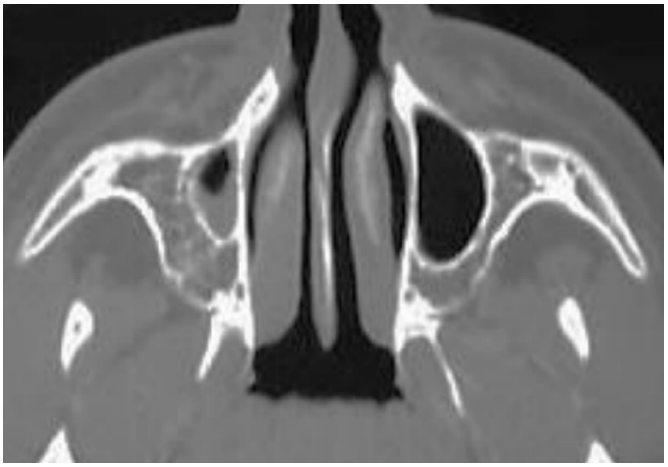
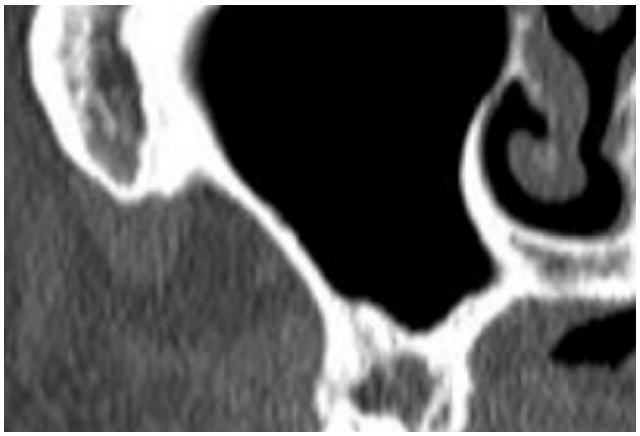


Figure 13: Axial cut at level of infraorbital foramen and pterygoid plates


Figure 14: Hypoplastic maxillary sinus

Figures 12 & 13 show axial views demonstrating the pterygopalatine fossa, pterygomaxillary fissure and pterygoid plates. Imaging may also reveal important anatomical variations that can affect the surgical approach e.g. congenital hypoplasia (*Figure 14*).


Figure 15: Floor of sinus lower than nasal floor in adults

The dimensions of the maxillary sinus change with age, and may affect surgery. Expansion at 2-3 mm/year of the maxillary sinuses continue until adulthood. At birth they are small and the floors of the sinuses are approximately 4 mm above the nasal floor; at 8-9 years of age the floors of the sinuses and nasal cavity are at about the same levels and the sinus dimensions are 2 x 2 x 3 cm. In adults the sinus floor is 0.5-1 cm below that of the nasal cavity (*Figure 15*). The maxillary alveolus atrophies in edentulous patients so that the floor may be even lower.

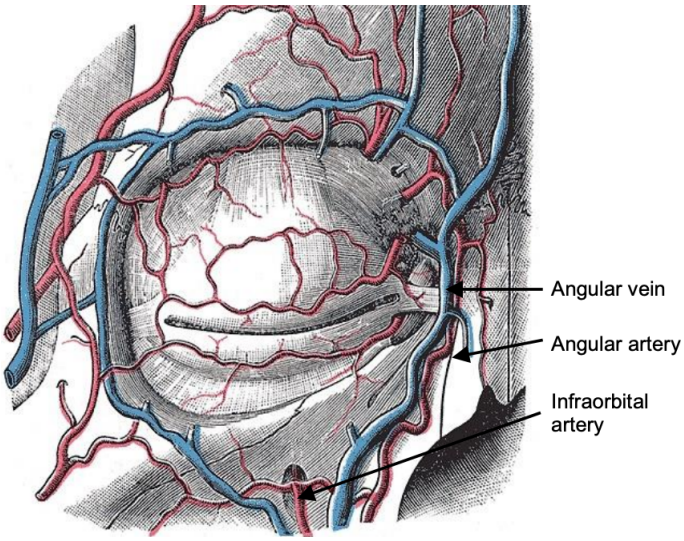


Figure 16: Vasculature around the orbit

No significant ***vessels*** are encountered during Caldwell-Luc antrostomy other than the small ***infraorbital vessels*** that exit the infraorbital foramen to supply the overlying soft tissues of the face (*Figure 16*).

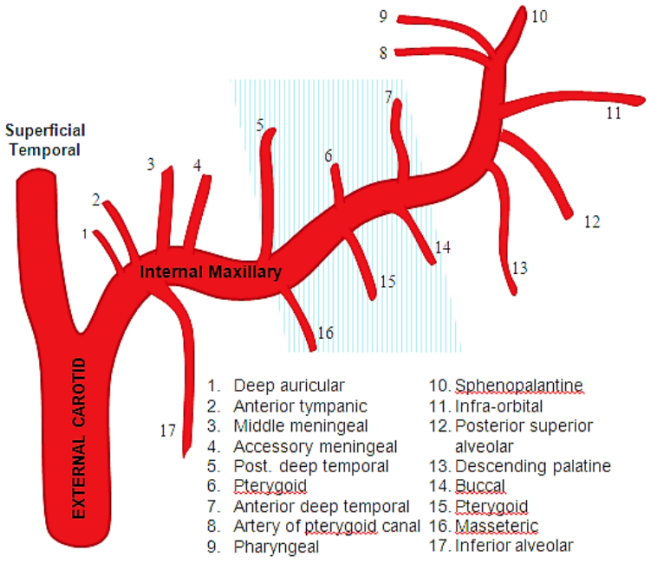


Figure 17: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa

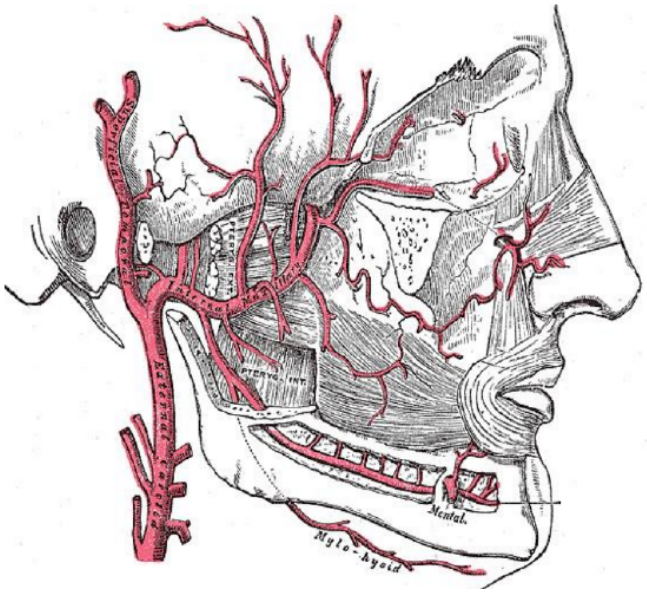


Figure 18: Branches of internal maxillary artery

Only if one breaks through the posterior wall of the sinus does one encounter the ***internal maxillary artery***, a branch of the external carotid artery, which, passes through the pterygomaxillary fissure to enter the pterygopalatine fossa (*Figures 17, 18*).

Caldwell-Luc / Radical antrostomy

The Caldwell-Luc operation involves making an opening in the thin bone of the canine fossa and entering the maxillary sinus. It was first employed to remove infection and to strip diseased mucosa from the maxillary sinus; counter-drainage into the nose was established via an inferior meatal antrostomy. However with an improved understanding of sinus pathophysiology, and introduction of endoscopic, mucosa-sparing functional sinus surgical techniques, the Caldwell-Luc procedure is now infrequently used to treat sinusitis.

Indications

- Biopsy or resection of tumors of the nose and paranasal sinuses
- Transantral access for tumors in the pterygopalatine fossa
- Transantral ligation of internal maxillary artery and its branches for epistaxis
- Transantral access for fractures of the midface and orbital floor
- Orbital decompression
- As part of medial maxillectomy procedure e.g. to resect juvenile nasopharyngeal angiofibromas
- Removal of foreign bodies e.g. bullets or dental roots, from the antrum
- Removing base of antrochoanal polyp
- Transantral ethmoidectomy approach to ethmoids and sphenoid e.g. for pituitary resection
- Repairing oroantral fistulae
- Dental cysts
- Vidian neurectomy
- Chronic sinusitis in the absence of endoscopic sinus surgery facilities

Age considerations

Caldwell-Luc is generally contraindicated if <7 years of age

- Expansion of maxillary sinus continues until adulthood at 2-3 mm/year
- At birth, the floor of sinus approximately 4 mm above nasal floor
- At 8-9 years: Floors of sinus and nasal cavity about at same level, and sinus dimensions 2 x 2 x 3 cm
- Adult: Sinus floor usually 5-10 mm lower than nasal cavity

Imaging

This is routinely done to assess the size of the sinus and the height of its floor relative to the nasal floor, to exclude hypoplasia and unerupted dentition, and to evaluate underlying pathology. Even though centres may only have access to sinus X-rays, CT scan is a far superior investigation. Both axial and coronal CT should be requested. Coronal views provide information about the orbit, orbital floor, sinus floor and alveolus, and lateral wall of the nose and sinus ostia. Axial views provide information about the anterior wall of the sinus, the pterygopalatine fossa and infratemporal fossa (*Figures 1, 12, 13*). MRI may be useful to assess pathology as it distinguishes between soft tissue and mucus.

Consent

- Sublabial incision
- Possibility of sensory loss of cheek, lower eyelid, side of nose, upper gum and teeth
- Change in facial contour: initial swelling of cheek, and if large antrostomy, hollowing of cheek
- Risk of oroantral fistula

Anesthesia

- General or local anesthesia block of posterosuperior alveolar nerve and the buccogingival sulcus with lidocaine 1% with 1:100,000 epinephrine
- Prophylactic antibiotics and steroids are not routinely administered
- Supine position
- Decongest nasal mucosa with nasal decongestant if intranasal surgery is anticipated
- Intubation: transnasal (contralateral) or transoral
- Throat pack: author does not use a throat pack, but suction the throat at conclusion of surgery

Surgical steps



Figure 19: Incising gingivolabial/gingivobuccal mucosa on (R) side

- Retract the upper lip with retractors (*Figure 19*)
- Incise the gingivolabial /gingivobuccal mucosa from the lateral incisor to the 2nd molar with a scalpel or with diathermy, 1 cm from the gingivolabial sulcus to leave a free edge of mucosa that can be sutured at the end of the procedure (*Figure 19*). Avoid placing the incision over the antrostomy to lessen the risk of an oroantral fistula
- Extend the incision through periosteum onto the bone of the face of the maxilla

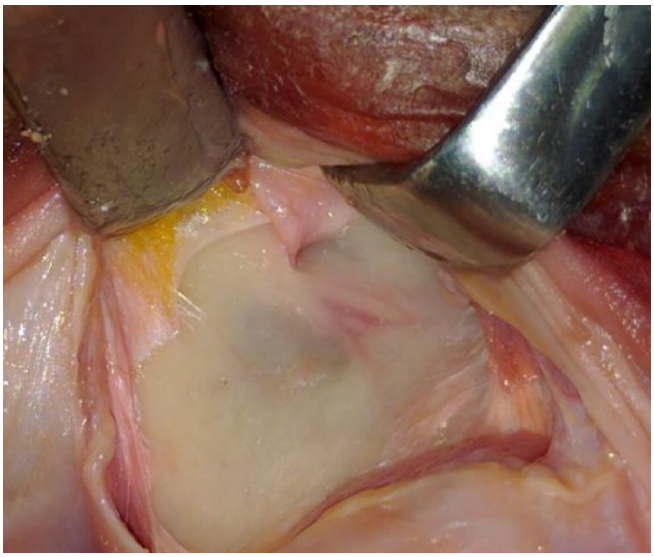


Figure 20: Elevate soft tissues off face of maxilla and expose infraorbital nerve and foramen; note thin bone of canine fossa

- Elevate the soft tissues superiorly off the face of the maxilla in a subperiosteal plane with a periosteal elevator (*Figure 20*)
- Identify and preserve the infraorbital nerve and its branches at the infraorbital foramen (*Figure 20*)

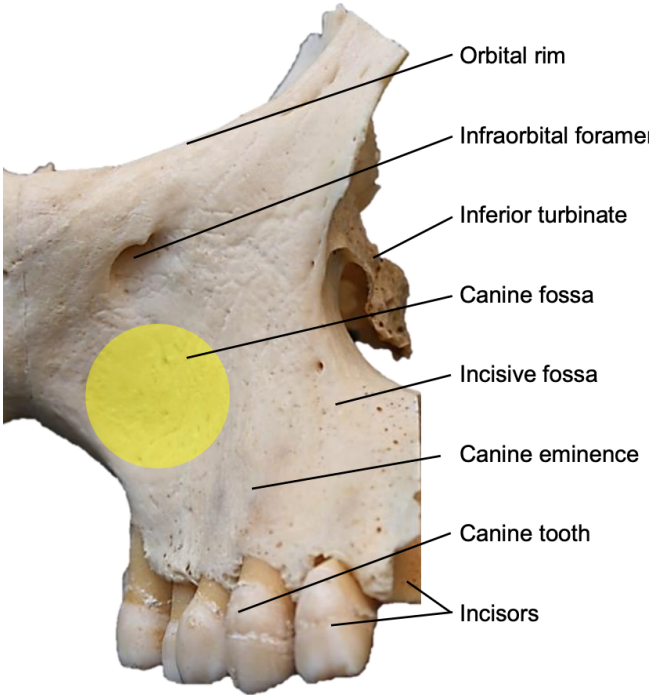


Figure 21: Right canine fossa (yellow), incisive fossa and canine eminence

- Identify the following bony surface landmarks: canine eminence, infraorbital foramen, and canine fossa (*Figures 20, 21*)

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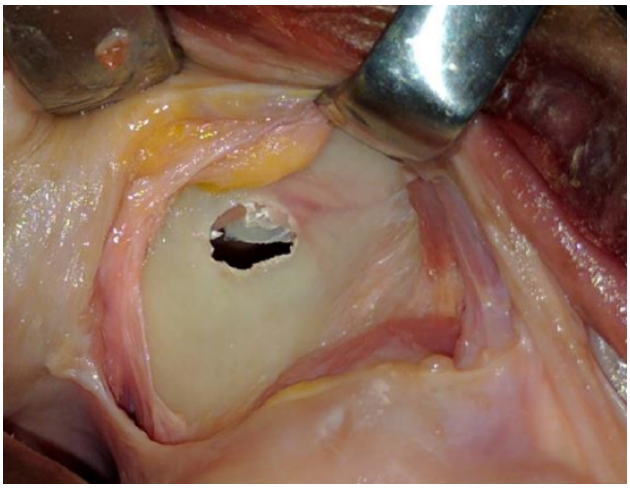


Figure 22: Antrostomy in canine fossa

- Use a small osteotome and mallet or a cutting burr to make an antrostomy in the thin bone of the canine fossa (*Figure 22*)
- Sample pus encountered in the maxillary sinus for culture
- Inspect the antrum

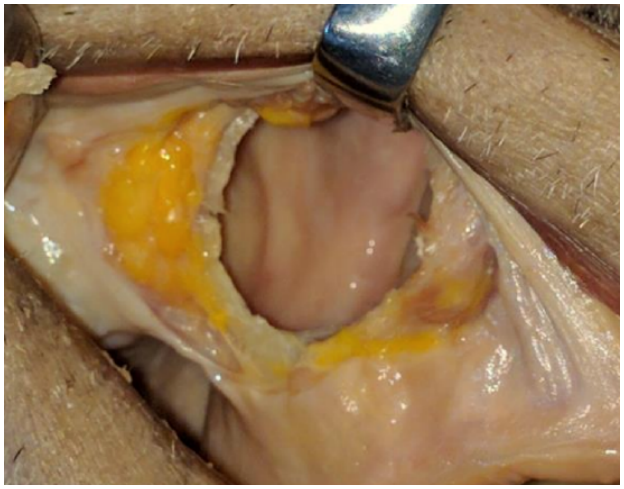


Figure 23: Enlarge antrostomy avoiding injury to neurovascular supply to dental roots and infraorbital nerve

- Enlarge the antrostomy with Kerrison's rongeurs or a bone nibbler or a drill as much as is required, taking care not to injure the neurovascular supply to the dental roots and the infraorbital nerve (*Figure 23*)
- Address the underlying pathology
- Irrigate the sinus
- Control bleeding from the edges with electrocautery, or bone wax
- At conclusion of surgery, carefully close the incision with absorbable sutures e.g. catgut or vicryl to avoid an oroantral fistula

Complications

- Bleeding: pack nose
- Sensory loss of infraorbital nerve: most patients have temporary hypesthesia due to traction on the nerve which resolves in 4-6 weeks
- Numbness of canine and premolar teeth: this may occur when excessive removal of bone in dentate patients injures branches of the superior alveolar nerve as they traverse the inferior anterior maxillary wall
- Sublabial oroantral fistula
- Osteomyelitis of maxilla
- Injury to nasolacrimal duct with inferior meatal antrostomy

Closing a Caldwell-Luc related oroantral fistula

- Local mucosal flaps
- Buccal fat pad flap
- Superiorly-based buccinator myomucosal flap

Inferior meatal antrostomy

Inferior meatal antrostomy is done only in selected cases to provide drainage, aeration, and to remove packing from the antrum or to facilitate postoperative surveillance. Ciliary action continues to propel mucus towards the middle meatus; therefore inferior meatal antrostomy achieves only dependent drainage of antral secretions.



Figure 24: The (R) inferior meatus is tucked under the inferior turbinate

The inferior meatus is tucked under the inferior turbinate (*Figure 24*). The turbinate is attached along the lateral bony nasal wall in an arc with its highest point (genu) situated at the junction of its anterior and middle thirds. The nasolacrimal duct opens at or just anterior to the most cephalic portion of the inferior meatus, under the genu of the turbinate.

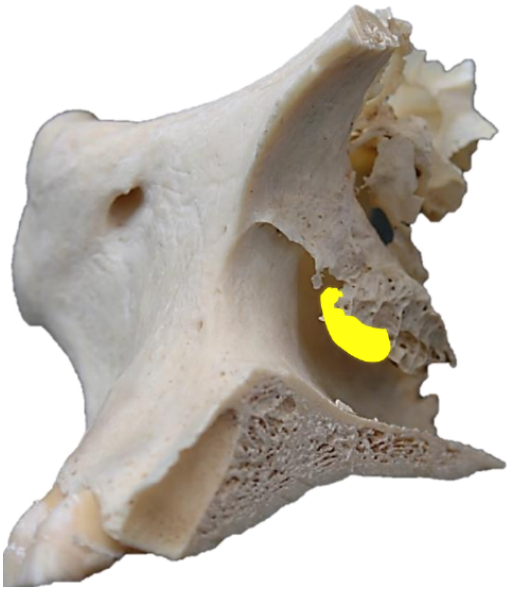


Figure 25: Inferior meatal antrostomy is made through the thin medial wall of antrum medial to the inferior turbinate

The thinnest bone lies in the superior, central portion of the meatus (*Figure 25*). The thickness and quality of the bone changes within the inferior meatus; there is a gradual switch from compact to lamellar bone as one moves from to top to bottom, and from

the front to the back.

The thickness of the bone inferiorly makes it difficult to extend the antrostomy to the nasal floor. The bony thickness and decreasing height of the meatus prevents anterior surgical extension, hence making injury to the nasolacrimal duct unusual.

- Spray the nasal cavity with decongestant and wait a few minutes for shrinkage of the mucosa to occur; this facilitates insertion of cotton wool into the inferior meatus and drainage through the natural maxillary ostium



Figure 26: Exposing inferior turbinate with Thudicum speculum

- Visualize the inferior turbinate and inferior meatus with a headlight using a Thudicum speculum (*Figure 26*)
- Elevate the inferior turbinate with an elevator and insert cotton wool soaked with topical anesthesia/vasoconstrictor into the inferior meatus and/or infiltrate lidocaine 1% / epinephrine 1:100,000

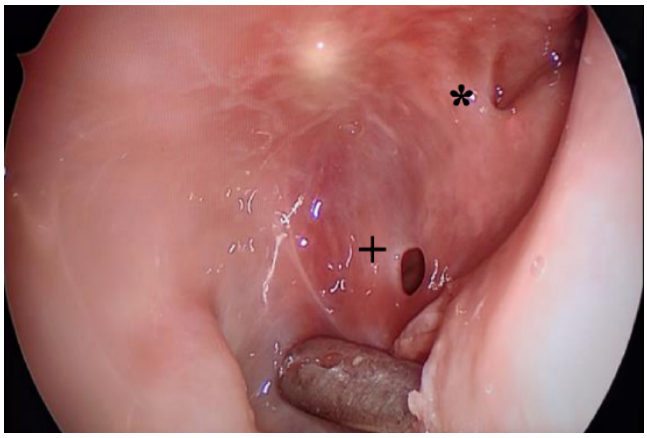


Figure 27: View from inside antrum of instrument entering (R) antrum via inferior meatal antrostomy. Note accessory (+) and natural maxillary ostia (*)

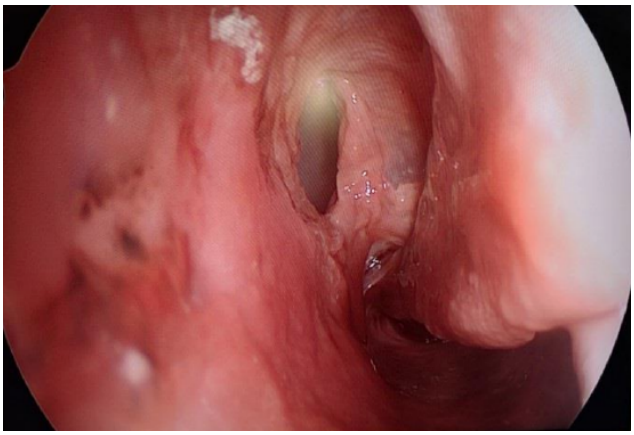


Figure 28: (R) inferior meatal antrostomy through thin medial wall of antrum medial to the inferior turbinate

- Advance a curved hemostat into the antrum from the inferior meatus and punch through the thin bone at the highest point under the genu of the turbinate at the junction of the anterior and mid-thirds of the inferior meatus (*Figures 27, 28*)



Figure 29: Trocar with outer cannula for proof puncture and sinus irrigation

- Enlarge the antrostomy with side-biting forceps to make a 2 x 1 cm window (*Figure 29*)
- Lower the inferior rim as much as possible to minimize a sump effect
- Reposition the inferior turbinate
- Some surgeons trim a small anterior segment from the inferior turbinate
- Saline irrigation is used postoperatively

Packing the antrum

- This may be required for bleeding
- Pack the antrum with ribbon gauze impregnated with liquid paraffin or antiseptic cream
- Bring the end of the ribbon through the inferior meatal antrostomy for later removal through the nose

Postoperative Care

- Apply ice packs to the cheek to reduce edema and discomfort
- Remove packing after 24 hours
- Avoid blowing the nose to prevent surgical emphysema
- Irrigate the nose with saline if an inferior meatal antrostomy has been done
- Avoid inserting an upper denture for 7- 10 days to allow the gingivolabial incision to heal and to avoid an oroantral fistula

Complications of inferior metal antrostomy

- ***Hemorrhage*** from inferior meatal branch of the lateral sphenopalatine artery if the antrostomy is extended too far posteriorly hemorrhage
- ***Nasolacrimal duct injury*** is rare due to its position and the quality of the surrounding bone

Canine Fossa Puncture (CFP)

CFP is employed to obtain a sample of mucus or pus from the maxillary sinus, and to irrigate the sinus (*Figure 29*). It is particularly useful in a patient lying supine e.g. in intensive care, and is preferred to inferior meatal puncture in a patient with a coagulopathy as bleeding can be controlled by applying local pressure to the puncture site.



Figure 30: Thicker (4 mm) trocar with outer cannula through which an endoscope can be passed into the antrum

CFP is also used to insert an endoscope into the maxillary sinus as an adjunct to transnasal endoscopic sinus surgery to improve visualization of e.g. the anterior sinus or the pterygopalatine fossa (*Figure 30*).

- Positioning
  - Sitting position to allow sinus contents to drain through the nose into a bowl held under the nose
  - In unconscious patients, suction the oropharynx during sinus puncture to protect the airway
- Anesthesia: In adults it is usually done using local anesthesia/vasoconstrictor (e.g. lidocaine 1% with epinephrine 1:100,000) infiltrated into the region of the canine fossa; a general anesthetic is usually required with children
- Apply the tip of the trocar to the mucosa overlying the canine fossa, and push it through the thin bone into the antrum, keeping in the same vertical plane as the hard palate to avoid the orbital floor. As the sinus measures 38- 45 mm in length in the adult, you are unlikely to penetrate its posterior wall
- Remove the inner trocar leaving the outer cannula in the sinus
- Advance the cannula until it makes contact with the posterior wall of the sinus
- Retract the cannula 1-2 cm so that the tip is in the center of the sinus cavity
- Fit a saline-filled syringe to the cannula
- Aspirate and send the aspirate for MCS
- Refill the syringe with saline, and gently flush the sinus while observing the eye for swelling in the event that the floor is dehiscent or has been entered with the trocar
- Keep irrigating the sinus until the fluid exiting the nose is clear
- Remove the cannula

Inferior Meatal Puncture

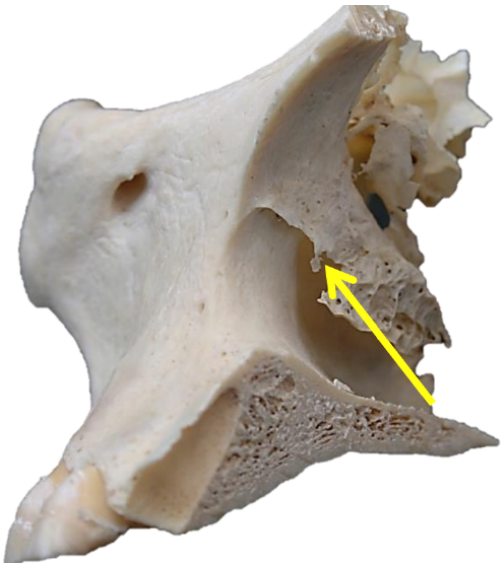


Figure 31: Thin medial wall of antrum medial to inferior turbinate through which inferior meatal puncture is done

Inferior meatal puncture is employed to obtain a sample of mucus or pus from the maxillary sinus, and/or to irrigate the sinus using a trocar and cannula (*Figure 31*).

The inferior meatus is tucked under the inferior turbinate (*Figures 24*, *31*). The turbinate is attached along the bony lateral nasal wall in an arc with its highest point (genu) situated at the junction of its anterior and middle thirds. The nasolacrimal duct opens at or just anterior to the genu. The thinnest bone lies in the superior central portion of the meatus. Hence IMP is done through the thin bone at the genu of the turbinate high up in the middle meatus at the junction of the anterior and mid-thirds of the inferior meatus.

- Place the patient in a sitting position to allow sinus contents to drain through the nose into a bowl held under the nose
- Spray the nasal cavity with decongestant and wait a few minutes for shrinkage of the mucosa to occur; this facilitates insertion of cotton wool into the inferior meatus and drainage through the natural maxillary ostium
- Visualize the inferior turbinate and inferior meatus with a headlight using a Thudicum speculum (*Figure 27*)
- Insert cotton wool soaked with topical anesthesia/vasoconstrictor into the inferior meatus and/or infiltrate lidocaine 1% / epinephrine 1:100,000 into the region of the canine fossa; a general anesthetic is usually required with children

- Pass the tip of the trocar into the nose (curved trocar preferred to reduce risk of orbital injury); control the trocar by holding its body in the palm of the hand and the index finger on the shaft
- Advance the tip of the trocar superiorly below the inferior turbinate along the inferior meatus towards its genu (1 cm above the floor of the nose, one third of the way along the length of the turbinate)
- Steady the back of the head with opposite hand



Figure 32: Note proximity of orbital floor making it easy to direct the trocar into the orbit

- Direct the trocar through the thin bone, aiming for the tragus of the patient's ear to avoid the orbital floor (*Figure 32*)
- Advance the trocar into the sinus
- Remove the trocar, leaving the cannula in place
- Advance the cannula until you feel the posterior wall of the sinus
- Retract the cannula 1-2 cm so that the tip is in the center of the sinus cavity
- Lean the patient forward while holding a bowl under the chin to collect the irrigation fluid, and tell him/her to breathe through the mouth
- Fit a saline-filled syringe to the cannula
- Aspirate and send the aspirate for MCS
- Refill the syringe with saline and gently flush the sinus while observing the cheek and the eye for swelling in the event that the floor is dehiscent or has been entered with the trocar
- Avoid insufflating the sinus with air as a fatal air embolus may ensue
- Keep irrigating the sinus until the fluid exiting the nose is clear
- If the sinus ostium is occluded, introducing a second cannula alongside the first drainage may facilitate lavage
- Remove the cannula

Contraindications for meatal punctures

- Children < 3 years: Proximity of orbital floor and teeth in a small maxillary sinus; underdeveloped maxilla has thick bony walls
- Untreated febrile acute maxillary sinusitis: inferior meatal puncture may cause osteomyelitis and septicemia
- Midfacial trauma: may have disrupted the orbital floor

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ENDOSCOPIC DACRYOCYSTORHINOSTOMY (DCR) SURGICAL TECHNIQUE

Hisham Wasl, Darlene Lubbe

Endoscopic dacryocystorhinostomy (DCR) is a ***surgical intervention for epiphora caused by obstruction of the nasolacrimal duct***. Understanding endonasal anatomy, wide endoscopic marsupialization of the lacrimal sac, and meticulous care of the nasal mucosa are important to achieve good results.

Patients develop symptoms of tearing when there is an imbalance between tear production and drainage function of lacrimal system. Tearing can therefore be caused by

- Hypersecretion
- Epiphora
- Combinations of the above

Hypersecretion (lacrimation) is excessive tearing caused by reflex hypersecretion due to irritation of the cornea or conjunctiva e.g. trigeminal nerve stimulation in corneal disease.

Epiphora occurs with poor lacrimal drainage due to

- ***Mechanical obstruction*** of the lacrimal drainage system related to trauma, dacryocystolithiasis, sinusitis, and congenital nasolacrimal duct obstruction in children
- ***Lacrimal pump failure*** (functional epiphora) may be caused by eyelid laxity (as in facial nerve palsy), eyelid malposition, and punctum eversion

Relevant anatomy

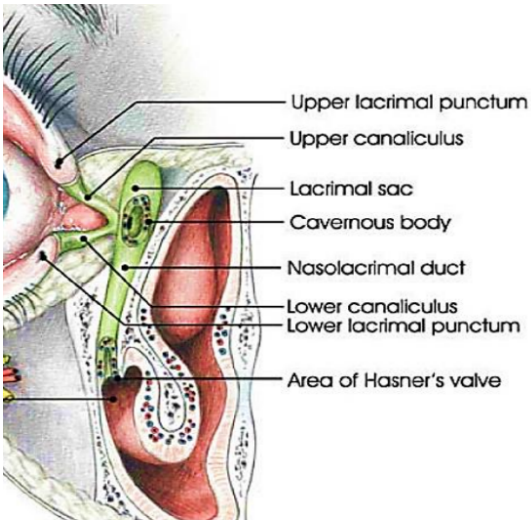


Figure 1: Ocular and nasolacrimal duct anatomy

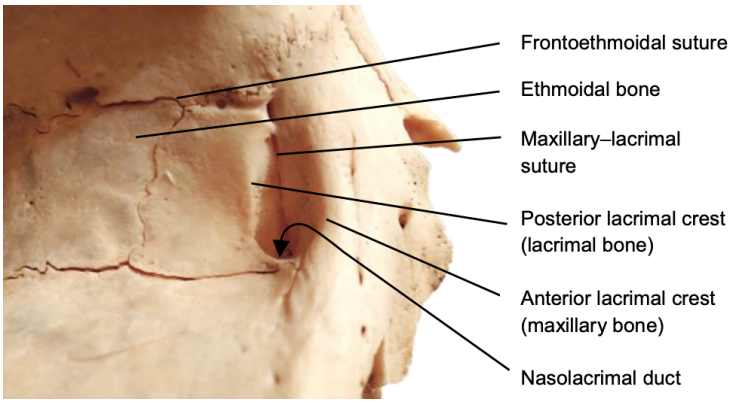


Figure 2a: Anterior and posterior lacrimal crests are formed by the frontal process of maxillary bone and lacrimal bones

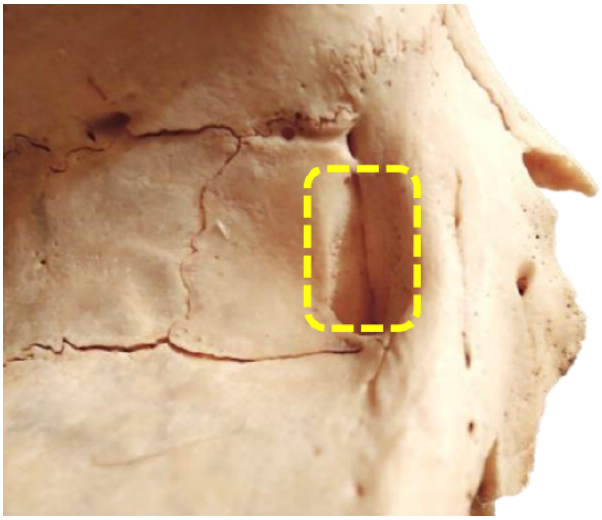


Figure 2b: Area of bone to be removed

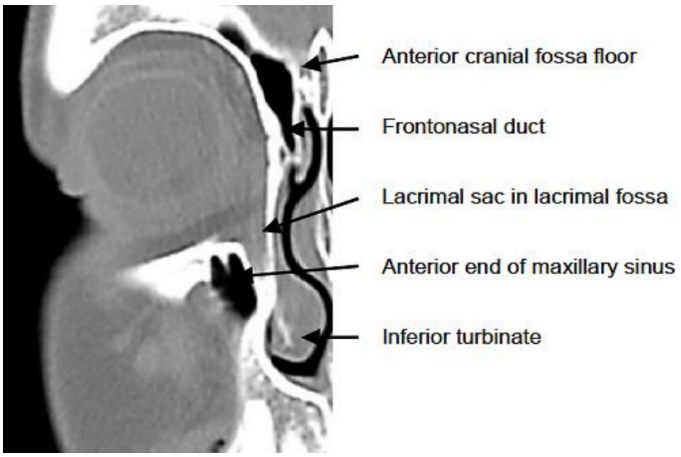


Figure 3a: Coronal CT scan through the lacrimal sac

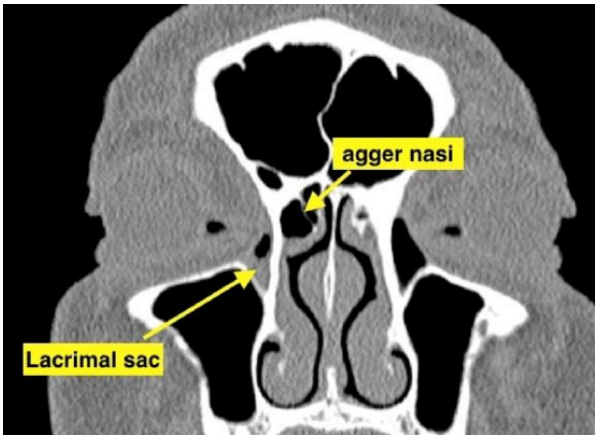


Figure 3b: Coronal CT scan through the lacrimal sac and agger nasi cell

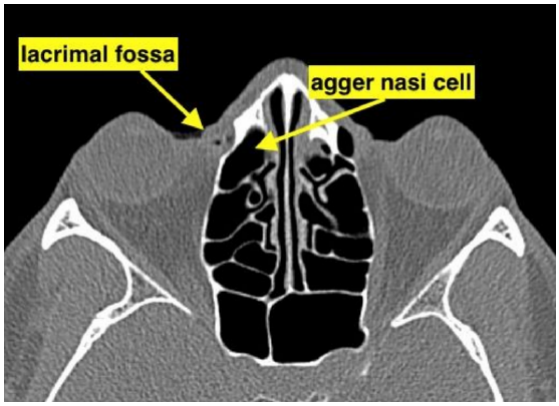


Figure 3c: Axial CT scan demonstrates anatomical relations between lacrimal fossa and agger nasi cell

The lacrimal puncta open at the medial ends of the upper and lower eyelids and drain into the lacrimal sac via the upper and lower canaliculi (*Figure 1*). The lacrimal sac is located in the lacrimal fossa and drains into the nasolacrimal duct (*Figures 2*, *3*). The nasolacrimal duct runs within a bony canal created by the maxillary and lacrimal bones and opens into the inferior meatus of the nose (*Figures 1-3*).

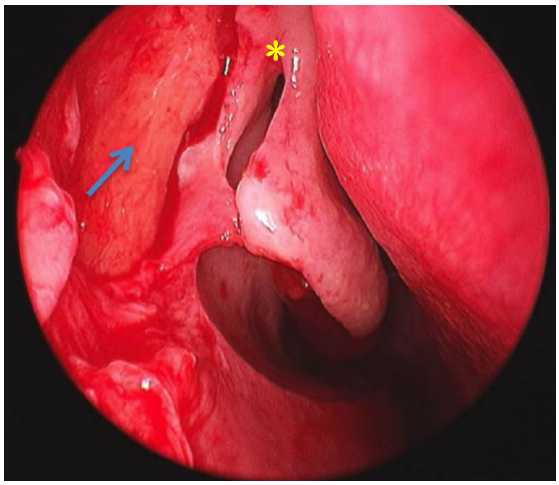


Figure 4: Endoscopic view of the axilla of the right middle turbinate (*) with mucosal flap raised to expose bone covering the lacrimal sac (arrow)

The lacrimal bone extends between the frontal process of the maxilla anteriorly (*Figure 2*), to the attachment of the uncinate posteriorly. It is important to note that the lacrimal bone and sac are located just anterior to the orbit. ***The retrolacrimal region of the lamina papyracea is thin and careless surgery to the uncinate at this point may lead to penetration of the orbit***. The lacrimal sac extends approximately 9 mm above the axilla of the middle turbinate (*Figure 4*). The common canaliculus opens high on the lateral wall of the sac; this area should be exposed, and all bone removed during endoscopic DCR for a better result.

Evaluation of patients with epiphora

Clinical History and Examination

A detailed history and clinical examination help to

- Differentiate between hypersecretion, lacrimation and epiphora
- Define the pathological process
- Distinguish whether tearing is due to a functional or anatomical disorder
- Identify the site of the blockage
- Define a surgical approach (if required)

Examination includes

- *Eyelids*: Lower lid laxity, ectropion, entropion, punctum eversion, trichiasis, blepharitis
- *Medial canthus*: Lacrimal sac enlargement below the medial canthal tendon
- *Palpation of lacrimal sac*: Reflux of mucopurulent material from the punctum; pressure over sac in acute dacryocystitis causes pain

Special Investigations

Diagnostic tests are used to identify the cause of an obstruction and to choose appropriate treatment[1]. Diagnostic tests can be classified as follows:

- Anatomical tests to locate the site of obstruction
  - Diagnostic probing
  - Syringing (irrigation)
  - Dacryocystography
  - Nasal examination
  - CT, MRI
- Physiological/Functional tests
  - Fluorescein dye disappearance
  - Scintigraphy
  - Saccharine test
- Secretion tests
  - Schirmer’s test
  - Bengal rose test
  - Tear-film breakup
  - Tear lysozyme

Diagnostic probing & lacrimal syringing (irrigation)

Diagnostic probing and irrigation of the lacrimal system are important anatomical tests. They provide information about the site of obstruction but are unable to give information about functional insufficiency. Teaming up with ophthalmologists help ENT surgeons to obtain the required skills of probing and syringing the lacrimal system. The required instrumentation is shown in *Figure 5*.

Syringing

This is generally done by ophthalmologists in an outpatient clinic under local anesthesia

- Apply topical anesthesia by applying 1-2 drops of Oxybuprocaine or Benoxinate HCl 0.4% (Novesin Wander ® by Novartis) onto the puncta

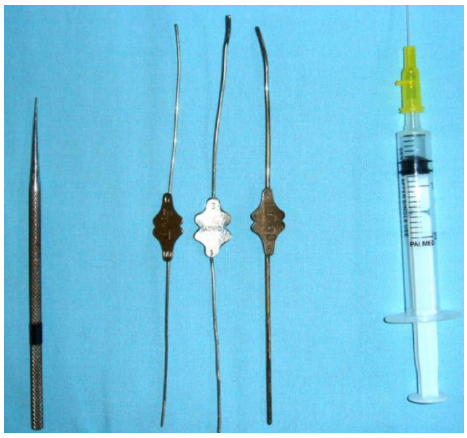


Figure 5: Dilator, probing and syringing instrumentation

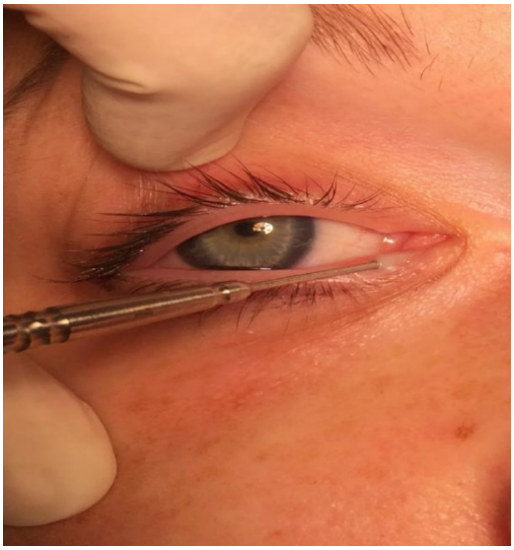


Figure 6: Punctum dilated with a punctum dilator

- Dilate the puncta with a punctum dilator if the puncta are small (*Figure 5,6*)



Figure 7: Syringing via lower canaliculus

- Insert a 24G (yellow) intravenous cannula into the inferior canaliculus, first aiming vertically and then horizontally (*Figures 5, 7*)
- Straighten the lower canaliculus by pulling the lower eyelid downwards and laterally (*Figure 7*)
- Advance the tip of the cannula 3-6 mm into the canaliculus
- Irrigate the lacrimal drainage system with sterile water

How to interpret syringing tests

- Reflux through the opposite punctum suggests obstruction in the common canaliculus or distal to it
- Fluid coming directly back through the same punctum indicates a canalicular obstruction; repeat syringing through the other canaliculus
- Distention of the lacrimal sac indicates obstruction of the nasolacrimal duct
- Irrigation into the nose indicates an anatomically patent system, but not necessarily a functional system

Diagnostic Probing Probing is indicated only if syringing demonstrates obstruction and the site and extent of the obstruction need to be determined. If fluid refluxes through the opposite punctum, it suggests obstruction of the common canaliculus or more distally; this distinction should be made with diagnostic probing

- Apply topical anesthesia by using 1-2 drops of Oxybuprocaine or Benoxinate HCl 0.4% Novesin Wander ® by Novartis) onto the puncta and wait 20 seconds
- Dilate the puncta with a punctum dilator



Figure 8: Diagnostic probing

- Advance an appropriately sized lacrimal probe into the canaliculus (*Figures 5, 8*)
- First pass the probe vertically through the punctum, and then horizontally until it encounters the lacrimal bone or meets the canalicular obstruction

How to interpret a diagnostic probing test

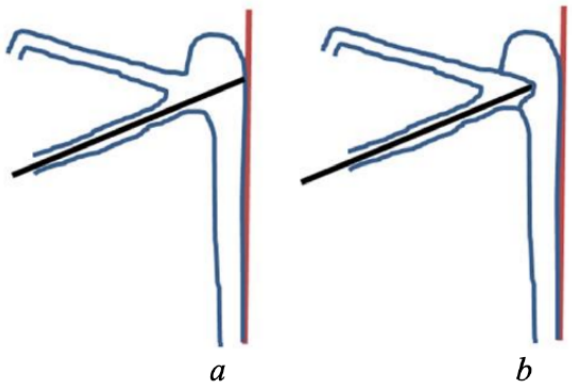


Figure 9a: “Hard stop” when probe is passed into lacrimal sac and hits medial bony wall; b: “Soft stop” when probe displaces common canaliculus towards medial wall of sac…is associated visible medial shift of inner canthus

- A ***hard stop*** is when the probe is advanced along the canaliculus and encounters the lacrimal bone. This means that the probe has passed into the sac and touched its bony medial wall, and that the common canaliculus is patent (*Figure 9a*)
- A ***soft stop*** is a spongy feeling encountered when there is an obstruction proximal to the lacrimal sac and the probe cannot be passed into the sac. In such cases the obstruction is at the common canaliculus and the lacrimal probe presses the common canaliculus and the lateral wall against the medial wall of the sac (*Figure 9b*). There will also be a medial shift of the inner canthus when advancing the probe toward the lacrimal bone due to the probe displacing the common canaliculus medially
- Reflux through the opposite punctum when syringing a hard stop suggests obstruction of the sac or the nasolacrimal duct

It is important to note the presence of a hard stop or a soft stop, because the treatment of an obstruction at the lacrimal sac or duct vs. at the common canaliculus requires different surgical interventions.

Radiological investigations

Radiological investigations are done if doubt exists about the surgery that is required[2, 3]. Both dacryocystography and scintigraphy provide some idea of the level of obstruction and whether a tight common canaliculus is contributing to the epiphora.

Dacryocystography is indicated when there is obstruction in the lacrimal system with syringing. It can assist with understanding the internal anatomy of the lacrimal system. Indications for dacryocystography include

- Complete obstruction: size of sac, determining exact site of obstruction (common canaliculus or sac)
- Incomplete obstruction and intermittent tearing: site of stenosis, diverticula, stones, and absence of anatomical pathology (functional disorders)
- Failed lacrimal surgery: size of the sac
- Suspicion of sac tumors

Nuclear lacrimal scintigraphy is a functional test, and is useful to assess the site of delayed tear transit. It is especially helpful in difficult cases with an incompletely obstructed system e.g. questionable eyelid laxity, and questionable epiphora.

Computed tomography (CT) is used with tumors, rhinosinusitis, facial trauma, and following facial surgery. With concomitant sinus disease, CT assists a surgeon to address the sinuses at the same time as the DCR.

Magnetic resonance imaging (MRI) is rarely used to investigate tearing patients.

Nasal endoscopic examination

Endoscopic examination of the nasal cavity is obligatory. It provides very important information about e.g. nasal polyps, nasal masses, rhinosinusitis, tumors, anatomical variations, and nasal septal deviation.

Endoscopic DCR surgery technique

Anesthesia and preparation of surgical field

- Surgery is performed under general anesthesia with the endotracheal tube out of the way of the endoscope and instruments
- The patient is placed supine, either flat or slightly flexed to 15 degrees, and slightly rotated towards the surgeon

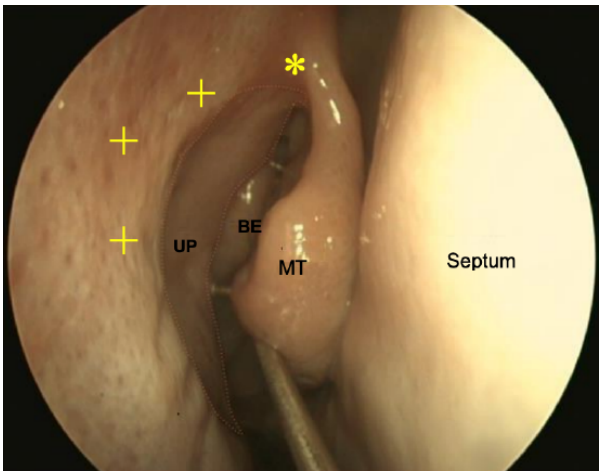


Figure 10: Injection points of lidocaine with 1:100,000 adrenaline into axilla of middle turbinate (*) and frontal process of maxilla (+)

- Using a dental syringe, inject 2 mL of 1% lidocaine with 1:100,000 adrenaline into the axilla of the middle turbinate and the frontal process of maxilla (*Figure 10*)
- Insert ribbon gauze or neurosurgical patties soaked in 2 mL of 1:1000 adrenaline between the inferior turbinate and the nasal septum and in the middle meatus to achieve topical decongestion
- A dose of co-amoxiclav or cefazolin is given at induction of anesthesia

Surgical instruments



Figure 11a: Kerrison punch

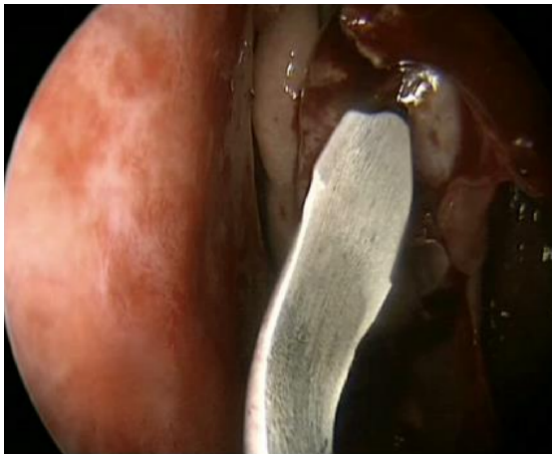


Figure 11b: 2.75 mm Cataract knife

- Surgical instruments required:
  - Dental syringe
  - No 15-scalpel blade
  - Suction Freer elevator
  - Kerrison punch (*Figure 11a*)
  - 2.75 mm Cataract knife (*Figure 11b*)
  - Small Blakesley forceps

- Punctum dilator and probes
- DCR intubation set

It is quicker to remove bone with a Kerrison's punch than with a DCR burr. The DCR bur is only used when the punch is unable to engage the bone adequately.

Surgical steps

1. Septoplasty

- Have a low threshold for performing a septoplasty if a septal deviation hampers access to the middle meatus and lateral nasal wall
- Ideally place the septal incision on the side contralateral to the DCR

2. Create a posteriorly based mucosal flap to expose the lacrimal bone

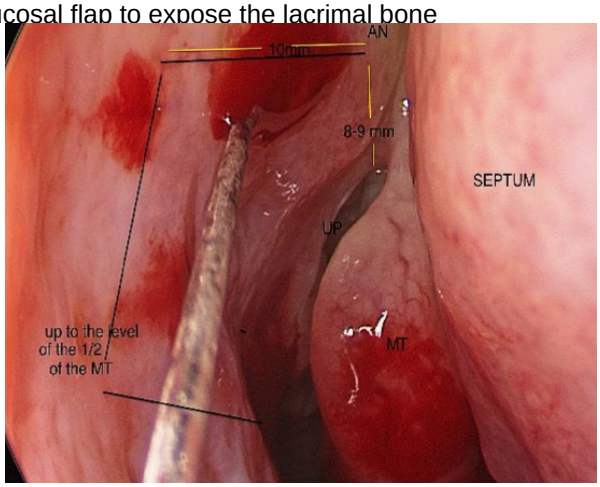


Figure 12: Superior and inferior incisions and the area where the local anesthetic is injected

- Use a no 15 scalpel blade to make a superior incision that runs horizontally 8-9 mm above the axilla of the middle turbinate (*Figure 12*)

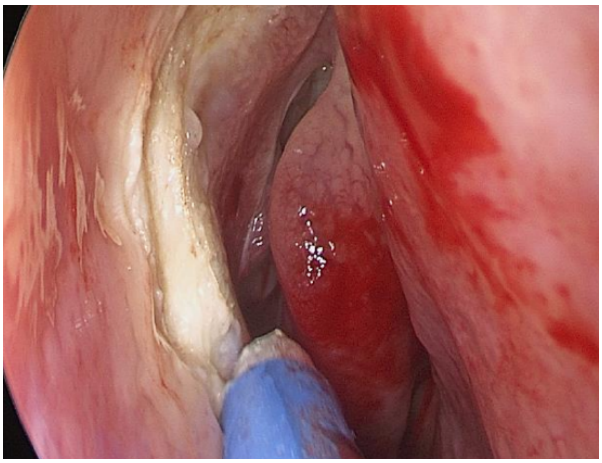


Figure 13: Suction diathermy can be to cauterize the incision sites for hemostasis

- One can use suction diathermy to cauterize the incision line before making the cut (*Figure 13*)
- Extend the incision anteriorly for approximately 10 mm onto the frontal process of the maxilla

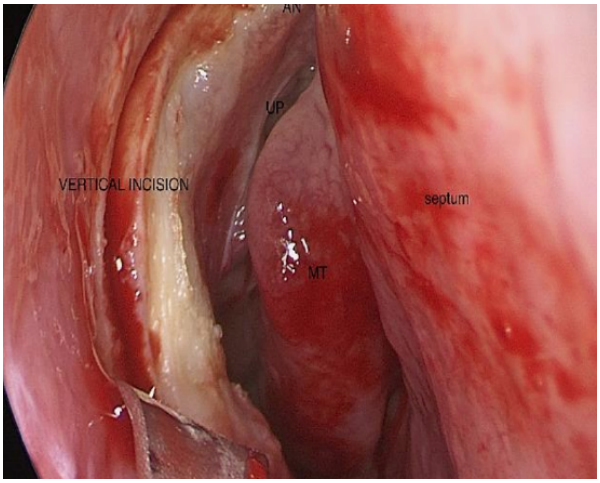


Figure 14: Vertical incision

- Turn the blade vertically and make a cut onto the frontal process of the maxilla from the superior incision to just above the insertion of the inferior turbinate (*Figure 14*)
- Turn the blade horizontally and make the inferior incision from the insertion of the uncinate to join the vertical incision (*Figures 12, 14*)

3. Raise a mucosal flap

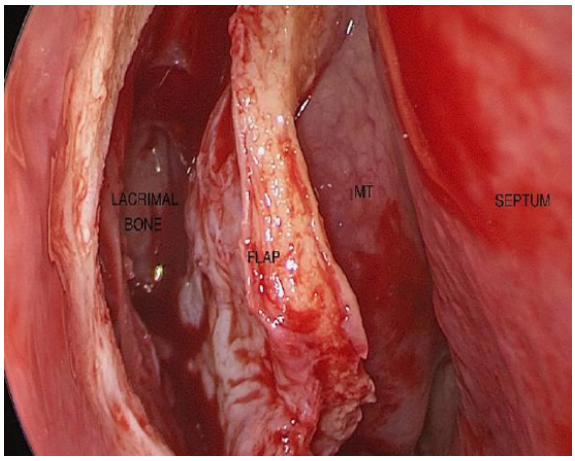


Figure 15: Raising the mucosal flap

- Use a suction Freer dissector to raise a mucosal flap and to expose the underlying bone (*Figure 15*)
- It is important to stay on bone to avoid losing the surgical plane

4. Remove bone to expose lacrimal sac

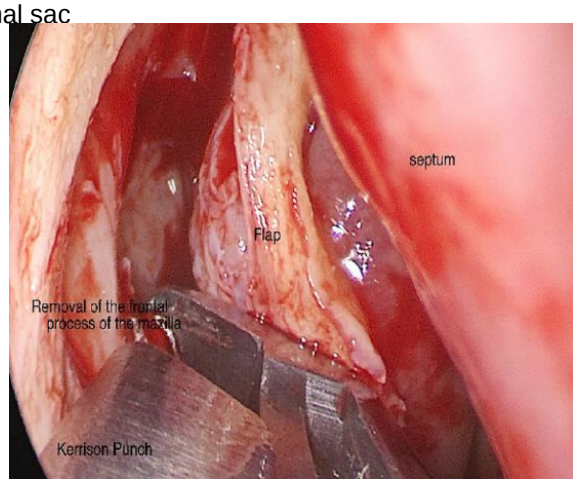


Figure 16: Removal of bone of the frontal process of the maxilla exposes the lacrimal sac

- Use a Kerrison's punch to remove the bone of the frontal process of the maxilla overlying the lacrimal sac (*Figure 16*)
- It is quicker to remove bone with a Kerrison's punch than with a DCR bur
- Only use a DCR bur when the punch is unable to adequately engage the bone
- Expose the sac by removing bone up to the mucosal incisions superiorly, inferiorly, and anteriorly, so the sac forms a prominent bulge into the nasal cavity (*Figure 16*)
- Remove all the lacrimal bone up to the insertion of the uncinate, but do not disturb the uncinate itself
- The lacrimal probe should be passed from the puncta through to the nasal cavity without feeling any bone obstructing the pathway of the probe. If this is not so, then more bone should be removed superiorly
- This retrolacrimal region where the uncinate inserts into the lamina papyracea is extremely thin, so take care not to cause an accidental orbital injury
- The common canaliculus opens high on the lateral wall of the sac; this area should be exposed during endoscopic DCR for a better result

5. Expose agger nasi cell

- The agger nasi cell is situated medially, superiorly and more posteriorly to the lacrimal fossa (*Figure 3b*)
- Open the agger nasi cell using a Kerrison's punch

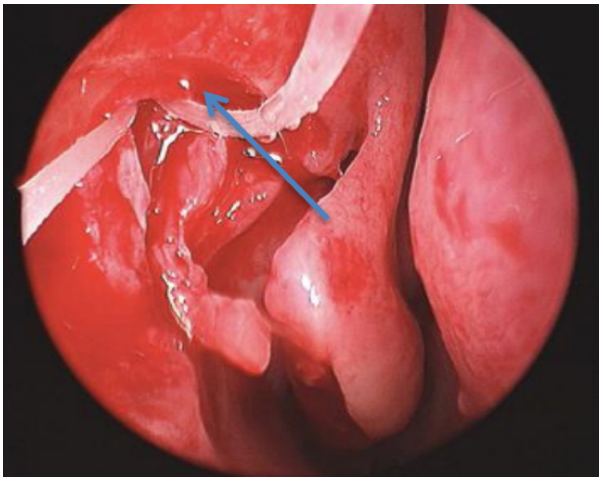


Figure 17: Exposure of agger nasi (arrow); 2 silastic tubes visible

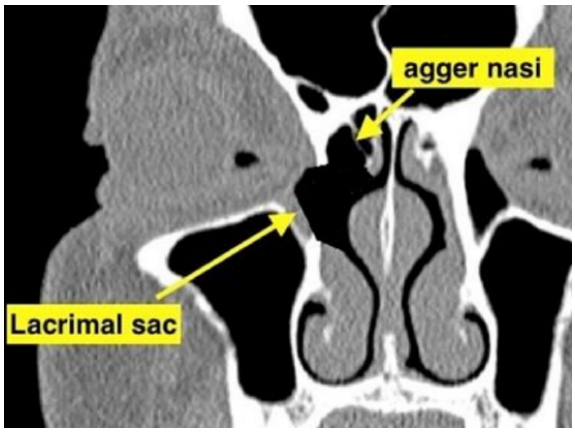


Figure 18: Agger nasi (arrow) has been opened (compare to Figure 3b)

- This allows better exposure of the lacrimal sac and allows the mucosa of the sac to lie against the agger nasi mucosa (*Figures 17, 18*)

6. Marsupialize the lacrimal sac

- Cannulate the superior or inferior canaliculus with a probe, taking great care not to make a false passage in the delicate lacrimal system
- Both the upper and lower canaliculi have an angulated course that needs to be carefully followed to avoid creating such a false passage

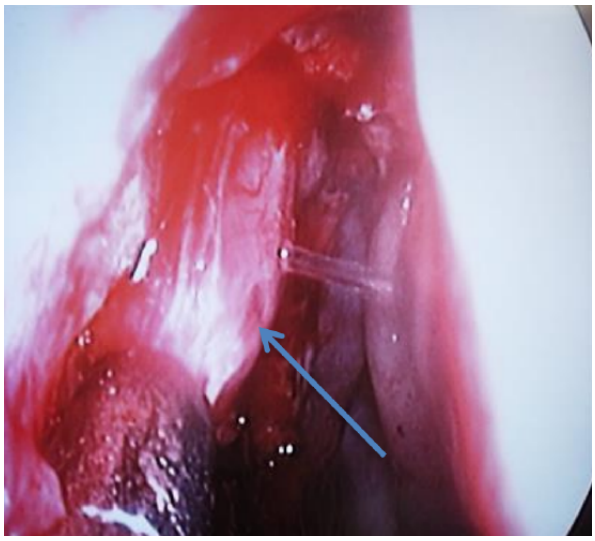


Figure 19: Tenting the wall of the sac with a probe before incising the lacrimal sac

- Tent the lacrimal sac with the lacrimal probe under endoscopic vision (*Figure 19*)
- Incise the medial wall of the sac only when the lacrimal probe can be clearly seen tenting the sac wall
- Use a DCR knife or cataract knife to vertically incise the sac
- Cut releasing incisions in the posterior and the anterior flaps of the sac
- Either Bellucci micro ear scissors or a sickle knife can be used for the release incisions
- The sac must be widely marsupialized, and be widely open and lying flat on the lateral nasal wall (*Figure 17*)

7. Trimming the nasal mucosal flap

- Preserve the mucosal flap until the end of the procedure to protect the nasal septum during the surgery
- Trim the mucosal flap so that only small superior and inferior rims remain, and the lacrimal sac remains wide open
- Return the remainder of the flap onto the lateral wall and ensure that the exposed bone is covered

8. Inserting silastic stents

- The authors prefer to stent the DCR neo-ostium (not all surgeons do so)
- Two silastic lacrimal tubes are used to stent the lacrimal system (*Figures 17, 19*)
- Dilate the puncta with a punctum dilator if the puncta are small (*Figure 6*)

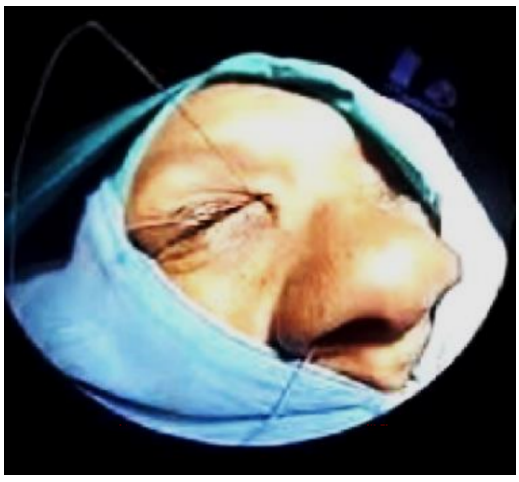


Figure 20: Pass the lacrimal tubes through the inferior and superior puncta into the nose

- Pass the silastic lacrimal tubes through the superior and inferior puncta into the nasal cavity (*Figure 20*)
- Secure the tubes by tying the ends together, using 4-6 knots, on the nasal side
- It is important not to tie the tubes too tightly as this can cause adhesions between the puncta at the medial canthus; this is avoided by passing the tip of an artery clip through the loop at the medial canthus while knotting the tubes

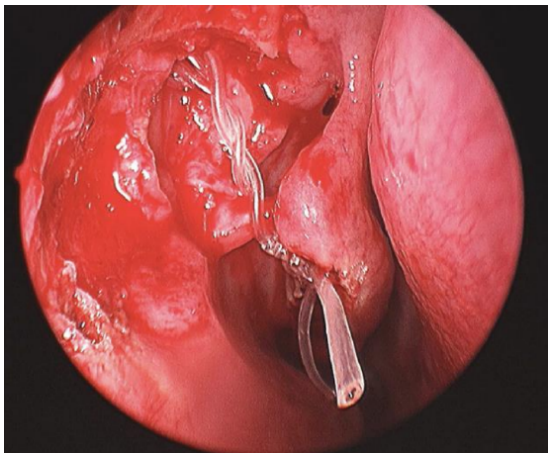


Figure 21: Endoscopic view of tied ends of silastic tubes passing through the common canaliculus into the nasal cavity

- Use a Tilley's nasal forceps to advance the knot, which is tied outside the nasal cavity, down the nasal cavity (*Figure 21*)
- The first knot should be about 5 mm below the opened sac to avoid the knots getting stuck within the sac itself
- Check that there is no tension on the tubes at the medial canthus or in the nose

Postoperative Care

- Patients are generally discharged within a few hours
- Prescribe a 5-day course of decongestant nasal drops
- Apply antibiotic eye drops for 2 weeks
- Irrigate the nose with saline
- Patients are again seen at 2 weeks to clean the nose, remove crusts and to remove early adhesions
- Silastic tubes are removed in the office after 4-6 weeks

Complications

Early

- Adhesions can form if care is not taken to preserve the mucosa of the nasal septum and middle turbinate
- If the tubes are tied too tightly, an adhesion can form at the medial canthus between the upper and lower puncta, and may require difficult oculoplastic corrective surgery
- If the tubes are tied too tightly in the nasal cavity the knots can cause granulation tissue at the neo-ostium
- Epistaxis is unusual unless there has been significant trauma to the nasal mucosa or turbinates

Late

- Restenosis
- Failed surgery

Revision surgery

Revision surgery is occasionally indicated. It is imperative that the reason for failure is ascertained, which may include:

- Not enough bone removed superiorly
- Not enough bone removed inferiorly causing a sump effect with tears collecting in the sac
- Sac not marsupialized widely enough
- Missed foreign body or stones within the sac
- Stenosis of the superior or inferior canaliculi
- Stenting that caused excessive granulations

References

1. Hurwitz JJ. The Lacrimal System. Lippincott-Raven Publishers, Philadelphia (1996).
2. Hurwitz JJ, Welham RAN. Radiography in functional lacrimal testing. Br J Ophthalmol 1975; 59:323–31
3. Hurwitz JJ, Molgat Y. Radiological test of lacrimal drainage. Diagnostic value versus cost-effectiveness. Lacrimal system. Symposium on the Lacrimal System, Brussels, 23–24 May 1992, pp 15– 26

Authors

Hisham Wasl MD, FCORL
University of Cape Town
Karl Storz Rhinology Fellow
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
hisham707@yahoo.com

Darlene Lubbe MBChB, FCORL
Associate Professor
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
doclubbe@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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EXTERNAL DACRYOCYSTORHINOSTOMY (DCR) SURGERY TECHNIQUE

Pieter Van Der Merwe, Hamzah Mustak

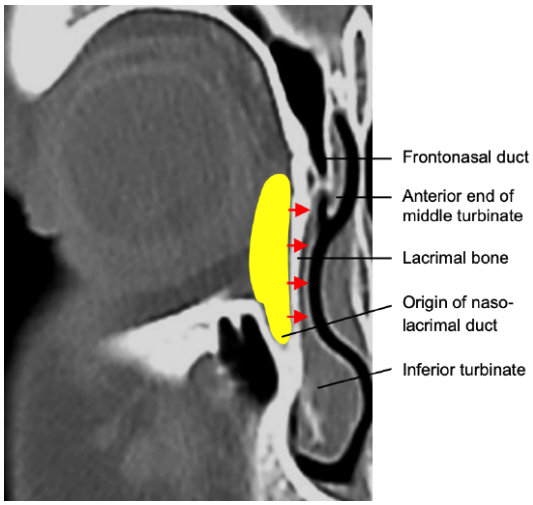


Figure 1: DCR involves removing the bone between the lacrimal sac (yellow) and the nasal cavity

Dacryocystorhinostomy (DCR) is done to bypass obstruction of the nasolacrimal duct i.e. distal to the lacrimal sac, to re-establish drainage of tears into the nasal cavity. It involves removing the bone between the lacrimal sac and the nasal cavity and anastomosing the mucosa of the lacrimal sac to the nasal mucosa (*Figure 1*).

The operation can be done either by external or endoscopic approach with success rates of >90% for both techniques. This chapter describes the external approach.

Etiology

Nasolacrimal duct obstruction (NLDO) can be categorized as ***either congenital or acquired. Congenital NLDO*** occurs because of an imperforate duct, often with a membrane overlying Hassner's valve. Most cases spontaneously open within the first year. Congenital NLDO requiring intervention responds well to direct probing and perforation of the membranous occlusion.

Acquired NLDO can be further categorized as either primary or secondary.

- ***Primary NLDO*** is a clinical syndrome characterized by chronic inflammation and fibrosis of the nasolacrimal duct. The exact pathogenesis is not known. It occurs most commonly in middle aged females.
- ***Secondary NLDO*** may be caused by trauma, chronic rhinosinusitis, chronic ocular surface inflammation and previous radiotherapy.

Clinical presentation of NLDO

Epiphora is the main presenting complaint. Epiphora is typically consistent and continuous, and worse with conditions that stimulate reflex tear production. Patients frequently report "thickened tears" with a sticky discharge most commonly noted on waking from sleep.

With total or near-total obstruction, a lacrimal sac mucocele may form. Patients can get recurrent episodes of acute infection of a mucocele presenting with a tender swelling in the area of the medial canthus (acute dacryocystitis).

Clinical evaluation

Evaluation of epiphora involves careful examination to exclude causes of reflex tear production as well as to determine the location and degree of obstruction within the outflow tract.

Lacrimal sac distension or a mucocele confirms the presence of NLDO. Patients who present with a mucocele or acute dacryocystitis therefore do not require probing and syringing as the clinical features are diagnostic of NLDO.

With partial NLDO, the presence of a thickened, increased tear lake and reflux on expression of the lacrimal sac are suggestive signs. Diagnostic probing and syringing are required in such cases to confirm a stricture in the outflow tract.

Diagnostic procedures

Confirmation of NLDO is achieved using both passive and active investigative procedures. Tests common utilized to evaluate the lacrimal drainage system are the dye disappearance test (DDT), and the Jones 1 (JT1) and Jones 2 tests (JT2). The tests are generally performed in the following order: DDT → JT1 → JT2.

Inserting instruments into the canaliculi

Procedures that require inserting instruments into the canaliculi include

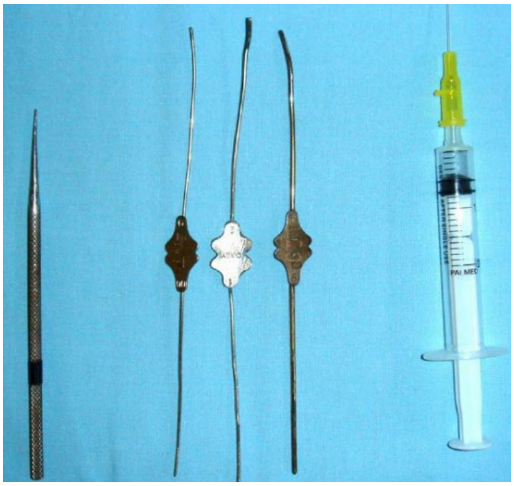


Figure 2: Dilator, Bowman probes and syringing instrumentation

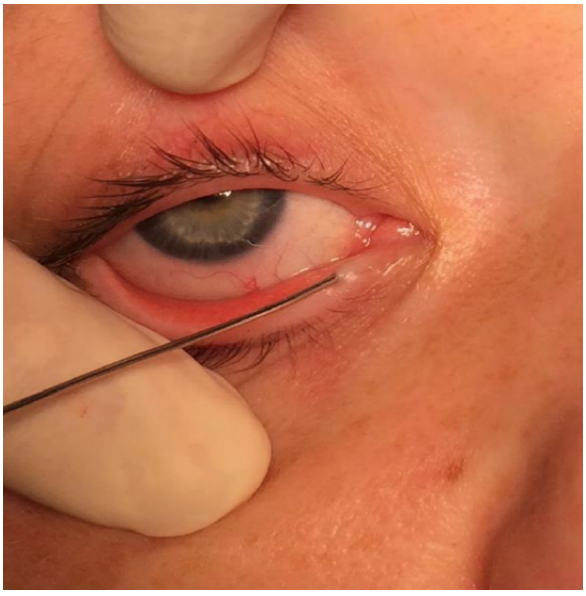


Figure 3: Punctum dilated with a punctum dilator

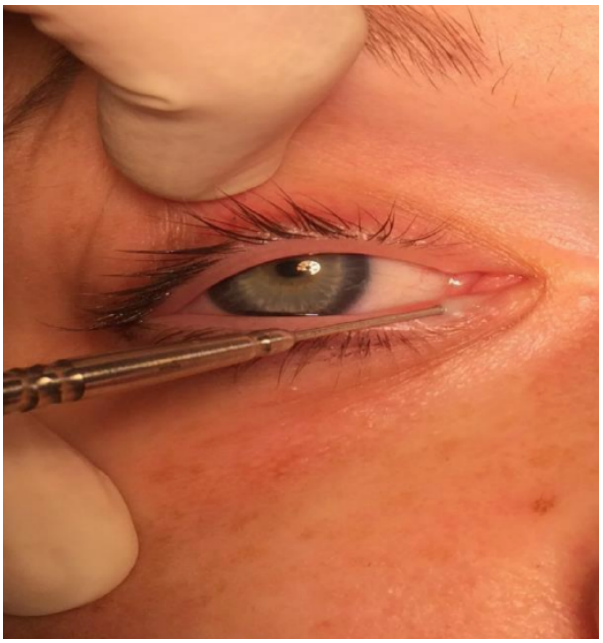


Figure 4: Diagnostic probing



Figure 5: Syringing via lower canaliculus

- Punctal dilation (*Figure 3*)
- Probing (*Figure 4*)
- Syringing (*Figure 5*)

Insert the instrument vertically into punctum for 2 mm, then put lateral traction on eyelid while rotating the instrument horizontally and advance the instrument horizontally toward nasolacrimal sac at the level of the medical canthal tendon (MCT).

The total distances of insertion are:

- Punctal dilation: As far as is necessary to dilate punctum
- Probing: ±12mm (or until hard/soft stop)
- Syringing: ±5mm

Dye disappearance test (DDT)

Technique

- Apply 1-2 drops of topical anesthesia e.g. Oxybuprocaine or Benoxinate HCl 0.4%, into the conjunctival fornix
- Wait 10 seconds before applying 1 drop of Fluorescein 2% into the conjunctival fornix
- Check the height of the fluorescein meniscus 5 minutes after applying the fluorescein

Findings

- Normal: little or no dye
- Abnormal: residual or excessive dye (also compare to contralateral side)

Interpretation

- Significant residual dye, especially if asymmetrical, could be indicative of physiological or anatomical (partial or total) obstruction

Jones test 1 (JT1)

- Apply topical anesthesia and fluorescein as described in the DDT (if not already applied)
- Check for fluorescein under inferior turbinate with cotton-tipped bud moistened in local anesthetic 5 min after applying fluorescein
- Positive JT1: Fluorescein on cotton bud
- Negative JT1: No fluorescein on cotton bud

Jones test 2 (JT2)

- Apply topical anesthesia as described in the DDT (if not already applied)
- Any residual fluorescein is washed from conjunctival fornix with saline irrigation
- Dilate punctum with a Punctal Dilator
- Warn patient that they might taste salty fluid in the back of the throat and that they will have to swallow it. It is important that they tell you if they taste it
- Insert a 24G (yellow) intravenous cannula as described above and syringe the lacrimal system with saline while holding a cotton bud under the inferior turbinate (*Figure 5*)
- Positive JT2: Fluorescein on cotton bud
- Negative JT2: No fluorescein on cotton bud

Probing and syringing

Probing can be diagnostic (congenital and acquired causes of epiphora) and therapeutic (only in congenital NLDO)

- Apply 1-2 drops of topical anesthesia e.g. Oxybuprocaine or Benoxinate HCl 0.4%, into the conjunctival fornix
- Dilate the puncta with a punctal dilator as described above (*Figure 3*)
- Probe the upper and lower canaliculi with a Bowman probe size “0” or “1” as described above (*Figure 4*)
- Only in Congenital NLDO
  - After hard stop, rotate the probe back to a vertical orientation while holding the probe flat on face
  - Advance the probe downwards, inferiorly, and laterally until a “pop” is felt as the probe enters the NLD
- Result and Interpretation
  - Soft stop (probe catching on soft tissue): Same canaliculus or common canaliculus obstruction
  - Hard stop (probe stopped by mucosa overlying lacrimal bone: no canalicular obstruction

Syringing

- Apply 1-2 drops of topical anesthesia (e.g. Oxybuprocaine or Benoxinate HCl 0.4%) into the conjunctival fornix
- Dilate puncta with punctal dilator as described above
- Warn patient that they might taste salty fluid in the back of their throat. It is important that they tell you if they taste it and that they will have to swallow it.
- Insert a 24G (yellow) intravenous cannula as described above and syringe the lacrimal system with saline mixed with fluorescein
- Interpretation of results is summarized in Table 2

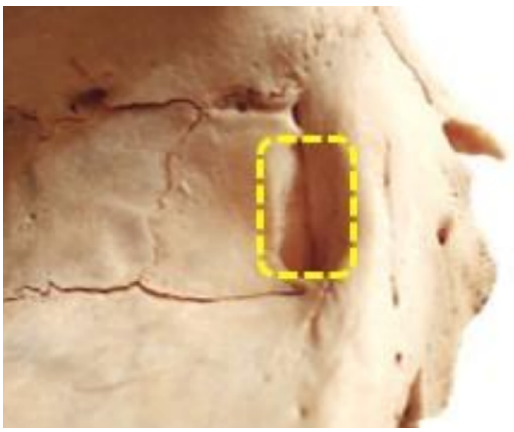


Figure 6: Area of bone removed

The objective of external DCR is to re-establish the lacrimal outflow passage into the nasal cavity by creating a fistula between the lacrimal sac and the nasal mucosa. To achieve this, a bony osteotomy involving the lacrimal and maxillary bones is created (*Figures 1*, *6*).

Surgical anatomy

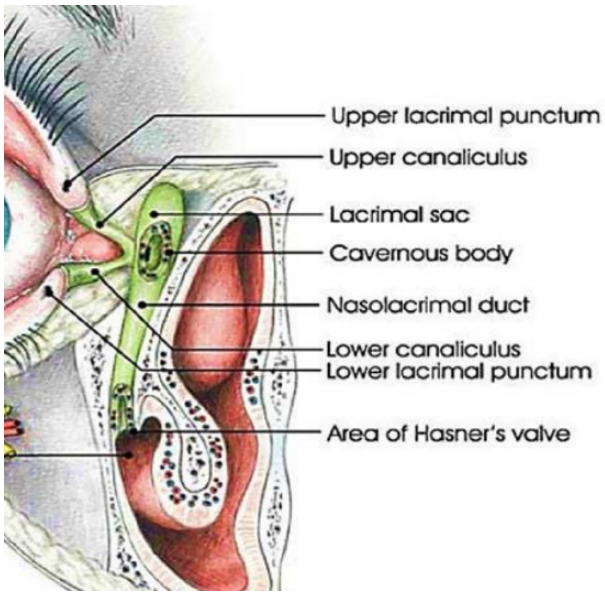


Figure 7: Ocular and nasolacrimal duct anatomy

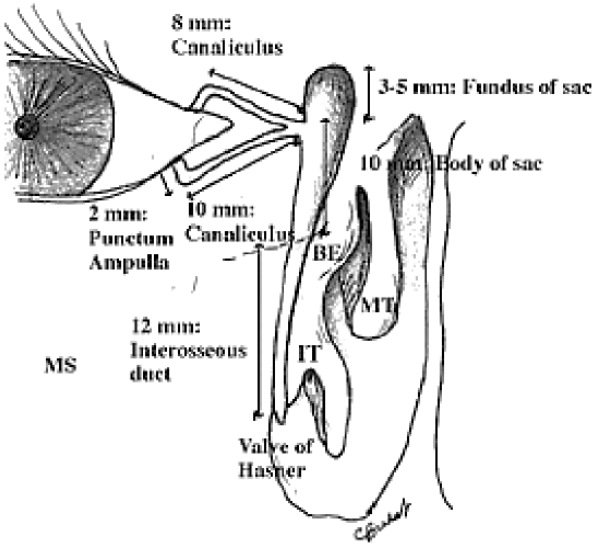


Figure 8: Approximate dimensions of the lacrimal excretory system. BE, bulla ethmoidalis; IT, inferior turbinate; MS, maxillary sinus; MT, middle turbinate http://www.oculist.net/downaton502/p...8/v8c002a.html

The lacrimal sac is located within the lacrimal fossa and drains into the nasolacrimal duct (*Figures 7*, *8*). The lacrimal puncta open at the medial ends of the upper and lower eyelids and drain into the lacrimal sac via the upper and lower canaliculi (*Figure 7*). The common canaliculus opens high on the lateral wall of the lacrimal sac.

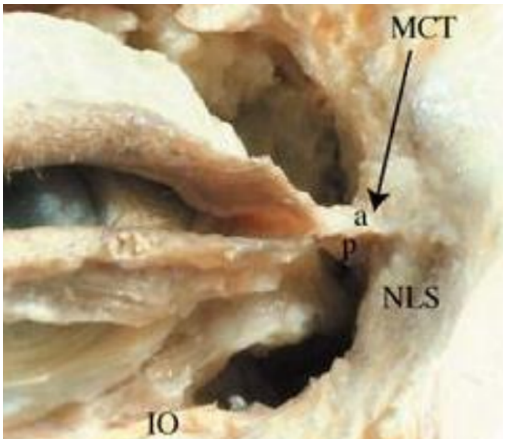


Figure 9: The thick anterior limb of the medial canthal tendon wraps along the anterior upper half of the lacrimal sac to insert onto the anterior lacrimal crest, and the thin posterior limb passes behind the sac to insert onto the posterior lacrimal crest. IO, inferior oblique muscle origin; MCT-a, medial canthal tendon-anterior limb; MCT-p, medial canthal tendonposterior limb; NLS, nasolacrimal sac http://www.oculist.net/downaton502/p...8/v8c002a.html

The lacrimal sac extends approximately 9 mm above the axilla of the middle turbinate. The thick anterior limb of the medial canthal tendon wraps along the anterior upper half of the lacrimal sac to insert onto the anterior lacrimal crest, and the thin posterior limb passes behind the sac to insert onto the posterior lacrimal crest (*Figure 9*).

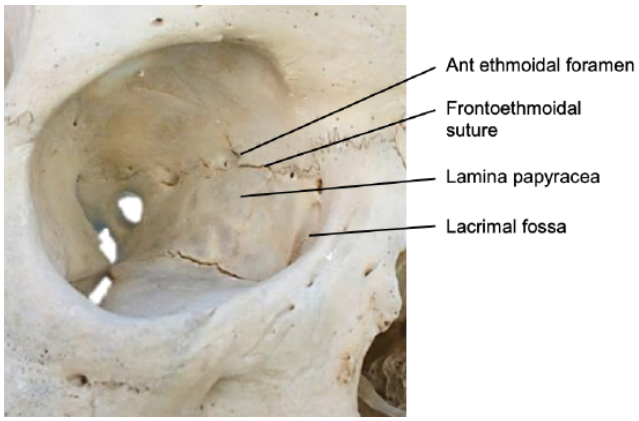


Figure 10: Right medial orbital wall

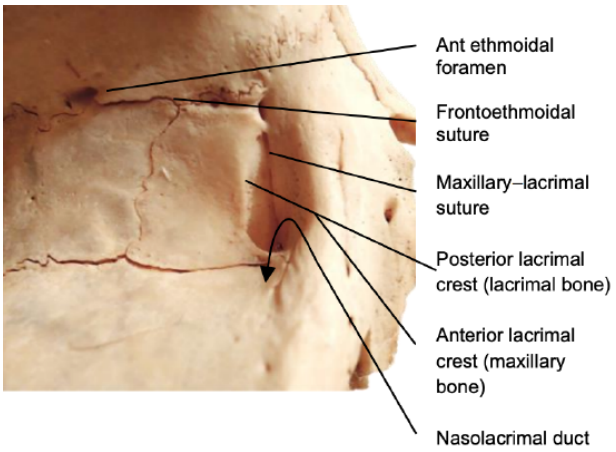


Figure 11: Anterior and posterior lacrimal crests are formed by the maxillary and lacrimal bones

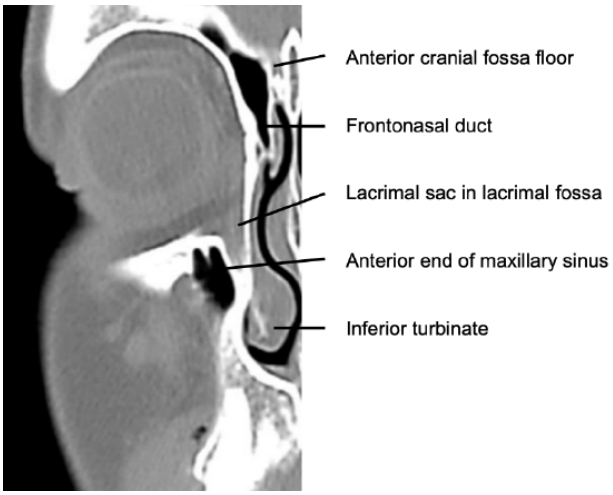


Figure 12: Coronal CT slice through lacrimal fossa

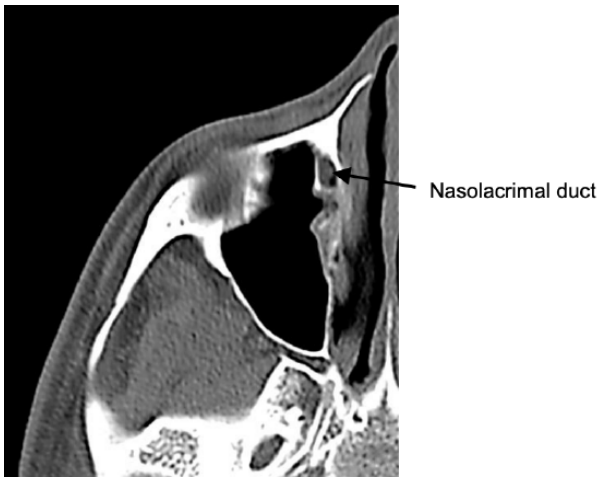


Figure 13: Nasolacrimal duct seen in axial cut at level of infraorbital nerve and orbital floor

The lacrimal sac is located within the lacrimal fossa (*Figures 10-12*). The nasolacrimal duct runs within a bony canal created by the maxillary and lacrimal bones and opens into the inferior meatus of the nose (*Figures 7, 8, 11-13*).

The lacrimal bone extends between the frontal process of the maxilla anteriorly (*Figure 11*), to the attachment of the uncinate posteriorly. It is important to note that the lacrimal bone and sac are located just anterior to the orbit. The retrolacrimal region of the lamina papyracea is a thin bone and forms the medial wall of the orbit (*Figure 10*)

Vasculature

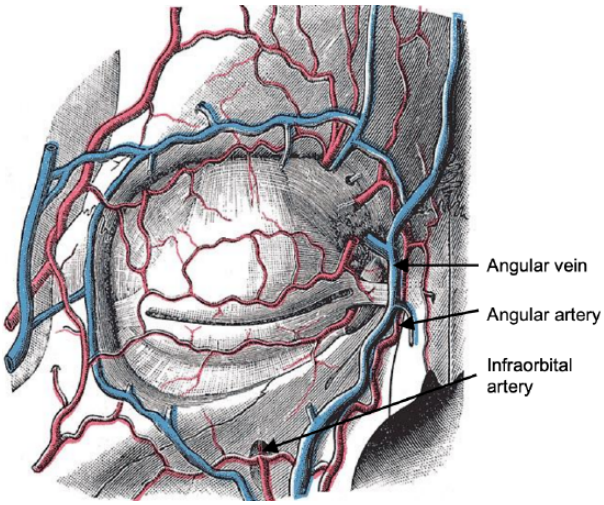


Figure 14: Vasculature around the orbit

The angular artery and angular vein are located near the medial orbit and are the only significant vessels encountered during external DCR (*Figure 14*).

The angular artery is generally a branch of the facial artery; however, some studies have shown that it can occasionally originate from the ophthalmic artery. It terminates in an anastomosis with the dorsal nasal branch of the ophthalmic artery.

External DCR steps

Anesthesia

Preferred routes of anesthesia

- General anesthesia with local anesthesia augmentation
- Local anesthesia with sedation

Local anesthesia

- 50:50 mix of 2% lignocaine and 0.5% bupivacaine with 1:00000-1:200000 epinephrine

- The authors use the following regional blocks:
  - Infratrochlear block
  - Infraorbital block
  - Anterior ethmoidal block
- In addition, the following areas are infiltrated with local anesthetic
  - Skin along intended incision
  - Nasal mucosa overlying the lacrimal fossa
- Topical anesthetic drops are instilled into the conjunctival fornix

General anesthesia / sedation

- Total intravenous anesthesia (TIVA) is considered the best as it avoids vascular dilatation caused by volatile gasses

Optimizing hemostasis

Preoperative

- Control blood pressure
- Stop anticoagulants in consultation with treating physician
- Rule out bleeding diathesis

10 min prior to starting surgery

- Insert ribbon gauze soaked in 2 mL 1:1000 adrenaline, between the inferior turbinate, nasal septum and into the middle meatus (superior and posterior direction)
- Administer local anesthesia as described above
- Administer broad spectrum antibiotic

Intraoperative

- Reverse Trendelenburg position (15^{o} head-up)
- General anesthesia
  - Hypotensive anesthetic
  - TIVA
- Local anesthesia with adrenaline as described above
- Judicious use of cautery
- Hemostatic powder or sponges should be available if needed
- Packing wound
  - Adrenaline /saline moistened gauze
  - Nasal packing with absorbable surgical cellulose sponge
- Gentle handling of tissues and avoiding known vessels

Instrumentation



Figure 15: Crescent knife



Figure 16: Kerrison Punch

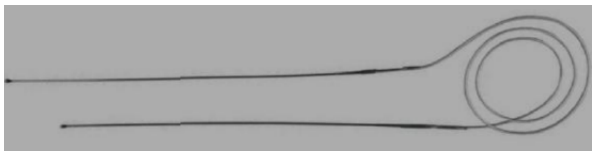


Figure 17: Crawford stents

- Toothed forceps
- Needle holder
- Punctal dilator (*Figure 2*)
- Bowman probe 0 or 1 (*Figure 2*)
- Freer's periosteal elevator
- Blades
  - No 15-scalpel blade
  - Crescent knife (*Figure 15*)
- Kerrison Punch (*Figure 16*)
- Stitches
  - 4-0 chromic or 6-0 vicryl
  - 6-0 silk
- Lacrimal (Crawford) stents (*Figure 17*)

Surgical Steps

1. Incision



Figure 18: Skin incision site is marked 3-4 mm anterior to the medial canthus and 10-20 mm in length

- Make a 10-20 mm (depending on age) skin incision with a No 15 scalpel blade (*Figure 18*)
- Start 3-4 mm medial to medial canthus and 2-3 mm above the MCT, and curve the incision along the apex of the anterior lacrimal crest, extending it inferiorly and laterally
- Avoid injuring the angular artery and vein
  - Make the initial incision only though skin to avoid the angular vessels that run at a deeper plane
  - Dissect bluntly through the subcutaneous tissue
  - Identifying the angular vessels and keep them reflected medially throughout surgery



Figure 19: Blunt dissection through the orbicularis oculi to expose the anterior limb of the MCT. The angular vein is displaced anteriorly

- Dissect through subcutaneous tissue and orbicularis to the periosteum (*Figure 19*)
  - Blunt dissection with spring scissors
  - Identify, avoid, and reflect the angular vessels medially
  - Expose and identify the MCT as an important anatomical landmark

2. Periosteal elevation and reflecting sac out of the lacrimal fossa



Figure 20: Elevating the lacrimal sac from lacrimal fossa



Figure 21: Periosteal elevator is used to strip the anterior limb of the medial canthal tendon to start the subperiosteal dissection

- Use a Freer's periosteal elevator to incise the periosteum with a side-to-side cutting motion along the anterior lacrimal crest (*Figure 20*)
- Elevate the periosteum
  - Posterior to the anterior lacrimal crest, lifting the lacrimal sac out of the lacrimal fossa, until you reach the lamina papyracea
  - Superiorly & inferiorly as much as is reasonably possible
  - MCT: Some authors preserve the MCT while others free up the MCT with the periosteum

3. Create and enlarge the bony ostium

It is important to avoid inadvertently injuring your nasal mucosa by Initial controlled inward fracture of the lacrimal fossa bone with the Freer's periosteal elevator, and gentle insertion of the Kerrison's bone punch between bone and nasal mucosa during bone removal

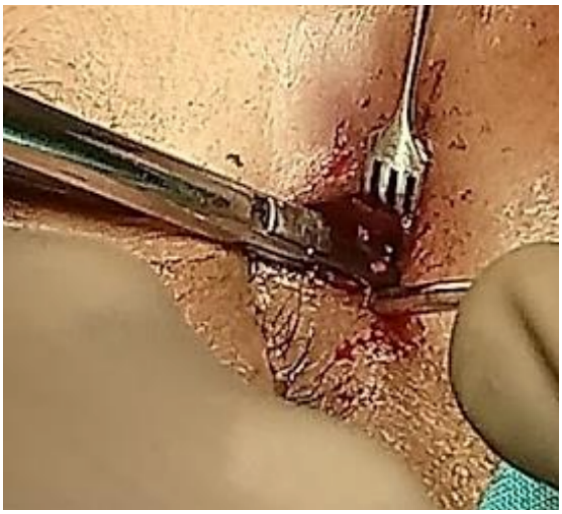


Figure 22: A Kerrison's punch is used to create an osteotomy by removing lacrimal bone. Care is taken not to injure the underlying nasal mucosa



Figure 23: Exposure of nasal mucosa via wide osteotomy

- Fracture the thin bone of the lacrimal fossa inward with the Freer's periosteal elevator
- Enlarge the ostium with a Kerrison punch (*Figure 22*)
  - Anteriorly: up-to-and-including the anterior lacrimal crest
  - Posteriorly: up-to-and-including the posterior lacrimal crest (up to lamina papyracea)
  - Superiorly: to just inferior to the MCT
  - Inferiorly: to the beginning of the NLD
- Expose the nasal mucosa via a wide osteotomy (*Figure 23*)

4. Create a lacrimal sac flap



Figure 24: A Bowman probe is then inserted into the lower canaliculus and advanced into the sac. The sac can then be tented as shown to aid incision of the sac



Figure 25: A No 10 blade is used to incise the sac over the probe to avoid injuring the common canalicular opening



Figure 26: Incision into the sac reveals the Bowman probe as well as the intact common canalicular opening



Figure 27: Wescott spring scissors

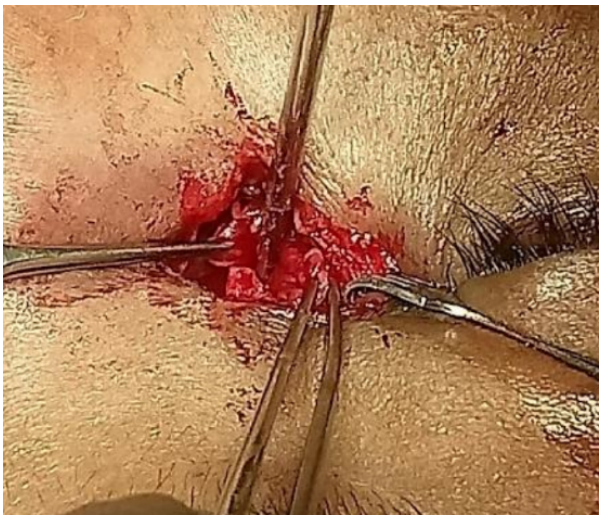


Figure 28: An H shaped flap is created in the lacrimal sac mucosa as well as in the nasal mucosa to create anterior and posterior flaps

- Dilate the upper and lower puncta with the punctal dilator as previously described
- Probe the lacrimal sac with a Bowman probe 0 or 1. Use the probe to tent the lacrimal sac and to create counterpressure for to incise the sac (*Figure 24*)
- Tent the lacrimal sac more posteriorly as this will create a longer anterior flap (*Figure 24*)
- Incise the lacrimal sac in an H-configuration, thereby creating both anterior and posterior flaps (*Figures 25, 26*)
- Make the 1st incision in a superiorinferior direction with a crescent knife. One can use Wescott spring scissors to extend the incision superiorly and inferiorly (*Figure 27*)
  - Try to make this incision a little more posteriorly as this will create a longer anterior flap and shorter posterior flap
  - Superiorly, direct the blade away from common canaliculus to avoid injury
  - Inferiorly, extend the incision to the NLD opening to avoid lacrimal sump syndrome
- The subsequent incisions are horizontal cuts to create an H-configuration. The crescent knife or the Wescott spring scissors can be used for this purpose

5. Create a nasal mucosal flap

- Incise the nasal mucosa in an H-configuration, thereby creating anterior and posterior flaps
- The 1st incision is made in a superiorinferior plane with a crescent knife. One can also use spring scissors to extend the incision superiorly and inferiorly
- Try to make the nasal mucosal incision the same length as the one in the lacrimal sac
- Make this incision a little more posteriorly to create a longer anterior and a shorter posterior flap
- The subsequent incisions are horizontal cuts to create an H-configuration. The crescent knife or the Wescott spring scissors can be used for this purpose

6. Suture the posterior flaps

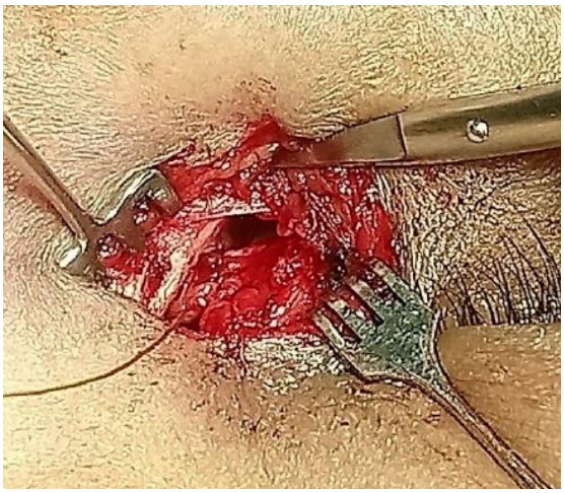


Figure 29: The posterior flaps are sutured together with the inserted lacrimal probes lying between the anterior and posterior flaps

- Suture the posterior nasal and lacrimal sac flap together with 4-0 chromic or 6-0 vicryl (*Figure 29*)
- 2x interrupted stitches are usually adequate
- A half circle needle is more convenient as this suture is passed deep in the wound

OR

- Amputate the posterior flaps

7. Intubate upper and lower canaliculi



Figure 30: Lacrimal stents are intubated into the canaliculi, advanced into the sac, and guided into the nose via the newly created ostium



Figure 31: The tubes are then retrieved from the nose

- The upper and lower puncta have already been dilated
- Intubate the upper and lower canaliculi with Crawford or other preferred lacrimal stents and pass the tubes out through the nose (*Figures 30, 31*)
- Tie the tubes together with 4-0 silk just inside the nasal opening so they do not become displaced
- Put the tubes on a mild stretch and at a length where if the tension on the tubes is released, they retract to just inside the nose where they do not bother the patient
- Check that the tube is not too tight at the medial canthus as it may cause lead to “cheese-wiring” of the medial canthus
- Cut the tubes at nasal opening while applying putting the tubes on a mild stretch

8. Suture the anterior flaps



Figure 32: Anterior flaps sutured over the stent with 4/0 chromic suture

- Suture anterior flaps together with 4-0 chromic or 6-0 vicryl (*Figure 32*)
- 2x interrupted sutures are usually adequate
- Excessive nasal mucosa can be:
  - Excised in a controlled manner

OR

- Sutured to the overlying orbicularis oculi muscle

9. Wound closure



Figure 33: Orbicularis and skin are closed in layers with absorbable sutures such as 6/0 vicryl or 6/0 chromic suture

- Orbicularis oculi is approximated with interrupted 6-0 Vicryl (*Figure 33*)
- Skin is closed with interrupted 6-0 silk

Postoperative care

Discharge instructions and medications

- Bedrest with head-up positioning for 24 hours to reduce nasal venous congestion
- Hot drinks and food avoided for 12 hours to reduce epistaxis due to vasodilation
- Nose blowing avoided for 1 week
- Dressing removed Day 1
- Medication
  - Antibiotic/steroid drop qid into conjunctival fornix
  - Saline nasal douche tds… continue for 1 month after surgery
  - Paracetamol po
  - Antibiotic ointment to skin wound

At 1-week follow-up visit

- Remove skin sutures
- Medication
  - Saline nasal douche tds until 4 week visit
  - Antibiotic/steroid drops qid until 4 week visit

At 4-week visit

- Remove stents
- Stop medication

Complications

Intraoperative

- Bleeding
- Canalicular injury
  - Gently pass probes and tubes to avoid forming false tracts
  - Direct scalpel blade away from the common canaliculus when creating the lacrimal sac flaps
- Cerebrospinal fluid leak: Caused by inadvertent fracture of the cribriform plate
- Orbital entry causing prolapse of orbital fat

Postoperative (Early)

- Hemorrhage
  - Mild: Head-up position and nasal icepacks

- Moderate: Pack the nose with nasal tampon or ribbon gauze moistened in 1:1000 adrenaline
- If severe or persistent: consult ENT

- Stent prolapse or canalicular “Cheesewiring”
- Wound infection (Single dose intraoperative systemic antibiotic recommended for prophylaxis)
- Wound breakdown with fistula

Postoperative (Late)

- Keloid
- Nasolacrimal drainage failure, usually due to too small anastomosis window
- Lacrimal sump syndrome due to lacrimal sac not incised inferiorly up to opening of NLD

Recommended reading

Surgical Anatomy of the Lacrimal Fossa. A Prospective Computed Tomodensitometry Scan Analysis Ophthalmology 2005;112: 1119 - 28 © 2005

Physiology of the Lacrimal System by Burkat CN, Hodges RR, Lucarelli MJ, and Dartt DA

Authors

Pieter Van Der Merwe MBChB, FCOphth (SA)
Division of Ophthalmology
University of Cape Town
Cape Town, South Africa
pjsvandermerwe@hotmail.com

Hamzah Mustak, MBChB, FCOphth (SA)
Specialist in Ocular Oncology, Oculoplastics & Orbital surgery
Division of Ophthalmology
University of Cape Town
Cape Town, South Africa
hamzah.mustak@uct.ac.za

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ENDOSCOPIC APPROACH TO ORBITAL CAVERNOUS HEMANGIOMA (OCH) AND INTRACONAL TUMORS: SURGICAL ANATOMY AND TECHNIQUES

Catherine Banks, Benjamin Bleier

The position of intraconal tumors relative to the optic nerve dictates the choice of surgical approach. Tumors with their epicenter medial to the optic nerve or “below a plane of resectability” (POR), which represents a plane subtended by the contralateral nostril and the long axis of the optic nerve, are amenable to an endoscopic approach. The feasibility and safety of this approach has been demonstrated in the literature. Tumors located lateral and superior to the POR are not candidates for an exclusively endoscopic resection.

The composition of the surgical team varies depending on the institution. However, a multidisciplinary team including an otolaryngologist, oculoplastic surgeon and in some cases, a neurosurgeon, is invaluable.

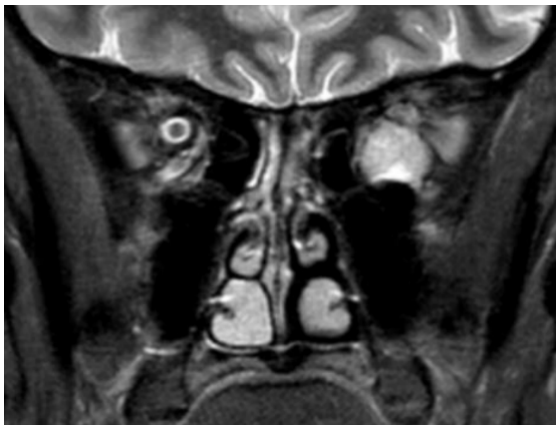


Figure 1: Coronal T2 weighted MRI scan demonstrating a left OCH

The endoscopic approach to intraconal tumors will be described in this chapter using orbital cavernous hemangioma (OCH) as an example, as is it the most common primary orbital tumor in adults, with a reported incidence of 5-15% of all orbital tumors (*Figure 1*).

Orbital cavernous hemangiomas (OCH)

The International Society for the Study of Vascular Anomalies classifies OCHs as slow-flow cavernous venous malformations. OCHs are more common in women and occur in the 4th and 5th decades of life[1]. The natural history remains elusive. Progesterone may play a role in the clinical course which may explain sudden growth of OCH seen during pregnancy and a reduction in size or stabilization in postmenopausal women; however, the exact role of progesterone is yet to be fully elucidated.

A significant number of OCHs present as asymptomatic lesions incidentally found on CT or MRI performed for unrelated reasons. Previous studies have shown that asymptomatic lesions often show no progression[2,3]. In many cases if an incidental OCH does not change over several years, it is unlikely to do so over more prolonged periods of followup.[4]

The majority are located between the optic nerve and the extraocular muscles and are therefore intraconal. It is well documented that OCH have a predilection for the intraconal space. The single most common anatomical location is lateral to the optic nerve, which may reflect the relationship between the optic nerve and the distribution of the ophthalmic vasculature. However, OCH can be found throughout the orbit, including the medial intraconal space, extraconal space, and within the optic canal.[5] Rarely, they extend beyond the confines of the orbit into the pterygopalatine fossa,[6] cavernous sinus,[7] and intracranial space.[8]

Histologically OCHs appear as cavernous venous malformations and have exclusively venous vasculature. Despite suggestion of arterial flow on imaging studies, histologically there is no evidence of the elastic lamina associated with arterioles. The thicker walled vessels are thought to be the result of thrombosis and recanalization. If any arterial component is present, it is thought to be inconsequential both histologically and clinically.[9] OCHs are characterized as lesions with mature cellular components and do not tend toward dysplasia or hypercellularity. Although they can incorporate surrounding vessels and nerves, they do not typically infiltrate into surrounding tissue.[10] OCHs tend to be slow growing vascular lesions with a radiological growth rate of 10-15% per year.[10] The growth of OCH is thought to be a cycle of stasis and thrombosis with endothelial cellular proliferation and recanalization into multiple clefts and vascular channels.

They have a firm fibrous capsule that makes them amendable to endoscopic resection. Surgical resection is indicated for symptomatic lesions whilst smaller asymptomatic lesions can be observed. The goal of surgery is definitive resection. However, given its benign nature, complete resection must be balanced against iatrogenic morbidity. Partial resection of intraconal OCH has been reported, but long term outcomes remain unknown.[14]

Surgical approach

The position of intraconal OCHs within the orbit relative to the optic nerve dictates the choice of approach. OCHs with an epicenter medial to the optic nerve or "below a plane of resectability" (POR), which represents a plane subtended by the contralateral nostril and the long axis of the optic nerve, are amenable to an endoscopic approach.[11] The feasibility and safety of this approach has been consistently demonstrated.[10,12-20] OCHs located lateral and superior to the POR are not candidates for an exclusively endoscopic resection.[21]

Surgical anatomy

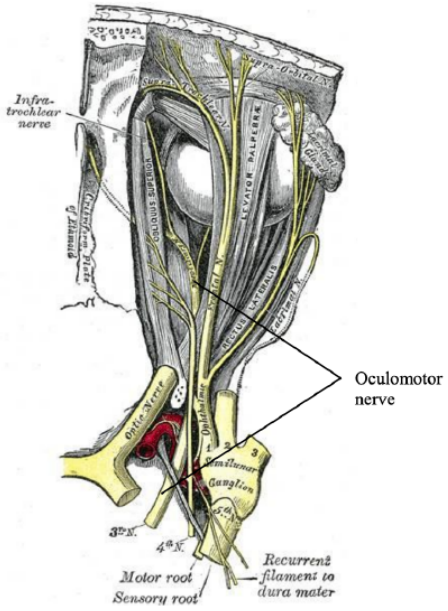


Figure 2: A branch of the oculomotor nerve penetrates the medial rectus one-third of the distance from the annulus of Zinn to its insertion onto the globe

Knowledge of the neurovascular anatomy within the orbit is crucial and directs safe placement of a ball probe on the medial rectus and the degree of retraction. A branch of the oculomotor nerve penetrates the medial rectus one-third of the distance from the annulus of Zinn to its insertion onto the globe (*Figure 2*); therefore, direct or prolonged traction here should be avoided.[22]

Operating room set-up

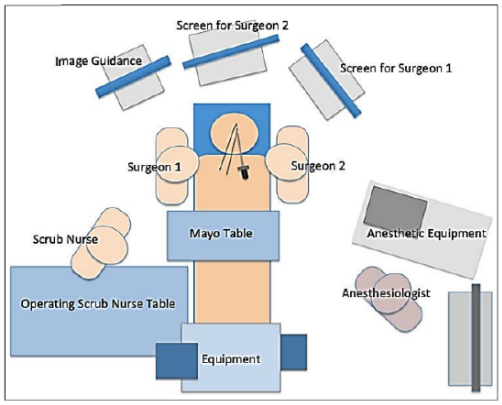


Figure 3: The operating room setup for a binarial four-handed 2 surgeon transseptal approach. The endoscope is held by surgeon 2 (in this case for a left-sided tumor; the surgeons can be reversed for right-sided tumors). Surgeon 1 performs the dissection and retraction

Figure 3 demonstrates a typical layout of the operating room. This allows for a binarial, four-handed transept approach that is commonly used for intraconal OCH resection. With a binarial approach, a posterior septectomy or septal window is required. This has minimal morbidity, allows maneuvering of endoscopes and other instruments, and may be integrated into elevation of a nasoseptal flap for medial wall reconstruction.[20]

Essential instrumentation (Figure 4)



Figure 4: (A) Penfield dissector number 4; (B) Curved olive tip suction; (C) Frazier suction cannula; (D) Lusk ball tip probe

- Rigid endoscopes:
  - 0-degree
  - Angulated 30, 45 and 70-degree
- Pledgets soaked in saline
- Suction cannulae
  - Frazier size 9 and 10
  - Curved olive tip suction
- Medial rectus retractor
- Penfield dissector Number 4
- Lusk ball tip probe

Surgical Steps

1. Anesthesia and positioning

The patient is placed supine in a head ring with the head of the bed raised 15-30 degrees. Total intravenous anesthesia is used. The patient is intubated with the tube positioned to the left. The room is set up as seen in *Figure 3*.

2. Preparation of nasal cavity

The nasal cavity is prepared with cottonoid pledgets soaked in 1:1000 adrenaline. This is then changed to saline soaked pledgets once the periorbita are exposed. The nasal cavity is infiltrated with 10 mL of lignocaine 1% with 1:100,000 adrenaline.

3. Create a working space and define orbital wall and orbital axis

This is a fundamental part of the surgery and requires the following

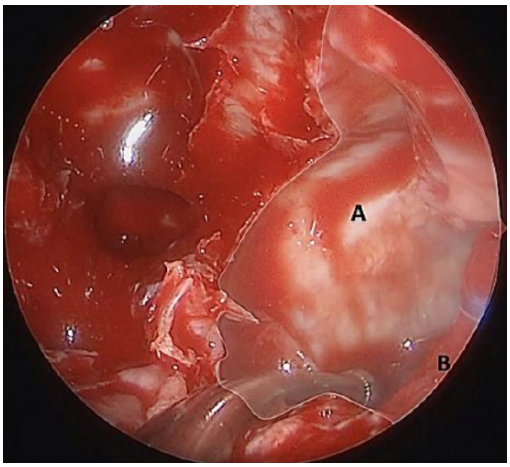


Figure 5: Placement of cottonoid to retract left posterior maxillary mucosa. (A) marks the maxillary sinus with the mucosa elevated to expose the bone of the posterior maxillary wall; (B) indicates the cottonoid placed between the mucosa and posterior maxillary wall to assist with the dissection and securing and protecting the mucosa

- Complete uncinectomy
- Wide maxillary antrostomy
- Sphenoethmoidectomy
- The middle turbinate may be resected to improve access and visibility
- Reflect the mucosa from medial to lateral off the posterior wall of the maxillary antrum
- Use the Lusk ball probe to assist with removal of the maxillary sinus mucosa and place a pledget to hold the mucosa out of the operating field (*Figure 5*)

4. Posterior septectomy & nasoseptal flap

- The need for a posterior septectomy vs. a septal window with reconstruction is based on the tumor location and extent of the dissection required
- Raise the nasoseptal flap on the contralateral side of the nose
- Tailor the size of the flap to the individual case
- Begin the incision inferiorly, starting at the anterior inferior choana and sweeping anteriorly and inferiorly towards the floor of the nose
- Carry this incision anteriorly along the floor of the nose, and tailor it to the anticipated defect of the exposed lamina papyracea
- Raise the anterior flap by blunt dissection with a Cottle elevator to the sphenoid ostium
- Make the superior incision with cold steel dissection
- Tuck the flap into the nasopharynx until completion of the resection
- The septectomy is then made posteriorly in a location that will permit unrestricted passage of instruments

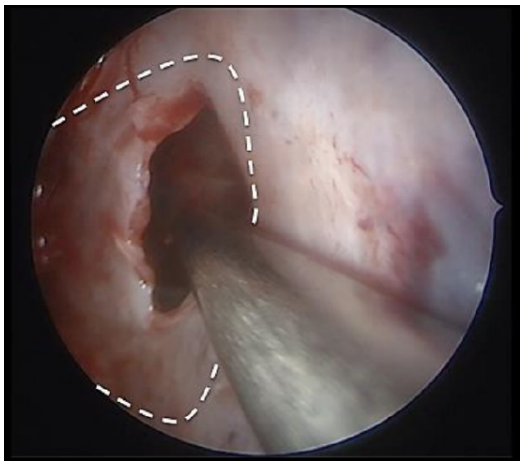


Figure 6: Nasal septal flap (outlined) and posterior septectomy viewed from right (contralateral) nose

5. Posterior maxillary wall and orbital process of palatine bone

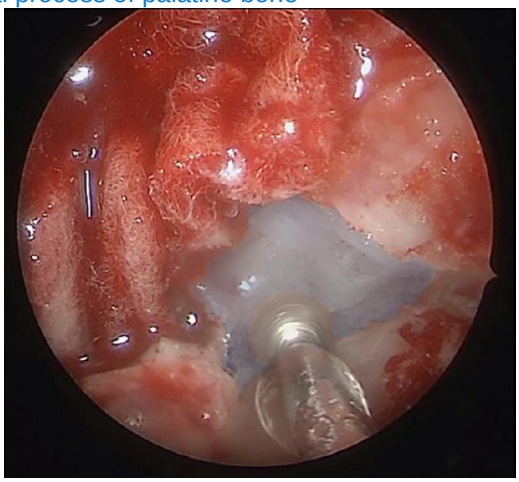


Figure 7: Posterior medial maxillary wall over the orbital process of the palatine bone is drilled with 15-degree diamond burr. (Blue - highlights the location of the orbital process of the palatine bone)

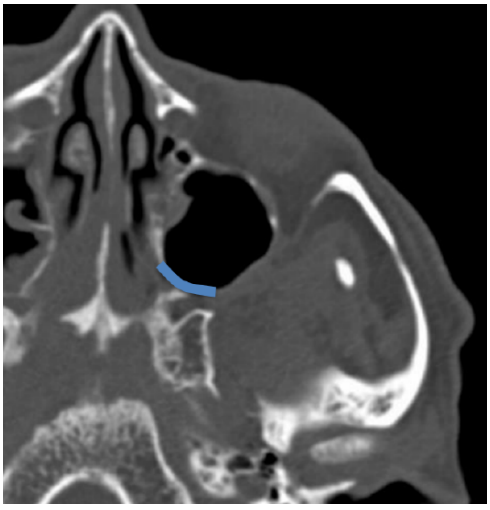


Figure 8: Axial CT scan demonstrating where bone is removed from the posterior medial maxillary wall and the orbital process of the palatine bone is thinned

- The ipsilateral posterior maxillary wall and the orbital process of the palatine bone is then thinned using a 15-degree diamond burr (*Figures 7*, *8*)
- Removing the orbital process provides an additional 0.36+/-0.42cm^3 of exposure in the inferolateral vector.[23]

6. Exposing periorbita (Figures 9, 10)

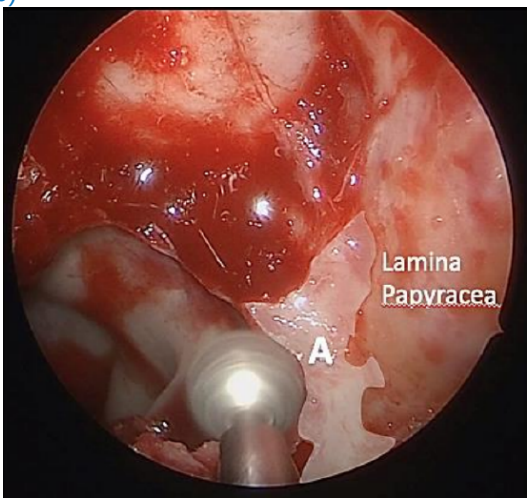


Figure 9: Lamina papyracea removal and drilling of the thick optic strut

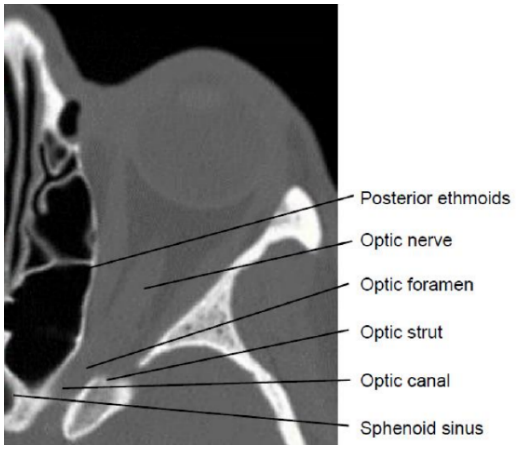


Figure 10: CT scan illustrating lamina papyracea and the thick optic strut

- Remove the lamina papyracea with blunt dissection to expose the underlying periorbita
- If necessary, the optic strut may be drilled to facilitate safe removal of the bone overlying the optic nerve (*Figure 10*)

7. Retraction of medial rectus

- Create a periorbital window to identify the extraconal fat and muscles

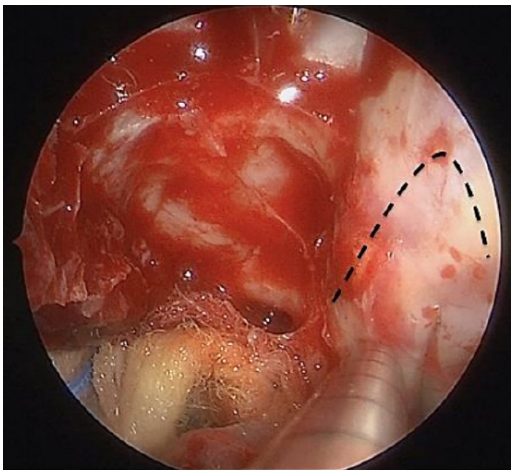


Figure 11: Incision line of the periorbita in a reverse hockey stick fashion. This can be performed with a sickle knife

- Incise the periorbita in a reverse hockey stick fashion using a sickle knife (*Figure 11*)
- Place the incision just anterior to the border of the tumor to prevent unnecessary fat prolapse into the anterior surgical field

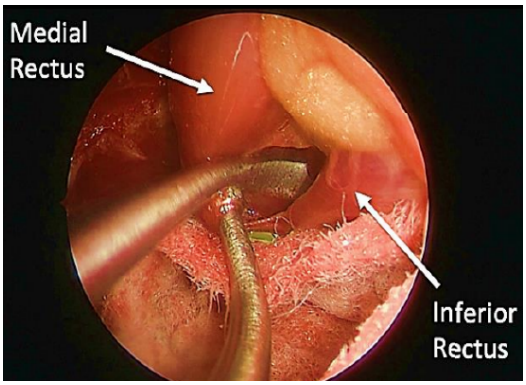


Figure 12: Medial rectus as a landmark of the medial orbit retracted to enter the intraconal space

- The ***intraconal dissection corridor*** is bordered by the medial rectus muscle above and the inferior rectus muscle below (*Figure 12*)
- Use a dissector e.g. Penfield or Lusk probe to bluntly dissect between the medial and inferior rectus muscles and to visualize the intraconal space
- The medial rectus serves as a landmark of the medial orbit and must be retracted to access intraconal OCHs
- Retract the medial rectus with care using a right-angled instrument under the inferior border of the muscle and gently and dynamically retract the muscle in a superomedial direction to prevent postoperative diplopia

8. Hemostasis

Judicious and precise use of bipolar cautery, saline soaked cottonoid pledgets, and warm water irrigation are relatively safe. Avoid monopolar cautery within the orbit due to the significant risk of thermal injury to important neural structures.

9. Orbital fat

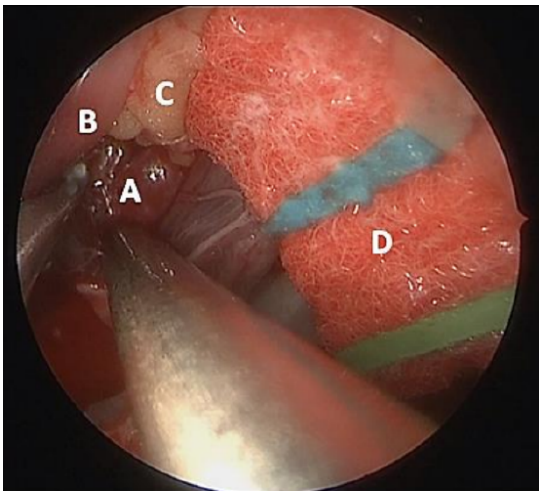


Figure 13: Cottonoid pledgets used to retract the intraconal fat. (A) Intraconal hemangioma; (B) Medial rectus; (C) Intraconal orbital fat; (D) Cottonoid pledget retracting orbital fat

Fat herniation can be troublesome and keeping the intraconal dissection corridor open is challenging. Preserving extraconal fat not only helps to preserve orbital volume, but also minimizes the risk of medial rectus scarring and entrapment. Proper placement of the periorbital incision as previously described and the use of cottonoid pledgets to separate and retract the orbital fat can assist with visualization and should avert the need to remove extraconal fat (*Figure 13*).

10. Resection techniques

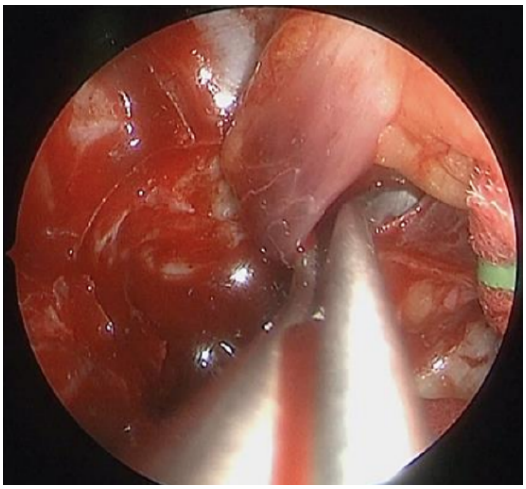


Figure 14: Blunt dissection is employed using the Lusk ball probe to retract the medial rectus and the Penfield number 4 dissector to resect the OCH

- The fibrous capsule permits dissection in an extracapsular plane with preservation of the capsule
- A process of gentle traction, use of cottonoids, and blunt dissection is used
- Sharp cutting instruments have also been used but do increase the risk of bleeding from inadvertent arteriolar injury
- Incomplete resection has been documented in cases where the lesion is adherent to the optic nerve, although long-term follow-up results are unknown [14]

11. Reconstructing medial orbital wall

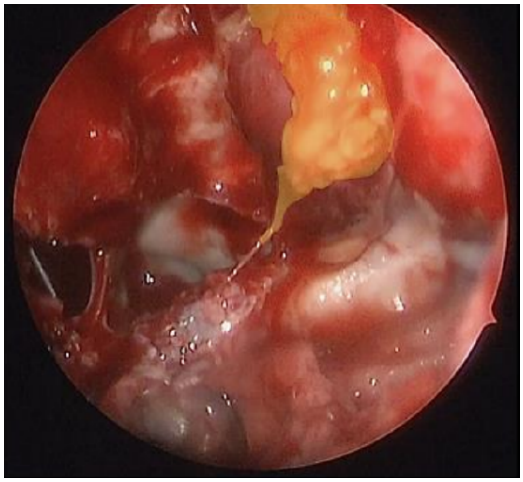


Figure 15: Extraconal orbital fat placed over the medial rectus muscle

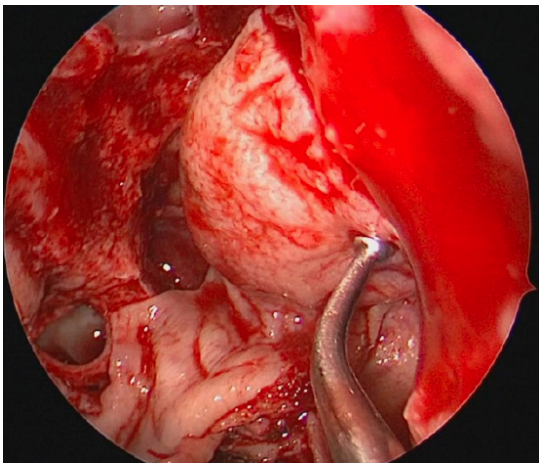


Figure 16: The pedicled nasoseptal flap draped along the medial orbital wall



Figure 17: A left compartment syndrome with an IOP of 55 mmHg

- Placement of orbital fat over the exposed extraocular muscles should be considered to prevent scarring [12,26] (*Figure 15*)
- Reconstructing the medial orbital wall to preserve orbital volume should be strongly considered following removal of intraconal or large extraconal lesions
- There is no clear consensus on the best method of reconstruction
- A pedicled nasoseptal flap technique is preferred by the authors as it provides the opportunity for delayed contraction thereby reducing the risk of diplopia and enophthalmos [26] (*Figure 16*)
- Immediate rigid reconstruction does place the orbit at risk for compartment syndrome secondary to edema and postoperative bleeding (*Figure 17*)

12. Nasal packing

There is lack of consensus on the use of post-surgery nasal packing. Nasal packing is not recommended by some studies, citing possible exertion of pressure on the globe or optic nerve.[12,21] Alternatively, absorbable hemostatic packing has been used [27] and the use of a polyvinyl acetate sponge placed in the nasal cavity to assist with adherence and positioning of a nasoseptal flap for 7 days has been reported. However, packing should not be placed in a position which could risk exerting direct pressure on the exposed orbit.

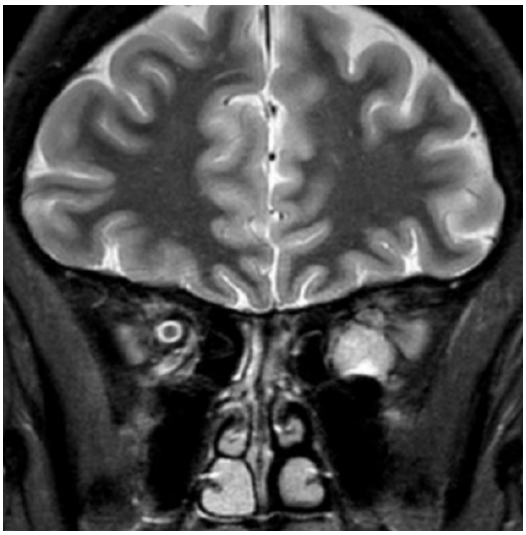


Figure 18a: A T2-weighted MRI coronal scan demonstrating a left orbital hemangioma

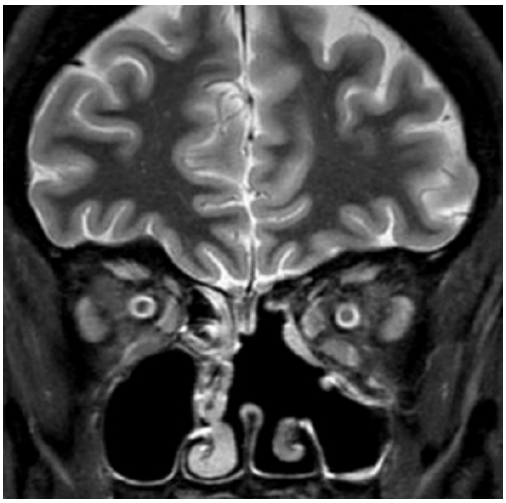


Figure 18b: A T2-weighted MRI coronal scan demonstrating postoperative situation with a left nasoseptal flap positioned along the medial orbital wall

References

1. Calandriello L, Grimaldi G, Petrone G, et al. Cavernous venous malformation (cavernous hemangioma) of the orbit: Current concepts and a review of the literature. Surv Ophthalmol. 2017; 62 (4):393-403
2. 2. Scheuerle AF, Steiner HH, Kolling G, Kunze S, Aschoff A. Treatment and long-term outcome of patients with orbital cavernomas. Am J Ophthalmol. 2004;138(2):237-44
3. Harris GJ, Perez N. Surgical sectors of the orbit: using the lower fornix approach for large, medial intraconal tumors. Ophthalmic Plast Reconstr Surg. 2002;18(5):349-54
4. McNab AA, Tan JS, Xie J, et al. The natural history of orbital cavernous hemangiomas. Ophthalmic Plast Reconstr Surg. 2015;31(2):89-93
5. Chen Y, Tu Y, Chen B, et al. Endoscopic Transnasal Removal of Cavernous Hemangiomas of the Optic Canal. Am J Ophthalmol. 2017; 173:1-6
6. Yoshimura K, Kubo S, Yoneda H, Hasegawa H, Tominaga S, Yoshimine T. Removal of a cavernous hemangioma in the orbital apex via the endoscopic transnasal approach: a case report. Minim Invasive Neurosurg. 2010;53(2):77-9
7. Wiwatwongwana D, Rootman J. Management of optic neuropathy from an apical orbital-cavernous sinus hemangioma with radiotherapy. Orbit. 2008;27(3):219-21
8. Lee KY, Fong KS, Loh HL, et al. Giant cavernous hemangioma mimicking a fifth nerve neurofibroma involving the orbit and brain. Br J Ophthalmol. 2008;92(3): 423-5
9. Rootman DB, Heran MK, Rootman J, et al. Cavernous venous malformations of the orbit (so-called cavernous hemangioma): a comprehensive evaluation of their clinical, imaging and histologic nature. Br J Ophthalmol. 2014;98(7): 880-8
10. Bleier BS, Castelnuovo P, Battaglia P, et al. Endoscopic endonasal orbital cavernous hemangioma resection: global experience in techniques and outcomes. Int Forum Allergy Rhinol. 2016;6(2):156-61
11. Gregorio LL, Busaba NY, Miyake MM, et al. Expanding the limits of endoscopic intraorbital tumor resection using 3-dimensional reconstruction. Braz J Otorhinolaryn gol. 2017. https://doi.org/10.1016/j.
12. Castelnuovo P, Dallan I, Locatelli D, et al. Endoscopic transnasal intraorbital surgery: our experience with 16 cases. Eur Arch Otorhinolaryngol. 2012;269 (8):1929-35
13. Lenzi R, Bleier BS, Felisati G, Muscatello L. Purely endoscopic trans-nasal management of orbital intraconal cavernous hemangiomas: a systematic review of the literature. Eur Arch Otorhinolaryngol. 2016;273(9):2319- 22
14. Chhabra N, Wu AW, Fay A, Metson R. Endoscopic resection of orbital hemangiomas. Int Forum Allergy Rhinol. 2014;4(3):251-5
15. Stamm A, Nogueira JF. Orbital cavernous hemangioma: transnasal endoscopic management. Otolaryngol Head Neck Surg. 2009;141(6):794-5
16. Tomazic PV, Stammberger H, Habermann W, et al. Intraoperative medialization of medial rectus muscle as a new endoscopic technique for approaching intraconal lesions. Am J Rhinol Allergy. 2011;25(5):363-7
17. Lazar M, Rothkoff L, Drey JP. Treatment and long-term outcome of patients with orbital cavernomas. Am J Ophthalmol. 2005;139(4):753; author reply 753

18. Karaki M, Kobayashi R, Mori N. Removal of an orbital apex hemangioma using an endoscopic transethmoidal approach: technical note. Neurosurgery. 2006;59 (1 Suppl 1):ONSE159-160; discussion ONSE 159-60
19. Wu W, Selva D, Jiang F, et al. Endo scopic transethmoidal approach with or without medial rectus detachment for orbital apical cavernous hemangiomas. Am J Ophthalmol. 2013;156(3):593-9
20. Murchison AP, Rosen MR, Evans JJ, Bilyk JR. Endoscopic approach to the orbital apex and periorbital skull base. Laryngoscope. 2011;121(3):463-7
21. Paluzzi A, Gardner PA, FernandezMiranda JC, et al. "Round-the-Clock" Surgical Access to the Orbit. J Neurol Surg B Skull Base. 2015;76(1):12-24
22. Bleier BS, Healy DY, Jr., Chhabra N, Freitag S. Compartmental endoscopic surgical anatomy of the medial intraconal orbital space. Int Forum Allergy Rhinol. 2014;4(7):587-91
23. Mueller SK, Freitag SK, Bleier BS. Morphometric Analysis of the Orbital Process of the Palatine Bone and its Relationship to Endoscopic Orbital Apex Surgery. Ophthalmic Plast Reconstr Surg. 2018;34(3):254-7
24. Lee JY, Ramakrishnan VR, Chiu AG, et al. Endoscopic endonasal surgical resection of tumors of the medial orbital apex and wall. Clin Neurol Neurosurg. 2012;114(1): 93-8
25. Stamm AC, Vellutini E, Harvey RJ, et al. Endoscopic transnasal craniotomy and the resection of craniopharyngioma. Laryngoscope. 2008;118(7):1142- 8
26. Healy DY, Jr., Lee NG, Freitag SK, Bleier BS. Endoscopic bimanual approach to an intraconal cavernous hemangioma of the orbital apex with vascularized flap reconstruction. Oph thalmic Plast Reconstr Surg. 2014;30 (4):e104-6
27. Muscatello L, Seccia V, Caniglia M, et al. Transnasal endoscopic surgery for selected orbital cavernous hemangiomas: our preliminary experience. Head Neck. 2013;35(7):E218-20

Authors

Catherine Banks MBChB FRACS
Department of Otolaryngology
Head & Neck Surgery.
Rhinology Fellow
Massachusetts Eye and Ear Infirmary/
Harvard, Boston MA 02114 USA
catherinebanks@MEEI.HARVARD.edu

Benjamin Bleier MD FACS
Associate Professor of Otolaryngology
Massachusetts Eye & Ear Infirmary/
Harvard, Boston MA 02114 USA
Benjamin_Bleier@MEEI.Harvard.edu

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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THE PECTORALIS MAJOR FLAP

Johan Fagan

The *pectoralis major flap* comprises the pectoralis major muscle, with or without overlying skin, and may include the underlying ribs. It has an axial blood supply and is based superiorly on the pectoral branch of the thoracoacromial artery.

It is very useful in the head and neck, and can *inter alia* be used for the following: reconstruction of soft tissue defects of the oropharynx, oral cavity, hypopharynx, and skin of the neck; to augment pharyngeal repairs following salvage laryngectomy following previous chemoradiotherapy, and to cover carotid or jugular vein blowouts etc. Rib may be included to bridge mandibular defects.

Relevant Anatomy

Pectoralis major muscle (Figure 1)

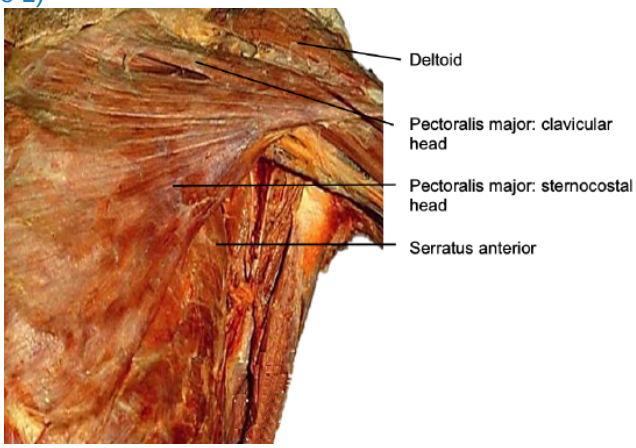


Figure 1: Superficial dissection

This muscle originates from the anterior aspect of the medial half of the clavicle; from the anterior surface of the sternum; from the cartilages of all the true ribs and from the aponeurosis of the abdominal external oblique muscle. The muscle fibers converge toward its insertion on the humerus. Muscle fibers arising from the clavicle pass transversely and are often separated from the rest of the muscle by a slight gap. The remainder of the muscle courses superolaterally.

Deep relations of pectoralis major muscle (Figure 2)

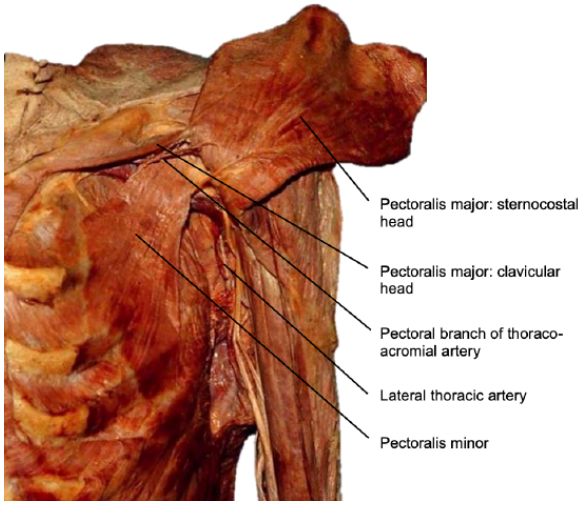


Figure 2: Deep relations of pectoralis major muscle

Deep to the pectoralis major muscle is its vascular pedicle, the pectoralis minor muscle, the costal cartilages, and inferiorly the costal attachments of the external oblique muscle.

Blood supply of pectoralis major flap (Figures 2, 3)

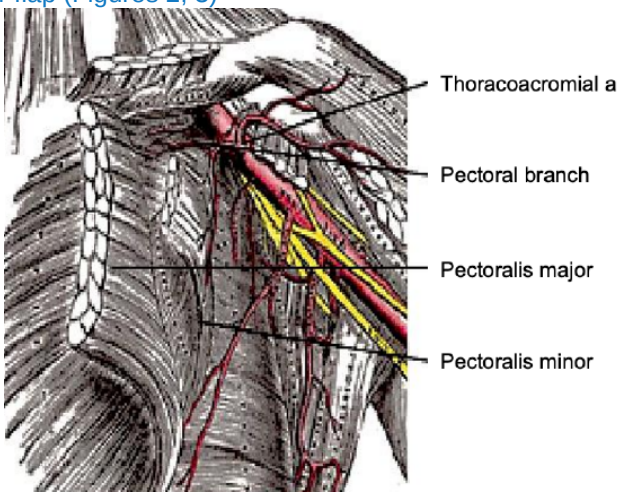


Figure 3: Blood supply of pectoralis major flap

The pectoralis major flap is an axial flap and is based primarily on the pectoral branch of the thoracoacromial artery and its accompanying veins. The thoracoacromial artery is a branch of the axillary artery, itself a continuation of the subclavian artery. The pectoral branch of the thoracoacromial artery courses within a well-defined fascial plane on the deep surface of the pectoralis major muscle (*Figures 2, 9*). There is a clear dissection plane between this fascial layer and the superficial aspect of the pectoralis minor muscle making it possible to strip the pectoralis major and its blood supply off the pectoralis minor with blunt finger dissection. Additional blood supply arises medially from the internal mammary artery, and laterally from the long thoracic artery, branches of which are generally sacrificed during elevation of the flap to secure adequate pedicle length. Care must be taken should the skin island be located distally in the region of the costal margin at, or beyond, the lower extent of the pectoralis major muscle, as the blood supply then becomes random as opposed to axial, making perfusion of the flap less reliable.

Innervation

The pectoralis major is innervated by the lateral pectoral nerve which can be located just inferior to the clavicle with the pectoral branch of the thoracoacromial artery. The medial pectoral nerve passes through the pectoralis minor muscle and sends 2 to 3 branches to the pectoralis major. All these nerves are normally divided during elevation of the flap. The denervated muscle loses bulk with time which might be advantageous or disadvantageous, depending on the functional and cosmetic objectives of the flap.

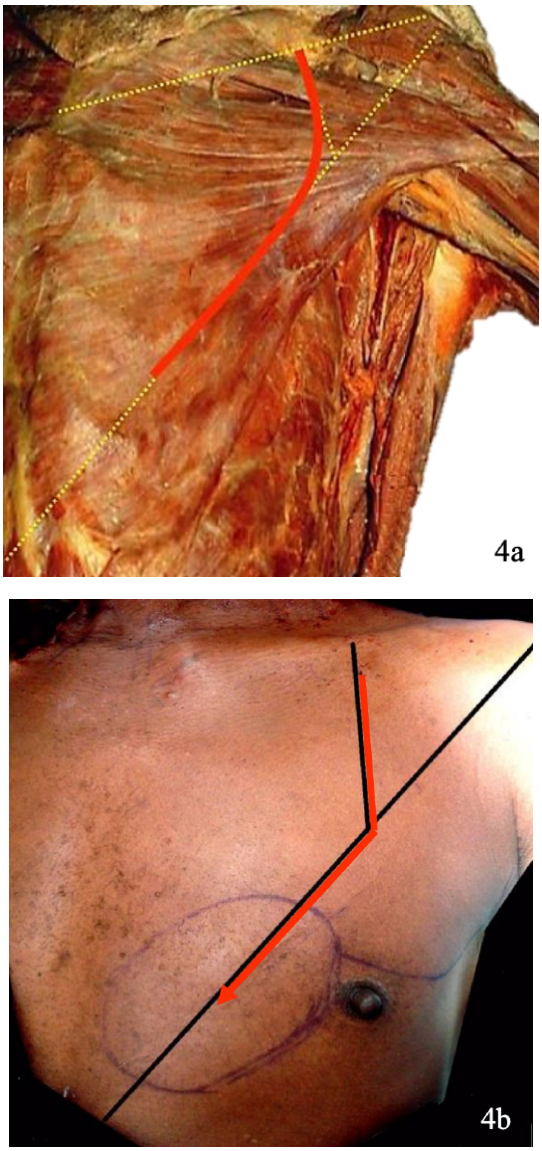
Flap design

The flap may be employed either as a muscular or musculocutaneous flap, with or without the 4th or 5th ribs. The following discussion will focus on raising a musculocutaneous island flap.

Positioning, prepping and draping

The patient is placed in a supine position with the chest exposed and prepped up to the midline, and inferiorly to the costal margin. The upper arm is abducted slightly to expose the anterior axillary fold and lateral chest wall.

Surface markings of vascular pedicle



Figures 4a,b: Surface markings of pectoral branch of thoracoacromial artery

The surface markings of the vascular pedicle are determined by drawing a line from the shoulder to the xiphisternum and another line vertically from the midpoint of the clavicle to intersect the 1st line (*Figures 4a, b*).

Skin paddle design

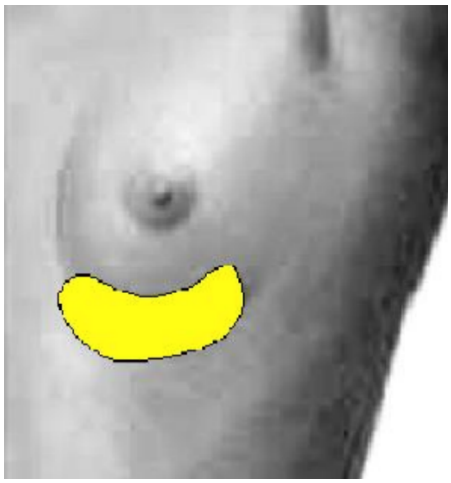


Figure 5: Inframammary skin paddle



Figure 6: Dissection of skin paddle onto pectoralis major muscle, and incision along anterior axillary fold

The skin paddle is positioned over the pectoralis major muscle along the course of the pectoral branch of the thoracoacromial artery (*Figures 4*, *5*, *6*). In order to ensure that the pedicle is of adequate length, the distance between the top of the skin paddle and the inferior edge of the clavicle should equal or exceed the distance between the recipient site for the flap and the inferior edge of the clavicle. In women the paddle may be placed in the inframammary crease to include skin on either side of the crease, to avoid excessive bulk from breast tissue and for cosmetic reasons (*Figure 5*).

Should additional pedicle length be required, the flap may be extended up to 2.5 cm beyond the pectoralis major muscle inferiorly at the costal margin, with the knowledge that the flap then becomes a random pattern flap and the blood supply more tenuous.

Elevation of skin paddle

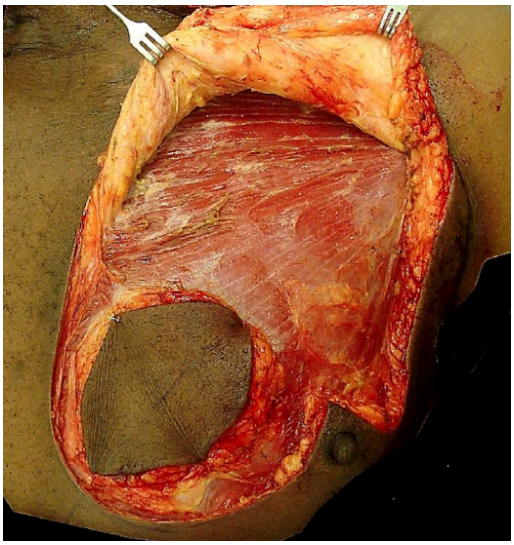


Figure 7: Exposure of pectoralis major muscle pedicle

The skin is incised around the skin paddle, and the dissection is extended onto the sursace of the pectoralis major muscle. As the vascular pedicle is located deep to the muscle, this may be quickly and safely performed using the bovie / monopolar diathermy. Care must be exercised not to undercut the skin paddle, but rather to bevel the dissection radially so as to include as many myocutaneous perforators as possible that supply the skin paddle (*Figure 6*). The skin paddle is tacked to the underlying pectoralis major muscle with a few sutures to minimize the risk of shearing injury to the myocutaneous perforators (*Figure 7*).

Exposure of pectoralis major muscle

An incision is extended laterally from the peripheral margin of the skin paddle along the anterior axillary fold, which corresponds with the lateral margin of the pectoralis major muscle (*Figure 6*). The skin and breast tissue above the skin paddle is then widely elevated from the pectoralis major muscle with diathermy up to the clavicle (*Figure 7*).

Elevation of pedicle

The pectoralis major muscle is incised with cautery medially and inferiorly to the skin paddle and is dissected from the ribs and intercostal muscles. The muscle is **not** divided superior to the skin paddle, as this might divide the vascular pedicle.

The pectoralis major muscle is then freed alongside the sternum with cautery. During this dissection perforators from the internal mammary artery are transected and cauterized.

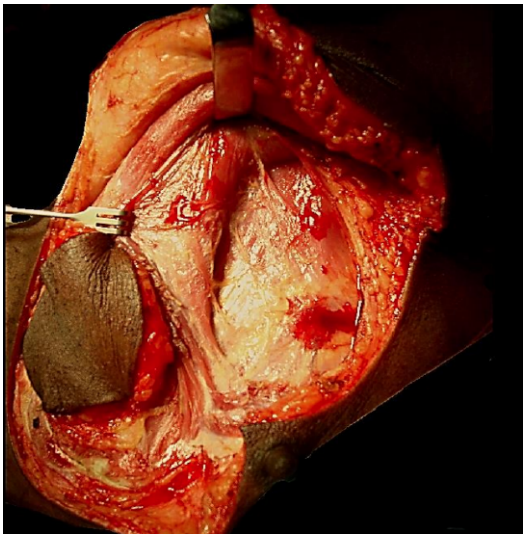


Figure 8: Elevating pectoralis major from pectoralis minor along lateral margin of muscle

The dissection plane between the pectoralis minor and major muscles and the vascular pedicle is found by dissecting along the lateral border of the pectoralis major muscle with electrocautery (*Figure 8*). Once this intermuscular plane has been identified, one

can readily free the pectoralis major and its vascular pedicle from the pectoralis minor by stripping with a finger towards the clavicle (*Figure 8*).

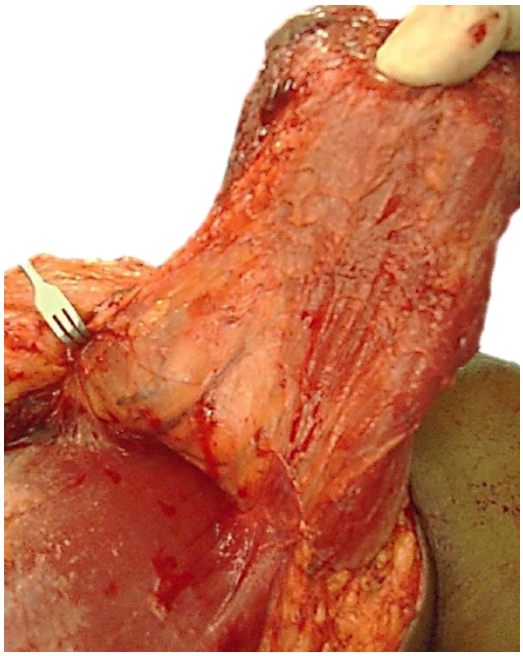


Figure 9: Vascular pedicle visible on deep aspect of pectoralis major muscle

This brings the vascular pedicle (pectoral branch of thoracoacromial artery) clearly into view within the fascia on the deep surface of the pectoralis major muscle (*Figure 9*). The pedicle is kept in view and protected from injury while the branches from the lateral thoracic artery, and the branches of the medial pectoral nerve that traverse the pectoralis minor and enter the deep surface of the flap, are divided. The pectoralis major muscle is divided lateral to the pedicle while keeping the pedicle in view, thereby freeing it from the humerus.

Skin tunnel over clavicle



Figure 10: Flap is passed over the clavicle though a wide skin tunnel

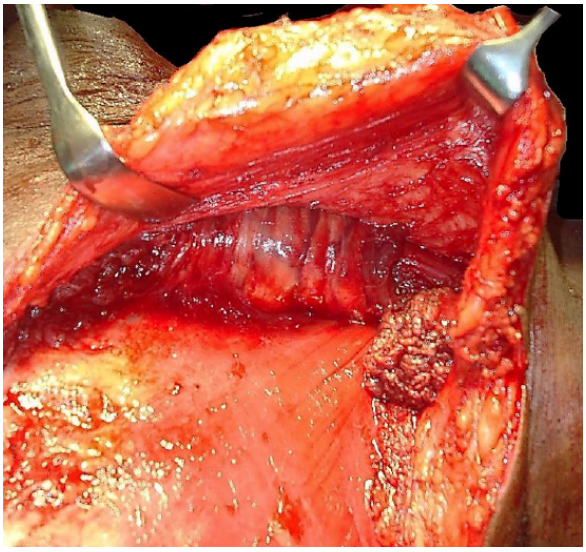


Figure 11: Check that pedicle is not twisted

The flap is generally passed into the neck superficial to the clavicle through a wide subcutaneous tunnel (*Figure 10*). The tunnel should be large enough to permit easy delivery of the flap into the neck without shearing the musculocutaneous perforators supplying the skin paddle, and to avoid strangulating the vascular pedicle. Dividing the subdermal connective tissue fibers of the skin above the skin tunnel with an upturned scalpel is a helpful adjunct to gain additional space.

After passing the flap into the neck, check that the pedicle is not twisted (*Figure 11*).

Gaining additional length

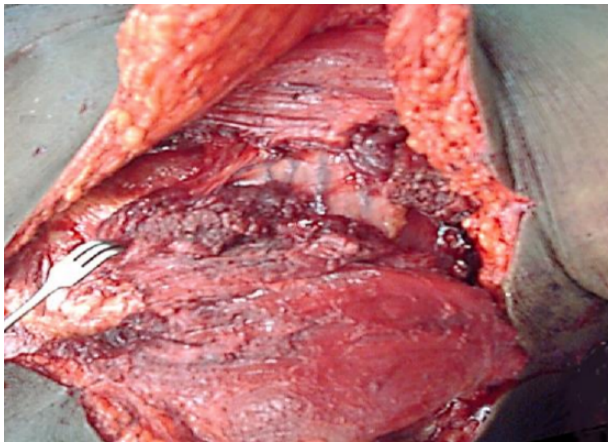


Figure 12: Vascular pedicle visible following division of muscular pedicle

If the pedicle is too short, two maneuvers may add additional length. The 1st is to transect the pectoralis major muscle just below the clavicle, taking great care to preserve the vascular pedicle (*Figure 12*). An infraclavicular segment of muscle may also be excised. This has the benefit that the pedicle is directly applied to the clavicle, without intervening muscle. It has the added bonus of avoiding an unsightly, bulky pedicle over the clavicle.



Figure 13: Gaining additional length by passing pedicle behind clavicle

A 2nd maneuver to gain additional length is to pass the flap behind the clavicle (*Figure 13*).

Should there be a concern about injury to the vascular structures deep to the clavicle, one can create a subperiosteal tunnel by incising the clavicular periosteum longitudinally along both the superior and inferior aspects of the clavicle. Since the periosteum is by its nature unyielding, this tunnel may be overly tight, but it can be relaxed by making incisions through the periosteum at its medial and distal ends, allowing easy passage of the flap. This maneuver adds some 3-4 cm to the reach of the flap which may be just enough in a tight situation.

Closure of donor site defect

The donor site is either closed primarily with a closed suction drain, or a split skin graft is applied. Primary closure may be facilitated by undermining the surrounding skin.

Some Clinical examples

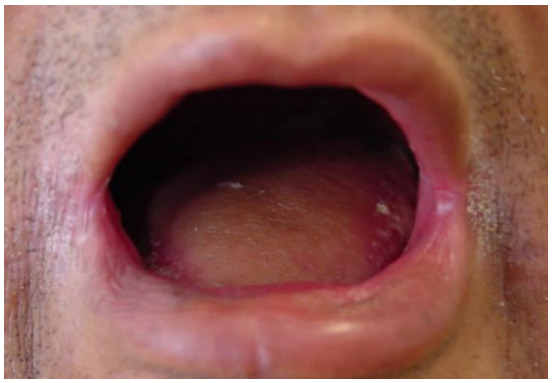


Figure 14: Reconstruction following total glossectomy

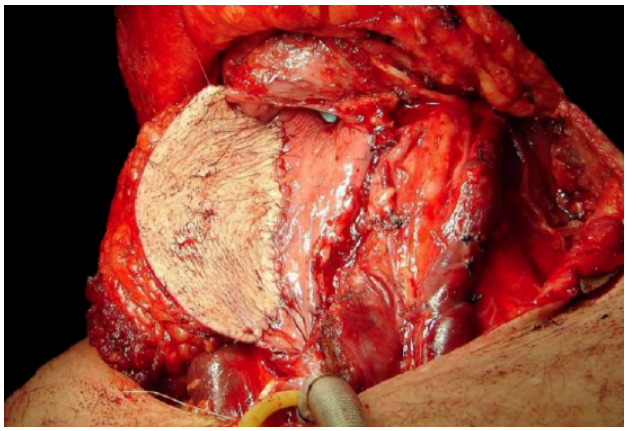


Figure 15: Augmentation of pharynx with pectoralis major myocutaneous flap following total laryngectomy with partial pharyngectomy

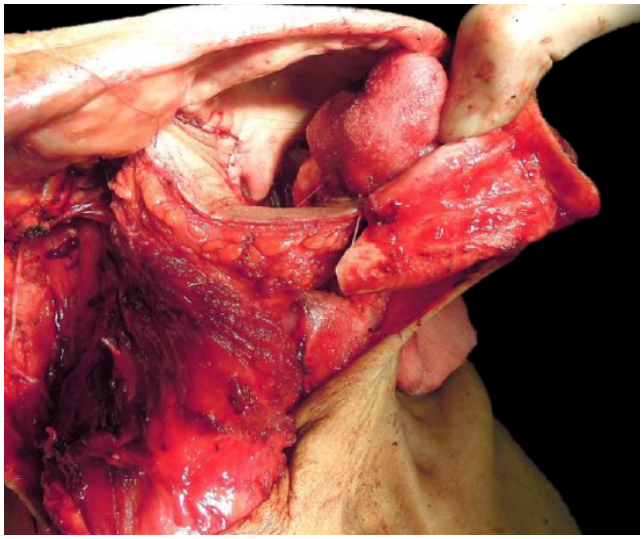


Figure 16: Reconstruction following segmental mandibulectomy and resection of tonsil, soft palate, and base of tongue

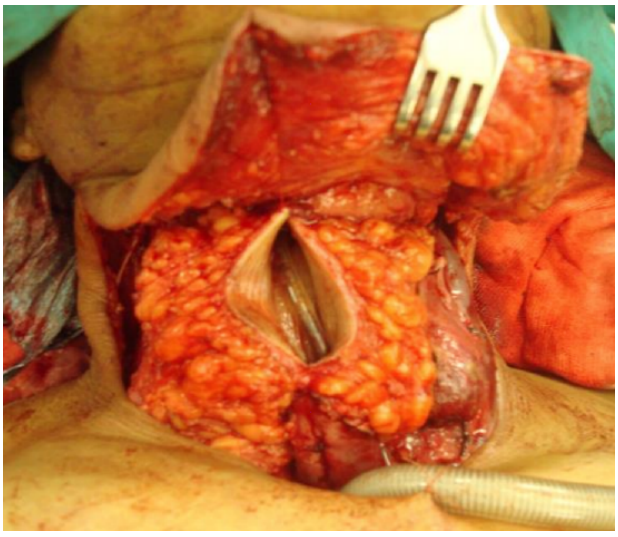


Figure 17: Laryngopharyngoesophagectomy defect reconstructed with tubed pectoralis major flap interposed between oropharynx and gastric pull-up that was too short to reach oropharynx

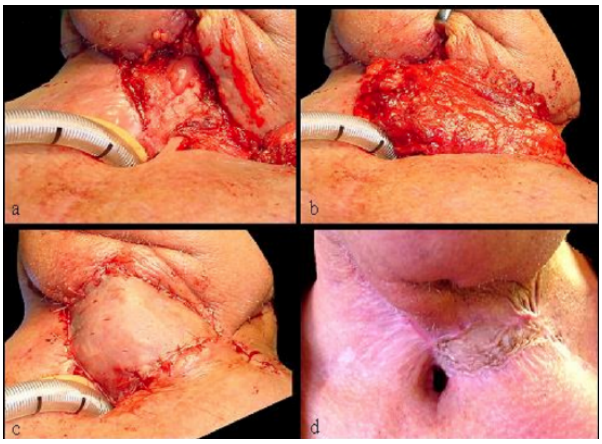


Figure 18: Reconstruction of (a) pharyngocutaneous fistula with (b) pectoralis major muscle flap and (c) split skin graft and (d) final result

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

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5.2: Cervicofacial Flap for Head and Neck Reconstruction

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

CERVICOFACIAL FLAPS IN HEAD AND NECK RECONSTRUCTION

Wayne Manana, Johan Fagan

Despite the advent of vascularized free tissue transfer flaps, cervicofacial flaps remain a ‘‘workhorse’’ for reconstruction of large cheek defects, especially in many regions where economic or infrastructural facilities limit the use of free tissue transfer flaps.

First described by Esser in 1918, the cervicofacial flap was first described in its modern form by Juri and Juri in 1979[1]. It is a random flap comprising skin, subcutaneous fat, superficial neck veins, and platysma muscle. It includes the delicate superficial cervical fascia just deep to skin that envelopes the platysma and muscles of facial expression and extends from the epicranium above to the axilla and upper chest below; over the face it is represented by the superficial musculoaponeurotic system (SMAS).

The cervicofacial flap has a wide pedicle and can be employed to cover large anterolateral craniofacial defects. Superiorly it can reach the supraorbital margin, laterally the postauricular area, and medially up to the midline.

The cervicofacial flap provides an excellent color match as well as thickness and texture, can be performed under local anesthesia, and provides concomitant exposure for neck dissection and parotidectomy, has very acceptable donor site scars, scars are camouflaged in the cheek borders, and requires minimal surgical time and has minimal postoperative morbidity.

As it is a thin flap, additional bulk may be provided with a pectoralis major muscle flap placed deep to the cervicofacial flap. It may also be an option for patients not suitable for free tissue transfer flaps e.g. elderly of medically unfit patients who cannot tolerate prolonged operations.

Indications

- Superficial defects up to 14 x 10 cm
- All zones of the cheek, external ear
- Temporo-frontal and brow defects
- Orbital exenteration defects
- To provide skin cover in combination with muscle flaps e.g. pectoralis major and temporalis flaps

Contraindications

- Poor skin laxity
- Active wound infection
- Smoking: stop 2 weeks pre- and 1 week postoperatively
- Previous radiation to surgical site
- High risk of keloid
- Through-and-through defects particularly when the following structures are missing: masseter, mandible, maxilla and temporalis muscle

Advantages

- Technically simple
- Reliable, with low failure rate i.e. “very forgiving” even with inexperienced surgeons
- Single team approach
- Shorter anesthetic and surgical time than for free flaps with cost-saving and favoring unfit patients
- Can be performed under local anesthesia
- No postoperative ICU monitoring required
- Single-stage procedure
- Few perioperative complications and morbidity
- Versatile with multiple applications
- Proximity to the defect

- Good arc of rotation
- Covers defects up to 14 x 10 cm
- Excellent color and texture match with facial skin
- Camouflage scars in the cheek borders (inconspicuous and follows borders of facial subunits)
- Reduced costs: short operating time and hospital stay
- Simultaneous exposure for parotidectomy and neck dissection (*Figure 1*)







Figure 1: A, B demonstrate excellent exposure of cervicofacial flap for parotidectomy and neck dissection. C shows immediate postoperative view of cervicofacial flap for patient in image B

Relevant Anatomy

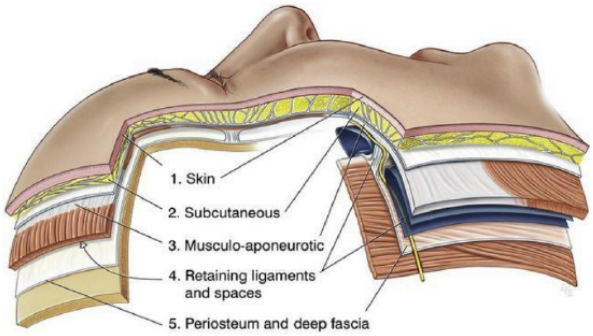


Figure 2: Layers of facial / cheek portion

The cervicofacial flap is divided into 2 portions, the facial (cheek) and the cervical portions. The cheek is a laminated structure (*Figure 2*) composed superficial-to-deep of:

1. Epidermis
2. Dermis
3. Subcutaneous tissue
4. Superficial muscular aponeurotic system (SMAS)

Immediately deep to the SMAS are branches of the facial nerve, the parotid gland, the buccal fat pad, and the mandible inferiorly. The branches of the facial nerve are protected beneath the SMAS in most locations. Thus, a surgeon who prefers to dissect beneath the SMAS layer must be familiar with facial nerve anatomy.

Identifying the borders of the cheek with other facial subunits is essential to camouflage the scar lines, including the infraorbital rim, nasolabial fold, preauricular crease, and inferior mandibular margin.

The SMAS was first described by Mitz and Peyronie in 1976[2]. It encloses the platysma, risorius, triangularis, auricularis, occipitallis, and frontalis muscles. The SMAS is connected to the dermis by fibrous septae allowing movement of the skin for facial expression. It is confluent with the galea layer of the scalp and with the temporoparietal fascia in the temporal region. In the neck, the SMAS continues as the superficial cervical fascia. The surgical importance of the SMAS lies in its relationship with the facial nerve. The facial nerve branches are found deep to the fascia, whereas the sensory supply to the face is located superficial to it.

The vascularity of the SMAS has been debated for many years. Although anatomic studies report that the SMAS is an avascular layer, there is clinical evidence suggesting otherwise. Schaverien 3 used sequential dying and 3-dimensional computed tomographic angiography and venography on 24 hemifaces[2]. They reported that the SMAS is perfused by the transverse facial

artery perforator branches on their route to the subdermal plexus. This finding is supported by the observation that skin necrosisis more frequently encountered in subcutaneous face-lifts where the SMAS is not included in the flap.

Arterial supply

The blood supply of the cervicofacial flap can be divided into 2 portions i.e. facial and cervical.

The ***facial portion*** of the flap receives its blood supply via the subdermal plexus in a random pattern from the facial artery, transverse facial artery and the superficial temporal artery via its orbito-zygomatic branch. It is dissected in a subcutaneous plane. A modification of this portion of the flap is to incorporate the SMAS as proposed by Kroll[4] to enhance the vascularity by providing the flap with an axial blood supply via perforators from the transverse facial artery.

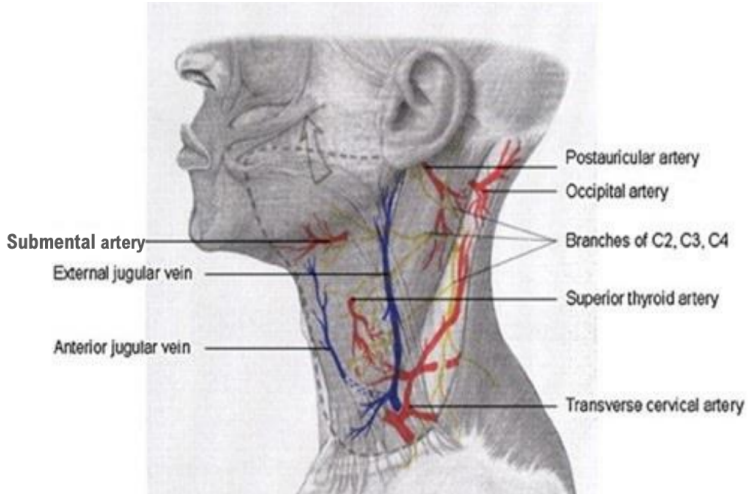


Figure 3: Neurovascular supply

The ***cervical portion*** of the flap, on the other hand, is dissected in a subplatysmal plane. By doing so, the platysma provides blood supply to this region. The platysma, as described by Hurwitz[5], is supplied by the occipital and postauricular arteries posteriorly, the submental artery superiorly and medially, the superior thyroid artery centrally, and the transverse cervical artery inferiorly (*Figure 3*). However, during flap elevation, only the perforators from the submental artery are preserved.

Venous drainage

Both the facial and cervical portions have a venous system that accompanies the arteries. The venous drainage is however mainly provided by the external jugular vein and randomized dermal venous drainage (*Figure 3*). Enclosing the external jugular vein in the flap helps to reduce venous congestion and the risk of ischaemic necrosis.

Innervation

Sensory innervation is provided by branches of the greater auricular (C2-C3) and lesser occipital (C2) nerves. Careful dissection reduces the risk of paraesthesia, and patients should be informed of this potential complication.

Flap elevation

- The patient is placed in a supine position with the head turned to the opposite side and with a head ring to stabilize the head and shoulder roll to extend the neck
- Inject local anesthetic mixed with adrenaline in the subcutaneous plane
- Defects less than 3 x 3 cm can be closed under local anesthesia. Though supraSMAS dissection can easily be performed under local anesthesia, subplatysmal dissection is difficult to perform under local anesthesia because of the risk of bleeding and patient discomfort
- A deliberate attempt to camouflage the postoperative scars is achieved by placing incisions along the various grooves, facial subunits and shadows in the head and neck region
- The incisions generally follow an imaginary line drawn along the following landmarks (*Figure 3*)
  - Nasolabial fold
  - Infraorbital, subciliary or subtarsal
  - Zygomatic arch/hairline

- Preauricular crease
- Retroauricular / posterior hair line
- Lateral border of trapezius
- Modification includes extension along deltopectoral groove

- The flap components depend on the anatomical location
  - ***Superior to zygomatic arch***: skin and subcutaneous tissue
  - ***Inferior to zygomatic arch***: skin, subcutaneous tissue, and SMAS
  - ***Cervical portion***: platysma and skin. The importance of including platysma in the cervical portion of the flap has been demonstrated by Hakim[6]

Reconstruction

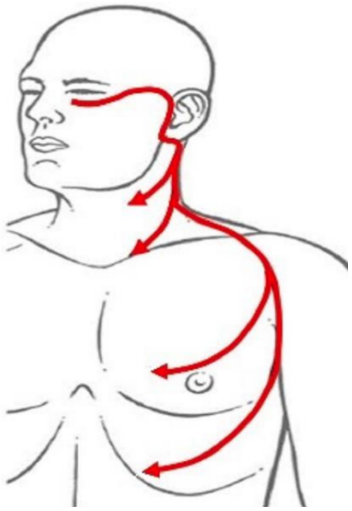


Figure 4: Incisions for cervicofacial flap

Roth[7] divided the cheek into Zones to help determine the method of cheek reconstruction (*Figure 4*)

- Zone 1: Infraorbital and lower eyelids
- Zone 2: Preauricular and parotid
- Zone 3: Chin and antero-inferior cheek

The versatility of the cervicofacial flap is demonstrated by its ability to close defects in all the three zones.

Zone 1 presents a unique challenge because of its proximity to nearby vital structures. Inappropriate flap selection in Zone 1 reconstruction can cause ectropion and hence significant aesthetic and functional problems. ***Zones 2 and 3*** provide the best opportunity for direct closure, especially in elderly patients. ***Zone 2*** is reconstructed mainly with the cervical (platysmal) portion of the cervicofacial flap (*Figures 7, 9, 11*). The flap design for Zone 2 is also known as the Mustarde flap (*Figures 5 and 6*).

Examples of Zone 1 defect repairs

Case 1: Complete excision of lower eyelid for basal cell carcinoma and use of a cervicofacial flap to reconstruct cutaneous portion of lower eyelid (Figure 6)

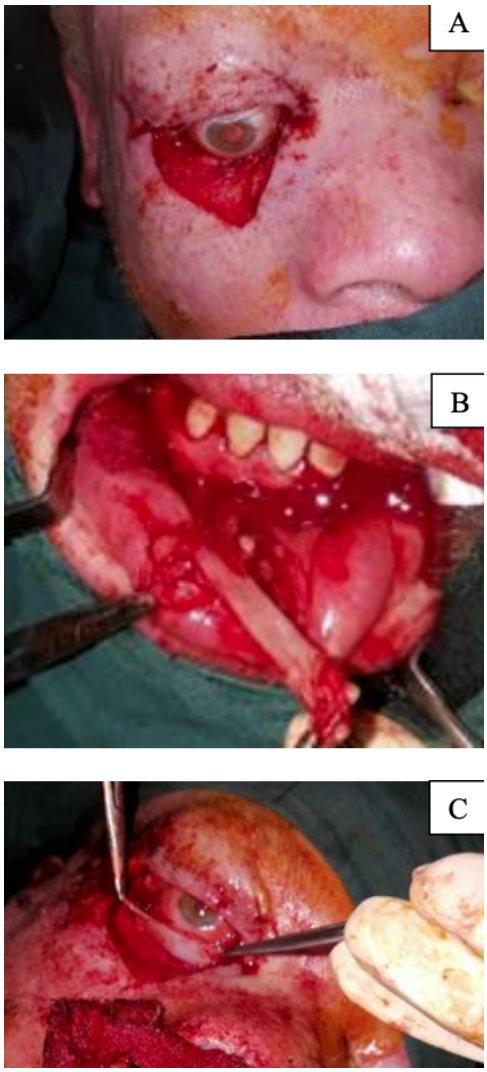

A
B
C



Figure 6: (A) Complete excision of lower eyelid in a patient with BCC; (B) Harvesting of labial mucosa to recreate conjunctiva; (C) Nasal septal cartilage used to recreate tarsal plate; (D) Cervicofacial flap to reconstruct cutaneous portion of lower eyelid; (E) Tarsorrhaphy to reduce risk of ectropion

Case 2: Excision of SCC lower eyelid and infraorbital region with reconstruction with cervicofacial flap (Figure 7)

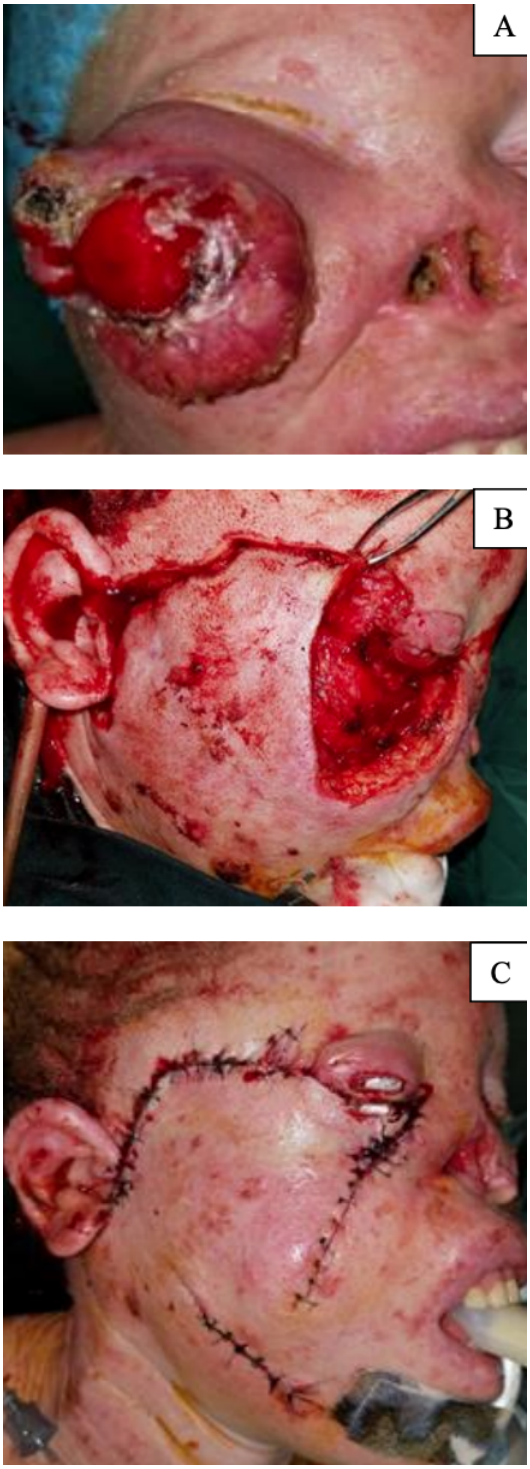


Figure 7: Excision of SCC of lower eyelid and infraorbital region with reconstruction with cervicofacial flap

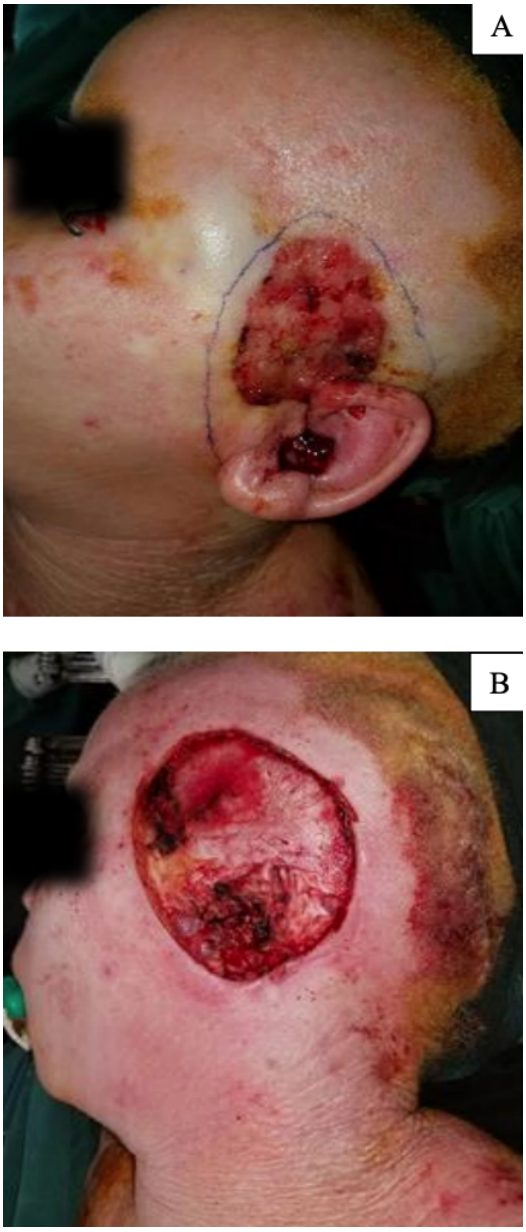

A
B



Figure 8: 10 cm Zone 2 defect reconstructed with a cervicofacial flap

Example of Zone 2 defect repair: 10 cm Zone 2 defect reconstructed with a cervicofacial flap. The underlying deep temporal fascia has been preserved. This demonstrates how the flap can be used for closure of temporal defects particularly when the ear has been sacrificed (*Figure 8*)

Modifications of Cervicofacial Flaps

Cervicothoracic flap: Inferior extension of over chest wall

The modern cervicofacial flap has facial and cervical portions; however, when a ***greater arc of rotation is needed, a pectoral extension can be used***.

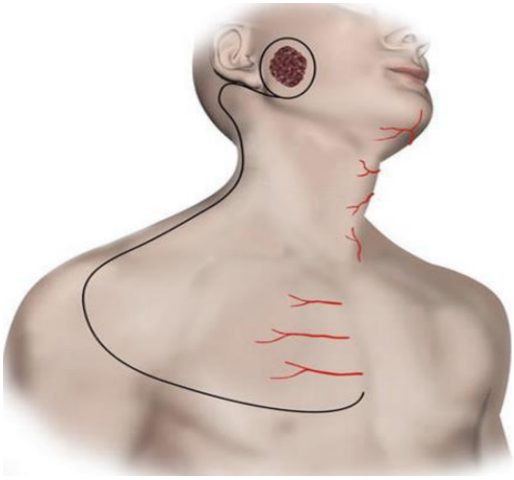
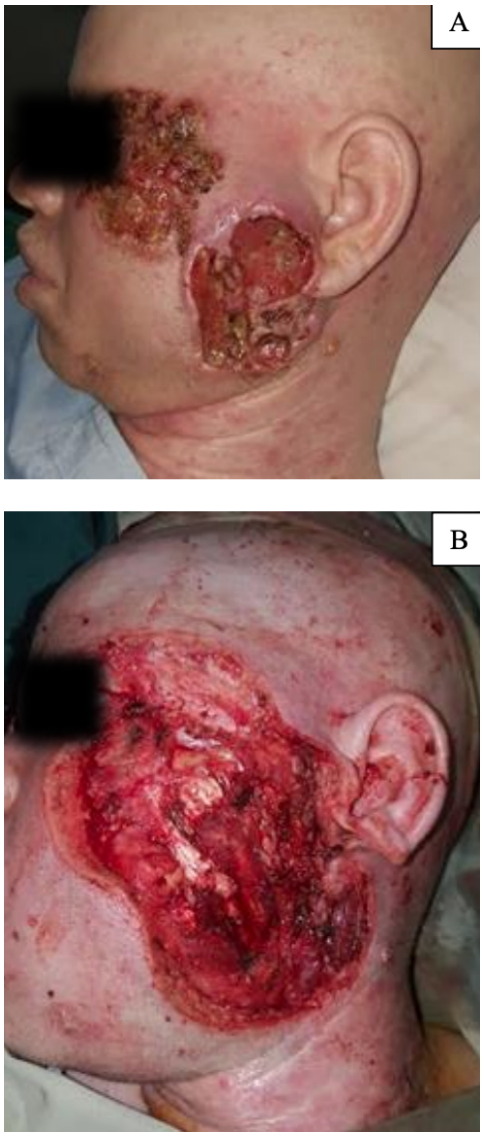


Figure 9: Cervicothoracic flap design, a modification of the cervicofacial flap that includes the deltopectoral flap [10]

The cervicothoracic flap was first described by Conley [9] in 1960, and later by Garrett [10] in 1966 (*Figure 9*). In addition to the blood supply to the cervicofacial flap, the cervicothoracic flap also receives blood supply via perforators from the internal mammary artery. In order to preserve the internal mammary perforators, the medial extent of the flap elevation ***should not extend beyond 2 cm from the lateral sternal border***.

The facial and cervical portions of the flap are raised in a similar manner to the conventional cervicofacial flap, with the pectoral portion raised in a subcutaneous plane. The cervicothoracic flap can be extended inferiorly to the costal margin, but most recommend not extending the flap beyond the nipple.

When comparing outcomes of the cervicothoracic and the conventional cervicofacial flap, Moore [11] and Liu [12] reported similar complication rates for the two flaps.


A
B

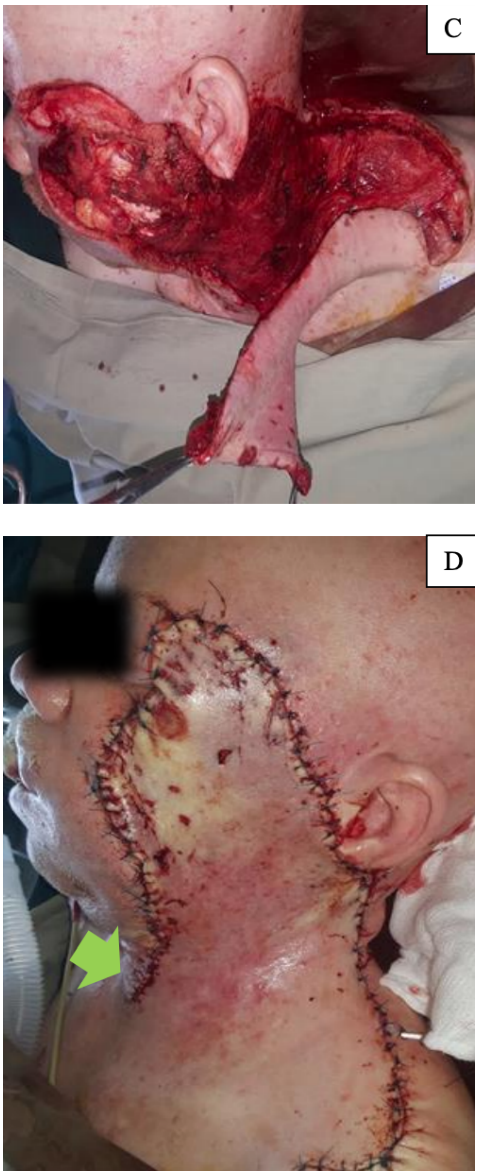


Figure 10: 16 x 10 cm Zone 2/3 defect closed with cervicothoracic flap. The anterior release incision (green arrow) greatly increases the flap coverage by combining advancement and rotational movements. The orange arrow show distal tip necrosis healing by secondary intention

Example of Zone 2 and 3 defect repair: Cervicothoracic flap used for 16 x 10 cm Zone 2/3 defect (*Figure 10*)

Subcutaneous vs. sub-SMAS dissection in facial portion of flap

The dissection plane in the facial portion of the flap can be either in the subcutaneous or sub-SMAS levels. The incorporation of the SMAS can theoretically change the blood supply of the flap from a random to an axial pattern via perforators from the transverse facial artery. This benefit was first advocated by Barton and Zilmer at the American Society of Plastic and Reconstructive Surgery meeting in 1982 and later published by Kroll [4] in 1994. However, this theoretical benefit was challenged in Whetzel and Stevenson's [13] cadaver study, in which they found no difference in blood supply based on ink-injection patterns between the two skin flaps. Jacono [14] conducted a retrospective clinical study to compare these 2 techniques, and reported no difference in skin necrosis, except in patients with a history of tobacco smoking. Moreover, dissection beneath the SMAS layer likely increases the risk of injuring the facial nerve. The intimacy of the nerve to the SMAS and the relatively high success rate of the subcutaneous dissection technique has many surgeons questioning the value of incorporating the SMAS.

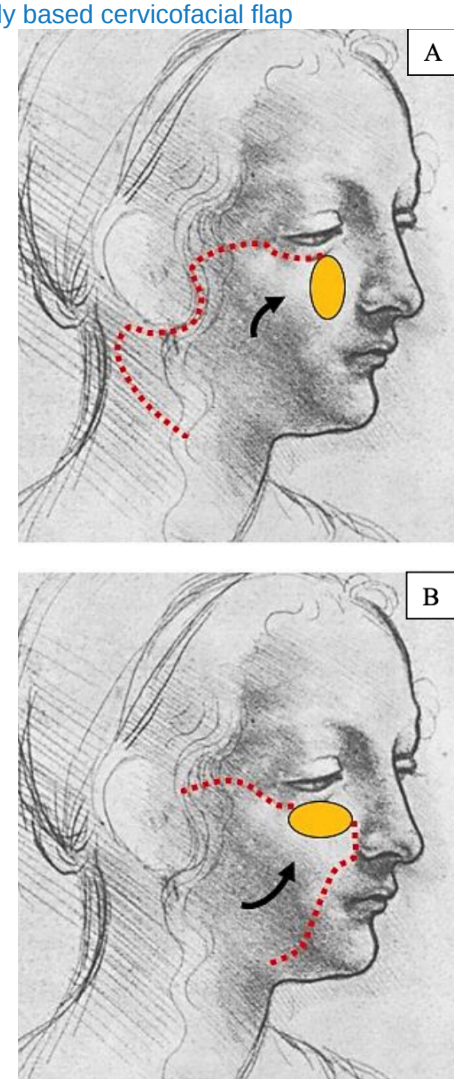


Figure 11: (A) illustrates the typical anteriorly based cervicofacial flap; note the vertical orientation of the infraorbital defect. (B) shows a reverse/posteriorly based cervicofacial flap; note the horizontal orientation of the infraorbital defect. The incision for the reverse cervicofacial flap follows the nasolabial groove

The flap can be based posteriorly. Boyette and Vural [15] advocate the use of the reverse flap for superomedial cheek defects in which the horizontal axis is greater than the vertical (*Figure 11*). They described its use in 6 cases with a mean flap size of 6 x 4.9 cm and reported no flap failures; 3 patients had ectropion not requiring surgical intervention. The investigators opine that a reverse cervicofacial flap for horizontally oriented defects helps to decrease flap tension and minimises excessive skin excision for standing cone deformities.

It is the 1st author's (W.M.) experience that combining the anteriorly based cervicofacial flap with an anterior release incision greatly increases the arc of rotation and permits closure of bigger defects of up to 16 x 10 cm. This is however associated with a higher incidence of distal flap necrosis as the submental artery is usually sacrificed in the process. Distal flap necrosis has however not been a concern as the wounds eventually heal by secondary intention (*Figures 10, 11, 12*).

Example of Zone 2/3 defect repaired combining a conventional cervicofacial flap and anterior release incision (*Figure 12*)





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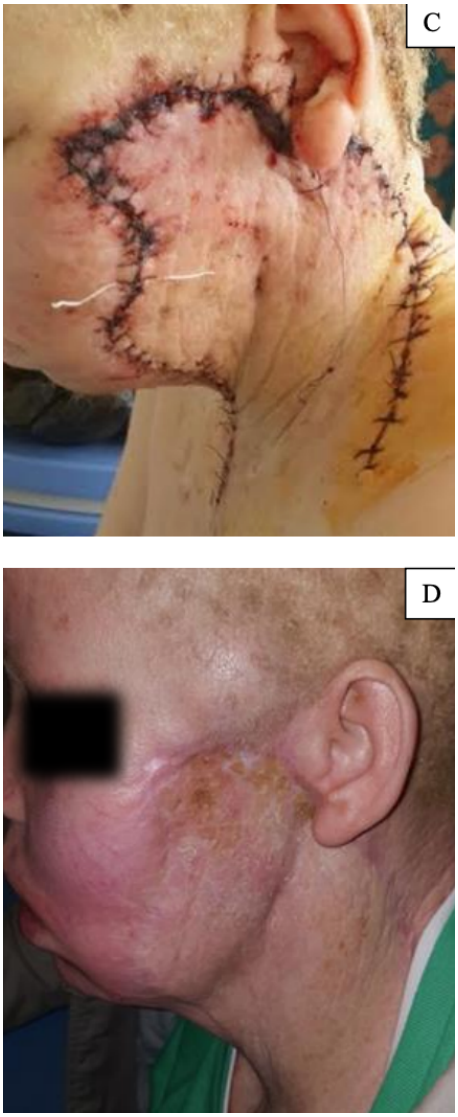


Figure 12: Large squamous cell carcinoma closed by modified cervicofacial flap, combining a conventional cervicofacial flap and an anterior release incision

Combination cervicofacial flap with other flaps for complex defects

Cervicofacial flaps generally do not provide much bulk. For deeper defects, additional bulk can be achieved by placing a free fat graft or a muscle flap e.g. temporalis or pectoralis major, deep to the flap. For complex reconstructions, a cervicofacial flap may also be used in combination with free flaps e.g. free fibula, anterolateral thigh or radial forearm flaps.

Tissue expansion



Figure 13: Tissue expander used to increase size of cervicofacial flap [16]

Prior tissue expansion can be employed to increase the size of a cervicofacial flap for larger defects (*Figure 13*).

Postoperative care

- Keep the head elevated to reduce edema of the flap
- Remove drains when output is <50 mL/24 hrs
- Remove dressing 2 days postoperatively to inspect the wound
- Should distal tip necrosis occur, consider debridement followed by daily dressing until the wound heals by secondary intention

Complications

Patients with decreased skin laxity, sebaceous skin, higher Fitzpatrick grading, or a history of keloids may present a greater surgical challenge. Proper patient selection, gentle handling of the tissues, and good hemostasis minimize complications. Hematomas require immediate evacuation because they may jeopardize the blood supply to the flap, potentiating the risk of necrosis. Infections are treated with drainage and antibiotics.

Complications specifically related to cervicofacial flaps are standing cone deformity, long-term ectropion, distal tip necrosis, and nerve injuries.

Standing cone deformity or dog-ear cosmetic problem: This is best addressed at the time of the initial surgery.

Postoperative ectropion: This occurs when a flap is extended to the infraorbital region. Postoperative edema causes eversion of the lower eyelid, and as healing proceeds, scarring and fibrosis may ensue and maintain the eyelid in an everted position. Extending the flap superiorly to the lateral canthus and suturing it to the periosteum reduces the risk of persistent ectropion.

Another way to prevent this complication is the use of a temporary suspension suture (Frost suture). A 4-0 nylon suture is passed through the inferior tarsal plate and then secured to the supraorbital region. The free ends are then joined and form a sling counteracting caudal tension.

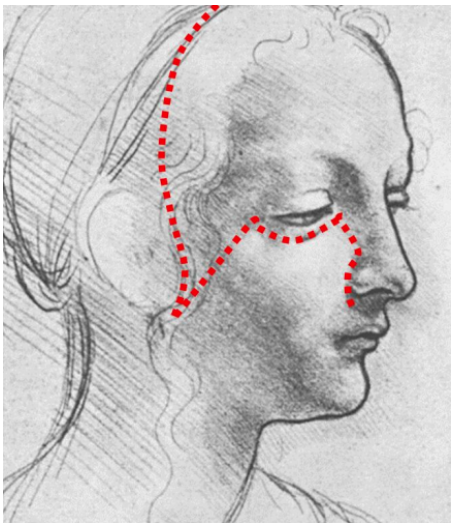


Figure 14: Yin-Yang rotation

Another way to prevent ectropion is to use the Yin-Yang rotation, as described by Belmahi, [17] for cases in which minimal skin laxity is appreciated (*Figure 14*). A temporoparietal scalp flap is raised and rotated in the opposite direction to the cervicofacial flap to close the preauricular cutaneous defect. Raising the additional temporoparietal scalp flap helps to minimize wound tension and provides cephalic anchorage to the facial flap, which reduces the incidence of ectropion.

Distal tip necrosis (*Figure 11*): This may occur due to unreliable random pattern vascularization of the flap. The reported incidence is about 15%. Risk factors include a history of smoking, radiation therapy, thinner skin in older patients and diabetes. Although raising the flap with the SMAS may theoretically increase the blood supply, this has not been borne out by clinical studies. Incorporating the SMAS for patients without risk factors may therefore not be beneficial. However, those with associated risk factors may find significant benefits as demonstrated in a study by Jacono[14]. Another measure to reduce distal tip necrosis is to include the external jugular vein with the flap to improve the venous drainage. When flap tension is unavoidable because of the size of the defect, additional grafts or flaps should be employed to avoid undue tension.

Facial nerve injury: This is a dreadful complication and has major functional and aesthetic consequences. A detailed knowledge of facial and facial nerve anatomy, use of blunt dissection and bipolar electrocautery, are mainstays of preventing injury. The incidence of facial nerve injury is low, and when it occurs, it is usually transient. Facial nerve injury should therefore initially be managed conservatively. Persistent paralysis without improvement may warrant facial reanimation surgery.

References

1. Juri J, Juri C. Advancement and rotation of a large cervicofacial flap for cheek repairs. Plast Reconstr Surg 1979; 5:692-6
2. Mitz V, Peyronie M. Plastic & Reconstructive Surgery 1976. 58(1):80-8
3. Schaverien MV, Pessa JF, Saint-Cyr M, et al. The arterial and venous anatomies of the lateral face lift flap and the SMAS Plast Reconstr Surg. 2009; 123(5): 1581-7
4. Close SS, Kroll GP, Reece G. et al. Deep-plane cervicofacial rotationadvancement flap for reconstruction of large cheek defects Plast Reconstr Surg. 1994;94(1):88-93
5. Close DJ, Hurwitz JA, Rabson JW, Futrell JW. The anatomic basis for the platysma skin flap. Plast Reconstr Surg. 1983;72(3): 302-12
6. Hakim SG, Jacobsen HC, Aschoff HH. et al. Including the platysma muscle in a cervicofacial skin rotation flap to enhance blood supply for reconstruction of vast orbital and cheek defects: anatomical considerations and surgical technique Int J Oral Maxillofac Surg. 2009;38(12):1316-9
7. Roth DA, Longaker MT, Zide BM. Cheek surface reconstruction: best choices according to zones Operat Tech Plast Reconstr Surg. 1998;5(1):26-36
8. Cabrera R, Zide BM, Cheek Reconstruction: In: Aston SJ, Beasley RW, Thorne CHM, Eds. Grabb and Smith's Plastic Surgery, 5th ed. Philadelphia: Lippincott 1999: pp. 501-512
9. Conley JJ. The use of regional flaps in head and neck surgery. Ann Otol Rhinol Laryngol. 1960; 69:1223-34
10. Garrett WS, Giblin TR, Hoffman GW. Closure of skin defects of the face and neck by rotation and advancement of cervicopectoral flaps. Plast Reconstr Surg. 1966; 38:342–6

11. Moore BA, Wine T, Netterville JL. Cervicofacial and cervicothoracic rotation flaps in head and neck reconstruction. Head Neck. 2005; 12:1092- 101
12. Liu FY, Xu ZF. The versatile applications of cervicofacial and cervicothoracic rotation flaps in head and Neck surgery. World J Surg Oncol. 2011; 9:135
13. Whetzel TP, Stevenson TR. The contribution of the SMAS to the blood supply in the lateral face lift flap. Plast Reconstr Surg. 1997; 100:1011-8
14. Jacono AA, Rousso JJ, Lavin TJ. Comparing rates of distal edge necrosis in deep-plane vs subcutaneous cervicofacial rotation-advancement flaps for facial cutaneous Mohs defects. JAMA Facial Plast Surg. 2014;16(1):31
15. Boyette JR, Vural E. Cervicofacial advancement-rotation flap in midface reconstruction: Forward or reverse? Otorhinolangol Head Neck Surg. 2011.144(2):196-200
16. Ashab Yamin MR, Mozafari N, Mozafari M, Razi Z. Reconstructive surgery of extensive face and neck burn scars using tissue expanders. World J Plast Surg 2015;4(1):40-9
17. Belmahi A, Oufkir A, Bron T, Ouezzani S. Reconstruction of cheek skin defects by the 'Yin-Yang' rotation of the Mustardé flap and the temporoparietal scalp. J Plast Reconstr Aesthet Surg. 2009 Apr;62(4):506-9

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author

Wayne Manana BA (Zim), BDS (UZ), MDS OMFS (UoN)
Specialist Oral & Maxillofacial Surgeon
Department of Maxillofacial Surgery
University of Zimbabwe College of Health Sciences
Harare, Zimbabwe
docmanana@gmail.com

Editor and Author

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

BUCCAL FAT PAD FLAP

Johan Fagan

The buccal fat pad flap is an axial flap and may be used to fill small-to-medium sized soft tissue and bony defects in the palate, superior and inferior alveoli and buccal mucosa. It is often encountered as it bulges into the surgical field during surgery in the pterygomandibular region.

Relevant Anatomy

Buccal fat pad

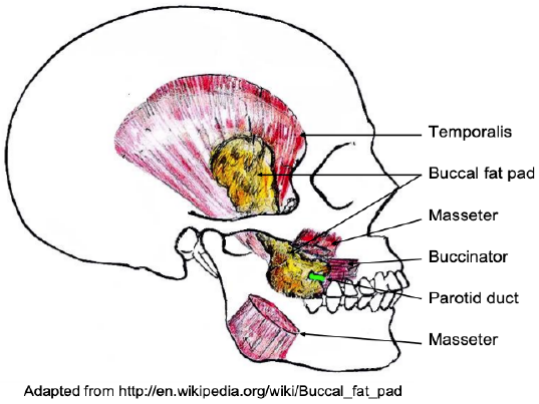


Figure 1: Buccal fat pad

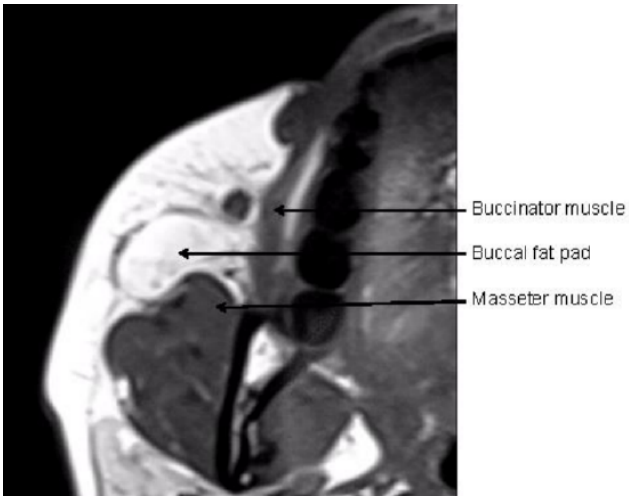


Figure 2: MRI (axial view) illustrating the anatomical relationship of the buccal fat pad to masseter and buccinator muscles

The buccal fat pad (*Figure 1*) is an encapsulated, mass of specialized fatty tissue, the volume of which varies throughout life. It is distinct from subcutaneous fat (*Figure 2*). It fills the deep tissue spaces and acts as gliding pads when masticatory and mimetic muscles contract, and cushions important structures from forces generated by muscle contraction.

The parotid duct passes along the lateral surface or penetrates the body of the fat pad before traversing the buccinator muscle and entering the oral cavity (*Figure 1*). It is attached by six ligaments to the maxilla, posterior zygoma, inner and outer rims of the infraorbital fissure, temporalis tendon, and buccinator membrane.

The buccal fat pad has a **body** and **four processes**. The body is located behind the zygomatic arch. The **body** is divided into **3 lobes** – **anterior, intermediate and posterior,** in accordance with the structure of the lobar envelopes, the ligaments and the feeding vessels. The **anterior lobe** is located below the zygoma, and extends to the front of the buccinator, maxilla and the deep space of the quadrate muscle of the upper lip and zygomaticus major muscle. The canine muscle originates from the infraorbital foramen and passes through the medial part of the anterior lobe. The parotid duct passes through the posterior part, and the anterior facial vein passes through the anteroinferior margin. The anterior lobe also envelopes the infra-orbital vessels and nerve, and together enters the infraorbital canal. The branches of the facial nerve lie on the outer surface of its capsule. The **intermediate lobe** is situated in and around the posterior lobe, lateral maxilla and anterior lobe. It is a membrane-like structure with thin fatty tissue in adults, but is a prominent mass in children. The **posterior lobe** is situated in the masticatory and neighboring spaces. It extends up to the inferior orbital fissure and surrounds the temporalis muscle, and extends down to the superior rim of the mandibular body, and back to the anterior rim of the temporalis tendon and ramus. In doing so it forms the buccal, pterygopalatine and temporal processes.

Four processes (buccal, pterygoid, superficial and deep temporal) extend from the body into surrounding spaces such as the pterygomandibular and infratemporal fossae.

Blood supply

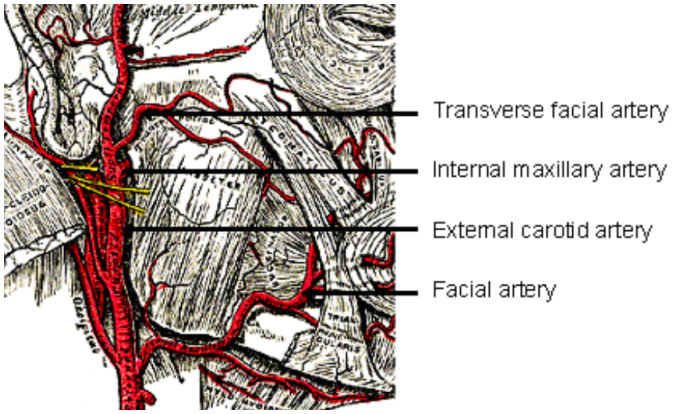


Figure 3: Blood supply to buccal fat pad

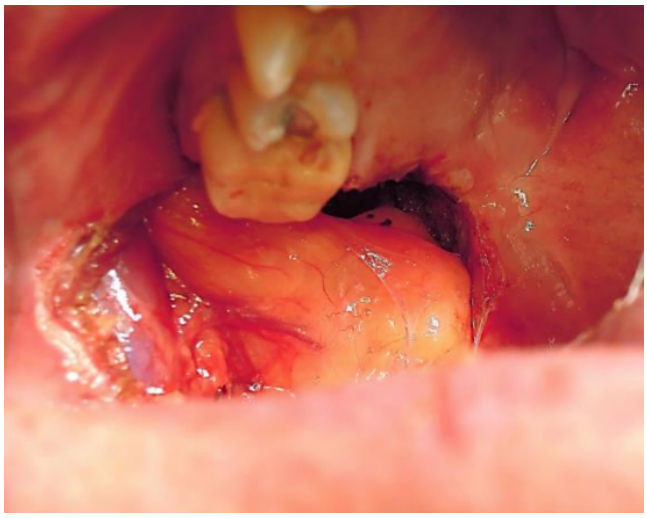


Figure 4: Note the clearly visible vascular supply to the flap

The buccal fat pad flap is an axial flap. The facial, transverse facial and internal maxillary arteries and their anastomosing branches enter the fat to form a sub-capsular vascular plexus (*Figures 3, 4*).

Indications

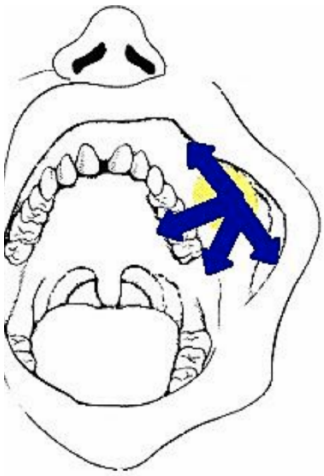


Figure 5: The buccal fat pad can be rotated to cover a variety of defects

- Reconstruction of small to medium (<5 cm) congenital or acquired soft tissue and bony defects in the oral cavity. This includes oronasal and oroantral communications following dental extraction; surgical defects following tumor excision, excision of leukoplakia and submucous fibrosis; and primary and secondary palatal clefts (*Figure 5*)
- Coverage of exposed maxillary and mandibular bone or bone grafts and bone flaps
- Alternative or backup for failed buccal advancement flaps, palatal rotation and transposition flaps, tongue and nasolabial flaps, and radial free forearm flaps.

Surgical Steps

- Surgery may be done under local or general anesthesia

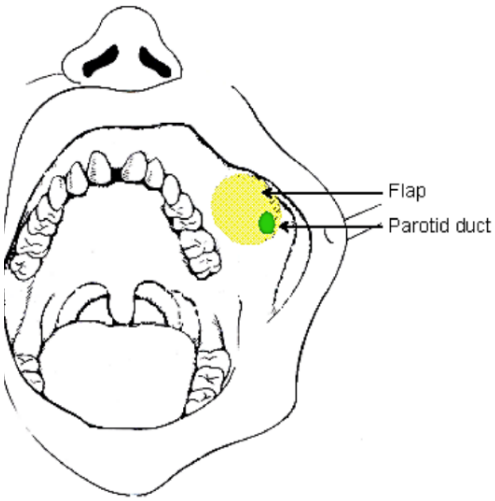


Figure 6: Position of fat pad relative to parotid duct

- Three approaches (*Figure 6*)
  - Incise buccal mucosal membrane 1 cm below the opening of parotid duct (Matarasso's method)
  - Incise behind the opening of parotid duct (Stuzin's method)
  - Incise superior gingivobuccal sulcus
- Cut through the buccinator muscle with diathermy and dissect bluntly until the buccal fat pad is found
- Incise the thin capsule of the buccal fat pad

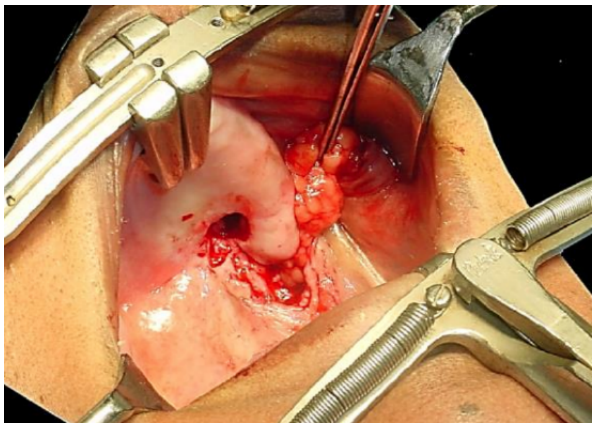


Figure 7: Careful delivery of fat pad after incising the capsule

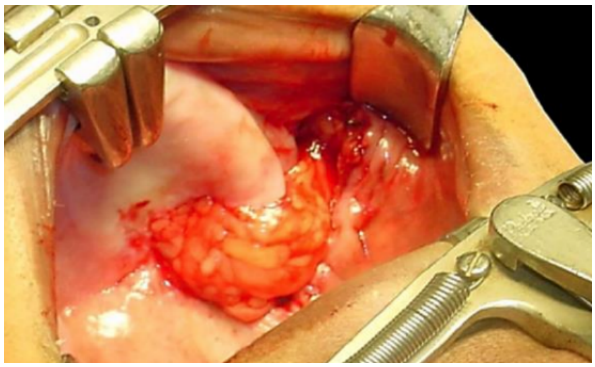


Figure 8: Flap placed over an oronasal defect

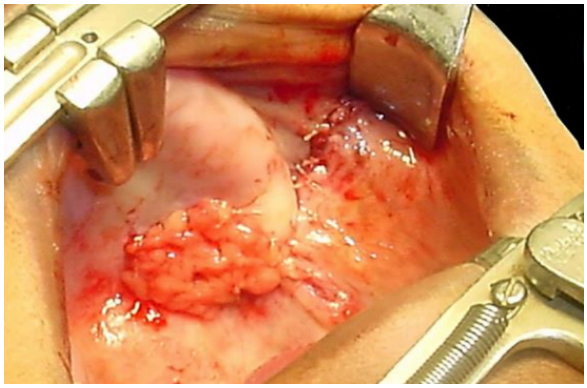


Figure 9: Flap sutured to defect, and pedicle covered with mucosa



Figure 10: Mucosalized flap approximately a month postoperatively

- Gently deliver the required volume of buccal fat tissue into oral cavity by gentle to-and-fro traction on the buccal fat, so as not to disrupt the blood supply and hence devascularize the flap (*Figure 7*)
- Take care not to injure the inferior buccinator branches of facial artery so as to avoid causing a hematoma
- Freshen the edges of the recipient site
- Position the buccal fat pad flap in defect and secure it with absorbable sutures (*Figures 8, 9*)
- Cover the flap with mucosa if feasible (*Figure 9*)
- Await epithelialization of the flap which usually occurs within 1 month (*Figure 10*)

Complications

Complications rarely occur and may include partial necrosis and excessive scarring. With large flaps used for buccal defects there is a risk of fibrosis and trismus.

Clinical examples

Case 1: Interalveolar carcinoma resected with exposed vertical ramus of mandible

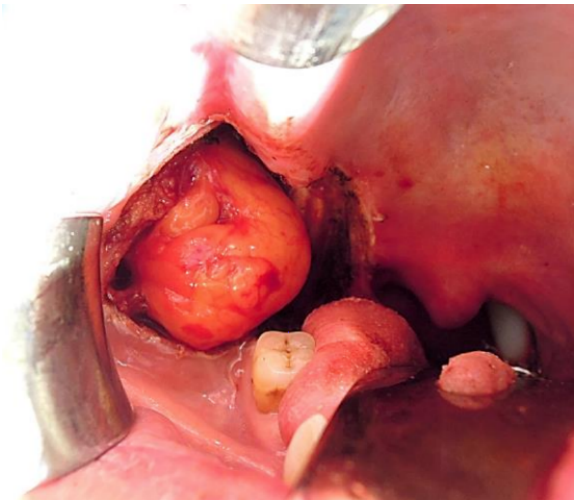


Figure 11a: Buccal fat pad adjacent to interalveolar defect

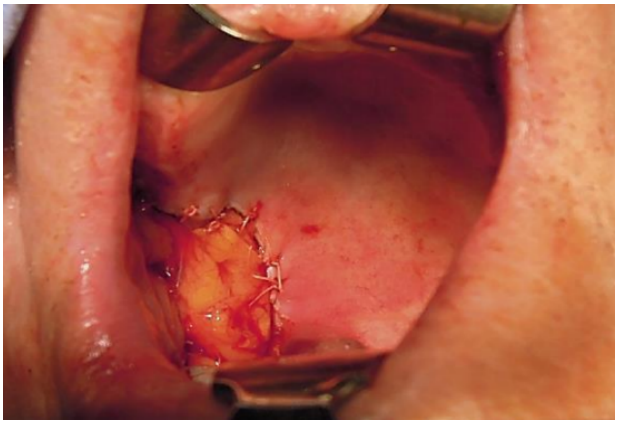


Figure 11b: Defect filled with buccal fad pad

Case 2: Mucoepidermoid carcinoma resected at junction of hard and soft palate

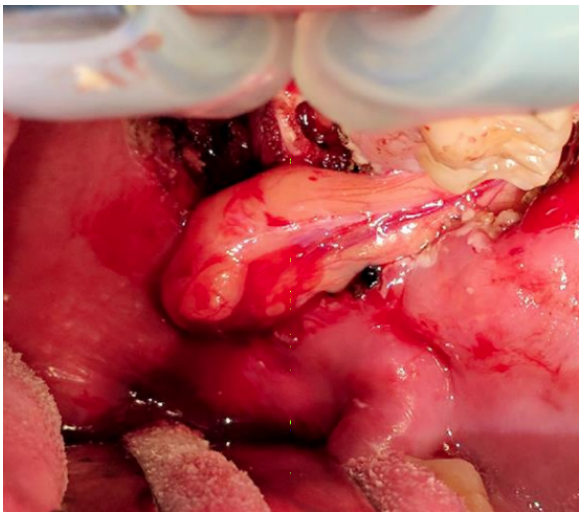


Figure 12a: Buccal fat pad adjacent to palatal defect, illustrating the vascular pedicle



Figure 12b: Defect filled with buccal fad pad; note vascular pedicle

Summary

The buccal fat pad is a simple, reliable flap for repair of small-to-medium sized oral defects. It has an excellent blood supply and causes minimal donor site morbidity.

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
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Author & Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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BUCCINATOR MYOMUCOSAL FLAP

Johan Fagan

The Buccinator Myomucosal Flap is an axial flap, based on the facial and/or buccal arteries. It is a flexible and versatile flap well suited to reconstructing soft tissue defects of the oral cavity, oropharynx and nasal septum. Unlike most free flaps, it provides mucosal cover, as opposed to skin cover, and is sensate. The donor site can usually be closed primarily without causing deformity or scarring. The flap is about 5 mm thick, and comprises buccal mucosa, submucosa and buccinator muscle, with the feeding vessels and vascular plexus.

Relevant Anatomy

Buccinator muscle

The buccinator muscle is a thin, quadrilateral muscle in the cheek. It originates from the outer surfaces of the alveolar processes of the maxilla and mandible. Posteriorly it arises from the pterygomandibular raphe. Anteriorly it inserts into the orbicularis oris muscle. Laterally it is related to the ramus of the mandible, the masseter and medial pterygoid muscles, the buccal fat pad and the buccopharyngeal fascia. Medially, it is covered by the submucosa and mucosa of the cheek. It is part of the pharyngealbuccal-orbicularis sphincter system and functions to facilitate whistling, sucking, propelling food during mastication and voiding the buccal cavity.

Blood supply (Figure 1)

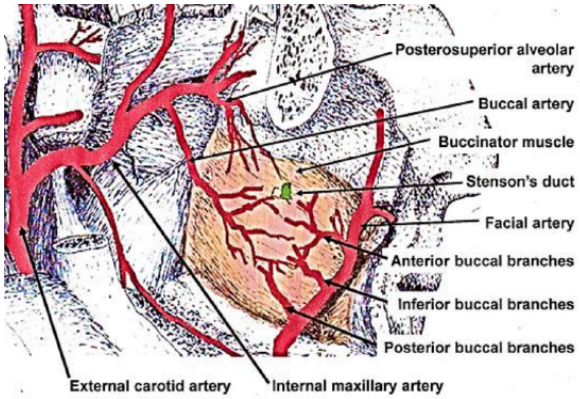


Figure 1: Blood supply of buccinator muscle, demonstrating vascular plexus

The buccal, facial and posterosuperior alveolar arteries provide the main blood supply to the muscle. These arteries form an extensive **vascular anastomotic plexus** on the lateral surface of the muscle and within its fibers.

The **buccal artery** is a branch of the internal maxillary artery and supplies the posterior half of the muscle. It courses anteroinferiorly under the lateral pterygoid muscle to reach the posterior half of the muscle, where it anastomoses with the posterior buccal branch of the facial artery.

The **facial artery** hooks around the inferior margin of the mandible at the anterior edge of the masseter muscle, and supplies numerous branches to the buccinator muscle, the largest of which is the posterior buccal artery that supplies the posterior half of the muscle. The facial artery also gives off 1-3 inferior buccal branches to supply the inferior half of the muscle, and then continues in an anterosuperior direction to give off 3-5 small, anterior buccal branches to the anterior half of the muscle. The **posterosuperior alveolar artery** is a branch of the internal maxillary artery and provides 2 small branches that enter the muscle posterosuperiorly. The **infraorbital artery** gives off a few small branches which enter it anterosuperiorly. **Venous drainage** occurs via the pterygoid plexus and internal maxillary vein. It lies posterior, superior and superficial to the buccinator muscle and drains into the buccal vein via the deep facial vein. Anteriorly, the deep facial vein drains into the facial vein proper.

Innervation

Mucosal sensory innervation is by the long buccal nerve, a branch of the maxillary division of the trigeminal nerve, which courses with the buccal branch of the internal maxillary artery. **Motor innervation** of the buccinator muscle is via the temporal and cervical divisions of the facial nerve laterally in the buccal fat pad.

Parotid duct

The duct pierces the buccinator muscle opposite the 2nd upper molar, slightly above the center of the muscle, and should be identified and preserved when raising the flap.

Elevation of flap

A flap as large as 7 x 5 cm may be raised. The extent is limited by the parotid duct posterosuperiorly, the oral commissure anteriorly and the pterygomandibular raphe posteriorly. It may be based **posteriorly (buccal artery), or anteriorly (facial artery) or superiorly (facial artery)**.

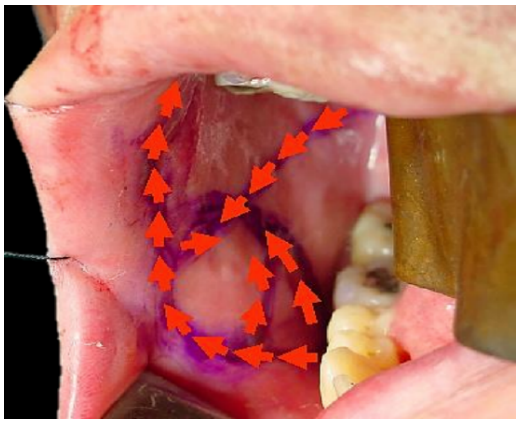


Figure 2: Vessels mapped out with handheld Doppler probe

Although not essential, a handheld Doppler can be used to map out the facial artery and the buccal artery before raising the flap (*Figure 2*). If a Doppler is not used, then care has to be taken to place the initial incisions so as not to separate the vessels from the flap.

The buccal mucosa and the buccinator muscle are incised to the level of the buccopharyngeal fascia, and the flap elevated, generally in an anterior to posterior direction. The flap is elevated in the loose areolar plane between the buccinator muscle and the buccopharyngeal fascia.

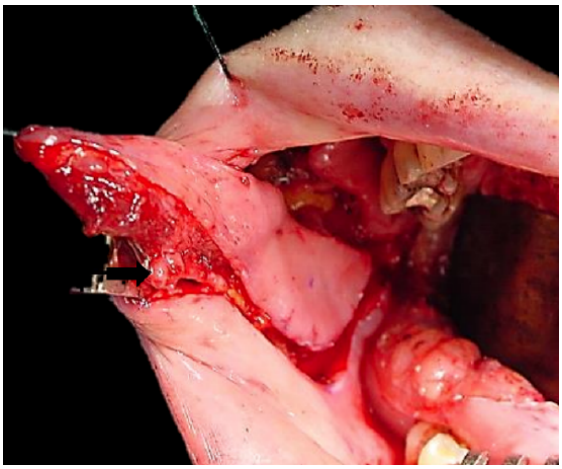


Figure 3: Flap elevation commences after identifying artery (Black arrow)

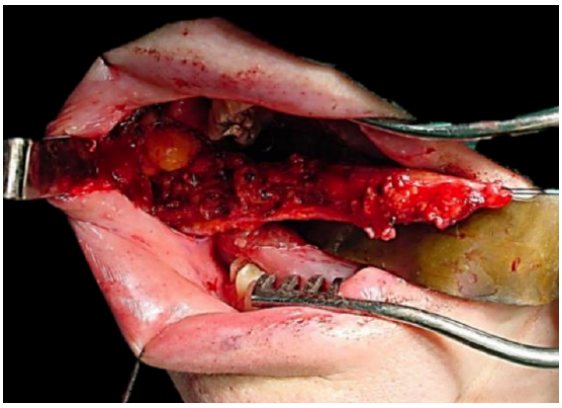


Figure 4: Flap elevated keeping artery in view

The artery that the flap will be based on is identified, and dissection proceeds between the artery and the buccopharyngeal fascia, directed towards the origin of the vascular pedicle, keeping the vessel in full view, using dissecting scissors (*Figures 3*, *4*). Preservation of the buccopharyngeal fascia prevents herniation of buccal fat and avoids injury to branches of the facial nerve. Minor bleeding vessels are coagulated with bipolar electrocautery.

The flap is rotated to fill the soft tissue defect. The mucosa and muscle are generally not divided where the flap is pedicled. The pedicle may however be isolated to facilitate rotation, and to create a '**buccinator myomucosal neurovascular island pedicle flap**'. If the pedicle must cross the alveolus e.g. to reach the floor of mouth, then care has to be taken that the pedicle does not interpose between the molar teeth, as this may interfere with mastication and might injure the pedicle. In such cases some teeth may need to be extracted to create space for the pedicle, or an island flap must be created; alternatively, the vascular pedicle may be divided after a delay of a few weeks. Due to the elasticity of the buccal mucosa, the donor site can generally be closed primarily with vicryl absorbable sutures.

Posteriorly Based Buccinator Flap

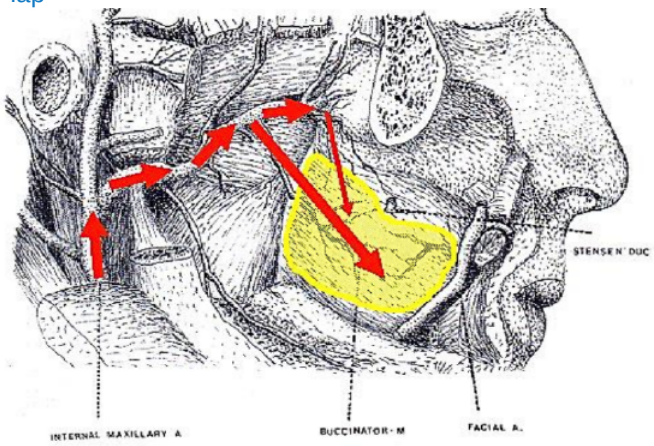


Figure 5: Blood supply of posteriorly based buccinator flap



Figure 6: Posteriorly based flap used to reconstruct soft palate and tonsil fossa

This flap can be rotated to reconstruct defects of the oropharynx (soft palate, base of tongue, tonsil fossa), lateral floor of mouth, and lateral tongue. It is based posteriorly on the **buccal artery** and buccal venous plexus (*Figures 5*, *6*).

Once the course of the buccal artery has been identified with Doppler ultrasound, the buccal mucosa and the buccinator muscle are incised to the level of the buccopharyngeal fascia, and the flap elevated in an anterior-to-posterior direction up to the pterygomandibular raphe where the neurovascular bundle enters the flap. The mucosa at the posterior end of the flap may also be divided from the underlying muscle and freed of its insertion to the pterygomandibular raphe and passed through a short tunnel under the pterygomandibular ligament.

Anteriorly Based Buccinator Flap

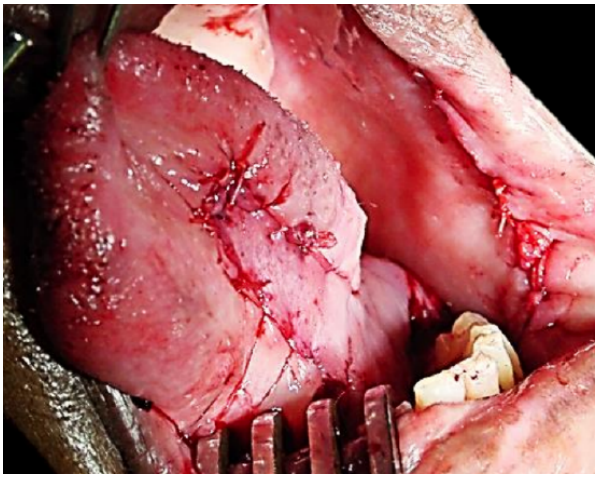


Figure 7: Flap for anterior floor of mouth

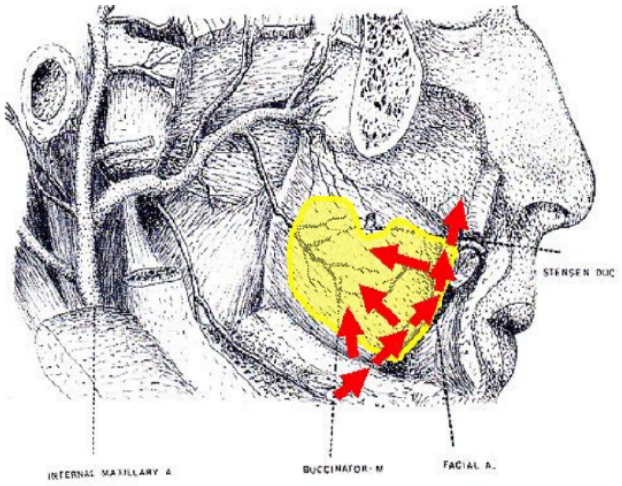


Figure 8: Blood supply of anteriorly based buccinator flap

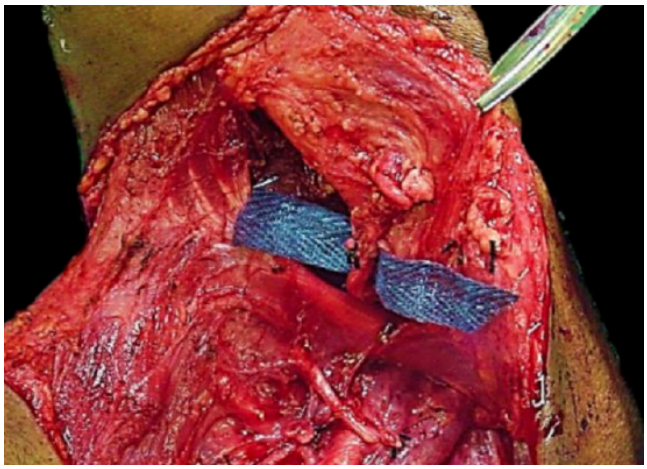


Figure 9: Preserved facial artery

The anteriorly based flap is well suited to reconstructing soft tissue defects of the inferior alveolus, lateral and anterior floor of mouth and oral tongue and lower lip (*Figure 7*). It is based anteroinferiorly on the inferior and posterior buccal branches of the facial artery (*Figure 8*). It is however **essential that the facial artery be preserved** when dissecting Level 1b of the neck. This requires division and ligation of branches of the facial artery where it passes through or alongside the submandibular salivary gland (*Figure 9*).

The mucosa and the buccinator muscle are incised just posterior (approx. 1 cm) to the commissure of the mouth, and the facial artery is identified in the cheek. The artery is ligated and divided superiorly. The dissection continues in a plane lateral to the vessels, as the flap is raised from front-to-back, and from superiorly-to-inferiorly.

Superiorly Based Buccinator Flap

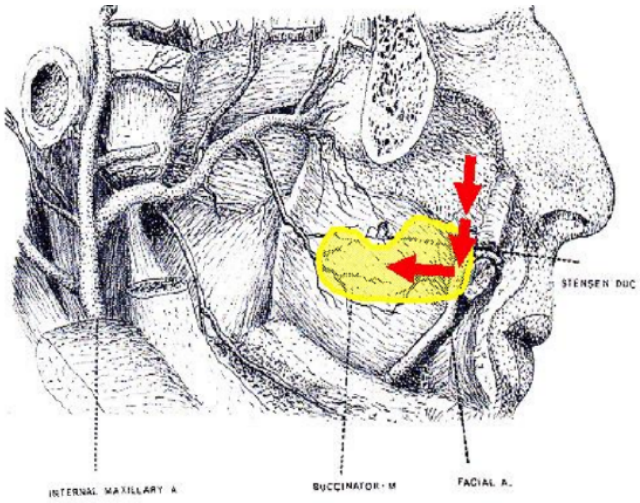


Figure 10: Blood supply of superiorly based buccinator flap

This is a reversed-flow flap based on the facial artery and its anterior buccal branches (*Figure 10*).

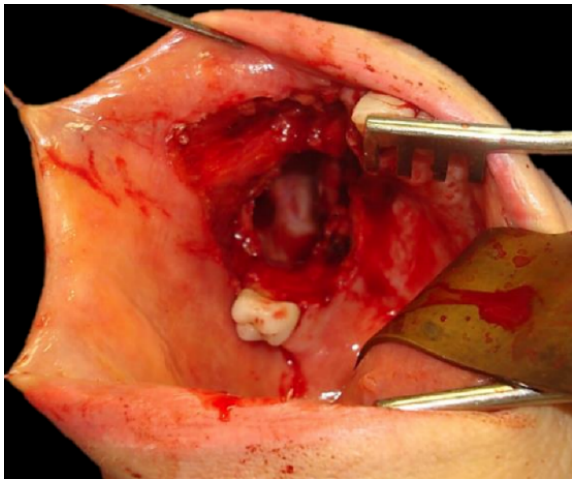


Figure 11a: Defect into antrum following alveolectomy

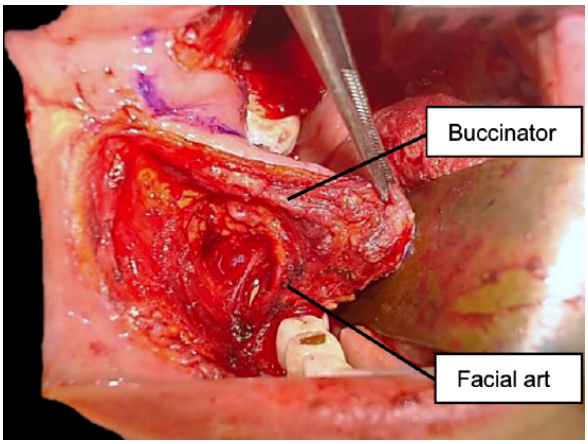


Figure 11b: Elevating flap after mapping facial artery with Doppler (purple line)

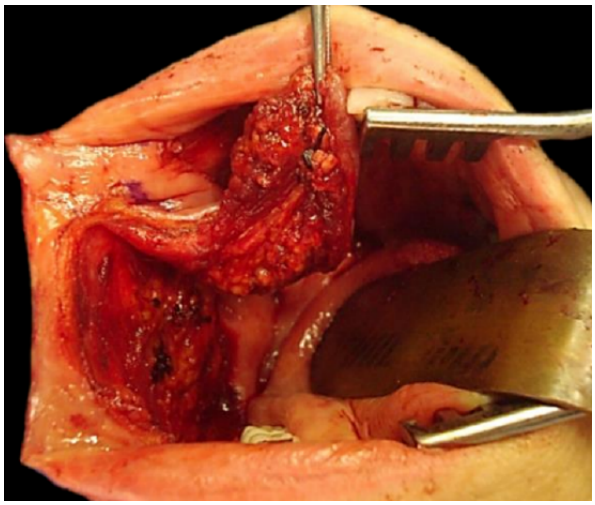


Figure 11c: Superiorly based pedicle with facial artery ligated at level of mandible

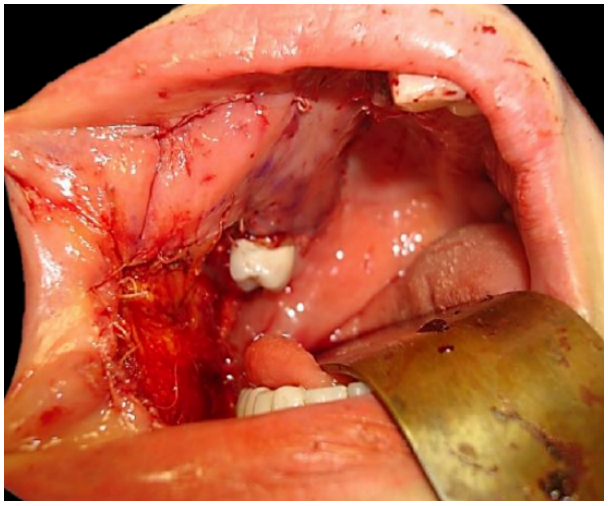


Figure 11d: Flap inset to cover antral palatal defect

It can be used for soft tissue defects of the hard palate and superior alveolus (*Figure 11a*), including oroantral and oronasal fistulae, as well as for nasal nasal septal defects.

Dissection is commenced at the anterior/inferior margin of the flap, where the facial artery is identified and ligated; the flap is then elevated in a superior direction and inset with vicryl sutures. If the donor defect cannot be completely closed, then it is left open to mucosalise (*Figures 11b-d*).

Benefits of buccinator flap

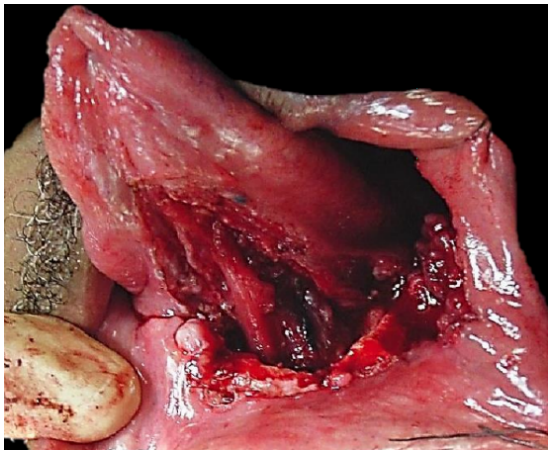


Figure 12a: Defect following anterolateral floor of mouth resection and marginal mandibulectomy

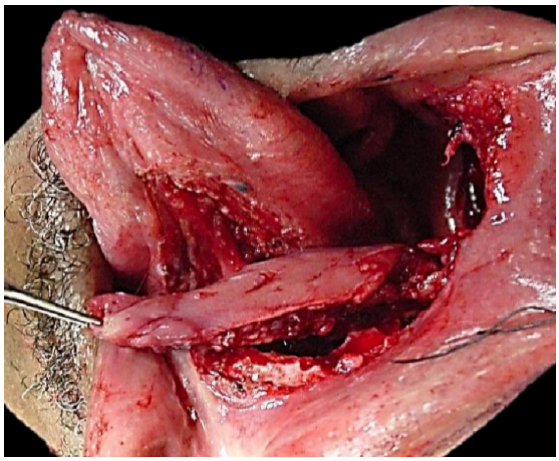


Figure 12b: Elevation of flap



Figure 12c: Inset of flap

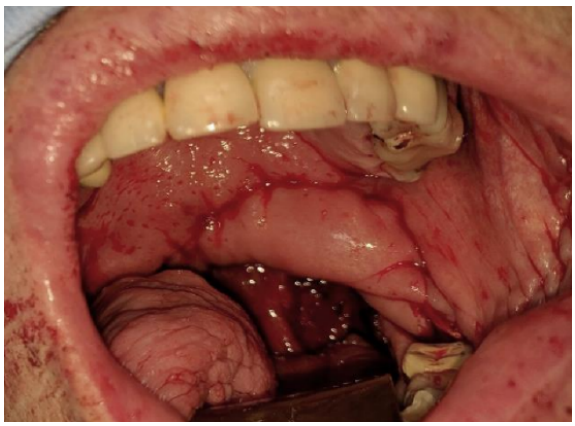


Figure 13: Soft palate and tonsil fossa defect reconstructed with buccinator flap

The buccinator flap is a versatile flap that can be used to reconstruct a variety of defects. It is very reliable, simple and quick to raise, replaces mucosa with mucosa, is sensate, and has very little donor site morbidity. It is remarkably elastic and malleable and can be stretched to conform to complexly shaped defects and is an excellent alternative to radial free forearm flaps for reconstruction of small and moderate sized defects of the oral cavity (*Figures 12 a, b, c*) and oropharynx (*Figure 13*).

Useful reference

Van Lierop A, Fagan JJ. Buccinator myomucosal flap: Clinical results and review of anatomy, surgical technique and applications. J Laryngol Otol, 2008; 122: 181-7

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccal fat pad flap

- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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THE TEMPORALIS MUSCLE FLAP

Johan Fagan

The temporalis muscle flap comprises the temporalis muscle, with or without the overlying temporalis fascia. It is an axial flap based on the anterior and posterior deep temporal arteries.

The temporoparietal fascial flap, on the other hand, is also an axial flap but is based on the superficial temporal vessels (Moore EJ. Temporoparietal Fascia Flap. Emedicine).

Relevant anatomy

Superficial temporalis fascia

Deep to the skin and subcutaneous tissues is the superficial temporal fascia, also known as the temporoparietal fascia. At the superior temporal line, this fascial layer continues superiorly as the epicranium, also known as the galea aponeurotica. It continues inferiorly at the level of the zygoma as the SMAS, or superficial musculoaponeurotic system.

Deep temporalis fascia

This layer of fascia is an inferior extension of the pericranium. From the superior temporal line, it overlies the temporalis muscle. Below the superior margin of the orbit, it separates into superficial and deep layers of deep temporalis fascia to attach inferiorly to the lateral and medial margins of the zygomatic arch respectively, with the superficial temporal fat interposed between the two layers.

Temporalis muscle

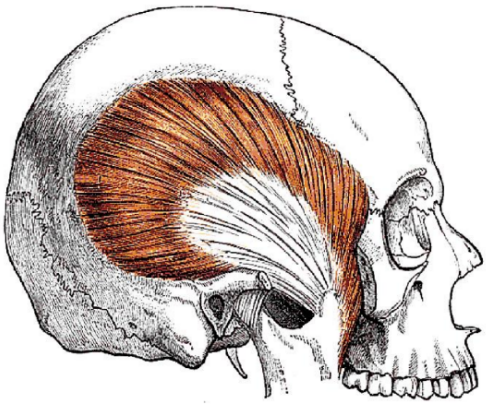


Figure 1: Temporalis muscle

The muscle is fan-shaped, and arises from the lateral surface of the cranium. It fills the temporal fossa and is covered laterally by the deep temporalis fascia. It passes medial to the zygomatic arch to insert onto the coronoid process and the anterior border of the ascending ramus of the mandible (*Figure 1*).

Innervation

The muscle is innervated by the deep temporal nerves that arise from the mandibular division of trigeminal nerve.

Blood supply (Figure 2)

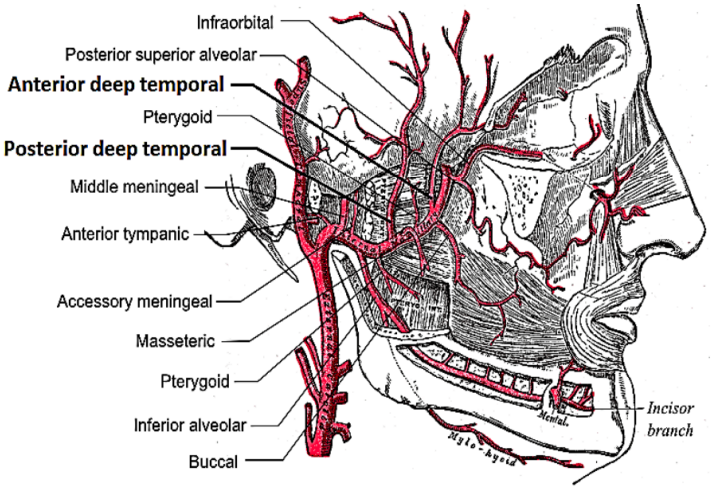


Figure 2: Blood supply

The muscle is supplied by the anterior and posterior deep temporal arteries which are branches of the internal maxillary artery. The arteries are situated on the medial (deep) aspect of the muscle and are medial to the coronoid process. Care therefore has to be taken not to injure the vessels during maxillectomy or oropharyngeal resection. These vessels anastomose within the muscle with the middle temporal artery which is a branch of the superficial temporal artery.

Facial nerve (Figure 3)

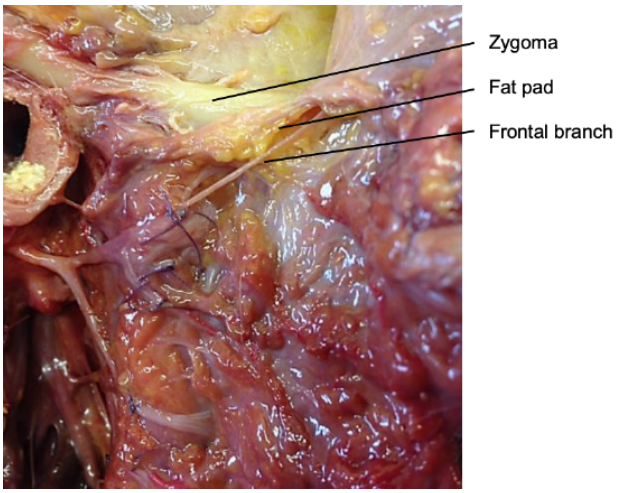


Figure 3: Frontal branch of facial nerve crossing zygoma at fat pad

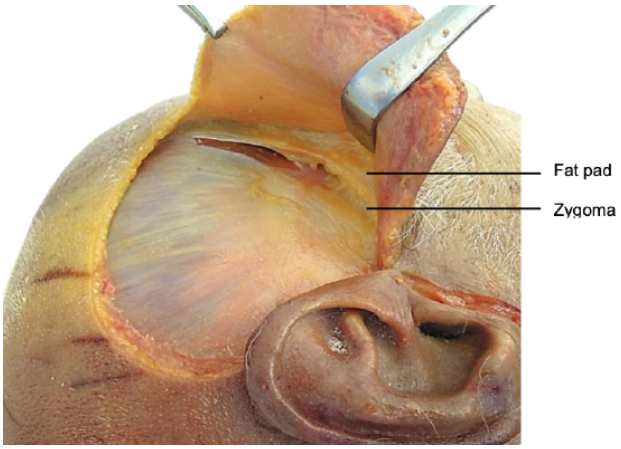


Figure 4: Hemicoronal incision, exposed temporalis fascia and fat pad

Frontal/temporal branches of the nerve cross the zygomatic arch, and run across the superficial temporal fat pad which is deep to the orbicularis oculi muscle just lateral to the orbital rim (*Figures 3, 4*).

Raising the flap

The flap is accessed via a hemicoronal skin incision commencing in a preauricular skin crease just below the level of the zygoma and placed behind the hairline for cosmetic reasons (*Figure 4*). The incision is extended to the temporalis fascia. The skin and subcutaneous tissue are elevated in the plane situated on the temporalis fascia (*Figure 4*). Anteriorly, elevation in this plane is stopped when the superficial temporal fat pad with the facial/temporal branches of the facial nerve is encountered.

At this point the deep layer of deep temporalis fascia is incised in a vertical direction, and the underlying temporalis muscle is exposed (*Figure 4*).

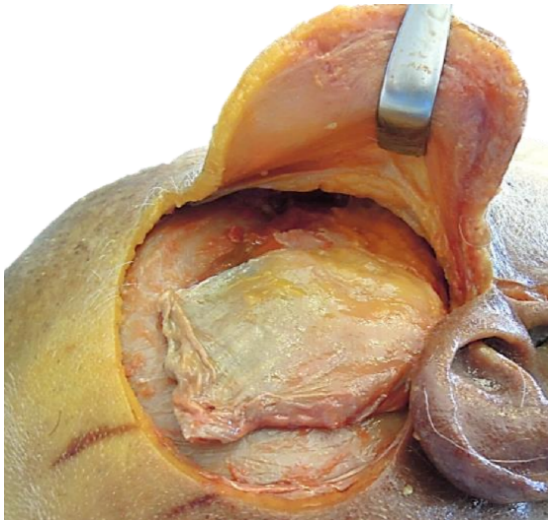


Figure 5: Mobilization of temporalis muscle and exposure of zygomatic arch

Anteriorly, further dissection is done in a subfascial plane, deep to the fat pad, up to the lateral orbital bony rim (anterior margin of temporal fossa). The temporalis fascia is now incised along the superior temporal line and the posterior margins of the muscle, down onto the bone (*Figure 5*).

If an extended flap is planned, then the superficial temporal vessels are identified and preserved in the preauricular area.

The superior aspect of the zygomatic arch is identified along its full length. This might require quite forceful retraction of the soft tissues with a Langenbeck retractor. The two layers of deep temporal fascia are incised along the superior margin of the zygoma.

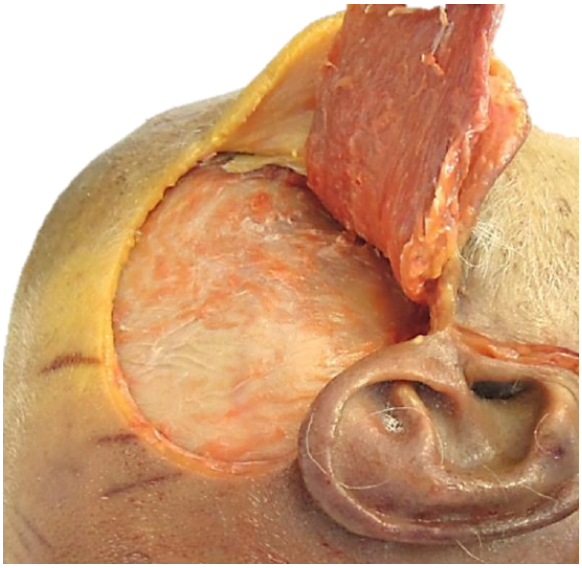


Figure 6: Flap completely elevated from temporal fossa

The temporalis muscle is elevated from the bone of the temporal fossa using either diathermy or a periosteal elevator. The dissection remains hard on the bone and extends medial to the coronoid process of the mandible that is now readily palpable medial to the zygoma, especially when the mouth is closed (*Figure 6*).

Should the flap need to be passed into the oral cavity, then a finger can now been tunneled into the mouth medial to the muscle and its origin from the coronoid process. With a thin muscle the flap can now be passed through this tunnel into the mouth, taking care not to rotate the flap and strangulate its blood supply. With a bulky muscle, the zygomatic arch and/or the coronoid process of the mandible may be osteotomized to permit passage of the flap. The zygomatic bone can be kept in saline and plated/wired back later in the procedure. The coronoid osteotomy is done either from above via the temporal fossa, or via the mouth. Great care has to be taken not to injure the deep temporal vessels by staying close to the bony surface of the coronoid.

Additional length of flap may be obtained by transecting or resecting the coronoid process and thus freeing the origin of the muscle from the bone, or by using an extended myofascial flap that includes additional temporalis fascia.

Clinical Applications

The temporalis muscle flap may be used for reconstruction of defects of the oral cavity (floor of mouth, tongue, buccal, retromolar trigone, palate), oropharynx, nasopharynx, orbit, maxilla and facial soft tissues.

Palatal and maxillary resections

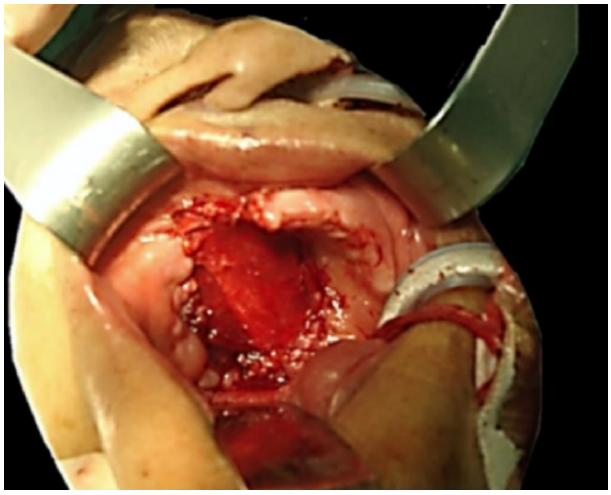


Figure 7: Reconstruction of inferior maxillectomy defect

The flap is ideally suited for reconstruction of the palate following Le Fort 1 maxillectomy (*Figure 7*), but also following total maxillectomy. The coronoid process of the mandible on which it is pedicled is immediately adjacent to the defect. It may reach across the midline. The muscle is left bare in the mouth, and mucosalises within a matter of weeks. Bilateral palatal resection defects may be reconstructed with bilateral temporalis muscle flaps that are sutured together in the midline.



Figure 8: Mucosalized muscle following palatal reconstruction

Note in *Figure 8* how the muscle has become covered with mucosa in a patient with bilateral temporalis muscle flaps for bilateral inferior maxillectomy.

Orbital exenteration



Figure 9: Temporalis muscle filling the orbit



Figure 10: Outcome of primary closure of skin over temporalis muscle flap

The lateral wall of the orbit is removed to provide space for passage of the muscle pedicle. The orbit is filled with the temporalis muscle flap (*Figure 9*), and is covered with skin or split skin graft, or closed primarily if a lid has been spared (*Figure 10*).

Drawbacks of temporalis muscle flap

Temporal fossa concavity (Figure 11)



Figure 11: Temporal fossa concavity

The concavity of the temporal fossa from which the muscle has been mobilized can be quite pronounced. It may be filled with a fat graft or hydroxyapatite or molded prosthetic implants.

Dental rehabilitation

Due to the absence of alveolar bone, it is not possible to insert dental implants following inferior maxillectomy reconstruction. With bilateral inferior maxillectomy, it is not possible to fit and retain an upper denture.

Another clinical example (Courtesy Dr Zenon Yeung, Hong Kong)

This patient underwent left inferior maxillectomy via Weber-Ferguson approach. The defect was repaired with a temporalis muscle flap.

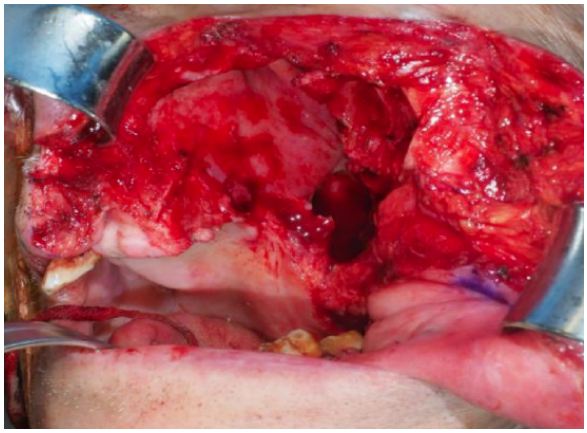


Figure 12: (L) inferior maxillectomy defect



Figure 13: Temporalis muscle flap elevation

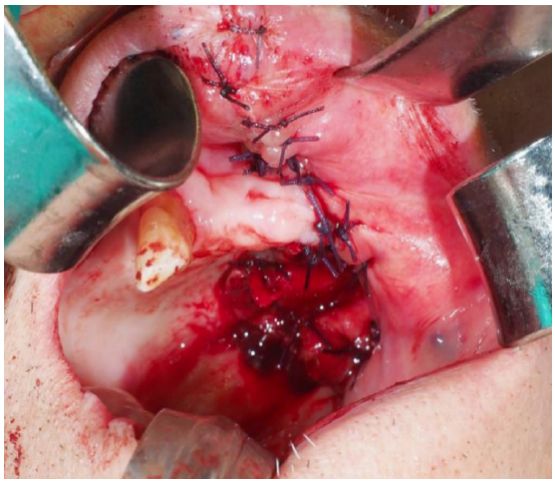


Figure 14: Temporalis muscle flap inset into inferior maxillectomy defect

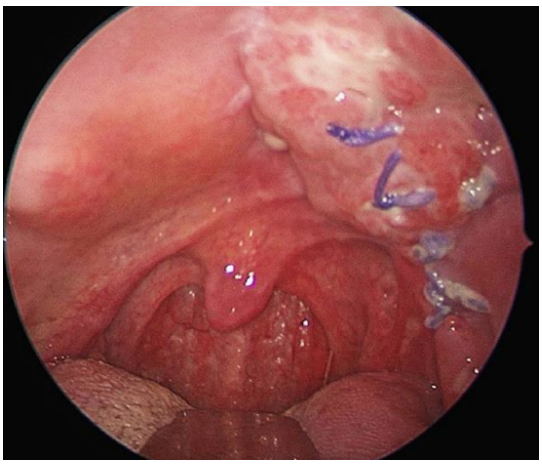


Figure 15: Oral view of flap at 17 days

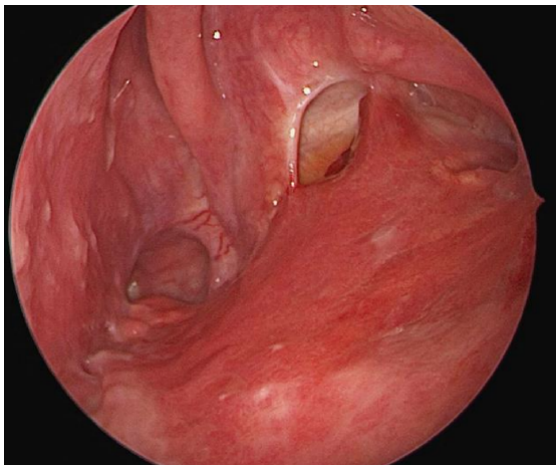


Figure 16: Transnasal view of flap at 17 days

Some useful references

1. Moore EJ. Temporoparietal Fascia Flap. emedicine
2. Smith J, Ducic Y, Adelson R. The utility of the temporalis muscle flap for oropharyngeal, base of tongue, and nasopharyngeal reconstruction. Otolaryngol Head Neck Surg 2005;132:373- 80

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
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- Nasolabial flap
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Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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NASOLABIAL FLAP FOR ORAL CAVITY RECONSTRUCTION

Harry Wright, Scott Stephan, James Netterville

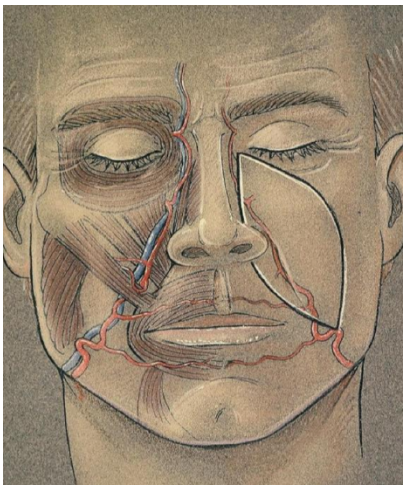


Figure 1: Relationship of the facial artery to the design of the nasolabial flap

Designed as a true myocutaneous flap pedicled on the facial artery, the nasolabial flap is a robust and versatile flap that is well suited to single-stage reconstruction of oral cavity defects or to staged reconstructions of facial defects (*Figure 1*). This chapter will focus on oral cavity reconstruction. The redundant skin extending from the medial canthus of the eye to the inferior margin of the mandible (nasolabial sulcus and nasofacial groove) defines the donor site for the nasolabial flap. This area is relatively hairless except for the lower cheek in males, an important consideration in oral cavity reconstruction. The flap itself is comprised of skin, subcutaneous tissue and the underlying musculature.

Surgical Anatomy

Blood Supply



Figure 2: The facial artery displayed in a cadaver dissection, showing the more common medial course

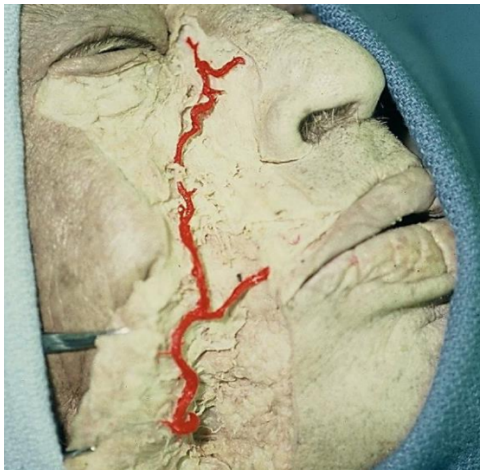


Figure 3: Cadaver dissection showing a less common lateral course of the artery

The subdermal plexus is supplied by feeder vessels from the branches of the facial artery and provides the blood supply to the nasolabial muscle and skin. This allows for high viability and permits bold thinning and shaping. The facial artery has four main branches in the face: the inferior labial artery, superior labial artery, alar artery and lateral nasal artery, and terminates as the angular artery. In a majority of dissections, the facial artery takes a medial course as shown in *Figures 1 & 2*, rather than a lateral course as shown in *Figure 3* (unpublished data). The artery resides in the dense fibrous tissue at the oral commissure and continues along the superior border of the upper lip to the nasal ala. It then continues in a medial course along the nasofacial groove toward the medial canthus of the eye. Arterial perforators are especially concentrated in the inferior two-thirds of the nasolabial groove.

When raising a laterally-pedicled flap, as is often the case in single-stage oral cavity defect reconstructions, incorporation of the lower one-third of the nasolabial groove is essential to ensure a robust vascular musculocutaneous base.

Muscle

The relevant musculature is best understood as it relates to the facial artery. The facial artery is deep to the platysma, risorius, zygomaticus major and minor, levator labii superioris, and levator labii superioris alaeque nasi muscles. The artery is superficial to the mandible, buccinators muscle, and levator anguli oris muscle. The position of the artery deep to the majority of facial mimetic muscles suggests that the nasolabial flap may incurporate this muscle layer and be developed as a true musculocutaneous flap.

Flap design

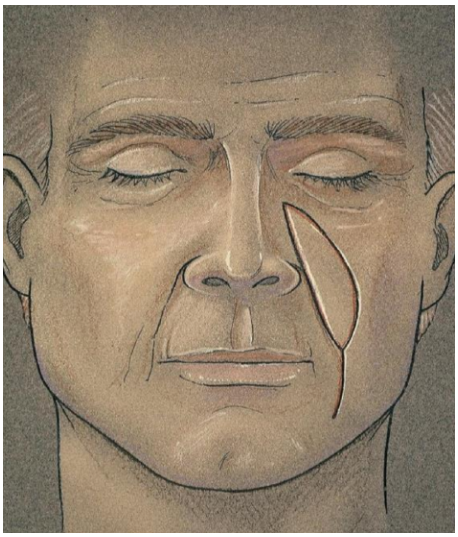


Figure 4: Approximate dimensions of the nasolabial flap

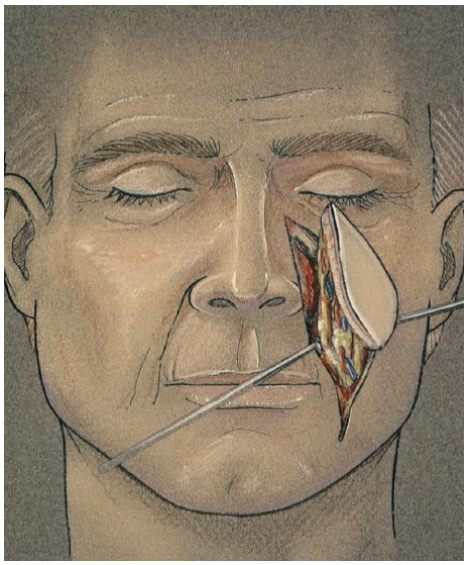


Figure 5: Illustration demonstrating the the laterally based pedicle

A fusiform flap is marked ensuring that the medial border of the flap is on the nasofacial groove (*Figures 1, 4, 5*). A pencil Doppler probe may be useful to locate and delineate the course of the artery. Average flap dimensions are 2.5 cm in width and 6 cm in length. The width may be closer to 5 cm when the facial skin is very redundant. The superior border of the flap is inferior to the medial canthus along the nasofacial junction. Placement of the inferior border depends on the nature of the defect. For floor of mouth reconstruction, the inferior border of the flap should be at the superior border of the mandible; reconstruction of palatal defects, however, requires the inferior border to be approximately at the level of the oral commissure.

Flap harvest

The skin incision is carried through the dermis and subcutaneous fat to the level of the underlying musculature. As shown in the anatomic dissections above and below, the artery lies in a plane deep to the facial mimetic musculature and in a medial position along the nasofacial groove. The flap is elevated in a superior-to-inferior fashion in a plane deep to the facial musculature, artery and vein, with the artery identified carefully by blunt dissection. The parotid duct is identified and preserved. The superior labial artery may require ligation.

Inset

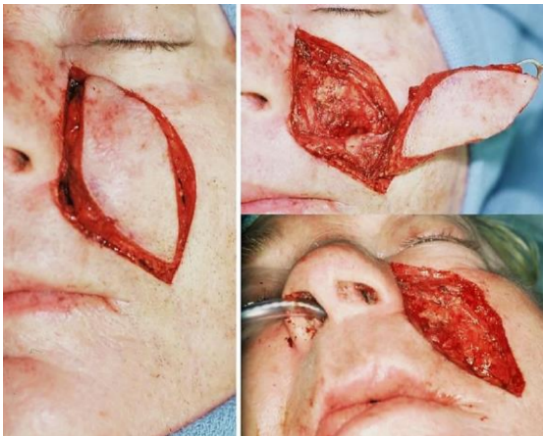


Figure 6: The flap is narrowly pedicled on the facial artery, and then is tunneled via the buccal space into the oral cavity

Thus a musculocutaneous flap is developed and pedicled on the facial artery (*Figures 5*, *6*, Case #6). The flap is then tunneled through the buccal space to repair the intraoral defect, as shown in *Figure 6* and in several cases below. If single-stage reconstruction is the goal, the tunneled segment of the flap must be de-epithelialized. Staged reconstruction with delayed division of the pedicle may be performed, with the delay necessary to ensure adequate neovascularization.

Donor site closure

The donor site is irrigated prior to layered closure with 4-0 Vicryl providing deep dermal closure and 5-0 fast absorbing catgut sutures to approximate the skin edges. The closure should advance the lateral skin flap in a superior and medial direction to avoid distortion of the lower eyelid.

Clinical Applications & Selected Cases

A nasolabial flap is suited to reconstructing small-to-medium oral cavity defects including, but not limited to alveolus (Case #1), floor of mouth (Cases #2, #3), buccal cavity (Case #4) and palate (Cases #5, #6).

Case #1: Superior alveolus reconstruction



Figure 7: Tumor of superior alveolus

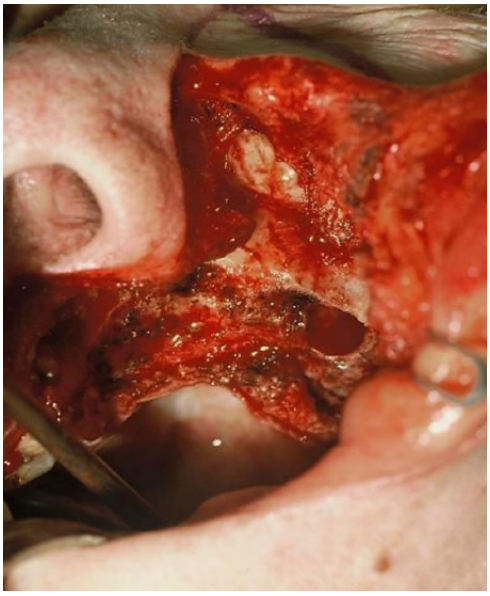


Figure 8: Alveolectomy defect

This superior alveolus tumor was resected by superior alveolectomy. A lip-split approach was utilized for resection and to facilitate the reconstruction (*Figures 7*, *8*).



Figure 9: Nasolabial flap being designed and raised



Figure 10: Flap turned in to reconstruct the defect



Figure 11: Nasolabial flap inset into the defect and donor site and lip-split closed

A nasolabial flap was designed, raised and turned in to reconstruct the defect (*Figures 9-11*).



Figure 12: Wound closure and final result

Figure 12 illustrates a Penrose drain left in a dependent portion of the donor site; and a postoperative image showing the donor site and accessory incisions to be well healed.

Case #2: Mouth floor reconstruction



Figure 13: Defect following resection



Figure 14: Outline of flap

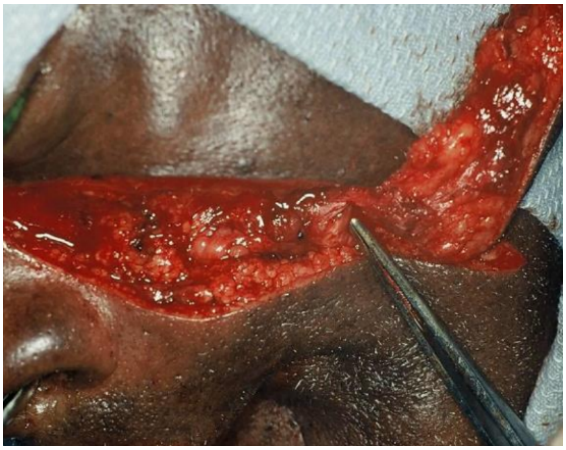


Figure 15: Facial artery is bluntly dissected



Figure 16: Flap inset into floor of mouth

This floor of mouth cancer resection resulted in an alveolar ridge, gingiva, and floor of mouth defect; the inferior border of the defect is at the level of the superior border of the mandible (*Figure 13*). The defect was reconstructed with a nasolabial flap (*Figures 14-16*).

Though the flap is hairless in the image shown, the surgeon must anticipate the implications of transferring hair-bearing skin intraorally.

Case #3: Mouth floor reconstruction



Figure 17: The robust nasolabial flap minimizes the risk of ankyloglossia

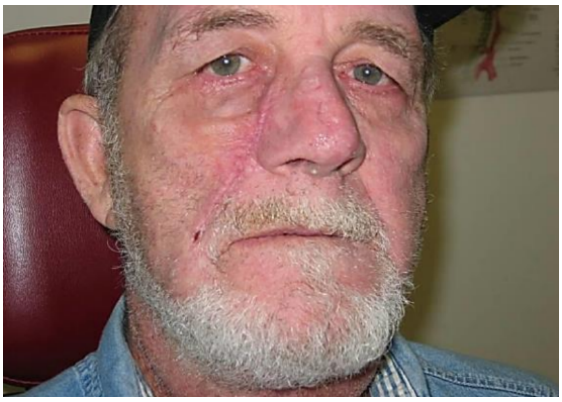


Figure 18: Early postoperative image shows aesthetically acceptable appearance of donor site



Figure 19: Later image shows a well-healed floor of mouth reconstruction



Figure 20: Though the right upper lip is paralyzed, the concomitant lip lift provided by the harvest of nasolabial donor skin aids with symmetry at rest

Figures 17-20 illustrate the postoperative results of reconstruction of an anterior floor of mouth defect crossing the midline.

Case #4: Buccal cavity reconstruction



Figure 21: Buccal defect



Figure 22: Flap inset into buccal defect

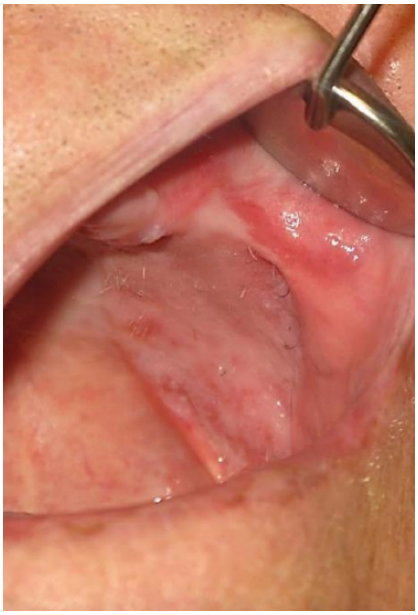


Figure 23: Healed flap in buccal defect

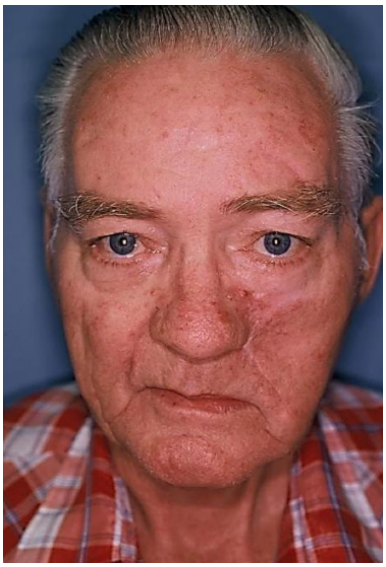


Figure 24: Final cosmetic result

The robust blood supply to the nasolabial flap permits shaping of the flap to precisely fill the defect (*Figures 21-24*).

Case #5: Palate reconstruction (postoperative)



Figure 25: Healed palatal defect

Figure 25 demonstrates a healed palatal reconstruction, with an implant visible for a dental prosthesis.

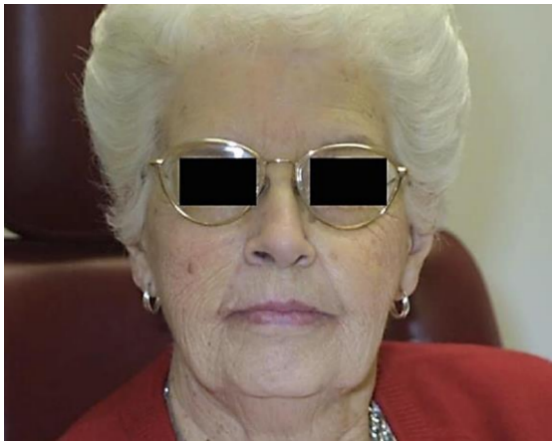


Figure 26: Excellent camouflage of scar and facial symmetry at rest

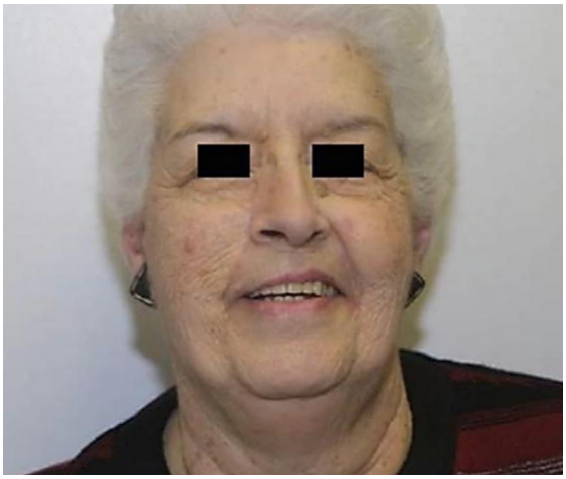


Figure 27: Asymmetry with smiling

Reconstruction of palatal defects requires that the inferior border of the incision be approximately at the level of the oral commissure. Note the excellent camouflaging of the scar and the facial symmetry at rest (*Figure 26*). When smiling the patient demonstrates the expected paralysis of the ipsilateral upper lip which is generally well-tolerated (*Figure 27*); this adverse outcome is further discussed below.

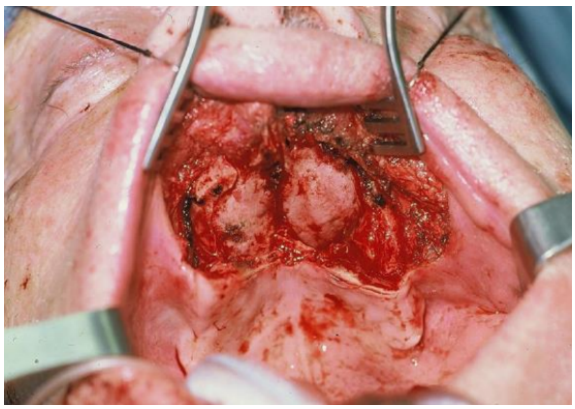


Figure 28: Defect of hard palate, alveolus and gingivobuccal sulcus

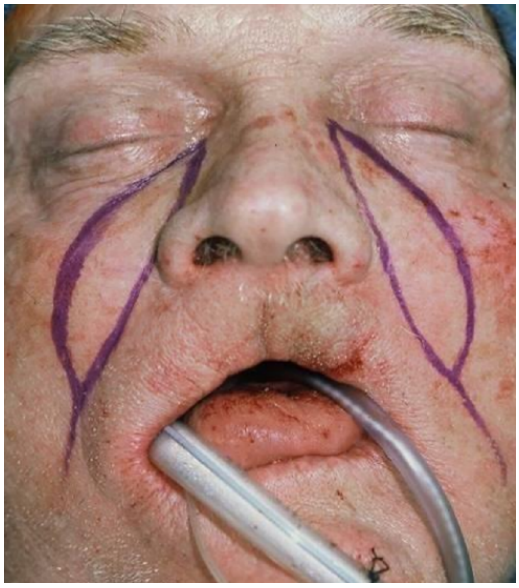


Figure 29: Bilateral nasolabial flaps

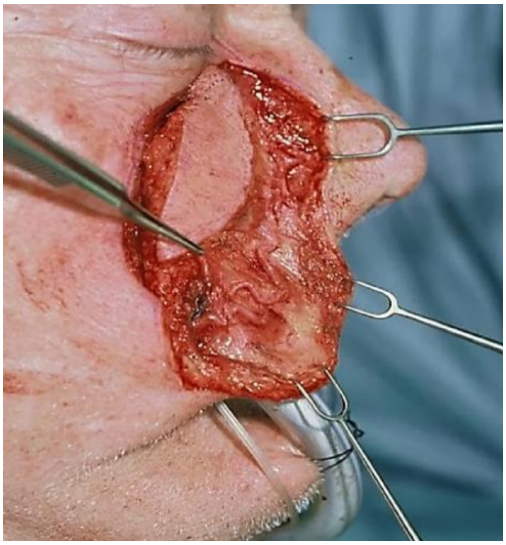


Figure 30: Angular artery visible

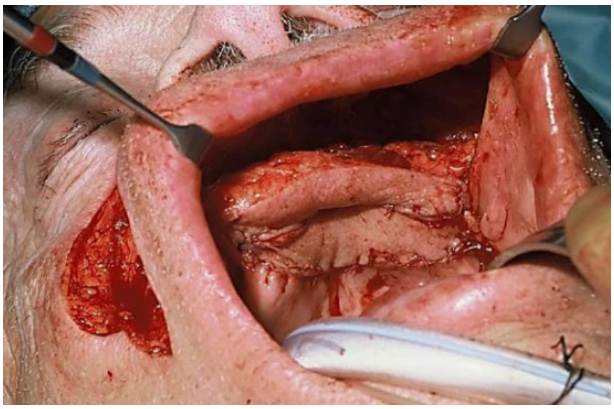


Figure 31: Flap being inset in a side-by-side configuration

This patient has a large defect of the hard palate, alveolus and gingivobuccal sulcus (*Figure 28*). Bilateral nasolabial flaps were raised (*Figure 29*). In *Figure 30* the terminal branch of the facial artery i.e. the angular artery, is demonstrated.

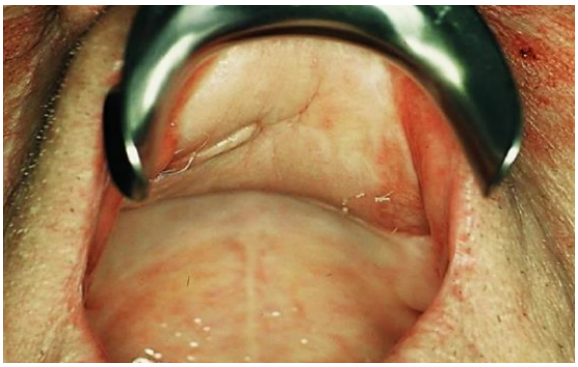


Figure 32: Healed palatal reconstruction



Figure 33: Healed facial scars

Postoperative images show well-healed donor sites and intact and symmetric elevation of the corners of the mouth i.e. intact cranial nerve VII (*Figures 32, 33*).

Adverse Outcomes

Upper lip weakness

Upper lip weakness may result if the terminal buccal branches of the facial nerve supplying lip elevators are lysed or if the principle lip elevators (zygomaticus major/minor, levator labii alique nasi, levator anguli oris) are completely divided. Muscle disruption may occur when extensive mobilization and rotation of the flap is required.

A unilateral nasolabial flap typically does not result in any appreciable ipsilateral lip weakness. As a correlation, deinnervated Abbe flap reconstruction of the upper lip has been shown on electromyography (1 and 5 years post-op) to regain 80 and 100% reinnervation of the transposed muscle segment.[1] However, extensive disruption of innervation and mimetic muscle integrity

during harvesting of bilateral nasolabial flaps may result in clinically appreciable weakness of the upper lip. Though permanent, it is usually well tolerated. As shown in the selected cases above, the resulting upper lip weakness is mitigated by the mild lip lift provided by closure of the donor site.

Oral competence

Bilateral upper lip weakness and numbness could significantly impair oral competence, especially lip-pursing, and must be considered if bilateral nasolabial flaps are planned. Special care should be taken to avoid disruption of the distal facial nerve branches in such cases.

Summary

Nasolabial flap reconstruction of intraoral defects is a well-recognized technique. Because the flap is pedicled on the facial artery, single-stage closure with a smaller pedicle may be achieved if the proximal portion of the flap is de-epithelialized. A robust blood supply helps to ensure flap viability and prevents flap breakdown and fistula formation even in adverse conditions of excess tension or mild compression of the transbuccal pedicle. The bulk provided by the facial musculature helps to fill larger defects. It does not impair speech and causes only minimal donor site morbidity. The flap is not overly time-consuming or technically difficult to master; however, knowledge of the relevant anatomy is essential.

References

Burget G, Menick F. Aesthetic restoration of one-half of the upper lip. Plast Reconstr Surg. 1986;78(5):583–93

Acknowledgements

- Illustrations by Paul Gross
- Cadaver dissections by David Haynes, MD FACS

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Harry V. Wright MD, MS
Fellow
Facial Plastic and Reconstructive Surgery
Otolaryngology and Head & Neck Surgery
University of South Florida, USA
dr.hvwright@gmail.com

Scott Stephan MD
Assistant Professor

Facial and Plastic Surgery
Vanderbilt Bill Wilkerson Center
Nashville, TE, USA
stephan@vanderbilt.edu

James L. Netterville MD
Director of Head and Neck Surgery
Vanderbilt Bill Wilkerson Center
Nashville, TE, USA
james.netterville@vanderbilt.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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5.7: Principles and Technique of Microvascular Anastomosis for Free Tissue Transfer Flaps in Head and Neck Reconstructive Surgery

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

FREE TISSUE TRANSFER FLAPS IN HEAD & NECK RECONSTRUCTION: MICROVASCULAR ANASTOMOSIS TECHNIQUE

Ottie van Zyl, Johan Fagan

This chapter describes the surgical technique of microvascular anastomosis, and the management of patients undergoing vascularized free tissue transfer reconstruction of the head and neck.

Readers are referred to the open access atlas chapters on vascularized free fibula (FFF), radial free forearm (RFFF), anterolateral thigh (ALTF), rectus abdominis and jejenum flaps for technical details about how to raise these flaps, and to chapters about their applications to reconstruct oropharyngeal, cervical esophageal, floor of mouth, partial glossectomy, total glossectomy, total maxillectomy, inferior maxillectomy, and total laryngectomy defects.

Preoperative evaluation

Preoperative evaluation is important in order to select the most suitable flap, and to select patients and to optimize their medical status. Factors to consider include:

- Flap
  - Vascular status
  - Tissue quantity and quality
- Donor site: Functional and cosmetic morbidity
- Patient: Medical and oncologic status

Vascular status

- Elevate hand
- Clench hand into fist for 30 seconds
- Occlude both ulnar and radial arteries
- Open hand while still elevated
- Hand appears blanched
- Release pressure on ulnar artery
- Color returns in 7-10 seconds
  - Ulnar arterial supply to hand insufficient
  - RFFF has risk of causing vascular insufficiency

Table 1: Allen test

Most head and neck cancer patients are smokers and are middle aged or older. Therefore, one must carefully assess the peripheral circulation and the quality of the skin. Severe atherosclerosis is not necessarily a contraindication to free flap surgery; in the authors' experience, with careful suturing, rigid, hard arterial walls of flap vessels actually splint and keep an anastomosis patent. Enquire about a history of intermittent claudication, deep vein thrombosis, limb trauma and varicose veins; previous trauma or fractures may warrant taking x-rays. An Allen test should be done prior to harvesting a RFFF to assess whether collateral ulnar arterial supply to the hand is sufficient if radial artery supply is lost (*Table 1*).

Only if concerns exist about arterial and/or venous insufficiency are further investigations indicated. Duplex color-flow Doppler will usually suffice. Only very rarely is MRI angiography or invasive angiography indicated. Should there be a major concern about vascular supply then an alternative donor site should be considered.

Tissue quantity and quality of flap

Adequate skin should be harvested to reconstruct the defect. With through-and-through defects one may add a 2nd skin island based on the same pedicle; or a 2nd free flap; or leave muscle of the flap exposed intraorally to epithelialize; or cover the external surface of the flap with split skin graft. Thick inelastic skin may be inappropriate to reconstruct defects where mobility is important e.g. RFFF is the preferred option for larger floor of mouth or anterior tongue defects. Thickness of subcutaneous fat is important in terms of tissue bulk and pliability; it should be minimal with anterior oral cavity reconstruction and may preclude using ALTFs in some patients. In other situations additional bulk may be advantageous e.g. following total glossectomy. The quality, volume and length of bone required with osseous flaps depend on the defect. Fibula (FFF) is the most versatile bone to reconstruct bony defects in the head and neck. Bone stock should be adequate if dental implants are to be inserted.

Donor site: Functional and cosmetic morbidity

Functional morbidity may influence the choice of flap e.g. a painter or sportsman may prefer to have the non-dominant forearm used. Avoid using disfiguring pedicled flaps from the head/neck/ shoulder/chest regions, and flaps that cause tethering or downward traction on facial tissue (e.g. pectoralis major and deltopectoral flaps). Skin that is transposed from the trunk and limbs is of a much lighter, pale/yellow color (especially Caucasians) compared to the face, whereas regional flaps taken from the neck such as submental artery flaps gives a better color match (has limited utility if neck dissection done). The ALTF has gained popularity because unlike the RFFF its scar is less obtrusive and can be hidden under clothing.

Patient: Medical and oncologic status

Assess the patient's fitness to undergo major surgery and optimize his/her medical status. Advanced age and lack of fitness does not rule out using free flaps per se. ***It is critical not to waste time by working as two surgical teams*** and being technically competent and quick in frail patients; with high risk patients one might even opt for a much quicker and less invasive option such as simple primary closure following e.g. hemimandibulectomy. Although using regional flaps e.g. pectoralis major myocutaneous flaps may appear to be a more sensible choice in high risk patients, it may be detrimental, firstly because operating time may be increased when a 2-team approach is not possible and, secondly because pain at the donor site may increase risks of atelectasis and chest infection.

Operating room setup



Figure 1: Two-team approach with anesthetic equipment stationed at foot of bed

Resect the primary tumor and elevate the flap simultaneously as a ***2-team approach*** to reduce surgical time (*Figure 1*); minimizing length of surgery has benefits both for the patient and for flap survival.

Create working space around the head and neck region by placing the anesthetic machinery at the foot of the bed with extensions for intravenous lines and anesthetic tubing. Two electrocautery systems are used. Cautery and other equipment are positioned at the foot of the bed, contralateral to the operated limb. A warming blanket covers the torso and the opposite limb when elevating a FFF or ALTF. The heights of the table and/or chair are adjusted so that the surgeon and assistant are seated while raising the flap (*Figure 1*).

Loupes vs. Microscope [1] (Figure 2)



Figure 2: Surgeon uses 4.5x loupes; assistant can use 2.5x loupes

While many surgeons use microscopes, it is the 1st author's preference to use loupes with 4-5x magnification whenever possible; the assistant may use 2.5x (*Figure 2*). Recipient vessels in the neck are quite large as are vessels in free flaps used in head and neck reconstruction (unlike replant and experimental laboratory surgery). Loupes are more appropriate for surgeons with steady hands and stable heads. As long as a surgeon is capable and confident about his/her visual acuity and never has doubts about placing sutures, surgery with loupes is very efficient.

Advantages of loupes include:

- No visual adjustment required between elevating the flap and suturing the anastomosis
- Wider field of vision
- Greater mobility and ability to access difficult areas
- Can move around patient's head for better position and improved visual access
- Quicker surgery, shorter operating time
- More space in the operating room
- Ability to work in different hospitals and operating rooms without needing to adjust to unfamiliar microscopes
- Assistants do not need to be trained to work with an operating microscope
- Cheaper

Surgical instrumentation (Figures 3-5)



Figure 3: Microinstruments and single microvascular clamps



Figure 4: Baby Satinsky vascular clamp and double microvascular clamp



Figure 5: Hemostatic Ligaclip applier and clips

- Microsurgical forceps x 3 (minimum)
- Micro needle holder
- Microscissors (straight and curved)
- Microvascular clamp (selection of single and double clamps)
- Baby Satinsky vascular clamp (for endto-side anastomoses)
- Bipolar coagulation forceps
- Hemostatic Ligaclip appliers (small and medium)

It is preferable to use longer forceps and needle holders as it reduces crowding in restricted spaces by the 2 pairs of hands. Shorter forceps are also less stable if not securely placed on the dorsal aspect of the first web of the hand.

The most appropriate suture to use for the microvascular anastomosis when using loupes, is 8/0 nylon.

Irrigation fluids

Heparin-saline solution

- 5000 units in 50 mL saline
- Mixed in a small bowl
- Draw up two 5 mL syringes with intravenous cannula attached
- To flush and irrigate vessels (without separating or damaging endothelial layer of artery)
- To hydro-dissect adventitia off vessels

Lignocaine solution 1%

- 5 mL/500 mg ampoule in 50 mL saline
- Apply topically via 20 mL syringe with venous cannula attached
- To relieve spasm with small caliber vessels while dissecting a perforator flap

Lignocaine 10 % (undiluted)

- Soaked into a gauze swab
- Applied topically to anastomosis to relieve spasm (if necessary)
- Papaverine may be used as an alternative, but is less readily available

Choice of limb

Selecting the appropriate donor leg or arm is based on the type and location of the surgical defect and which the side of the neck is to be used for the vascular anastomoses (Refer to chapters on free fibula, anterolateral thigh and radial forearm flaps for detail).

Flap design

The flap should ideally have been elevated at the same time as completion of resection of the primary and the neck dissection. With a two-team approach the oncologic surgeon therefore resects the primary tumor **early** so that the reconstructive surgeon can inspect the defect and plan the flap. The resection is done first, or immediately following dissection of Levels I & II of the neck. The reconstructive surgeon starts elevating the flap once he/ she has some idea about the dimensions of the defect, or if the proportions of the flap can be adjusted subsequently.

It is best to inspect the tumor at the time of initial exposure prior to resection and to “picture” the normal anatomy and that of the defect; then to draw the flap on paper; to cut out the paper template and then to transpose it to the donor site to plan the dimensions of the flap (The author rarely measures the resected specimen to determine the dimensions of the flap, as shrinkage of soft tissue and postsurgical changes can modify the shape and size of the defect). With experience, inspecting the tumor prior to dissection is often adequate to design an appropriate flap.

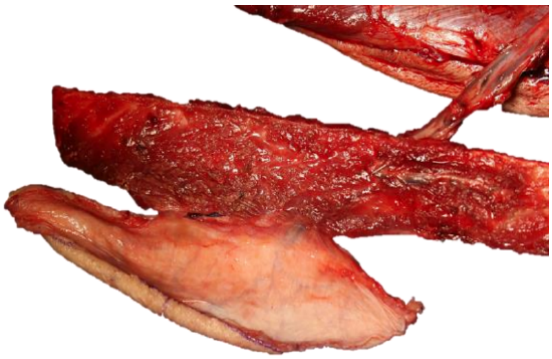


Figure 6: Skin island, perforator, fibula, and vascular pedicle ready to be detached

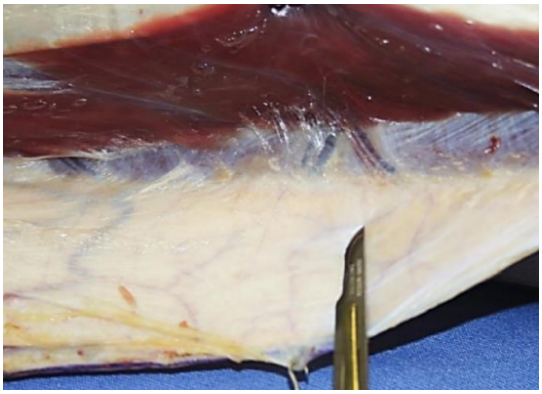


Figure 7: Perforators tracking across the posterior crural intermuscular septum of the leg (free fibula flap)

Unexpected problems may necessitate one to raise a different size or shape of flap, or even a totally different flap e.g. the resection may be greater or lesser than planned; one may encounter unexpected anatomical variations; or there may be severe atherosclerosis or unreliable perforators (*Figures 6*, *7*).

Principles of elevating a flap

Size

Design a large enough flap but avoid large and bulky flaps especially in the anterior oral cavity.

Bloodless field

Perforator flaps are meticulously elevated in a bloodless field without using a tourniquet. RFFF and FFFs are done with tourniquet compression; in adults the average tourniquet pressure for the arm is 250 mmHg, and 300 mmHg for the leg. Note: vessels appear smaller when operating with a tourniquet in a bloodless field.

Ligaclips (Figure 5)

Ligaclips are preferable to bipolar coagulation. Only use bipolar coagulation away from vessels supplying/draining the flap, as coagulation can cause thermal injury of critical vessels; this is certainly true when elevating perforator flaps. Ligaclips avoid narrowing or occlusion of veins sometimes seen when venous tributaries are ligated with braided (silk/vicryl) ties.

Preparing the vascular pedicle

- Continuously apply topical lignocaine to the perforator pedicle
- Keep vessels (especially veins) intact until a decision has been made about what vessels are to be used for the anastomosis
- Fashion the length of the pedicle so that it reaches the mid-internal jugular vein, the superior thyroid artery, facial artery or transverse cervical artery
- Problems with pedicle length may occur especially when the contralateral neck is used for vascular anastomoses e.g. with revision flaps, following previous neck dissection or irradiation, or when reconstructing midface or maxilla. In such cases the oncologic surgeon should maintain continuity of the facial artery and keep the common facial vein and/or external jugular vein intact; even the anterior jugular veins may be used
- Select the ***most suitable vein*** and ligate the others; only one vein is generally needed

- It is better to interpose a vein graft to a larger vessel than to anastomose to a small vein or for the anastomosis to be under tension
- Carefully ***separate the vein and artery*** from each other to permit the arterial and venous anastomoses to be placed some distance from each other if necessary
- ***Deflate the tourniquet***
- ***Obtain meticulous hemostasis*** of the flap and the surgical bed with bipolar cautery, ligaclips and ligatures

Preparing the flap

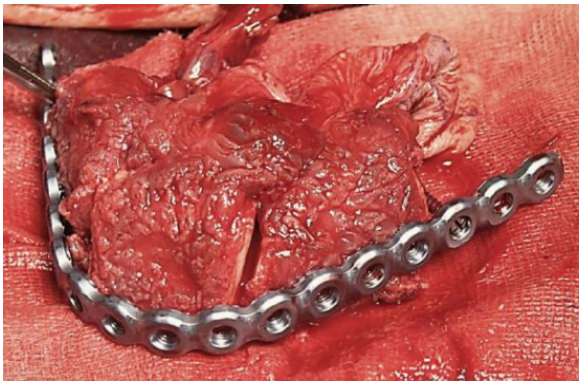


Figure 8: Bony segments fixed to plate with vascular pedicle still attached to leg

In order to ***minimize ischemic time, leave the flap attached by its vascular pedicle*** until tumor resection is complete, and the donor vessels have been prepared. If possible, complete the osteotomies and secure bony segments to the reconstruction plate before detaching the vascular pedicle (*Figure 8*) so that the bony reconstruction is virtually completed with the vascular pedicle still attached. Only if this is not possible should the bony segments be fixed to the plate after transposing the flap to the mandibular or maxillary defect.

Selecting the donor vessels

An ***end-to-end arterial anastomosis*** is generally done to the facial, superior thyroid, external carotid or transverse cervical arteries. The surgeon selects the most suitable donor artery based on the anatomical relationship of the donor artery to the defect, access to do the anastomosis, the relative diameters of the flap and neck arteries, atherosclerosis, scarring from previous surgery and/or irradiation, and the length of the vascular pedicle. Dividing the posterior belly of digastric and the stylohyoid muscle may improve access to the stump of the facial artery. When the artery of the flap is hard and rigid due to atherosclerosis and cannot be twisted or curved towards the donor artery, warn the oncologic surgeon that a longer donor artery pedicle is required that can reach across to the flap's artery.

An ***end-to-side venous anastomosis*** is generally done to the internal jugular vein, or to one of its major tributaries.

Preparing the donor artery in the neck

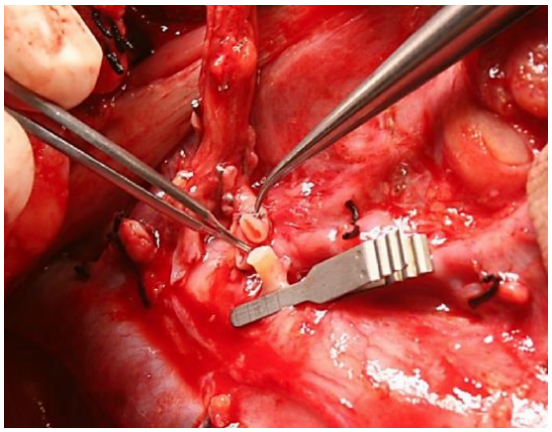


Figure 9: Microvascular clamp placed across origin of superior thyroid artery; peroneal artery of free fibula flap vascular pedicle lies adjacent

- Determine the required length of the artery

- Place a micro clamp proximally on the donor artery (*Figures 3, 4, 9*)
- Divide the artery with micro scissors
- Remove excess adventitia from the tip of the artery
- Irrigate the lumen with heparin/saline
- Inspect the arterial lumen and remove fibrin from the lumen with microforceps (occurs if artery was ligated during neck dissection)
- Carefully dilate the arterial lumen with the rounded tip of a micro needle holder taking extreme care not to traumatize the endothelium
- Observe whether the endothelium has separated from the mesothelium; this necessitates additional trimming of the end of the artery, or taking special care to catch the loose endothelial layer with the sutures when doing the microanastomosis, thus preventing dissection of the endothelial layer, formation of an endothelial flap and thrombosis
- Again, irrigate the arterial lumen with heparin/saline to remove blood clots
- Trim loose advential strands around the tip of the vessel with microscissors to prevent them from prolapsing into the arterial lumen and causing thrombosis

Preparing the Internal Jugular Vein

- Select the segment of the jugular vein that is to be used for the anastomosis

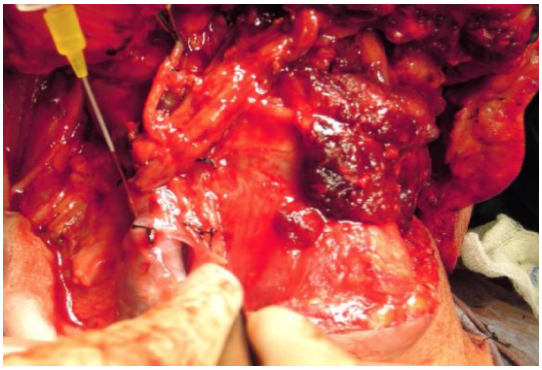


Figure 10: Separating adventitia of carotid sheath off internal jugular vein with gentle hydrodissection

- Use hydro dissection to elevate and separate any remaining adventitia (carotid sheath) over the vein by irrigating the surface of the vein with the heparin/saline solution (*Figure 10*)
- Remove this adventitial layer with microscissors

Dividing the vascular pedicle of the flap

- Divide and ligate the vascular pedicle of the flap only after the recipient vessels in the neck have been prepared
- Flush the vein and the artery with the heparin/saline solution

Securing the flap prior to doing the microvascular anastomosis

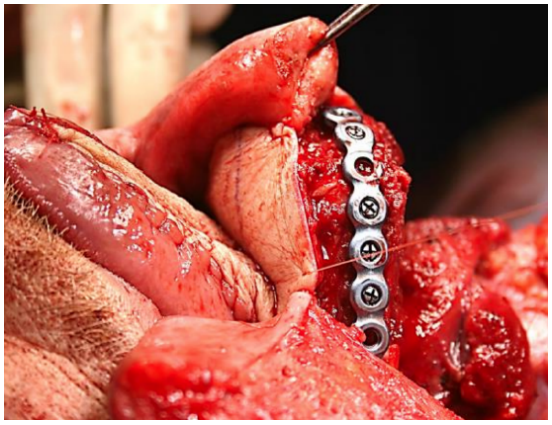


Figure 11: Flap partially sutured and bone secured prior to commencing microvascular anastomosis

- Secure bone flaps to mandible/maxilla and suture skin flaps to mucosa or skin (*Figure 11*) to avoid inadvertently applying traction to the microvascular anastomoses

- Do not entirely suture a skin flap at this stage to have access to the deep aspect of the flap to secure hemostasis should bleeding occur from the flap once it is revascularized

Orientating the vascular pedicle

It is crucial to avoid kinking or rotating the vascular pedicle. Mark the anterior edge of the pedicle with blue ink as it lies in situ, to avoid twisting the pedicle when it is transferred. Consider that the pedicle elongates after it has been revascularized due to the vessels distending with blood.

It may be difficult to atraumatically pass the vascular pedicle through a soft tissue tunnel. A long artery forceps can be passed through the tunnel, taking hold of adventitia near the end of the pedicle and gently drawing the pedicle through the tunnel. Alternatively, it can be done by first passing a pencil drain through the tunnel, advancing the pedicle into the pencil drain by flushing saline through the drain alongside the pedicle, and then jointly retracting drain and pedicle into the neck.

Handling the microinstruments

Microinstruments are extremely delicate and are expensive and must be handled with extreme care (*Figure 3, 4*)

- Do not drop the forceps as the tips will bend out of alignment or break
- Place microinstruments separately and away from other surgical instruments
- The scrub nurse should clean the microinstruments with a warm, wet gauze swab every time they are handed off to remove dried blood and tissue
- Microsuture needles, sutures and microclips are easily lost during surgery; once lost they are extremely difficult to find

Suturing technique and tips

It is the authors' preference to employ a continuous suture technique for both the arterial and venous anastomoses, except when suturing extremely small vessels. Although many surgeons use interrupted sutures, using continuous sutures is much quicker and causes less anastomotic leaks.

- Suturing technique should be practiced in an animal laboratory
- The author uses an 8/0 nylon suture on a taper pointed needle
- Stabilizing the wrists is important
  - Rest them on the operative field
  - A patient's chest movement may affect the stability of a surgeon's hand
  - The arterial anastomosis is usually done close to the carotid; the surgeon needs to adapt to the pulsations of the carotid
- Avoid moving one's hands outside the visual field
- Suturing tips
  - It is easier to run a suture towards yourself
  - Avoid transferring a needle directly from forceps to needle holder as the "spring" in a curved needle can propel the needle and thread a considerable distance from the operating field
  - Pass the needle through the vessel wall about a vessel wall's thickness (or slightly more) from the free edge of the vessel o Pull the thread through the wall to 1-2 cm from the end of the suture
  - Pass the needle through the other vessel's wall
  - The assistant uses microforceps to approximate the ends of the pedicle and donor vessels
  - Tie a knot by holding the longer length of suture with the needle holder about 2-3 cm from the exit point from the vessel and then tying it to the shorter suture

Arterial microvascular anastomosis

The arterial microanastomosis is usually done first. This allows one to untwist and correctly position the remainder of the pedicle and the vein; kinking and twisting the vein can block venous outflow. If the artery and vein of the pedicle cross over each other, then the vein should be orientated to cross superficially over the artery.

The author employs two anastomotic techniques depending on the relative diameters of the donor and recipient vessels i.e. end-to-end and occasionally, a sleeve anastomosis

End-to-end arterial anastomosis

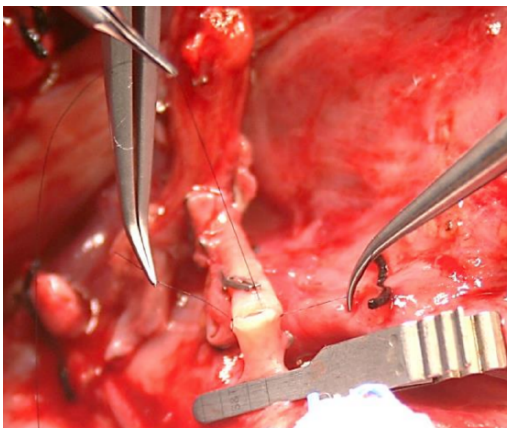


Figure 12: Stay sutures held with curved non-toothed forceps while surgeon inserts row of running sutures

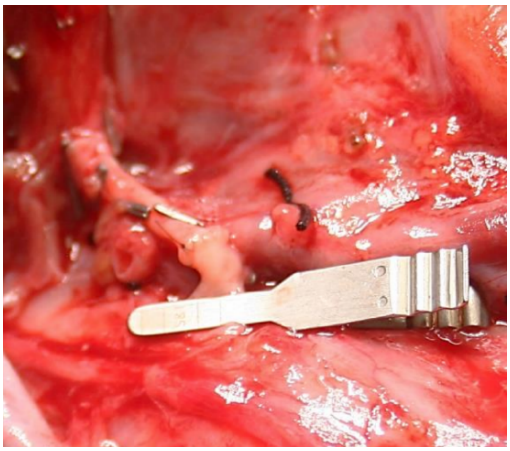


Figure 13: Completed arterial anastomosis

- Flush the donor and recipient arteries with the heparin/saline solution again
- Join the two vessels with a single stay suture, knot it, and cut it to a length of about 2 cm (*Figure 12*)
- Insert a 2nd stay suture at the opposite side of the vessel's circumference, knot it, but do not cut it (*Figure 12*)
- The assistant stabilizes the vessels by holding the two stay sutures with nontoothed forceps (*Figure 12*)
- Anastomose the anterior walls of the vessels with a continuous running suture taking care to:
  - Avoid constricting the lumen
  - Avoid catching the back walls of the vessels with the sutures
  - Include the endothelial layer with the suture, especially if separated from the mesothelium
  - Space the sutures to compensate for vessels of unequal diameter
- Tie it to the 2nd stay suture
- Flip / rotate the vessels to access the side opposite to the anastomosis
- Check the suturing on the inside of the vessel
- Complete the 2nd side of the anastomosis with a running suture (*Figure 13*)
- Tie the end of the suture to the 1st stay suture

Sleeve arterial anastomosis (Figure 14)

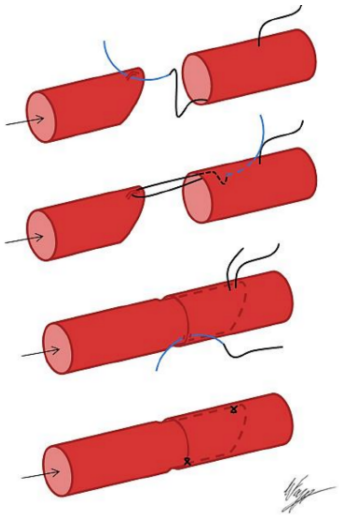


Figure 14: Sleeve arterial anastomosis (arrow indicates direction of blood flow): Cut proximal vessel at 450 angle; pass suture into lumen of larger vessel some distance from end, and through adventitia close to end of smaller vessel; pass suture back along lumen of larger vessel and through its wall; telescope smaller vessel into larger vessel; tack adventitia together

The 1st author uses the sleeve anastomosis technique only when a substantial mismatch exists in the diameters of a larger flap vessel and smaller recipient vessel which makes an end-to-end anastomosis difficult to achieve. It is quick and fairly simple and there are no intraluminal sutures; however, the mismatch in vessel diameters must not be too great, and vessel spasm is more pronounced and lasts longer following release of the clamps.

Venous microvascular anastomosis

The venous anastomosis is done end-to-side to the internal jugular vein, or to a major tributary e.g. the common facial vein. Rarely, it is done as an end-to-end anastomosis to a very small internal jugular vein or one of its tributaries. ***Never allow the internal jugular vein to dry out as it is then more likely to thrombose with loss of the flap***.

- Identify the vein in the vascular pedicle which is to be anastomosed
- Ensure that the vein is not kinked or rotated
- Flush the vein with heparin/saline solution
- Cut the flap vein obliquely to angle the end-to-side anastomosis at 45^0
- Choose the exact point of the internal jugular for the anastomosis
  - Vein must reach it comfortably
  - Avoid suturing under tension or under suboptimal conditions - rather interpose a vein graft
  - Anastomosis usually on the side of the vein so that vein of the pedicle lies comfortably without a likelihood of kinking

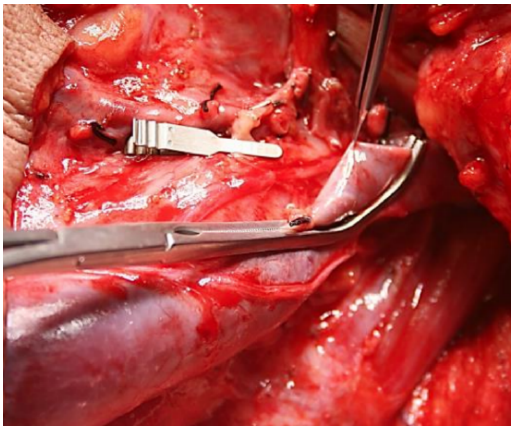


Figure 15: Applying baby Satinsky vascular clamp to internal jugular vein

- Atraumatically isolate the segment of internal jugular vein with a baby Satinsky vascular clamp (*Figure 15*)
- Incise the internal jugular vein with sharp microscissors. The defect in the vein should exceed the diameter of the recipient vein to stretch the vein open

- Flush the lumen of the internal jugular vein with heparin/saline solution
- Join the two vessels together at one end of the incision in the internal jugular vein with a single stay suture, knot it, and cut it to a length of about 2 cm
- Insert a 2nd stay suture at the opposing end of the jugular vein incision, knot it, but do not cut it
- The assistant may hold the stay sutures with non-toothed forceps to improve exposure
- Anastomose one side of the suture line with a continuous suture
- Space the sutures to compensate for unequal lengths of the vessel walls
- Tie the suture to the stay suture on completion of the 1st suture line
- Flip / rotate the vessels to access the 2nd anastomotic suture line
- Irrigate the lumen of the internal jugular vein and inspect the completed suture line

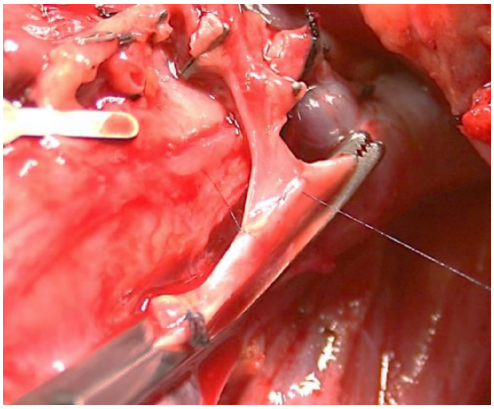


Figure 16: Complete 1st anastomotic suture line; commencing 2nd suture line

- Complete the 2nd suture line taking care not to catch the back walls of the vessels (*Figure 16*)
- Tie the suture to the stay suture on completion of the 2nd suture line

Revascularizing the flap (Figure 17)

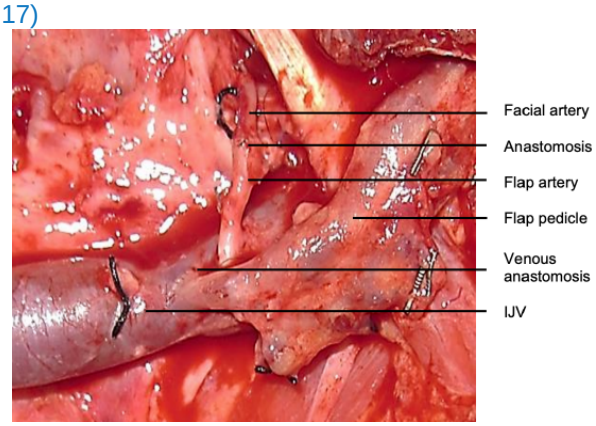


Figure 17: Pedicle anastomosed to facial artery (FA) and internal jugular vein (IJV)

- Ask the anesthetist to raise the mean arterial blood pressure to within a normal range
- Release the vascular clamp on the internal jugular vein
- Check venous filling/distension in the vascular pedicle
- Check for bleeding from the venous anastomosis
- Minor bleeding settles within a few minutes; significant leaks need to be sutured
- Release the microclamp on the artery
- Check for arterial filling/distension and arterial pulsation in the pedicle
- If arteries are in spasm, apply a swab soaked in 10% lignocaine to the vessel for a few minutes
- Check for bleeding from the arterial anastomosis
  - Minor bleeding settles within a few minutes
  - Significant leaks need to be sutured

Anastomotic bleeding

- The assistant irrigates the suture line with heparin/saline solution to better identify the site of the leak
- Insert a single 8/0 suture at bleeding point and ligate to seal the bleeding point

Checking perfusion of the flap

Be happy with the anastomosis before closing the wound. Check flow across the anastomoses and perfusion of the flap using the following measures:

- Ensure an adequate blood pressure
- Observe and feel pulsation of the arterial pedicle
- Check for bleeding from the flap
- Prick the skin flap with a needle if spontaneous bleeding is not observed
  - No bleeding suggests arterial inflow obstruction
  - Dark blood suggests venous outflow obstruction
- Intra- and postoperative Doppler of the vascular pedicle (not routinely)
- Continuous invasive monitoring of oxygenation of the flap e.g. Licox P02 microprobe (not routinely)

Complete inset of skin flap

Always leave some of the suturing of the flap to be done after the anastomoses have been completed to be able to control bleeding from the deep aspect of the flap. This also creates time for blood pressure to normalize, spasm to settle, and for a "2nd look", prior to closing the neck. If necessary, cover the arterial anastomosis and pedicle with a swab soaked in 10% lingocaine to relieve arterial spasm while completing the soft tissue repair. If any doubt exists about the anastomosis it should be taken down and redone.

Hemostasis

It is critical to achieve meticulous hemostasis before closing the neck as a hematoma increases the failure rate of flaps. Inspect the deep aspect of the skin flap and obtain hemostasis with bipolar cautery and/or ligaclips. Take care not to injure the vascular pedicle or perforators. A Valsalva maneuver is done, and the neck wound checked for bleeding.

Wound closure

- Insert a suction drain into the neck taking care for it ***not to pass close to the anastomoses, and not to cross over the microvascular repair or over the internal jugular vein*** (may obstruct internal jugular vein and cause thrombosis and flap failure)
- ***Suture the tracheostomy*** to the skin; ***avoid ties around the neck*** as they may occlude the internal jugular vein and cause venous outflow obstruction and flap failure
- Repair the donor site

Postoperative management

Patients are ideally initially managed in a high care / step down unit where the following parameters that may contribute to flap failure are closely monitored and corrected:

- Reduced cardiac output
- Hypotension
- Hypovolaemia
- Hypercoagulability
- Anemia or polycythaemia
- Hypothermia
- Shifting of suction drain to cross and compress internal jugular vein
- Wound hematoma
- Tracheostomy tapes too tight (once tube is changed)
- Excessive movement of flap
- Neck position which may kink the pedicle
- Wound sepsis
- Alcohol withdrawal syndrome

Monitoring flap perfusion

Flaps are most likely to fail in the 1st 48 hours. If detected and acted on timeously it may be possible to salvage a poorly perfused flap. Therefore, regular and close monitoring of perfusion is imperative. The following methods may be employed to monitor perfusion:

- Color
- Temperature
- Needle pricks to check bleeding (presence/absence and color)
- Invasive monitoring of oxygen saturation (Licox)
- Doppler monitoring of arterial inflow

Final comments

Successful free tissue transfer depends on the many factors outlined in this chapter. By attending to all these measures one can achieve outstanding results even in a developing world setting (flap success rates approx. 95% in our own public hospital in Cape Town[1]. However, failure to pay attention to detail and to all these factors may lead to flap failure and a very difficult and often catastrophic course for a head and neck patient.

Reference

1. Dos Passos G, Rogers A, Price C, et al. Loupe Magnification for Head and Neck Free Flap Reconstruction in a Developing Country. European J Plastic Surg 2015:1-8 (http://link.springer.com/article/10....238-015-1108-z)

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap

Author

JE (Ottie) Van Zyl MBChB, FCS
Plastic & Reconstructive Surgeon
Groote Schuur Hospital
Cape Town, South Africa
ottie@mweb.co.za

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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VASCULARISED FREE FIBULAR FLAPS (FFF) IN HEAD AND NECK RECONSTRUCTION

Ottie van Zyl, Johan Fagan

The vascularized free fibular flap (FFF) is the most commonly used flap in head and neck for bony reconstruction. It is a vascularized free composite flap containing bone and muscle, with or without skin and provides reliable single-stage reconstruction with excellent functional and aesthetic results. Other vascularized bone flaps used in the head and neck include iliac crest, scapula and radial forearm flaps.

Microvascular free tissue transfer allows one to transfer well-vascularized, bone-containing flaps for oromandibular and midface reconstruction. Compared to bone grafts or metal plates, well-vascularized bone is associated with a major reduction of surgical complications and has had an enormous impact on the success of such reconstructions. Vascularized flaps withstand irradiation much better than bone grafts or plates, and when reconstructing within a previous irradiated field, has the benefit of importing tissue with a new blood supply.

FFFs are commonly used for reconstruction of oromandibular and midface/maxillary defects; and of upper and lower limb long bones; the pelvis; and joints.

Benefits of FFF

- Large vessels
- Long vascular pedicle
- Well vascularized bone
- Long length of donor bone (>25 cm)
- Adequate bone stock
- Bony strength permits good screw fixation and solid reconstruction
- Bony reconstruction can be shaped with multiple segmental osteotomies
- Stable bicortical osseointegrated dental implant fixation is possible
- Thin, pliable overlying skin (usually)
- Skin island adequate for most head and neck reconstructions
- Very little soft tissue bulk (usually)
- Simultaneous cancer resection and harvesting of flap possible due to distant location of the donor site from head and neck resection

Caveats with FFF

- **Donor site morbidity**: Delayed wound healing and skin graft loss especially following peroneal tendon exposure; nerve injury; ankle instability; pseudocompartment syndrome, and muscle necrosis
- **Preoperative vascular problems**: Peripheral vascular disease, venous insufficiency, previous deep vein thrombosis, congenital absence of lower leg vessels (rarely)
- **Poor skin quality**: Obesity, stasis and ischemia
- **Previous lower limb trauma**: Fractures, vascular injury

Anatomy

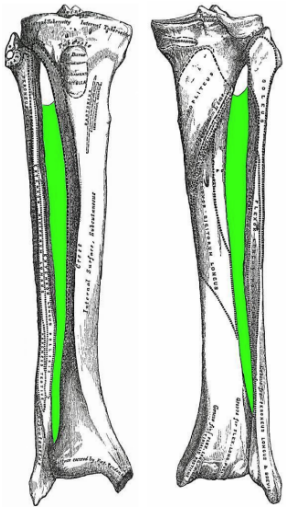


Figure 1: Anterior and posterior views of tibia, fibula and interosseus membrane (green) of right leg

The lower leg has two long bones i.e. tibia and fibula (*Figure 1*). The tibia is the principal weight-bearing bone and is much stronger than the slender fibula. The fibula is triangular in cross-section, but has 4 surfaces i.e. medial, lateral, and posterior with a narrow anterior surface. It serves as a bony pillar for the origins of eight muscles and insertion of one, as well as the attachment for ligaments and fascial septa. It contributes to stabilizing the knee by the insertions of the biceps femoris tendon and lateral collateral ligament onto the fibular head, and of the ankle where the lateral malleolus forms the lateral part of the mortise or socket, to hold the talus in place.

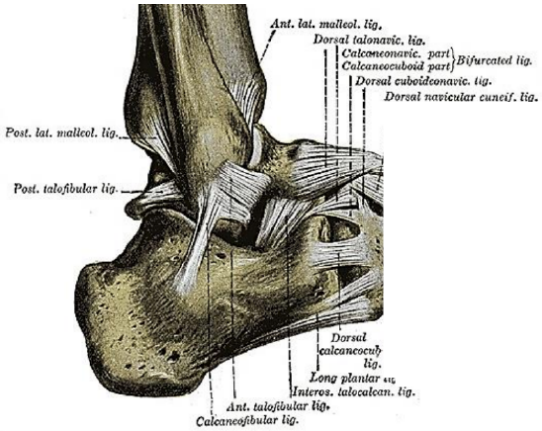


Figure 2: Ligaments attached to the distal fibula of right ankle

The fibula also stabilizes the ankle via the anterior and posterior tibiofibular ligaments, the anterior and posterior talofibular ligaments, and the calcaneofibular ligament (*Figure 2*). The stability and position of the lateral malleolus and distal fibula are further supported by the distal part of the very strong ***interosseous membrane*** which extends between the fibula and tibia (*Figure 1*). The interosseous membrane holds the two bones together and gives origin to some of the muscles of the lower leg. It has a defect proximally through which the anterior tibial artery gains access to the anterior compartment of the leg after the bifurcation of the popliteal artery (*Figure 1*).

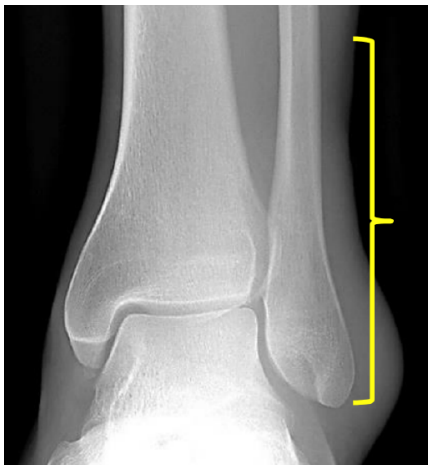


Figure 3: Preserve distal 5-6 cm of fibula to preserve stability of ankle

When harvesting a FFF it is of paramount importance to retain at least 5-6 cm of distal fibula to maintain the integrity of the distal interosseous membrane and of the ligaments mentioned in order to preserve the stability of the ankle (*Figure 3*).

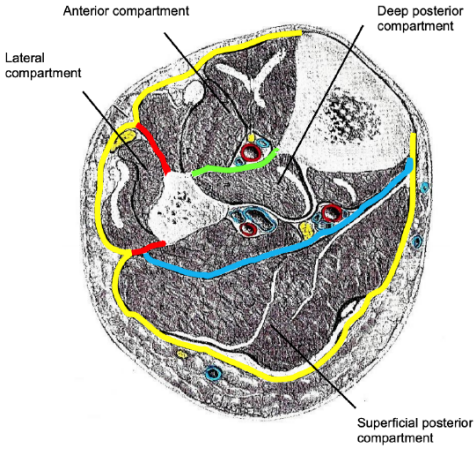


Figure 4: Fascial layers, compartments and cross-sectional anatomy of left leg: Investing layer (yellow); interosseus membrane (green); anterior and posterior crural intermuscular septa (red); transverse crural intermuscular septum (blue)

The ***investing deep fascia*** circumferentially encloses the muscles of the lower leg; it is attached to the anterior and medial borders of the tibia (*Figure 4*). The lower leg is separated into ***four fascial compartments i.e. anterior, lateral, and deep and superficial posterior*** (*Figure 4*). The interosseous membrane separates the anterior from the posterior compartment. The lateral compartment overlies the lateral fibula and is separated from the other two compartments by anterior and posterior crural intermuscular septa attached to the fibula. A transverse crural intermuscular septum divides the posterior compartment into superficial and deep compartments.

Contents of compartments (Figures 4, 5):

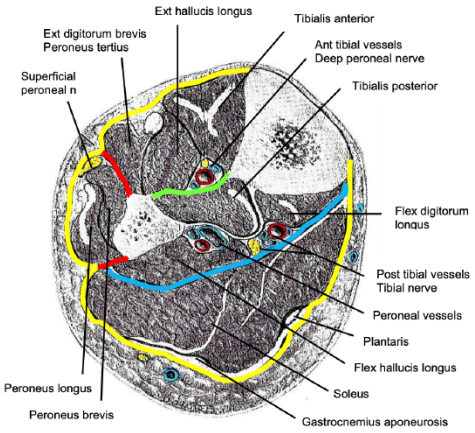


Figure 5: Contents of fascial compartments

Anterior compartment

- Tibialis anterior, extensor hallucis longus, extensor digitorum brevis, peroneus tertius
- Tibialis anterior artery & vein
- Deep peroneal nerve

Lateral compartment

- Peroneus longus, peroneus brevis
- Superficial peroneal nerve
- Blood supply to peroneal muscles are branches of the peroneal artery which lie within the posterior compartment

Superficial posterior compartment

- Gastrocnemius (medial & lateral), soleus, plantaris

Deep posterior compartment

- Tibialis posterior, flexor hallucis longus, flexor digitorum longus
- Tibial nerve
- Tibial & peroneal arteries and veins

Muscles attached to fibula (Figs 1, 4, 5, 6)

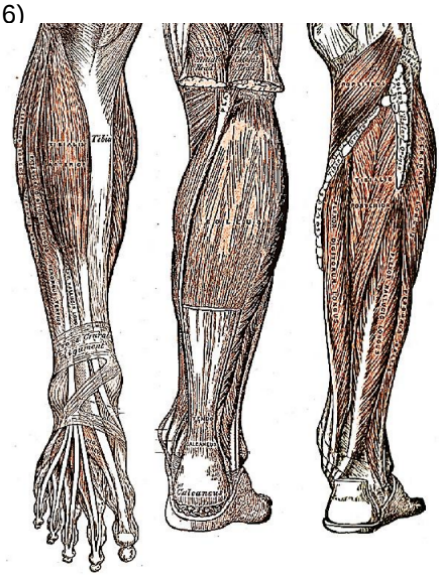


Figure 6: Anterior and posterior views of muscles of leg

- Soleus
- Peroneus longus
- Peroneus brevis
- Peroneus tertius

- Tibialis posterior
- Flexor hallucis longus
- Extensor hallucis longus
- Extensor digitorum longus

Muscles encountered when raising a FFF

- Peroneus longus
- Peroneus brevis
- Extensor digitorum longus
- Tibialis posterior
- Soleus
- Flexor hallucis longus

(The muscles subsequently reattach to scar tissue and the divided interosseous membrane)

Vasculature

The FFF is based on the peroneal artery and its venae comitantes.

Perforators supplying the skin run around the fibula via the posterior crural septum (*Figure 4*). The fibula has ***both endosteal and periosteal blood supply***. The ***endosteal supply*** is via a branch of the peroneal artery which usually enters the bone at the junction of its proximal and middle thirds; this supply plays a role in long bone reconstruction where no osteotomies are performed. ***Periosteal blood supply*** is critical to vascularity of the bone when the fibula is shaped by performing osteotomies. Therefore, as much periosteum as possible, as well as a cuff of muscle, is preserved around the fibula.

The ***periosteal supply*** to the distal two thirds of the bone is via the peroneal vessels.

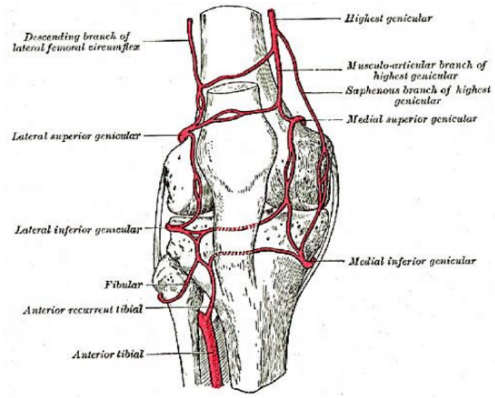


Figure 7: Blood supply to proximal fibula

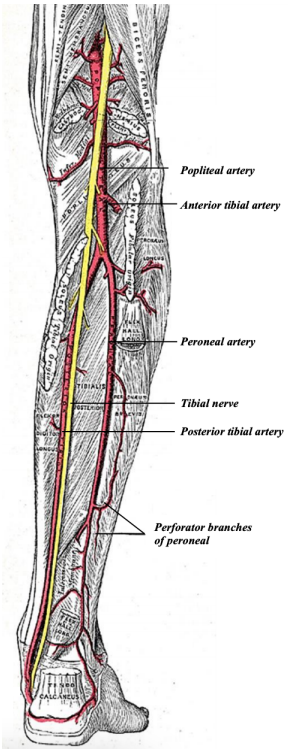


Figure 8: Course of peroneal artery

The ***head of the fibula and a variable length of the proximal third of the fibula*** are supplied by the ***anterior tibial vessels*** via the ***anterior recurrent tibial*** and/or ***lateral inferior genicular recurrent*** branches (*Figures 7, 8*).

The tibioperoneal trunk in turn bifurcates into the ***posterior tibial and peroneal arteries***. The posterior tibial artery courses deeply along the lateral aspect of the leg and can be palpated as the posterior tibial pulse (*Figures 5, 8*).

The ***peroneal artery*** originates as a large branch of the ***posterior tibial artery***, just below the popliteal fossa, 2-3 cm below the tendinous arch of the soleus (*Figure 8*). The artery is accompanied by ***paired venae comitantes***.

The ***peroneal vessels*** are in close proximity to the fibula as they course along the entire length of the bone (*Figures 5, 8*). The artery descends along the medial side of the fibula where it lies posterior to the tibialis posterior muscle and anterior to the flexor hallucis longus muscle (*Figure 5*). It is closely applied to the fibula, but veers away, and more medially, towards its origin from the posterior tibial artery at the upper third of the fibula. Variations of lower leg vascular supply are uncommon but are important to consider. With a dominant peroneal artery, the pedal circulation is more dependent on this artery; sacrificing the artery may render the foot susceptible to ischemia.

Nerves (Figures 5, 8, 9, 10)

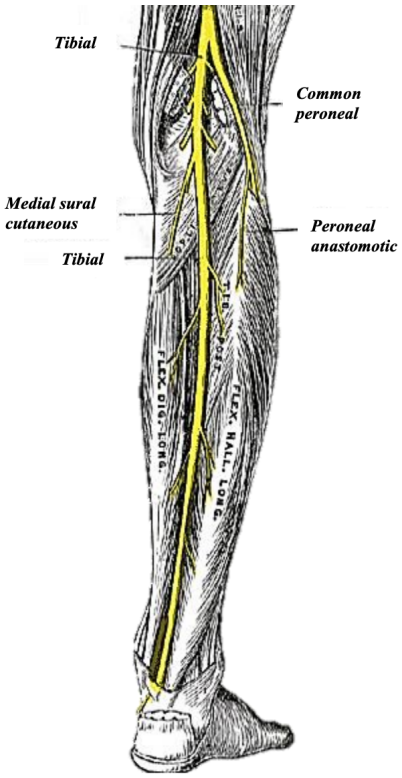


Figure 9a: Nerves of lower leg

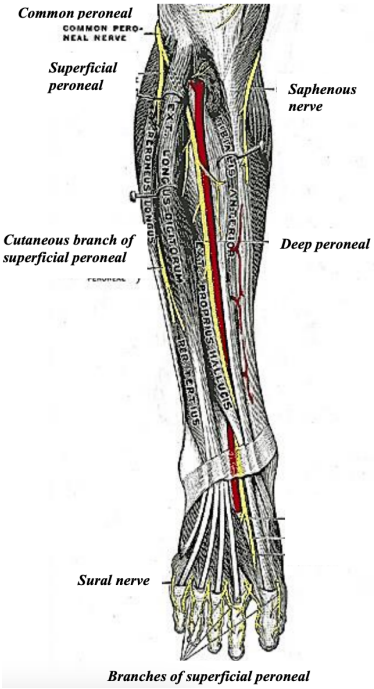


Figure 9b: Nerves of lower leg



Figure 10: Two-team approach with anesthetic equipment at foot of bed

The ***sural, common peroneal and superficial peroneal nerves are vulnerable*** during elevation of a FFF. The ***sciatic nerve*** divides into the ***tibial*** and ***common peroneal nerves*** in the superior popliteal fossa. The ***tibial nerve*** gives off the ***medial sural cutaneous nerve*** which descends between the two heads of the gastrocnemius, pierces the deep fascia at about the middle of the back of the leg, to innervate the medial calf (*Figure 9*). It subsequently joins the ***communicating branch of the common peroneal*** to form the ***sural nerve***. The sural nerve innervates the lateral leg. It is ***vulnerable at the posterior border of FFF skin elevation***. It lies in close proximity to the small saphenous vein and passes distally near the lateral margin of the calcaneus tendon. It perforates the deep fascia in the midcalf to continue subcutaneously, passing midway between the lateral malleolus and the Achilles tendon to supply sensation to the lateral foot and little toe.

The ***common peroneal nerve***, after giving off the sural communicating branch to the sural nerve and the lateral sural cutaneous nerve which supplies sensation to the lateral calf (may be used as sensory input to the FFF skin island), exits the popliteal fossa by passing superficial to the lateral head of the gastrocnemius muscle, lying just posterior to the biceps femoris tendon (*Figures 5, 9*). It ***winds from posteriorly around the lateral surface of the neck of the fibula*** and then beneath peroneus longus where it divides into the ***deep*** and ***superficial peroneal nerves*** (*Figures 5, 9b*). ***The common peroneal nerve is vulnerable when the proximal fibula and its head are harvested***.

The ***deep peroneal nerve*** pierces the anterior crural intermuscular septum and travels deep to the extensor digitorum longus to join the anterior tibial artery in the anterior compartment, where it lies between tibialis anterior and extensor hallucis longus (*Figures 5, 9b*). It innervates these muscles and provides sensory innervation to the web between the 1st two toes and an area proximal to this on the dorsum of the foot.

The ***superficial peroneal nerve*** travels beneath the peroneus longus muscle in the upper third of the lateral leg and descends beneath the deep fascia in the anterior part of the lateral compartment or within the anterior crural intermuscular septum (*Figures 5, 9b*). It pierces the deep fascia to lie superficially in the distal leg. The nerve is ***vulnerable during elevation of the anterior aspect of the skin flap***. It supplies sensation to the anterior surface of the distal leg and to most of the dorsum of the foot and toes.

Preoperative Evaluation

Preoperative evaluation is directed at ***determining the vascular status of the FFF***. Take note of a history of intermittent claudication, deep vein thrombosis, lower limb trauma and the presence of varicose veins. Previous lower limb trauma or fractures may warrant X-rays. Assess the circulation of the foot and quality of the skin. Only if there is concern about possible arterial or venous insufficiency are further investigations indicated. Duplex color flow Doppler will usually suffice. Only very rarely is CT angiography or invasive angiography indicated. Should there be concern about vascularity an alternative donor site should be considered.

Informed consent

This should include a discussion about incisions, donor site morbidity including the possibility of a skin graft being required, failure rates, and dental rehabilitation.

Surgical setup

Resection of the primary tumor and elevation of the FFF are done simultaneously as a ***2-team approach*** in order to minimize the duration of surgery (*Figure 10*). To create working space around the head and torso, the anesthetic equipment is placed at the foot of the bed with extensions for intravenous lines and anesthetic tubing. Two electrocautery systems are required. Cautery and other equipment are positioned at the foot of the bed contralateral to the operated leg. A tourniquet is placed around the thigh and a 3-liter infusion bag is placed under the buttock on the side of the FFF to internally rotate the leg as much as possible. The lower leg is

shaved if necessary. A warming blanket covers the lower torso and opposite leg; alternatively, it may be placed under the patient. Intermittent calf compression is applied to the opposite leg. The table and/or chair heights are adjusted so that the surgeon and assistant are seated while raising the FFF.

Which donor leg to use?

Factors to consider include:

- Is a skin paddle required?
- Is the skin paddle to be used for internal or external construction? (the pedicle(s) to the skin island passes from the peroneal vessels around the posterior aspect of the fibula and exits the posterior crural septum)
- What side of the neck will be used for the donor vessels?

Donor leg for mandible reconstruction (Table 1)

Defect	Neck Vessels	Donor Leg
Intraoral	Ipsilateral	Contralateral
Extraoral	Ipsilateral	Ipsilateral
Intraoral	Contralateral	Ipsilateral
Extraoral	Contralateral	Contralateral

Table 1: Choice of leg with mandible reconstruction

- The ***lateral surface of the fibula becomes the outer surface*** of the ***"neomandible"*** and is the surface to which the reconstruction plate is applied
- For ***intraoral soft tissue reconstruction***, the skin paddle needs to lie above the "neomandible"; yet it lies inferiorly while the pedicle is still attached to the lower leg. The bone and flap therefore are flipped over in a longitudinal axis when the FFF is transposed to the defect with the lateral surface of the fibula remaining laterally
- For ***reconstructing extra-oral or cutaneous defects*** the skin paddle needs to be inferolateral to the "neomandible"
- ***Combined intra- and extra-oral defects*** can be reconstructed with a single skin paddle which is de-epithelialised between two skin islands. Depending on the relative sizes of each area to be reconstructed, the flap can be harvested from the ipsilateral or contralateral lower leg

Exceptions to Table 1

- The vascular pedicle usually exits from the lateral side of the "neo-mandible"; however, if the contralateral neck is used for donor vessels it needs to exit on the medial side of the flap
- When the ascending ramus is reconstructed up to the angle it may be preferable to have the pedicle exit inferomedially and taken to the ipsilateral neck to avoid kinking the pedicle as it would have to "double-back" towards the neck if it exits posterosuperiorly

Donor leg for midface/maxillary reconstruction

The ***ipsilateral leg*** is generally selected, and the ipsilateral neck is always used (or selected in bilateral maxillary reconstruction) for the vascular anastomosis. The palatal defect is the most important part of the reconstruction; this requires the skin paddle to exit below the bone. Again, the lateral surface of the fibula usually faces anteriorly.

Exsanguinating the leg

- Elevate the leg 60^0 without exsanguinating the leg
- Select the widest tourniquet cuff possible to occlude blood flow at a lower pressure and thus reduce risk of injury
- Insert soft padded protection between the skin and the cuff to prevent skin abrasions and blisters
- Inflate ***tourniquet*** to at least 100 mmHg above the patient's systolic blood pressure (adults)
- ***Record the tourniquet inflation time***; the surgeon should be informed when tourniquet has been inflated for 60 min
- There is no clear-cut rule as to how long a tourniquet may be safely inflated for
- A ***maximum tourniquet time of 90 min*** for the leg has been proposed; thereafter deflating the cuff for 15 minutes to allow reperfusion; then the cuff can be reinflated for another 90 minutes

Skin Markings

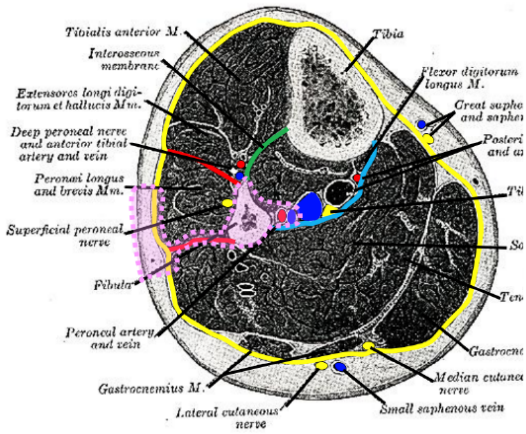


Figure 11: Cross-sectional outline of FFF (pink), based on peroneal artery, its venae comitantes and perforators that enter the skin via the posterior crural septum (red)

The FFF is based on the ***peroneal artery*** and its ***venae comitantes; perforators*** enter the skin via the posterior crural septum (*Figures 4, 5, 8, 11*).

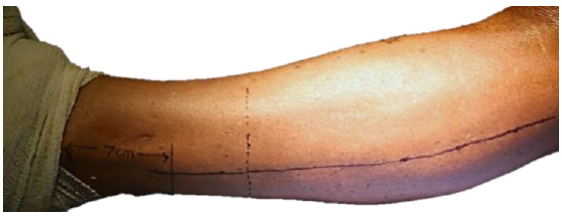


Figure 12: Skin markings

- Mark the ***head of the fibula and lateral malleolus*** (*Figure 12*)
- Draw a ***line along the posterior border of the fibula*** along the posterior crural intermuscular septum (*Figures 4, 11, 12*). This is visible as the indentation between the peroneus (superior to the line) and soleus muscles (posterior to the line)
- Mark the ***distal osteotomy site*** (*Figure 12*) by drawing a transverse line at the level of the planned osteotomy; at least 5 cm (preferably >7 cm if less bone is required) above the projection of the lateral malleolus to maintain ankle stability (*Figure 3*)
- Beware of the ***superficial peroneal nerve*** which is located 3-4 cm anterior to the longitudinal line in the lower half of the leg, and the ***sural nerve*** which is 3-4 cm posterior to this line
- ***Plan the dimensions of the skin flap***
- ***Mark the width of the flap on the leg***; it may be as narrow as 1 cm or as broad as 12 cm. When harvesting a narrow skin island, it is critical to ***determine the position of the posterior crural intermuscular septum*** as it carries the perforators; the safer option is to harvest a wider flap which is trimmed later
- ***Mark the position of the flap*** along the length of the leg; one does not know at this stage where along the length of the leg the skin perforators are
- If a ***long flap*** is required, center it over the junction of the distal and middle thirds of the leg



Figure 13: Flap centered over junction of the distal and middle thirds of leg

- With ***smaller flaps*** one runs the risk of not positioning it over a perforator; the ***safer option is first to incise the skin along the anterior margin*** of the flap in a gentle curve, permitting one to extend the length of the skin island if a perforator is situated outside the initial mark-up (*Figure 13*)

Raising the flap

- It is the author's preference to keep the ***knee extended*** as the leg is more stable, less assistance is required, and it makes the operation easier; others prefer to raise the FFF with knee flexed



Figure 14: With smaller flaps the safer option may be 1st to incise the skin along the anterior margin of the flap and find the perforator

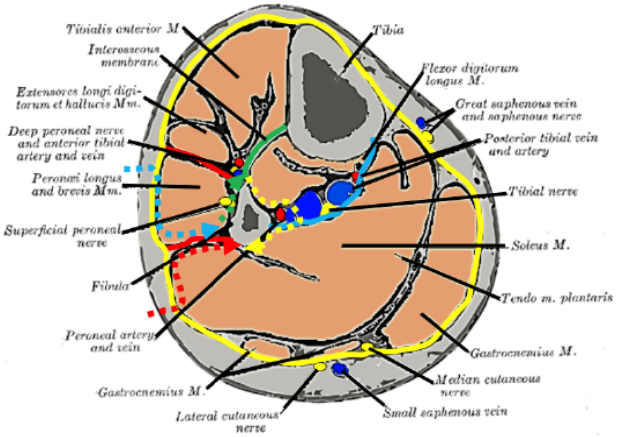


Figure 15: Sequence of surgery: blue arrow → red arrow → green arrow → yellow arrow

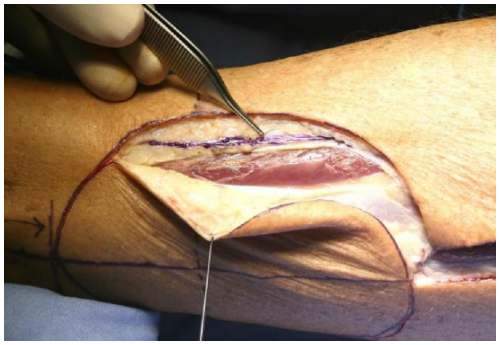


Figure 16: Avoid injury to the superficial peroneal nerve (inked)

- ***Make and incision along the anterior margin*** of the skin flap (*Figures 14, 15, 16*)
- Cut through deep dermis, fat and carefully through investing deep fascia with monopolar electrocautery (*Figure 14, 16*)
- Avoid the ***superficial peroneal nerve*** where it lies just beneath the deep fascia as it courses from lateral to a more anterior position and subcutaneously in the lower third of the lower leg (*Figures 9, 11, 15, 16*)
- The ***muscles in the lateral compartment (peronei longus & brevis) are now exposed*** (*Figures 5, 11, 15, 16*)
- ***Retract the anterior edge of the flap laterally*** with skin hooks placed on the deep fascia; cat's paw retractors are used to pull the peroneal muscles anteriorly (*Figure 16*)

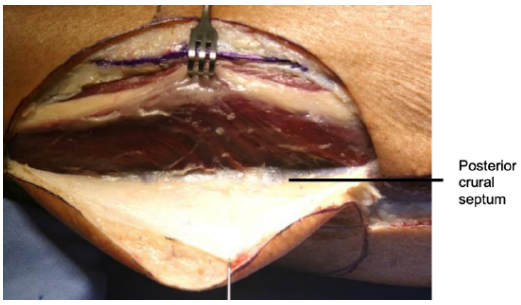


Figure 17: Freeing flap and deep fascia from lateral surface of peronei up to posterior crural intermuscular septum

- Use a #15 scalpel blade to ***separate the peroneal muscles from the deep fascia up to the posterior crural intermuscular septum*** (*Figures 15, 17*)

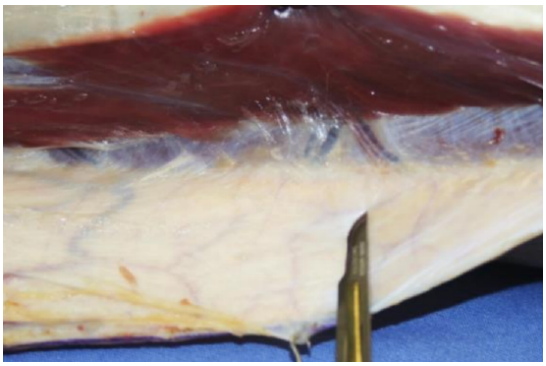


Figure 18: Perforators in view along posterior crural septum

- As sharp dissection is continued posteriorly along the septum, ***one or two perforators*** will come into view as they curl around the posterior margin of the fibula (*Figure 18*). Mark their positions on the skin and deep fascia with ink
- The flap may now be redesigned and ***centered over the perforator(s),*** especially if the skin island is to be rotated with the perforator as its pivot point
- ***If no perforators are seen, look more proximally***, and if found, modify the flap to include them. One can also use a ***proximal musculocutaneous perforator*** to supply an additional island of skin. If no other source is available and the flap is to remain attached over an extended length of the fibula, the ***supply via minute capillaries*** may be adequate and can be assessed following deflation of the tourniquet. If necessary a ***second flap***, e.g. radial free forearm or anterolateral thigh free flap may be harvested and anastomosed to the distal peroneal vessels sequentially or to separate vessels in the neck. A final option is to ***harvest fibula only with a thicker cuff of muscle*** which is left to granulate and epithelialize in the mouth without skin cover

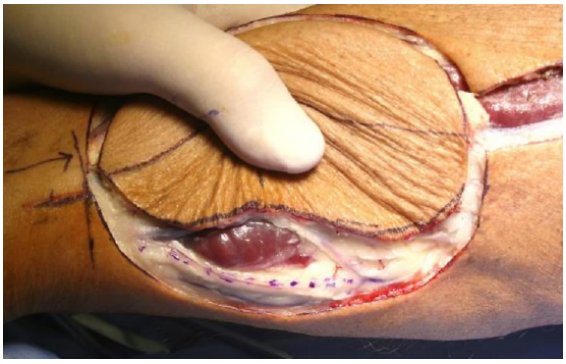


Figure 19: Dissection of posterior margin of flap taking care not to injure sural nerve (inked) and lesser saphenous vein

- ***Dissect the posterior margin*** of the flap taking care not to injure the ***sural nerve*** and ***lesser saphenous vein*** (*Figures 15, 19*)

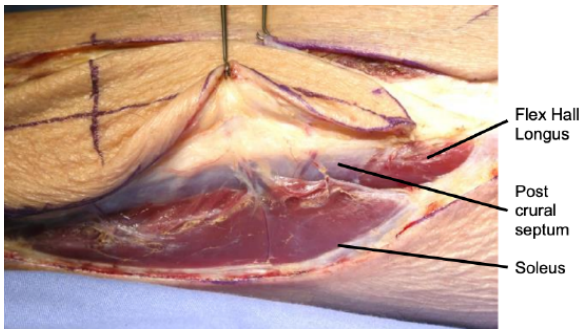


Figure 20: Deep fascia elevated off soleus up to posterior aspect of posterior crural intermuscular septum where perforators again come into view; note muscular branches

- Retract the posterior edge of the flap anterolaterally with skin hooks; use sharp dissection to ***elevate the deep fascia off the soleus muscle*** up to the posterior aspect of the ***posterior crural intermuscular septum*** where the ***perforator(s) again come into view*** (*Figures 15*, *20*)

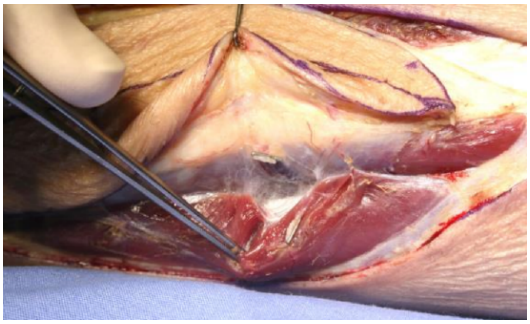


Figure 21: Muscular branches to soleus and flexor hallucis longus have been clipped and divided

- Small ***muscular branches*** to soleus and flexor hallucis longus may branch from the perforators (*Figure 20*); these are ligated with ligaclips and divided (*Figure 21*)



Figure 22: Identify flexor hallucis longus and divide the intermuscular septum

- Continue with sharp dissection deep to soleus; identify flexor hallucis longus and ***divide the intermuscular septum*** that covers it along its full length (*Figures 15*, *22*)
- Now return to the ***anterior surgical dissection*** (*Figure 15*: Green arrow)

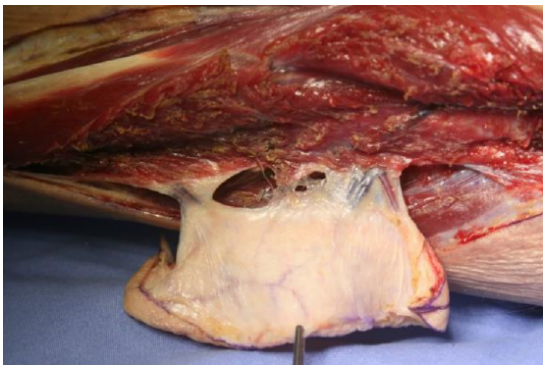


Figure 23: Posterior crural septum has been divided with scissors, leaving enough septum to protect perforators

- ***If mobility or propeller rotation of the skin island*** is required, the posterior crural septum may now be divided with scissors, leaving only enough septum to protect the perforator(s) from traction injury (*Figure 23*)



Figure 24: Release peronei, leaving a cuff of muscle on bone

- Release the ***peroneal muscles*** in the lateral compartment from the fibula with electrocautery, leaving a 5 mm cuff of muscle on the bone. First retract the muscles with cat's paws and then with Langenbeck retractors as the muscle is mobilized, while the surgeon uses the non-dominant thumb to elevate and palpate the muscle over the bone. Palpating with the thumb helps to determine the amount of muscle cuff to be left on the bone (*Figure 24*)

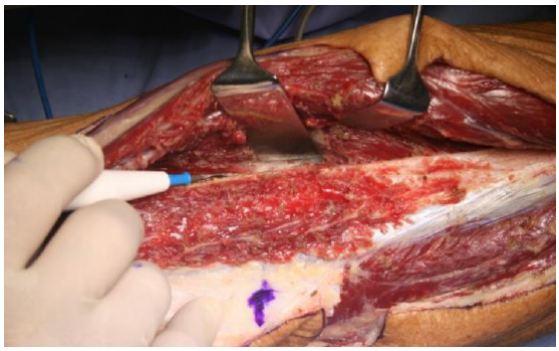


Figure 25: Incising the anterior crural intermuscular septum

- Use cautery to extend the dissection ***through the anterior crural intermuscular septum*** (*Figures 15, 25*)

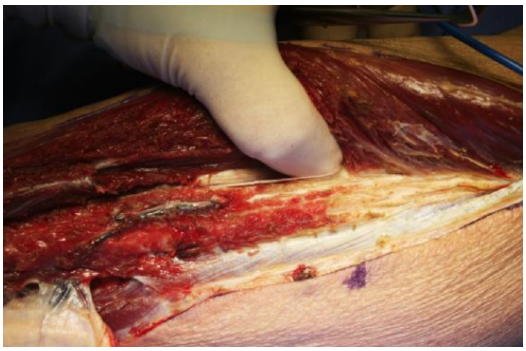


Figure 26: Stripping the proximal part of the peronei and anterior crural intermuscular septum off fibula with a finger

- Extend the dissection proximally; when dissecting proximally beyond the length of bone required for reconstruction, a finger is used to ***strip the proxymal part of the peronei and anterior crural intermuscular septum off the bone*** as no muscular cuff is required there (*Figure 26*)

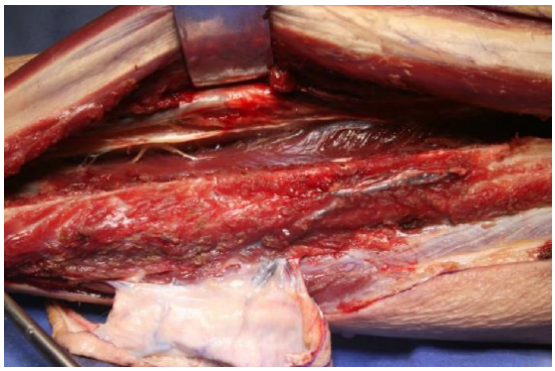


Figure 27: Retracting peronei anteriorly to expose extensor digitorum longus

- Deeper retractors may now be required to firmly retract the peronei anteriorly and the extensor digitorum longus medially (*Figure 27*)

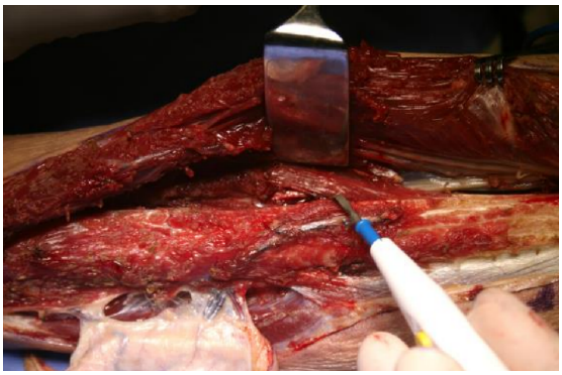


Figure 28: Dividing extensor digitorum longus fibers

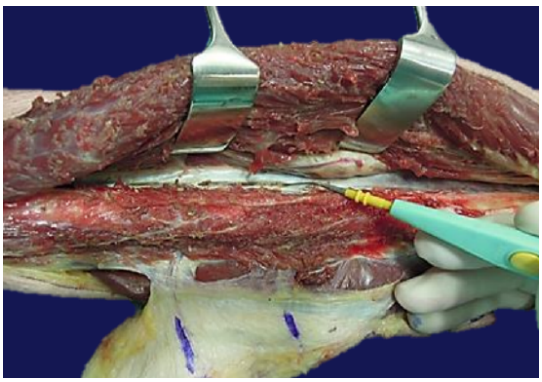


Figure 29: Dividing the interosseous membrane

- ***Divide the extensor digitorum longus and the deeper extensor hallucis longus fibers*** with cautery, a few millimeters from the free edge of the fibula (*Figures 28*)
- Expose and divide the ***interosseous membrane*** with electrocautery (*Figure 29*); this dissection is extended proximally to ***fully release the strong interosseous membrane***; if not done it will prevent the fibula from being retracted laterally to expose the tibialis posterior muscle and peroneal vessels. Tibialis posterior protects the peroneal vessels while doing this
- The ***proximal and distal osteotomies*** are now performed. The length of fibula to be removed is the length of bone required for reconstruction plus a generous length of bone proximally as determined by the length of the vascular pedicle required
- ***Divide the muscle and periosteum transversely*** with a scalpel over the lateral surface of the fibula onto bone
- Do a ***subperiosteal dissection*** around the remainder of the fibula with a delicate dissector such as a Freer's elevator or Mitchell's trimmer, taking care not to injure the peroneal vessels or to excessively strip periosteum
- Perform the ***osteotomies***. Use a metal plate to protect the vessels while performing the osteotomies with a high speed electric or air-driven oscillating or reciprocating microsaw
- Insert a bone or tendon hook in the marrow cavity at the distal osteotomy to ***retract the bone laterally*** while retracting the peroneal and anterior compartment muscles medially
- This exposes the tibialis posterior muscle; the ***anterior tibial vessels and deep peroneal nerve are seen lying medially*** on the cut interosseous membrane, lateral to the tibialis anterior muscle
- This exposure may be difficult; failure to have fully divided the interosseous membrane will not permit the fibula to swing laterally. Additional mobility can be achieved by retracting the proximal segment of the fibula laterally and carefully dividing the flexor hallucis fibers and strong intermuscular fascia between the peroneal vessels and the fibula by staying on the bone
- The ***segment of fibula is now released laterally***

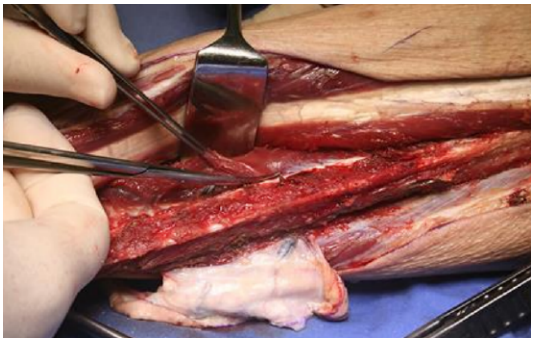


Figure 30: Tibialis posterior

- Retracting the distal end of the bone laterally, ***divide*** the ***tibialis posterior muscle*** from distally-to-proximally with Metzenbaum scissors (*Figure 30*)

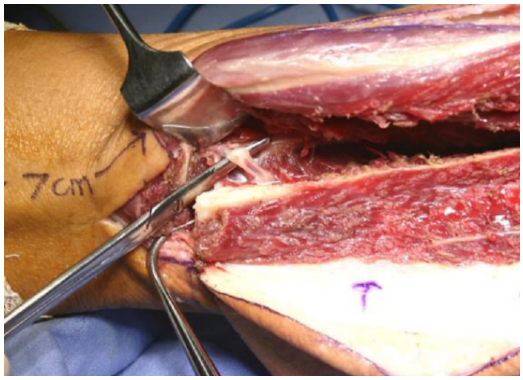


Figure 31: Distal peroneal vessels

- The ***peroneal vessels*** are now seen sloping away from the bone medially and are ***ligated adjacent to the distal osteotomy*** (*Figure 31*)
- As the tibialis posterior muscle is divided more proximally, the intermuscular septum under the muscle and covering the peroneal vessels is exposed

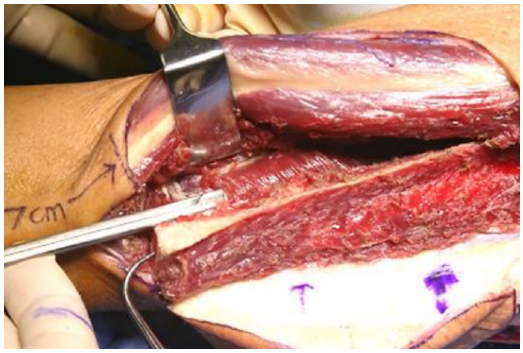


Figure 32: Scissors advanced along the avascular plane between intermuscular septum and peroneal vessels

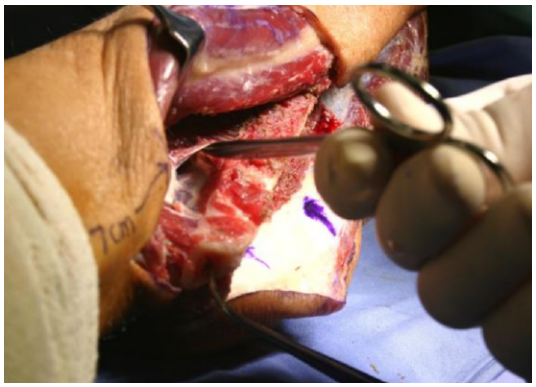
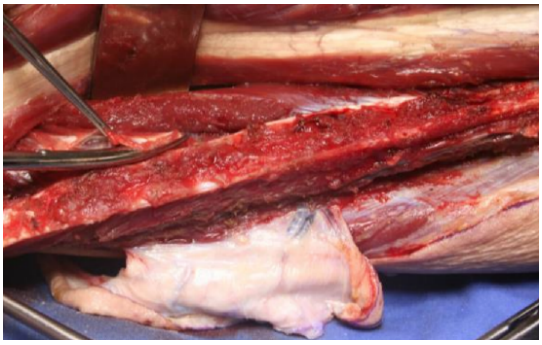
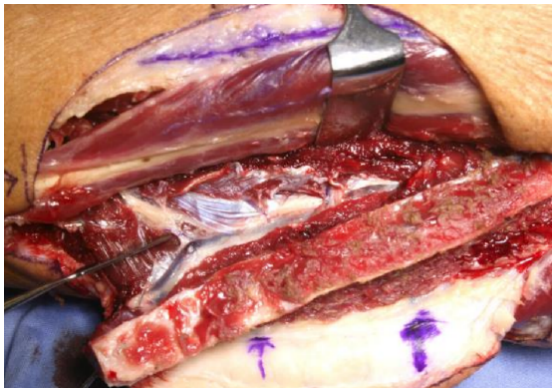


Figure 33: Avascular plane

- A relatively avascular plane exists between the ***intermuscular septum and the peroneal vessels; establish a dissection plane by advancing the closed tips of the scissors beneath the septum*** (*Figures 32*, *33*)


Figure 34: Dividing the interosseous membrane


Figure 35: Peroneal vessels exposed after dividing intermuscular septum

- ***Divide the septum over the medial aspect of the vessels*** with scissors. Continue this division proximally until the ***peroneal vessels are exposed along their entire lengths; the large vein(s) lie anterior to the artery*** (*Figures 34*, *35*)

- A few small side branches emerge, mainly medially, to supply tibialis posterior and are ligated with ligaclips and divided. More proximally, larger branches supplying soleus and other muscles are also ligated and divided

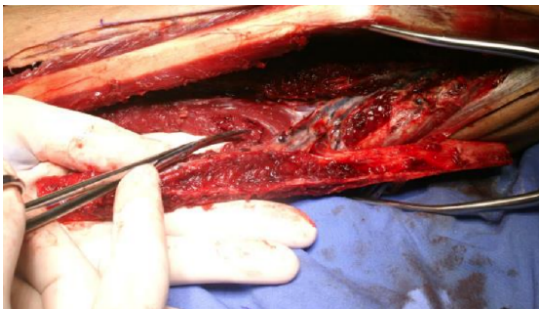


Figure 36: Flap being detached from flexor hallucis longus; index finger protects perforators

- Once all vascular side branches have been divided, ***detach*** the ***flap*** from its only remaining posteromedial attachment to the flexor hallucis longus. This is achieved by holding the fibula with the left hand and placing the index finger over the perforator to protect it and to remind the surgeon of its position. The muscle is divided from distally to proximally, leaving a generous cuff of muscle especially in the area of the perforating pedicle (*Figure 36*). Some surgeons prefer to harvest the whole flexor hallucis muscle with the flap because the muscle's blood supply originates mainly from the peroneal vessels; hence the viability of remaining muscle may be compromised



Figure 37: Skin island perforator, fibula, and vascular pedicle ready to be detached

- Once the flap (other than vascular pedicle) is completely free, the ***peroneal vessels are inspected*** (*Figure 37*)
- There are usually two and occasionally three veins. The ***most suitable vein is selected and the others are ligated*** as only one vein is needed for the anastomosis
- Carefully ***separate the vein and artery*** from each other for a few centimeters to permit the vascular anastomoses to be made some distance from one other
- The ***tourniquet is usually deflated*** following flap elevation, but if it has been elevated within an hour, one may continue with 3-dimensional shaping of the fibular osteotomies while the tourniquet is kept inflated
- Control bleeders from the flap and in the surgical bed with bipolar cautery, ligaclips and ties

Plating systems (Figures 38, 39)



Figure 38: Reconstruction (blue) vs. miniplates (grey)

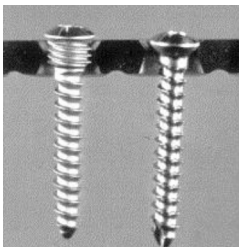


Figure 39: Locking vs. compression screw

Reconstruction plates simplify planning and allow for accurate preplating. They are strong and withstand the muscle forces and torque exerted on the reconstruction, give an extremely stable reconstruction and do not require intermaxillary fixation (IMF) postoperatively. The sizes of the plate and screws, and difficulty to remove them (not normally required) can however prove problematic.

Miniplates (load sharing) are used for maxillary reconstruction; although they may be used for mandibular reconstruction, the plates are more likely to fracture and there is more mobility of the bony segments, necessitating IMF. Miniplates cause less radiation scatter and inserting dental implants is simpler as the plates are smaller and are easily removed. Because fixation is less rigid it permits molding into proper dental occlusion with IMF.

Locking titanium (loadbearing) reconstruction plate systems are preferred so as to avoid compressing the plate against the bone and causing subcortical bone resorption and loosening of screws (*Figure 39*).

Three-dimensional shaping of fibula

A variety of methods are employed to achieve near-perfect mandibular form and occlusion. Critical elements are to accurately bend/fashion the reconstruction plate and to use the plate(s) to plan the osteotomies. The plates can be shaped in the following ways:

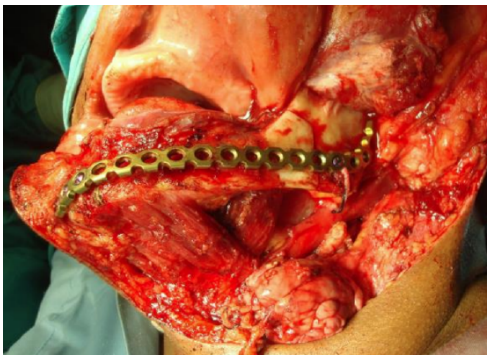


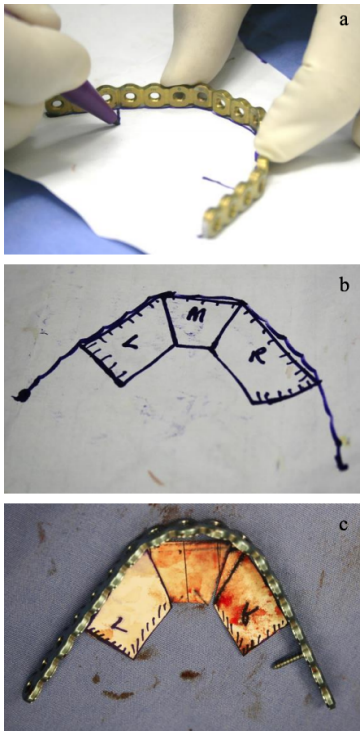
Figure 40: Preplating the mandible

- ***Preplating by contouring the plate*** on the exposed mandible ***prior*** to resection (authors' preference) is done if tumor does not distort the outer surface of the mandible; if tumor needs to be elevated off the mandible to permit the plate to sit flush with the bone, the plate is then cleaned and autoclaved before using it. This method assures good form and occlusion (*Figure 40*)
- ***Preoperative computer-generated model plate contouring***, especially when preplating is not possible due to distortion of the lateral surface of the mandible by tumor (expensive)
- ***Intermaxillary fixation (IMF)*** and "blind" plate contouring after tumor resection
- ***Intraoperative external fixation devices*** and "blind" plate contouring when IMF not possible
- ***"Blind" plate contouring*** after tumor resection

The description of FFF that follows is an anterior mandibular reconstruction with an intraoral flap and anastomosis to the ipsilateral neck vessels.

- The mandibular osteotomy sites are marked on the mandible with the saw
- A (locking) reconstruction plate is fashioned by contouring it on the outer surface of the mandible; the plate is positioned just above the lower border of the mandible
- At least three screw holes are drilled to either side of the planned mandibular osteotomies and the plate is temporarily fixed to the bone with bicortical locking screws

- The positions and angles of the planned osteotomies are precisely drawn on the external surface of the plate at both osteotomy sites. If the resection includes the angle of the mandible, the angle is marked on the plate
- The plate and screws are removed, and the plate is handed to the reconstructive team to use as a template to plan and design the fibular osteotomies
- The mandibulectomy is completed



Figures 41a, b, c: Drawing angles of osteotomies

- Draw the profile of the required bony reconstruction on stiff paper (*Figures 41a-c*)
  - There are two profiles to consider i.e. one viewed from above and the other viewed from anterolaterally
  - Place the plate vertically on a firm sheet of paper and looking from superiorly, draw an ink line along the inner aspect of the plate to outline the horizontal segment of the mandible up to the angle of the mandible
- Accurately draw the angles of the osteotomies as viewed from above, using a ruler to outline the segments; the osteotomies are drawn at 900 to the plate (*Figures 41a, b, c*)
- Avoid unnecessary osteotomies and bony segments of <1.5 cm
- Two to three fibula bone segments are generally required with a unilateral segmental mandibulectomy, 3-4 following hemimandibulectomy and up to 7 for bilateral mandibulectomy The lateral (horizontal ramus of mandible) and vertical (ascending ramus) limbs of the plate, as viewed from anterolaterally, are drawn on paper up to the ***medial aspect*** of the lateral horizontal bone segment. Keep the plate flat by marking on the edge of an instrument table. Mark the point of the mandibular angle and the osteotomy angle between the horizontal and vertical segments; mark the uppermost osteostomy
- There are thus two sets of paper segments; one viewed from above and the other viewed from anterolaterally
- The segment medial to the angle will have a 900 angle to the plate at the mandibular angle as viewed from above, but approximately a 600 angle on the anterolateral view
- Mark the individual paper segments to identify and to orientate them. They may be redrawn on a firmer material such as sterilized X-ray plates



Figure 42: Paper templates

- By positioning the segments in a straight line, one can draw V-shaped templates to be used for V-shaped osteotomies, if preferred (*Figure 42*)

- While attached to the leg, the fibula is usually upside down with the pedicle on the wrong side for intraoral reconstruction. To avoid confusion, it is easier to place the fibula in the correct orientation as it would lie in the mouth by flipping it over in its longitudinal axis while still attached by its vascular pedicle

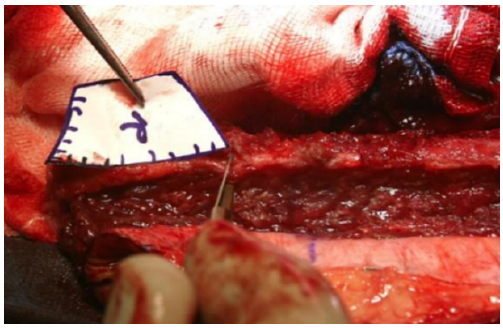


Figure 43: Transferring paper segment to the fibula

- Transfer the paper segments to the fibula to plan the osteotomies starting at the distal end of the fibula and using the superior-view templates first (*Figure 43*)

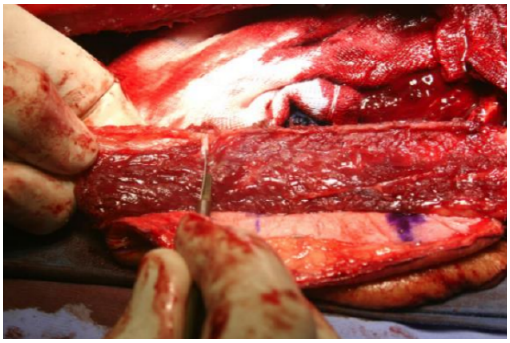


Figure 44: Incising periosteum on lateral surface of fibula for osteotomies

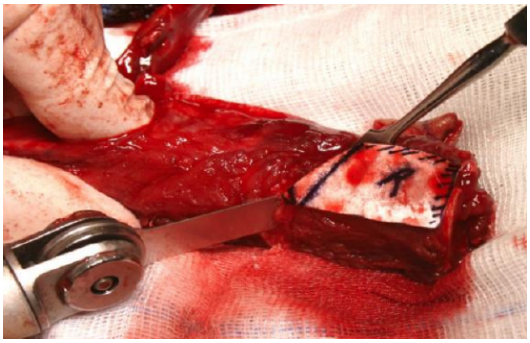


Figure 45: Osteotomy cuts

- Make scalpel cuts at precise angles on the lateral surface of the fibula, stripping only enough periosteum to make the saw cuts (*Figures 44*, *45*)
- Hold the fibula with Kocher's or bone-holding forceps and make the osteotomies

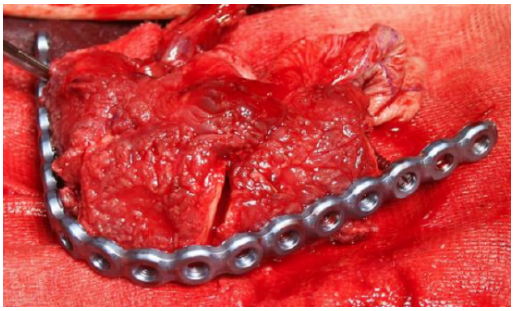


Figure 46: Attaching bone with flap still attached to leg

- The bony segments may be fixed to the plate and the mandible reconstruction virtually completed with the vascular pedicle still attached to the leg (*Figure 46*); alternatively, the final fixation of the bony segments to the plate is done after transposing the flap to the bony defect
- ***Only after the recipient vessels in the neck have been prepared, is the pedicle divided***
- The individual bony segments are fixed to the plate with unicortical screws, while the plate is fixed to the mandible with bicortical screws. Use only one or two screws per segment to facilitate placing dental implants

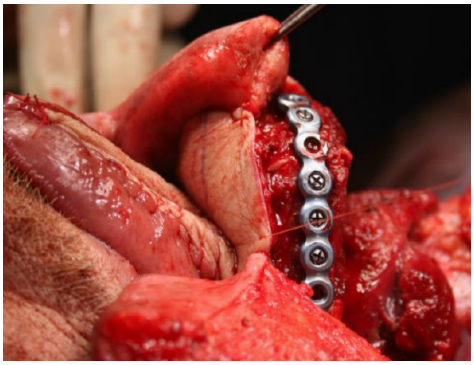


Figure 47: Flap fixed into place

- The flap is screwed into place, and at least part of the skin flap sutured to the mucosa or skin to stabilize the flap while doing the microvascular anastomosis (*Figure 47*)

Microvascular anastomosis

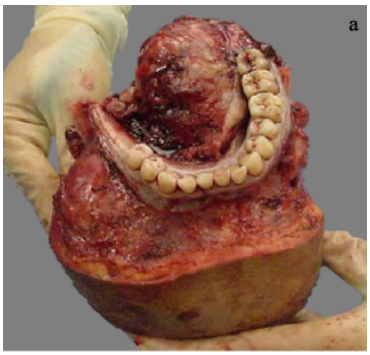
Readers are referred to the chapter Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery for a detailed description of the surgical technique. Key points include the following:

- Standard microvascular anastomoses are performed with strict attention to technique
- Avoid kinking or rotating the vascular pedicle
- The artery is generally anastomosed end-to-end either to the facial or the superior thyroid artery. Other options are the external carotid artery or the transverse cervical artery
- One vein is anastomosed end-to-side to the internal jugular vein. Occasionally it may be anastomosed either end-to-side or end-to-end to a major tributary of the internal jugular vein or to the external jugular vein
- Beware of kinking of the vessels at the point where they depart from the bone as this lies deep to the bone and is not visible once bony fixation is completed
- A palpable pulsating artery does not necessarily imply that there is adequate flap perfusion. One should feel confident when seeing bleeding from the muscle or skin edges

Wound closure

- A Valsalva maneuver is done and the neck wound checked for bleeding and haemostasis achieved
- A suction drain is inserted into the neck, taking care for it ***not to cross over the microvascular repair or over the internal jugular vein*** (may thrombose the vein)
- ***Suture the tracheostomy to the skin***; avoid ties around the neck as this may occlude the internal jugular vein and cause venous outflow obstruction and flap failure
- Repair the ***fibula donor site*** by suturing the lateral compartment muscles to the soleus muscle over a suction drain. Avoid suturing the wound under tension as this may cause skin necrosis, delayed wound healing and pseudocompartment syndrome. Skin grafting is done if required; if possible, cover exposed tendon or fascia with muscle before applying the skin graft
- Apply a posterior lower limb foot gutter splint for one week with the ankle at 900. Full weight bearing is commenced after one to two weeks
- The lower limb should be elevated as much as possible during the first 6 weeks to avoid swelling and edema.
- Physiotherapy to the lower limbs is commenced as early possible or as soon as the skin graft will permit

Examples of FFF reconstructions





Figures 48a, b: Resection of mandible and FFF reconstruction

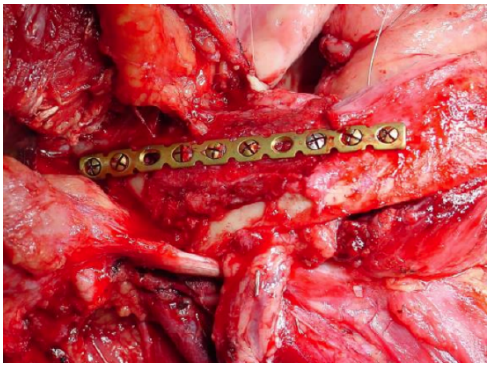


Figure 49: FFF onlay osseocutaneous flap following marginal mandibulectomy

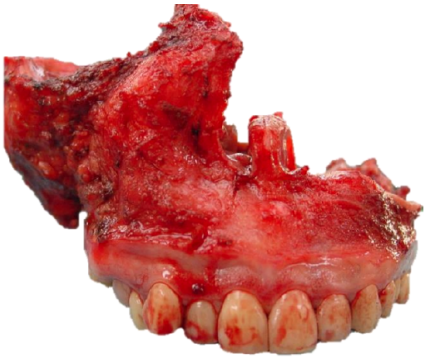


Figure 50a: Bilateral maxillectomy



Figure 50b: FFF ready to be inset

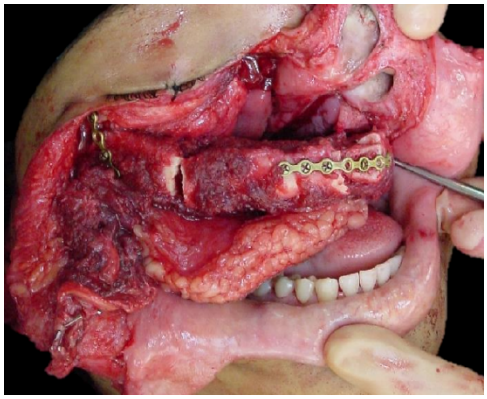


Figure 50c: Inset of FFF

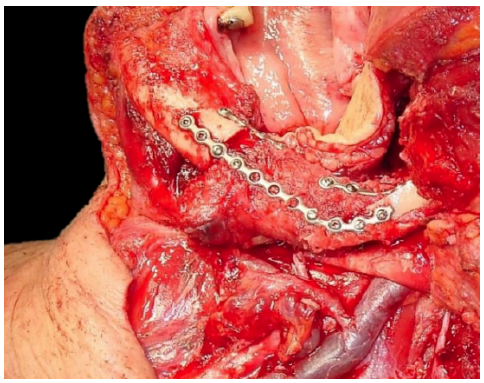


Figure 51: FFF reconstruction of lateral segmental mandibulectomy using miniplates

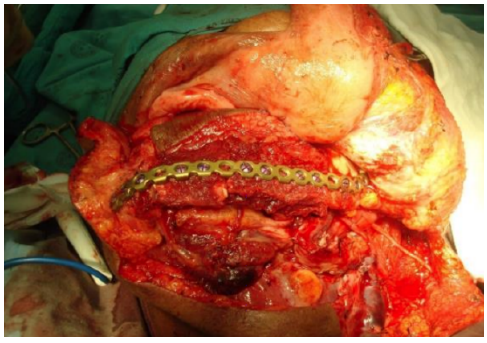


Figure 52: FFF reconstruction using a reconstruction plate following segmental mandibulectomy

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author

Ottie (JE) Van Zyl MBChB, FCS
Plastic & Reconstructive Surgeon
Groote Schuur Hospital
Cape Town, South Africa
ottie@mweb.co.za

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

RADIAL FREE FOREARM FLAP (RFFF): SURGICAL TECHNIQUE

Ottie van Zyl

The radial free forearm flap (RFFF) was one of the first free tissue transfer flaps to be described. It has since become a workhorse for soft tissue replacement in head and neck cancer surgery, being commonly used to replace external skin and internal mucosal linings. It is an extremely versatile flap allowing intricate folding of the skin, using two or more skin paddles/ islands, and incorporating vascularized tendon and/or bone (osteocutaneous flap).

Common reconstructive applications

- Floor of mouth, tongue, soft and hard palate, buccal mucosa, pharynx and esophagus
- Lips
- Orbit
- External skin defects
- Incorporating part of radius as osteocutaneous flap for premaxillary, maxillary, nasal, and selected mandibular defects
- Incorporating palmaris longus tendon sling to support lower lip reconstruction

Advantages

- Very pliable, thin skin, especially at distal forearm (one of thinnest skin flaps)
- Usually very little soft tissue bulk
- Large flap may be harvested (30 x 15 cm)
- Multiple skin islands can be used
- Sensory innervation possible
- Can incorporate radius bone or tendon
- Easy flap elevation
- Large, reliable, constant vessels
- Long pedicle usually available
- Distant location of donor site from head and neck resection permits simultaneous harvesting and resection
- Large distal size of vessel allows it to be used as a "flow-through-flap" for an additional flap to be attached distally

Caveats

- Potentially poor skin quality: in certain individuals the flap may be quite bulky, especially proximally; this can compromise certain reconstructions
- Donor site morbidity: loss of skin graft and tendon exposure; visible donor site and possible poor cosmetic result
- Vascular: atherosclerosis (seldomly); postoperative vascular compromise of hand (rarely)

Surgical anatomy of volar forearm

The skin of the volar (anterior) surface of the forearm is usually thin and pliable, especially the distal half. It is however unfortunately hair-bearing skin, especially on the proximal and lateral sides of the forearm; consequently, one might have hair growth e.g. in the oral cavity. The subcutaneous fat is thin, especially over the distal third of the forearm. However, overweight patients and even some normal individuals may have a disproportionate amount of fat in this distal area.

Venous system

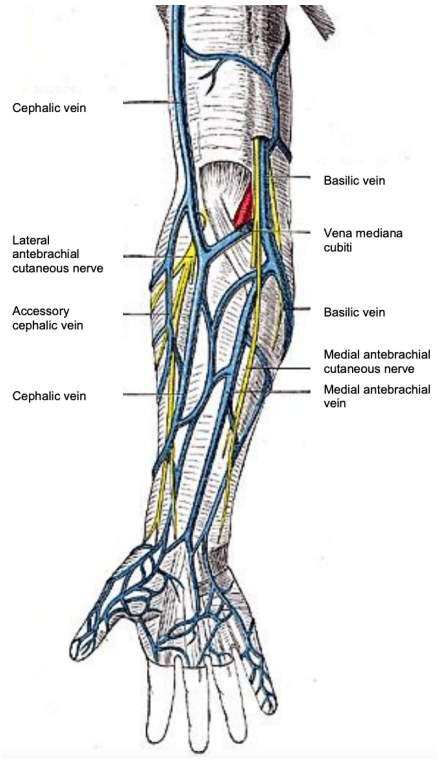


Figure 1: Volar surface of **right** forearm demonstrating cephalic and basilic venous systems, the median antebrachial vein of the forearm and the associated nerves

In the subcutaneous tissues lie the small venous tributaries of the ***main superficial venous drainage system*** of the forearm, i.e. the ***cephalic*** and ***basilic veins***, which lie deep to the fatty layer (*Figure 1*).

The ***cephalic vein*** is the most commonly used single vein for venous drainage of RFFFs (*Figure 1*). It is a large, thick-walled vein and is found in a relatively constant location deep beneath the subcutaneous fat. Unfortunately, due to its size and superficial position, it is also very often used for intravenous lines, which may cause fibrosis and/or thrombosis of the vessel. It drains the anterolateral forearm and is formed mainly by the confluence of superficial veins on the dorsal aspect of the hand (*Figure 1*). From there the vein, or its tributaries, traverses the lateral "snuffbox" area to lie over the lateral side of the distal forearm. It gradually courses more medially towards the mid-lateral cubital fossa. It is accompanied by the lateral antebrachial nerve (*Figure 1*). The superficial branch of the radial nerve lies in close proximity to the vein in the distal third of the lateral forearm and over the "snuffbox" area up to the lateral aspect of the dorsum of the hand.

The ***basilic vein*** runs towards the lateral cubital fossa along the medial side of the forearm and is located deep beneath the subcutaneous fat.

The ***median (antebrachial) vein of the forearm*** lies between the cephalic and basilic veins. Occasionally it may be large and be a better drainage system to use for a flap (*Figure 1*). It is usually thin-walled and is situated more superficially in the subcutaneous fat than the cephalic and basilic veins.

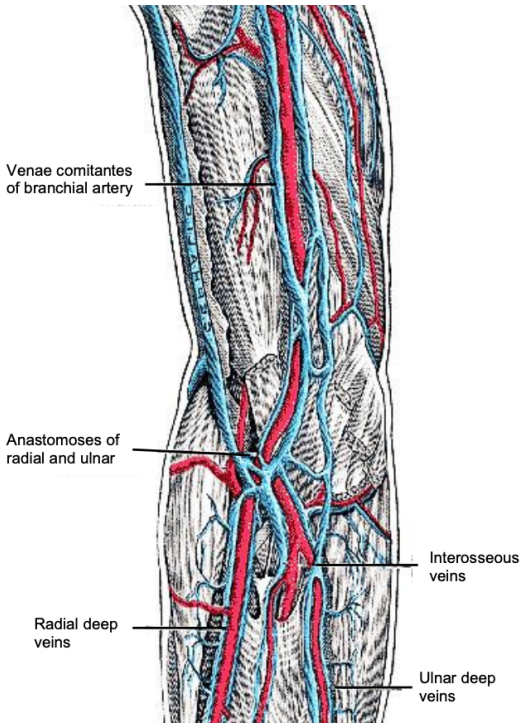


Figure 2: Venous anatomy at **right** cubital fossa

A great variety of venous interconnections may be encountered in the ***cubital fossa***. The ***median cubital vein (vena mediana cubiti)*** runs obliquely from lateral to medial to connect the cephalic and basilic systems (*Figures 1, 2*). There is often an important connection between the superficial veins and the deep brachial venous system in the cubital fossa; this is usually between the brachial venae comitantes and the median cubital vein or the cephalic vein.

The forearm and cubital fossa are invested by the ***deep fascia***; in the cubital fossa it is strengthened by the ***bicipital aponeurosis*** (*Figure 1*). The perforating vein connecting the superficial and deep venous systems lies lateral to the bicipital aponeurosis and the brachial vessels immediately deep to it (*Figure 1*).

Nerves

The superficial nerves accompany the superficial veins (*Figure 1*). The ***lateral antebrachial nerve*** (*Figure 1*) is the termination of the musculocutaneous nerve which, after supplying the flexors of the upper arm, pierces the deep fascia just proximal to the cubital fossa. The ***anterior branch of the antebrachial nerve then accompanies the cephalic vein*** distally (*Figure 1*) and supplies sensation to the anterolateral forearm, (which is also the main area of a distal RFFF). The posterior branch supplies sensation to the posterolateral forearm.

The ***medial antebrachial nerve runs with the basilic vein***; they pierce the deep fascia in the medial part of the mid-upper arm. It too, has an ***anterior branch*** supplying sensation to the anteromedial forearm and a ***posterior branch*** to the posteromedial forearm.

Deeper nerves include the ***median, ulnar nerves***. These are usually not at risk when elevating the flap. The ***median nerve*** lies between the flexor carpi radialis and palmaris longus tendons. The ***palmar cutaneous branch of the median nerve*** arises just above the flexor retinaculum at the wrist and becomes cutaneous between the tendons of palmaris longus and flexor carpi radialis. Elevation of a very distal skin flap may injure the latter branch and cause sensory loss of the proximal midpalm.

Muscles

The muscles of the forearm will be described according to their relationships to the radial artery.

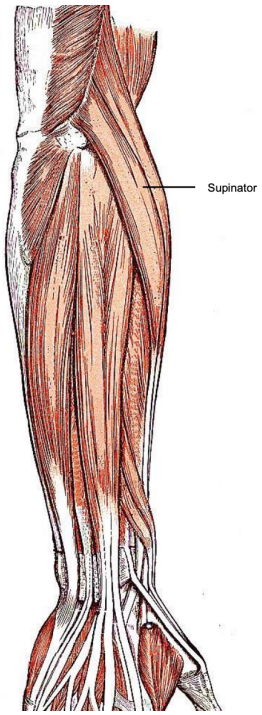


Figure 3: Dorsal view of **right** forearm demonstrating the supinator muscle

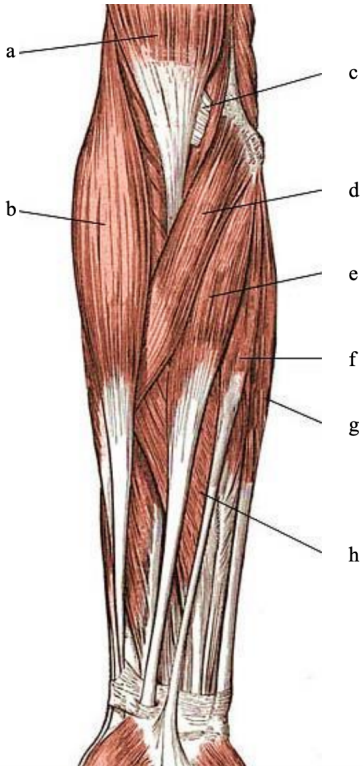


Figure 4: Volar view of **right** forearm: a: biceps brachii; b: brachioradialis; c: biceps brachii tendon d: pronator teres; e: flexor carpi radialis; f: palmaris longus; g: flexor carpi ulnaris; flexor digitorum longus

Where the radial artery enters the forearm it lies superficial to the ***supinator*** (*Figure 3*), ***pronator teres*** and ***flexor digitorum superficialis (FDS) muscles*** in the proximal third of the forearm, and superficial to the ***flexor pollicis longus (FPL)*** and ***pronator quadratus muscles*** in the distal third (*Figure 4*).

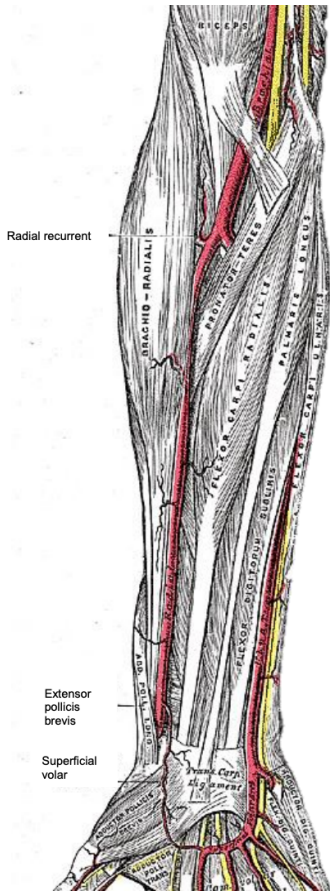


Figure 5: Volar view of **right** forearm demonstrating course of radial artery relative to brachioradialis, pronator teres and flexor carpi radialis muscles

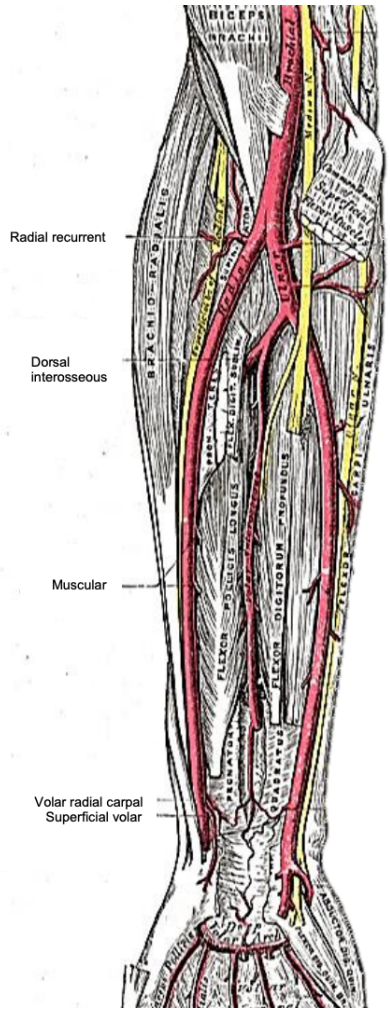


Figure 6: Volar view of **right** forearm demonstrating course of radial artery with brachioradialis muscle reflected

The ***radial artery*** runs in the ***lateral intermuscular septum*** which separates the flexor and extensor compartments of the forearm. Medially are the ***flexor carpi radialis (FCR)*** and the other forearm flexor muscles (*Figures 5, 6*). Laterally is the extensor compartment.

The ***key muscle when elevating a RFFF*** is the ***brachioradialis muscle and its tendon*** (*Figures 4, 5, 6*). The muscle overlies the anterolateral side of the artery (*Figures 5, 6*). It is supplied by the radial nerve of the extensor compartment, even though it is an elbow flexor. This bulky muscle belly ***lies anterior to, and covers, the radial artery in the proximal half of the forearm*** (*Figure 5*). In the distal forearm the muscle be-comes a flat tendon. It is ***important to know that the tendon commonly covers the artery either partially or completely***. The significance of this will become apparent during flap elevation and protection of the perforators. ***At the wrist the radial artery lies between the brachioradialis and flexi carpi radialis tendons*** (*Figure 5*).

The ***palmaris longus tendon*** (*Figures 4, 5*) can be sacrificed without causing a functional deficit. It is absent in ca. 13% of individuals. Its tendon and muscle can be incorporated in a forearm flap for various reconstructive possibilities and it may therefore be an extremely valuable adjunct in complex reconstructions.

Radial artery and its branches

The brachial artery bifurcates into ulnar and radial arteries (*Figures 5, 6*). The ***radial artery*** starts in the medial cubital fossa, 1 cm distal to the elbow crease, just medial to the biceps tendon (*Figures 5, 6*). It then courses down the forearm ***in the lateral intermuscular septum which separates the flexor and extensor compartments of the forearm*** to the (palpable) radial pulse, just medial to the tip of the styloid process of the radius. Branches in the forearm include the ***radial recurrent artery*** close to its origin (*Figures 5, 6*); and distally, the ***palmar carpal branch*** (*Figure 6*), the ***superficial palmar branch*** and the continuation of the artery, the ***dorsal carpal branch***. Along its course in the forearm it gives off ***muscular branches*** (*Figures 5, 6*).

A variable number (average 12) of ***septocutaneous perforators*** exit the artery to supply the overlying fascia and skin. The greatest number of perforators is found in the distally third of the forearm, approximately 12-20 cm from the origin of the radial artery. A major perforator is located 0-2 cm proximal to the radial styloid process; and a cluster of perforators is located in the distal 1/5 of the forearm with another cluster in the proximal forearm[1].

Periosteal blood supply to the distal radius is via branches to the deep flexor pollicis longus and pronator quadratus muscles; perforators also pass through the lateral intermuscular septum from the radial artery to the periosteum.

Radius bone (Figure 7)



Figure 7: Volar view of right radius bone

The ***distal 10-12 cm of the anterolateral radius*** can be harvested as an osteocutaneous RFFF. Knowledge of the anatomy of the shaft and its distal end are important when raising an osteocutaneous flap. The shaft increases in size from proximal to distal and bows laterally. The medial side of the shaft has a sharp interosseous border at the attachment of the interosseous membrane. The wide distal end tapers into the pyramidal styloid process.

Evaluation of vascular status

Harvesting the radial artery is associated with a remote possibility of vascular compromise causing ***claudication*** of the hand. The surgeon should confirm the presence of a ***radial arterial pulse***. Enquire about the patient's occupation or leisure activities e.g. a pianist may be concerned about claudication.

Modified Allen Test: This is used to assess the adequacy of the ulnar artery and crossflow through the palmar vascular arches of the hand

- Ask the patient to elevate the arm and to make a tight fist
- Occlude the radial and ulnar arteries for a few seconds by digital pressure
- Ask the patient to release the hand into a relaxed, slightly flexed position
- Check whether the palm and fingers have blanched; if not, then occlusion of the vessels is inadequate, and the test is repeated
- Release pressure from the ulnar artery
- With a positive Allen Test the hand flushes and the color changes from pallor to rubor within 5-15 seconds; it can be concluded that there is good crossflow from the ulnar artery
- With a negative Allen Test the circulation is considered inadequate and it is a relative contraindication to proceeding with a RFFF
- Even though there is controversy about the reliability of the Modified Allen Test, the author routinely does the test; in equivocal cases when there is some delay in the "flush", he has always continued with the RFFF and has never encountered symptomatic vascular compromise or ischemia in more than 700 RFFFs

Choice of arm

It is not as critical as with free fibular flaps what side to use. Although it is preferable to have the operating arm table on the contralateral side to the resection to create enough space for two surgical teams to work simultaneously, it is not that difficult to work on the same side of the patient. Previous intravenous lines, surgery, injury, scars, skin deformities, fractures or vascular compromise may necessitate one to use a specific arm. The patient's preference is also taken into account.

Preoperative counseling

Patients are properly counseled about the outcomes following flap harvest, particularly ***visibility of the scar or skin graft***, a (possibly) ***poor cosmetic result***, the possibility of ***hypertrophic scarring*** and using a prophylactic pressure garment to avoid it; ***delayed wound healing*** and possible ***loss of a skin graft***. Mention should also be made of possible temporary or permanent variable ***sensory loss*** over the radial thenar region, the metacarpal region of the dorsum of the thumb or less commonly, of the dorsal hand; as well as ***claudication***.

Operating room setup



Figure 8: Two-team setup: RFFF being harvested (foreground); head & neck resection (background); anesthetics (right)

- Resect the primary tumor and elevate the RFFF simultaneously as a 2-team approach to minimize the length of surgery (*Figure 8*)
- • Create working space around the head and torso by placing anesthetic and other equipment at the foot of the bed with extensions for intravenous lines and anesthetic tubes (*Figure 8*)
- Two bipolar and monopolar electrocautery systems are required
- Place the arm on an arm table
- Avoid hyperextending or hyperabducting the shoulder
- Shave the forearm
- Apply a tourniquet to the upper arm
- Adjust the operating table and/or the chairs so that the reconstructive surgeon and assistant are seated

Surface markings for RFFF

- Palpate and mark the ***radial artery*** at the wrist between the brachioradialis and flexor carpi radialis tendons
- Palpate the vessel proximally and mark its course on the skin up to the midmedial cubital fossa
- Draw the superficial venous vessels in the mid- and lateral forearm
- Inflating the tourniquet to just above diastolic pressure may help delineate the superficial veins
- Especially with fat arms, the ***cephalic vein*** may not be visible; use your anatomical knowledge to mark its probable course
- Before shaving the arm, note the ***hair growth*** in the intended harvesting area of the RFFF, in case the flap can be positioned more medially in the distal forearm where there is less hair (most flaps undergo radiation with loss of hair growth)
- Assess the ***fatty layer*** of the arm and reposition the flap if necessary
- Mark the ***flap design*** on the forearm
- Consider which side of the flap the vascular pedicle is to exit from:
  - Which side of the neck will be used for the vascular anastomoses?
  - What is the most favorable position for the pedicle at the reconstruction site to avoid kinking the pedicle?
  - Determine the pedicle length required and draw the flap as distal as necessary
  - Let the pedicle exit the flap on the edge closest to the anastomosis site
- Generally, the flap is ***centered over the radial artery***
- The flap may be placed ***more medially if an osteocutaneous flap*** is to be used to provide more skin and soft tissue cover over the area of bone harvesting and the (probable) area of prophylactic plating of the radius

- ***Do not extend the flap too far over the lateral aspect*** of the forearm, because the cosmetic outcome of donor site will be worse. Sensitivity of the superficial radial nerve is also avoided if skin protection can be achieved over the nerve
- A risk of ***placing the flap too medially*** is that the cephalic vein may be positioned too laterally to be safely used as the draining vein. However, this is generally not the case; and the lateral part of the skin flap does not need to extend fully to the cephalic vein, as long as the intervening subdermal tissue between the skin flap and vein is preserved

Tourniquet

- Elevate the arm without exsanguinating it and inflate the tourniquet to at least 100 mmHg above the patient's systolic blood pressure. (Usually set at 250 mmHg)
- Record the tourniquet time (maximum time of 90 minutes permitted)

Elevating the RFFF

Many methods have been described. Some advocate elevating the flap from distal-toproximal in its entirety; others elevate the flap medially, then laterally, then distal-toproximal. The author has done >700 RFFFs and describes his preferred method.

Critical points

- Careful flap and template design
- Flap design on the forearm to include the lateral intermuscular septum as well as a superficial vein (usually cephalic)
- Elevate medial and lateral fasciocutaneous parts of the flap and dissect towards the lateral intermuscular septum
- ***Brachioradialis muscle is most critical element*** of elevating the flap
- Start flap elevation at lateral edge over brachioradialis muscle
- Progress towards intermuscular septum (not always well defined) and down to the lateral aspect of the artery
- Proceed to medial dissection
- Dissect vessels and elevate flap from distal-to-proximal

Author's reasoning for above sequence

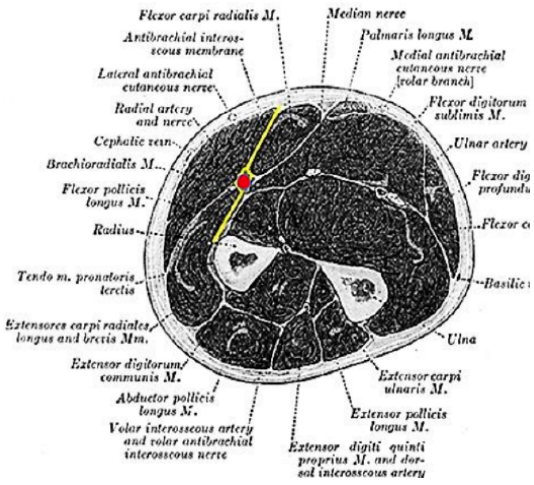


Figure 9: Cross-section of forearm demonstrating brachioradialis muscle, radial artery and oblique plane of the intermuscular septum

- Refer to the anatomy of the forearm (*Figure 9*)
- Note how the radial artery lies within the lateral intermuscular septum which extends ***obliquely*** (anteromedially) towards the skin (*Figure 9*)
- Posteromedial to the septum are the flexor muscles and specifically flexor carpi radialis
- Anterolaterally lie the muscle belly of brachioradialis proximally, and its flat tendinous part that covers the artery distally
- Therefore, to reach the radial artery the brachioradialis muscle and tendon need to be elevated like "opening a book"
- The artery and perforators are then visible as they run obliquely anteriorly, from lateral-to-medial

Subfascial RFFF elevation technique

This is the preferred technique for less experienced surgeons. Readers are referred to a later description of an alternate suprafascial/fascia-sparing elevation technique

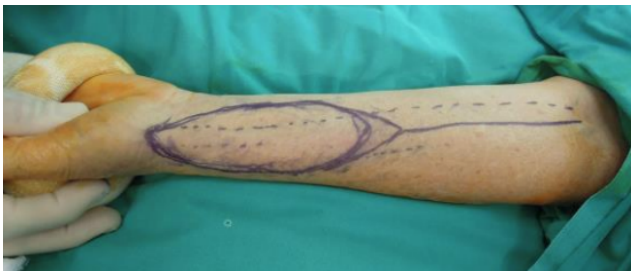


Figure 10: Flap designed to include lateral intermuscular septum and superficial vein

- Design the flap on the forearm to include the lateral intermuscular septum as well as a superficial vein, usually the cephalic vein; the preferred position of the proximal extension is laterally between the radial artery and cephalic vein (*Figure 10*)

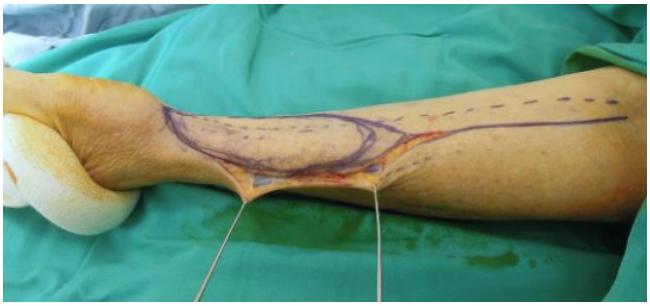


Figure 11: Skin incision along lateral aspect of flap (Left arm)

- Start the dissection laterally, with two skin hooks anchoring the skin lateral to the flap (*Figure 11*)
- Incise the circumference of the skin flap and the proximal curvilinear extension towards the cubital fossa with a No. 15 scalpel blade

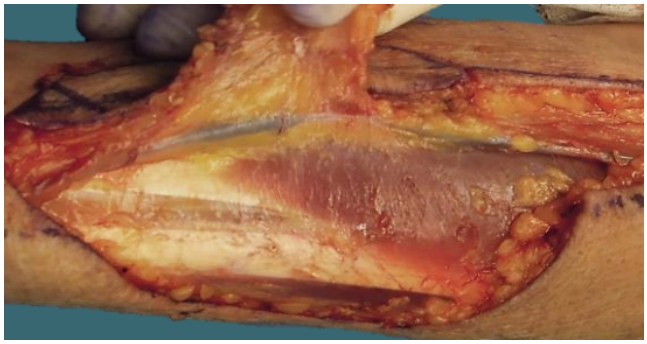


Figure 12: Skin flap elevated in deep subcutaneous plane to expose the cephalic vein

- Elevate the flap with a scalpel from laterally in a ***deep subcutaneous (not subdermal) plane*** until the cephalic vein which lies deep to the subcutaneous fat comes into view (*Figure 12*)
- Using a scalpel, elevate the cephalic vein from lateral-to-medial with the intervening subcutaneous tissue between vein and flap (*Figure 12*)



Figure 13: Arrow points to lateral antebrachial cutaneous nerve parallel to cephalic vein

- ***Elevate and skeletonize the cephalic vein*** proximal to the flap (*Figure 13*)

- The ***lateral antebrachial cutaneous nerve*** accompanies the cephalic vein in the same subcutaneous plane (*Figure 13*). If an innervated flap is planned, this nerve is elevated with the cephalic vein

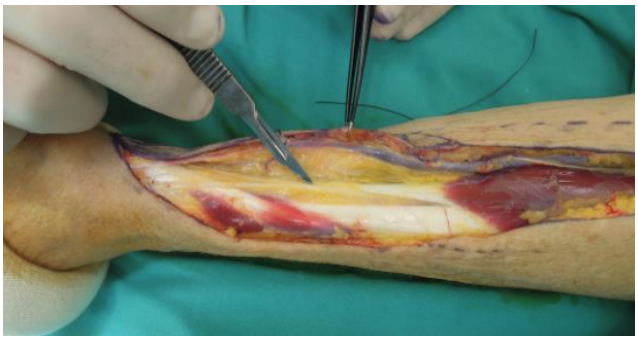


Figure 14: Scalpel points to superficial branch of radial nerve lateral to brachioradialis

- Separate the vein without its surrounding soft tissue from the main vascular pedicle using sharp scalpel dissection
- Elevate the lateral aspect of the flap in a subfascial plane over the extensor and abductor tendons with a No. 15 scalpel blade (*Figure 14*)
- Identify the superficial branch of the radial nerve lateral to the brachioradialis and medial to the extensor pollicis brevis and abductor pollicis longus (*Figure 14*)

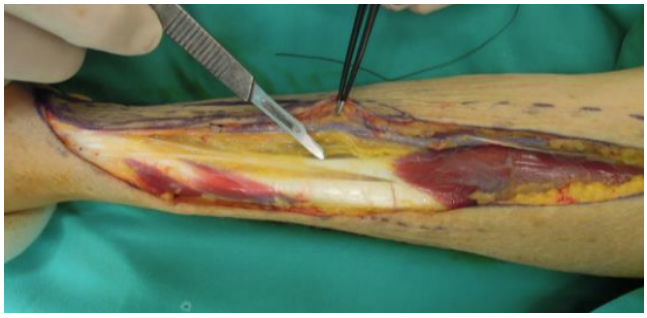


Figure 15: Scalpel points to brachioradialis tendon

- Extend the dissection medially over the epitenon covering the latter two tendons and the radial nerve, until the flat tendon of brachioradialis is visualized (*Figure 15*)
- It is very important to maintain epitenon over these tendons to provide a "cover" for skin grafting, if required
- Carefully continue with sharp dissection over the brachioradialis tendon up to its sharp medial edge
- To retract the brachioradialis muscle and tendon, the ***assistant stands on the radial side*** of the arm and the surgeon sits next to the trunk of the patient where he/she is protected from physical interference by the resection team

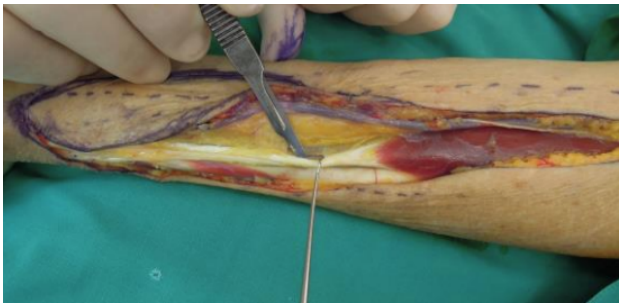


Figure 16: Sharp medial edge of brachioradialis tendon, and cutting along undersurface of brachioradialis tendon

- While the assistant applies lateral traction to the muscle with skin hooks, release the medial edge of the brachioradialis muscle off the (poorly defined) underlying lateral intermuscular septum using sharp dissection (*Figure 16*)
- Sharply dissect and elevate the tendon superiorly up to its musculotendinous junction; the ***radial artery generally lies immediately below the tendon***; therefore, the angle of the scalpel blade is changed to a horizontal plane to cut along the under surface of the brachioradialis tendon (*Figure 16*)

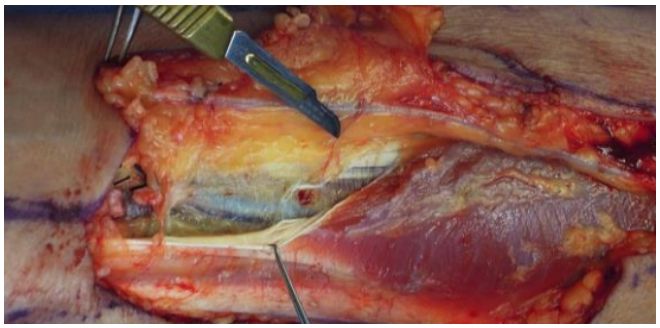


Figure 17: Perforators within the septum are vulnerable to injury where they hook around the medial edge of brachioradialis tendon

- Distally, the perforators commonly hook around the medial edge of the brachioradialis tendon where they are vulnerable to injury, especially when incising perpendicularly past the medial edge of the tendon (*Figure 17*)





Figures 18a, b: Medial edge of brachioradialis tendon and muscle (retracted) and incising muscle fascia lateral to vascular pedicle

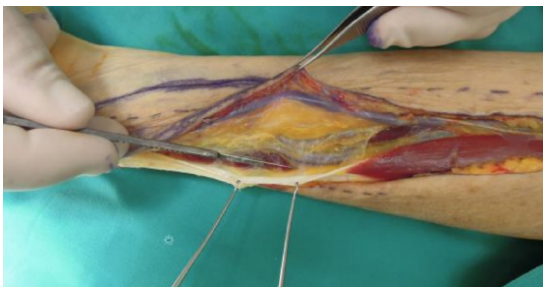


Figure 19: Brachioradialis muscle mobilized to expose full length of radial artery



Figure 20: Dividing muscle perforators

- Incise the fascia overlying the muscle lateral to the vascular pedicle (*Figure 18*)
- Once the brachioradialis muscle has been mobilized, the full length of the radial artery is visible and the likelihood of injuring the perforators is much less (*Figure 19*)
- Ligate and divide larger muscle perforators with Liga clips and coagulate small ones with bipolar forceps (*Figure 20*)
- Next ***elevate the medial side of the flap*** by cutting the epimysium covering the wrist flexor muscles with a scalpel

- Elevate the deep fascia over the tendons, but preserve the epitenon covering the tendons

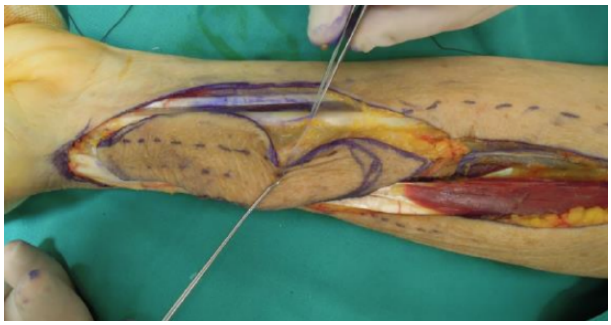


Figure 21: Elevate the deep fascia over the tendons, preserving epitenon

- Elevate beyond the flexor carpi radialis and incise the deeper muscle fascia over the flexor digitorum superficialis muscle (*Figure 21*)



Figure 22: Radial artery



Figure 23: Radial artery divided



Figure 24: Distal-to-proximal dissection

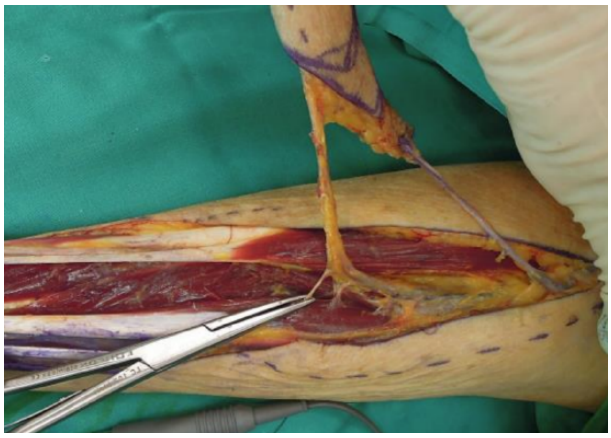


Figure 25: Applying Liga clips and dividing side branches of the radial artery; note the cephalic vein

- Incise the fascia over the radial artery and isolate, ligate and transect the artery and venae comitantes (*Figures 22*, *23*)
- Dissection now proceeds from distalto-proximal (*Figure 24*)
- Meticulously divide the side-branches along the artery until enough vessel length is achieved to reach the recipient vessels in the neck; this permits drainage of both the superficial and deep venous systems via a single venous anastomosis (*Figure 25*)
- ***Selecting a vein as drainage vessel***
  - The ***cephalic vein*** may be divided at any point along its course
  - The cephalic vein may be dissected into the cubital fossa where connections may exist between one (or both) branches of the ***venae comitantes*** of the radial artery and, more commonly to the ***median cubital*** or the ***cephalic veins***
  - More rarely the ***deep and superficial systems are anastomosed separately***, utilizing the cephalic and one of the large cubital veins
  - Occasionally a very large dominant ***median vein of the forearm*** can be used
  - Avoid using ***venae comitantes*** for anastomoses if at all possible, due to their small size
- Deflate the tourniquet
- While awaiting reperfusion of the flap vasculature, the surgeon prepares the recipient vessels in the neck
- Control bleeding side-branches on the pedicle and on the flap with bipolar coagulation and/or Liga clips before disconnecting the flap from its blood supply

Reconstruction site

Check the reconstruction site for bleeding. Inspect the neck dissection for bleeding and ask the anesthetist to perform a ***Valsalva maneuver*** to demonstrate bleeders or lymphatic leaks.

Recipient vessels and nerves

The recipient vessels are selected and prepared for anastomosis. The ***distance between the recipient artery and vein*** must allow the donor vessels to reach both vessels comfortably, although this is not a problem when the cephalic vein is used as it is totally separate from the main vascular pedicle.

The ***recipient artery*** is selected according to size; access; and position to avoid kinking or excessive tension. The ***facial artery*** is most commonly used, although a more inferiorly placed artery such as the ***superior thyroid artery*** or even the ***transverse cervical artery*** may in some cases be a better choice.

The author's preference for ***venous anastomosis*** is the ***internal jugular vein***, followed by the ***common facial vein*** and ***external jugular vein***.

If ***sensory innervation*** of the flap is planned using the ***lateral antebrachial nerve***, the surgeon should identify and mark e.g. the lingual nerve with a suture at the time of tumor resection, as the nerve may be difficult to identify later.

Transfer and inset of flap

- Only after the recipient area and recipient vessels have been fully prepared are the flap vessels divided
- Prepare the vessels for anastomotic suturing
- Ensure that there is no bleeding from the flap before transferring it to the neck

- Refer to chapter: Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Suprafascial RFFF elevation technique

The main reason for elevating the RFFF suprafascially is to reduce the failure rate of the skin graft by maintaining a fascial covering over the exposed tendons. It does also allow the flap to be thinned in patients with very thick subcutaneous fat layers (Extreme care should be taken if the latter is attempted).

Only the most lateral and medial parts of the flap may be partially thinned of deep fat. More extensive thinning of the flap may interrupt critical blood supply by the perforators.

- Elevate the flap laterally, including the cephalic vein, which lies superficial to the fascia
- Maintain a superficial dissection plane up to the medial edge of the brachioradialis tendon
- Incise the deep fascia at the medial edge of the tendon, but not beyond
- Perform the brachioradialis tendon and muscle elevation and mobilization as described previously
- Incise the deep fascia on the pronator quadratus, flexor pollicis longus and flexor digitorum superficialis lateral to the vascular pedicle
- Suprafascially elevate the medial extent of the flap up to the lateral edge of the flexor carpi radialis tendon and muscle
- Incise the deep fascia beyond this point down to the deeper muscles (flexor pollicis longus and flexor digitorum superficialis)
- Complete the flap elevation as previously described
- Following complete elevation of the flap, it is often possible to approximate the two edges of the cut deep fascia to achieve complete fascial closure (*Figure 26*). If not, at least the tendons have a more reliable cover to avoid loss of the skin graft, exposed tendons and infection

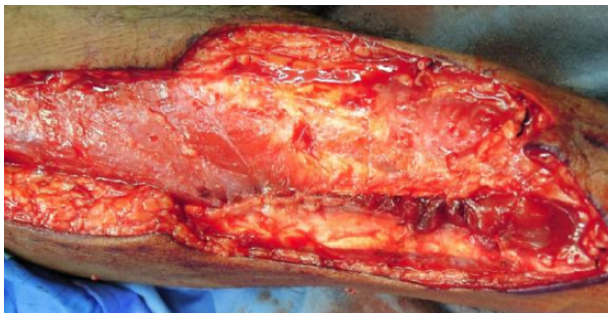


Figure 26: Edges of deep fascia approximated to achieve complete fascial closure

Composite flaps

The palmaris longus muscle and tendon are commonly used for tendon transfers and as grafts for tendon or ligament reconstruction. In the head and neck the tendon is mainly used in total or near-total lower lip reconstruction to suspend the lower lip to the facial muscles at the oral commissure or to the maxilla. Harvesting the tendon or muscle does not cause significant loss of hand function. The palmaris longus tendon is identified preoperatively and easily incorporated in the flap by incising the deep fascia medial to the tendon down to the deeper muscles when medially elevating the flap, and including the tendon in the flap. The palmaris longus muscle and tendon may be absent in up to 15% of individuals. In such situations the flexor carpi radialis tendon may be incorporated in the flap with minimal functional deficit of hand and wrist flexion.

Osteocutaneous RFFF

Addition of radius bone to a RFFF has some ***major benefits*** including having a composite flap with a ***long pedicle and thin, pliable skin*** for soft tissue reconstruction; ***vascularized bone which is not bulky***; and the ability to use the flap for structural bone and soft tissue reconstruction ***without reverting to the use of two flaps***, such as a forearm flap in combination with a fibula flap (although the latter combination may still be required).

The osteocutaneous RFFF is used especially in midface and periorbital reconstruction, but also as an "onlay" vascularized bone flap following marginal mandibulectomy and may occasionally be used for segmental defects of the ascending ramus of the mandible. It may also be use in total nasal reconstruction to provide an “L” strut and internal nasal lining (See clinical examples at end of chapter).

Disadvantages compared to a free fibula flap include ***lack of bone stock*** for osseointegrated implants, ***inadequate bone strength*** for reconstruction of areas subjected to greater force and torque e.g. the symphysis, parasymphysis and body of the mandible; ***limited bone length***; and the risk of subsequent ***forearm fracture***.

The available bone lies between the insertion of the pronator teres muscle on a small area on the mid-lateral radius, and the insertion of brachioradialis laterally at the base of the radial styloid. Up to 40% of the circumference may be harvested. To avoid a subsequent fracture, ***prophylactic plating*** is done after the bone has been harvested.

- It is preferable to place the flap more medially on the forearm so that the area of harvesting and the plate are covered with intact skin
- This might preclude the use of the cephalic vein and the lateral antebrachial nerve, as they may lie too far laterally
- Periosteal and musculoperiosteal perforators provide the blood supply to the bone. Great care should be taken to elevate the brachioradialis tendon by cutting horizontally underneath the tendon with a No.15 blade to avoid injury to the perforators exiting the radial artery laterally that supply the bone and flexor pollicis longus and pronator quadratus muscles
- Extend the dissection deep to brachioradialis more laterally by widely retracting the tendon and muscle and dissecting beneath the superficial radial nerve



Figure 27: Perforators to the bone are identified and protected

- Identify and protect the perforators to the bone (*Figure 27*)
- Elevate the medial part of the flap Incise the deep fascia over the pronator quadratus, flexor pollicis longus and flexor digitorum superficialis muscles
- Retract the flap and vascular pedicle laterally (distal pedicle not yet divided)

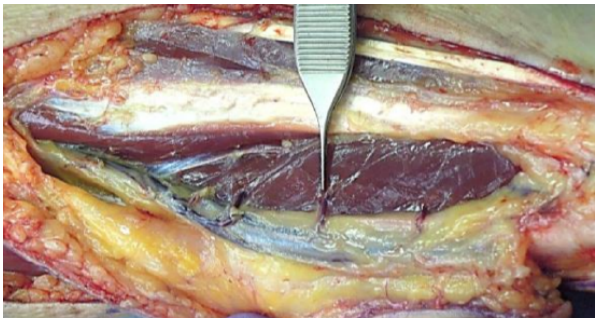


Figure 28: Muscle perforators entering the muscle

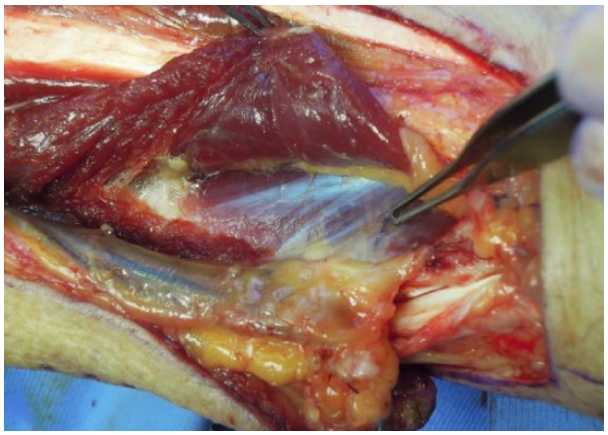


Figure 29: Flexor digitorum superficialis partially released to expose the flexor pollicis longus muscle and the lateral intermuscular septum and vascular pedicle

- Flexor carpi radialis may need to be retracted medially to expose the flexor digitorum superficialis muscle (radial head). Muscle perforators enter the muscle (*Figure 28*)
- Partially release the flexor digitorum superficialis from inferior to superior, enough to expose the flexor pollicis longus muscle and its origin from the anterior surface of the radius (*Figure 29*)
- Retract the cut flexor digitorum superficialis medially while gently retracting the lateral intermuscular septum and vascular pedicle laterally (*Figure 29*) The ***thickness of the radial bone is determined proximally*** during the dissection and a longitudinal cut is made through the flexor pollicis longus and periosteum on the medial surface of the radius with a No. 15 scalpel blade
- Mark the length of bone required starting 2.5 cm proximal to the radial styloid to permit distal fixation of the plate, and mark the proximal end
- A maximum length of about 12 cm can be harvested, but even more can be used if the insertion of pronator teres is detached from the radius and later reattached to the bone or plate
- A high-speed oscillating saw, directed from the medial/ulnar side, is used to divide the radius along its length, starting proximally where the radius has a smaller circumference; do not start cutting distally, as one may end up with too little bone stock proximally

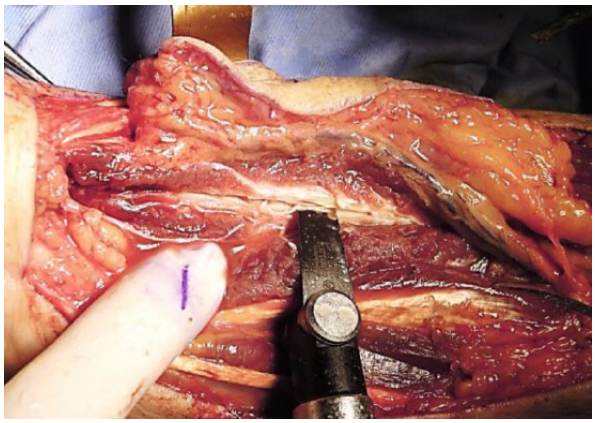


Figure 30: Cutting cortices longitudinally while protecting radial nerve and laterally placed tendons with a metal (copper) plate

- Divide both cortices longitudinally; use a metal plate held on the dorsolateral side to protect the radial nerve and the laterally placed tendons (*Figure 30*)
- The volar-lateral segment is used in the flap
- Make the cut so that approximately 60% of the dorsomedial circumference remains



Figure 31: Beveled ends of bone

- Bevel the proximal and distal osteotomies at an angle of about 50^{o} to avoid a weak (stress) point (which would occur if it was to be cut at 90^{o}) (*Figure 31*)
- To avoid cutting too deep when doing the two osteotomies, insert a ruler in the longitudinal cut to act as a stopper [2]
- Elevate the flap from distal to proximal

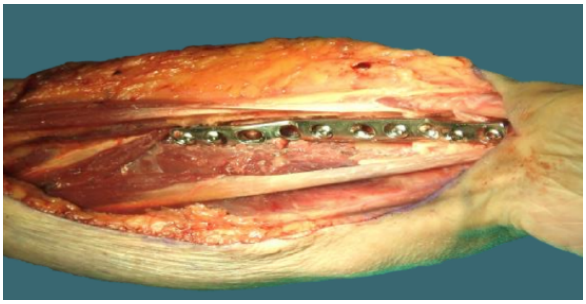


Figure 32: Plating of radius

- Avoid fracturing the remaining radius (disastrous and very difficult to manage) by ***prophylactically doing a plate fixation*** with an appropriate thickness plate (*Figure 32*)
- To insert the plate, firm retraction of the abductor pollicis longus and the long extensors of the thumb are required distally and proximally for exposure
- The supinator muscle may need to be partially detached to place the plate
- It is probably better not to bend the plate to the contour of the bony defect, but to bridge the gap which may allow more bone formation beneath the plate
- At least 2 bicortical screws are placed distally and 3 bicortical screws proximally
- Mobilize skin over the lateral forearm to cover the plate
- The soft tissue is covered with a skin graft
- A volar splint is worn for 2 weeks

Innervated sensate RFFF

The ***lateral antebrachial cutaneous nerve*** runs alongside the cephalic vein and is well suited for simple, rapid inclusion of the nerve with a RFFF (*Figure 1*). Its cutaneous supply closely matches most RFFF designs. When designing a more medially placed RFFF as with an osteocutaneous flap, the ***medial antebrachial nerve*** may be a better choice (*Figure 1*). The nerve is connected to an appropriate sensory nerve in the area to be reconstructed e.g. mental, inferior alveolar or lingual.

Achieving additional bulk

Additional soft tissue bulk may be required e.g. when reconstructing the orbit following orbital exenteration. This can be achieved by de-epithelializing part of the RFFF and folding the fascial component of the RFFF into the cavity.

Optimizing cosmetic result of forearm donor site

- Attempt to advance skin to cover the exposed tendons
- Skin grafts
  - Maintain epitenon over tendons
  - Bury tendons by oversewing with deeper muscles
  - Always fix and immobilize skin graft with sutures and appropriate dressings

- Use volar splint to restrict movement of flexor tendons beneath skin graft
- Negative pressure wound therapy (NPWT) of the donor site for 1 week may improve the graft bed by improving the bed vascularity, achieving granulation tissue cover over exposed tendons and a smoother graft bed. A drawback is that a 2nd surgical procedure is required for skin grafting

- Suprafascial flap elevation (Author's preferred method)
- Flap reconstruction of smaller round or more horizontally orientated defects. This may be achieved with an ulnar based V-Y rotation-advancement flap which is based on perforators from the ulnar artery
- Avoid using meshed skin grafts on the forearm. They leave an unsightly, permanent "patterned" scar

Clinical examples of RFFFs

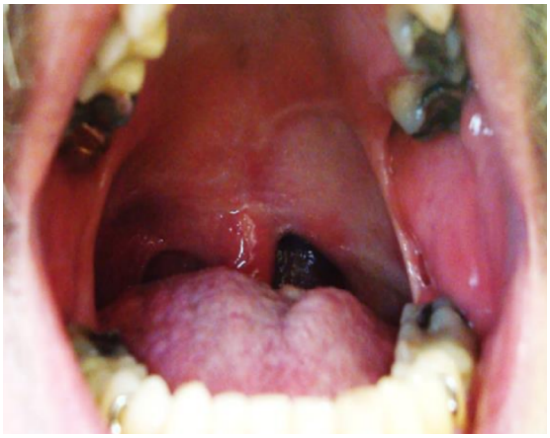


Figure 33: Soft palate and tonsil fossa



Figure 34: Hemiglossectomy



Figure 35: Lower lip reconstruction (Courtesy of CR Leemans)

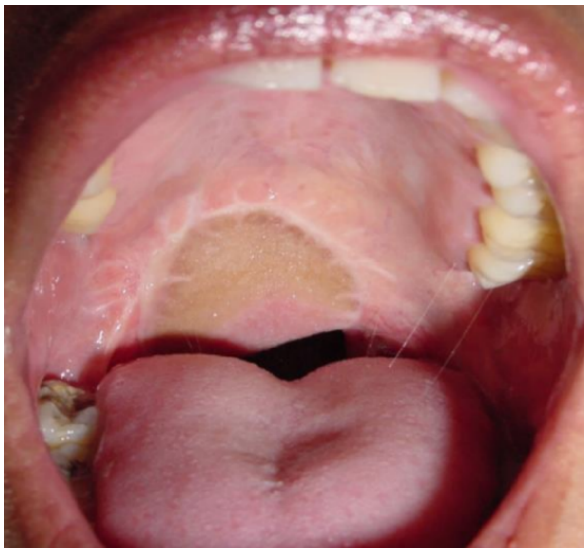


Figure 36: Soft palate reconstruction



Figure 37: Buccal reconstruction

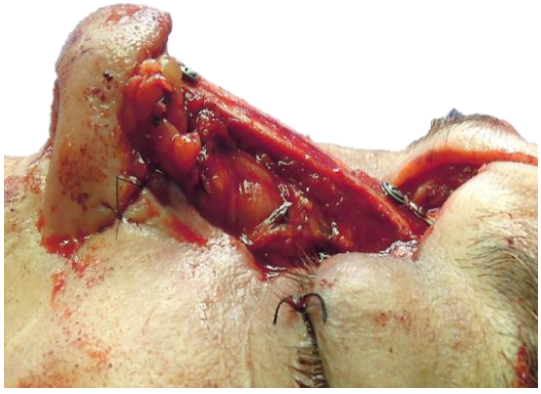


Figure 38: Total nasal reconstruction with osteocutaneous RFFF providing “L” strut and internal nasal lining, with forehead flap for external skin

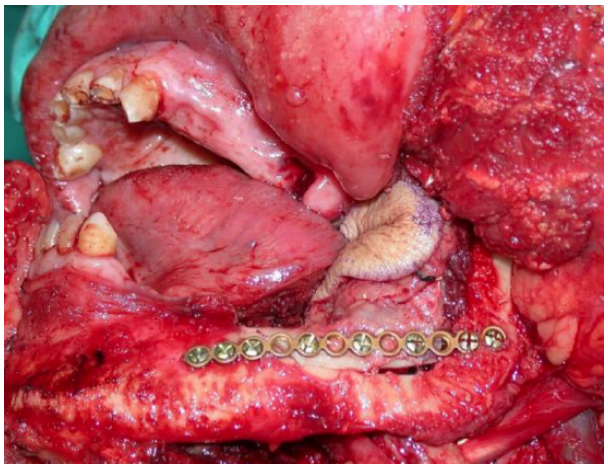


Figure 39: Onlay osteocutaneous RFFF

References

1. Saint-Cyr M, Mujadzic M, Wong C, Hatef D, Lajoie A, Rorich R. The radial artery pedicle perforator flap: Vascular analysis and clinical implications. Plast Reconstr Surg. 2010 125: 1469-78
2. Shnayder Y, Tsue TT, Toby EB, Werle AH, Girod DA. Safe Osteocutaneous Radial Forearm Flap Harvest with Prophylactic Internal Fixation. Craniomaxillofacial Trauma & Reconstruction. 2011;4(3):129-36

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author

JE (Ottie) Van Zyl MBChB, FCS
Plastic & Reconstructive Surgeon
Groote Schuur Hospital
Cape Town, South Africa
ottie@mweb.co.za

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

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SURGICAL REANIMATION TECHNIQUES FOR FACIAL PALSY/PARALYSIS

David Sainsbury, Gregory Borschel, Ronald Zuker

The facial nerve not only provides conscious and subconscious motor control of the facial musculature, but also enables ocular protection, nasal airflow, oral continence and bilabial speech articulation. Additionally, it facilitates a defining human characteristic, the ability to smile. Consequently, facial nerve injury may inflict a spectrum of functional, aesthetic and psychosocial insults. Facial disfigurement has been described as the “last bastion of discrimination” and those with facial palsy may be considered “different”, suffering social and workplace discrimination (McGrouther 1997). This may lead to social isolation, decreased self-esteem and negative self-image (Newell 1991) and there is a high incidence of depression in individuals with facial palsy (Ryzenman et al. 2005). As with any form of disfigurement the degree of injury does not necessarily correlate with the severity of psychosocial disturbance (Robinson 1997). Moreover, psychological stress rather than functional deficit, is often the key determinant in predicting social handicap and need for surgical intervention (Van Swearingen et al. 1998; Bradbury et al. 2006).

Whenever possible, surgeons should promptly repair facial nerve injuries in order to restore neural continuity from the facial motor nucleus to the distal facial nerve branches. Such repairs may involve direct microsurgical repair or nerve grafts. If these are not possible then other techniques may be used to re-establish facial resting symmetry and mimetic movement. This chapter explores the anatomy and etiology of facial nerve injury and then focuses on the management of facial palsy with particular emphasis on facial reanimation.

Anatomy

The facial nerve (cranial nerve VII) is embryologically derived from, and consequently innervates all structures originating from, the second branchial arch. Arbitrarily, the facial nerve can be divided into three segments along its course: intracranial, intratemporal and extratemporal.

1. Intracranial anatomy

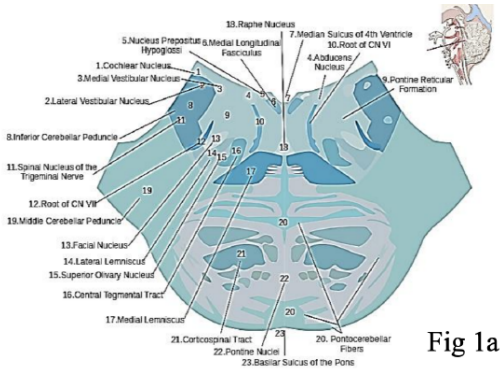


Fig 1a

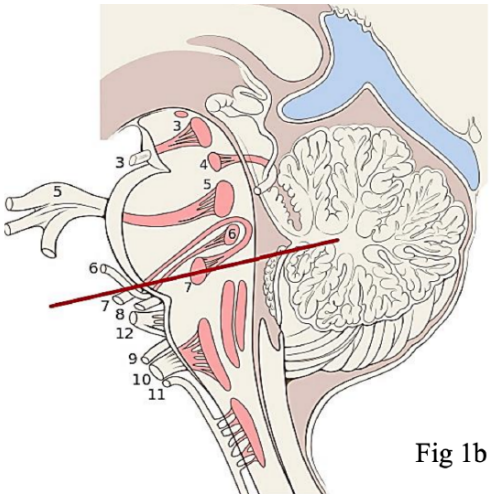


Fig 1b

Figures 1a,b: Origin of the facial nerve from the pontine region of the brainstem. Note the close proximity of the facial nerve (cranial nerve VII) and vestibulocochlear (cranial nerve VIII) at the cerebellar pontine angle. This explains why vestibular schwannomas, or surgery to remove them, may result in facial nerve injury

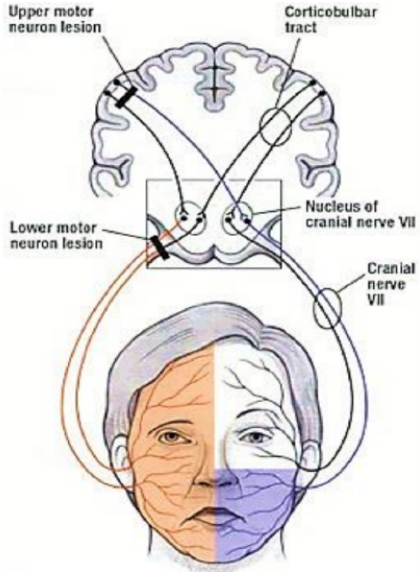


Figure 2: The cell bodies giving rise to the frontal branch of the facial nerve receive bilateral cortical input explaining why an upper motor neurone lesion results in contralateral facial paralysis with sparing of the frontalis muscle. Conversely, a lower motor neurone lesion to the facial nerve causes ipsilateral facial hemiplegia, including the ipsilateral frontalis mus cle (http://teachmeanatomy.info/neuro/des...g-tracts-motor)

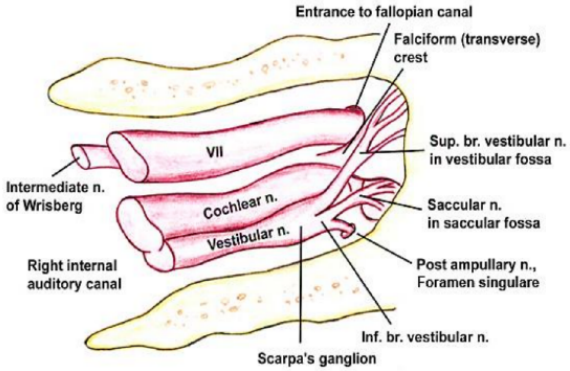


Figure 3: The facial nerve enters the internal auditory canal of the temporal bone with the vestibulocochlear nerve (VIII cranial n) and the nervus intermedius (Nerve of Wrisberg). The nervus intermedius is part of the facial nerve between the motor component of the facial nerve and the vestibulocochlear nerve. It transmits sensory and parasympathetic fibers http://emedicine.medscape.com/articl...view#aw2aab6b5

The facial nerve originates from the pontine region of the brain stem (*Figure 1*). The cell bodies giving rise to the frontal branch receive bilateral cortical input (all the other facial nuclei cell bodies receive contralateral cortical input). This explains why an ipsilateral supranuclear lesion (upper motor neurone lesion) to the facial nerve results in contralateral facial paralysis but with bilateral sparing of the frontalis muscle. Conversely, a lower motor neurone lesion to the facial nerve results in ipsilateral facial hemiplegia, including the ipsilateral frontalis (*Figure 2*). The facial nerve enters the temporal bone at the internal auditory meatus with the eighth cranial nerve, the vestibulocochlear nerve (*Figure 3*).

2. Intratemporal anatomy (Figures 4, 5)

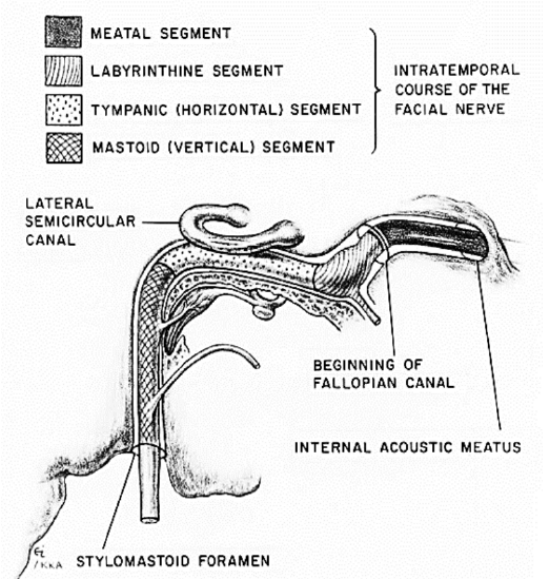


Figure 4: Intratemporal course of VII nerve

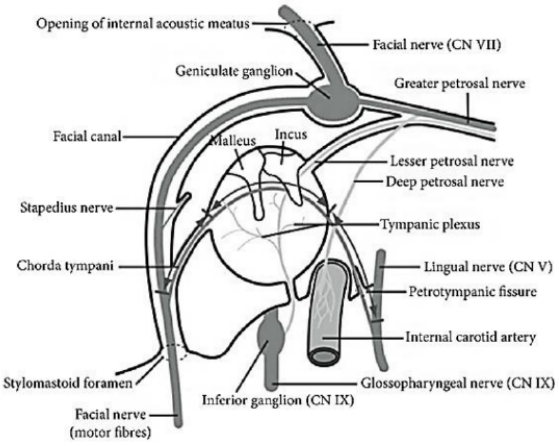


Figure 5: The intratemporal course of the VII nerve from internal auditory meatus to stylomastoid foramen, with its branches

The facial nerve enters the internal auditory canal and travels with the acoustic and vestibular nerves for about 8-10 mm. It then enters the Fallopian canal, which has 3 segments:

a. Labyrinthine segment: This is 3-5 mm long, and courses from the entrance of fallopian canal to the geniculate ganglion. It is the narrowest segment of the fallopian canal, with a mean diameter of 1.42 mm and with the nerve occupying 83% of available space. At the geniculate ganglion the first branch of the facial nerve, the greater petrosal nerve, is given off. The greater petrosal nerve provides parasympathetic innervation to the lacrimal and palatal glands. The junction of labyrinthine and tympanic segments forms an acute angle and traumatic facial nerve shearing may occur here.

b. Tympanic segment: This is 8-11 mm long, and courses from the geniculate ganglion to a bend at the lateral semicircular canal.

c. Mastoid segment: This is 9-12 mm long and extends from the angle at the lateral semicircular canal to stylomastoid foramen. This segment has the widest cross-sectional diameter and gives off three branches:

- Tympanic nerve: This is a small sensory branch to the external auditory canal. Injury may cause hyperesthesia of part of the external auditory canal, known as Hitselberger's sign
- Nerve to stapedius: The stapedius muscle dampens loud noise. Interestingly, the cell bodies of the motor nerve are not located in the facial nucleus and consequently the stapedius muscle is unaffected in Möbius syndrome
- Chorda tympani: This is the last intratemporal branch of the facial nerve; it joins the lingual nerve to provide parasympathetic innervation to submandibular and sublingual glands and taste sensation to anterior two-thirds of the tongue
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3. Extratemporal anatomy

The facial nerve exits the temporal bone at the stylomastoid foramen. Here the mastoid tip, the tympanic ring and mandibular ramus confer protection. However, in children under 2 years of age the nerve is superficial and more prone to injury.

The ***posterior auricular nerve*** is the first branch of the facial nerve following its departure from the stylomastoid foramen and innervates the superior and posterior auricular muscles, the occipital muscles and provides sensory innervation to a small area behind the earlobe.

The next branch is the ***motor branch to the posterior belly of digastric and stylohyoid muscles***. Here the facial nerve is located just above the posterior belly of digastric.

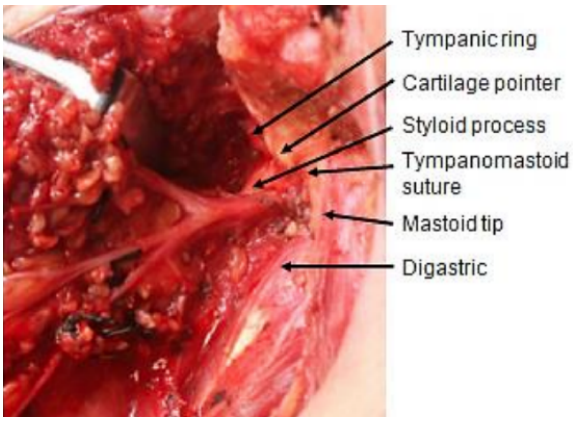


Figure 6: Intraoperative surgical landmarks for the facial nerve trunk

Anatomical pointers to find the trunk of the facial nerve where it exits the stylomastoid foramen include the posterior belly of digastric, tympanomastoid suture line, tragal pointer and styloid process (*Figure 6*). These are described in detail in the Parotidectomy chapter.

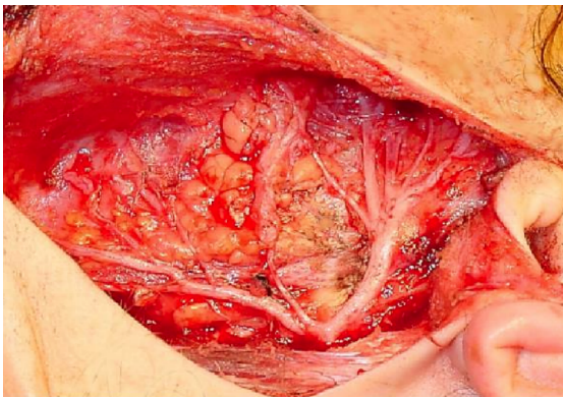


Figure 7: The superficial lobe of the parotid has been removed to expose the facial nerve trunk dividing into superior and inferior divisions at the pes anserinus

The facial nerve then enters the parotid gland and arborizes between the deep and superficial lobes of the parotid gland. The nerve first divides into temporozygomatic and cervicofacial divisions (*Figures 6, 7*).

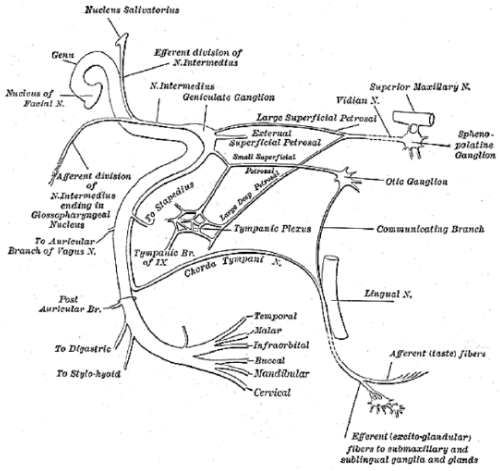


Figure 8: Extratemporal course of facial nerve

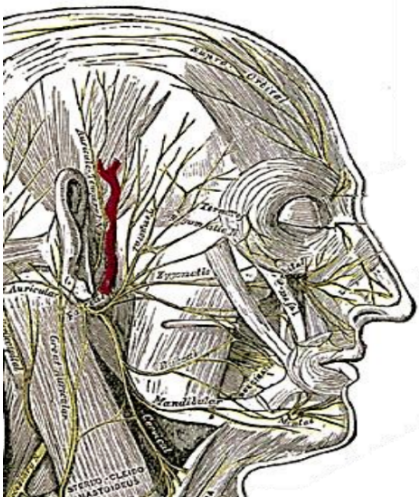


Figure 9: Extratemporal course of facial nerve

These divisions divide, rejoin and divide again to form the pes anserinus (Goose's foot) to ultimately give the terminal branches, namely, temporal (frontal), zygomatic (malar and infraorbital), buccal, mandibular and cervical nerves (*Figures 7-9*).

a. Temporal (frontal) branch: This is the terminal branch of the superior division and travels along Pitanguy's line which extends from 0.5 cm below the tragus to 1.5 cm above and lateral to the eyebrow. The nerve becomes increasingly superficial as it travels cephalad and lies just deep to the temporoparietal (superficial temporal) facia at the temple. At the level of zygomatic arch, it arborises into two to four branches to innervate the frontalis muscle from its inferior aspect. Temporal branch injury causes ipsilateral frontalis muscle paralysis.

b. Zygomatic branch: This is arguably the most important branch of the facial nerve as it supplies orbicularis oculi, which enables eye protection. Consequently, injury to the zygomatic branch may cause lagophthalmos (inability to completely close the eye) with risks of exposure keratitis, corneal ulceration and scarring. Ultimately, this may lead to blindness.

c. Buccal branch: This divides into multiple branches traveling at the level of the parotid duct. The surgical landmark to locate these branches is 1 cm or one finger breadth below the zygomatic arch. The buccal branch innervates the buccinator and upper lip musculature. It is also important for lower eyelid function, as the medial canthal fibers of buccal branch innervate the inferior and medial orbicularis oculi. Injury to the buccal branch causes difficulty emptying food from the cheek and an impaired ability to smile. However, due to the high degree of arborisation (buccal branch always receives input from both the superior and inferior divisions of the facial nerve) damage to this branch is less likely to result in a functional deficit. The zygomatic/ buccal motor branch, that innervates the zygomaticus major can consistently be found at the midpoint (Zuker's point) of a line drawn between the helical root and the lateral oral commissure (Dorafshar et al. 2013)

d. Marginal mandibular branch: This is a terminal branch of inferior division and runs just below the border of mandible, ***deep*** to platysma and superficial to the facial vein and artery. It supplies the muscles of the lower lip (depressor anguli oris). Injury results in ipsilateral lack of depression of the lower lip and asymmetry of open mouth smiling or crying. It is connected to other rami in only 15% of cases; consequently, clinical weakness is highly likely following injury.

e. Cervical branch: This is a terminal branch of the inferior division of the facial nerve. It runs down into the neck to supply platysma (from its deep surface)

Interconnections exist between buccal and zygomatic facial nerve branches in 70-90% of patients; hence injury to these branches may be clinically compensated for by these interconnections. This is not true for the frontal and marginal mandibular branches which are terminal branches without significant crossover. Hence injuries to the frontal and marginal mandibular branches are less likely to clinically recover.

Clinically it may be possible to ***predict the site of facial nerve injury***. Injuries at or distal to stylomastoid foramen only have paralysis of facial musculature. More proximal injuries may also manifest loss of taste and hyperacusia.

Etiology of Facial Paralysis

Congenital causes include obstetric, developmental facial paralysis, Möbius syndrome and idiopathic mandibular division palsy. Acquired causes include traumatic temporal bone fracture or facial injury, neoplastic, infectious, neuromascular and iatrogenic (parotidectomy or acoustic neuroma excision) (Westin & Zuker 2003).

Obstetric injury, often with forceps delivery, is the commonest cause of congenital cause; most recover within a month.

Idiopathic marginal mandibular nerve palsy (asymmetrical crying facies/con genital unilateral lower lip palsy/CULLP) causes unilateral weakness of depressor anguli oris and is associated with other major congenital anomalies in 10% of children, most commonly the cardiovascular system (44%). It affects about one in 160 live births.

Möbius syndrome is a rare condition of unknown origin. Children usually present at an early age with facial and ocular symptoms which include incomplete eye closure, mask-like face, inability to follow gaze, drooling and difficulty sucking. The facial nerve is always involved, the abducens nerve is involved in 75-100% of cases, and the hypoglossal nerve is commonly implicated. Other cranial nerves e.g. oculomotor, trigeminal, glossopharyngeal and spinal accessory may be involved. The condition is often bilateral, but can be unilateral, with complete or incomplete paralysis of the affected nerves. Limb abnormalities may be present in up to 25% of cases, e.g. clubbed feet, congenital hand anomalies (including syndactyly) and pectoral anomalies in 15% (Poland's syndrome). A myriad of other associated conditions including hypotonia, hearing problems, Pierre-Robin sequence, congenital heart disease, spinal anomalies, microglossia and peripheral neuropathies are described.

Goldenhar's syndrome comprises hemifacial microsomia, epibulbar dermoid cysts and vertebral anomalies, and may have facial nerve weakness.

Bell's palsy accounts for 66-85% and is the commonest cause of acquired facial palsy. Etiology is unknown although polymerase chain reaction studies of viral DNA suggest that latent herpes viruses may be responsible. Swelling of the nerve within the fallopian canal may cause nerve compression and an immune reaction. This disrupts the neural microcirculation resulting in demyelination and impaired conduction of neural impulses. It has an incidence of 1 in 5000 and carries a 1 in 60 lifetime risk. It affects males and females equally, although it is associated with pregnancy and is four times more common in diabetics. It is typified by sudden onset of unilateral facial paresis or paralysis. There may be a prodromal taste disturbance due to conduction anomalies in the chorda tympani, pain, hyperacusis (due to stapedial denervation) and excessive lacrimation. Signs include brow and forehead ptosis, upper eyelid retraction, ectropion (orbicularis oculi dysfunction), decreased blink reflex and decreased ability to close the eye. Initial management may include corticosteroids and antivirals. The use of acyclovir however is controversial and systematic reviews of randomized controlled trials showed no benefit over corticosteroid therapy alone (Lockhart et al. 2009). A typical regime in adults is 30 mg prednisolone twice a day for 5 days with a tapering dose over 5 days. Particular attention should be made to eye protection using frequently applied lubricating eye drops by day and eye gel at night. All patients with Bell's palsy begin to recover function within 6 months and almost none will remain totally paretic. However, a significant proportion has residual weakness, synkinesis (coarse, uncoordinated facial movement e.g. involuntary eye closure when smiling due to aberrant regeneration) or hemifacial spasm. Recovery begins within three weeks in 85% of patients, but only at three to six months in 15%. Most show some signs of recovery within four weeks. Earlier recovery por tends a better prognosis. Recovery continues over a period of up to 12-18 months. Predictors of a poor outcome include initial complete paralysis, no recovery at three weeks, >60 years of age and low electromyogram amplitudes. About 10% of Bell's palsies may recur.

Trauma is the 2nd commonest cause and may be due to temporal bone fracture, penetrating wounds or obstetric injury.

Temporal bone fractures (longitudinal, transverse or mixed) are classified according to the fracture line in relation to the long axis of the temporal bone. Facial paralysis is more likely with transverse fractures. End-to-end coaptation of a disrupted intratemporal facial nerve requires an otologic approach.

With ***penetrating facial wounds***, nerve injury to facial nerve branches medial to a line drawn vertically through the lateral canthus of the eye may retain facial movement because of the degree of arborization; nevertheless, nerves should be repaired if possible. However, injury to the frontal and marginal mandibular nerves manifesting with weakness should always be repaired as the likelihood of spontaneous recovery is poor. Nerve repair should ideally be done within 72 hours to permit identification of the distal ends of the severed nerves by electrical stimulation; beyond 72 hours neurotransmitter stores may become depleted.

Tumors may cause facial palsies and can have a variable presentation of onset (sudden or insidious), severity (complete or incomplete), number of episodes (single or multiple) and presence of facial muscle hyperkinesis. A neoplastic cause should be considered with unilateral facial weakness which slowly progresses over several weeks/months, or with an abrupt onset without return of function at 6 months, or with associated hyperkinesis. Malignancy causing facial paralysis most commonly originates in the parotid gland or may be due metastases from skin cancers. Other diagnoses include acoustic neuroma (including neurofibromatosis Type 2), cholesteatoma of the ear, and intracranial tumors.

Viral infections account for about 12% cases of facial paralysis. Ramsay-Hunt syndrome is a Varicella zoster infection causing facial paralysis, otalgia and a rash within the external auditory meatus. Treatment involves prednisolone 1 mg/kg/day divided into two doses per day. Acyclovir is recommended by some (800 mg 5 times per day for 10 days) (Gnann 2007).

Lyme disease is a tick-borne bacterial infection (Borrelia) may present with bilateral facial palsy.

HIV may cause either unilateral or bilateral facial paralysis and may be caused by toxoplasmosis, encephalitis, lymphoma, Herpes simplex and Herpes zoster infection (Ramsay-Hunt Syndrome).

Melkersson-Rosenthal Syndrome, a rare condition of unknown etiology, characterized by a triad of non-inflammatory facial edema, congenital tongue fissures (lingua plicata) and facial palsy (RiveraSerrano et al. 2014). Not all the features of the triad may be present or fully expressed. Facial palsy may be recurrent. A hereditary factor (autosomal dominant with variable expressivity) has been implicated. Treatment is usually conservative.

Assessment of Facial Palsy

Patients should ideally be assessed and managed by a multidisciplinary team i.e. otolaryngology, plastic surgery, neurosurgery, ophthalmology, psychology, speech and language therapy, occupational therapy and physiotherapy.

History

This includes demographic details, occupation, and hobbies, general past medical history, current medications, allergies, smoking and alcohol consumption.

It is important to determine when the facial palsy was first noticed; whether the onset was insidious or rapid; any deterioration or improvement; whether it is bilateral or unilateral; and whether it is complete or partial. The etiology may be relatively clear e.g. obstetric forceps or sharp trauma. Previous treatment for the palsy should be elicited.

Ask the patient (or parent) to describe what the main problems are; these may be ***functional, aesthetic and/or psychosocial***.

Functional problems are assessed using a "top down" approach:

- ***Brow***: Brow ptosis may cause visual occlusion, and/or an older or tired appearance which can in turn result in psychosocial or occupational problems
- ***Eyes***: Excessive watering, dryness, irritation or impaired field of vision
- ***Nose***: Difficulty breathing, nasolabial scoliosis
- ***Mouth***: Labial articulation difficulty, inadvertent lip or cheek biting, drooling or problems with retropulsion of a buccal food bolus

Aesthetic problems may be a consequence of facial asymmetry at rest, possibly with severe facial droop, and an uneven or absent smile.

Psychosocial problems may include social avoidance and withdrawal, embarrassment of eating in public, avoiding being photographed, relationship problems, anxiety or depression.

Examination

Inspect the face to assess skin quality, gross symmetry between the two sides of the face, evidence of scars or previous trauma and the presence of synkinesis at rest. Assess the ***integrity of each facial nerve division*** by asking the patient to raise their eyebrows, close their eyes, blow out their cheeks, show their teeth, and smile.

Use a "top down" approach; divide the face into upper, middle and lower thirds:

Upper third:

- ***Forehead***: Presence or absence of wrinkles and position of the brow
- ***Upper eyelid***: Position and dermatochalasis. Assess movement and strength of eye closure. Measure lagophthalmos (inability to completely close the eye) with a handheld ruler
- ***Lower eyelid***: Inspected for ectropion. Determine the laxity of the lower lid by doing a "snap-test"; gently pull the lower eyelid downward and away from the globe for several seconds, releasing the lid and seeing how long it takes to return to its original position without the patient blinking. Normally, the lower eyelid springs back almost immediately to its resting position. The more time it takes for the lid to resume its normal position the greater the lid laxity
- ***Conjunctiva***: Check for exposure i.e. inflammation and dilated vessels
- ***Bell's phenomenon***: Check for the presence or absence of a Bell's phenomenon. It refers to upward and outward movement of the globe when an attempt is made to close the eye, is present in 75% of people, and is a defensive mechanism to protect the cornea. Absence thereof puts the cornea at risk of desiccation.

Middle third:

- ***Nasal airways***: Assess each nose to exclude rhinitis or fixed nasal obstruction. Use Cottle's manoeuvre (lateral traction at alar base improves heminasal breathing) to collapse of the internal nasal valve
- ***Cheek***: Check for ptosis and asymmetry of the nasolabial crease
- ***Mouth***: Determine the resting position of the mouth and for commissural droop. Check for contralateral philtral deviation; in congenital conditions this is often pulled to the normal side, whilst in resolved/resolving acquired conditions it is often to the affected side due to hypertonicity
- ***Oral commissure excursion***: Measure commissural excursion with a handheld ruler
- ***Lower lip***: Observe for weakness of the depressor anguli oris due to marginal mandibular nerve weakness
- ***Upper teeth***: Degree of upper tooth show
- ***Smile***: Document the type of smile (Rubin 1974; Paletz et al. 1994; Manktelow et al. 2008)

Lower third:

- ***Chin***: Note the position of the chin.
- ***Platysma***: This is assessed by asking the patient to pretend to shave. At this point it is important to look for the presence of synkinesis.

Functional assessment (speech, drinking and eating) is performed. ***Medical photography or videography*** can provide a preoperative baseline.

Electromyography may provide prognostic information in individuals with acute complete (<18 months) or partial facial palsies but is rarely meaningful in those with an established paralysis.

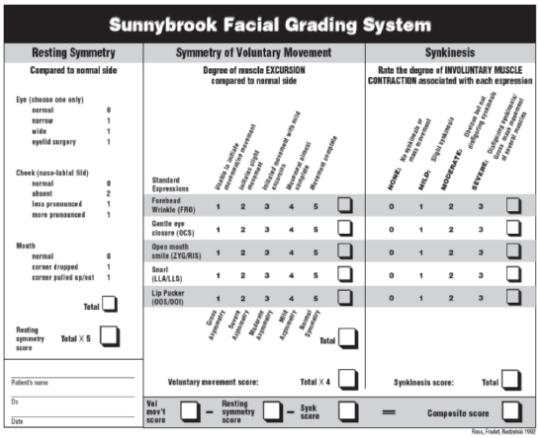


Table 1: The Sunnybrook Facial Grading System provides a composite score (based on voluntary movement, resting symmetry and synkinesis) which may be used to monitor recovery after facial nerve injury

Grading scales, such as the Sunnybrook Facial Grading system (*Table 1*) which assesses resting symmetry, voluntary movement and degree of synkinesis, may be of benefit. They provide longitudinal, numerical data, which may help quantitate post-intervention changes.

The House-Brackmann scale is unhelpful to report postoperative outcomes as it is subjective and was not designed to report reconstructive outcomes (House & Brackmann 1985). The FaCE (Facial Clinimetric Evaluation) scale and videographic analysis may also be used (Kahn et al. 2001; Frey et al. 1999). The FaCE Scale comprises 51 items: 7 visual analogue scale items to measure patients' perceptions of broader, global aspects of facial dysfunction and 44 Likert scale items rated from 1 (worst) to 5 (best) to measure patients' perceptions of specific aspects of facial impairment and disability.

Finally, examine the patient with a view to corrective surgery. Examine the nerve supplies (trigeminal nerve; CN V) to the temporalis and masseter muscles; and the spinal accessory (CN XI) and hypoglossal (CN XII) nerves to determine their utility as donor nerves. Palpate the superficial temporal and facial vessels or use a handheld Doppler to assess their suitability as recipient vessels if free tissue transfer is to be done.

Management of Facial Palsy

Management can be ***non-surgical or surgical***. It should be tailored to the individual to restore function, regain resting symmetry and dynamic, spontaneous movement. Determining which strategy to pursue requires a multidisciplinary approach and intimate involvement of the patient and the family. The patient's age, prognosis, and functional, aesthetic and psychological concerns are important considerations. These may take some time to be fully elicited so patience, empathy and sensitivity are paramount. Repeated consultations are often necessary.

Non-Surgical Treatment

The ***first priority is to protect the eye***. This may be achieved by regular use of lubricating drops and gel, protective glasses, and taping the eyelids. A humidification chamber may benefit less compliant patients. Horizontal taping of lower lids may aid paralytic ectropion.

Botulinum toxin can be employed on the normal side to improved symmetry; it paralyzes selected muscles by disrupting acetylcholine release from motor nerve endplates. E.g. if the marginal mandibular branch is damaged then depressor anguli oris denervation can result in an asymmetrical lower lip, which "rides high" on the affected side and is particularly noticeable on smiling. If this occurs in a neonate it is known as crying facies syndrome. Reducing the activity of the normal depressor anguli oris may improve symmetry. Botulinum toxin is also used to weaken the contralateral frontalis muscle (Moody et al. 2001); and can also be used to treat spasticity, such as platysmal bands, and synkinesis (Maio and Bento. 2007).

Other non-operative interventions include ***physiotherapy, mime therapy and speech therapy***.

Psychological support and social skills training for people with facial disfigurement has many advocates (MacGregor 1990; Kapp-Simon et al. 1992). This includes the use of cognitive behavioural therapy, anxiety-management techniques and communication workshops (Partridge 1994; Kent 2003).

Surgical Treatment

The aims of operative treatment are to protect the eye, restore facial symmetry, facilitate a spontaneous, dynamic smile and improve speech. ***Operative procedures may be static or dynamic***.

Static Procedures

Static procedures ***do not reproduce the dynamic movement*** of the face, although it may be ameliorated. Static procedures may be very beneficial to provide corneal protection, improve the nasal airway, prevent drooling and improve facial asymmetry at rest. They are potentially indicated in the elderly, the unfit, those unwilling or unfit to undergo prolonged surgery, those with established paralysis without viable facial musculature, as a temporizing measure, with massive facial defects secondary to trauma or cancer extirpation, or after failed microvascular procedures.

Static procedures to correct functional disabilities include temporary or permanent tarsorrhaphy; insertion of gold weights, palpebral springs or lid magnets; Müllerectomy; brow lift or suspension; forehead skin excision; unilateral facelift type procedures; and static slings.

Temporary tarsorrhaphy: Temporary tarsorrhaphy (lateral or medial) narrows the palpebral fissure by approximating parts of the eyelids. It aids eyelid closure and may be performed if there is an expectation of recovery. It may be indicated if ocular surface symptoms do not improve or if definitive surgical correction is not achieved within a few weeks.

Permanent tarsorrhaphy: This is a definitive solution, but because of the significant disfigurement it causes, it is rarely performed. It may be indicated if there is little expectation of recovery of eyelid closure. An example is the McLaughlin tarsorrhaphy, a lash preserving procedure, where flaps are elevated from the lateral thirds of the eyelids. The flaps are posteriorly based on the lower lid and anteriorly based on the upper eyelid and are sutured together.

Gold weights (1-1.6g), palpebral springs or lid magnets: Insertion of a gold weight into the upper eyelid may aid eye closure. Platinum chains, palpebral springs and lid magnets have also been described. These procedures are generally technically easy to do and can be reversed or modified. Good symptomatic relief from corneal exposure and decreased burden of care are often achieved by using gold weights. ***Gold weights*** are placed immediately in front of, and sutured to, the tarsal plate. Consequently, they are visible through the skin. Gold is generally used as it is skin colored, comfortable and inert. However, there is a high extrusion rate (approximately 10%) after 5 years (Rofagha and Seiff 2010). With longer follow-up the exposure rate continues to increase. However, extruded weights may be replaced many times and often continue to provide good benefit.

- Select the appropriate gold weight preoperatively by taping a series of implants in 0.2 gram increments to the outside of the upper lid until the patient is able to achieve complete lid closure. Permit the patient to wear the weight for 15 minutes and check for comfort and size. Check that lid closure is achieved when lying supine
- Surgery is done under local anesthesia
- Mark the supratarsal crease about 10 mm from the inferior lid margin
- Inject local anesthetic/vasoconstrictor into the upper lid

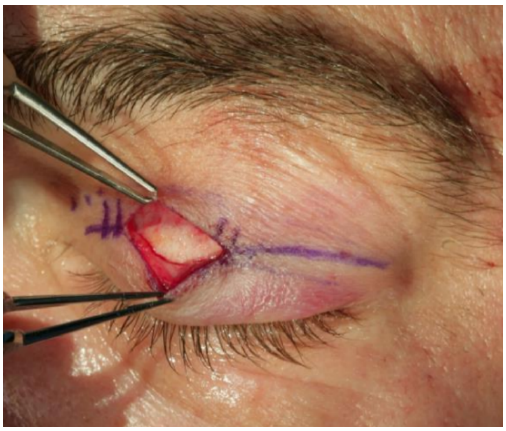


Figure 10: Tarsal plate exposed

- Make a 2 cm incision in the supratarsal crease (*Figure 10*)
- Cut through the orbicularis oculi muscle and expose the tarsal plate (*Figure 10*)
- Create a pocket for the implant between the orbicularis oculi and the tarsal plate

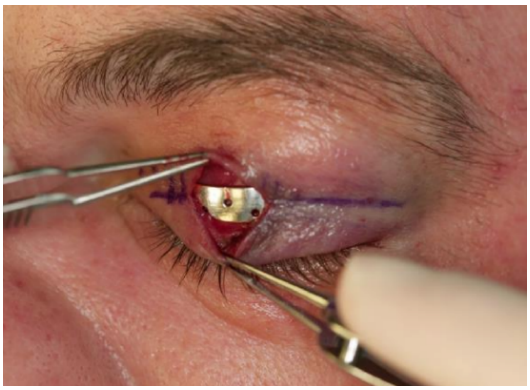


Figure 11: Gold weight centered over the medial limbus of the iris

- Center the gold weight over the medial limbus of the iris (*Figure 11*)
- Fix the weight by passing clear 6-0 nylon sutures through the holes in the weight and with partial thickness sutures in the tarsal plate
- Inspect the underside of the eyelid to ensure that the conjunctiva has not been breached
- Repair the orbicularis oculi muscle with interrupted 5-0 vicryl sutures
- Close the skin with 6-0 fast absorbing sutures

Müllerectomy: This may be a more suitable alternative to gold weight insertion in some individuals. It is performed by advancing the levator aponeurosis and may drop the upper eyelid by 2-3 mm. A successful procedure requires the combined function of the levator and Müller's muscles (Scuderi et al. 2008); hence it requires good muscle function. Müller's muscle is an involuntary and sympathetically innervated muscle. It originates inferior to the levator aponeurosis distal to Whitnall's ligament, and attaches to the cephalad tarsal border, and is estimated to produce 2-3 mm of eyelid elevation (Mercandetti et al. 2001). The conjunctiva and muscle are separated from the levator aponeurosis. The anterior aponeurosis is bluntly dissected and separated from the orbicularis muscle. The aponeurosis and Müller's muscle are then sutured to the anterior portion of the tarsal plate (Mercandetti et al. 2001; Scuderi et al. 2008). Complications (Mercandetti et al. 2001) include: excessive or inadequate correction; corneal abrasion; ulceration; hemorrhage and infection Because a Müllerectomy does not allow for intraoperative adjustment of upper eyelid height, unlike a levator resection, the estimation of the resection length is made preoperatively using various reported ratios of muscle resection to eyelid elevation (1 mm resection for 0.32 mm elevation was reported by Mercandetti et al. 2001).

Brow lift / Suspension: These are used to elevate a ptotic brow caused by a paralyzed frontalis muscle. Brow lifts not only improve the aesthetic appearance but remove obstruction to the upper visual field. Endoscopic or open techniques can be used, and scars are often inconspicuous. The lift achieved is less than that achieved with a direct lift achieved with the forehead skin excision technique. Transpalpebral browpexy has also been described which has the advantage of placing the scar within the upper eyelid (Niechajev 2004).

Forehead skin excision: A melon-slice shape of skin may be excised immediately above the eyebrow or in the temple. It is probably most effective in patients with complete facial palsy and brow ptosis. It produces a visible scar and is usually performed in older patients.

Unilateral facelift-type procedure: Cosmetic facelifts have been described for facial palsy. They remove excess skin and improve facial symmetry; however, results probably only last for the short to medium term. Other procedures include a subperiosteal facelift with lower lid rebalancing and a suborbicularis oculi fat lift (Ramirez et al. 1991; Horlock et al. 2002). These are probably more effective techniques and raise the suborbicularis fat in conjunction with the origins of the zygomaticus and levator muscles of the lip and suspend them from the deep temporal fascia. Thread-lift and endotine lifts have also been described although the results are still in their infancy (Stephens et al. 2009).

Static slings: Airway obstruction due to hypotonia of the nasal musculature is often overlooked but may have a significant functional effect and should be evaluated and addressed. It may be aggravated by rhinitis or a fixed nasal airway obstruction.

Tensor fascia lata (TFL) and palmaris longus: Gore-Tex/polytetrafluoroethylene slings have also been described but are associated with high complication rates. These may be used to support several structures:

- ***Lower eyelid***: Ellis and Kleiman (1993) described a Gore-Tex sling, tunneled subcutaneously from the anterior lacrimal crest to the zygomatic process to suspend the medial lower lid. Tension on the sling elevates the lid and positions the punctum against

the globe.

- ***Recreate the nasolabial fold***
- ***Elevate corner of the mouth*** (Leckenby et al. 2013)
  - A 5 cm x 25 cm of TFL is usually harvested
  - Incise the face using the routine facial palsy incision with a parotid extension
  - Raise a skin flap up to the oral commissure to facilitate exposure of the modiolus and to avoid an additional nasolabial incision
  - Make 2 vertical stab incisions in the midline of the upper and lower lips
  - Tunnel the upper slip of the TFL graft to the midline of the upper lip
  - Pass this slip around the orbicularis oris and suture it in place with a non-absorbable suture (e.g. 4-0 prolene)
  - Secure the lower slip to the lower lip; this should be inset roughly 1 cm tighter than that of the upper lip and acts to effectively support the lower lip
  - Anchor the final slip to the orbicularis oris at the modiolus
  - Attach the proximal end of the graft under tension to the temporalis and parotid fascia
- ***Elevate the cheek and nose and draw the nasal ala laterally to open the external nasal valve***
  - The static slings are passed subcutaneously from the corner of the mouth, ala of the nose or cheek and anchored onto the deep temporalis fascia
  - A superior vector acting on the oral commissure can improve oral competence and bilabial speech and achieve resting symmetry

Dynamic Procedures

Dynamic procedures attempt to improve facial symmetry in repose and to provide synchronous facial movement, preferably in a spontaneous manner.

The authors' reanimation strategy for facial paralysis is generally as follows:

- "Early" (usually < 1 yr after injury): nerve-based reconstruction
- "Late" (usually > 1 yr after injury) or developmental: muscle-based reconstruction; preferably segmental free muscle transplants for versatility and precision
- "Longstanding": segmental free muscle transfers for versatility, precision and spontaneity
- If the contralateral facial nerve is healthy then this is used to power a cross-facial nerve graft. If there is no healthy contralateral nerve or the patient has bilateral facial palsy, then the nerve to masseter can be used

Nerve repair

Direct nerve repair should be performed before the nerve ends retract. Depending on the nature and location of injury, facial nerve repair should be attempted at the time of, or as soon as possible after the event. Exploration within 48-72 hours permits identification of the distal nerve stump by using a nerve stimulator, thereby reducing the probability of erroneous nerve repair. Although nerve repair should be undertaken within one-year, good results have been reported up to three years following injury. Nerves regenerate at approximately 1 mm per day after an initial period of two to four weeks of no growth. Close observation is probably the best management for blunt facial nerve injury although synkinesis may result from axonotmesis.

- A 'less is more' approach is probably best: accurate, tension free coaptation with minimal epineural sutures are the hallmarks of sound direct nerve repair
- A key principle is to have ***no tension*** (breakage of 8-0 gauge suture is a traditional rule of thumb that the repair is under too much tension; if there is undue tension, then another means of repair, e.g. nerve grafting, is used
- Minimally debride the nerve ends to expose the epineurium
- Free the nerve from some of the surrounding tissues both proximally and distally from the site of injury; but this should not be extensive (< 2 cm) as this might devascularize the nerve
- Orientate the fascicles and match them as accurately as possible
- Epineural nerve repair is performed using an 8-0 or finer gauge suture
- If possible, this is performed under an operating microscope, or with high powered loupes



Figure 12: Close-up view of completed nerve repair

- Use the least number of sutures to achieve accurate coaptation (*Figure 12*)

Harvesting nerve grafts

The greater auricular nerve, sural nerve and branches of the cervical plexus are potential donor nerves.

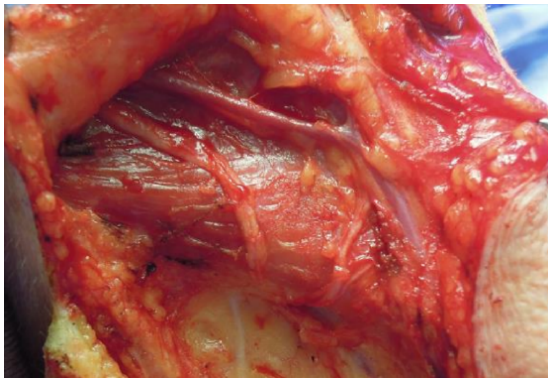


Figure 13: Greater auricular nerve runs parallel to external jugular vein. Note transverse cervical nerves coursing anteriorly from Erb's point

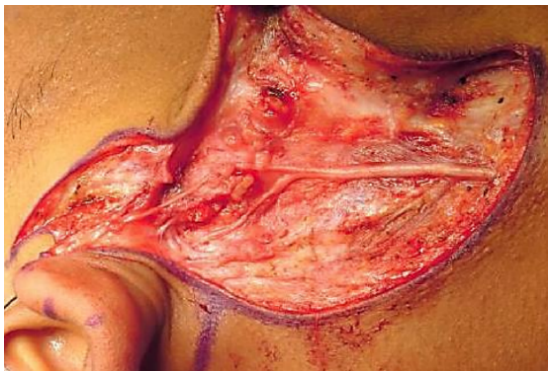


Figure 14: Greater auricular nerve dividing into two branches

Greater auricular nerve: This nerve is well-matched to the facial nerve diameter, is in the same surgical field, and leaves patients only with sensory loss of the inferior 2/3 of the auricle and over the angle of the mandible. It is found just deep to platysma, and runs superiorly over the sternomastoid muscle from Erb's point (one-third of the distance from either the mastoid process or the external auditory canal to the clavicular origin of the sternomastoid muscle) parallel and 1-2 cm posterior to the external jugular vein (*Figure 13*). It generally divides superiorly into two branches that can be anastomosed to two branches of the facial nerve (*Figure 14*).



Figures 15a, b: Sural nerve harvesting techniques

Sural nerve: Being distant to the face it facilitates a two-team approach, is well-matched to the facial nerve diameter, and leaves minimal donor site morbidity (scars are often inconspicuous and the patients are usually left with sensory loss on the lateral border of the foot) (Ijpma et al. 2006). It is located posterior to the lateral malleolus and has several branches and is of greater length that the greater auricular nerve making it better suited to bridging longer defects and for grafting to more peripheral branches (*Figure 15*). The nerve is harvested as follows:

- A longitudinal incision or transverse "step ladder" incisions may be used (*Figures 15a, b*)
- Make the initial incision behind the lateral malleolus
- Identify the nerve approximately 2 cm behind and 1-2 cm proximal to the lateral malleolus
- If the small saphenous vein is found, the nerve will be located medial to it
- If using stepladder incisions, make another small incision at the junction of the middle and distal third of the leg and identify where the lateral sural cutaneous nerve branches off the medial sural cutaneous nerve
- Divide the lateral sural cutaneous nerve from the medial sural cutaneous nerve
- Dissect the medial sural cutaneous nerve proximally to just below the popliteal fossa
- This provides 30-35 cm of nerve for grafting
- Transect the nerve proximally and wrap it in a moist gauze swab

Primary nerve grafting

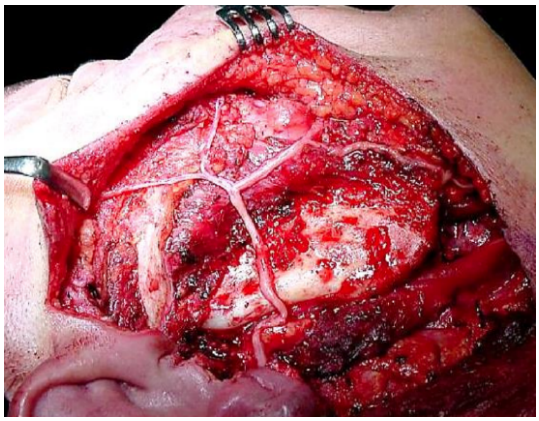


Figure 16: Sural nerve graft following facial nerve resection for a malignant parotid tumor

Nerve grafting should be performed if there is tension on a direct repair as tension reduces neuronal sprouting (Sunderland et al. 2004). Breakage of an 8-0 gauge suture when attempting primary neurorrhaphy suggests that the repair is under excessive tension.

As a general rule nerve grafting should be used to provide coaptation if the gap between the two facial nerve stumps is greater than 2 cm. This may occur, for example, following nerve resection during tumor removal (*Figure 16*). Grafting may be attempted three weeks to one year after injury. After this time meaningful reinnervation is unlikely to be successful due to motor endplate degeneration and facial muscle atrophy. There is likely to be a 6- 24-month interval before any functional recovery is observed.

Cross-facial nerve grafting (CFNG)

The CFNG harnesses neuronal activity from the uninjured facial nerve activity to the contralateral side to power a free muscle transfer. It is probably the gold standard to accomplish symmetrical, spontaneous facial movement. However, a CFNG alone is usually not powerful enough to produce an adequate smile.

Indications for CFNG include:

- A distal stump is present
- Complete transection when the ipsilateral proximal facial nerve stump is unavailable for grafting
- The facial muscles are capable of useful function following reinnervation (probably <1 year post-injury before motor endplate degeneration is likely to have occurred)

Numerous techniques have been described (Scaramella 1971; Fisch 1974; Scaramella 1975); Anderl 1979; Baker & Conley 1979a). A variety of techniques have been described relating to surgical exposure of the donor and recipient nerves, the length and positioning of jump grafts, and timing of 2nd stage neurorrhaphy in the VII-VII CFNG technique. Because of inadequate data, it is difficult to determine the best technique (Fisch 1974; Smith 1971; Anderl 1977).

CFNG is probably most useful in association with other reanimation techniques to address a single territory within the face rather than to reinnervate the entire contralateral facial nerve e.g. using it for an isolated marginal mandibular nerve paralysis (Terzis and Kalantarian 2000).

CFNG may also be useful with a partial facial palsy to enhance residual function. A sural nerve graft may be used to connect healthy peripheral nerve branches on the normal side to corresponding branches supplying specific muscle groups on the paralyzed side. This can be performed using an end-to-side coaptation on the weakened or paralyzed side to minimize reduction of the remaining function on the affected side (Frey et al. 2006; Fattah et al. 2011). Less success has been reported with reinnervation of the marginal mandibular or temporal branches, although it may provide adequate tone (Fattah et al. 2012). Limited success has been reported with this technique as facial musculature usually reinnervates poorly with time and the results are inconsistent.

CFNG may be done as a one- or two stage procedure

One-stage CFNG: Both ends are repaired at the same operation.

Two-stage CFNG

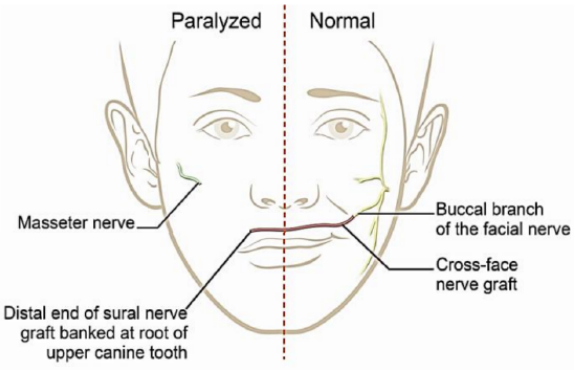


Figure 17: 1st stage of 2-stage CFNG

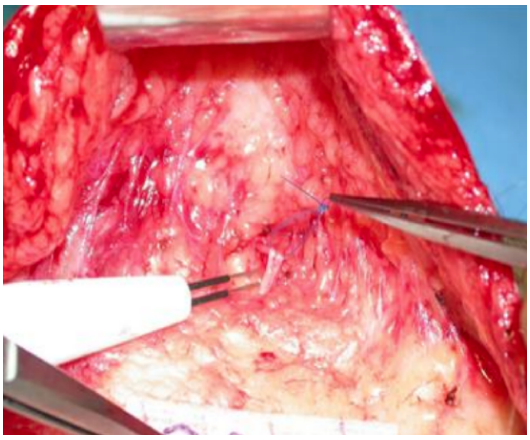


Figure 18: Identifying a buccal branch using electrical stimulation



Figure 19a: End of sural nerve

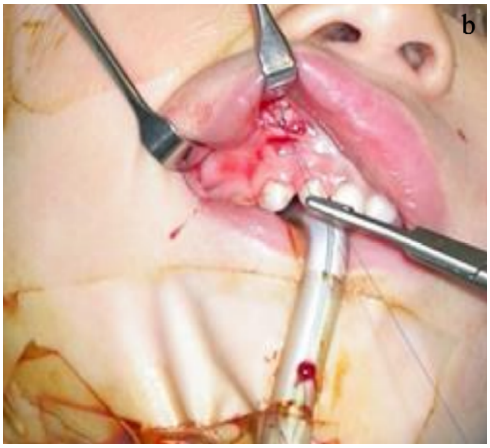


Figure 19b: End of sural nerve sutured into a pocket created above the upper canine

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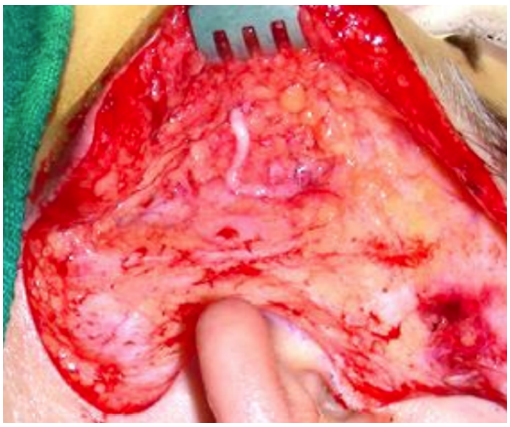


Figure 20: Coaptation of sural nerve graft to the functioning facial nerve

- ***1st stage*** (*Figure 17*)
  - Harvest a sural nerve graft (*Figures 15a, b*)
  - Identify a suitable buccal branch of the functioning facial nerve via a nasolabial fold or preauricular incision (*Figure 18*)
  - Tunnel subcutaneously from the buccal branch across the face to the root of the upper canine tooth on the non-functioning side
  - Pass the sural nerve along the tunnel
  - Suture the end of the sural nerve to the tissues in the pocket in the buccal sulcus above the upper canine to avoid it retracting (*Figures 19a, b*)
  - Coapt the other end of the sural nerve to the end(s) of the freshly divided edges of one or several buccal branches of the functioning facial nerve (*Figure 20*)
- ***2nd stage***
  - This is often performed 9-12 months following the 1st stage
  - A positive Tinel's sign can be elicited at the end of the nerve graft (tapping on the graft produces a tingling sensation); this indicates the presence axonal regeneration and that the nerve fascicles have reached the end of the nerve graft
  - The surgery is done only on the paralyzed side
  - Resect the terminal neuroma on the sural nerve
  - Suture the graft to distal (paralyzed) stump of facial nerve

Nerve transfers

Nerve transfers are relatively easy to do and require nerve regeneration only over a single neurorrhaphy. They therefore usually provide powerful reinnervation, and good muscle tone and powerful excursion. However, nerve transfer may produce grimacing, mass facial movement and synkinesis; this may be palliated with botulinum toxin. The function of the donor nerve is also sacrificed.

Potential indications for nerve transfers include:

- The distal stump is present
- Proximal, ipsilateral facial nerve stump is unavailable for grafting
- Facial muscles are capable of useful function after reinnervation

The distal facial nerve stump may be coapted to:

- Hypoglossal nerve (most common)
- Nerve to masseter
- Glossopharyngeal nerve
- Accessory nerve
- Phrenic nerve

Hypoglossal nerve transfer

The hypoglossal nerve transfer is best suited to providing input to the facial nerve following extirpation of tumors involving the facial nerve proximally. When successful, intentionally manipulating the tongue causes facial movement. It can provide excellent

tone, a normal appearance at rest in 90% of patients, and protection of the eye. It also permits intentional facial movement. However, unlike CFNG, changes in facial expression are not spontaneous. Recovery generally occurs over 6-24 months and may be observed for up to 5 years. Outcomes are variable.

The time interval between initial denervation and nerve transfer is the primary marker of success. It would appear that reinnervation must occur within 2 years after injury, otherwise atrophy and neuromuscular fibrosis mitigates the reestablishment of meaningful tone and movement (May 2000). Paralysis and atrophy of the ipsilateral tongue occurs due to its denervation. This may be marked in up to 25% of patients leading to speech and swallowing impairment (Conley & Baker 1979). Hypoglossal nerve transfer is contraindicated for the same reason in patients at risk of developing other cranial neuropathies e.g. with neurofibromatosis type II, or patients with concomitant, ipsilateral low cranial nerve dysfunction (CN IX, X, XI) palsies. A combined CN X-XII deficit may cause profound swallowing dysfunction.

To combat the above functional problems, the following hypoglossal nerve transfer techniques have been described and are described below.

Hypoglossal nerve transfer: Common initial steps

- Expose the trunk of the facial nerve as described in the Parotidectomy chapter
- Identify the pes anserinus

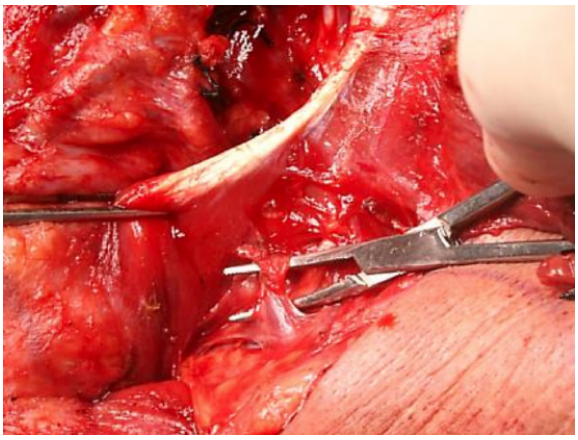


Figure 21: Divide the veins that cross the XIIn

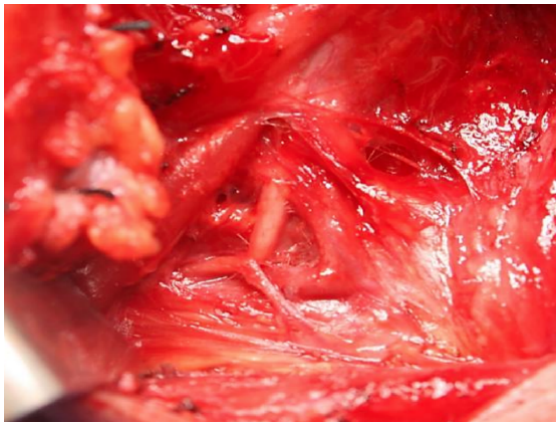


Figure 22: Sternomastoid branch of occipital artery tethering the XIIn

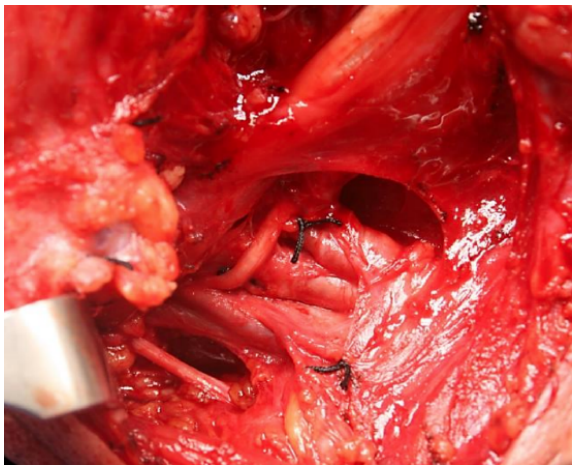


Figure 23: Dividing the sternomastoid branch of the occipital artery frees the XIIn and leads the surgeon directly to IJV. Note the XIn behind IJV

- Identify the horizontal portion of the hypoglossal nerve just inferior to the posterior belly of the digastric and the greater cornu of the hyoid bone (*Figures 21-23*)
- Expose the hypoglossal nerve posteriorly by dividing the lingual veins (*Figure 21*)
- Identify and divide the sternomastoid branch of the occipital artery; this frees up the vertical portion of the hypoglossal nerve and leads one up to the anterior aspect of the internal jugular vein (*Figures 22, 23*)

Classic hypoglossal nerve transfer technique (Figure 24)

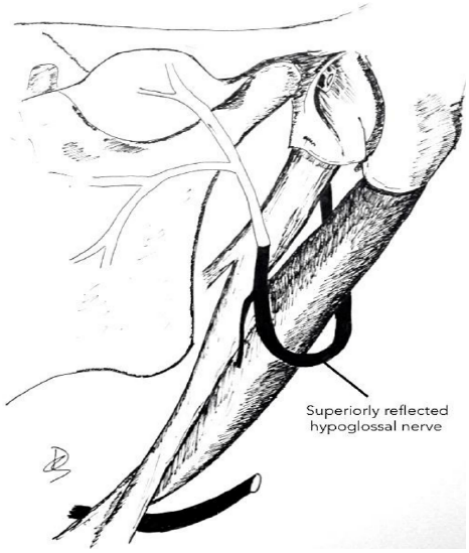


Figure 24: Classic hypoglossal nerve transfer technique (from Hadlock et al. 2004)

- Divide the facial nerve close to the stylomastoid foramen
- The facial nerve can be further mobilized by dissecting it freeing it from the parotid distal to its bifurcation
- Reflect the distal trunk of the facial nerve inferiorly
- Sharply divide the hypoglossal nerve quite far anteriorly along its course to secure an adequate length of nerve to transfer
- Reflect it superiorly up to the distal facial nerve stump
- Coapt the hypoglossal and facial nerves with 5 to 7, 10-0 nylon epineural microsutures

Split hypoglossal transfer technique (Figure 25)

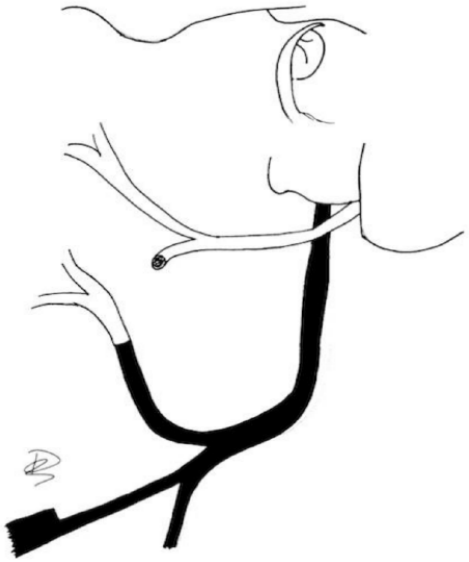


Figure 25: Split hypoglossal transfer (from Hadlock et al. 2004)

The split hypoglossal nerve transfer is designed to reduce mass movement (synkinesis). Approximately 30% of the diameter of the hypoglossal nerve is divided from its parent trunk for several centimeters. This is reflected superiorly. As it provides fewer axons, it is best connected only to the lower division of the facial nerve (Conley & Baker, 1979). Other techniques may then be used to address the upper face.

Hypoglossal jump graft techniques (Figure 26)

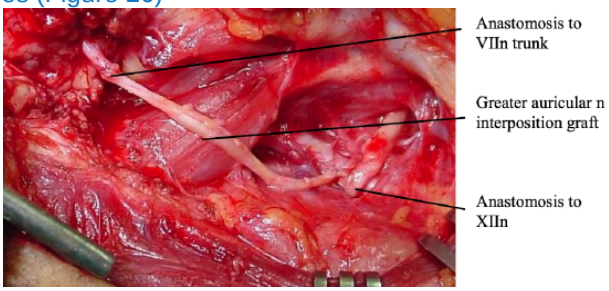


Figure 26: Hypoglossal jump graft

This is identical to hypoglossal nerve transfer, except that it involves partial sectioning of the hypoglossal nerve, and performing an end-to-side neurorrhaphy between the hypoglossal nerve and a donor nerve graft which is then connected to the distal facial nerve, thereby preserving ipsilateral hypoglossal function (May et al. 1991). It can be used when there is ipsilateral lower cranial nerve dysfunction or if the patient is unwilling to accept tongue dysfunction.

- Excise a patch of epineurium from the hypoglossal nerve
- Make a 30% incision into the hypoglossal nerve and allow the defect to splay open
- Lay the recipient nerve (sural or greater auricular) into the defect, facing the proximal cut surface, and secure it with microsutures
- Alternatively, the distal stump of the facial nerve can be directly sutured to the hypoglossal nerve. Additional facial nerve length can be gained by mobilizing the mastoid segment of the facial nerve as far as the 2nd genu, and/or freeing it from the parotid tissue distal to its bifurcation

Other attempts to preserve the hypoglossal function include the use of ***end-to-side coaptation*** (Venail 2009)

Babysitter procedure

A cranial nerve (usually hypoglossal) is transferred to achieve quicker reinnervation and to preserve musculature and potentially the denervated stump while axons migrate across the CFNG (Terzis & Tzafetta 2009)

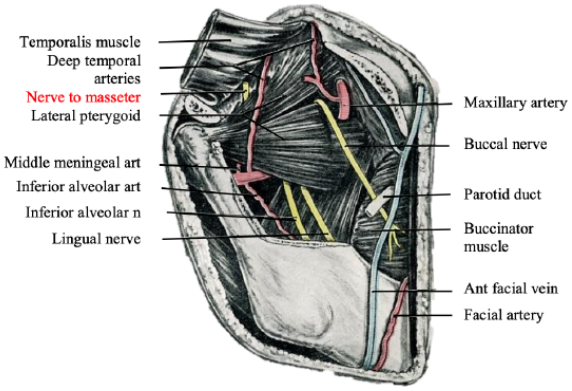


Figure 27: Zygoma, masseter and mandible removed to demonstrate the nerve to masseter

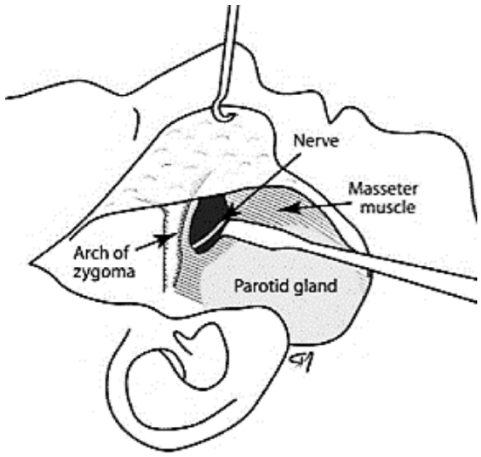


Figure 28: Nerve-to-masseter

The motor nerve to the masseter muscle is a branch of the mandibular division of the trigeminal nerve (*Figure 27*). It is increasingly being used for facial reanimation and is the senior authors' preferred option due to its minimal donor morbidity (Manktelow et al. 2006). Its anatomical location is consistent (Borschel et al. 2012) (*Figure 28*)

- Make a preauricular incision and elevate a skin flap over the parotid (*Figure 28*)

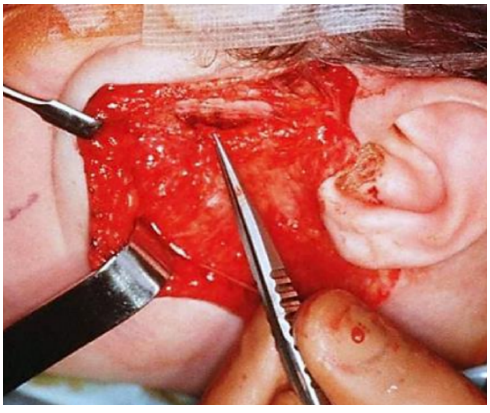


Figure 29: Nerve to masseter is located 3 cm from the tragus and 1 cm below the zygoma

- Make a transverse incision in the parotid capsule approximately 1 cm below the zygomatic arch and 3 cm anterior to the tragus (*Figure 29*)
- Bluntly dissect through the parotid tissue up to the surface of the masseter muscle to avoid transecting branches of the facial nerve
- Split the masseter to gain access to the deep surface of the muscle

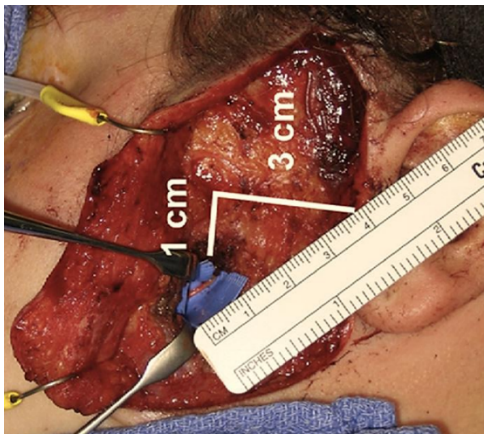


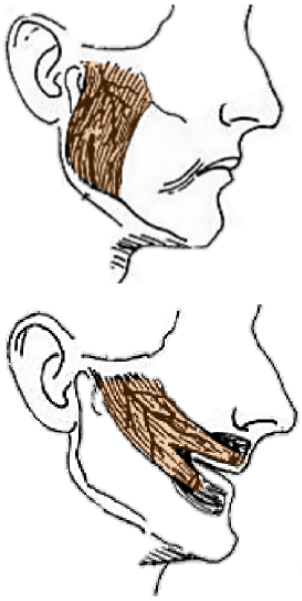
Figure 30: Nerve to masseter

- Use a nerve stimulator to locate the nerve; the nerve is generally located approximately 1.5cms deep to the superficial muscular aponeurotic system (SMAS) (*Figure 30*)
- Follow the nerve anteriorly until it ramifies
- There is usually a branch-free segment measuring 1 cm that can be cleanly transected distally and reflected laterally into the wound, ready for coaptation to the stump of the facial nerve

Local muscle flaps

Local muscle flaps e.g. masseter and temporalis flaps may be used when there is an absence of suitable mimetic muscles after long-standing atrophy with no potential for useful function after reinnervation. They can also be used as an adjunct to the mimetic muscles to provide new muscle and myoneurotisation.

Masseter flap (Figure 31)


Figure 31: Masseter flap

All or part of the masseter can be used as a local muscle flap for facial reanimation.

It may be performed via intraoral approach (Adams 1947; Sachs and Conley 1982). For example, the muscle's insertion can be detached from the lower mandibular border, transposed anteriorly, divided into three slips and inserted into the dermis above the lip, at the oral commissure and below the lip (Baker and Conley 1979b) (*Figure 31*). This procedure gives motion to lower half of the face and usually achieves good static control. However, the lateral vector yields an unnatural smile. A useful clinical situation would be during a radical parotidectomy, where the masseter is already exposed and can be transposed and interdigitated into freshly denervated mimetic muscles to provide maximal myoneurotisation.

Temporalis Myoplasty (Gilles 1934; Labbé and Huault 2000; Sherris 2004; Nduka et al. 2012)

Temporalis myoplasty involves detaching the insertion of the temporalis muscle to the coronoid process of the mandible and transposing and inserted it around the eye and the mouth. Sir Harold Gilles (1934) originally described the temporalis muscle flap with fascia lata grafts to reach the oral commissure.

The temporalis muscle is innervated by the trigeminal nerve. The muscle can be used to provide static support to the oral commissure and trigeminal-innervated dynamic movement. It is a good option for smile reinnervation in the chronically paralyzed face. It may also be employed as a temporising measure when the regenerative potential of the facial nerve is in doubt (e.g. following skull base surgery), or during the waiting period for regeneration, as it does not interfere with any potential facial nerve regeneration (Cheney et al. 1995). It may also be used to manage the upper face in conjunction with a hypoglossal nerve transfer to the lower division of the facial nerve.

Before embarking on temporalis myoplasty, its neurovascular supply must be confirmed to be intact as neurotologic procedures may damage these structures and congenital facial palsy syndromes may be associated with other cranial nerve anomalies that may affect temporalis function. Severe temporalis atrophy, as may found in the edentulous patient, is a further contraindication.

Temporalis myoplasty has been modified by many authors (Andersen 1961; Baker & Conley 1979b; Burggasser et al. 2002) but probably has been best popularized by Daniel Labbé (Caen, France). Labbé and Huault (2000) originally approached the temporalis muscle using a bicoronal incision, performing an anterograde dissection of the temporalis from its origin in the temporal fossa. This negated the need for any grafts as the temporalis muscle could slide forward to reach the mouth once the temporalis had been freed from its insertion on the coronoid process. The zygomatic arch was detached using two osteotomies and the tendinous part of the temporalis, now detached from the coronoid process, was tunneled through the buccal fat pad. Others have modified the procedure to allow a more limited incision directly over the temporalis and without a need for zygomatic osteotomies.

A video of lengthening temporalis myoplasty technique

Although temporalis myoplasty provides good static control, it has been criticized as it is generally unable to recreate a spontaneous, dynamic smile as its activation often requires clenching of the teeth (Fattah et al. 2012).

Effective rehabilitation through training and physical therapy is necessary to optimize outcomes. The literature supports the theory of cortical plasticity whereby following a rehabilitation period, individuals with trigeminally innervated muscle transfers perform facial movements without having to clench their teeth. There are also reports of subconscious smiling with this technique. Whether this is a central or a peripheral phenomenon is unclear (Rubin 1999). CFNGs coapted to the contralateral facial nerve may help synchronize smiling on both sides of the face (Freilinger 1975; Terzis and Kalantarian 2000).

Temporalis Lengthening Myoplasty: Surgical Technique

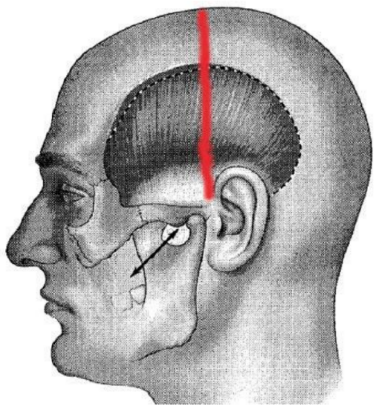


Figure 32: Original bicoronal incision (Labbé 2000)

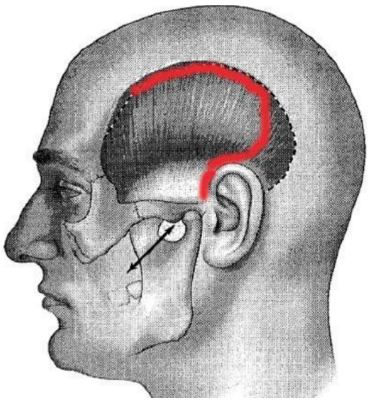


Figure 33: Modified incision

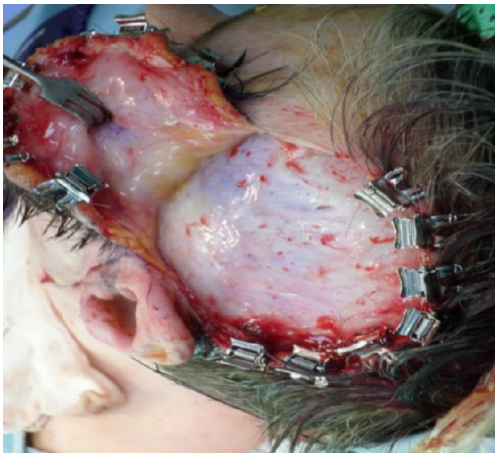


Figure 34: The flap has been elevated in the loose areolar plane above the superficial layer of the deep temporal fascia. Cologne clips have been applied to the skin edge. The temporal fat pad can be seen through the superficial layer of deep temporal fascia just above and in front of the ear at the inferomedial aspect of the wound

- Following injection of local anesthetic with epinephrine, make a bicoronal or hemicoronal incision from the superior temporal line to the attachment of the lobule of the ear (*Figure 32*)
- The incision may be modified to be curved superiorly to follow the curve of the superior and posterior temporal crest before descending preauricularly (*Figure 33*)
- Extend the scalp incision down to the superficial layer of the deep temporal fascia, a robust, white layer of glistening fascia (*Figure 34*)
- Place Cologne or Raney clips along the cut edge of the scalp to control bleeding (*Figure 34*)
- Elevate this flap in a plane deep to the loose areolar layer and immediately above the superficial layer of the deep temporal fascia to avoid damage to temporal branch of facial nerve if intact

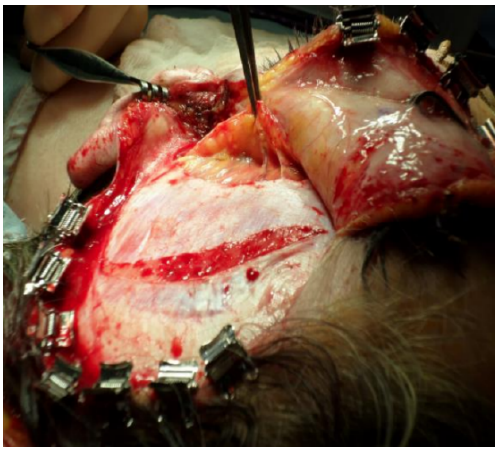


Figure 35: The temporal fat pad is held by the forceps. The incision in the superficial layer of the deep temporal fascia is made to preserve a 1 cm cuff of fascia superiorly to allow for subsequent reapproximation. The temporalis muscle is visible beneath the superficial layer of the deep temporal fascia

- Pause the dissection when the temporal fat pad, which is invested between the superficial and deep layers of deep temporal fascia, is reached above the zygomatic arch (*Figures 34, 35*)
- Preserve this temporal fat pad to prevent temporal hollowing and to avoid injury to the temporal branch of the facial nerve lies within this loose areolar tissue
- Cut through both layers of the deep temporal fascia along the posterior edge of the temporal fat pad to allow elevation of the temporal fat pad with the overlying fascia (*Figure 35*)
- Continue to dissect inferiorly between the posterior aspect of the temporal fat pad and the temporalis muscle until the coronoid process of the mandible is reached
- Return to the superior aspect of the temporalis muscle and incise through the superficial layer of the deep temporal fascia approximately 1 cm below the superior temporal crest. This preserves a 1 cm strip of the superficial layer of the deep temporal fascia which is later loosely sutured with a small gap to give the temporalis something to contract against (*Figure 35*)

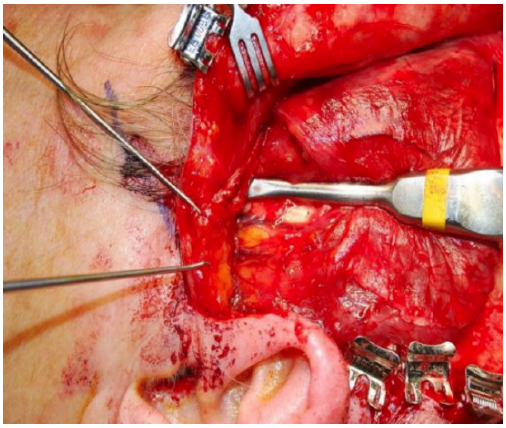


Figure 36: The fascia has been raised off the muscle and a periosteal elevator is being used to free the temporalis muscle to beneath the zygomatic arch. This allows mobilization of the muscle under the zygoma and facilitates good glide of the muscle/tendon complex

- Using a periosteal elevator, free the fan shaped temporalis muscle from its underlying attachment to the cranium in its posterior two-thirds leaving it attached to the skull anteriorly (*Figure 36*)
- The posterior aspect of the temporalis can now be rotated inferiorly to allow lengthening of the muscle. ***This lengthening is usually sufficient to permit its tendinous insertion, once detached from the coronoid process of the mandible, to reach the nasolabial fold***
- If there is insufficient length e.g. because of scarring, then a fascia lata graft maybe be used as an extension
- Dissection of the deep aspect of the muscle from the cranium following dissection of the superficial aspect of the muscle facilitates preservation of the temporal fat pad
- Place an incision in the nasolabial fold
- Dissect in a subdermal plane for the initial 1-2 cm

- Continue the dissection through the buccal fat pad up to the coronoid process of the mandible

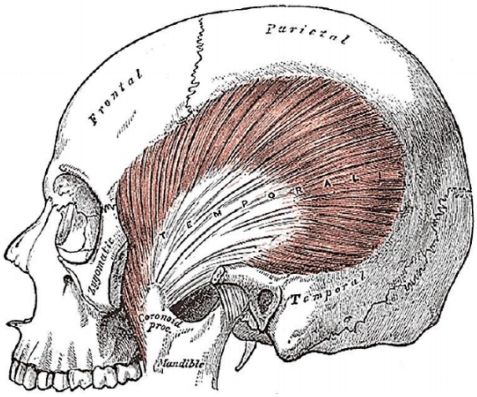


Figure 37: Temporalis muscle inserts into coronoid and anteromedial surface of vertical ramus of mandible

- Identify the insertion of the temporalis to the coronoid process and free the surrounding tissue (*Figure 37*)
- Hold the tendinous fibers of the temporalis with clamps e.g. a bowel clamp or Satinsky clamp superior to the coronoid process
- Use a saw to sever the tip of the coronoid process for its neck
- Removed any residual bone fragments
- Retain a good hold on the tendinous fibers because if the hold is lost, they are very difficult to retrieve
- Insert the tendinous fibers into the dermis of the upper lip, oral commissure and lower lip to replicate the smile on the contralateral side using 4-0 undyed prolene sutures

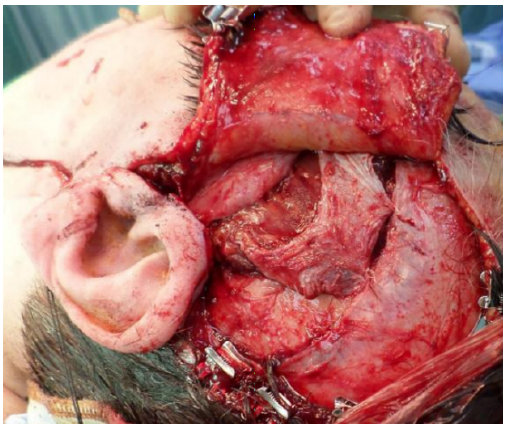


Figure 38: Final position of the temporalis muscle. The posterior part of the muscle has been detached thus allowing it to rotate inferiorly and for it to lengthen. The superficial layer of the deep temporal fascia is loosely approximated to allow the temporalis muscle to contract against a fixed point

- Loosely approximate the superficial layer of deep temporal fascia with 3 to 4 3-0 PDS sutures; this gives the temporalis muscle something to contract against (*Figure 38*)
- Close the incision in the nasolabial fold with 6-0 nylon interrupted sutures
- Close the scalp with staples and the preauricular wound with 6-0 nylon or monocryl
- Prescribe a soft diet for 3 weeks
- Physical therapy is key to achieving satisfactory muscle function and is instituted within weeks to develop appropriate control and excursion of the transferred muscle

Cross-facial nerve grafting with free muscle transfer

Facial reanimation requires either the restitution of neural control of denervated facial musculature and/or importation of a muscle to reconstruct a symmetrical, resting face and a spontaneous, dynamic smile. CFNG and free muscle transfer is indicated when it is anticipated that the facial muscles on the affected side will not provide useful function following reinnervation. Facial muscles may remain viable up to 12-24 months following injury after which they undergo irreparable atrophy. In situations of nonviable muscle, the CFNG and free muscle transfer provide new, vascularized muscle that can pull in various directions and can potentially produce a spontaneous, dynamic smile. The success of this procedure decreases with increasing patient age.

Numerous techniques have been reported. It may however be performed as a ***one- or two-stage operation***.

One-stage operation

The advantages are that axons need only regenerate over a single anastomotic site and that it avoids the need for a 2nd operation. However, few suitable muscles have sufficiently long nerves. Furthermore, the transferred muscle remains denervated for a longer period of time than with two stage operations; this may compromise the final result.

Two-stage operation

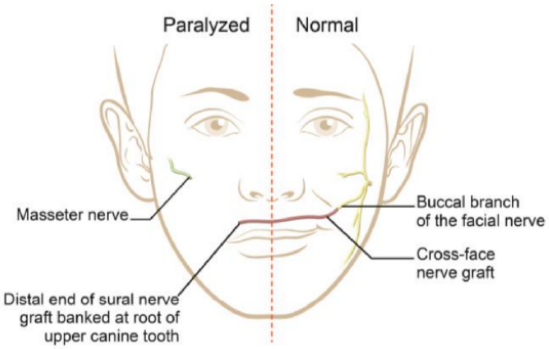


Figure 39: Diagram demonstrating the options to innervate a gracilis muscle: CFNG connected to a functional buccal branch of the normal facial nerve, on the non-paralyzed side; or connection to the masseter nerve on the paralyzed side

- ***1st stage*** (*Figure 39*)
  - Harvest the sural nerve
  - Reverse the nerve to minimize axonal growth up side-branches
  - Tunnel subcutaneously across the face above the upper lip (*Figure 19a*)
  - Coapt the sural nerve to the working facial nerve
  - The senior author's preference is to "bank" the distal end of the sural nerve graft in the upper buccal sulcus at the level of the root of the upper canine tooth (*Figure 19a*)
  - Alternatively secure the free end of the sural nerve to the tragus or mark it with a permanent, colored suture to facilitate its identification at the 2nd stage
- ***2nd stage***
- A ***muscle flap*** replicates the pull of the zygomaticus major. Although no free muscle transfer completely fulfils all the characteristics, the ideal free donor muscle:
  - Provides muscle excursion equal to the normal side of face
  - Is small and can be divided into numerous independent slips
  - Has reliable vascular and nerve patterns of similar size to that of the recipient structures
  - Has a long neurovascular hilum
  - Does not cause significant functional or aesthetic donor site morbidity
  - Is located sufficiently far away from the face to allow two operating teams to work simultaneously; one team prepares the face and neurovascular structures while the other team harvests the muscle

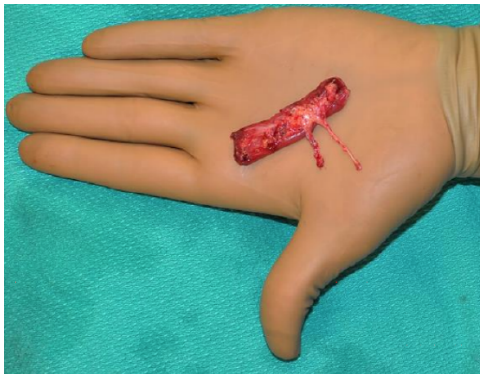
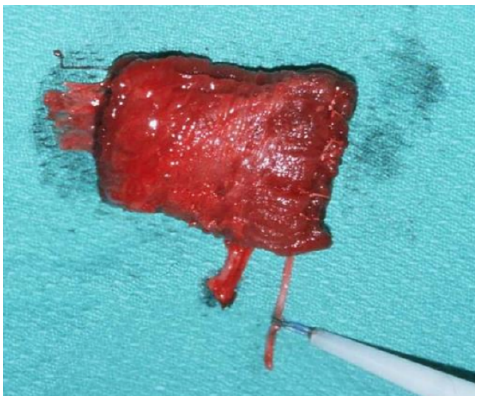


Figure 40: Gracilis muscle with nerve and vascular pedicle





Figures 41a, b: Gracilis muscle with nerve and vascular pedicle uncontracted (a); and contracted (b)

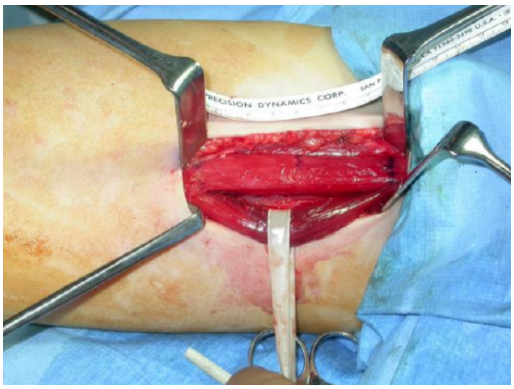


Figure 42: Segmental muscle dissection to reduce bulk

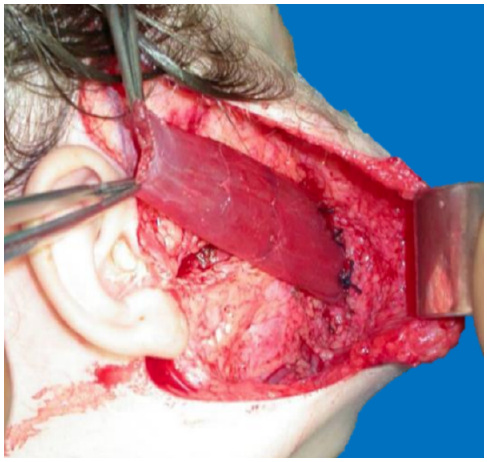


Figure 43: Inset into orbicularis oris



Figure 44: Gracilis muscle sutured to deep temporal fascia

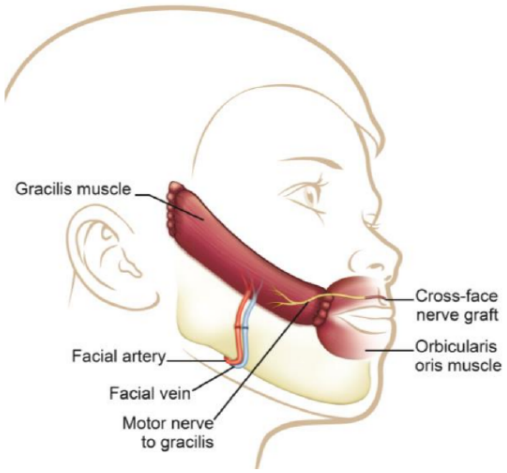


Figure 45: Gracilis flap with vascular anastomosis and CFNG

Gracilis muscle: The gracilis muscle is most commonly used as it is thin, causes minimal donor site morbidity, leaves no functional deficit, has reliable anatomy, and has a relatively long motor nerve (*Figure 40*). It has strong contractility (*Figures 41a, b*) and allows a two-team approach. Its bulk may be markedly reduced by segmental muscle dissection (Manktelow and Zuker 1984) (*Figure 42*). Distally it is inset into the orbicularis oris near the modiolus, just lateral to the oral commissure to replicate the smile on the contralateral side (*Figure 43*). Proximally it may be inset onto the body of the zygoma or onto the deep temporal fascia (*Figures 44, 45*). One may need to resect buccal fat or subcutaneous fat to accommodate the bulk of the muscle and to achieve a normal facial contour.

Pectoralis minor: The pectoralis minor has been widely used (Terzis and Manktelow 1982; Harrison 1985). It is a flat muscle, the harvest of which leaves minimal morbidity and it is transferable without excessive bulk. The medial and lateral pectoral nerves and a direct arterial branch from the axillary artery are used for the nerve and vascular anastomoses. However, the anatomy of the neurovascular pedicle may be somewhat variable (Macquillan et al. 2004; Manktelow 1985).

Other muscles used for facial reanimation include the latissimus dorsi, rectus femoris, extensor digitorum brevis, serratus anterior, rectus abdominis and platysma (Dellon & Mackinnon 1985; Mackinnon & Dellon 1988; Hata et al. 1990). Even though the extensor digitorum brevis would appear to be an ideal candidate as it is flat, small and leaving minimal donor site morbidity, results have been disappointing (Mayou et al. 1981; O'Brien et al. 1980). The latissimus dorsi muscle may be divided into two independently innervated zones and has been advocated for single stage bilateral reconstruction in individuals with Möbius syndrome (Mackinnon & Dellon 1988; Woollard et al. 2010); however, it is often bulky in the face and does not facilitate a two-teach approach.

Authors

David C. G. Sainsbury MBBS, BMedSci (Hons), MSc, FRCS (Plast)
Division of Plastic and Reconstructive Surgery

The Hospital for Sick Children, and University of Toronto
Toronto, Ontario, Canada
davidsainsbury@mac.com

Gregory H. Borschel MD, FAAP, FACS
Division of Plastic and Reconstructive Surgery
The Hospital for Sick Children, and University of Toronto
Toronto, Ontario, Canada
borschel@gmail.com

Ronald M. Zuker MD, FRCSC, FAAP, FACS
The Hospital for Sick Children
555 University Avenue
Toronto, Ontario, Canada, M5G 1X8
ronald.zuker@sickkids.ca

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Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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5.11: Facial Nerve Grafting- Indications and Techniques

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

FACIAL NERVE GRAFTING: INDICATIONS AND TECHNIQUES

Vincent Darrouzet & Erwan de Mones del Pujol

The facial nerve is at risk in trauma of the temporal bone and face. It can also be harmed in surgery for tumors of the parotid, temporal bone or cerebellopontine angle (CPA). Often it is only a transient injury, and purely inflammatory in nature. But sometimes, despite the progress of otoneurosurgery and technical refinements limiting the risk of severe damage to a healthy nerve, and especially because some lesions interrupt or invade the nerve, the surgeon may have to manage a loss of actual nerve tissue. In either situation, nerve graft is the best solution, provided that it is technically possible and that it is carried out according to the very precise rules that we describe in this chapter. It should be noted that the technique used depends on the site and the nature of the trauma.

1. Influence of the site of the lesion

The site of the lesion is a key element when electing a strategy when a nerve graft is required. The approach also differs depending on whether the lesion involves 1 or more of the 3 distinct regions of the nerve's course

- CPA and internal auditory meatus (IAM)
- Temporal bone
- Parotid

Making this distinction is important because in the CPA and IAM, the nerve does not have an ***epineurium covering***. It is therefore technically impossible to perform needle sutures without transfixing the nerve fibers and causing axonal loss and fibrosis that may impede nerve regrowth. Sutures are also very difficult to place at this level, because of the narrowness and depth of access, the pulsatility of the area and the immersion in cerebrospinal fluid (CSF). In the temporal bone and parotid, conditions are more favorable because the nerve is more ***superficial and accessible***. It is also protected by an increasingly strong and defined epineurium that serves as an excellent anchor for sutures.

The ***mobility of the nerve*** in the anatomical regions in which the graft must be performed must also be taken into account. The nerve in the parotid region is subject to movements of the mandible ; hence the nerve should be sutured when grafting in this region. On the other hand, in the temporal bone, a technique of fibrin-bonding can be used because the nerve repair will remain stable due to lack of movement.

2. Expected results

A well performed nerve transplant should provide a satisfactory House Brackmann Grade 3 facial mobility at one year postoperatively, regardless of the region repaired, even in the CPA where the surgery is the most challenging[1]. There is one caveat to this good result: recovery of frontalis muscle mobility is always disappointing, not that reinnervation does not take place, but because of the antagonistic competition between recovery of the frontalis muscle and the rhizorius. which is always at the expense of the first. This is referred to as the paradox of Stennert[2], and mirrors our own experience.

To achieve good results it is necessary to ***operate as early as possible*** after the nerve injury, and if possible, immediately. After an interval of 1-2 years the results are much more disappointing. If one is compelled by circumstances to intervene beyond this time, it is probably preferable to apply other surgical techniques such as free muscle transfers or pedicles (See Chapter: Surgical reanimation techniques for facial palsy/paralysis).

Patients must be warned that functional recovery can take 4-10 months, depending on the location of the injury; proximal lesions take longer to recover. After this time further recovery may take 1-2 years. Surgery should be followed by rehabilitation, excluding any electrical stimulation.

In some situations it is possible to reroute the petrous and intraparotid facial nerve segments to gain additional length and achieve a direct, end-to-end, tension-free repair, thus avoiding the need for an interposition graft. However, such a diversion may be as time-

consuming as harvesting and placing a graft, and mobilization of the nerve from the Fallopian canal can cause nerve ischemia and hence disappointing results. ***In practice, an end-to-end repair does not result in a better functional result than a well-done nerve graft***[3].

3. Five prerequisites for grafting

Nerve grafting is only feasible and effective under certain conditions:

- There should be ***no tension*** along the suture line. Failure to adhere to this principle leads to poor outcomes.
- The ***proximal end of the nerve must be perfectly healthy***. To be sure, it is advisable to transect the nerve in a clearly healthy area, even if this leads to a longer graft. This situation generally does not apply in tumor resections in the CPA, because of difficulties related to compression and edema of the nerve. The nerve endings must be histologically free of tumor invasion on frozen section.
- A ***traumatic neuroma*** must be resected widely. The proximal end of the nerve must be transected in a healthy area.
- The graft must be placed in a ***vascularized area***. This is a principle that is often neglected, and explains many poor outcomes. In the temporal bone in particular, the graft needs to be placed in contact with the bone that provides vascular support. It must not be surrounded by fat as it will become necrotic or move as the fat resorbs.
- It should not be ***delayed too long***; this will be referred to again later.

4. Indications for grafting

4-1 Temporal bone trauma (See Chapter: Temporal bone trauma)

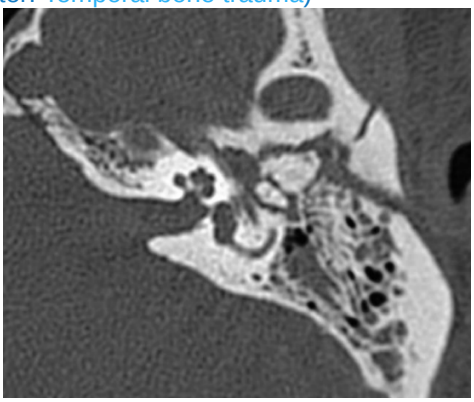


Figure 1: CT scan of left temporal bone with extralabyrinthine comminuted fracture. The fracture line points to the geniculate ganglion

Temporal bone fractures are less frequent today. They are mostly longitudinal extralabyrinthine fractures (*Figure 1*).

The facial nerve is generally injured at the geniculate ganglion, and is severed by a bony spur. Grafts are difficult to place in a trauma situation due to contusion of the nerve endings, associated extradural hematoma and the delicateness of the labyrinthine portion of the nerve.

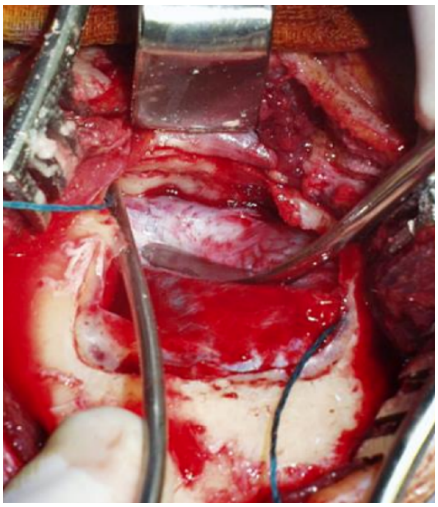


Figure 2: Right middle fossa craniotomy

A craniotomy is required for access (*Figure 2*). It allows good exposure of a sufficient length of the labyrinthine segment of the nerve without injuring the labyrinth, while ensuring access to transect the nerve in a healthy area to achieve a good result. However, it requires specialized otoneurosurgical training and expertise.

The situation is very different and simpler when the fracture is translabyrinthine, as the nerve is generally interrupted in the tympanic segment. A transmastoid, translabyrinthine approach is then simpler to use, and access is less restricted which makes it much easier to control the nerve endings.

4-2 Iatrogenic lesions in the temporal bone or parotid

The most common situations are the following:

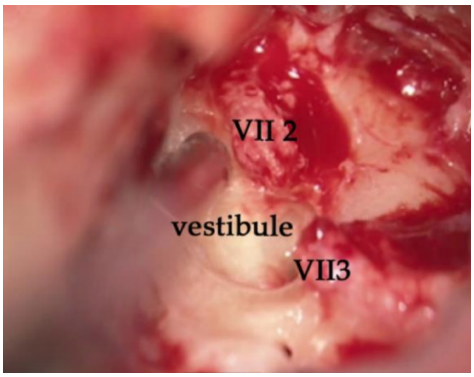


Figure 3: Iatrogenic lesion of the right facial nerve by a cutting burr associated with an accidental opening of the vestibule. Note the loss of nerve substance in the area over the vestibular cavity

- In the temporal bone, the nerve is usually damaged at the 2nd genu[4]. Injury with a cutting burr creates a substantial loss of nerve substance that can only be treated with a graft (*Figure 3*). In cases of thermal injury, which always has a poor prognosis, where the nerve has been transected is more important.

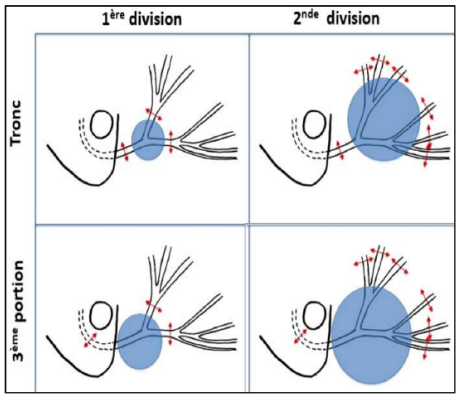


Figure 4: Different lesional locations along the intraparotid facial nerve.

- In the parotid, anything is possible. Injuries range from a localized lesion of the facial nerve trunk to loss of nerve affecting the first division of the nerve or beyond this to involve distal subdivisions of the nerve. When the lesion is near the stylomastoid foramen, it becomes necessary expose the nerve in the mastoid to permit proximal anastomosis of the graft (*Figure 4*).

4-3 Cancer of temporal bone and parotid

Nerve reconstruction should not be ignored when treatment is with curative intent and the excision follows oncological principles. The nerve should be resected to ensure tumor free nerve endings. This applies especially to adenoid cystic carcinoma as perineural invasion can even extend intracanially. In such cases it is advisable to be extremely cautious to secure clear margins.

4-4 Benign tumors or intermediate malignancies of the temporal bone, intrinsically or extrinsically affecting the facial nerve

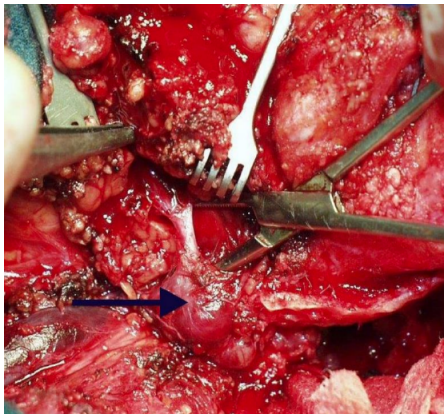


Figure 5: Neuroma of left facial nerve at stylomastoid foramen

This includes congenital cholesteatoma, jugulotympanic paraganglioma, adenocarcinomas, endolymphatic sac tumors, facial nerve neuromas and hemangiomas (*Figure 5*). Here again, it should be ensured that the nerve ends are free of tumor.

4-5 CPA tumors (schwannomas of vestibular and facial nerves, meningiomas, epidermoid cysts)

The most complex situation is that of neuromas arising from the facial nerve itself, as the discovery of the origin of the tumor may only be made intraoperatively, especially as the facial nerve is very rarely functionally impaired preoperatively. It is sometimes not possible to continue the surgery without interrupting the continuity of a functional nerve. Nerve monitoring helps to be sure. But often the nerve is already no longer continuous, and the decision to graft should be made during the procedure after a very precise assessment of the extent of the tumor along the nerve. Very often the nerve invasion extends within the temporal bone. In such cases the graft must be interposed between the proximal end of the nerve in the CPA and the healthy part of the intrapetrous nerve. Translabyrinthine and retrolabyrinthine approaches are the only ones that permit nerve grafting. The retrosigmoid approach makes it difficult to manage these situations.

We recommend planning for this possibility in any CPA tumor surgery by incorporating the upper cervical region in the surgical field to make the greater auricular nerve accessible as a graft. When the proximal end of the facial nerve in the CPA is not visible or is nonviable, the best alternative, even if it does not offer the same results, is to perform a hypoglossal-facial end-to-end or end-to-side anastomosis, the latter having the advantage of avoiding weakness of the tongue[5]. This intervention can take place at the same

time or is most often delayed by 2-3 months depending on the general condition of the patient. (See Chapter: Surgical reanimation techniques for facial palsy/ paralysis).

5. Graft material

5-1 Greater auricular nerve

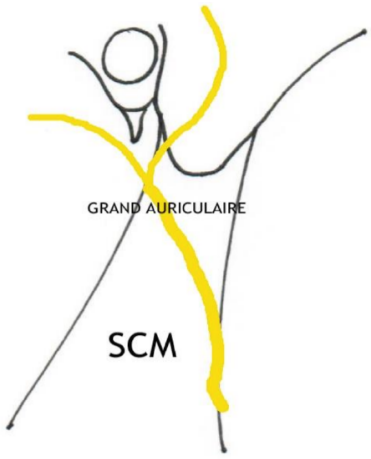


Figure 6: Diagram of the left great auricular nerve as it crosses over the sternocleidomastoid. An incision 1 to 2 cm below the mastoid tip will identify it before it divides

This is the most commonly used graft. It is conveniently closely situated to otological, otoneurosurgical and cervical approaches. The nerve is located 1 cm below the mastoid tip on the surface of the sternocleidomastoid muscle via a 4 cm transverse incision (*Figure 6*). Add 1 cm to the required graft length to permit trimming of the ends of the nerve graft. The greater auricualr nerve has the disadvantage of not providing a long length of graft because it divides quickly (<10 cm). Similarly, it is not advisable to use it in ipsilateral parotid or temporal bone cancers when the nerve is likely to be affected by the disease.

5-2 Sural nerve



Figure 7: Finding and isolating the right sural nerve by a retromalleolar incision and a horizontal step incision in the leg

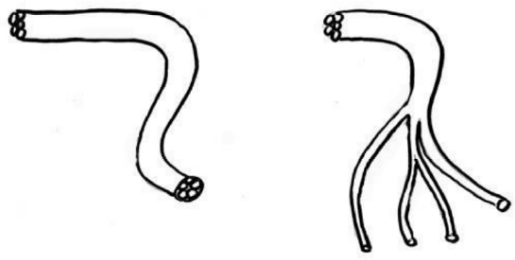


Figure 8: The fascicles of the sural nerve allows nerve subdivision particularly suited to parotid surgery

It is much less accessible and locating it is more difficult. It requires a 2nd operating field and its removal must be anticipated. It has two important advantages: it is a very fasciculated nerve that is easy to subdivide and a long length can be harvested as it divides

late. These important benefits make it the preferred choice when it comes to placing split grafts in the parotid or temporal bone-to-parotid. It is located 2 cm behind the lateral malleolus, almost subcutaneously (*Figure 7 and 8*). It is possible to harvest it via horizontal incisions along the leg. Postoperatively the patient may have pain in the foot and leg causing transient functional impairment. It may be necessary to prescribe anticoagulants to avoid secondary venous thrombosis. Sensory deficits caused by harvesting the sural nerve are limited to the lateral edge of the foot and are not very troublesome.

6. Grafting technique

6-1 In the CPA

In the CPA, the authors favor a fibrin-bonding technique with an "aponeurotic sleeve". This replaces suturing, and provides much better results.

- Harvest a 4 cm temporalis fascia graft to wrap the "sutures"

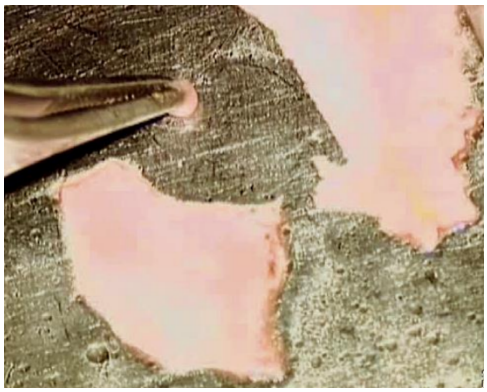


Figure 9: Temporalis fascia spread and divided for fibrin-bonding

- Carefully spread the fascia on a metal plate and divide it into two pieces of equal size (*Figure 9*)
- Identify the proximal end of the facial nerve
- Carefully clean and cut the nerve. If necessary, bevel it to increase the anastomotic surface
- Ensure that the nerve is perfectly healthy, undamaged and tumor free
- Do the same for the nerve graft, and bevel it at both ends
- The nerve graft must be long enough to be positioned without tension and to make good contact with the petrous bone which must provide vascularization
- Before grafting, ensure perfect hemostasis in the CPA
- One of the two fragments of fascia, which serves as the bed of the graft, is then spread across the nerve defect

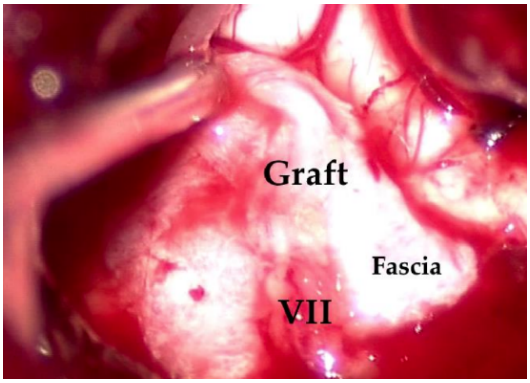


Figure 10: Perfect apposition of the proximal tip of the facial nerve and graft on a bed of fascia positioned across the defect

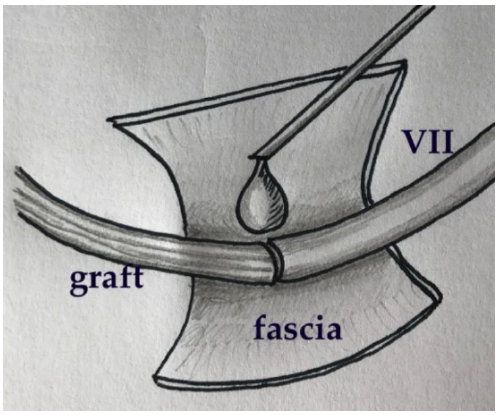


Figure 11: Diagram illustrating the fibrin-bonding and wrap technique used in CPA

- With the greatest precision possible and using fine forceps, place the ends of the facial nerve and graft in contact with one another (*Figure 10*).
- Use 2 drops of biological glue to secure the assembly (*Figure 11*)
- Fold the fascial graft over the nerve junction to wrap and protect it
- Glue is again used to secure the repair in this pulsatile environment
- A Surgicel® sheet, also glued to the area of repair, may be used as an additional layer

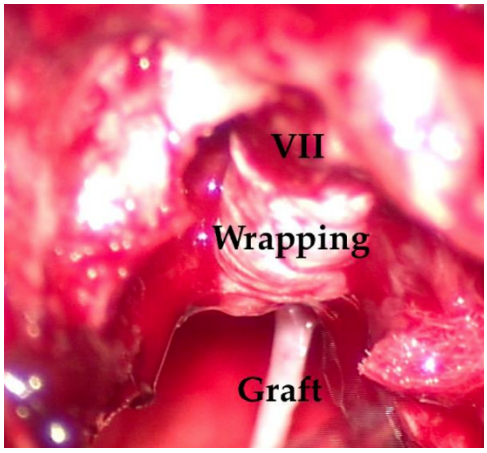


Figure 12: Fibro-bonding of the distal end of the graft and the distal end of the facial nerve to the medial bony wall of the internal auditory meatus (left translabyrinthine route)

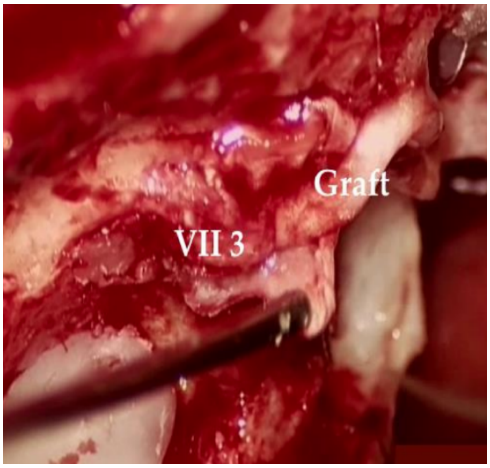


Figure 13: Distal fibrin-bonding in a case of facial nerve neuroma invading the geniculate ganglion and the initial portion of the tympanic portion of the facial nerve. The graft is positioned here in contact with the mastoid portion of the facial nerve (left translabyrinthine pathway)

- The distal anastomosis is done using the same steps, and wrapped with the second fragment of fascia (*Figure 12*).

- If the tumor extends in the nerve along the Fallopian canal, the graft is joined to the distal branch in the temporal bone, and is laid in a bony canal created to provide good stability and vascular support (*Figure 13*). This technique is quick and much simpler to implement in this "hostile" environment (narrow approach, pulsation, LCS outcome) than using conventional sutures

6-2 In the mastoid

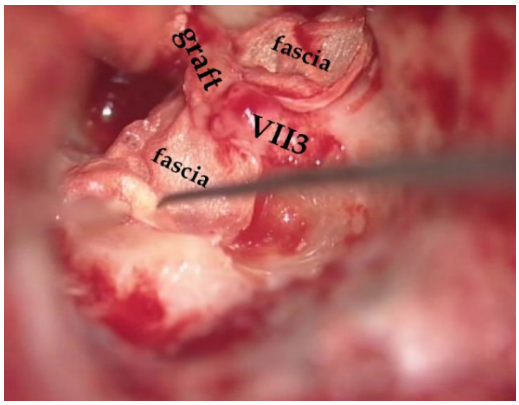


Figure 14: Iatrogenic traumatic lesion of the right facial nerve. Temporalis fascia wrap and distal fibrin-bonding of the graft in contact with the mastoid portion of the facial nerve

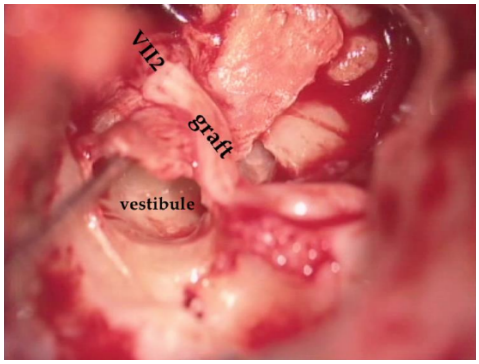


Figure 15: Iatrogenic traumatic lesion of the right facial nerve. Temporalis fascia wrap and proximal fibrin-bonding of the graft in contact with the initial tympanic portion of the facial nerve. The transplant is in the bridge over the vestibule

Here the graft is naturally stabilized in the Fallopian canal. It is also necessary to create bone contact for good vascularization of the graft (*Figure 14 and 15*). Unless the proximal branch is intradural in the IAM, the sleeve does not need to be circumferential and a simple fascial covering on the nerve repair will be sufficient. Here again there is no need for a nerve suture. Fibrin-bonding is sufficient.

Difficulties encountered are twofold:

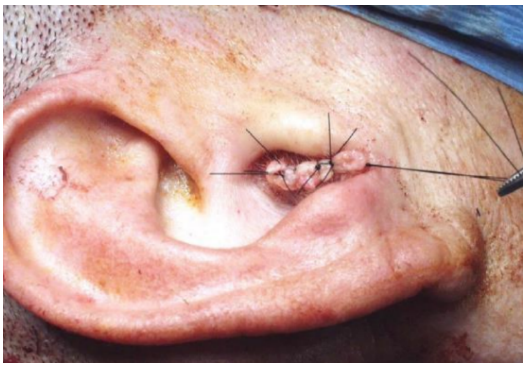


Figure 16: Closing the skin of the external auditory meatus

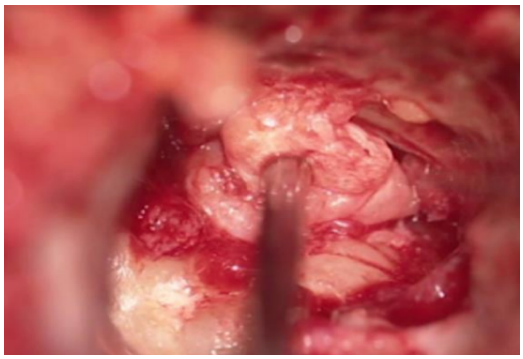


Figure 17: Iatrogenic traumatic lesion of the right facial nerve. The Eustachian tube is closed by successive layers of bone wax and fascia

6-2.1 The proximal fragment of the nerve is difficult to access without affecting the anatomy of the middle ear. In cases of iatrogenic trauma at the genu of the nerve, access to the tympanic portion or to the geniculate ganglion may require sacrificing all or part of the ossicular chain or external auditory meatus bone This may require isolating the middle ear after closure of the external cutaneous auditory meatus (*Figure 16*) and obliteration of the Eustachian tube by fascia (*Figure 17*). The decision may also depend on associated lesions (ossicular and labyrinthine).

6-2.2 The viable proximal fragment is deeply located in the labyrinthine portion of the VIIn or even in the IAC, whereas labyrinthine function is preserved and a translabyrinthine approach is therefore not possible. If the temporal bone is highly pneumatized, the labyrinthine portion of the nerve is partially accessible. On the other hand, if the narrowness of the temporal bone does not permit access or if the graft must be done in the IAM, it becomes necessary to include a middle fossa approach to allow both to connect the graft in the IAM or to the labyrinthine portion and a transmastoid pathway to connect to the mastoid portion.

6-3 In the parotid

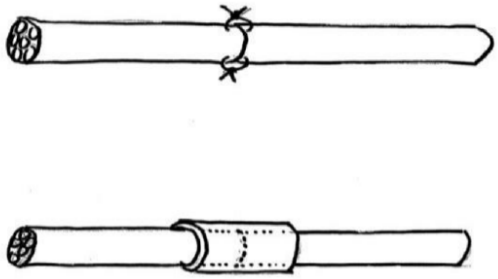


Figure 18: Diagram illustrating the microsuture-wrap technique adapted to parotid surgery

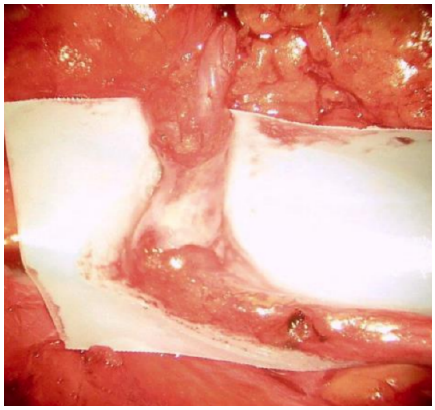


Figure 19: Operative photo of micro-suture-wrap in parotid surgery

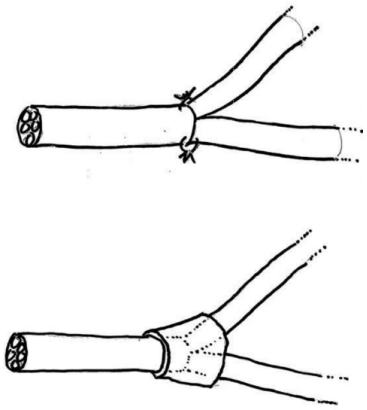


Figure 20: Diagram illustrating technique of microsuture-wrap at nerve division adapted to parotid surgery

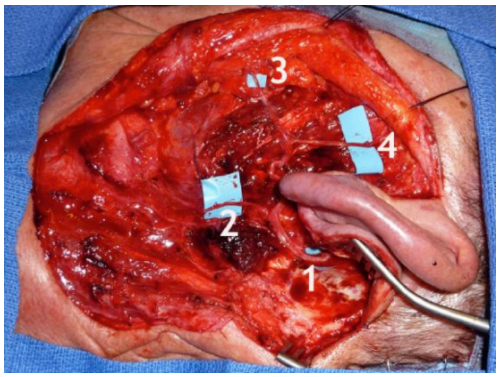


Figure 21: After resection of left parotid carcinoma, a split sural nerve graft is interposed between the mastoid facial nerve (1) and distal branches (2, 3, 4)

Nerve grafts are frequently used with malignancy and sacrifice of the facial nerve, provided the prognosis is favorable and the resection is considered curative. Radiotherapy does not preclude a good functional result, provided that the graft is placed on a well-vascularized bed and that the assessment of nerve invasion by tumor is correct. Particular attention should be paid with adenoid cystic carcinoma, as tumor can ascend along the facial nerve into the CPA. It is recommended that the nerve is sutured at one or two points with 9 or 10/0 sutures. A wrap and extra glue are useful (*Figures 18 to 20*). If it is necessary to address tumor invasion beyond the stylomastoid foramen and to expose the mastoid portion of the facial nerve, grafting at this level can be done without sutures. When the intraparotid facial nerve is completely sacrificed due to nerve infiltration (preoperative facial palsy), a sural nerve graft is split to provide a multiple branches to the frontal, orbicularis oculi, orbicularis oris, and marginal mandibular branches (*Figure 21*).

Stab or firearm injuries are sometimes encountered. In cases of stab wounds, a simple approximation-suture is sometimes possible. The prognosis is good. With firearm injuries the local mechanical and thermal trauma always requires trimming and a significant nerve graft in accordance with the protocol previously described. The prognosis is more uncertain, because infection may occur in a potentially polluted setting.

References

1. Ramos DS, Bonnard D, Franco-Vidal V, Liguoro D, Darrouzet V. Stitchless fibrin glue-aided facial nerve grafting after cerebellopontine angle schwannoma removal : technique and results in 15 cases. Otol Neurotol. 2015 Mar;36(3): 498-502
2. Stennert E. Why does the frontalis muscle "never come back"? Functional organization of the mimic musculature. Eur Arch Otorhinolaryngol. 1994 Dec: S91-5
3. Charachon R, Tixier C, Lavieille JP, Reyt E. End-to-end anastomosis versus nerve graft in intratemporal and intracranial lesions of the facial nerve. Eur Arch Otorhinolaryngol. 1994 Dec: S281-3
4. Linder T, Mulazimoglu S, El Hadi T, Darrouzet V, Ayache D, Somers T, Schmerber S, Vincent C, Mondain M, Lescanne E, Bonnard D. Iatrogenic facial nerve injuries during chronic otitis media surgery: a multicentre retrospective study. Clin Otolaryngol. 2017 Jun;42(3):521-527
5. Franco-Vidal V, Blanchet H, Liguoro D, Darrouzet V. L'anastomose hypoglossofaciale latéro-terminale. Résultats à long terme et indications. A propos de 15 cas sur 10 ans. Rev Laryngol Otol Rhinol (Bord). 2006; 127(1-2):97-102

Authors

Prof Vincent Darrouzet
Service d'ORL
Fédération de Chirurgie de la Base du Crâne
CHU Bordeaux, Université de Bordeaux
vincent.darrouzet@chu-bordeaux.fr

Dr Erwan de MONES del PUJOL
Service d'ORL
Fédération de Chirurgie de la Base du Crâne
CHU Bordeaux, Université de Bordeaux
erwan.de-mones-delpujol@chu.bordeaux.fr

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chair
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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5.12: Rectus Abdominis Free Tissue Transfer Flap

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

RECTUS ABDOMINIS FLAP FOR HEAD & NECK RECONSTRUCTION

Patrik Pipkorn, Brian Nussenbaum

The rectus abdominis flap is based on the deep inferior epigastric artery. It is a composite flap and comprises muscle, overlying fascia and skin. It is versatile and provides a large volume of soft tissue and is technically straightforward to raise. Many variations based on the inferior epigastric artery, including perforator flaps, have been described.

In the head and neck it is typically used to reconstruct large oral defects, skull base defects, maxillectomy defects or whenever a large volume of soft tissue is required. In the head and neck it has more recently been largely supplanted by the anterolateral thigh free flap.

Benefits of the rectus flap include

- Technically straightforward and quick to harvest
- Constant anatomy with anatomic variations being rare
- Harvesting in a supine position makes a two-team approach feasible
- Provides the largest volume of soft tissue based on a single pedicle
- Long pedicle and 2-4 mm diameter artery
- Reliable perforators that do not need to be dissected or visualized
- Low donor site morbidity

Caveats include

- Obesity makes for a very bulky skin flap and might preclude its use
- Take care to look for previous abdominal surgery that might have disrupted the vascular supply. Most abdominal surgery is done through a midline incision and does not interfere with vascularity. Prior surgery might also make harvesting more difficult due to scarring and increase the risk of entering the peritoneal cavity

Surgical anatomy

Rectus sheath (Figures 1-5)

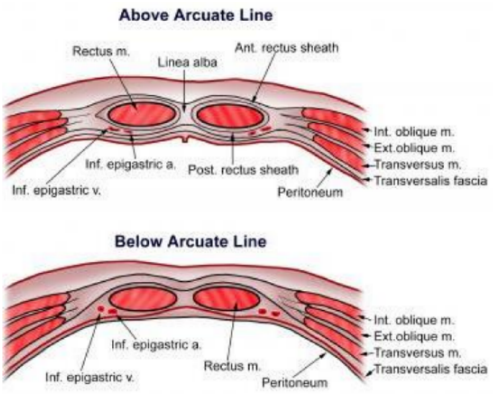


Figure 1: Anterior abdominal wall cross sectional anatomy and arcuate line

The rectus sheath is an aponeurosis arising from the external oblique, internal oblique and transversus abdominis muscles (*Figure 1*). It encircles the paired rectus muscles. The anterior and posterior rectus sheaths merge in the midline to form the linea alba that separates the paired rectus muscles (*Figure 1*).

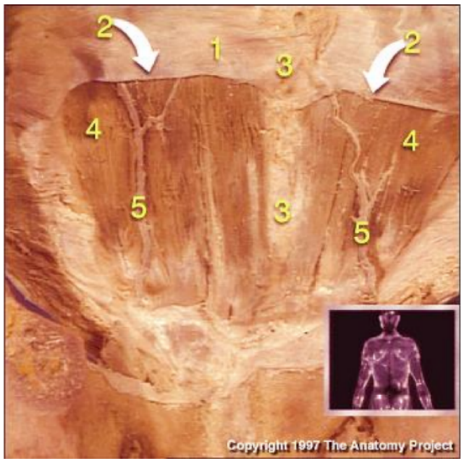


Figure 2: Posterior wall of rectus sheath (1); Arcuate line (2); Linea alba (3); Rectus abdominis (4); Inferior epigastric vessels (5)

When harvesting a rectus flap, the anterior rectus sheath is incised vertically over the midportion of the rectus muscle, whereas the posterior sheath is preserved. The ***arcuate line*** (*Figures 1, 2*) is located a few centimeters below the umbilicus or at the level of the anterior superior iliac spine and demarcates the ***lower limit of the posterior layer of the rectus sheath***. Above the arcuate line the internal oblique aponeurosis splits and contributes to both the anterior and posterior rectus sheaths. Below the arcuate line, the internal oblique and transversus abdominis aponeuroses contribute only to the anterior rectus sheath (*Figure 1, 2, 5*); the posterior rectus sheath here consists of the transversalis fascia and is considerably weaker. This is an important surgical consideration as the ***anterior rectus sheath should not be excised below the arcuate line as the abdominal wall will be considerably weaker and be more prone to herniation***.

Rectus abdominis muscle

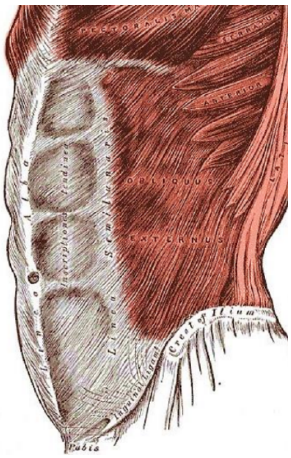


Figure 3: External oblique inserts into linea semilunaris; linea alba in midline

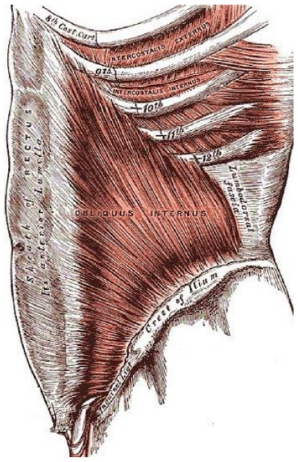


Figure 4: Internal oblique aponeurosis splits around rectus muscle to contribute to whole anterior layer of rectus sheath (above), but is absent posteriorly below arcuate line

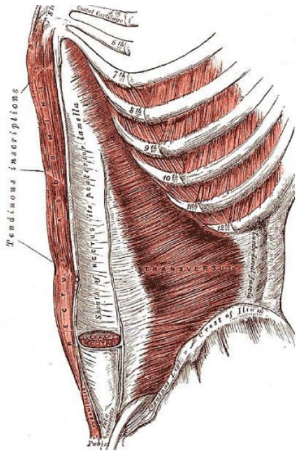


Figure 5: Transversus abdominis aponeurosis contributes to posterior layer of rectus sheath, but is absent posteriorly below the arcuate line

The rectus abdominis muscles are paramedian, paired, vertically oriented muscles in the anterior abdominal wall (*Figures 1-5*). Each muscle arises from the pubic tubercle and inserts into the xiphoid process and the 5^{th} - 7^{th} ribs of the anterior chest wall. Its primary function is to flex the trunk. Three bands of connective tissue named ***tendinous inscriptions*** (*Figure 5*) traverse the muscle to create three to four separate muscle bellies, giving the appearance of a "six pack" in well-trained people.

Vascular supply

The rectus abdominis has a rich blood supply. It is primarily supplied by the inferior and superior epigastric vessels. The rectus muscle also receives blood supply laterally from small contributions from the lower six intercostal arteries.

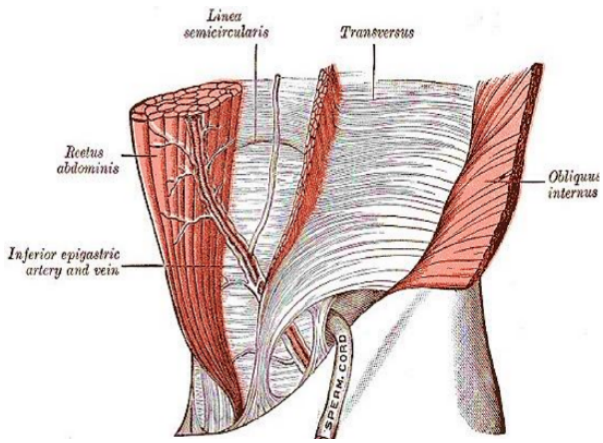


Figure 6: Arcuate line (linea semilunaris) and inferior epigastric vessels

The flap is ***based on the inferior epigastric artery***. The inferior epigastric artery arises from the external iliac artery and courses superiorly in an extraperitoneal plane (*Figures 2, 6*).

It crosses the lateral border of the rectus muscle and pierces the transversalis fascia about 3-4 cm inferior to the arcuate line (*Figures 2, 6*). It then continues superiorly on the posterior aspect of the muscle between the muscle and the posterior rectus sheath. Superiorly it anastomoses with the superior epigastric artery. It gives off musculocutaneous perforators along its superior course. The ***highest density of perforators is located in the periumbilical area***.

The ***superior epigastric artery*** arises from the internal thoracic (internal mammary) artery. It travels inferiorly on the posterior aspect of the sternum along the sternocostal junctions giving off perforators. These perforators also supply the deltopectoral flap and may be encountered when raising a pectoralis flap when the muscle is divided medially.

Innervation

The muscle has segmental innervation from thoracoabdominal nerves T7-T11

Surgical steps

Informed consent

A preoperative discussion should include the risk of seroma or haematoma formation, of developing unsightly scars and of an abdominal hernia. Patients must be counselled about the risks of flap failure and postoperative paralytic ileus. The strength of the abdominal wall will also be affected which can affect one's ability for athletic and other strenuous activities.

Prepping and draping (Figure 7)

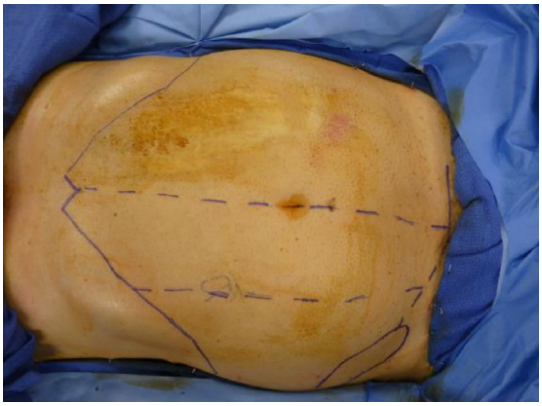


Figure 7: Prepping and draping

The abdomen is prepped and draped in a standard sterile fashion from just above the xiphoid, laterally along the midaxillary line and inferiorly along the inguinal ligament to permit harvesting of the whole muscle if needed and dissection of the pedicle (*Figure 7*).

Skin paddle

- ***Design the flap only after resecting the tumor and inspecting the defect***

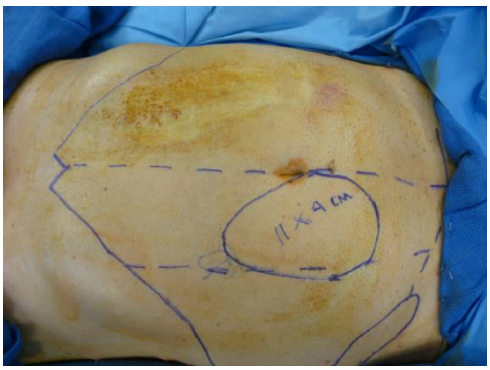


Figure 8: Skin paddle includes periumbilical area

- Draw the skin paddle (*Figure 8*)

- Perforators supply a large area of skin via the subdermal plexus
- Generally, 8-10 cm of skin can be harvested with primary closure of the donor site
- A simple ***pinch test*** will give assurance that there is enough laxity for primary closure of the donor site
- Although skin paddles can be harvested in different orientations, it ***should include the periumbilical area*** as the largest and most reliable perforators are located within a few centimeters of this area
- A variety of fasciocutaneous flaps with muscle sparing techniques requiring perforator dissection have also been described

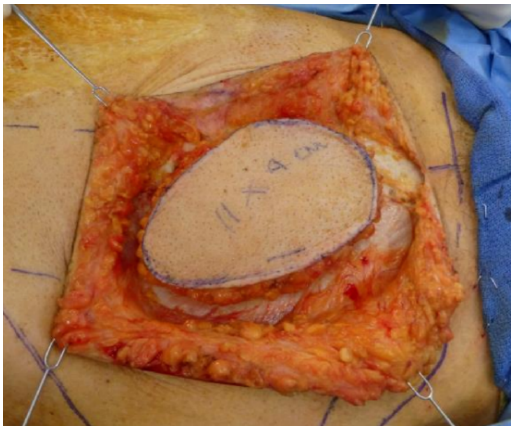


Figure 9: Circumferential exposure of rectus sheath

- Circumferentially incise the ***skin and subcutaneus tissue*** through adipose tissue, Scarpa's fascia and down to the rectus sheath (*Figure 9*)

Raise flaps circumferentially to expose the linea alba in the midline and linea semilunaris laterally which marks the transition between rectus abdominis and external oblique. There is nothing to hurt in this area as the vascular pedicle runs deep to muscle

Incising the anterior rectus fascia

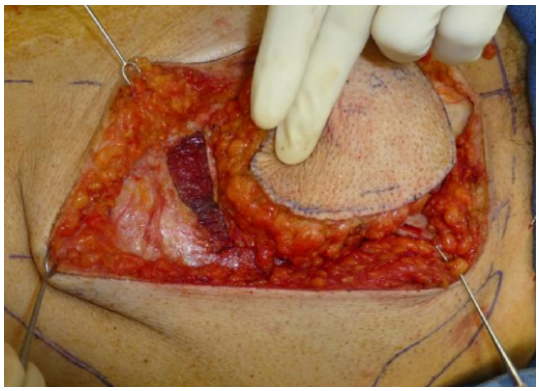


Figure 10: Incising rectus sheath superiorly to expose the rectus muscle

- Start superiorly (*Figure 10*)
- Using careful blunt dissection medial to the linea semilunaris in a lateral-to-medial fashion, the surgeon can often identify the first set of perforators (This step is not essential)
- Incise the fascia lateral to these perforators, leaving a cuff of rectus sheath laterally to facilitate later closure of the sheath
- If skin from the contralateral side is to be incorporated, then this skin is dissected towards the flap until linea alba is encountered
- Incise the anterior rectus sheath 1 cm lateral to the linea alba to leave a cuff for later closure

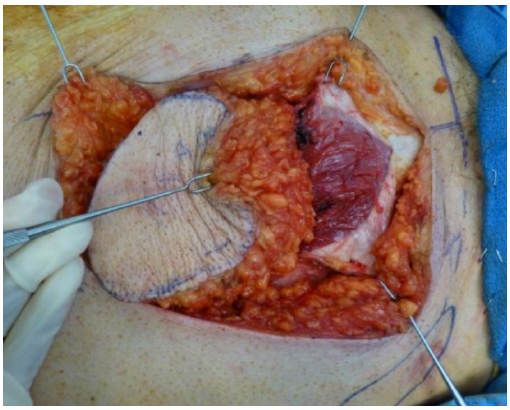


Figure 11: Incising rectus sheath inferiorly

- Next incise the skin inferiorly over the rectus muscle, gently curving inferolaterally to later facilitate easier dissection of the inferior epigastric pedicle (*Figure 11*)
- Expose the entire anterior rectus sheath inferior to the skin paddle down to the inguinal region
- Incise the anterior rectus sheath vertically over the midportion of the rectus muscle

Rectus muscle

- The whole muscle or portions thereof can be used
- The flap will shrink and lose bulk with time due to significant muscle atrophy, especially if postoperative radiation is employed
- A good rule of thumb is to harvest about 20-30% more tissue than the size of the defect
- To minimize muscle atrophy, segmental nerves can be anastomosed to motor nerves in the neck
- Transect the muscle superiorly at a suitable level
- Reflect the muscle from lateral-to-medial
- This exposes the segmental nerves which are transected

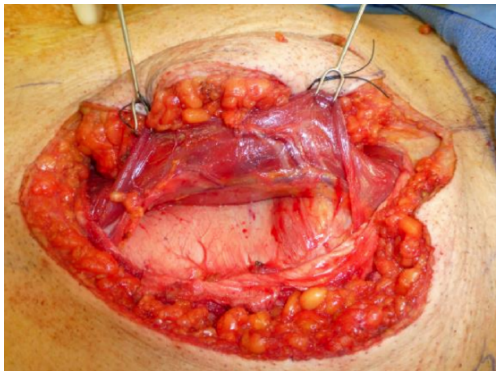


Figure 12: Inferior epigastric vessels exposed following division of segmental nerves

- Further reflection exposes the undersurface of the rectus muscle and the inferior epigastric vessels (*Figure 12*)

Vessel dissection

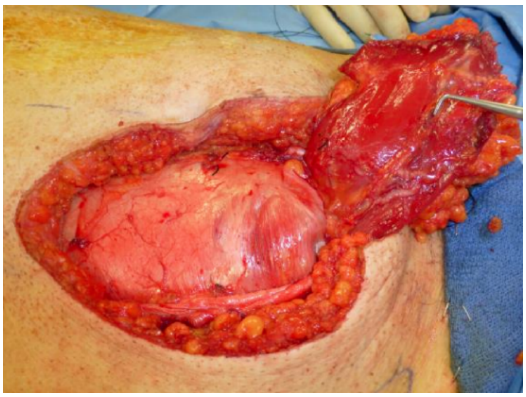


Figure 13: Inferior epigastric vessels exposed after ligating the vessels superiorly and reflecting the muscle inferiorly

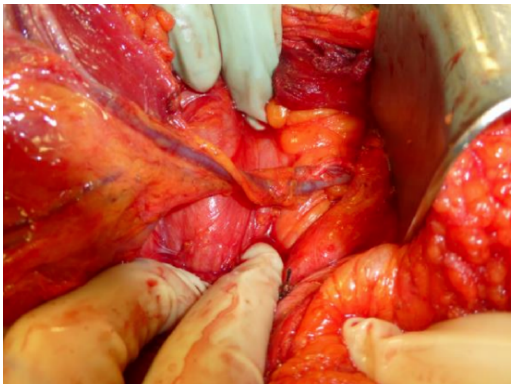


Figure 14: Inferior epigastric vessels being dissected towards the external iliacs



Figure 15: Rectus flap with its vascular pedicle

- Using large retractors, dissect the pedicle proximally (*Figures 13, 14*)
- Divide and ligate the pedicle proximally (*Figure 15*)
- Even if a long pedicle is not required, it is often useful to dissect the pedicle all the way to its origin from the external iliac vessels, as the inferior epigastric veins often merge at a variable distance from the external iliac vein

Closure



Figure 16: Preparing to suture the cut edges of the rectus sheath

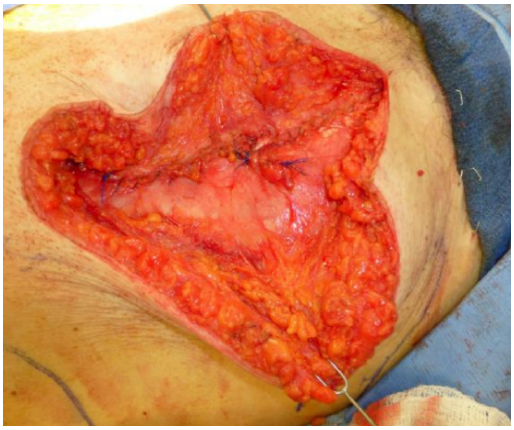


Figure 17: Sutured rectus sheath

- Reapproximate the anterior rectus sheath with large nonabsorbable sutures e.g. 0-Prolene (*Figures 16, 17*)
- Although the posterior rectus sheath superior to the arcuate line is probably strong enough, the remnants of the anterior rectus sheath at the level of flap are also reapproximated with nonabsorbable sutures taking great care not to inadvertently incorporate any peritoneum with the suture
- If direct suturing is not possible, consider using a mesh to strengthen the abdominal wall



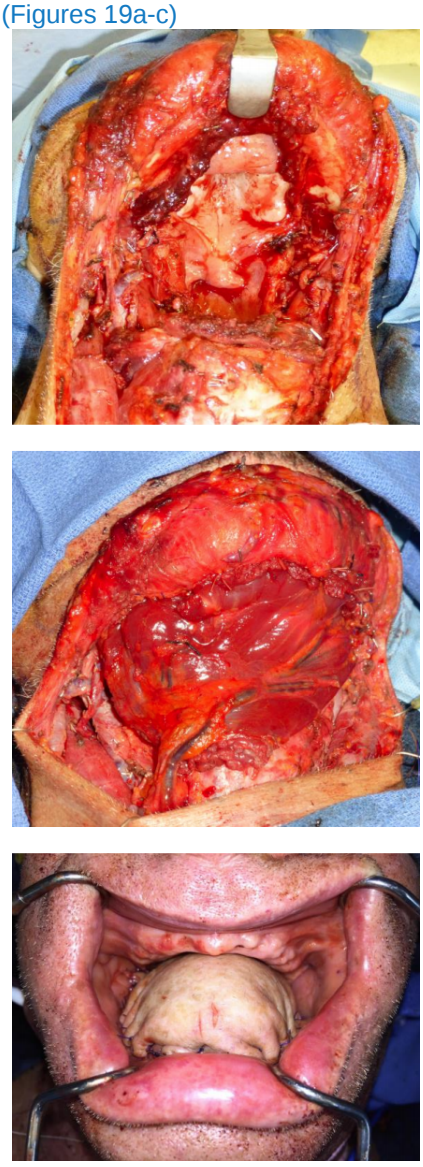
Figure 18: Sutured skin and suction drain

- Close the skin; undermining the skin may be required to ensure a tension free closure, and insert a suction drain (*Figure 18*)

Postoperative care

- Postoperative paralytic ileus as a consequence of retracting the abdominal cavity contents while dissecting the pedicle is not uncommon; withhold feeds until this resolves
- Mobilize the patient early
- Exercises that involve the abdomen may be resumed about six weeks following surgery

Rectus flap for total glossectomy defect (Figures 19a-c)



Figures 19a-c

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap

- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Patrik Pipkorn MD, Fellow, Head & Neck & Microvascular Reconstruction
Washington University
St Louis, MO, USA
patrikpipkorn@hotmail.com

Brian Nussenbaum, MD
Christy J. & Richard S. Hawes III Professor
Otolaryngology - Head & Neck Surgery Director, Head & Neck Surgical Oncology
Vice Chair of Clinical Affairs
Washington University
St Louis, MO, USA
Nussenbaumb@ent.wustl.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

LATISSIMUS DORSI FLAP FOR HEAD AND NECK RECONSTRUCTION

Patrik Pipkorn, Ryan Jackson, Bruce Haughey



Figure 1: Large pedicled latissimus dorsi flap

The latissimus dorsi is the largest muscle in the body by surface area. It can be as large as 20 x 40 cm, enabling latissimus dorsi flaps to cover very large defects (*Figure 1*).

The flap can be harvested as a pedicled or free flap and as a muscular or myocutaneous flap with an overlying skin paddle. It can also be harvested along with any other flap based on the subscapular vascular system as a chimeric or subscapular “megaflap”. Despite its size it can be harvested without significant donor site morbidity.

The muscle is normally about 1 cm thick. Because it atrophies significantly if it is not reinnervated, it is a popular option for scalp reconstruction and for other defects in the head and neck area including reconstruction of skull base and total glossectomy defects.

Benefits

- Easy flap to learn to harvest
- Large thin muscle that can cover very large defects
- Long (5-15 cm) vascular pedicle if dissected up to the subscapular artery
- The subscapular artery has a diameter of 2-5 mm
- Minimal long-term donor site morbidity
- Can be harvested as a muscle flap or with a skin paddle
- Can be harvested as a chimeric flap (multiple otherwise independent flaps that each have an independent vascular supply with all pedicles linked to a common source vessel) along with other flaps based on a singular subscapular artery

Caveats

- Donor site is close to head and neck area making two team harvest difficult, though not impossible
- Because the donor site is on the back, it makes positioning more tedious
- Large wound and potential dead space after harvest has high risk of a seroma

Surgical anatomy

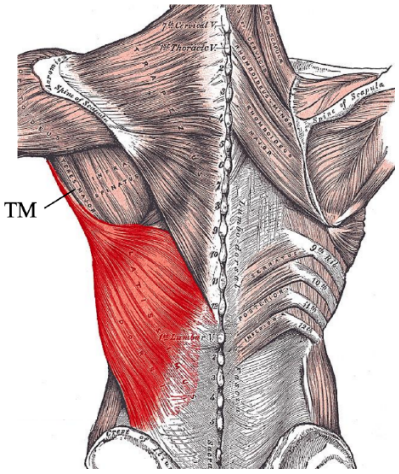


Figure 2: Posterior view of Latissimus dorsi muscle and Teres major (TM)

The latissimus dorsi mainly adducts and medially rotates the arm. It also rotates the shoulder inferiorly and posteriorly. It is a thin, flat muscle measuring about 20 x 40 cm (*Figure 2*). The muscle forms the posterior axillary fold together with the teres major muscle (*Figure 2*). It originates from the posterior iliac crest, the thoracolumbar fascia and spinous processes of T7- L5. Some muscle fibers may also originate from the lower ribs.

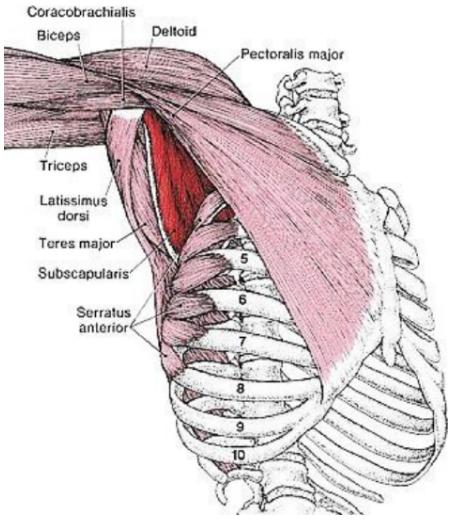


Figure 3: Anterolateral view of latissimus dorsi, teres major, serratus anterior, and pectoralis major

The muscle fibers run in a superolateral direction and insert into the floor of the intertubercular groove of the humerus between the teres major and pectoralis major muscles (*Figure 3*).

Some fibers also variably originate from the tip of the scapula where they intersperse with fibers of the teres major. Superomedially it lies deep to the trapezius muscle as the trapezius attaches all the way down to T12. Inferiorly it covers the serratus anterior and external oblique abdominis muscles (*Figure 3*).

Innervation

The latissimus dorsi is innervated by the thoracodorsal nerve. It is derived from the 6^{th}, 7^{th} and 8^{th} cervical nerve roots and arises from the posterior cord of the brachial plexus. The nerve runs with the thoracodorsal vascular pedicle. It only innervates the latissimus dorsi, so no other muscles are affected despite its transection when harvesting the flap.

Vascular anatomy

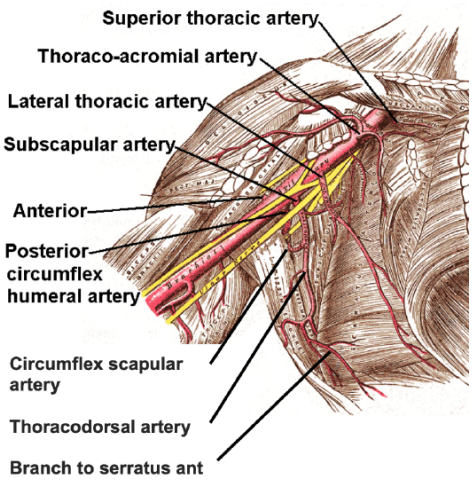


Figure 4: Anterolateral view of vascular anatomy; the subscapular artery is the largest of 3 branches of the third segment of the axillary artery

The thoracodorsal artery is the main blood supply to the latissimus dorsi; it is a terminal branch of the subscapular system (*Figure 4*). A sound understanding of the subscapular artery system is therefore important for a microvascular surgeon when harvesting flaps from the back. The subscapular artery is a very versatile system that supplies many flaps that can be harvested alone or as chimeric flaps with different tissues based on a single pedicle.

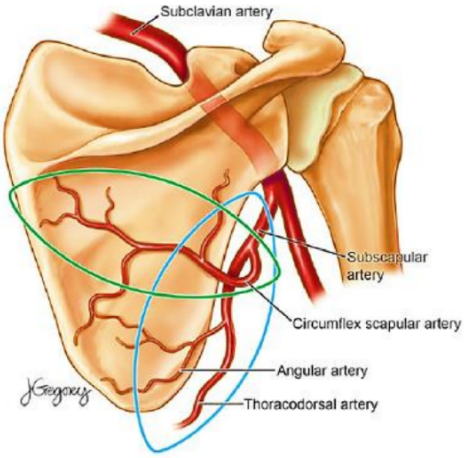


Figure 5: Subscapular artery and its branches depicted from posteriorly

The subscapular artery is a branch of the 3rd segment of the axillary artery after the axillary artery has crossed the pectoralis minor. The branching patterns of the subscapular system varies considerably. The subscapular artery divides into the circumflex scapular (CSA) and thoracodorsal arteries (*Figure 4*). The CSA continues from deep to superficial in the triangular space between the teres major, teres minor, the long head of the triceps and the lateral border of the scapula. After passing through this triangular space, the CSA divides into a horizontal and a vertical terminal branch, both which can be used for cutaneous flaps (*Figure 5*).

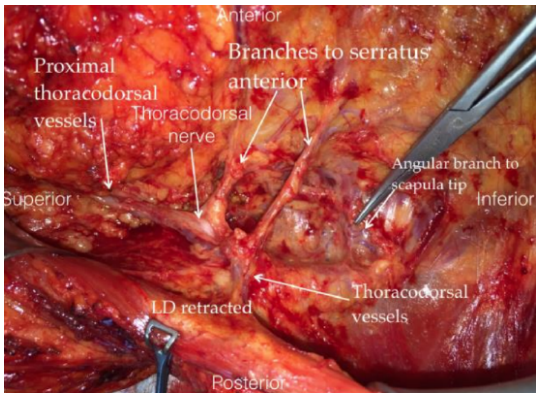


Figure 6: Right anterolateral view with latissimus dorsi (LD) retracted to demonstrate thoracodorsal vessels, nerve and branches to serratus anterior

The thoracodorsal artery continues deep to the teres major and latissimus dorsi muscle along the thoracic wall (*Figure 4*). There is some variability of the branching pattern but most often a separate branch, the angular branch, arises from the thoracodorsal artery and supplies the tip of the scapula (*Figures 5*, *6*). Before entering the latissimus dorsi muscle a 2nd branch, the branch to serratus anterior muscle, branches off (*Figures 4*, *6*).

Blood supply to latissimus dorsi muscle

The ***thoracodorsal artery*** provides the main blood supply to the latissimus dorsi. The thoracodorsal artery and vein course superiorly along the thoracic wall on the deep surface of the latissimus dorsi towards the axilla. The artery is 1.5 - 4 mm in diameter and the vein is usually 2.5 - 4.5mm in diameter. The muscular pedicle can be between 6-16 cm in length with an average length of 9 cm. It enters the muscle on its deep surface about 8-10 cm distal to its origin of the subscapular artery (*Figure 6*). To gain extra length, the artery can be dissected all the way to the axillary artery.

Just after the thoracodorsal artery enters the muscle it divides into two branches, one horizontal and one vertical enabling two different skin paddles to be harvested with the flap. The highest density of ***perforators*** is about 2 cm posterior to the anterior edge of the muscle, just after the artery enters the muscle. As with a pectoralis major flap these perforators are small and are not routinely dissected when harvesting the flap. To ensure incorporation of perforators into the flap, a Doppler can be used, although it is not essential to do so. Designing a larger skin paddle also makes the flap more reliable as the chance of incorporating perforator vessels increases.

The muscle also receives blood supply from segmental perforating vessels from ***thoracic and lumbar intercostal arteries***. These arteries are small and enter the muscle on its deep surface close to the spine. They supply the medial and inferior extensions of the muscle. Since these vessels are transected during flap harvest, the blood supply to the distal 1/3 of the muscle may be unreliable.

Informed consent

Preoperative discussion should include the risk of hematomas and seromas and developing an unsightly scar. Patients must be counseled about the risk of flap failure. Shoulder strength might be slightly affected, though not noticeably in most patients unless combined with other flaps that may affect shoulder strength e.g. pectoralis major or scapular flaps.

Positioning and draping

The classic way to position a patient for any of the flaps based on the subscapular system is to expose the full back of the patient by placing the patient in a lateral decubitus position with an axillary roll. This however makes it necessary to rotate the patient between the ablative and the flap harvesting stages, which requires repositioning and redraping, and adds considerable time and effort to the surgery.



Figure 7: Positioning to permit simultaneous cancer resection and harvesting of latissimus dorsi flap (Courtesy Jason Rich)

However, as the surgical incision is made on the lateral back and at no time during the surgery exposure is necessary beyond the midline, it is possible to put the patient in a 30-45 degree angle with the patient's contralateral side supported with a deflatable beanbag (*Figure 7*). Once the patient is properly secured to the bed, the bed can be rotated back by about 15-20 degrees permitting adequate exposure for both the ablative and reconstructive surgeons. This positioning technique saves considerable time and circumvents one of the major drawbacks of harvesting flaps from the back, namely, time-consuming repositioning, reprepping and redraping.

Key points for this positioning technique

- Once the patient is intubated and all the necessary intravenous and arterial lines, urinary catheter, and ECG leads have been placed, place the patient on a bean bag (*Figure 7*)
- Rotate the patient about 30-45 degrees to facilitate exposure of the back which will be used for the harvest (*Figure 7*)
- Deflate the bean bag to make a firm and stable base to hold the patient in position
- Expose the back up to the spinous processes
- Take care to pad any firm spots to minimize risks of pressure necrosis



Figure 8: The knee is kept slightly bent and a pillow is placed to minimize any pressure on bony prominences

- Place a pillow between the knees, which should be slightly bent (*Figure 8*)

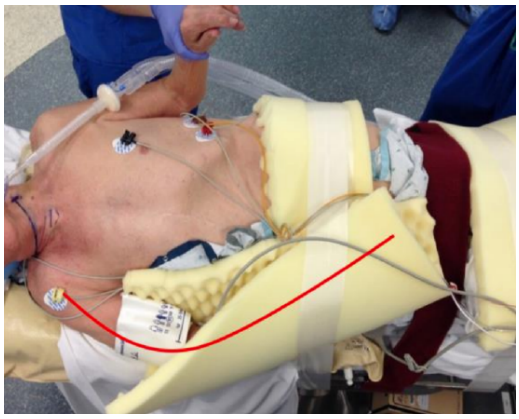


Figure 9: The lower arm is bent slightly and is padded well. Note that patient is well secured to the bed (Courtesy Jason Rich)

- Gently bend the contralateral arm with padding placed between the arm and the chest; a formal axillary roll is not required (*Figure 9*)
- Properly secure the patient to the bed with belts and tape so that the bed can be tilted, and the patient remains secure (*Figure 9*)
- Before prepping, perform a “tilt test” to make sure the patient is secure

Flap design

- Decide whether a skin paddle is required to reconstruct the surgical defect
- If a skin paddle is needed, it must be located over the latissimus dorsi muscle
- In general, a width of 10 cm can easily be harvested, still allowing the defect to be closed primarily; a simple “pinch test” will give one some indication
- A larger skin paddle tends to be more reliable as more perforators entering from the deep surface are incorporated

The latissimus dorsi flap may be employed either as a free microvascular transfer flap or a pedicled flap.

Surgical steps

In the following presentation, a muscleonly free flap is raised.



Figure 10: The patient is prepped with the arm free draped (Courtesy Jason Rich)

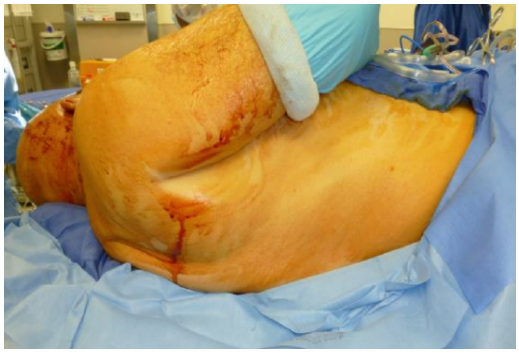


Figure 11: A sleeve is placed over the distal arm and hand. This sleeve can be secured to the drapes during the resection stage to ensure it does not fall off the table. Expose the back from the spinous processes medially, to the iliac bone below

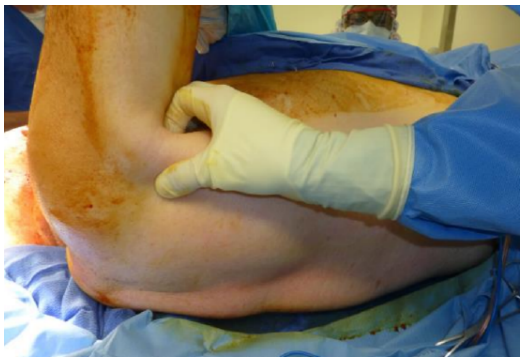


Figure 12: Start by feeling for the posterior axillary fold (teres major and latissimus dorsi)

- Prep the back up to the spine and include ipsilateral arm (*Figure 10*)
- Put a stocking over the arm and secure it to the drapes; being able to move the arm greatly increases the exposure when dissecting the pedicle into the axilla (*Figure 11*)
- Identify the anterior edge of the latissimus dorsi
  - This is done by identifying the posterior axillary fold (*Figure 12*)
  - The posterior axillary fold consists of teres major and the latissimus dorsi

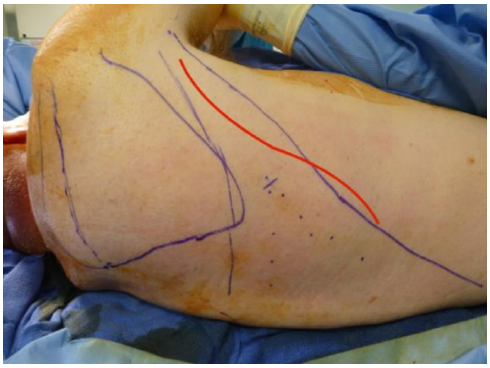


Figure 13: When a skin paddle is not needed, a lazy S incision is placed along the anterior border of latissimus dorsi. The position where the thoracodorsal artery pierces the muscle from the deep aspect is marked (X) as well as the vertical and horizontal branches (dotted lines)



Figure 14: Incise skin and subcutaneous tissue all the way down to the latissimus muscle

- Design a lazy-S shaped incision a few centimeters behind the anterior edge of the muscle (*Figure 13*)
- Incise the skin and subcutaneous tissue (*Figure 14*)

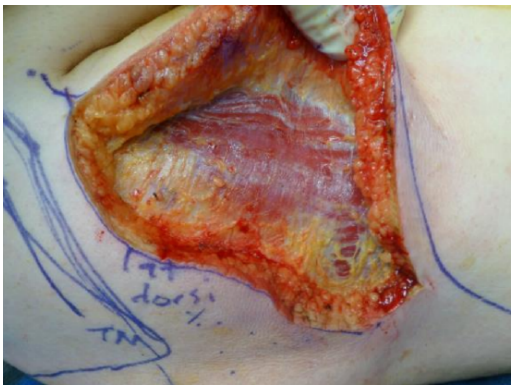


Figure 15: Latissimus muscle exposed

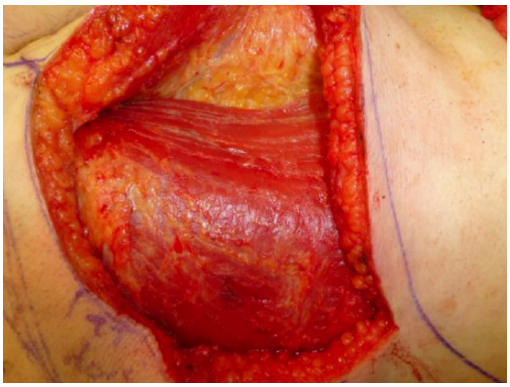


Figure 16: Identify anterior border of latissimus dorsi

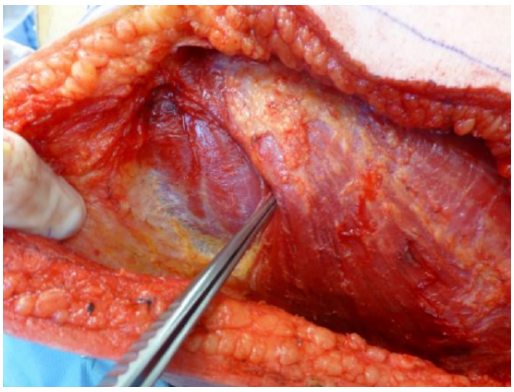


Figure 17: Continue dissecting superiorly and identify the posterosuperior border. This border is much more tedious to find as fibers intersperse with teres major muscles and some fibers attach to the scapula

- Extend the incision down to the muscle (*Figure 15*)
- Raise the anterior flap until the anterior edge of the latissimus dorsi muscle is identified (*Figure 16*)
- Now raise the flap posteriorly
- Superiorly this edge can be a little tedious to identify where the latissimus dorsi intersperses with the fibers of the teres major muscle (*Figure 17*)
- Once these landmarks have been identified the entire surface of the muscle is exposed using electrocautery as there are no major structures in this area that can be injured



Figure 18: With blunt finger dissection you can now further identify the anterior border and start separating the muscle from the chest wall

- Dissect the latissimus dorsi muscle off the thoracic wall using blunt finger dissection (*Figure 18*)
- Superiorly this dissection plane consists of loose areolar tissue which makes it easy to strip the latissimus dorsi from the underlying tissues

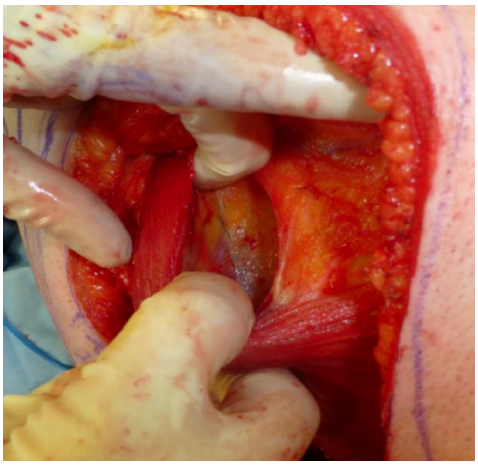


Figure 19: Identify the thoracodorsal pedicle as it pierces the deep aspect the muscle

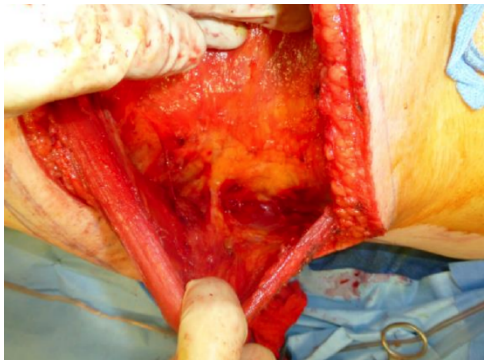


Figure 20: The remainder of the latissimus dorsi muscle is now exposed; this can be done quickly as there is nothing to hurt superficial to the muscle. The muscle is elevated off the chest wall. Inferiorly the muscle fibers intersperse with serratus and abdominal wall muscles

- By doing this maneuver, the pedicle should become visible as it enters the muscle on its deep aspect, superiorly (*Figure 19*)
- Having identified the pedicle, dissect the muscle off the thoracic wall in a proximal-to-distal fashion (*Figure 20*)
- Be sure to control small perforating vessels that enter the muscle from the thoracic wall
- The muscle does not separate as easily inferiorly as it attaches to the abdominal wall and intersperses with serratus anterior and external oblique muscle fibers

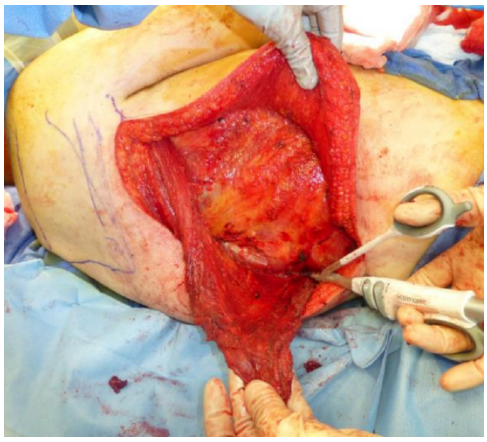


Figure 21: Start by dividing the muscle inferiorly, in this case with a harmonic scalpel, and then along the spinous processes

- Once the whole muscle is exposed as well as separated from the thoracic wall, the muscle is divided inferiorly (*Figure 21*)
- Once the inferomedial point is reached continue to free it medially along the spine (*Figure 21*)



Figure 22: Continue up along the spinous processes until the whole muscle is released

- Continue upward along the spinous processes until the entire muscle is released. Ensure good hemostasis as you encounter the spinous perforators (*Figure 22*)
- Superiorly the most medial aspect of the muscle may be obscured by the inferior aspect of trapezius muscle
- If the flap is to be used as a free flap, then it is advisable to delay dividing the humeral attachment of the latissimus dorsi until very late as this takes the weight off the flap when dissecting the pedicle, thus avoiding traction injury to the vessels
- The pedicle is now easily visualized
- Commence dissection of the pedicle
- Having someone lift the arm perpendicularly to the floor greatly facilitates the axillary exposure at this stage
- Expose the thoracodorsal artery as far proximally as needed for adequate vessel length
- To maximize the length of the pedicle, the artery can be traced to the axillary artery
    - Significant vessel variability exists in this region
    - To obtain maximum pedicle length the serratus branch as well as the circumflex vessels generally have to be divided if they are not necessary for other components of the subscapular system of flaps



Figure 23: Free flap with vascular pedicle

- Divide the pedicle and harvest the flap once donor vessels have been prepared (*Figure 23*)
- Before dividing the vessels, the thoracodorsal nerve which runs with the pedicle must be divided
- Before closing the defect, assure excellent hemostasis is achieved



Figure 24: The back is closed in layers after hemostasis has been achieved. Two large suction drains are placed and are left in for about 2 weeks

- Insert 2 large suction drains left in situ for 2 weeks (*Figure 24*)
- Close the skin in layers
- Sutures or staples are generally removed at 2 weeks

Postoperative care

The patient is encouraged to mobilize the arm postoperatively. The drains are left in place until the output has diminished. This may take up to 1-2 weeks as the surgical wound and the potential dead space is very large, leading to a high risk of postoperative seroma formation.

Latissimus dorsi pedicled regional flap

The latissimus dorsi flap may also be employed as a pedicled flap, and can reach ***as high as the temporal region or even the vertex*** if the skin paddle is placed caudally enough. Success rates of 90-95% have been reported for pedicled latissimus dorsi flaps.

Indications for pedicled as opposed to free latissimus dorsi flaps include:

1. A vessel-depleted neck where the patient's anatomy, previous surgery and/or irradiation may not offer safe options for microvascular anastomosis
2. A patient's general health does not permit additional time and risk associated with a microvascular free flap
3. Microsurgical expertise is unavailable

Surgical steps

- If the flap is to be harvested as a ***regional pedicled flap***, then the muscle is rotated up towards the head and neck area through a tunnel that is created between the pectoralis major and pectoralis minor muscles. The humeral attachment can then be left intact unless extra length is necessary and to create a gentler bend to the pedicle
- Raise the latissimus dorsi flap using the same surgical steps as described above for a free flap

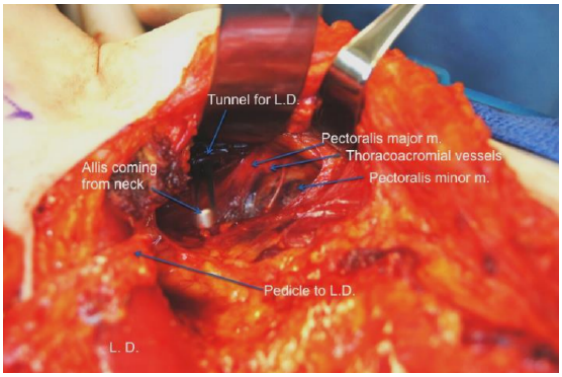


Figure 25: Tunnel between the pectoralis minor and pectoralis major muscles for the flap to be passed from the axilla into the neck (Courtesy Ralph Gilbert)

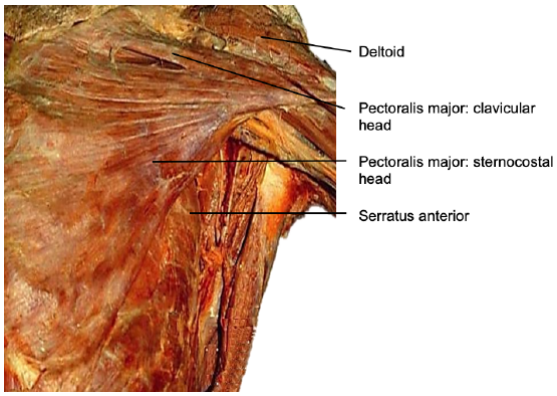


Figure 26: Pectoralis major and clavicular head

- Create a tunnel between the pectoralis minor and pectoralis major muscles for the flap to be passed from the axilla into the neck (*Figure 25*)
- Expose the lateral border of the pectoralis major muscle as when raising a pectoralis major flap (*Figure 26*)
- Separate the pectoralis major from the pectoralis minor by stripping with a finger in the loose areolar plane between the two muscles
- Cut across approximately 5 cm of the broad clavicular insertion of the pectoralis major with electrocautery to create a tunnel between the undersurface of the pectoralis major and the skin overlying the clavicle

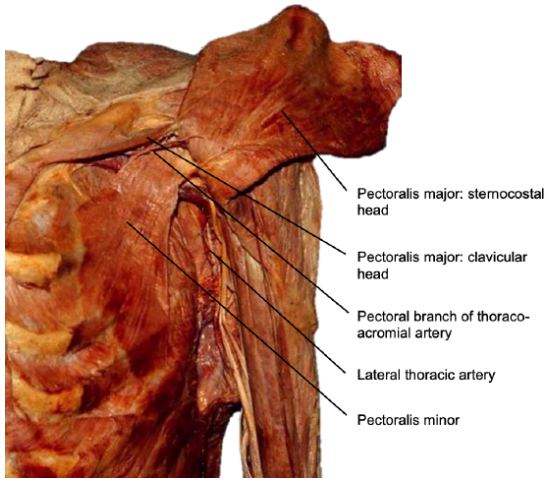


Figure 27: Deep relations of pectoralis major muscle; note pectoral branch of the thoracoacromial artery and the lateral branches to the pectoralis major from lateral thoracic vessels

- Take care to remain lateral to the pectoral branch of the thoraco-acromial artery in order to preserve the pedicle to the pectoralis major, thus keeping this flap as a later option (*Figure 27*)
- Lateral branches to the pectoralis major from the lateral thoracic vessels may have to be sectioned during this procedure (*Figure 27*)
- The remainder of the tunnel can now be created subcutaneously from the neck down towards the anterolateral aspect of the clavicle
- Dissect the pedicle of the latissimus dorsi flap towards the circumflex vessels
- Do not divide these vessels to ensure a gentle arc of the flap vessels as they are turned 180 degrees to reach the neck
- The proximal portion of the tendinous part of the humeral head, up to where the thoracodorsal vessels enter the flap, can be removed to reduce bulk that may compress the pedicle in the tunnel
- Once the flap is delivered, ensure that the flap vessels are gently curved and that the tunnel is wide enough to not exert any pressure on the pedicle

Flap variations

Different variations of the flap can be considered. The latissimus flap can be done as a chimeric flap as part of the subscapular system, in combination with tissue based on circumflex scapular vessel or serratus branches or can be raised alone. The flap can be tailored to the needs of the recipient defect. The flap can be harvested as a whole or partial muscle. The flap can be harvested as a

myocutaneous flap with overlying skin. The flap can even be harvested as a bony flap with underlying 9th or 10th rib. Great care then needs to be taken to not injure underlying pleura or transect the muscular attachments to the rib that supply periostal blood supply to the harvested rib.

Clinical examples

Resurfacing of neck with pedicled latissimus dorsi flaps



Figure 28: Courtesy Ralph Gilbert



Figure 29: Resurfacing of neck with pedicled latissimus dorsi flap for brachytherapy following prior irradiation

Reconstruction of total glossectomy defect with a hypoglossal to thoracodorsal neuroraphy

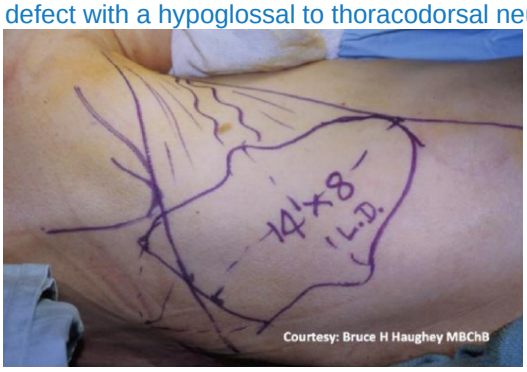


Figure 30: Flap design with bulk of skin overlying entry point of thoracodorsal artery



Figure 31: Flap with thoracodorsal vessels and thoracodorsal nerve

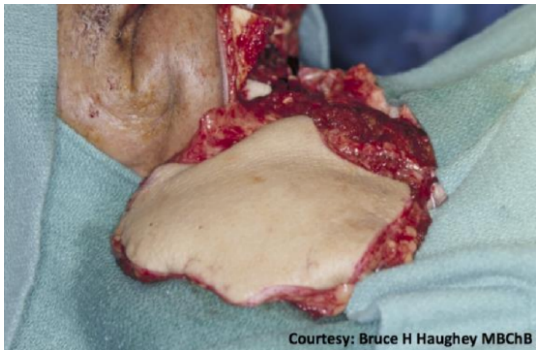


Figure 32: Flap anastomosed to facial vessels and neuroraphy performed to left hypoglossal nerve



Figure 33: De-epithelization of anterior portion and suturing of both epithelial borders help creating an anterior dome

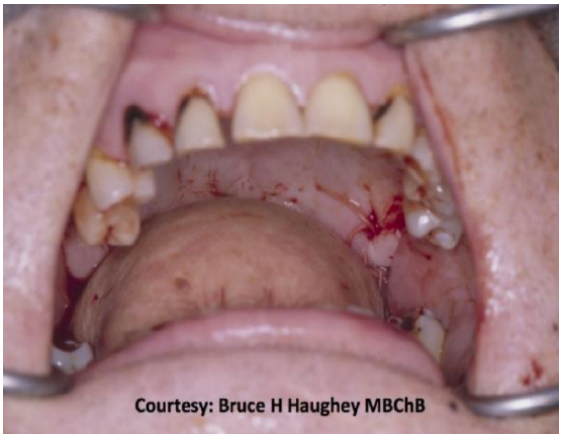


Figure 34: Immediate postoperative result

Myocutaneous flap for scalp defect



Figure 35: Surgical defect after recurrent cutaneous squamous cell carcinoma after failed radiation



Figure 36: Flap design



Figure 37: Muscle sutured to skin island to protect vascularity to flap

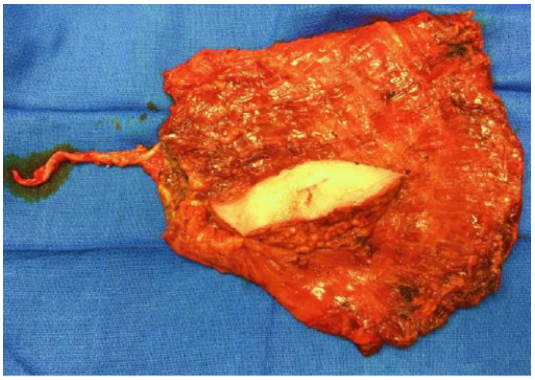


Figure 38: Flap harvested with an intraoperative monitor paddle (skin was later discarded)

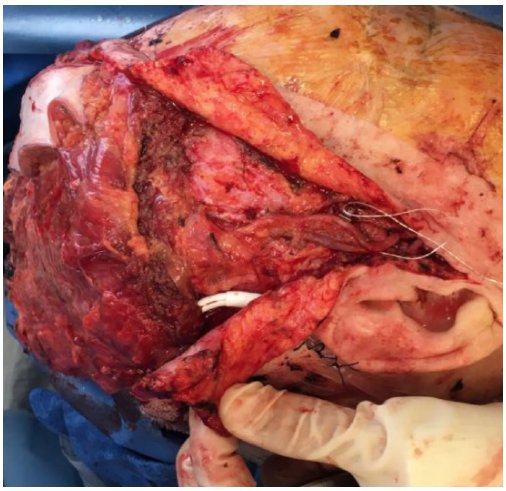


Figure 39: Vascular anastomosis to superficial temporal vessels; the facial vessels can often be used

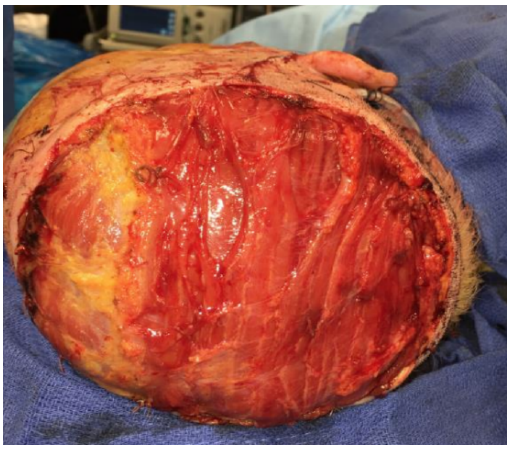


Figure 40: Flap in place

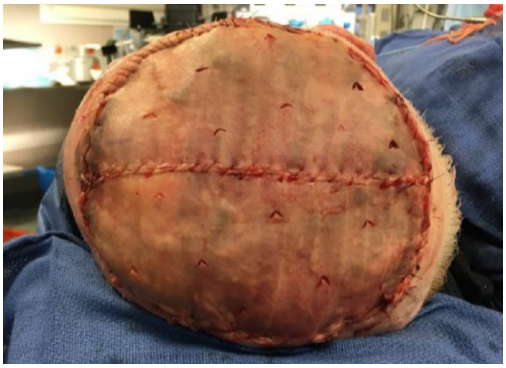


Figure 41: Split thickness skin graft covering muscle flap



Figure 42: Two months postop; note marked atrophy of the muscle, closely resembling the natural thickness of the native scalp

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Patrik Pipkorn MD, Assistant Professor
Head & Neck Microvascular Reconstruction
Department of Otolaryngology, Head and Neck Surgery
Washington University
St Louis, MO, USA
patrikpipkorn@hotmail.com

Ryan Jackson MD Assistant Professor
Head & Neck Microvascular Reconstruction
Department of Otolaryngology, Head and Neck Surgery
Washington University
St Louis, MO, USA
jacksonrs@wustl.edu

Bruce Haughey MBChB, MS, FRACS FACS
Head & Neck Oncologic & Reconstructive Surgeon
Florida ENT Surgical Specialists

Florida Hospital Celebration Health
Celebration, FL USA
bruce.haughey.md@flhosp.org

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SUBMENTAL ARTERY ISLAND FLAP FOR HEAD & NECK RECONSTRUCTION

Johan Fagan, Tareck Ayad, Mohammad Alfalasi



Figure 1: Submental island flap

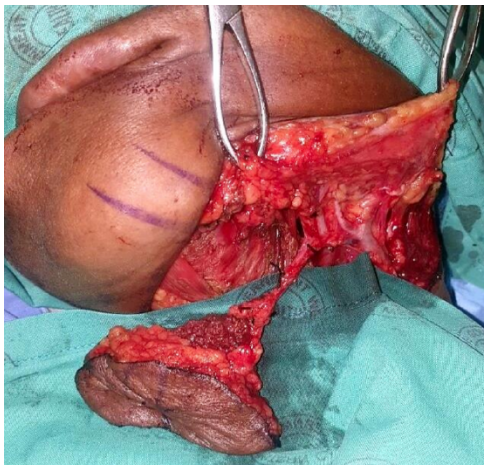


Figure 2a: Submental island flap including the anterior belly of digastric

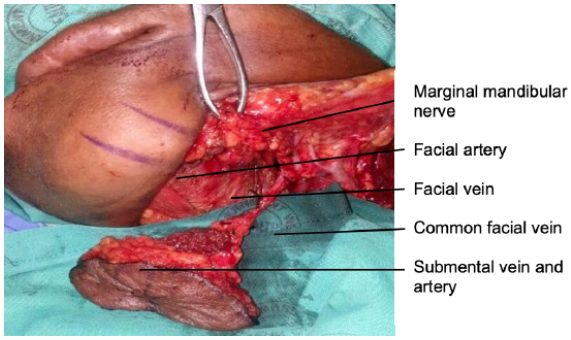


Figure 2b: Anatomy of veins, arteries and marginal mandibular nerve

The ***submental artery island flap (SIF)*** is an axial fasciocutaneous flap that includes skin, subcutaneous tissue, platysma, and fat and is pedicled on the ***submental artery and veins*** (*Figures 1, 2*).

The vascular pedicle has a length of up to 8 cm. It may be used for facial, oral cavity, oro- and hypopharyngeal soft tissue defects. If it is further dissected to its origin from the facial artery, the pedicle can be lengthened by an additional 1-2 cm to reach the lateral canthus and zygomatic arch.

Regional flaps like the SIF have distinct advantages over free tissue transfer flaps for selected soft tissue defects in the head and neck such as reduced operating time, donor site morbidity, level of surgical expertise required, and cost. Other regional flaps that may be considered for the oral cavity and pharynx include the buccinator, nasolabial, temporalis muscle, pectoralis major, and supraclavicular flaps.

Surgical anatomy

Submental island

The submental artery supplies a large skin paddle of as much as 10 x 16 cm, extending from one angle of the mandible to the other. The flap comprises skin, subcutaneous fat, platysma muscle, submental fat, and lymph nodes; the anterior belly of digastric and mylohyoid muscles may also be included. The entire flap can be pedicled on one submental artery because of crossover perfusion between the left and right submental arteries. The maximum anteroposterior dimension of the skin island is limited by the ability to achieve primary closure; this in turn depends on skin laxity and age.

Facial artery (Figures 2, 3, 4)

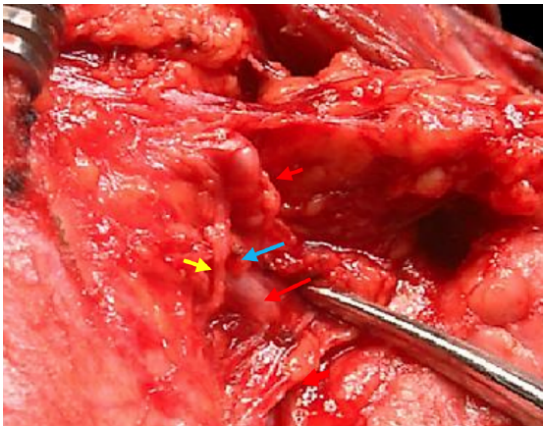


Figure 3: The right submandibular gland has been dissected in a subcapsular plane; the marginal mandibular nerve (yellow arrow) is seen crossing the facial artery (red arrows) and divided vein (blue arrow)

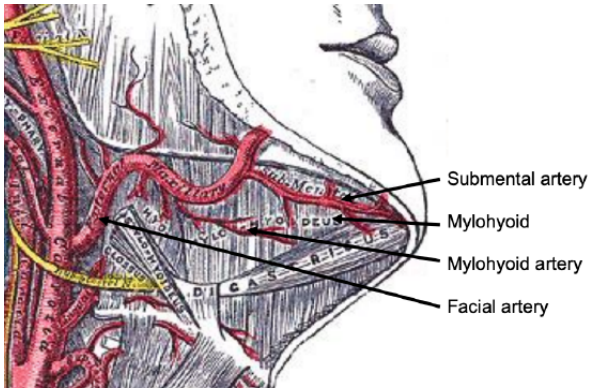


Figure 4: Submental, facial and mylohyoid arteries, and mylohoid muscle and anterior belly of digastric

The facial artery emerges from behind the posterior belly of the digastric muscle, and courses along the posterior surface of the submandibular salivary gland, giving off a variable number of branches to the gland along its course. The submental artery branches from the facial artery 3-15 mm below the mandible, just above where the facial artery emerges above the submandibular gland[1, 2]. The entire facial artery can be mobilized from the submandibular gland by dividing small branches to the gland along its course, and can be mobilized even more proximally by dividing the posterior belly of the digastric. Above the gland it is joined by the facial vein, both of which are crossed by the marginal mandibular nerve (*Figures 2b, 3*).

Submental artery (Figures 2 - 6)

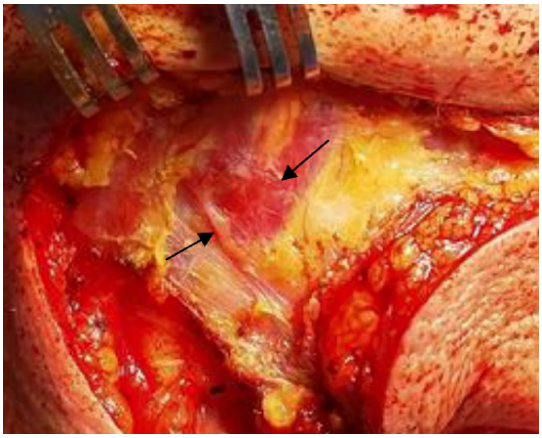


Figure 5: Perforator (arrow) crossing superficial to anterior belly of right digastric

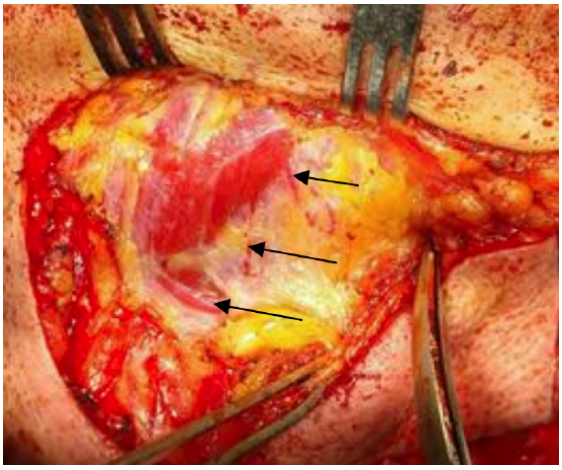


Figure 6: Perforators (arrows) crossing deep to anterior belly of right digastric

The submental artery has a diameter of 1-2 mm at its origin from the facial artery. It runs between the submandibular gland and the inferomedial margin of the mandible keeping deep to platysma but superficial to the mylohyoid muscle, where it gives off branches to the gland. Rarely, it passes through the submandibular gland[2]. It then runs either deep (>70%) or superficial to the anterior belly of digastric to enter the submental triangle. Here it gives off perforators to the subdermal plexus which perfuses platysma and skin. The positions of these perforators that perfuse the submental island are variable; usually there are 2 major perforators on either side of the anterior belly of digastric. The submental artery is about 6 cm long, and anastomoses with the contralateral artery in about 90% of cases[2]. It also anastomoses with the sublingual artery (which runs deep to the mylohyoid muscle) via a branch that pierces the mylohyoid muscle.

Marginal mandibular nerve (Figure 2)

This is a terminal branch of the inferior division of the facial nerve and crosses superficial to the facial vein and artery (*Figures 2b, 3*). It runs deep to platysma just below the border of mandible. Because it supplies the muscles of the lower lip (depressor anguli oris), injury results in loss of depression of the lower lip.

Venous anatomy (Figures 2, 7, 8)

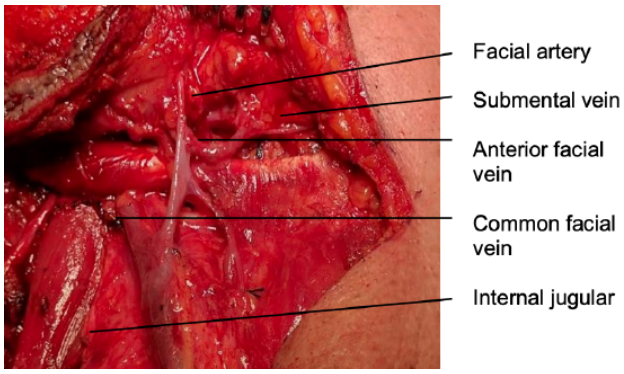


Figure 7a: Venous anatomy


Figure 7b: Venous anatomy

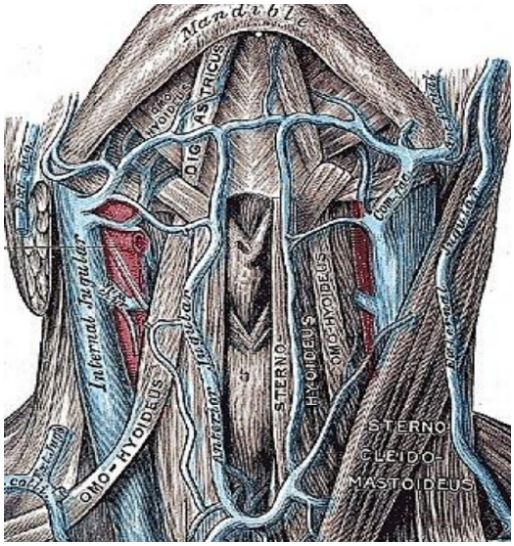


Figure 8: Venous anatomy

Venous drainage of the submental flap is via the submental vein. It measures about 2 mm in diameter[2]. The vein runs superficial to the anterior belly of digastric and courses parallel and generally just inferior to the submental artery to join the anterior facial vein (*Figures 7a,b - 8*).

Mylohyoid artery (Figure 9)

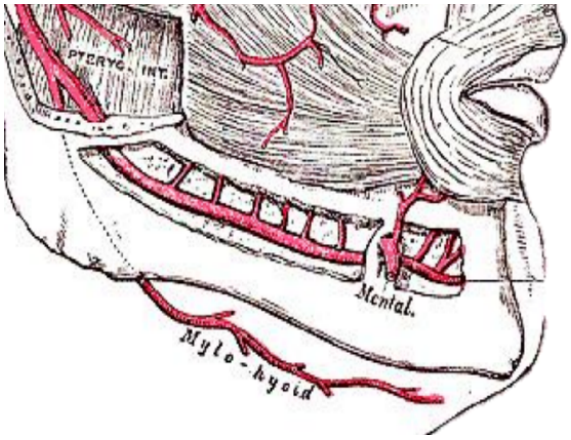


Figure 9: Mylohyoid artery is a branch of the inferior alveolar artery

The mylohyoid artery and vein are encountered when the surgeon elevates the anterior submandibular gland from the lateral surface of the mylohyoid muscle (*Figure 9*). It branches from the inferior alveolar artery just before it enters the mandibular foramen, crosses mylohyoid and disappears anteriorly behind the digastric. It ***has connections with the submental artery***, and via a defect in the mylohyoid with the sublingual artery in the floor of the mouth.

Indications for submental artery island flap

- Skin defects of the lower 2/3 of the face (excellent texture and color match)

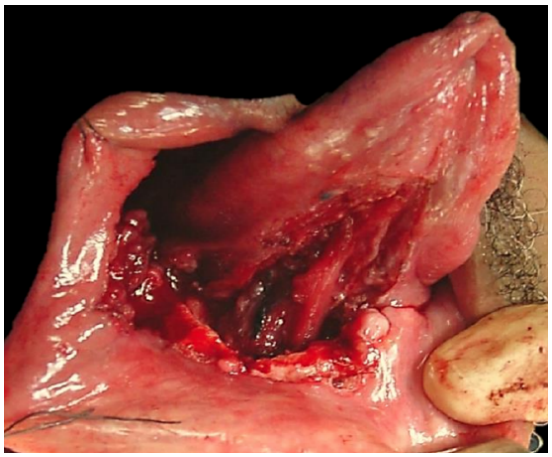


Figure 10: FOM defect suited to reconstruction with SIF

- Buccal, cheek, lateral floor of mouth and tongue resections (*Figure 10*)
- Oropharyngeal resections
- Hypopharyngeal resections
- Esophageal augmentation e.g. postlaryngectomy stenosis

Contraindications

- Sacrifice of facial artery or vein
- Inability to close donor site due to inadequate skin laxity
- Neck dissection requiring oncologic clearance of Level 1a, e.g. anterior floor of mouth cancers, as fat and lymph nodes of the submental triangle are included in the flap.

Relative contraindications

- Clinically palpable nodes in Level 1b
- Heavy beard growth may be problematic for intraoral reconstruction, although radiation therapy reduces hair growth

Anesthesia

Avoid muscle paralysis so that the surgeon can stimulate or monitor the marginal mandibular nerve

Surgical steps

- Expose the inferior margin of the mandible and the lower lip in the surgical field to monitor movement of the lip when the marginal mandibular nerve is mechanically or electrically stimulated



Figure 11: Pinching the submental skin



Figure 12: Outline of submental flap

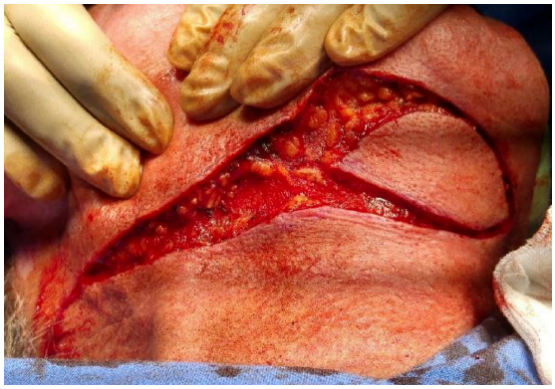


Figure 13: Platysma exposed

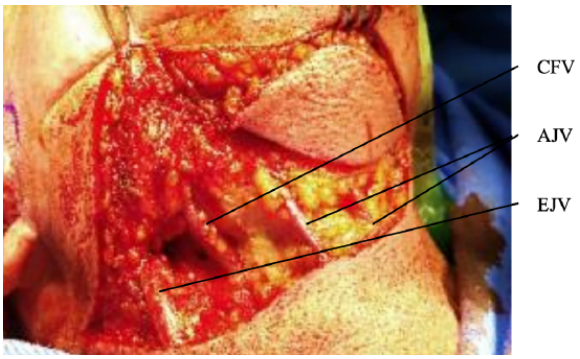


Figure 14: Incision through platysma, with anterior jugular (AJV), common (CFV) and external jugular (EJV) veins visible

- Pinch the submental skin to determine the maximum AP-dimension of the flap that can be closed (*Figure 11*)
- Design a skin incision along a cervical skin crease incision in the upper neck; the incision is preferably placed about 2 finger-breadths below the mandible to protect the marginal mandibular nerve (*Figure 12*)
- Design the flap in the submental (and submandibular) triangle to incorporate the cervical skin incision (*Figure 12*)
- Incise skin and fat down to platysma muscle; veins and marginal mandibular nerve are deep to platysma (*Figure 13*)
- ***Note: Unlike with neck dissections or submandibular salivary gland excision, the facial veins must be preserved***
- Extend the incision through platysma, taking care not to injure the common or anterior facial veins (*Figure 14*)
- Transect and ligate the anterior and external jugular veins
- Identify the common and anterior facial veins as they pass over the capsule of the submandibular salivary gland (*Figures 2, 7*)
- Raise a subplatysmal flap over the common and anterior facial veins and the facial artery superiorly using a dissecting scissors up to the mandibular ramus

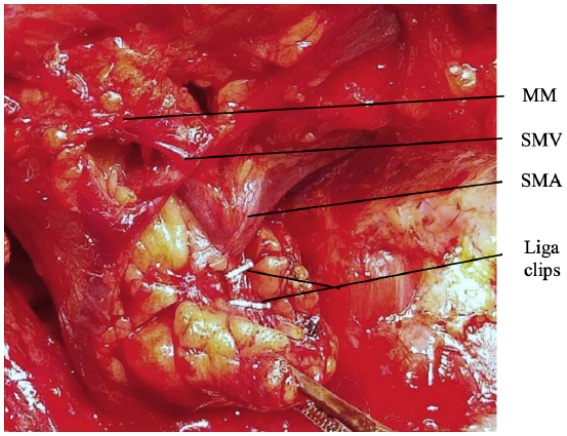


Figure 15: Marginal mandibular nerve (MM), submental vein (SMV), and submental artery (SMA), and Liga clips where branches of artery to submandibular salivary gland have been divided

- Identify the ***facial artery*** where it appears just above the posterosuperior edge of the submandibular salivary gland, just below the lower margin of the mandible (*Figure 15*)
- Identify the ***marginal mandibular nerve***; using scissors or a hemostat, carefully dissect cephalad along the lateral aspect of the anterior facial vein and facial artery to where the nerve crosses laterally over these vessels (*Figure 15*)

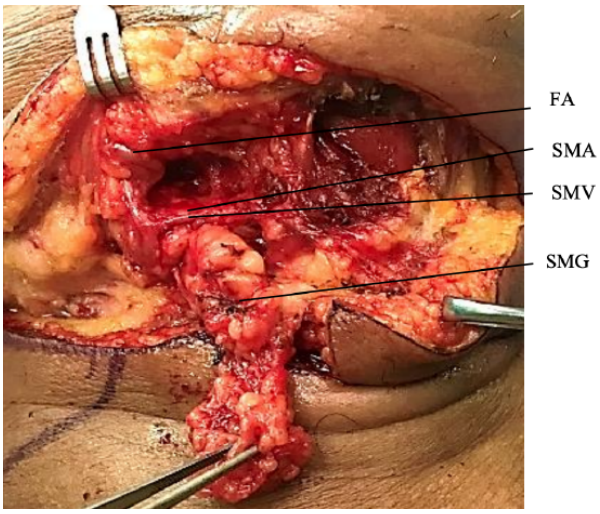


Figure 16: Facial nodes, fat and submandibular salivary gland (SMG) have been dissected from the submental vein (SMV) and artery (SMA) and facial artery (FA)



Figure 17: Facial nodes, fat and submandibular salivary gland have been dissected from the submental vein and artery

- ***Clear facial nodes*** and fatty tissue along the lower margin of the mandible if concern exists about ***metastases*** e.g. with cancer of the facial skin, lips, or floor of mouth and tongue, taking care to preserve the vascular pedicle and the marginal mandibular nerve (*Figures 16, 17*)

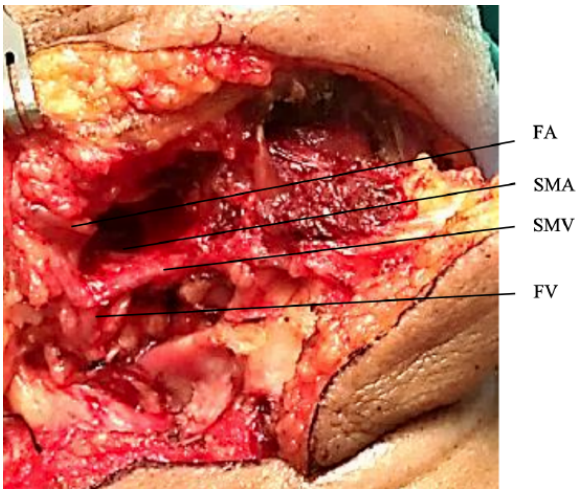


Figure 18: Submental vein (SMV), submental artery (SMA), facial artery (FA), facial vein (FV)

- Dissect the ***submental vascular pedicle*** (*Figure 18*)

- Identify the submental artery where it originates from the facial artery 3-15 mm below the mandible
- Identify and preserve the submental vein where it enters the facial vein
- Dissect anteriorly above the submental artery and vein as they course between the upper surface of the submandibular gland and the inner aspect of the mandible taking care not to injure the marginal mandibular nerve; the artery is generally superior to the vein
- Next dissect in a subcapsular plane over the submandibular salivary gland, and divide and ligate branches and tributaries between the submental artery and vein and the submandibular salivary gland as they are encountered (*Figure 18*)
- Note: If done for non-oncologic reasons, preserve a cuff of soft tissue around the vascular pedicle
- ***Avoid dissecting beyond the anterior belly of digastric as this would injure the perforators that supply the flap***

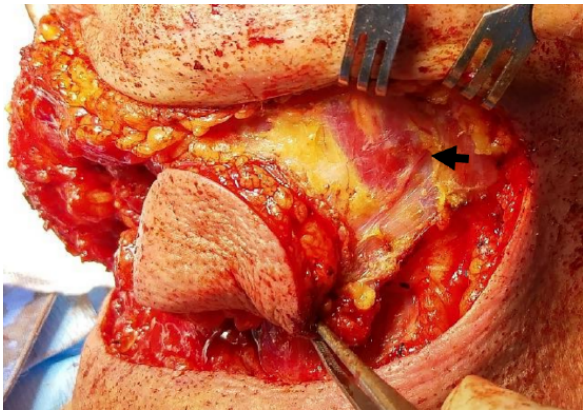


Figure 19: Skin, subcutaneous fat and platysma incised around perimeter of flap onto mylohyoid and opposite digastric; note branch of contralateral submental artery crossing digastric (arrow)

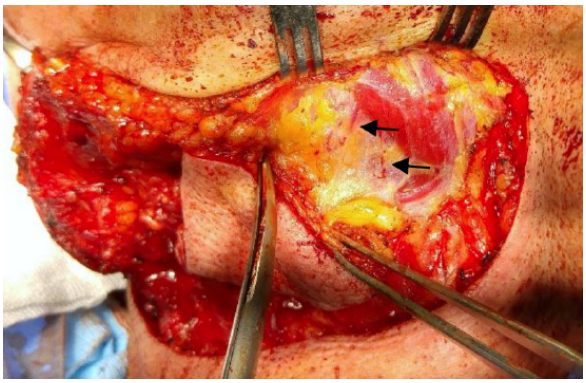


Figure 20: Skin, subcutaneous fat and platysma being elevated off opposite digastric and mylohyoid; note two branches of contralateral submental artery branches emerging from deep to anterior belly of digastric

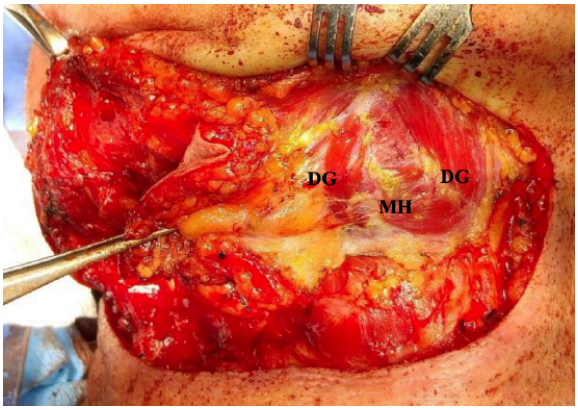


Figure 21: Flap elevated up to anterior belly of digastric (DG) which will be divided superiorly and inferiorly and be included in the flap (MH = mylohyoid)

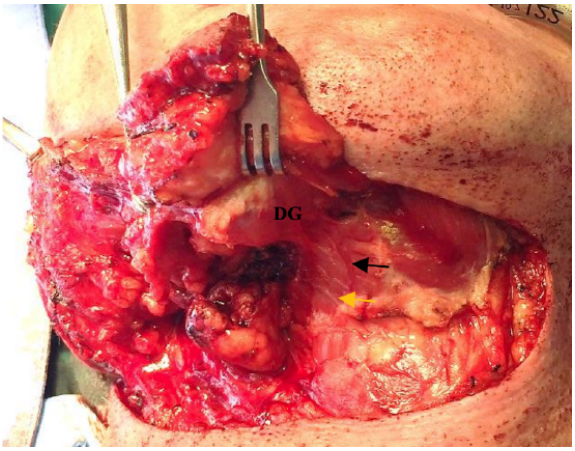


Figure 22: Anterior belly of digastric (DG) has been divided inferiorly and included in the flap, exposing the mylohoid and mylohyoid artery (black arrow) and nerve (yellow arrow)



Figure 23a: Skin cancer to be resected

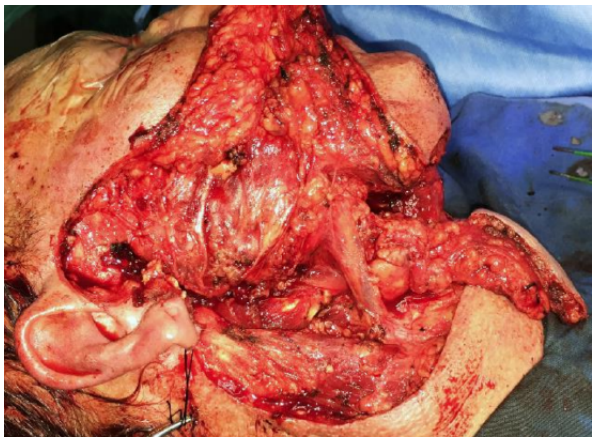


Figure 23b: Completed superficial parotidectomy and mobilized flap



Figure 23c: Flap ready to be inset



Figure 24: Closed donor site

- ***Raising the flap (SIF)***
  - Incise skin, subcutaneous fat, and platysma around the perimeter of the flap onto the mylohoid and contralateral digastric muscles (*Figure 19*)
  - Commence elevation of the flap inferiorly or on the contralateral side to the vascular pedicle
  - Divide and ligate the anterior jugular veins where they enter the flap inferiorly (*Figure 14*)
  - Elevate the flap off the contralateral digastric and mylohoid muscles up to the ipsilateral digastric (*Figures 20, 21*)
  - On the pedicled side of the flap, divide the anterior belly of digastric from its insertion onto the lesser cornu of the hyoid bone (*Figure 22*)
  - Include the anterior belly of digastric in the flap while reflecting the flap off the mylohyoid muscle to avoid injury to the two major perforators that run on either side to the digastric
  - The ***mylohoid vessels and nerve*** now come into view; branches to the submental artery may have to be divided
  - Divide the anterior belly of digastric superiorly at its insertion onto the mandible
  - The flap is now mobilized and can be transferred to the recipient site on its pedicle (*Figures 23a-c*)
- The donor site is closed over a suction drain (*Figure 24*)

Variations

1. If the SIF is to include ***skin of the submandibular triangle***, the superior flap should be raised in such a way to preserve the perforators between the submental vessels and the flap; this requires that the subplatysmal dissection is not carried beyond the upper margin of the submandibular salivary gland

2. If the ***submandibular gland is to be removed***, then the facial artery must be preserved by dividing the few small branches passing between the artery and the gland



Figure 25a: Large defect following resection of lateral and base of tongue cancer that crossed the midline posteriorly



Figure 25b: Submental flap outlined

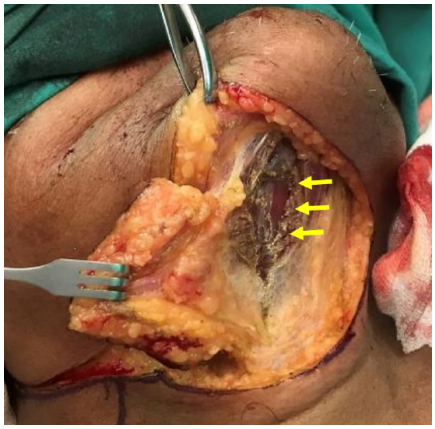


Figure 25c: Flap being elevated with mylohyoid divided along midline raphe (arrowed)

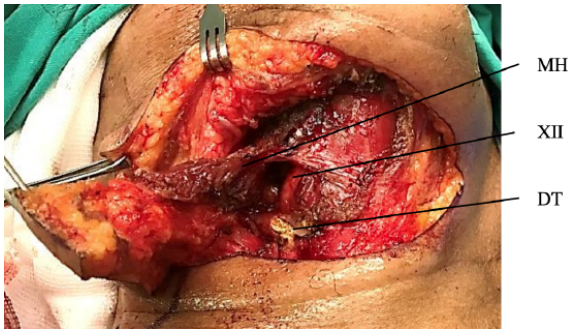


Figure 25d: Flap elevated with mylohyoid (MH) and digastric with divided digastric tendon (DT) and hypoglossal nerve (XIIn) visible

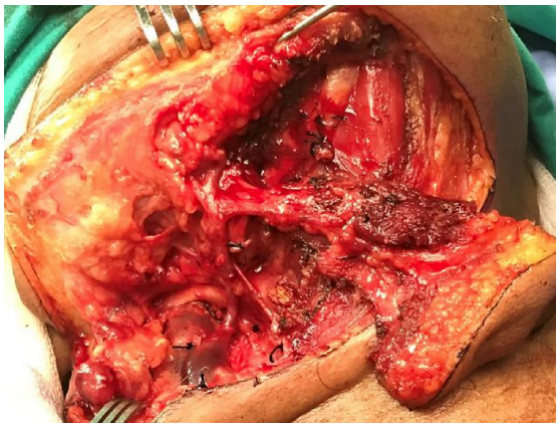


Figure 25e: Flap fully mobilized on vascular pedicle



Figure 25f: Flap delivered into mouth

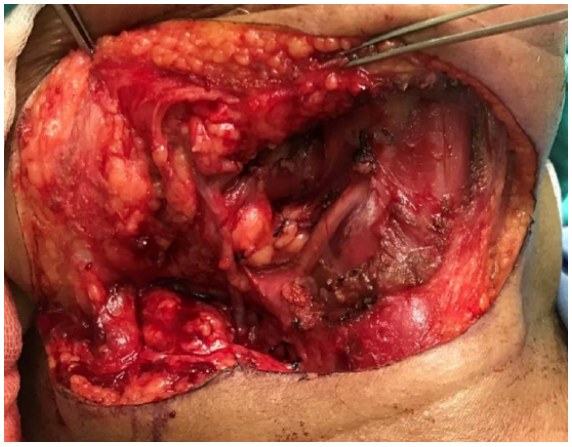


Figure 25g: View of vascular pedicle passing into mouth, divided digastric tendon, hypoglossal nerve, and cut edge of mylohyoid muscle

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Figure 25h: Final reconstruction

3. ***Including mylohyoid muscle*** in the flap (*Figures 25a-h*) http://www.ahns.info/resources/educa...d-flapharvest/

Some favor including the mylohyoid muscle in the flap to protect the distal vessels and perforators; or to provide additional bulk; or to provide direct access for the flap to the floor of the mouth. The release of the mylohyoid medially is done with electrocautery in the midline exposing the vertical orientation of the geniohyoid muscle; keeping the vessel protected between the mylohyoid and the anterior belly of the digastric is an excellent technique to protect the vascularization of the flap

- After mylohoid has been exposed in the submental triangle, the midline raphe between the two mylohyoids is divided to expose the geniohyoid muscles
- Divide the mylohyoid from the hyoid bone with electrocautery taking care not to injure the hypoglossal nerve or ranine veins
- Reflect the flap superiorly keeping deep to mylohyoid
- Divide the mylohyoid from the mandible superiorly *Figures 24a-h* illustrate a patient who underwent transoral resection of a large lateral and base of tongue cancer that crossed the midline posteriorly. The defect was repaired with a submental flap that included anterior belly of digastric and the mylohyoid muscle for additional volume.

4. ***Designing a large skin paddle***

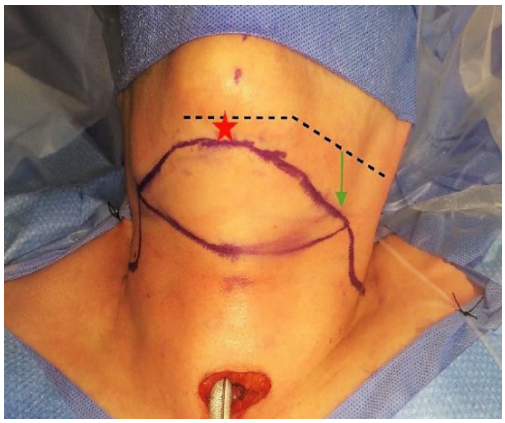


Figure 26: Skin paddle for large flaps: For extra width, the superior incision is done right under the lower border of the mandible (red star) and the lower incision as low as the pinch test allows in the submental area. Lateral extensions are drawn 4cm below the jaw line in the submandibular areas (green arrow)

For wide flaps, the superior incision is traced right under the mandible in the submental area and the inferior incision as low as the pinch test allows (*Figure 26*). The scar is then hidden under the jaw line and barely visible from a front view. For lengthy defects or when in need of a long reach, the skin paddle can be extended laterally as far as needed. To avoid hurting the marginal branch the lateral extensions are made about 4 cm below the jaw line (*Figure 26*).

5. ***Gaining additional pedicle length and arc of rotation***

- ***Facial artery***

- Divide the facial artery above the origin of the submental artery
- Free the facial artery from the submandibular salivary gland by dividing all its branches to the gland
- Even more length can be achieved by dividing the posterior belly of digastric to expose the facial artery behind the muscle to its origin from the external carotid artery

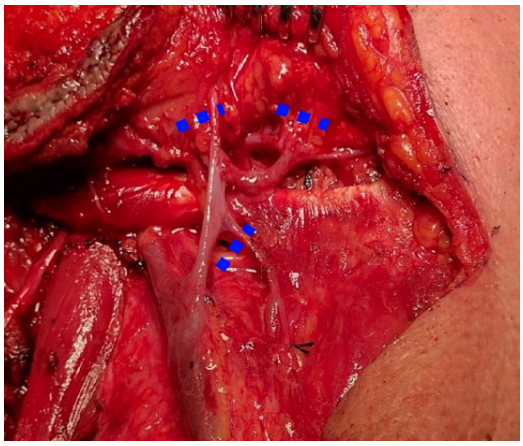


Figure 27: Gaining additional venous length and increasing arc of rotation by dividing veins at points shown

- ***Facial vein*** (*Figure 27*)
  - Divide the vein above the submental vein
  - Divide the posterior facial vein from the common facial vein

6. ***Reverse-flow SIF***

To reach more superior defects such as the upper face or the hard palate, the flap can be based on reverse-flow through the facial artery and vein by dividing the facial artery below the submental artery and the common facial vein below the submental vein or the posterior facial vein. There is however an increased risk of flap failure because of venous valves in the facial vein that can impair venous return in reverse flow flaps. A ***hybrid flap*** (facial artery pedicled, facial vein micro-anastomosed) can be done to avoid this complication.

7. ***SIF free microvascular transfer flap***

The SIF may be used as free microvascular transfer flap based either on the submental or the facial vessels. The limitation to rotate the submental flap higher superiorly is the vein; thus, to extend the submental flap more superiorly one must re-anastomose the submental vein with the retromandibular or temporal vein.

8. ***SIF with bone***

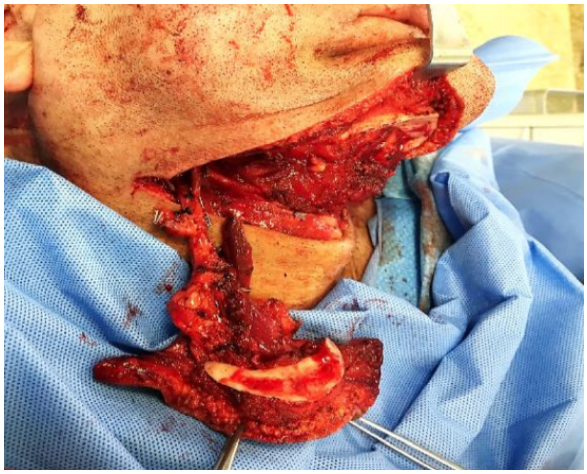


Figure 28a: Bone included in the SIF through an inferior marginal mandibulectomy in the symphysis/parasymphysis area

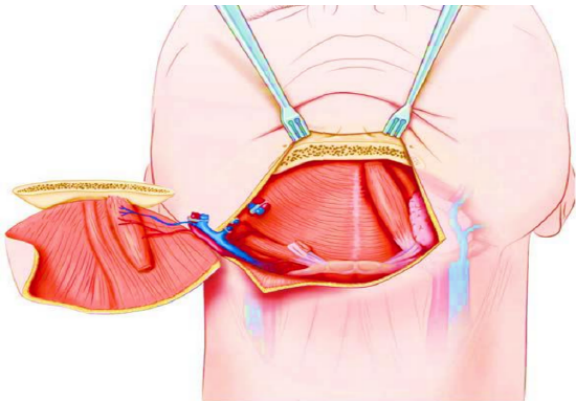


Figure 28b: Bone included in the SIF

An osteomyocutaneous SIF can be used to reconstruct small composite defects of the mandible, maxilla and orbit. A small rim of bone from the inferior part of the mandible in the symphysis and parasymphysis area is sectioned and kept attached to the flap (*Figures 28a,b*).

This inferior marginal mandibulectomy has little cosmetic impact on the shape of the mandible. One must consider that the freedom of motion between bone and skin will be very limited.

9. ***Deepithelialization***

The flap can be deepithelialized to counter the problem of hair growth in men.

Clinical examples

Case 1: *Figures 29a-d* illustrate a patient following resection of retromolar cancer, and reconstruction of the soft tissue defect with a submental flap.

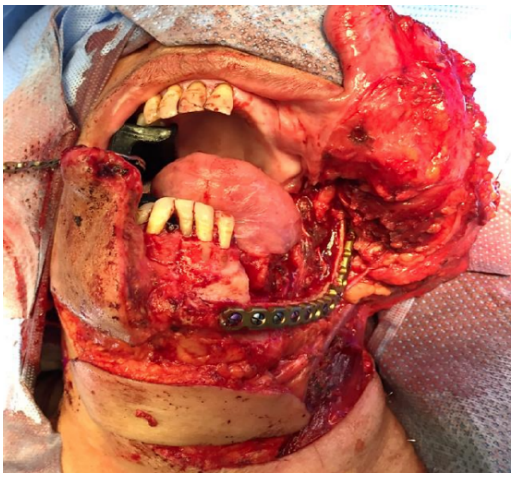


Figure 29a

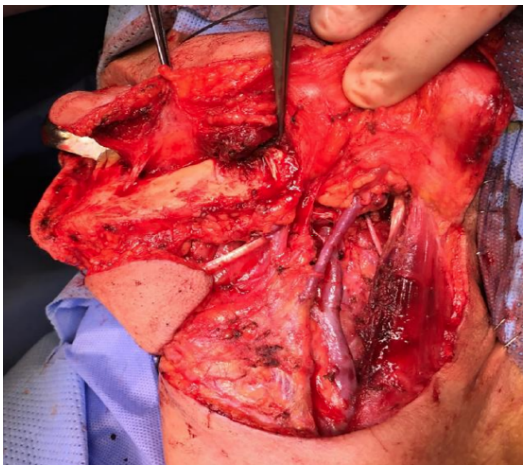


Figure 29b



Figure 29c



Figure 29d: Excellent cosmetic result and hidden scar post raising of an SIF flap to reconstruct the retromolar trigone deficit

Case 2: *Figures 30a-j* illustrate a patient who underwent a maxillectomy, in whom the orbital rim was reconstructed with a rim of mandible that was included in the submental flap.

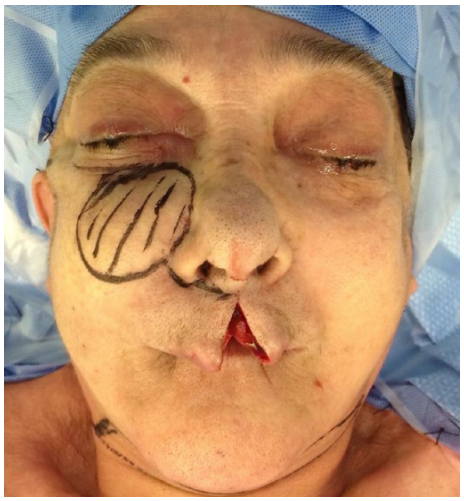


Figure 30a: Skin resection required



Figure 30b: Total maxillectomy defect



Figure 30c: Inferior marginal mandibulectomy

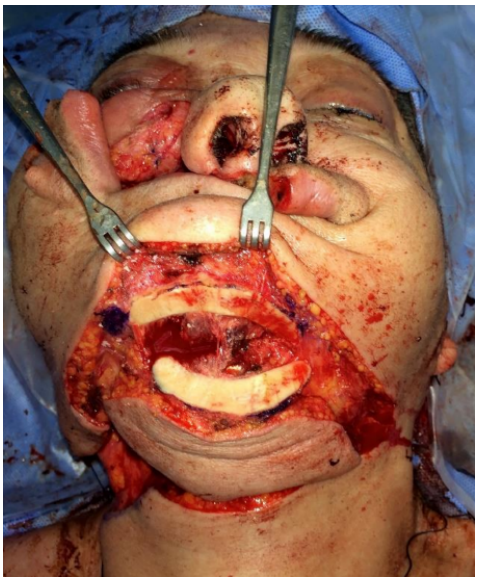


Figure 30d: Raising an SIF with inferior rim of the mandible



Figure 30e: Marginal mandibulectomy used to reconstruct inferior orbital rim



Figure 30f: Submental skin island used for infraorbital skin defect

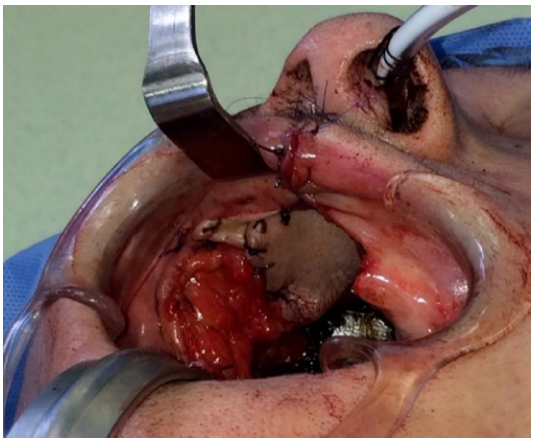


Figure 30g: Insetting the intraoral part of the flap after de-epithelialization of the middle part of the flap



Figure 30h: Completed reconstruction

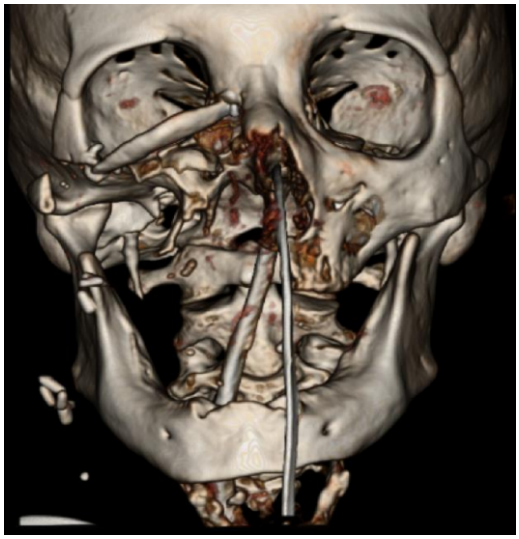


Figure 30i: Inferior orbital rim 6 months after the surgery

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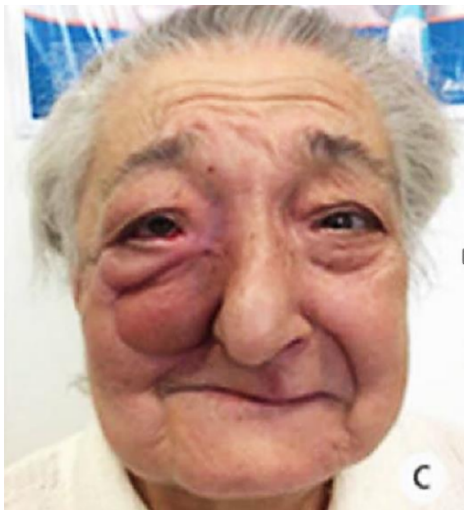


Figure 30j: Six months after SIF reconstruction of total maxillectomy

Case 3: *Figures 31a-d* illustrate a patient with a through-and-through defect of the cheek following wound complications after skin cancer resection and radiation therapy. The defect was repaired with a submental artery flap.



Figure 31a: Cheek defect



Figure 31b: Flap elevated with anterior belly of digastric muscle



Figure 31c: Note de-epithelialized strip to permit flap to be used both inside the mouth and externally



Figure 31d: Flap sutured into place

Case 4: *Figures 32a-c* illustrate employing a submental flap to reconstruct a large buccal mucosal cancer defect to avoid subsequent fibrosis and trismus

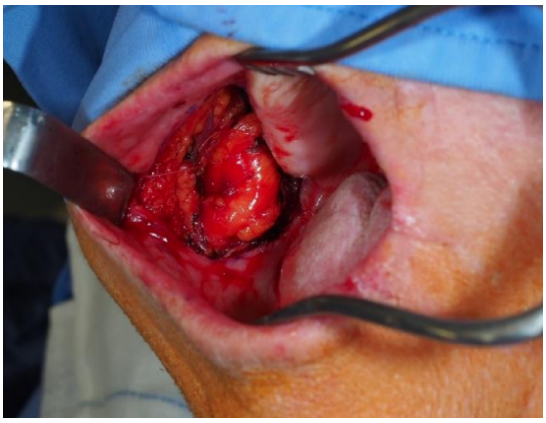


Figure 32a: Buccal defect

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Figure 32b: Flap outlined

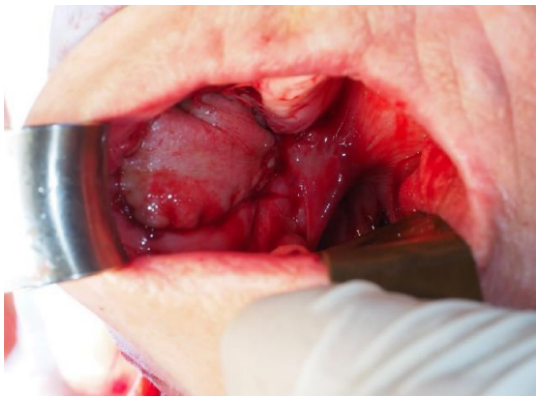


Figure 32c: Flap inset

Case 5: *Figure 33* illustrates the benefits of a submental artery island flap following resection of a large skin cancer of the cheek with parotidectomy in a patient with lupus, in terms of colour, texture and bulk.



Figure 33: Submental artery island flap prior to suturing to defect

Case 6: Buccal mucosal cancer resection defect in an elderly patient (Courtesy Zenon Yeung, Hong Kong)

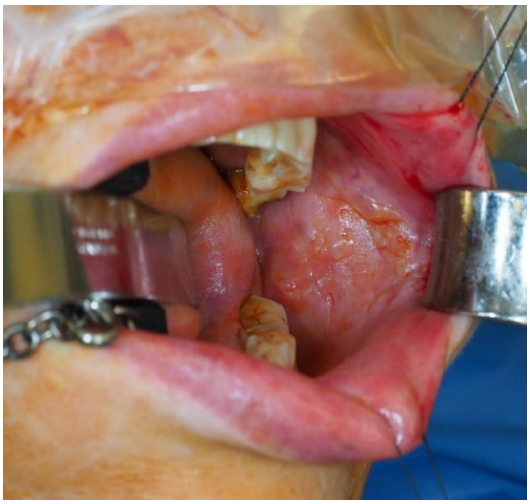


Figure 34a: Cancer of buccal mucosa

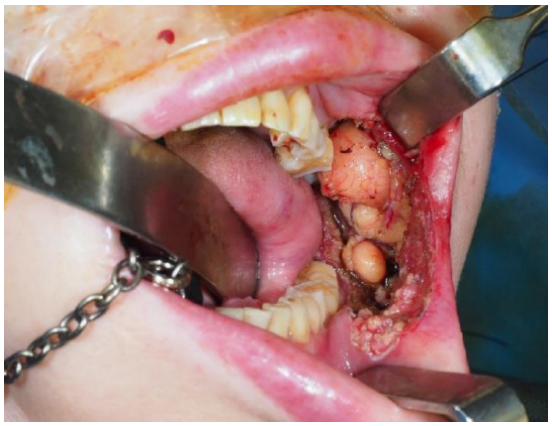


Figure 34b: Buccal defect with buccal fat visible

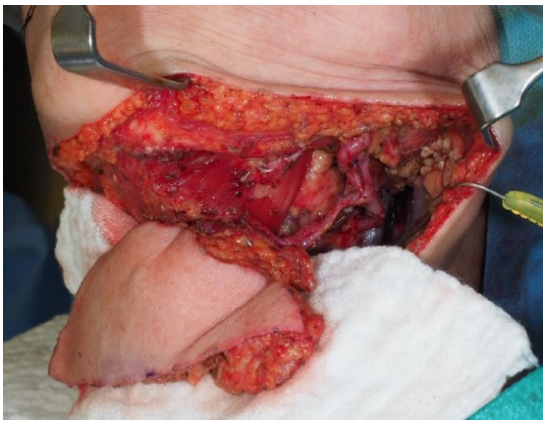


Figure 34c: Submental artery island flap prior to inset

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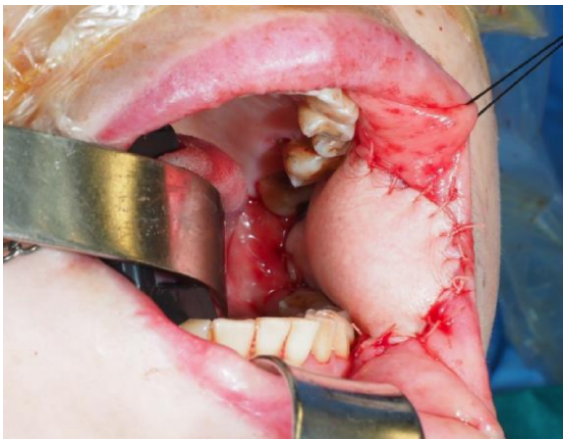


Figure 34d: Submental artery island flap sutured into defect

References

1. Faltaous AA, Yetman RJ. The submental artery flap: an anatomic study. Plast Reconstr Surg. 1996 Jan;97(1):56-60; discussion 61-2
2. Magden O, Edizer M, Tayfur V, Atabey A. Anatomic study of the vascularture of the submental artery flap. Plast Reconstr Surg. 2004 Dec;114(7):1719- 23

Video (American Head & Neck Society)

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Mohammad Alfalasi MD DES
Otolaryngology Residency Program Director
Tawam Hospital in affiliation with Johns Hopkins International
Abu Dhabi Al Ain, United Arab Emirates
mfelasi@hotmail.com

Tareck Ayad MD FRCSC
Associate Professor
Division of Otolaryngology Centre Hospitalier Universitaire de Montréal
Montreal, Canada
tareck.ayad@umontreal.ca

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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SUPRACLAVICULAR FLAP FOR HEAD & NECK RECONSTRUCTION

Marie-Renée Atallah, Mohammad Alfalasi, Tareck Ayad

The supraclavicular flap is a perforant pedicled fasciocutaneous flap with a reliable axial pattern, based on the supraclavicular artery. It is centered over the shoulder joint, extending from the supraclavicular region up to the lateral surface of the upper arm, overlying the deltoid muscle. It is well suited to restore lining and volume of head and neck defects, while preserving good function and acceptable cosmetic outcomes.

The supraclavicular flap was first described by Lamberty in 1979 [21]. However, because of a high incidence of distal flap necrosis, its use was limited at that time. In 1997, Pallua and Machens [3] described a modification of the flap, which was successfully used to reconstruct eight cases of neck contractures. They later published anatomical studies which helped the flap to regain respectability. Its use and indications have increased since then.

Surgical anatomy

Arterial vascular anatomy

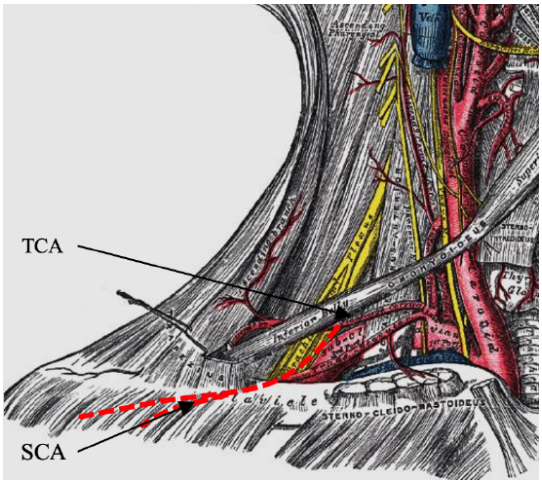


Figure 1: Typical anatomy of transverse cervical (TCA) and supraclavicular artery (SCA)

Transverse cervical artery (Figure 1): The transverse cervical artery branches off the thyro-cervical trunk in 60-95% of cases[1,5]. In the remaining cases, it originates from the first part of the subclavian artery. It courses along the base of the posterior neck and travels deep to the lateral part of the inferior belly of the omohyoid muscle. The diameter of the transverse cervical artery ranges from 2.5-3.5 mm[5]. It supplies the trapezius muscle and the skin over the shoulder through direct cutaneous branches located cephalad to the clavicular insertion of the muscle[2].

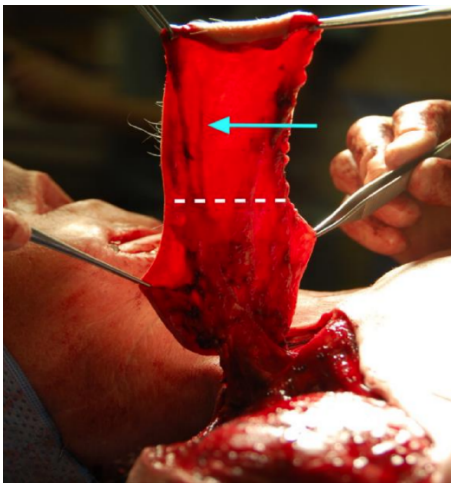


Figure 2: After the supraclavicular artery (arrow) exits from the deep fascia (area under the dotted line), it runs in a superficial plane

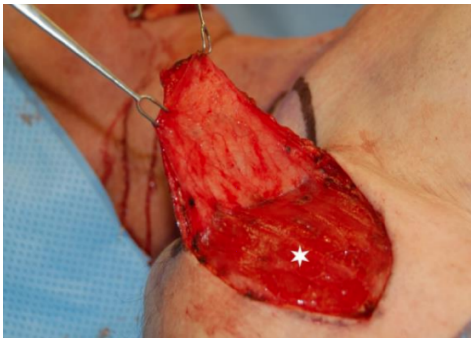


Figure 3: The supraclavicular artery generally divides into numerous branches over the deltoid muscle (white star) at the junction of the middle and lateral thirds of the clavicle

Supraclavicular artery (Figure 1): The supraclavicular artery generally originates from the transverse cervical artery [5,12]. Infrequently it arises from the suprascapular artery [1,4,5]. The supraclavicular artery has a diameter between 1-1.5 mm [5, 7, 14]. In 70-90% of cases its origin is in the area of mid-third of the clavicle [5,18]. In the remaining cases, it branches in the area of the lateral third of the clavicle. The supraclavicular artery then travels perpendicularly from the transverse cervical artery and pierces the deep fascia of the deltoid muscle 30 mm distally [5,14]. Before reaching this point, it can give off one or two small branches [5]. After its exit from the deep fascia, it runs in a superficial plane (*Figure 2*) and continues its course over the acromioclavicular joint, at the junction of the middle and lateral thirds of the clavicle. At this level, the artery generally divides into numerous branches over the deltoid muscle (*Figure 3*). These branches develop multiple anastomoses with the vascular network of the thoracoacromial artery [14], the posterior circumflex humeral artery [1] and the superficial branch of the transverse cervical artery [14].

These vessels form a consistent number of perforators interconnected by direct and indirect linking vessels through the subdermal plexus. Over the deltoid muscle, the direct linking vessels support the distal supraclavicular artery and drive the blood flow from the artery to the perforators. After the insertion of the deltoid muscle, their numbers decline and the vascularization of the distal flap relies principally on indirect linking vessels and recurrent flow. Thereby, beyond this point, the vascularization follows a random pattern and a higher incidence of necrosis is seen [14]. Accordingly, as described by Pallua and Noah [22], the angiosome extends from the supraclavicular region to the ventral surface of the deltoid muscle and ranges up to 10 cm in width and 22 cm in length.

Skin landmarks



Figure 4: The origin of the supraclavicular artery is located in a triangle bounded inferiorly by the clavicle (white line), medially by the posterior border of the sternocleidomastoid muscle (red line) and laterally by the external jugular vein (blue line)

The origin of the supraclavicular artery where it branches off the transverse cervical artery, is located in a triangle bounded inferiorly by the clavicle, medially by the posterior border of the sternocleidomastoid muscle and laterally by the external jugular vein [3] (*Figure 4*). It is found approximately 2.5-4 cm above the clavicle [7] and on average 2 cm posterior to the sternocleidomastoid muscle [22] and 6.5-10 cm from the sternoclavicular joint [5,7,18,22].

Venous anatomy

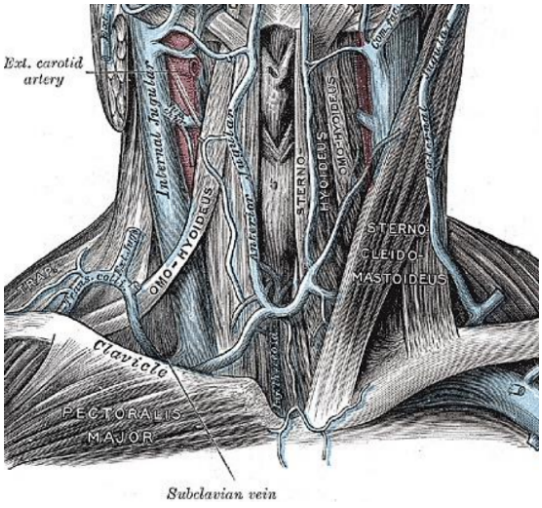


Figure 5: Transverse cervical vein

Two venae comitantes usually accompany the supraclavicular artery. They usually drain into the transverse cervical vein (*Figure 5*). One of the two veins may drain alternatively into the external jugular vein. They provide venous drainage to the skin proximal to the deltoid origin.

Distal to the deltoid's origin, the skin is drained by the subdermal veins, which in turn drain into either the cephalic vein or the comitant vein of the brachial artery [14]. There is also a secondary venous drainage for the skin over the deltoid via the perforating veins to the circumflex humeral veins.

Nerve anatomy

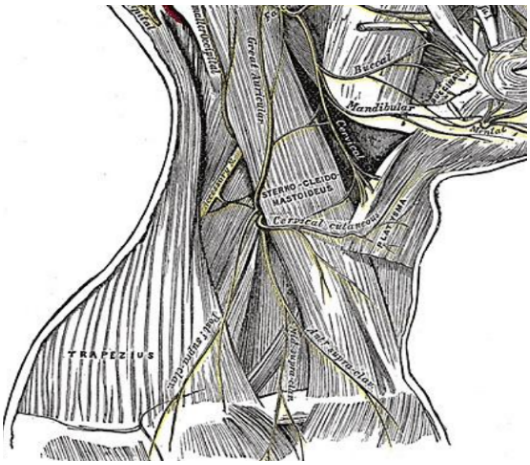


Figure 6: Medial, intermediate and lateral supraclavicular nerves

The 3rd and 4th cervical nerves merge and then arborise into 3 to 5 branches, forming the supraclavicular nerves [22] (*Figure 6*). These branches provide sensation to the region of the flap over the shoulder. They also supply the skin of the lateral neck and upper chest. The major cutaneous nerve root from the supraclavicular nerves pierces the deep fascia centrally with respect to the sternocleidomastoid muscle [15]. As this nerve root advances toward the pedicle, it gives two cutaneous branches, an anterior and a lateral branch. ***The anterior branch is located 1-2 cm anterior to the vascular pedicle and can sometimes be seen during flap harvest***.

Properties of supraclavicular flap

Raising a supraclavicular flap is a ***simple and quick*** procedure, usually done in less than an hour, and is a relatively ***easy to learn*** procedure. The flap is a good asset for the surgeon, as it is versatile and can correct multiple types of defects.

The flap is ***highly reliable*** and since the procedure is shorter than free flap reconstruction and does not require expertise in microsurgery, the supraclavicular flap is beneficial for high risks patients who can't sustain long operative time.

The supraclavicular flap is an excellent choice for reconstruction of skin defects in the lower face and neck because of a good ***texture and color match*** with the skin of the neck and lower face. It also has great ***pliability*** which makes it suitable for reconstruction of areas with high mobility, such as the neck and oral cavity. Also, since the skin in the supraclavicular area is generally ***hairless***, it is an appropriate for mucosal defects. The skin has a thin dermis and little fat, which accounts for the flap's ***thinness*** which makes it appropriate for reconstruction of contour sensitive areas such as the anterior neck and for pharyngeal defects in which a bulky flap may impair swallowing.

It can easily reach distant sites, such as the oropharynx, due to its ***long pedicle*** and ***broad arc of rotation***. It can also be used for ***large defects***, since the flap can reach a considerable size, with maximum dimensions of approximately ***10 x 20 cm***.

Indications

Historically the flap was used to reconstruct a variety of defects in the neck and lower third of the face, especially with release of scar contractures following burns, trauma or injuries with acid or Lye [3,16]. It is a good option for such defects because of its excellent color match and the skin properties being similar to the surrounding skin. The flap can also be used for head and neck oncologic reconstruction such as defects of the oral cavity, oropharynx, hypopharynx, and tracheostoma, and following parotid and pharyngoesophageal resection [4,12,13,17,20]. It has also been reported for reconstruction of the pinna [20,23] and lateral skull base [23]. More recently the flap has been successfully used to reconstruct defects following excision of massive arteriovenous malformations of the lower face [8] and in Noma patients [24]. It can be used as a primary choice of reconstruction but can also safely be used as a salvage procedure either after radiotherapy or after another flap failure.

Contraindications

The only absolute contraindication is when integrity of the pedicle has been compromised. This can occur in cases of radical neck dissection or neck dissection including Level V where the transverse cervical artery has been ligated. Other surgery that may damage the pedicle are shoulder surgery and excision of skin cancers in the shoulder area. It was previously stated that previous radiotherapy for the neck was a contraindication. It has now however been demonstrated that the flap can be safely used even in the

context of previous radiotherapy. If doubt exists concerning the integrity of the pedicle, it can be assessed using preoperative angiography.

Preoperative investigation

Although not routinely required, computed tomography angiography can be performed to assess the integrity of the vascular pedicle or when there is doubt about the supraclavicular artery anatomy.

Surgical technique

The supraclavicular flap can be employed as a rotation flap, tunneled flap, supercharged flap or as a free microvascular transfer flap. If a neck dissection is performed, then vessels to the distal external jugular vein and the transverse cervical artery need to be preserved.

Supraclavicular rotation flap

- Position the patient in a ***supine*** position with the ***head turned to the contralateral*** side
- Clean the entire neck and shoulder with an antiseptic solution
- ***Drape*** the patient to leave the neck, anterior chest and shoulder regions exposed



Figure 7: The origin of the supraclavicular artery is located in a triangle bounded inferiorly by the clavicle (white line), medially by the posterior border of the sternocleidomastoid muscle (red line) and laterally by the external jugular vein (blue line). The large "X" indicates the exact location of the supraclavicular artery, as identified by the Doppler



Figure 8: Patient with plate extrusion following total mandible reconstruction with a fibula flap and radiation therapy. The bone was viable. A supraclavicular flap was used for coverage of the soft tissue defect following removal of the plate. The base of the flap can reach the neck incision. The hatched part of the flap was included to allow primary closure without a dog ear deformity and was meant to be sacrificed after flap inset

- ***Draw*** the ***superficial landmarks for the supraclavicular artery*** i.e. clavicle, external jugular vein and posterior border of sternocleidomastoid (*Figure 7*)

- Use a ***Doppler probe to identify the supraclavicular artery*** in the triangle previously drawn, and mark its exact location on the skin (*Figure 7*)
- Use the ***finger pinch test*** to evaluate the elasticity of the soft tissue in the shoulder area to determine how much skin can be elevated and still allow primary closure
- ***Draw the skin island*** in an elliptical or fusiform design over the supraclavicular and shoulder / upper arm (*Figure 8*)
- ***Include the point where the supraclavicular artery pedicle*** was identified
- The base of the flap can be connected with the neck incision if needed (*Figure 8*)
- Design the size of the flap according to the defect to reconstruct; maximum size is approx. 12 cm wide x 21 cm long
- The insertion of the deltoid marks the farthest point that the flap can extend without concern for distal necrosis
- The flap can however be made longer if supercharged or pre-expanded
- Do not infiltrate the skin along the incision lines with a vasoconstrictor, as vasoconstriction might complicate assessment of flap perfusion



Figure 9: With the skin island flap delineated, the incision is taken down to the level of the deep fascia

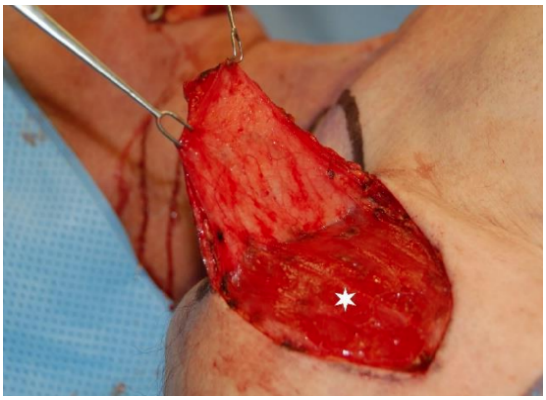


Figure 10: At the junction of the middle and lateral thirds of the clavicle, the supraclavicular artery generally divides into numerous branches over the deltoid muscle (white star)

- With the skin island flap delineated, incise the skin down to the level of deep fascia (*Figure 9*)
- Elevate the flap by dissecting from distal-to-proximal in a subfascial plane over the deltoid muscle (*Figure 10*); although some authors prefer to dissect from medial-to-lateral [3, 17]
- Elevate the flap using sharp (scalpel) dissection or needle monopolar electrocautery; when dissecting the proximal third of the flap, switch to bipolar electrocautery and cold dissection to avoid inadvertent injury to the supraclavicular artery

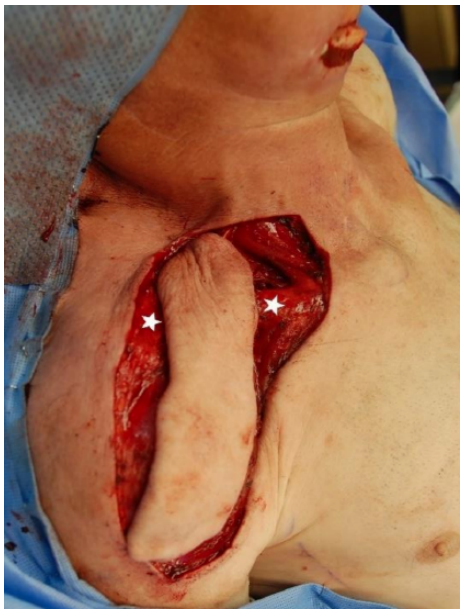


Figure 11: Over the clavicle, the flap is elevated over the periosteum of the clavicle (white stars)

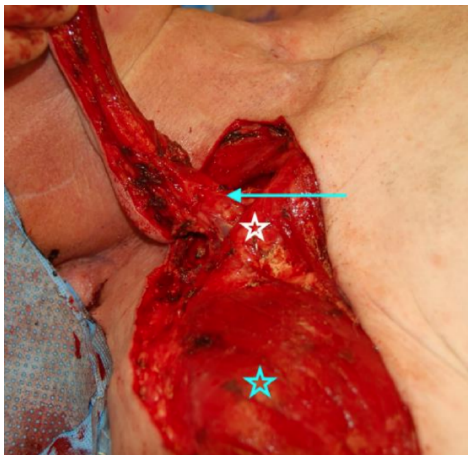


Figure 12: A moderate amount of fat (arrow) can be kept around the expected location of the supraclavicular artery to protect it from inadvertent damage and tension. The blue star is on the deltoid and the white star on the clavicle

- Elevate the flap over the periosteum of the clavicle (*Figure 11*)
- The ***pedicle does not need to be skeletonized*** unless extra mobility of the flap is required; a moderate amount of fat can be kept around the expected location of the supraclavicular artery to protect it from inadvertent damage and tension (*Figure 12*)
- If the pedicle needs to be skeletonized it can be precisely located with the help of a Doppler. The pedicle is then skeletonized and its attachments released



Figure 13: Subperiosteal dissection on the anterior surf

- Another technique to protect the pedicle is to perform a subperiosteal dissection on the anterior surface of the clavicle (*Figure 13*)
- Once the pedicle has been located, incise the skin island proximally
- With the flap completely elevated, trim the distal tip of the flap until proper bleeding is noted

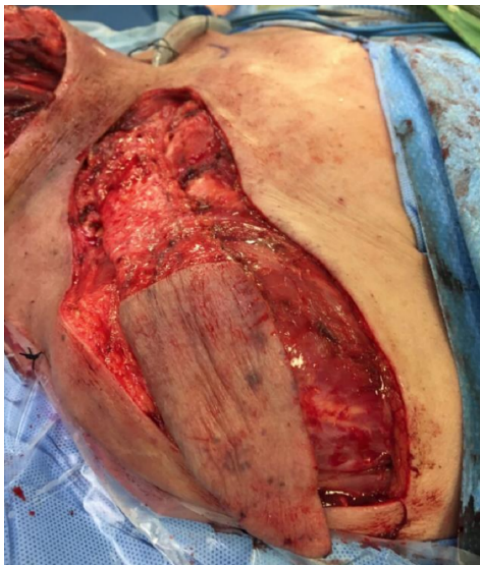


Figure 14: If the supraclavicular flap is tunneled, the proximal part should be deepithelialized



Figure 15: For intraoral reconstruction, the deepithelialized area can be large; care must be taken to preserve part of the dermis to protect the subdermal venous plexus

- If the flap is to be tunneled (*Figure 14*) or used to reconstruct a mucosal lining (*Figure 15*), the proximal portion is deepithelialized. Care must be taken to preserve part of the dermis to protect the subdermal venous plexus
- Rotate the flap to inset it into the defect



Figure 16: Extensive skin squamous cell carcinoma requiring wide local excision and functional neck dissection (Courtesy Dr Jackie Bibeau-Poirier)



Figure 17: The skin defect cannot be closed primarily. We elected to perform a supraclavicular flap to optimize color match and contour



Figure 18: Insetting flap following 1800 rotation. The donor site has been closed primarily

- The flap can tolerate 1800 rotation at its origin from the transverse cervical artery (*Figures 16, 17, 18*)
- Shape the flap to fit the defect and suture it into place; the last part of the flap to incorporate in the defect is the distal extremity, as it will be trimmed and discarded if not needed
- Take care not to stretch or kink the pedicle; keeping some fat around it helps to protect the pedicle
- Most donor sites can be closed primarily in a double layer fashion, using Vicryl 2-0 and staples (*Figure 18*); extensive undermining in a subcutaneous plane, anteriorly over the pectoralis major muscle and posteriorly over the trapezius muscle, is generally needed to close the donor site primarily
- Flaps that are wider than 10 cm are difficult to close without excessive tension. Options for closure in this case are split-thickness skin graft or a local flap harvested from the dorsal region [5,16]
- A suction drain is usually left in the donor site
- The skin island is monitored with coloration, refill and temperature for the first 72 hours

Tunneled flap

The same technique is generally used for tunneled flaps, with the added steps of deepithelialization of the flap and creation of a subcutaneous tunnel for its transposition. Tunneling has the advantage of providing superior aesthetic results. As the flap is thin, compression is rarely an issue. However, care should be taken to create a wide tunnel for the pedicle to avoid compromising the blood flow to the distal flap. Therefore, tunnel flaps are not recommended in previous radiated necks or with scar tissue.

Supercharged flap

The supraclavicular flap can be supercharged if a larger size is needed. The technique has been described using mostly the posterior circumflex artery. According to Vinh et al. [5], the anterior humeral artery, lateral thoracic artery perforator or the thoracoacromial artery perforator can be appropriate for supercharging.

Free flap

The application of the supraclavicular flap as a free flap has previously been described. Since the diameter of the supraclavicular artery is relatively small, its reliability is variable and we recommend using other options before reconstruction as a free flap is considered.

Complications

Superficial distal necrosis: Superficial distal necrosis occurs in 4%-22% of cases [2,5,16-19]. Principal causes are excessive tension on the pedicle and inappropriately long flaps. Excessive tension may result from tight closure, tunneling under scar or irradiated tissue, compressive dressings, postoperative neck edema or any other factors that may impair vascularization of the tip of the flap. Avoiding these may prevent distal flap necrosis. In most instances, the necrotic zones will reepithelialize naturally and no intervention is necessary.

Total flap necrosis: This is a dreaded complication, resulting from trauma to the supraclavicular artery during flap harvest. The incidence of total flap necrosis varies between 2-6% [5,9,19, 20]. Small and tortuous arteries which are more difficult to locate are risk factors for inadvertent injury to the pedicle. The modified supraclavicular island flap, in which fascia and fat are left surrounding the vascular pedicle may be helpful to prevent total flap necrosis.

Incisional dehiscence: Incisional donor site dehiscence occurs as a result of insufficient undermining when closing the donor site or use of an excessively large flap which results in excessive wound tension. The dehiscence is usually minor and resolve with local wound care. Vacuum assisted closure and skin graft are effective when the dehiscence is more significant.

Hematoma: This is a rare complication. It is important to recognize it promptly as it may prolong healing.

Seroma: Seromas develop in 0-15% [9] of cases and are generally treated with aspiration and wound care.

Shoulder dysfunction: There is minimal morbidity on the shoulder after the procedure. Few patients complain of shoulder pain after supraclavicular flap surgery and most of them respond well to antiinflammatories and physiotherapy. Around 14-22% [4,12,15,16] of patients describe referred sensation to the shoulder with sensate stimulus of the flap such as touching the flap or swallowing when the flap is used for mucosal lining. No paraesthesia or numbness over the shoulder area has been reported. Since the flap includes only skin, fat and fascia, upper limb movement is preserved [2,5,9]. When a limitation is present, it is generally temporary [2,9] and results from excessive tension on the closure causing a sensation of tightness over the shoulder area. Herr et al. [9] prospectively studied the shoulder function of 10 patients following supraclavicular flap with objective parameters. They showed that muscle strength was good to excellent in 90% of patients and that the limitations present were mostly range of motion, especially external rotation. Nonetheless, most patients are satisfied with the shoulder function [9,16] and appearance [5,16,20].

Clinical Cases

Case 1: A patient following total laryngectomy and partial pharyngectomy for hypopharyngeal cancer (*Figures 19-23*)



Figure 19: Mucosal defect requires reconstruction with a flap to avoid stenosis

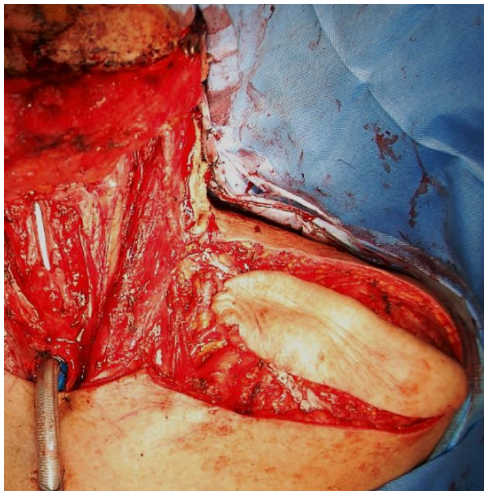


Figure 20: We elected to perform a left supraclavicular flap

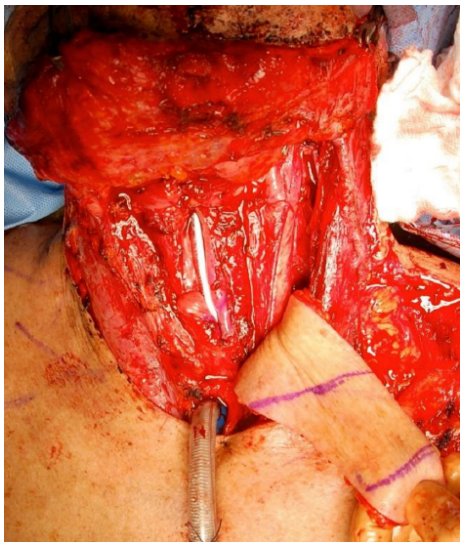


Figure 21: The skin in the central part of the flap between the purple lines was used to reconstruct the mucosal defect. The distal and proximal parts of the flap were deepithelialized and used for coverage and protection of the carotid axis

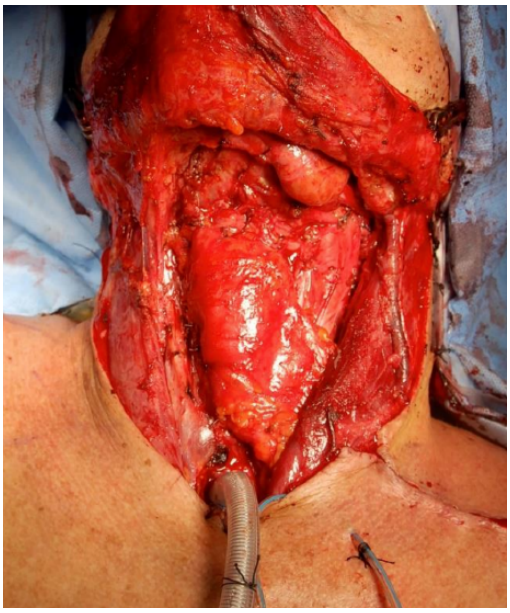


Figure 22: Flap inset



Figure 23: Scar in an irradiated area, 6 months following surgery

Case 2: 80-year-old female with cancer of buccal mucosa, inferior alveolus and floor of mouth involving skin. Underwent hemimandibulectomy, resection of skin and neck dissection. Reconstructed with pectoralis major (intraorally) and supraclavicular

artery island flaps (external skin)



Figure 24: Note cancer involving skin, and planning drawings of the pectoralis major and supraclavicular artery island flap



Figure 25: Supraclavicular artery island flap has been used to cover the skin defect, and pectoralis major for intraoral repair

Case 3: Squamous cell cancer of ear treated with superficial parotidectomy, lateral temporal bone resection and selective neck dissection.



Figure 26: Cancer destroying external ear and extending down ear canal



Figure 27: Completed superficial parotidectomy, lateral temporal bone resection and selective neck dissection



Figure 28: Supraclavicular artery island flap used to cover the lateral skull base defect

References

1. Lamberty BG, Cormack GC. Misconceptions regarding the cervicohumeral flap. Br J Plast Surg. 1983 Jan;36(1):60-3
2. Mathes SJ, Vasconez LO. The cervicohumeral flap. Plast Reconstr Surg. 1978 Jan;61(1):7-12
3. Pallua N, Machens HG, Rennekampff O, Becker M, Berger A. The fasciocutaneous supraclavicular artery island flap for releasing postburn mentosternal contractures. Plast Reconstr Surg. 1997 Jun;99(7):1878- 84; discussion 1885-6
4. Chiu ES, Liu PH, Friedlander PL. Supraclavicular artery island flap for head and neck oncologic reconstruction: indications, complications, and outcomes. Plast Reconstr Surg. 2009 Jul;124(1):115-23
5. Vinh VQ, Van Anh T, Ogawa R, Hyakusoku H. Anatomical and clinical studies of the supraclavicular flap: analysis of 103 flaps used to reconstruct neck scar contractures. Plast Reconstr Surg. 2009 May; 123(5):1471-80
6. DiBenedetto G, Aquinati A, Pierangeli M, Scalise A, Bertani A. From the "charretera" to the supraclavicular fascial island flap: revisitation and further evolution of a controversial flap. Plast Reconstr Surg. 2005 Jan;115(1):70-6

7. Chan JW, Wong C, Ward K, SaintCyr M, Chiu ES. Three- and fourdimensional computed tomographic angiography studies of the supraclavicular artery island flap. Plast Reconstr Surg. 2010 Feb;125(2):525- 31
8. Hormozi AK, Shafii MR. Supraclavicular flap: reconstructive strategy for massive facial arteriovenous malformations. J Craniofac Surg. 2011 May;22(3):931-6
9. Herr MW, Bonanno A, Montalbano LA, Deschler DG, Emerick KS. Shoulder function following reconstruction with the supraclavicular artery island flap. Laryngoscope. 2014 Nov;124(11):2478-83
10. Fischborn GT, Schmidt AB, Giessler GA. Prefabricated supraclavicular flap as a salvage procedure for a failed microvascular hypopharyngeal defect closure in a tetraplegic patient. Ann Plast Surg. 2011 Sep;67(3):245- 50
11. Goyal N, Emerick KS, Deschler DG, Lin DT, Yarlagadda BB, Rich DL, Durand ML. Risk factors for surgical site infection after supraclavicular flap reconstruction in patients undergoing major head and neck surgery. Head Neck. 2016 Nov;38 (11):1615-20
12. Giordano L, Di Santo D, Occhini A, Galli A, Bertino G, Benazzo M, Bussi M. Supraclavicular artery island flap (SCAIF): a rising opportunity for head and neck reconstruction. Eur Arch Otorhinolaryngol. 2016 Dec;273(12):4403-12
13. Emerick KS, Herr MA, Deschler DG. Supraclavicular flap reconstruction following total laryngectomy. Laryngoscope. 2014 Aug;124 (8):1777-82
14. Ross RJ, Baillieu CE, Shayan R, Leung M, Ashton MW. The anatomical basis for improving the reliability of the supraclavicular flap. J Plast Reconstr Aesthet Surg. 2014 Feb; 67(2):198-204
15. Sands TT, Martin JB, Simms E, Henderson MM, Friedlander PL, Chiu ES. Supraclavicular artery island flap innervation: anatomical studies and clinical implications. J Plast Reconstr Aesthet Surg. 2012 Jan;65(1):68-71
16. Loghmani S, Eidy M, Mohammadzadeh M, Loghmani A, Raigan F. The supraclavicular flap for reconstruction of post-burn mentosternal contractures. Iran Red Crescent Med J. 2013 Apr;15(4):292-7
17. Alves HR, Ishida LC, Ishida LH, Besteiro JM, Gemperli R, Faria JC, Ferreira MC. A clinical experience of the supraclavicular flap used to reconstruct head and neck defects in late-stage cancer patients. J Plast Reconstr Aesthet Surg. 2012 Oct;65 (10):1350-6
18. Nthumba PM. The supraclavicular artery flap: a versatile flap for neck and orofacial reconstruction. J Oral Maxillofac Surg. 2012 Aug;70(8): 1997-2004
19. Su T, Pirgousis P, Fernandes R. Versatility of supraclavicular artery island flap in head and neck reconstruction of vessel-depleted and difficult necks. J Oral Maxillofac Surg. 2013 Mar;71(3):622-7
20. Sandu K, Monnier P, Pasche P. Supraclavicular flap in head and neck reconstruction: experience in 50 consecutive patients. Eur Arch Otorhinolaryngol. 2012 Apr;269(4): 1261-7
21. Lamberty BG. The supra-clavicular axial patterned flap. Br J Plast Surg. 1979; 32:207-12
22. Pallua N, Magnus Noah E. The tunneled supraclavicular island flap: an optimized technique for head and neck reconstruction. Plast Reconstr Surg. 2000 Mar;105(3):842-51; discussion 852-4
23. Emerick KS, Herr MW, Lin DT, Santos F, Deschler DG. Supraclavicular artery island flap for reconstruction of complex parotidectomy, lateral skull base, and total auriculectomy defect. JAMA Otolaryngol Head Neck Surg. 2014 Sep;140(9): 861-6
24. Hartman EH, Van Damme PA, Suominen SH. The use of the pedicled supraclavicular flap in noma reconstructive surgery. Plast Reconstr Surg. 2006 Jul;118(1):270-1

Videos

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction

- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap

Authors

Marie-Renée Atallah MD
Resident
Otolaryngology - Head & Neck Surgery
Centre Hospitalier de l'Université de Montréal
Montreal, Canada
marie-renee.atallah@umontreal.ca

Mohammad Alfalasi MD DES
Otolaryngology Residency Program Director
Tawam Hospital in affiliation with Johns Hopkins International
Abu Dhabi Al Ain, United Arab Emirates
mfelasi@hotmail.com

Tareck Ayad MD FRCSC
Associate Professor
Division of Otolaryngology
Centre Hospitalier Universitaire de Montréal
Montreal, Canada
tareck.ayad@umontreal.ca

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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ANTEROLATERAL THIGH (ALT) FREE FLAP FOR HEAD AND NECK RECONSTRUCTION

Patrik Pipkorn, Ottie van Zyl

The Anterolateral Thigh (ALT) flap has gained increased popularity for head and neck reconstruction, mainly due to its minimal donor site morbidity.

Although it is a fasciocutaneous flap, it can be harvested with a cuff of vastus lateralis muscle. It is based on perforators of the descending branch of the lateral circumflex femoral artery and can provide large areas of vascularized skin for reconstruction. It can be used for any soft tissue reconstruction including facial skin, oral cavity e.g. partial or total glossectomy, and as semitubed or tubed flaps for pharyngeal defects.

Benefits of the ALT flap include

- Minimal functional and cosmetic donor site morbidity
- The scar may be hidden under clothing
- Up to 10x25 cm of skin can be harvested and still achieve primary closure of the donor site
- Even larger areas of skin can be harvested with split thickness graft coverage of the donor site
- Long vascular pedicle
- 2-5 mm diameter artery
- Donor site far from head enabling two-team approach
- Once the surgeon is familiar with the anatomy and its variations, it is easy and quick to harvest
- Can be harvested as a sensate flap using the lateral femoral cutaneous nerve
- Access to branches of femoral nerve to harvest nerve grafts e.g. for facial nerve reanimation
- Most of the flap can be raised without committing to a final design; this permits one to start harvesting the flap before knowing the final dimensions of the defect

Caveats include

- A bulky flap in patients with large thighs may preclude its use
- Significant perforator and vascular variations make it a somewhat more challenging flap for inexperienced microsurgeons
- The scar is always long, often stretched and unsightly; if a skin graft is required for donor site closure, the cosmetic result may be poor

Surgical anatomy

A sound knowledge of the anatomy of the anterolateral thigh is essential before attempting to harvest an ALT flap.

Fasciae and muscles (Figures 1, 2)

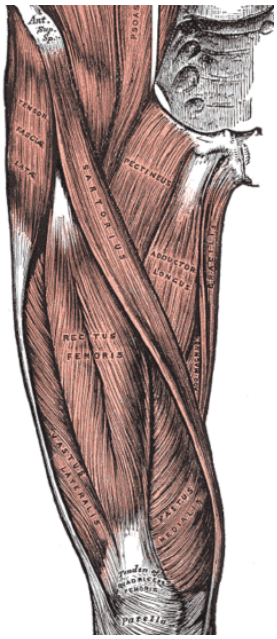


Figure 1: Muscles of thigh

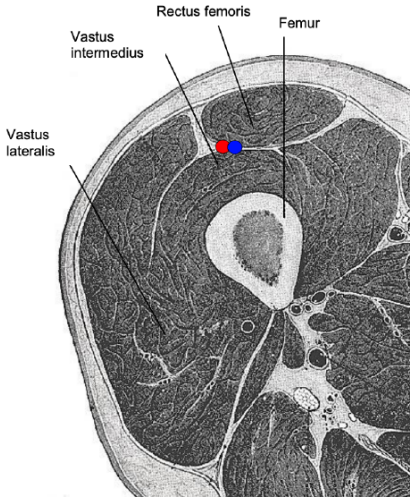


Figure 2: Cross-sectional anatomy of thigh indicating position of descending branch of lateral circumflex femoral artery and venae comitantes

The fascia lata is the deep fascia of the thigh, and completely encircles the muscles of the thigh. Its thickness varies; laterally it becomes thicker as it forms the iliotibial tract, a structure that runs to the tibia and serves as a muscle attachment. Superolaterally the fascia lata splits and encloses the tensor fascia lata muscle.

The thigh is divided into ***three separate compartments*** by septa. Each compartment has its own blood and nerve supply. The compartments are:

1. Anterior fascial compartment containing the extensors
2. Posterior fascial compartment containing the flexors
3. Medial fascial compartment containing the adductors

As only the anterior fascial compartment is encountered when harvesting the ALT flap, the other compartments are not further described in this chapter.

Muscles in the anterior compartment of the thigh include the pectinus, sartorius, and the four muscles of the quadriceps i.e. rectus femoris, vastus medialis, vastus intermedius and vastus lateralis. ***All the quadriceps muscles, except the vastus medialis, are encountered*** during ALT flap harvest.

The rectus femoris occupies the middle of the thigh. It originates on the ilium and attaches to the tibia via the patella. The other three vastus muscles originate from the body of the femur and join the rectus femoris by a strong tendon at the patella. The vastus intermedius lies deep to the rectus femoris and is not seen until this muscle is reflected. The sartorius is sometimes encountered superiorly when harvesting the flap, especially when opening the compartment between rectus femoris and vastus lateralis to gain access to the proximal vascular pedicle (*Figure 1*). It is a thin, superficial muscle that arises by tendinous fibers from the anterior superior iliac spine and runs obliquely across the upper and anterior part of the thigh in an inferomedial direction. It joins the tendons of gracilis and semitendinosus on the medial aspect of the knee as the pes anserinus before it attaches to the medial aspect of the tibia.

Vascular anatomy (Figures 2, 3)

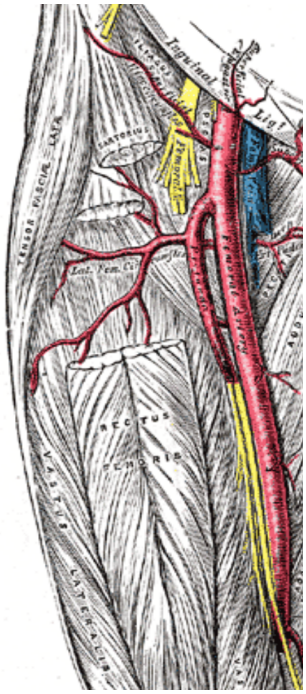


Figure 3: Lateral femoral circumflex artery branches from profunda femoris

Where the external iliac artery passes under the inguinal ligament it becomes the common femoral artery. The common femoral artery gives off the profunda femoris artery and continues as the superficial femoral artery.

The lateral femoral circumflex artery arises from the lateral side of the profunda femoris, passes horizontally between the divisions of the femoral nerve, and behind the sartorius and rectus femoris, and divides into ascending, transverse, and descending branches. The lateral femoral circumflex artery may occasionally arise directly from the femoral artery.

The ascending branch of the lateral circumflex femoral artery passes superiorly, underneath the tensor fasciae lata muscle and eventually anastomoses with branches of the deep circumflex iliac artery.

The descending branch of the lateral circumflex femoral artery runs inferiorly, under the rectus femoris, and along the anterior aspect of vastus lateralis (*Figure 3*). The continuation of this artery anastomoses with the superior lateral genicular artery.

A distinct oblique branch of the lateral femoral circumflex artery is found in about 35% of cases. It lies proximal, between the lateral and descending branches of the lateral femoral circumflex artery and most commonly arises from one of the above two branches. It enters the vastus lateralis in its proximal third.[2]

The transverse branch of the lateral circumflex femoral artery passes laterally over the vastus intermedius and pierces the vastus lateralis (*Figure 3*).

Perforator concept and variability

Most of the body's skin is supplied by perforators from larger vessels that run deep to muscles. These perforators branch out to supply the subdermal plexus. Perforators can be septocutaneous (S) or musculocutaneous (M); with ALT flaps, approximately 85% are musculocutaneous and 15% are septocutaneous.

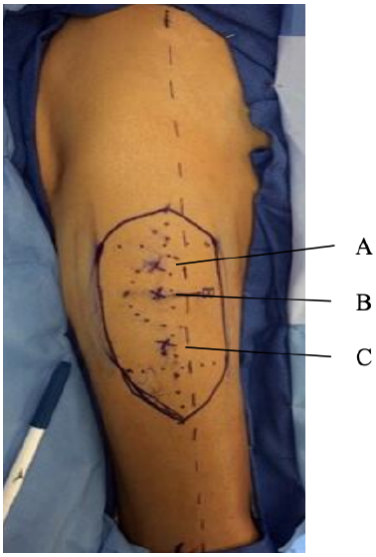


Figure 4: Perforators of (R) thigh

When raising an ALT flap, perforators can conveniently be named Perforators “A”, “B” and “C” (*Figure 4*).

- ***Perforator B*** is the most reliable and is present in about 90% of legs. It enters the skin about midway between the anterior superior iliac spine and the patella
- ***Perforator A*** is located about 5 cm proximal to “B” and is present in about 50% of legs
- ***Perforator C*** is located 5 cm distal to “B” and is present in about 60% of legs

Twenty five percent of legs have only one perforator; 50% have 2 perforators; and 24% have 3 perforators. About 1% have no perforators at all; in such cases a perforator is found on the contralateral side in about 2/3 of cases.[1]

Innervation

Motor innervation (Figure 5)

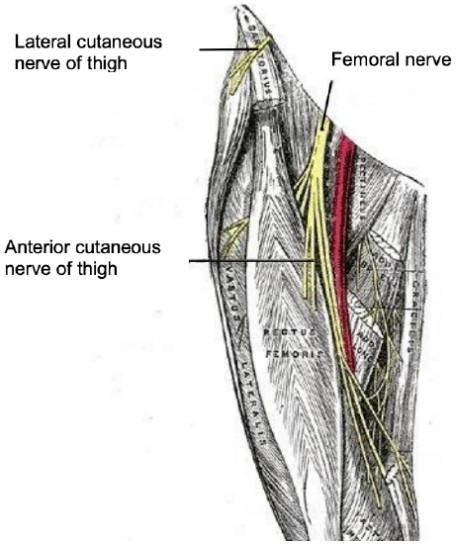


Figure 5: Lateral and anterior cutaneous nerves of thigh

The ***femoral nerve*** arises from the ventral rami of the 2nd to 4th lumbar nerves. After passing through the psoas major muscle and beneath the inguinal ligament, it enters the thigh and splits into anterior and posterior divisions. From the posterior division, a branch enters the rectus femoris on its inner surface. A large branch from the posterior division accompanies the descending branch of the lateral femoral circumflex artery to the lower part of vastus lateralis.

The ALT flap can be harvested as a sensate flap by including the ***lateral cutaneous nerve*** of the thigh. This nerve arises from the lumbar plexus. As it enters the thigh, it passes under the inguinal ligament, through the lacuna musculorum. An ***anterior cutaneous***

branch becomes superficial about 10 cm below the inguinal ligament where branches provide sensation to the anterior and lateral thigh.

Chimeric ALT flaps

Chimeric flaps consist of multiple independent flaps that each have an independent vascular supply, with all pedicles linked to a common vessel of origin. Once familiar with the anatomy of the ALT flap and its variations, different chimeric flaps can be fashioned. When there are robust perforators, separate skin paddles can be harvested if two separate defects exist, such as for an internal and external lining. The flap can also be harvested with a separate cuff of muscle based on the distal pedicle; or alternatively based on the transverse branch of the lateral circumflex femoral artery.

Informed consent

Discussion should include the risk of seroma or hematoma formation and development of an unsightly scar. Patients must also be counseled about the general risks of free flap surgery, such as flap failure and needing to re-explore a failing flap.

Prepping and draping

- Internally rotate the leg to enable easier harvesting, by elevating the ipsilateral hip off the bed with a folded sheet, a vacoliter, or 3-liter bag placed under the buttock
- Prep the anterior, medial and lateral thigh
- Drape in a sterile fashion to expose the thigh from the inguinal ligament to just below the knee
- Expose enough skin posteriorly to not limit surgical access

Flap design

Identify where perforators enter the skin

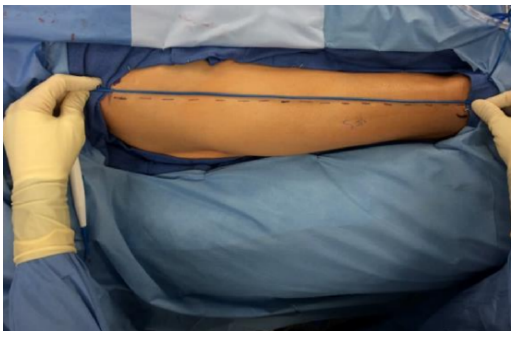


Figure 6: Straight line from anterior iliac spine to lateral patella of (R) leg

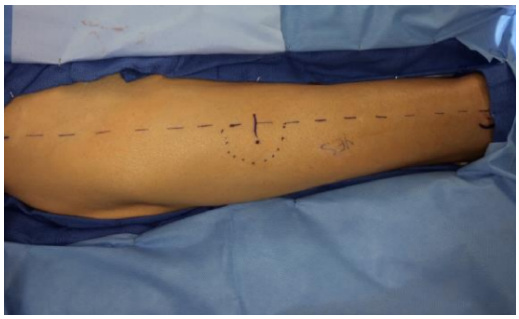


Figure 7: Mark 2 cm lateral to midpoint of this line and draw a 3 cm radius

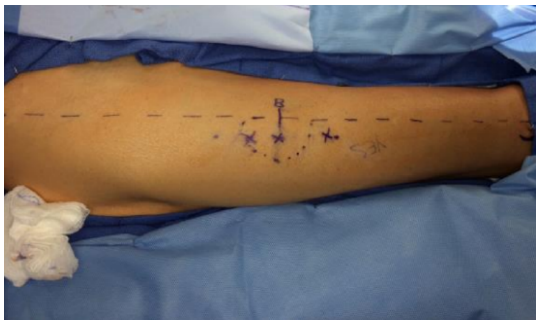


Figure 8: Perforators mapped with Doppler

- Draw a straight line from the anterior iliac spine to the lateral border of the patella (*Figure 6*)
- Make a mark 2 cm lateral to the midpoint of this line; it is usually possible to locate a dominant perforator within a 3 cm radius around this point (*Figure 7*)
- Although Doppler has poor specificity, it is useful early in one's career to map the perforators. It provides one with a good sense where the perforators are, and influences where the flap is placed (*Figure 8*)

Tentative design of the flap



Figure 9: Tentative flap design based on location of perforators

- It is based on the location of the perforators (*Figure 9*)
- The design can later be modified depending on where the perforators are found to be located at surgery
- Be careful to not to blindly commit the design to the Doppler perforator location

Flap Harvest

Commence with a medial incision (Figures 10, 11)

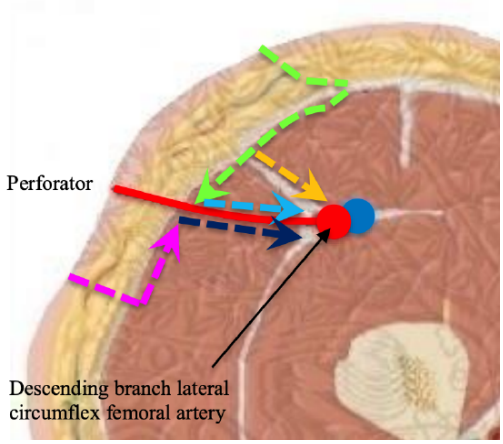


Figure 10: Sequence of surgical steps for pedicle skeletonization or muscle cuff perforator dissection

1. *Medial Elevation*
2. *Septal dissection between vastus intermedius and rectus femoris*
3. *Deroofing*
4. *Perforator skeletonisation*
5. *Lateral flap elevation*

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Figure 11: Commence with a medial incision

- The position of the medial incision is critical
- ***If placed too medially***, the flap width, (to included perforators which may be situated more laterally than expected) may end up being too wide to achieve primary skin closure
- More often, however, the incision is ***placed a little too lateral*** with the perforators piercing the deep fascia alarmingly close to the medial edge of the flap
- ***Therefore, bevel the dissection medially*** to ensure that perforators are not injured if the flap was placed too laterally (*Figure 10*)
- Extend the subcutaneous dissection medially while checking for perforators or suprafascial fascial vessels running laterally, before incising the deep fascia on the surface of the rectus femoris

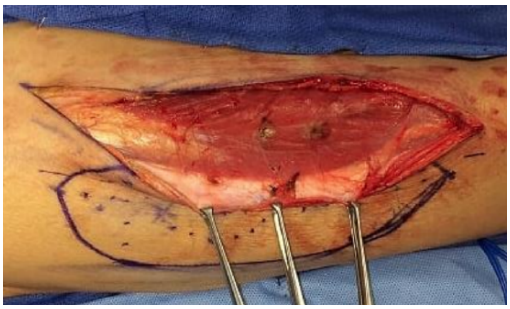


Figure 12: Medial incision through skin and fascia lata lifting fascia off the rectus femoris; ensure that the correct compartment has been entered; note fishtail configuration of rectus femoris

- Extend the incision longitudinally, ensuring that the correct compartment has been entered (*Figure 12*)
- The rectus femoris has a typical fish tail pattern with the “arrows” pointing towards the groin (*Figure 12*)

Look for the perforators emerging from the thigh and entering the fascia and skin (Figure 13)

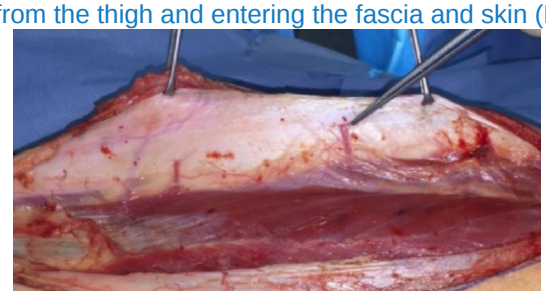


Figure 13a: Instrument points to a musculocutaneous perforator

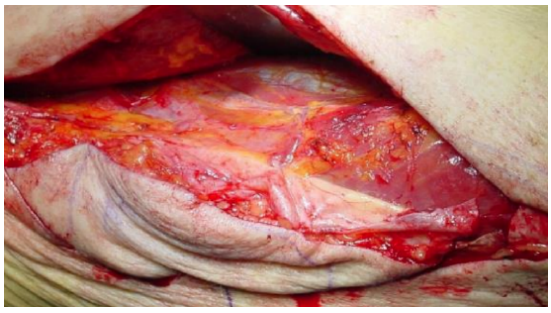


Figure 13b: Septocutaneous perforator (Right leg)

- This surgical step needs to be performed with ***utmost care*** as it is easy to injure the perforators at this stage

- Always maintain an absolutely dry, ***bloodless field*** when doing perforator flap surgery to ensure excellent vision of the perforators
- Initial identification of the perforators may be best done by standing on the opposite side of the patient, while the assistant elevates the lateral fascia with skin hooks
- Retract the muscles medially with a raytec swab and incise the thin fascia over the rectus femoris
- Maintain this counter traction and skeletonize the muscle laterally with great care using a No. 15 blade, while looking for perforators
- If no septocutaneous perforators are found, divide the thin fascia over vastus lateralis and continue to skeletonize laterally over the latter muscle
- Always continue looking proximally and distally for more perforators
- Then, using scissor-spread dissection, check for more laterally placed perforators
- Do not divide secondary perforators until the major perforator has been dissected without being traumatized
- Large flaps require >2 perforators; it is worthwhile including more perforators even in small flaps if they are nearby
- Once one has located all the perforators and ensured that no further perforators exist, proceed to locate the pedicle

Locating the pedicle

- Incise the thin fascia surrounding the rectus femoris



Figure 14: Sliding a finger between rectus femoris and its fascia

- Slide a finger between the muscle and the fascia to open this plane (*Figure 14*)
- Retract the rectus femoris muscle medially
- Superiorly the sartorius is encountered and is retracted medially to enable easy exposure of the pedicle later during the surgery
- The pedicle should now be visible as it runs deep to the rectus femoris on top of the vastus intermedius

Perforator dissection

- Perforator dissection should always be done with controlled tension, gently stretching the vessel. The assistant retracts nearby muscles with a skin hook or catspaw

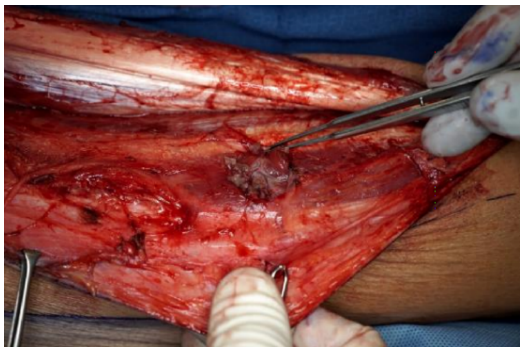


Figure 15: Dissecting through muscle leaving a small cuff of vastus lateralis on the perforator

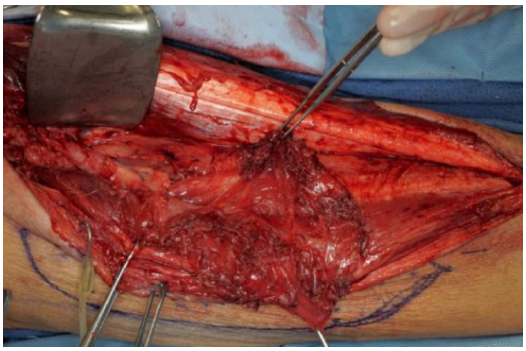


Figure 16: Perforator dissection

- As the perforators are most often musculocutaneous, they are followed through the muscle until they meet the pedicle (*Figures 15, 16*)
- Anterior/superficial to the perforators there are very few branches entering vastus lateralis and the muscle can be divided relatively bloodlessly
- Always stay on the surface of the vessels and avoid losing sight of its course and thus accidentally injuring the vessels
- Dissect with a fine, blunt tipped scissors using a spreading action, and under direct vision
- Cut the anterior muscle with scissors
- Compete this “de-roofing” procedure with all the perforators
- Skeletonize the perforators meticulously, working from distal to proximal
- Very small side and deep branches may be coagulated with bipolar coagulation, but always at a safe distance away from the perforator
- Use small Liga clips to divide larger branches
- ***Muscle cuff perforator dissection*** is an alternative method and is also done following deroofing. Instead of complete perforator dissection, a ***small cuff*** of muscle around the underside of the perforator is included or, alternatively, one can omit the perforator dissection completely and instead harvest a ***large cuff*** of muscle to ensure that the perforators are incorporated within the muscle. With both these procedures, one may encounter troublesome bleeding from side branches which, being surrounded by muscle, require more robust coagulation and thus, without having perfect visualization of the perforator, can cause perforator injury.

Dissecting the vascular pedicle

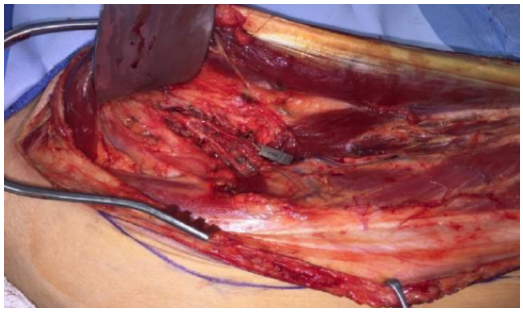


Figure 17: Pedicle exposed

- Follow the pedicle proximally until a decent caliber artery and vein are identified (*Figure 17*)
- Large branches to the undersurface of rectus femoris are encountered
- Significant variations in vascular anatomy are encountered especially of the vein. The two venae comitantes often merge into a single vein before entering the deep femoral vein
- With gentle blunt dissection, separate the fascia lata from the vastus lateralis lateral to the perforators

Making the lateral skin incision

- Ensure that the flap design does not need to be readjusted before making the lateral skin incision



Figure 18: Incise skin, subcutaneous tissue down to fascia lata

- Incise the skin and subcutaneous tissue down to fascia lata (*Figures 10, 18*)
- A cuff of fascia lata can be incorporated as needed



Figure 19: With a finger protecting the perforators incise the fascia

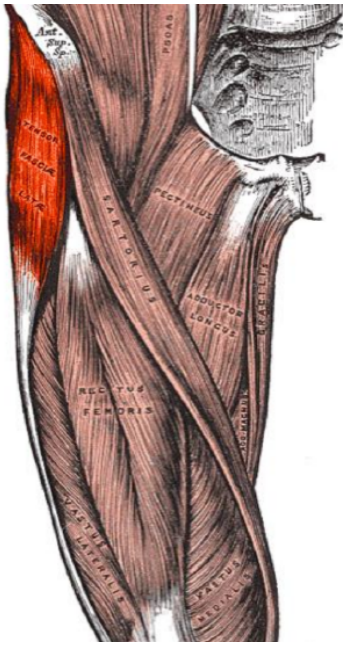


Figure 20: Tensor lata fascia and muscle

- Incise the fascia while protecting the perforators with a finger placed in the previously created tunnel lateral to the perforators (*Figure 19*)
- Superiorly the fascia lata splits, with the tensor fascia lata muscle located between these fascial layers (*Figure 20*)
- Depending of what the reconstructive needs are, a cuff of muscle can be harvested. Unless a muscle cuff is needed, ensure that you dissect on the inner aspect of this fascia

- While keeping the perforators in view, continue the back-dissection while protecting the pedicle (*Figure 10*)
- Use skin staples to secure the flap to the donor site to avoid inadvertent traction injury to the pedicle while preparing the vessels in the neck

Harvesting the flap

- Ligate the artery and vein with suture ligatures

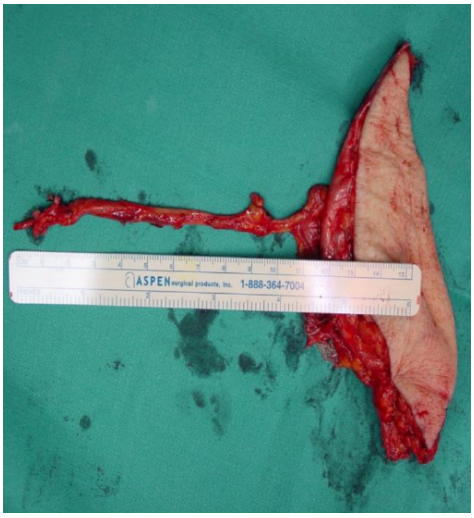


Figure 21: ALT flap

- Harvest the flap (*Figure 21*)
- Use utmost care when transferring the perforator pedicle to the donor vessel site to avoid rotation of the pedicle which may cause vascular compromise and flap loss
- The surgical technique of microvascular anastomosis is discussed in the chapter: Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery
- Following completion of the microvascular anastomosis, it may be prudent to anchor the pedicle to the surrounding tissues in the neck with 6/0 nylon to avoid rotation or kinking of the perforator and vascular pedicle

Closure of the thigh

- Achieve meticulous hemostasis
- Insert a closed suction drain



Figure 22: Closure with suction drain

- Close the leg in layers using absorbable sutures for deep dermis and staples or subcuticular sutures for skin; subcuticular absorbable skin sutures yield a better cosmetic result (*Figure 22*)
- Suprafascial skin flaps may be raised to achieve a tension free closure
- Occasionally the donor defect must be skin grafted. Skin graft take on muscle is very reliable but does compromise cosmesis

Postoperative care

- Mobilize the patient on Day 1
- Maintain drains until output <50mL/24hrs
- One commonly sees a transient increase in drainage output with immobilized patients once the patient starts to be mobilized
- Remove skin staples 2 weeks postoperatively

Clinical examples



Figure 23: ALT used for total glossectomy

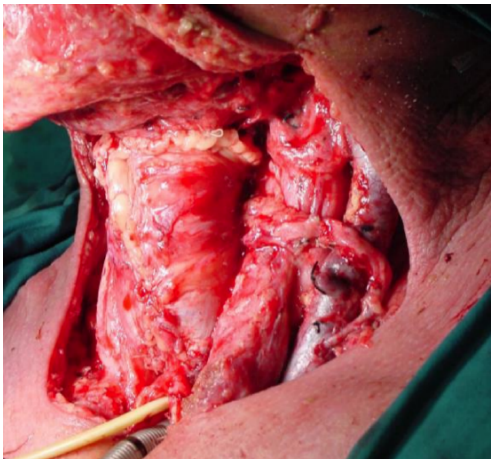


Figure 24: Tubed ALT flap used to replace hypopharynx and cervical esophagus



Figure 25: ALT used for facial soft tissue defect; note inferior color and texture match



Figure 26: ALT flap used for inferior maxillectomy defect

References

1. Yu P. Characteristics of the anterolateral thigh flap in a Western population and its application in head and neck reconstruction. Head Neck 2004;26: 759-69
2. CH Wong, FC Wei, B Fu, YA Chen, JY Lin. Alternative vascular pedicle of the anterolateral thigh flap: The oblique branch of the lateral circumflex femoral artery. Plast Reconstr Surg. 2009:123: 571-7

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental Artery Island flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Patrik Pipkorn MD, Assistant Professor
Head Neck, Microvascular Reconstruction
Department of Otolaryngology, Head and Neck Surgery
Washington University
St Louis, MO, USA
pipkornp@ent.wustl.edu

JE (Ottie) Van Zyl MBChB, FCS
Plastic & Reconstructive Surgeon
Groote Schuur Hospital
Cape Town, South Africa
ottie@mweb.co.za

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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PARAMEDIAN FOREHEAD FLAP NASAL RECONSTRUCTION SURGICAL TECHNIQUE

Brian Cervenka, Travis Tollefson, Patrik Pipkorn

The paramedian forehead flap is a versatile pedicled flap based on the supratrochlear artery and is commonly used for nasal reconstruction. First described in 700 BC in ancient Indian literature by Sushruta Samita to reconstruct nasal defects from punitive tip amputation, it has subsequently become a workhorse of nasal reconstruction requiring more than 2 cm soft tissue replacement on the external and internal nose [1-3].

Benefits of paramedian forehead flap

The paramedian forehead flap is simple to harvest, causes minimal donor site deformity, provides a large amount of skin and subcutaneous tissue that can be used for complete external and internal nasal defects, and has a robust vascular supply allowing successful flap inset even when perichondrium or periosteum of the recipient site has been removed or there is poor vascular supply. Drawbacks include that it is a 2-stage procedure, and transfer of hair bearing tissue in patients with a low-lying hairline to the external nose.

Framework concept of nasal reconstruction

The nose is composed of an internal mucosal lining, a cartilaginous and bony framework, and a cutaneous soft tissue envelope. It is critical to replace these removed subunits. If the overlying soft tissue is resected together with cartilage, a paramedian forehead flap must be accompanied by cartilaginous/bony framework reconstruction with cartilage or bone, based on preference and defect size. The authors prefer to use auricular cartilage when possible. If internal mucosal lining is missing as well, one must consider internal nasal grafts from adjacent tissue, or free grafts.

Surgical anatomy

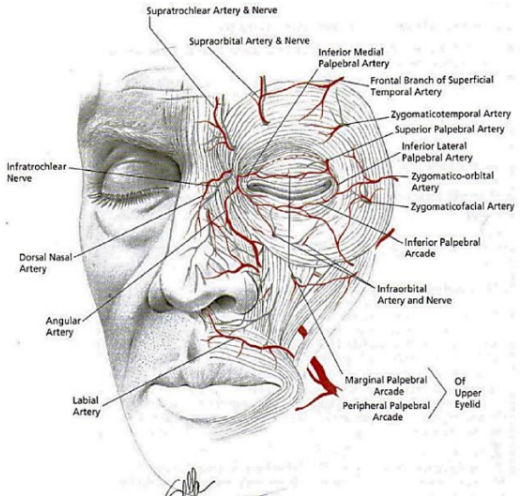


Figure 1: Superficial facial anatomy showing relationship of orbicularis oculi and supratrocheal artery

The paramedian forehead flap is based on an axial blood supply from the supratrochlear artery, which exits the orbit 1.7-2.2 cm lateral to the midline at the level of the superior orbital rim[4] (*Figure 1*).

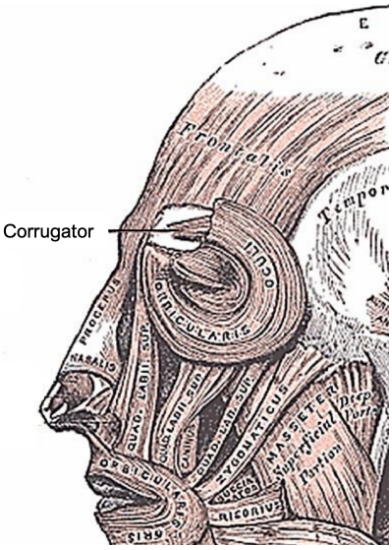


Figure 2: Facial muscles

It then travels deep to the orbicularis oculi and superficial to the corrugator supercilii muscle (*Figure 2*). It then penetrates the orbicularis and frontalis muscles at the level of the brow to run in a subcutaneous and subdermal plexus approximately 2 cm from midline or approximately at the level of the medial brow [4].

Informed consent

Discussion of specific risks related to paramedian forehead flaps include

- Flap loss
- Need for revision surgery
- Loss of sensation around the forehead
- Open wound and resultant scar over the superior aspect of the forehead
- Risk of bleeding, especially initially as the under surface of the flap is exposed
- Ensuring the patient understands that the pedicle of the flap will only be divided ~3 weeks after the initial surgery

Surgical technique

- The flap includes epidermis, dermis, subcutaneous tissue, frontalis muscle and associated fascia
- For nasal contouring, the frontalis muscle can be removed distally as well as the bulk of subcutaneous tissue, as the vascular supply has a large subdermal plexus component
- The supratrochlear nerve which provides sensation to the paramedian forehead is sacrificed as part of the pedicle division and therefore should not be isolated and preserved (*Figure 1*)

Prepping and draping

- Shave up to the anterior hairline and expose this region if a need for additional pedicle length is possible
- Prep with a betadine-based solution into the hairline and the entire face
- Prep and expose the ears if one anticipates a need to harvest conchal cartilage

Preparing the nasal defect

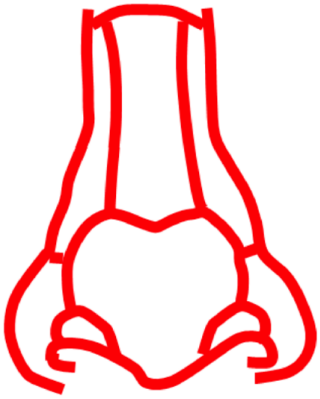


Figure 3: Nasal subunits

- Draw the nasal subunits and consider removing entire subunits when >50% has been resected (*Figure 3*)
- Reduce the size of the nasal defect
- Inject vasoconstrictive local anesthetic around the margins of the defect
- Undermine the defect in a supraperichondrial plane to mobilize the edges which will aid closure
- Reduce the nasal defect by local wound closure, or by performing a laterally based cheek flap (*Figures 18, 19*)
- The flap can be attached by anchoring sutures to the piriform aperture by drilling small holes in the bone

Making a template

- Using a template of the exact size and shape of the defect is a precise way to design a flap
- Dry the edges of the defect and mark them with a surgical pen so there is excess ink at the edges
- Use the unmarked internal surface of the foil of a suture packet, open it up completely so that the surface area is maximized, and press it onto the defect so that the inked margins are transferred onto the foil



Figure 4: Foil nasal template cut to size of defect

- Cut the foil along the inked lines with scissors to create a template (*Figure 4*)

Skin paddle design

- We typically harvest from the side ***contralateral*** to the nasal defect to allow for ease of rotation; however, one can use the ipsilateral side if there is scar or other prohibiting factors
- Skin paddle design is critical for good cosmetic and surgical outcomes



Figure 5: Pedicle drawn from nasal defect foil template with length estimated by the gauze

- Draw the pedicle location as described above (*Figure 5*)



Figure 6: Gauze being used to determine forehead pedicle length (based on pedicleto-nasal-defect marking)

- Use gauze or string from a sponge to determine how far superiorly the skin paddle must be taken from the forehead/scalp to cover the entire defect (*Figure 6*)
- It needs to be emphasized that it is better to err on the side of having excess flap length
- Repeat the length measurement to ensure accuracy
- Draw the position of the supratrochlear artery approximately 2 cm from midline (*Figure 5*)
- Place the shaped foil template on the forehead and draw the flap on the skin
- The pedicle is narrowed towards the supratrochlear artery but is not narrowed to less than 1.5 cm (*Figure 5*)

Harvesting the flap

- Inject vasoconstrictive local anesthetic around the flap, but not directly into the flap to avoid vasoconstrictive complications

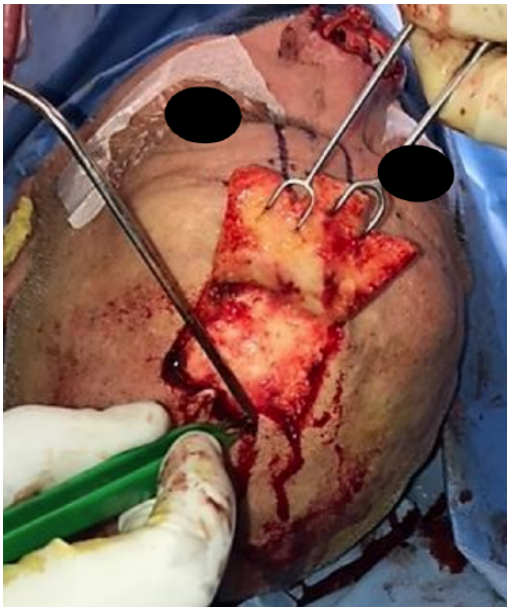


Figure 7: Distal tip being elevated in a subcutaneous layer

- Starting at the tip of the pedicle, incise through skin and subcutaneous tissue using skin hooks to generate tension and to pull the skin up and away from the periosteum (*Figure 7*)
- One can harvest the distal segment of the flap in a subcutaneous plane to allow for thinning of the nasal contour, as illustrated in *Figure 7*.
- You will feel the galea aponeurotica separate as it is released from the scalp when this layer is entered
- Incise 5 cm at a time down each of the lateral margins of the pedicle, ensuring to dissect down to and through galea
- Once the tip has been mobilized, finger dissection can be used in the loose galeal layer to establish a plane heading inferiorly toward the pedicle and making it easy to define the dissection plane
- You will recall that the supratrochlear vessels penetrate the frontalis muscle at the level of the brow to then travel superficial to the muscle

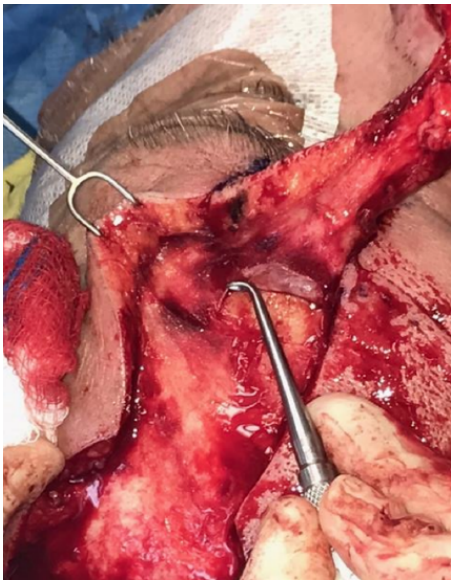


Figure 8: Supratrochlear artery and nerve demonstrated with elevator as dissection plane is changed to a subperiosteal plane

- Therefore, deepen the dissection to a subperiosteal plane to protect the vascular pedicle once you reach the superior aspect of the brow (*Figure 8*)
- This is achieved by incising the periosteum with a 15 blade and then using a a Freer's dissector to blunt dissect inferiorly in this plane

- If the pedicle is long enough that it reaches without tension, then stop dissecting the pedicle. However, if there is tension on the pedicle, then continue to dissect through the corrugator muscle, as this step provides significant additional length
- Prior to insetting the flap, assess the blood supply of the flap at the tip by rubbing it with a dry swab and by assessing for bleeding

Insetting the flap

- ***Before insetting the flap, you should already have reconstructed any internal lining or cartilaginous defects***. We typically use conchal cartilage to replace resected nasal cartilage.
- If the flap comes from a hair-bearing region, one can cauterize individual hair follicles…this can be done at a later time
- The flap is set into the defect and its thickness assessed
- Some loss of flap volume is expected to occur with healing
- As the blood supply to the skin runs in the subdermal plexus, it is feasible to thin the flap to the subcutaneous plane by removing the frontalis muscle
- Secure the flap using interrupted deep dermal 4-0 monocryl sutures and 6-0 nylon interrupted cutaneous sutures
- Loosely wrap the undersurface of the pedicle with xeroform to prevent postoperative bleeding from the wound edges

Closing the donor site

- The donor site is then closed using interrupted deep dermal 3-0 Vicryl sutures and 6-0 interrupted nylon cutaneous sutures and 5-0 nylon in the hairline

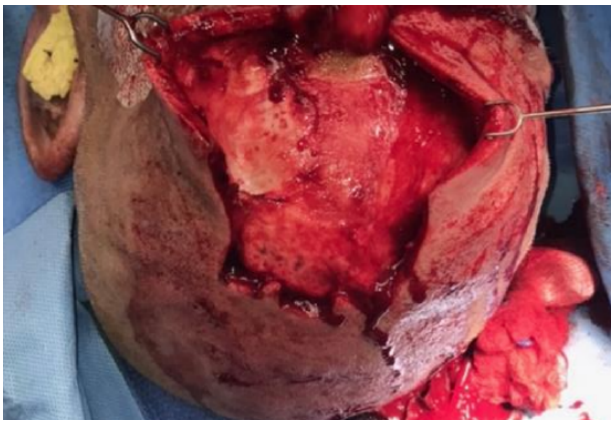


Figure 9: Undermining and galeotomies performed to increase skin laxity and primary closure

- If a large skin paddle was raised, primary closure of the donor site is difficult. In such cases we perform multiple lateral vertical cuts through the galea 2-3 cm apart with electrocautery to increase the skin mobility (*Figure 9*)



Figure 10: Following closure with residual superior skin defect, which is common, heals well with local wound care

- It is common to have a small remaining defect superiorly that is packed with Xeroform gauze and left to heal by secondary intention. This is encountered when the flap size is greater than 4.5 cm, but the cosmetic outcome is favorable and secondary scar revision is often not even necessary (*Figure 10*)
- Both wounds are covered with steristrips
- Before reversing the anesthetic, prick the flap with a 25G needle. Bright red blood indicates a good blood supply

Postoperative care

- The wound is kept moist and free from crusting using dilute hydrogen peroxide in saline or sterile water and antibiotic ointment applied after cleaning twice daily
- Sutures are removed between Days 5 and 7

Pedicle division

- The pedicle is divided 3 weeks later, once neovascularization has occurred and the flap has gained a local blood supply
- Pedicle division has three basic goals:

    1. Dividing and insetting the superior aspect of the flap
    2. Thinning the flap if necessary
    3. Elevating the brow where it was previously drawn inferiorly with the pedicle

- The pedicle is typically divided under general anesthesia at our institution, but can be done under local anesthesia
- Prep and drape and keep the entire face exposed
- Inject local anesthetic with a vasoconstrictive agent into both the brow and nasal reconstruction
- Place a clamp on the pedicle at the intended division site, ensuring enough distal pedicle length for proper inset
- Divide the pedicle
- Perform the nasal inset by thinning the pedicle in a subcutaneous plane and then trimming it to fit the residual defect
- An option at this stage is to elevate and thin the entire flap in the subcutaneous plane if there is excess bulk, using the previous incision lines



Figure 11: Pedicle had been divided (note divided pedicle inferiorly); now correcting donor eyelid position with triangular advancement flap



Figure 12: One month following flap takedown; note triangular advancement flap



Figure 13: One month following flap takedown

- Next turn your attention to the brow and elevating a triangular rotation advancement flap to raise the medial brow to the level of the contralateral brow (*Figures 11, 12*)
- The pedicle is then thinned proximally and inset

More clinical examples

Figures 14-17 are of a patient with soft tissue breakdown and exposure of titanium mesh following a previous resection and reconstruction with a soft tissue free flap.



Figure 14



Figure 15



Figure 16



Figure 17

Figures 18-23 illustrate the laterally based cheek flap to reduce the nasal defect, the vascular pedicle and repair of a lateral nasal defect.



Figure 18



Figure 19

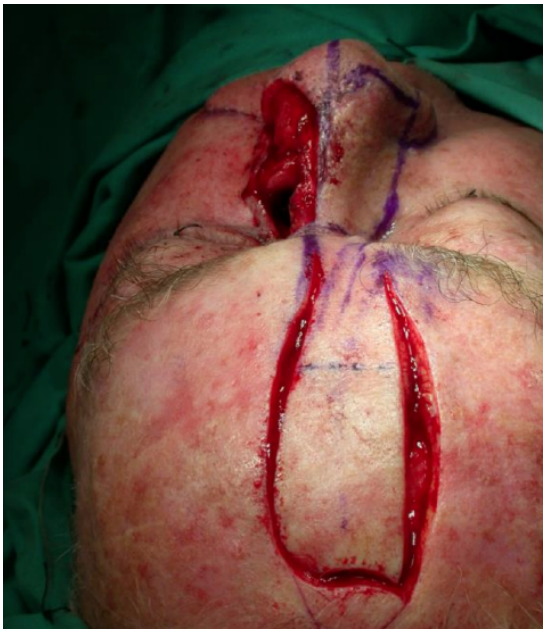


Figure 20

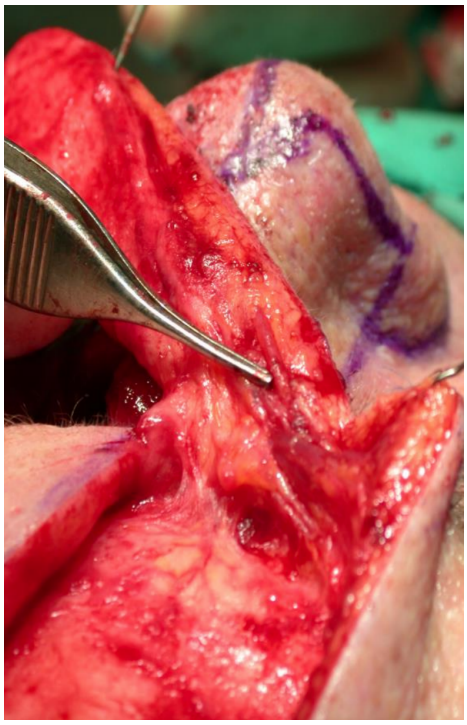


Figure 21: Vascular pedicle



Figure 22

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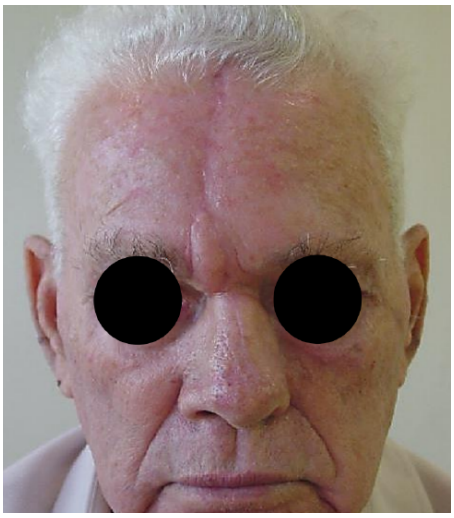


Figure 23

References

1. Burget GC, Menick FJ. Nasal support and lining: the marriage of beauty and blood supply. Plast Reconstr Surg. 1989;84(2):189-202
2. Conley JJ, Price JC. The midline vertical forehead flap. Otolaryngol Head Neck Surg. 1981;89(1):38-44
3. Jackson I. Local Flaps in Head and Neck Reconstruction. Mosby; 1985
4. Baker S. Local Flaps in Facial Reconstruction. St. Louis, Missouri: Mosby; 2007

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Authors

Brian P. Cervenka MD
Department of Otolaryngology, Head and Neck Surgery
University of California, Davis, Sacramento, CA, USA
bcervenka@ucdavis.edu

Travis Tollefson MD
Department of Otolaryngology, Head and Neck Surgery
University of California, Davis, Sacramento, CA, USA
tttolefson@ucdavis.edu

Patrik Pipkorn MD
Assistant Professor
Head & Neck Microvascular Reconstruction
Department of Otolaryngology, Head and Neck Surgery
Washington University
St Louis, MO, USA
patrikpipkorn@hotmail.com

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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THORACODORSAL ARTERY SCAPULAR TIP (TDAST) FLAP FOR HEAD AND NECK RECONSTRUCTION

Douglas Chepeha

The thoracodorsal artery scapular tip flap is the osseous (bone) component of the latissimus dorsi flap. The thoracodorsal artery supplies the scapular tip and the latissimus dorsi muscle (with overlying skin). Therefore, the scapular tip can be harvested as an independent osseous paddle or with the latissimus dorsi muscle or with the latissimus dorsi muscle and overlying skin or in some combination with the serratus muscle. There are many possible combinations of skin, muscle and bone paddles that make this arterial donor system valuable for head and neck reconstruction. In addition, the thoracodorsal arterial system can be combined with the circumflex scapular arterial system (both arteries arise from the subscapular system or are directly adjacent to one another) to further increase the skin and bone paddle options. Although it would not always be ideal, this donor site could be used to reconstruct all defects in the head and neck.

The scapular tip and lateral border have a unique shape. The tip of the scapula is the shape of the maxillary infrastructure when inset in an axial plane. It also mimics the rim of the orbit, depending on the extent of the defect, and can be inset in axial or coronal planes. The lateral border of the tip of the scapula is the shape of a hemimandible and is well suited for mandibular reconstruction. For posterior mandibular reconstruction the tip can be used for the angle and inset in a sagittal plane to reconstruct the ramus. For anterior defects it can be inset axially in a manner similar to maxillary reconstruction or it can be osteotomized and inset in a coronal orientation.

In this chapter we address the use of the bone paddle supplied by the thoracodorsal artery.

Benefits of TDAST

- Long vascular pedicle [1,2]
- Triangular 3-dimensional shape [2]
- Bone paddle easily shaped without osteotomy to reconstruct the infrastructure of the maxilla [3]
- Bone is surrounded by attached muscle that can be used to help close defects of maxillary and mandibular alveolus bone
- Can be harvested as a chimeric flap with a variety of skin and muscle paddle options [3-5]
- Independently mobile skin paddle [2,3]
- Thoracodorsal artery and vein are large vessels and most commonly connect to larger subscapular vessels

Caveats of TDAST

- Overall harvest is manageable but one must exercise caution with the identification of the angular branch and its connection to either the thoracodorsal artery or the serratus artery
- Shorter bone length (12 cm) than fibula [6-8]
- If the angular branch does not appear to supply the superior aspect of the lateral border of the scapula, then the circumflex scapular artery may have to be harvested to ensure vascularity
- Wide skin donor sites can be hard to close and can limit shoulder mobility
- The skin donor sites may be thicker than the forearm, anterolateral thigh and the lateral arm flaps depending on body habitus and gender
- Reduced shoulder mobility [9,10]
- Prior ipsilateral thoracotomy may limit skin paddle donor options
- Two-team surgery if a hydraulic arm holding device is not used [11]

Anatomy

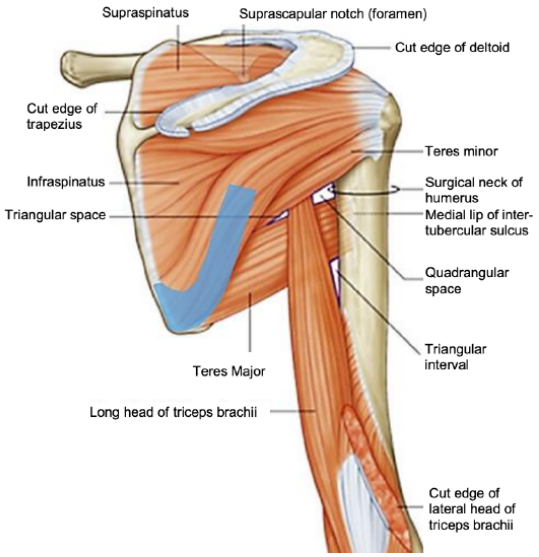


Figure 1: Posterior view of shoulder and arm

Harvesting the scapular tip involves transecting a portion of, or all the origins of the infraspinatus, subscapularis, teres major, the insertion of the serratus and, if a skin paddle is harvested, dissection and possible harvesting of the latissimus dorsi flap. Several of these muscles are part of the four muscles that form the rotator cuff that stabilizes the glenohumeral joint (*Figure 1*).

Rotator Cuff and Muscle Anatomy

Four muscles originate from the scapula and stabilize the glenohumeral joint (*Figure 1*):

1. ***Supraspinatus*** and ***infraspinatus*** muscles originate in fossae above and below the scapular spine and attach to the greater tubercle of the humerus. The supraspinatus initiates the first 15º abduction of the arm, whereas the infraspinatus allows lateral rotation of the arm on the glenohumeral joint
2. ***Teres minor*** arises from the lateral edge of the scapula and attaches to the greater humeral tubercle. It also allows lateral rotation of the arm
3. ***Subscapularis*** arises from the subscapular fossa (the part of the scapula that faces anteriorly toward the thorax) and inserts into the lesser tubercle of the humerus. It rotates the humerus medially on the glenohumeral joint.
4. ***Teres major*** is encountered surgically but is not a rotator cuff muscle. It arises from the inferior angle of the scapula and attaches to the anterior surface of the humerus, on the medial lip of the intertubercular sulcus. It allows medial rotation and adduction of the humerus on the glenohumeral joint. The long head of the triceps brachii is also encountered in this region as it originates in the infraglenoid tubercle of the scapula. It serves as an accessory adductor, an extensor of the forearm and a stabilizer of the glenohumeral joint

Vascular Anatomy

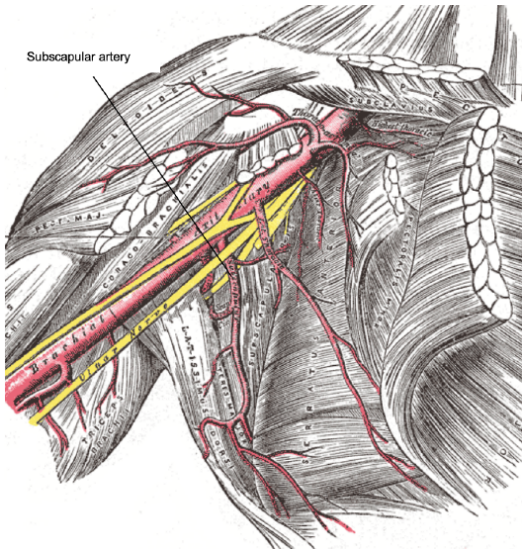


Figure 2: Origin of subscapular artery from axillary artery

The ***subscapular artery*** arises from the third part of the axillary artery (*Figure 2*).

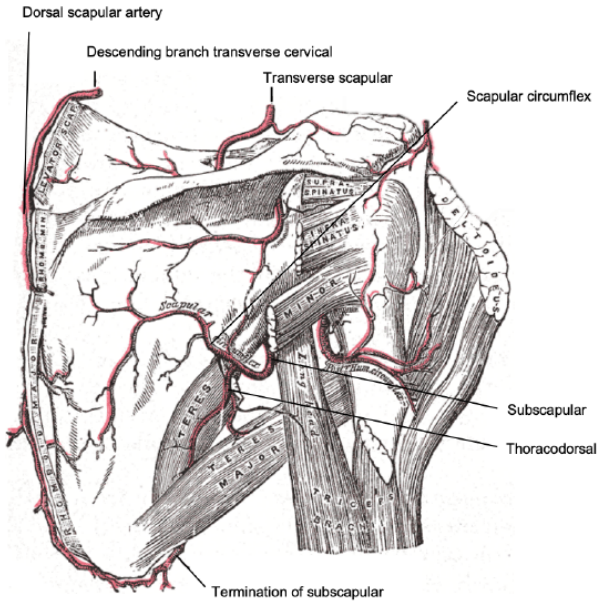


Figure 3: Vascular anatomy around the scapula

It gives rise to two branches: the ***thoracodorsal artery***, and ***circumflex scapular artery*** (*Figure 3*). The thoracodorsal artery and/or thoracodorsal vein can arise from the axillary vein, separate from the subscapular artery and/or the subscapular vein [12]

The ***thoracodorsal artery*** arises from the ***subscapular artery***, descending, roughly parallel to the lateral boarder of the scapula in an envelope of adipose tissue that emanates from the axilla (*Figure 3*). The thoracodorsal artery passes between the teres major and the thoracic cage (*Figure 2*) [12]. The thoracodorsal artery supplies the latissimus dorsi, serratus anterior, and scapular tip [13].

The thoracodorsal artery gives rise to a ***direct cutaneous branch***, the ***serratus artery***, the ***angular artery to the scapular tip***, the ***descending branch*** within the latissimus muscle and the ***transverse branch*** within the latissimus muscle. The ***direct cutaneous branch*** is present 47% of the time (reference Taylor 1984) and supplies the skin inferior to the axilla. The ***serratus branch*** supplies the serratus muscle that can be used for myogenous reconstruction or as an innervated subunit.

The ***angular branch to the scapular tip*** arises from the thoracodorsal branch [6] within 1.5 cm of the serratus artery branch or from the serratus branch within 1.5 cm of its branchpoint with the thoracodorsal artery. The origin of the vein and artery of the ***angular artery*** pedicle can be divided between the thoracodorsal branch and the serratus branch. The total length of the dissected pedicle

and bone paddle (distance from the axilla to the scapular tip) can be as long as 27 cm [1,2,14]. This is likely to be an overestimate; the total length is closer to 20 cm.

The ***descending and transverse thoracodorsal*** branches are within the latissimus muscle and can be used to supply some or all of a myogenous paddle, a myocutaneous paddle, or a cutaneous perforator (if present), and can be dissected through the muscle.

The ***circumflex scapular artery*** (*Figure 3*) travels through the ***triangular space*** [3] created by the teres major inferiorly, teres minor superiorly, and long head of triceps anteriorly (*Figure 1*). It divides into a ***terminal descending branch*** to the bone of the lateral border of the scapula; the ***circumflex scapular artery*** continues toward the skin and divides into ***transverse cutaneous*** and ***descending cutaneous branches***. The terminal descending branch supplies the lateral border of the scapula and the maximal bone length is 12 cm. The ***transverse cutaneous*** branch can be used to create a scapular cutaneous paddle [3]. The ***descending cutaneous branch*** is used to create parascapular cutaneous paddle [3].

Nerve Anatomy



Figure 4: Anterior view of right thoracodorsal nerve

The ***thoracodorsal nerve*** (*Figures 4, 11*) runs along the pedicle to the latissimus muscle. The nerve is about 2 mm in diameter. When harvesting the scapular tip, it should not be sacrificed and is a good guide for the direction of the pedicle and can help open the space over the pedicle. In the axilla, the cords of the brachial plexus run immediately superior to the axillary artery and vein. Care should be taken not to put traction on these nerves.

Preoperative Evaluation

No specific vascular testing is required. If a patient has a history of shoulder dislocation, rotator cuff tear, rotator cuff surgery, arthroscopy, joint replacement or brachial plexus injury one should avoid using the flap. Consideration must be given to the patient's occupation and recreational activities, as lifting heavy weights above the head is affected [2].

Informed Consent

Preoperative counseling should address ***general complications related to autogenous transplant*** including scarring, delayed wound healing, donor or recipient site hematomas, seromas, infection and transplant failure.

Specific complications include reduced shoulder mobility that makes full abduction and lifting heavy object above the head more difficult [15]. Larger bone paddles are associated with greater shoulder disability.

Surgical Setup

The surgical setup is very similar to the setup described in the chapter on latissimus dorsi flaps.

Patient Positioning

A ***key advance*** is to avoid repositioning by putting the patient in a ***semidecubitus*** [2] and using a beanbag to secure the patient's donor site about 20 degrees above the plane of the bed. Ensure that the entire scapula is accessible. Access to the scapula can be improved by abduction or medial rotation with the shoulder in an adducted position. Unfortunately, this setup still does not make 2-team surgery straightforward.



Figure 5: The patient's left arm and thorax are shown with the arm in a position of elevation for the thoracodorsal artery transplant (TDAST)



Figure 6: The patient's left arm and thorax are shown, with the arm in a resting position. To reduce the likelihood of a tourniquet effect on the arm, avoid wrapping the arm tightly, minimize the time the arm is wrapped and be mindful of a positive fluid balance during the procedure

A positioning device can be used to hold the arm in position [11] (*Figure 5*). These devices are in common use for rotator cuff repair and are available at many hospitals with orthopedic programs. Take care to put the arm in the device for the duration of the elevation and closure to avoid a tourniquet effect on the forearm (*Figure 6*).

- Rotate the ipsilateral pelvis and bend the knee; this will help keep the thorax off the surgical table
- To prevent compression of the brachial plexus the contralateral clavicle (nonoperative shoulder) needs to be at 90 degrees to the cervical spine. A shoulder roll will not help prevent brachial plexus compression. The purpose of a shoulder roll is to lift the thorax off the operative table when the patient is in a fully decubitus position so that the clavicle does not compress the brachial plexus
- Protect the contralateral (non-operative side) superficial peroneal nerve, radial nerve, ulnar nerve and brachial plexus
- Secure the patient to the operating table with a belt and tape over the pelvis to prevent him/her sliding off the table
- Place the patient on a gel mat over a beanbag. Be sure that there is an edge (or lip) on the beanbag ipsilaterally and ***contralaterally*** to hold the patient in position

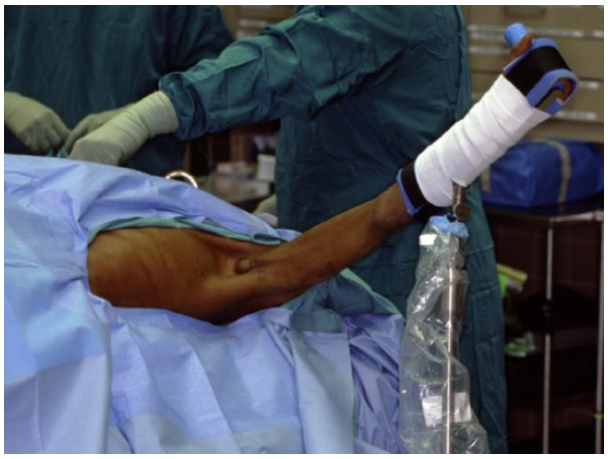


Figure 7: For patients who have a rounded thoracic cage, a scapula that has a lateral position and a flexible neck may undergo harvest on the side contralateral to the head and neck extirpation site (note lipoma in axilla)

- Some patients can undergo a contralateral scapular tip harvest if they have a very rounded thorax in cross-section, their scapula is in a very lateral position and they have mobile necks (*Figure 7*). In such cases, 2-team surgery is easier to accomplish

Surgical Steps

Surface Markings



Figure 8: Patient is turned to left side with left arm superiorly and harvesting on the left thorax. Locate and mark the scapular tip by palpation. The arm is in a neutral position at the upper right of the photo. Arrow points to bone paddle

- To safely locate the bone paddle the latissimus muscle and scapular tip have be palpated and marked out prior to incision. This is usually straightforward (*Figure 8*)
- The anterior edge of the latissimus muscle is marked by the ***midaxillary line***. It is best to mark the midaxillary line prior to prepping because the pelvis is usually covered by the belt that secures the patient to the operating table
- Locate the ***midaxillary line*** by drawing a line from the middle of the axilla to a point on the pelvis that is equidistant between the anterior and posterior superior iliac spines
- Identify the ***latissimus muscle***. It forms the posterior axillary fold as it crosses from the thorax to insert onto the humerus. The superior aspect of the latissimus muscle curves across the tip of the scapula as it heads to the origin of the muscle from thoracic vertebrae [6-12]
- Locate the ***scapular tip*** at the inferior aspect of the scapula, and mark it with the shoulder adducted (arm at patient's side)

Raising the Bone Paddle - Anterior versus Posterior Approach

The scapular tip can be approached either from the anterior, or the posterior aspect of the latissimus muscle. The ***anterior approach*** is the most commonly used. There is ***no distinct advantage*** of an anterior versus a posterior approach.

Anterior approach

- Considered easier and more flexible
- Easier to dissect all the branches of the thoracodorsal vascular pedicle

- Efficient if a myocutaneous skin/latissimus muscle paddle is part of the reconstructive plan
- Advantagous if a series of paddles are to be harvested that includes the circumflex scapular system, as the pedicle and the associated skin paddles are easier to expose in a single surgical field
- Favored if the descending branch of the thoracodorsal artery is going to harvested with preservation of the transverse portion of the thoracodorsal nerve

Posterior approach

- More difficult but more direct
- An advantage for harvesting a thoracodorsal perforator flap
- Good choice if scapular tip is sole donor paddle
- Good choice if direct cutaneous branch of thoracodorsal artery or a perforator of thoracodorsal artery is anticipated with the harvest

Raising the Bone Paddle: Anterior Approach

- Mark out an incision 1.5 cm anterior to the midaxillary line from a level just below the tip of the scapula tip to the axilla. In the axilla, it is better to angle the incision to run parallel to the relaxed axillary skin tension folds (*Figure 6*)

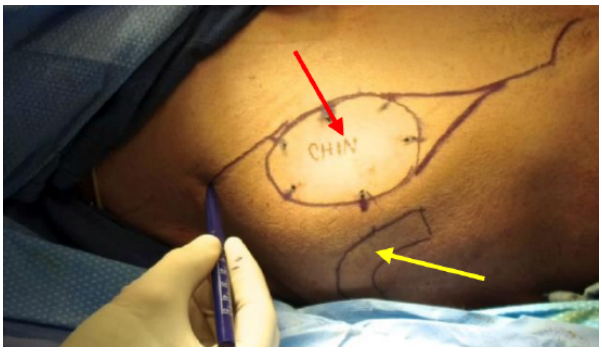


Figure 9: Patient is turned to left side axilla on right of picture and harvesting on the left thorax. The yellow arrow points to the bone paddle template. The latissimus muscle is in contact with and anterior to the scapula. The skin paddle (red arrow) is over the primary angiosome. The skin paddle overlies the latissimus muscle. The location of the skin paddle as shown in the figure is helpful for perforator dissection. If a longer pedicle to the skin paddle is desired, then the skin paddle can be elevated in a position that is just inferior to the scapular tip along the midaxillary line



Figure 10: Dissection of the myocutaneous donor paddle; with an anterior approach, the skin paddle is dissected first

- Commence the incision inferiorly to ***verify the location of the anterior border of the latissimus muscle*** to confirm that the surface marking has been made in the correct location (*Figure 10*)
- Once the location of the latissimus muscle has been confirmed, extend the incision up to the axilla
- ***Critical point***: It is important to understand that the ***incision crosses the expected location of the thoracodorsal pedicle***. Therefore, once the anterior border of the latissimus is identified at the level of the scapular tip, dissect just superficial to the

medial aspect (the side closest to the thorax) of the latissimus muscle until the thoracodorsal pedicle is seen penetrating the muscle

- Once the ***thoracodorsal pedicle has been identified***, trace it toward the axilla. The ***thoracodorsal nerve is a good landmark*** and speeds up the dissection
- ***Retract the latissimus muscle*** to open the space around the pedicle
- The pedicle is in a pocket of areolar tissue; therefore, gentle finger dissection will improve the efficiency of the dissection

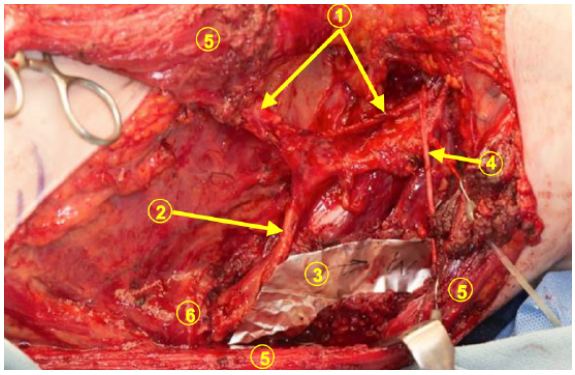


Figure 11: A different patient with more extensive bone harvest. The patient's axilla is at the right of the picture, and the harvest is on the left thorax. The skin paddle (superiorly) has been dissected and the remaining latissimus muscle (5) is retracted at the lower edge of the photo. The thoracodorsal artery (1) can be seen supplying the latissimus muscle. The angular branch (2) can be seen supplying the scapular tip (3 = template of bone paddle, 4 = thoracodorsal nerve, 6 = serratus branch)

- It is ***important to skeletonize the thoracodorsal pedicle and the branch(es)*** to the serratus muscle before any major branches are clipped because the ***branching pattern of the angular branch to the scapular tip is variable*** (*Figure 11*)
- The ***angular branch*** arises within 1.5 cm of the branch point of the serratus artery. The angular branch may arise from the thoracodorsal branch (the main pedicle) or it may arise from the serratus branch. The ***serratus branch*** comes off the thoracodorsal branch before it terminates in the latissimus muscle and after the circumflex scapular branch (*Figure 11*)
- ***Key point***: The ***angular branch*** arises within 1.5 cm of the serratus pedicle branch point. The angular artery and the angular vein may arise separately (but in close proximity) to the thoracodorsal branch and the serratus branch
- ***Locate the angular branch***. First identify the anterior border of the scapular tip. This area can be seen by retracting the latissimus muscle. Generally, the artery can be seen running along the anterior border of the scapula and can be traced back to the area around the branch point of the serratus branch from the thoracodorsal pedicle
- ***Key point: Fully dissect the angular branch before transecting any branches greater than 1 mm***. The angular branch is variable and circuitous and is vulnerable to transection before the course of the branch has been identified in its entirety
- Uncommonly, if the **angular branch is not easily seen** along the anterior border of the scapula:
  - Dissect anteriorly, leaving a cuff of fat over the serratus about 1.5 cm anterior to the scapular tip. Dissect layer-by-layer through fascia and fat
  - If the angular branch is still not seen, move superiorly staying well anterior to the scapula until the dissection is taken up to the thoracodorsal pedicle. As this space is carefully opened the branch to the scapular tip is seen coming off the serratus or the thoracodorsal pedicle

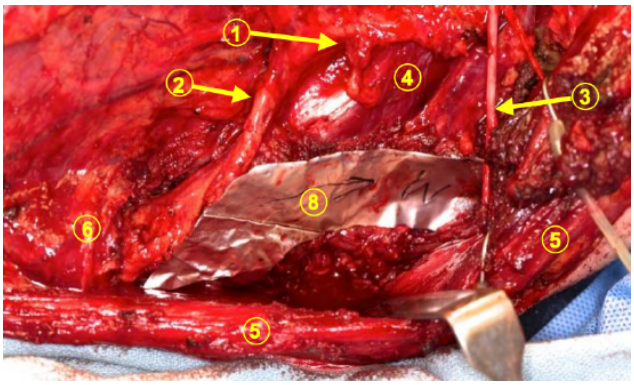


Figure 12: The teres major is transected. Both the angular branch (inferiorly) and the circumflex scapular branch (superiorly) are shown supplying the muscle (1 = thoracodorsal artery, 2 = angular artery, 3 = thoracodorsal nerve, 4 = subscapular muscle, 5 = latissimus muscle, 6 = serratus branch, 8 = bone paddle template

- After the pedicle has been identified, mobilize it by transecting the branches to the tissues that are not part of the donor system (*Figure 12*)
- Mark out the segment of bone that is to osteotomized into the skin paddle (*Figure 12*)

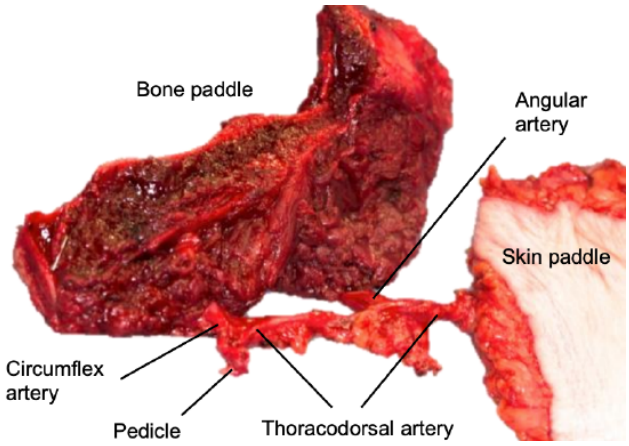


Figure 13: The bone paddle is the lateral border of the scapula with scapular tip. The skin paddle is a myocutaneous paddle based on the descending branch of the thoracodorsal artery

- If muscle is not needed for the reconstruction, it should be harvested with the bone in moderation. A cuff of about 7 mm should be left on the scapular tip to ensure adequate vascular supply (*Figure 13*)
- Should additional muscle be required for the reconstruction, then teres major, infraspinatus, or serratus can be harvested
- **Caveat**: Verify that the muscle has adequate blood supply for the planned reconstruction prior to transecting the pedicle and transferring the flap to the recipient site

Raising Bone Paddle: Posterior Approach

- Mark out the incision that is placed just posterior to the posterior edge of the latissimus muscle to a position just below the scapular tip

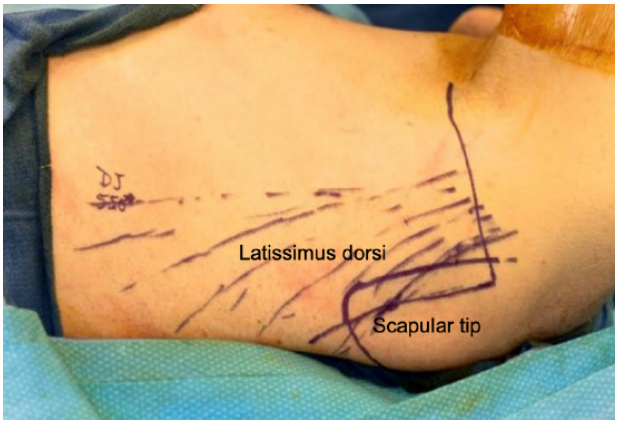


Figure 14: The scapular tip is marked out first, then the midaxillary line, followed by the expected location of the latissimus muscle

- Then mark an incision into the axilla that crosses the posterior axillary fold into the axilla and parallels the relaxed axillary skin tension lines (*Figure 14*)



Figure 15: A perforator has been located during the deep dissection and confirmed with Doppler. The skin is loosely reapproximated so that the donor skin paddle size can be matched to the size of the recipient site

- This incision is designed so that perforators can be picked up at the anterior edge of the latissimus muscle for design of a thoracodorsal artery perforator flap (*Figure 15*)
- The size of the skin paddle and the option to use perforators from the transverse branch of the latissimus pedicle, will result in a different incision location. A perforator that is suitable for a perforator based cutaneous skin paddle is not always present
- ***Difficult step***: It can be difficult to separate the teres major muscle from the latissimus muscle because the fibers may not be separated by an areolar layer. To assist with separation, increase the size of the operative field to identify the latissimus closer to its insertion and closer to its origin (*Figure 13*)

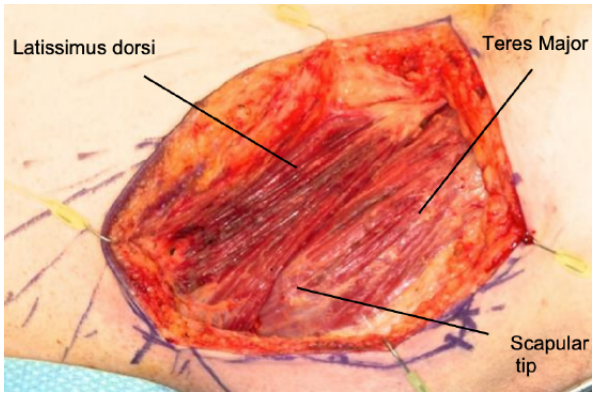


Figure 16: Separation of latissimus muscle from teres major muscle



Figure 17: Retraction of latissimus muscle inferiorly to expose scapular tip

- To harvest the scapular tip bone paddle, retract the superior edge of the latissimus muscle inferiorly and anteriorly to expose the scapular tip (*Figure 17*)
- Sometimes a perpendicular incision needs to be made in the superior aspect of the latissimus muscle over the scapular tip so that the tip can be visualized

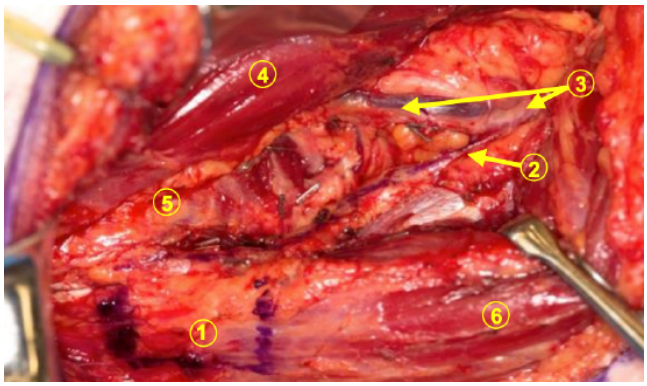


Figure 18: The planned bone paddle is marked out in blue ink just proximal to the scapular tip (1). The angular artery (2) is seen traveling from the thoracodorsal artery (3) down to a location just anterior to the bone paddle. Because this is a posterior approach, the latissimus dorsi muscle (4) is seen retracted along the upper aspect of the photo (5 = Serratus branch, 6 = Teres major muscle)

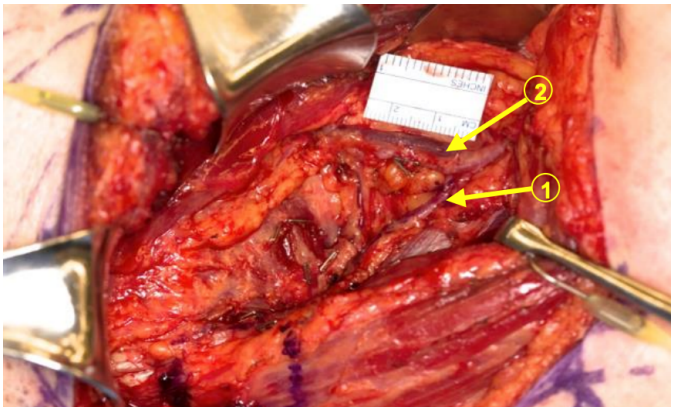


Figure 19: The ruler shows the angular branch (1) coming off the thoracodorsal artery (2) and vein 1.5 cm proximal to the serratus artery and vein

- ***Key point***: Look for the angular branch right on the scapular tip as it passes onto the serratus muscle insertion (*Figure 18*).
- ***Follow the angular branch*** up to the thoracodorsal branch or the serratus branch (*Figure 19*)

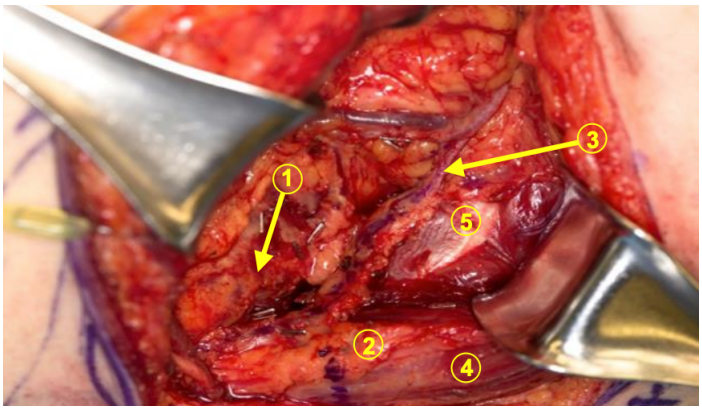


Figure 20: The serratus branch has been clipped (1), and the scapula (2) is being rotated off the thorax with a retractor. The dissected angular artery (3) to the scapular tip is well demonstrated (4 = teres major muscle, 5 = infraspinatus muscle)

- ***If the angular branch cannot be seen at the tip, do not dissect the fat immediately adjacent to the scapular tip*** because critical perforators from the angular branch can be injured as they pass to the scapular tip
  - A better decision may be to ***transition to the anterior approach***
  - Alternatively, one can do a more time consuming and difficult dissection as follows: Move the dissection anteriorly leaving a cuff of fat on the anterior aspect of the scapular tip and stay on the fascia on the medial aspect of the latissimus muscle. Once the dissection is 1.5 cm anterior to the scapular tip, dissect through the fascia and fat layer-by-layer. If the angular branch is not seen, move superiorly, staying well anterior to the scapula until the dissection is taken up to under the teres major. As this space is carefully opened the branch to the scapular tip or the thoracodorsal artery is revealed (*Figure 17*).

- If the posterior approach does not reveal the pedicle, the dissection can still default to the anterior approach because this provides a larger surgical field and is its easier to landmark the latissimus and serratus pedicles

- Mobilize the pedicle by dissecting towards the axilla
- The thoracodorsal nerve is a helpful guide for opening the space and should be preserved
- Muscle transection and bone paddle harvest are performed in the same manner as with the anterior approach (*Figures 21-23*)

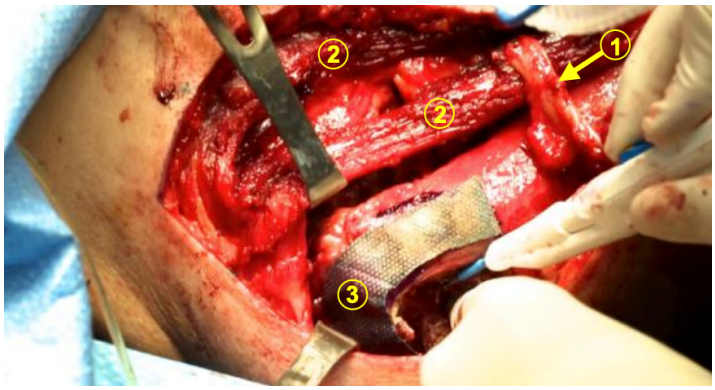


Figure 21: The patient's axilla is at the right, and the harvest is on the left thorax. The serratus has been cut to help retract the scapular tip from the thorax to aid dissection. The infraspinatus muscle is being cut in preparation for the osteotomy. The = thoracodorsal artery (1) is shown traveling to the mobilized skin paddle that is under the surgeon's right hand (2 = latissimus muscle, 3 = bone paddle)

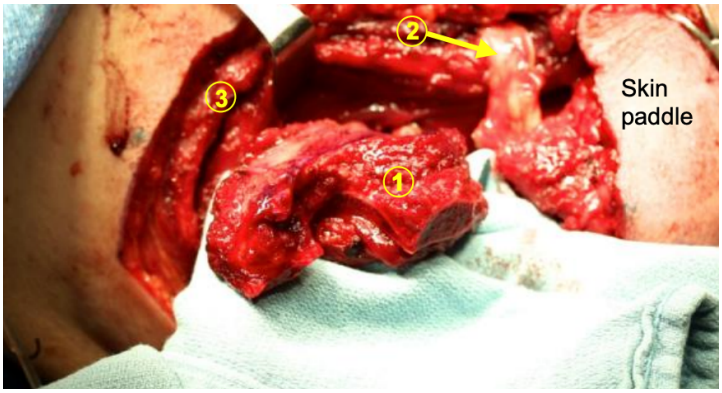


Figure 22: The osteotomized scapular tip (1) is shown in preparation for an axial inset for an anterior mandibular defect. A reciprocating saw with a long triangular blade is used for scapular tip osteotomies. Because of the curved shape of the scapula, hold the edge of the scapula with a thumb and 2nd finger to gauge the width of the bone that is being osteotomized (2 = thoracodorsal artery, 3 = latissimus muscle)

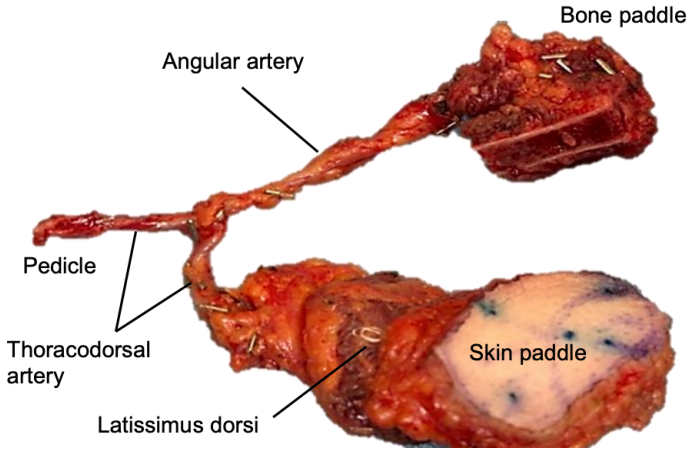


Figure 23: A chimeric segment of scapula adjacent to the scapular tip based on the angular branch and a 2nd skin paddle with a plug of muscle. This was inset into a defect that included the infraorbital rim and the cheek skin

Closure and wound drainage

Muscle closure should be performed with the shoulder in full abduction. The rotator cuff muscles should not be closed under tension and the serratus muscle should be reattached to the remaining distal end of the scapula.

The donor site is prone to seroma if the skin is loose after wound closure. Place drains in an inferior (dependent) location in the donor site. On occasion, patient may be discharged from hospital with drains in place until drainage is <20 mL per day.

Postoperative Care

- Start a passive range of movement early
- For the first 3-7 days the donor site is painful with movement
- A large skin paddle harvest with tight closure can limit mobility
- Introduce active range of motion exercises within 1-2 weeks
- There will be some associated moderate pain with this early program. It is important for the patient to know that they will not be pain free when starting the program
- The program is a combination of passive and active range of motion that would be performed after rotator cuff surgery and strengthening after neck dissection

Reconstructive Applications of Scapular Tip Bone Paddle

- The scapular tip is ***very versatile because of its 3-dimensional shape*** that is very similar to the size and shape of many head and neck bone defects [2]

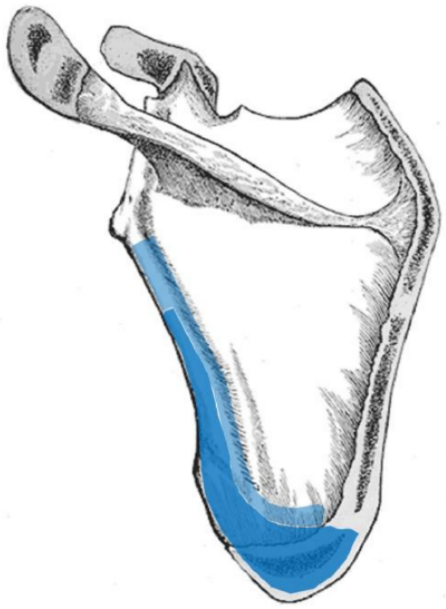


Figure 24: The maximum size of scapular harvest based on the angular branch. Darker blue indicates more reliable vascularity

- The scapular tip and lateral border of the scapula can be harvested based on the ***angular branch*** (*Figure 24*)
- ***If the angular branch inserts very distally*** on the scapular tip the bone of the lateral border of the scapula adjacent to the lip of the glenoid fossa in the expected location of the ***circumflex scapular*** artery may be inadequately perfused. In such cases the circumflex scapular should be harvested to supply this bone segment
- It also has a ***long pedicle*** that makes this donor site useful for vessel-poor necks or when the reconstruction is in the midor upper face [2].
- In addition, because of the ***multiple branches*** in the scapular subsystem there is a variety of skin paddle, muscle paddle, innervated muscle paddle, and bone paddle options that provide enough options that a second free flap donor site can be avoided

Maxillary Reconstruction

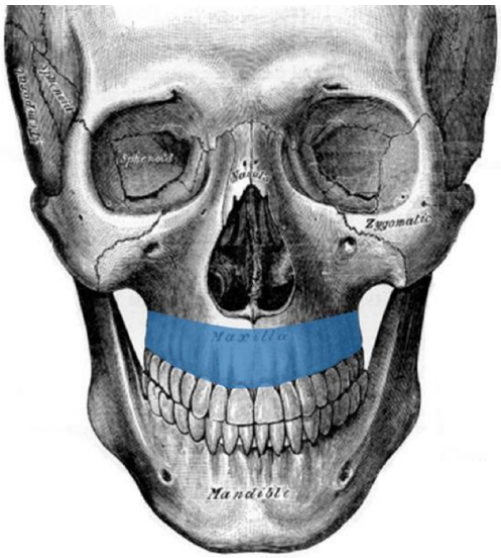


Figure 25: The most common use of a scapular tip transplant is a transverse insertion to replace part of, or the entire infrastructure of the maxilla

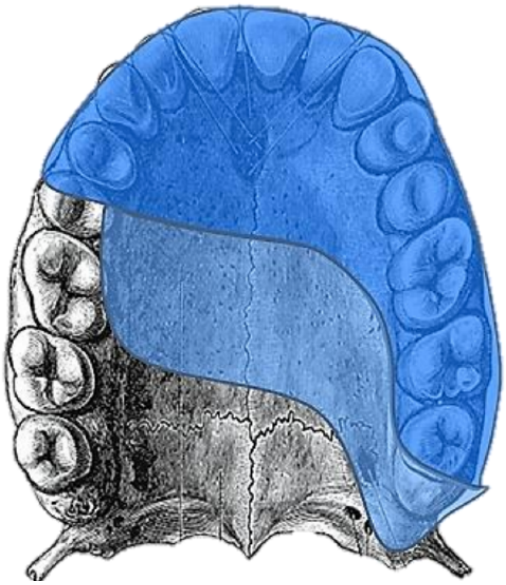


Figure 26: Total infrastructure palate

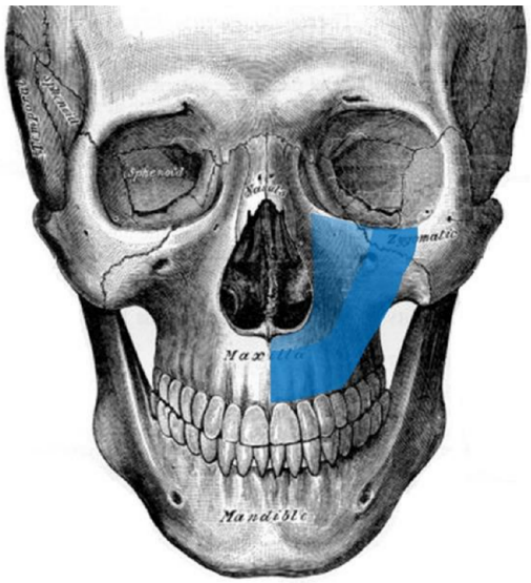


Figure 27: Hemimaxillectomy; the scapula is in a coronal orientation and is used to reconstruct alveolus and orbital rim

- Axial orientation is used for partial or total infrastructure maxillary reconstruction [1,9,10,15-17] (*Figures 25, 26*)
- A coronal orientation is used for hemimaxillectomy defects up to and including the infraorbital rim [5,9] (*Figure 27*)

Oral Cavity Reconstruction

- Sagittal orientation is used for most hemimandibulectomy reconstructions [7]

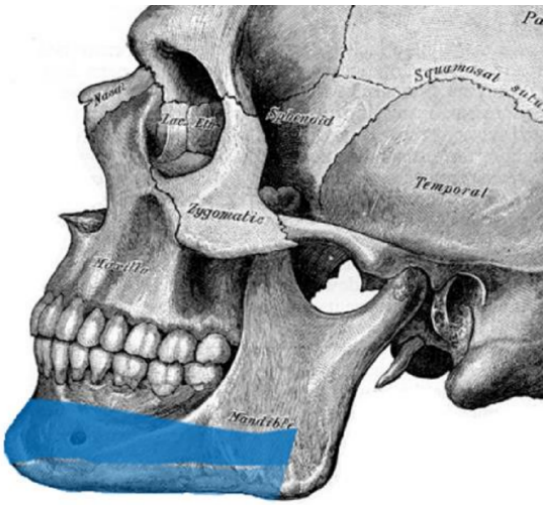


Figure 28: Hemimandible reconstruction with ipsilateral scapula. With this orientation the vascular pedicle is in a location that is less conducive to implants

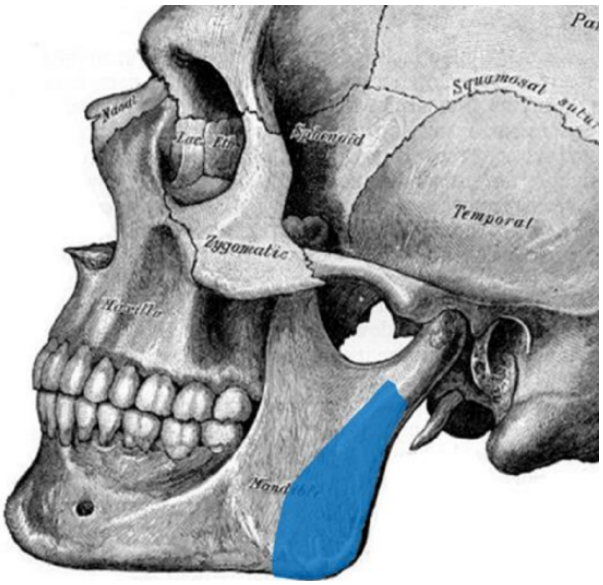


Figure 29: Angle and ramus reconstruction

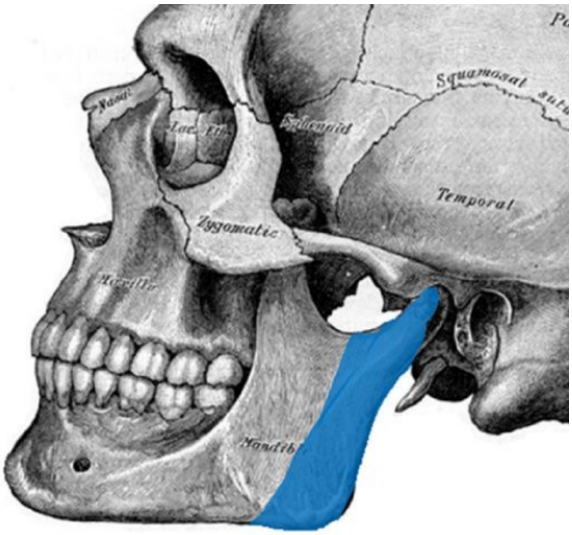


Figure 30: Condyle and ramus reconstruction

- The chest CT can be preoperatively to see if the contour matches a fit that would allow for inset without osteotomy (*Figure 28*)
- Sagittal orientation is used for the angle and ramus up-to-and-including the condyle of the mandible [12] (*Figures 29, 30*). The pedicle exits anteriorly or inferiorly. The tip of the scapula is used for reconstruction of the condyle

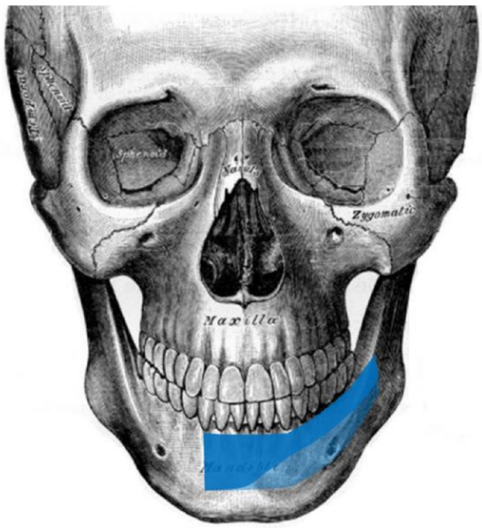


Figure 31: Partial symphysis and anterior body ipsilateral scapula reconstruction



Figure 32: Bilateral symphysis and anterior body reconstruction

- Axial orientation for the reconstruction of a portion of the symphysis and anterior body of the mandible (*Figure 31*)
- Axial orientation for anterior symphysis defect of the mandible. The tip of the scapula does not fit the mandibular symphysis as well as with the maxilla but depending on the shape of the donor scapula, the fit can be adequate (*Figure 32*). This approach works well for large anterior composite resection of the oral cavity that includes the tongue because the bone requirements are less sophisticated

Orbital Reconstruction

- Use the natural curve of the scapular tip [19-21]

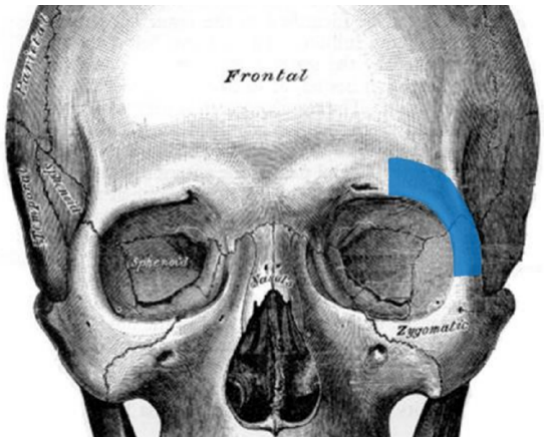


Figure 33: Lateral orbital rim reconstruction

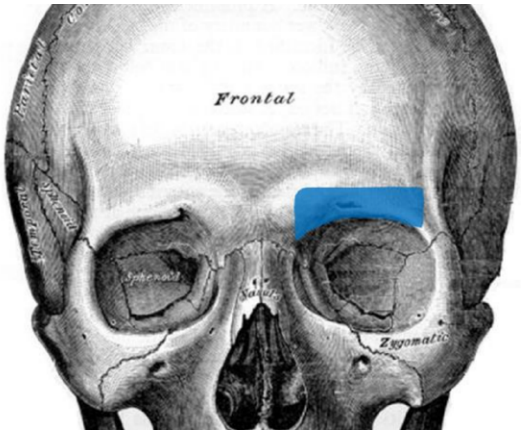


Figure 34: Supraorbital rim reconstruction

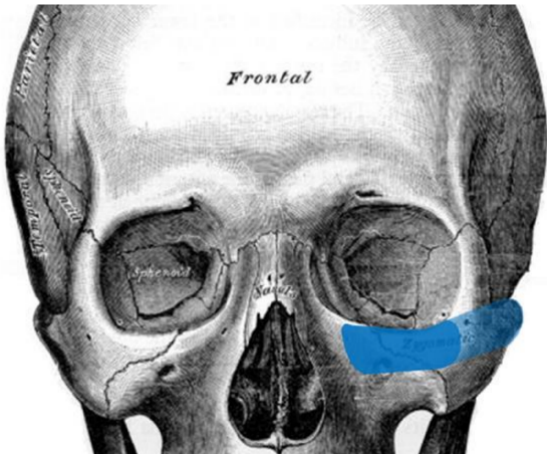


Figure 35: Infraorbital rim reconstruction

- Make a template of the missing segment of orbit and find the best match to this curve on the tip of the scapula (*Figure 33*)
- For reconstruction of the orbital rim use a short segment (*Figure 34*)
- For reconstruction of the orbital rim and orbital floor with an intact orbit. Use a small fragment of free bone or a MEDPORE orbital floor prosthesis (*Figure 35*)

Cricoid Reconstruction

- This is a very advanced reconstruction
- The curved scapular segment is 3 mm wide and must be covered with vascularized muscle [22]
- The inset is difficult because vascularity of the scapular segment is required

Suitability for Implants

Implants can be used in the craniofacial skeleton (orbit) or the oral cavity (maxilla or mandible). Although it is possible to implant the scapula [23], there are several barriers and as a result, patients are infrequently implanted.

There are a number of barriers to implantation: the bone must be in a location that facilitates an occlusal plane; the implants should be placed prior to radiation to reduce implant failures; soft tissue reconstruction has to result in an implantable alveolar subunit; and the tongue must be able to reach around the front of the prosthetic to clear food during mastication.

It is important to note that implant-borne prostheses can cover critical sensate tissue and/or impair tongue mobility. As a result, the long-term use of implant borne prostheses is limited because many patients can eat more efficiently with a softer diet without an implant borne prosthesis. The most frequent area of success with implant use is in the maxilla because the bone placement is more straightforward, the prosthesis does not impair tongue function or cover a critical sensate area. Of course, if the bone is placed prior to radiation, it will not be suitable for implantation. Implants can be placed around the orbit to retain an orbital prosthesis but most often, instead of a prosthesis, the orbit is filled with soft tissue and this achieves patient acceptance [19].

Summary

The thoracodorsal artery scapular tip flap is the osseous (bone) component of the latissimus dorsi flap. The donor material is extremely flexible, and presents many possible combinations of skin, muscle and bone paddles that makes this arterial donor system valuable for head and neck reconstruction. In addition, the thoracodorsal arterial system can be combined with the circumflex scapular artery system (both arteries arise from the subscapular system or are directly adjacent to one another) to further increase the skin paddle and bone paddle options. Although not always ideal, this flap may be used to reconstruct almost all defects in the head and neck.

References

1. Uglešić V, Virag M, Varga S, Knežević P, Milenović A. Reconstruction following radical maxillectomy with flaps supplied by the subscapular artery. J Craniomaxillofac Surg. 2000;28(3):53-60
2. Chepeha D, Khariwala S, Chanowski E, Zumsteg J, Malloy K, Moyer J, Prince M, Sacco A, Lee J. Thoracodorsal artery scapular tip autogenous transplant: vascularized bone with a long pedicle and flexible soft tissue. Arch Otolaryngol Head Neck Surg. 2010;136(10):958-64
3. Sullivan M, Carroll W, Baker S, Cromp ton R, Smith-Wheelock M. The free scapular flap for head and neck reconstruction. Am J Otolaryngol. 1990; 11(5):318-27
4. Urken M, Bridger A, Zur K, Genden E. The scapular osteofasciocutaneous flap: a 12-year experience. Arch Otolaryngol Head Neck Surg. 2001; 127(7):862-9
5. Brown J, Bekiroglu F, Shaw R. Indications for the scapular flap in reconstructions of the head and neck. Br J Oral Maxillofac Surg. 2010;48(5):331-7
6. Seneviratne S, Duong C, Taylor G. The angular branch of the thoracodorsal artery and its blood supply to the inferior angle of the scapula: an anatomical study. Plast Reconstr Surg. 1999; 104(1):85-4
7. Dowthwaite S. Theurer J. Belzile M, Fung K, Franklin J, Nichols A, Yoo J. Comparison of fibular and scapular osseous free flaps for oromandibular reconstruction: a patient-centered approach to flap selection. JAMA Otolaryngol Head Neck Surg. 2013;139(3): 285-92
8. Yoo J, Dowthwaite S, Fung K, Franklin J, Nichols A. "A new angle to mandibular reconstruction: the scapular tip free flap. Head Neck. 2013;35(7):980-6
9. Clark J, Vesely M, Gilbert R. Scapular angle osteomyogenous flap in postmaxillectomy reconstruction: defect, reconstruction, shoulder function, and harvest technique. Head Neck-J Sci Spec, 2008; 30(1):10-20
10. Miles B, Gilbert RW. Maxillary reconstruction with the scapular angle osteomyogenous free flap. Arch Otolaryngol Head Neck Surg. 2011;137(11):1130-5
11. Stevens J, Rosko A, Marchiano E, Haring C, Chinn S, Malloy K, Prince M, Casper K, Moyer J, Chepeha D, Stucken C, Spector M. The Spider Limb Positioner in subscapular system free flaps. Oral Oncol. 2018; 85:24-8
12. Seitz A, Papp S, C. Papp Maurer H. The anatomy of the angular branch of the thoracodorsal artery. Cells Tissues Organs. 1999;164(4):227-36
13. Rowsell A, Davies D, Eizenberg N, Taylor G. The anatomy of the subscapular-thoracodorsal arterial system: study of 100 cadaver dissections. Br J Plast Surg.1984;37(4):574-6

14. Wagner A, Bayles S. The angular branch: maximizing the scapular pedicle in head and neck reconstruction. Arch Otolaryngol Head Neck Surg. 2008;134(11):1214-7
15. Kakibuchi M, Fujikawa M, Hosokawa K, Hikasa H, Kuwae K, Kawai K, Sakagami M. Functional reconstruction of maxilla with free latissimus dorsiscapular osteomusculocutaneous flap. Plast Reconstr Surg. 2002;109(4):1238- 44
16. Hanasono M, Skoracki R. The scapular tip osseous free flap as an alternative for anterior mandibular reconstruction. Plast Reconstr Surg, 2010;125(4):164e6e
17. Pagedar N, Gilbert R, Chan H, Daly M, Irish J, Siewerdsen J. Maxillary reconstruction using the scapular tip free flap: a radiologic comparison of 3D morphology. Head Neck. 2012;34(10):1377-82
18. Chanowski E, Casper K, Eisbruch A, Heth J, Marentette L, Prince M, Moyer J, Chepeha D. Restoration of the orbital aesthetic subunit with the thoracodorsal artery system of flaps in patients undergoing radiation therapy. J Neurol Surg B Skull. 2013;74(5) 279-85
19. Chanowski E, Casper K, Eisbruch A, Heth J, Marentette L, Prince M, Moyer J, Chepeha D. Restoration of the orbital aesthetic subunit with the thoracodorsal artery system of flaps in patients undergoing radiation therapy. J Neurol Surg B Skull. 2013;74(5):279-85
20. Chepeha D, Wang S, Marentette L, Bradford C, Boyd C, Prince M, Teknos T. Restoration of the orbital aesthetic subunit in complex midface defects. Laryngoscope. 2004;114(10):1706-13
21. Moyer J, Chepeha D, Prince M, Teknos T. Microvascular reconstruction of the orbital complex. Facial Plast Surg Clin N Am. 2009;17(2):225-37
22. Chanowski E, Haxer M, Chepeha D. Microvascular cricoid cartilage reconstruction with the thoracodorsal artery scapular tip autogenous transplant. Laryngoscope. 2012;122(2). 282-5
23. Blumberg JM, Walker P, Johnson S, Johnson B, Yu E, Lacasse MC, Lam DK, Rittenberg B, Yao CM, Chepeha D, de Almeida JR. Mandibular reconstruction with the scapula tip free flap. Head Neck. 2019; doi: 10.1002/ hed.25702. [Epub ahead of print]

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author

Professor Douglas Chepeha MD, MSCPH, FRCSC, FACS
Head & Neck Oncology, Reconstructive Microsurgery
Universtiy Health Network, Princess
Margaret Hospital
Department of Otolaryngology-Head & Neck Surgery
University of Toronto
Toronto, Ontario, Canada
douglas.chepeha@uhn.ca

Acknowledgements

Carolyn Barsoum BSc
University of Manatoba
Winnipeg, Manitoba, Canada
carolyn.barsoum@uhn.ca

Feben Alemu BSc
University of Toronto
Toronto, Ontario, Canada
feben.alemu@uhn.ca

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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LOCAL FLAPS FOR FACIAL RECONSTRUCTION

Shiayin Yang, Carl Truesdale, Jeffrey Moyer

This chapter focuses on local flaps used in surgical management of cutaneous squamous (SCC) and basal cell carcinoma (BCC) of the face.

Nonmelanoma skin cancer (NMSC) is the most common type of skin cancer in the United States with an increasing annual incidence.[1] Worldwide, the incidence of skin cancer is also increasing.[2,3] Surgery is the most effective treatment for NMSC of the head and neck – excision or Mohs micrographic surgery (MMS). [4,5,6,7]

Parameters	Low Risk	High Risk
Clinical		
• Location[i] / size[ii]	Area L <20mm Area M[iii] <10mm[1]	Area L ≥20mm Area M ≥10mm Area H[iv]
• Borders	Well defined	Poorly defined
• Primary/recurrent	Primary	Recurrent
• Immunosuppression	No	Yes
• Site of prior RT	No	Yes
Pathologic[v]		
• Subtype	Nodular, superficial[vi]	Aggressive growth pattern[vii]
• Perineural involvement	No	Yes

i	*Area L = Trunk and extremities (excluding hands, feet, nail units, pretibial, and ankles) Area M = Cheeks, forehead, scalp, neck, and pretibial Area H = Central face, eyelids, eyebrows, periorbital skin, nose, lips [cutaneous and vermillion], chin, mandible, preauricular and postauricular skin/sulci, temple, ear, genitalia, hands, and feet*
ii	*Greatest tumour diameter*
iii	*Location independent of size may constitute high risk*
iv	*Area H constitutes a high-risk area on the basis of location, independent of size*
v	*See Principles of Pathology (BCC-A in the NCCN Guidelines for Basal Cell Skin Cancer)*
vi	*Includes other low-risk non-aggressive growth patterns such as include keratotic, infundibulo-cystic, and fibroepithelioma of Pinkus*
vii	*Having (mixed) infiltrative, micronodular, morpheaform, basosquamous, sclerosing, or carcino-sarcomatous differentiation features in any portion of the tumor. In some cases, basosquamous tumours may be prognostically similar to SCC; clinicopathologic correlation is recommended in these cases*

Table 1: National Comprehensive Cancer Net-work risk factors for recurrence of localised Basal Cell Skin Cancer (Adapted with permission from the NCCN Guidelines® for Basal Cell Skin Cancer V.1.2019) [5]

Parameters	Low Risk	High Risk
Clinical (Based on H&P)		
• Location[i] / size[ii]	Area L <20mm Area M[iii] <10mm[1]	Area L ≥20mm Area M ≥10mm Area H[iv]
• Borders	Well defined	Poorly defined
• Primary/recurrent	Primary	Recurrent
• Immunosuppression	No	Yes
• Site of prior RT or chronic inflammatory process	No	Yes
• Rapidly growing tumour	No	Yes
• Neurologic symptoms	No	Yes
Pathologic[v]		
• Degree of differentiation	Well to moderately	Poorly
• High-risk histologic subtype[vi]	No	Yes
• Depth[vii, viii] (thickness or level of invasion)	≤6mm and no invasion beyond subcutaneous fat	>6mm and no invasion beyond subcutaneous fat
• Perineural, lymphatic, or vascular involvement	No	Yes

i	*Area L = Trunk and extremities (excluding hands, feet, nail units, pretibial, and ankles) Area M = Cheeks, forehead, scalp, neck, and pretibial Area H = Central face, eyelids, eyebrows, periorbital skin, nose, lips [cutaneous and vermillion], chin, mandible, preauricular and postauricular skin/sulci, temple, ear, genitalia, hands, and feet*
ii	*Greatest tumour diameter, including peripheral rim of erythema*
iii	*Location independent of size may constitute high risk*
iv	*Area H constitutes a high-risk area on the basis of location, independent of size*
v	*See Principles of Pathology (SCC-A in the NCCN Guidelines for Squamous Cell Skin Cancer)*
vi	*Adenoid (acantholytic), acantholytic (adenoid), adenosquamous (showing mucin production), desmoplastic, or metaplastic (carcinosarcomatous) subtypes*
vii	*If clinical evaluation of incisional biopsy suggests that microstaging is inadequate, consider narrow margin excisional biopsy*
viii	*Deep invasion is defined as invasion beyond the subcutaneous fat OR >6 mm (as measured from the granular layer of adjacent normal epidermis to the base of the tumor, consistent with AJCC 8th edition)*

Table 2: National Comprehensive Cancer Net-work Risk Factors for Local Recurrence or Metastasis of Localized Squamous Cell Skin Cancer (Adapted with permission from the NCCN Guidelines® for Squamous Cell Skin Cancer V.2.2019) [4]

Cases of local basal [4] or squamous skin cancers [5] can be divided into low- and high-risk based on clinical and pathologic characteristics (*Tables 1, 2*). In addition to risk of recurrence, the best treatment plan is also dependent on the type of skin cancer, location, and patient's co-morbidities and expectations.

Standard excision

Standard excision of SCC and BCC includes excision with a margin of clinically normal appearing skin to ensure complete removal with histologically negative margins. For local low-risk SCC, standard excision of the lesion with a 4-6 mm clinical margin is a recommended option.[7] For local low-risk BCC, standard excision of the lesion with a 4 mm clinical margin is recommended.[6] The depth of the excision should extend into the subcutaneous tissue. The specimen should be sent for histologic assessment of the lesion and all margins. If there is concern that margins may be close or positive, then definitive reconstruction should be delayed until histologic confirmation of negative margins.

Mohs micrographic surgery (MMS)

MMS is a surgical technique that removes skin cancer with intraoperative histologic examination of 100% of surgical margins. A single surgeon excises the lesion and margins and then histologically examines the specimen. This process is repeated until the margins are negative. Clinical guidelines published by the American Academy of Dermatology recommends MMS for treatment of high-risk BCC and SCC.[8]

Local Flaps: Overview

A local flap comprises skin and subcutaneous tissue with a direct vascular supply, that is transferred to an adjacent or nearby site. The ***primary defect*** is the wound that is closed by the local flap; the ***secondary defect*** is the wound created after transfer of the local flap to the primary defect.

Local flaps have several advantages

- Reliable blood supply
- Good skin texture and color match
- A single stage procedure

Flaps can be defined by

- Blood supply (random or axial)
- Configuration (rhombic, bilobed)
- Location of defect (regional, interpolated)
- Type of transfer (advancement, rotation, transposition)

Choice of local flap

Determining the type of local flap to use depends on the location of the defect and the flap donor site. When planning placement and design of a local flap there are ***important tenets of reconstruction to bear in mind***.



Figure 1: Incisions and closures should be planned along the relaxed skin tension lines (RSTL) which are lines of skin tension that are created from the action of underlying muscle fibers that run perpendicular to the skin

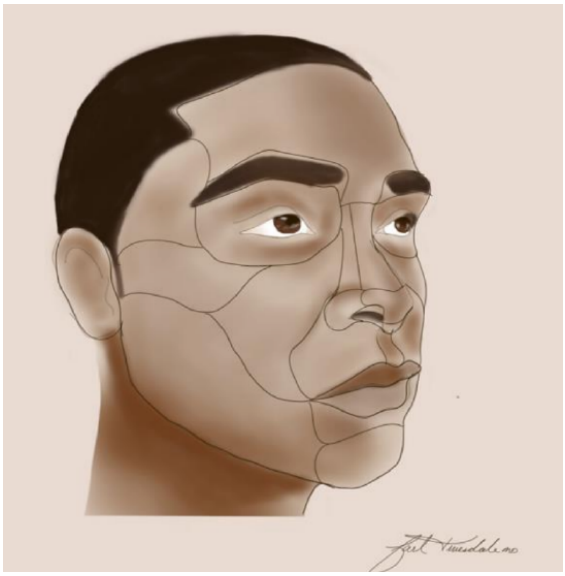


Figure 2: Illustration demonstrating aesthetic subunits of the face

1. ***Incisions and closures should be along relaxed skin tension lines (RSTLs)***. RSTLs are lines of skin tension that are formed by contraction of underlying facial mimetic muscle fibers which run perpendicular to the superficial skin rhytids (*Figure 1*). Incisions placed along RSTLs can mimic facial rhytids and are often less conspicuous. In addition, closing along RSTLs helps to minimize tension, especially in areas that have significant aesthetic and functional value.
2. ***Closures should be tension free***. This is best accomplished by undermining the skin along the lines of maximal extensibility (LME). LME is the direction in which skin is most extensible and runs perpendicular to RSTLs and parallel to facial mimetic

muscle fibers. Undermining parallel to LME allows maximal distribution of tension within the flap in order to minimize tension at the closure sites.

3. Flaps should ***respect and preserve facial aesthetic and functional subunits*** (*Figure 2*). Placing local flap incisions along the borders of subunits can help preserve the neighboring aesthetic subunit, prevent disruption of tissue contours and function, and conceal incisions in natural shadows formed by these borders.

Advancement Flaps

Advancement flaps are flaps that slide along a linear vector to close a defect. The flap relies on stretching of tissue for advancement and is best utilized in areas of good skin elasticity. The point of greatest wound tension is at the distal border of the flap. Advancement flaps include unipedicle, bipedicle, and V-Y flaps.

Unipedicle advancement flaps

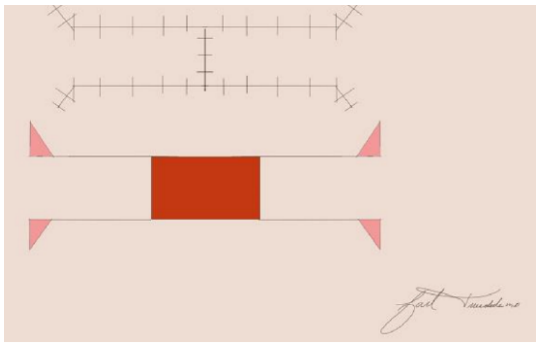


Figure 3: H-plasty

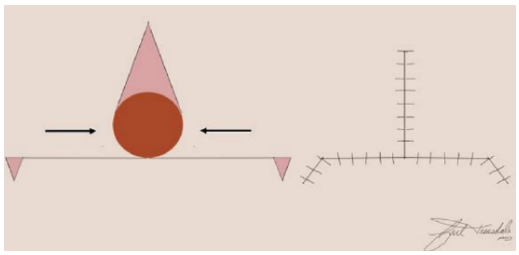


Figure 4: O-to-T flap

A unipedicle advancement flap shares a border with its defect and is advanced in a linear direction over the defect. The border between the defect and the flap becomes the leading edge of the advancement flap. As the flap is advanced, standing cutaneous deformities develop on either side of the flap's base and can be excised with ***Burrow's triangles***. Bilateral unipedicle advancement flaps can be used to close larger defects by placing the flaps on opposing sides of the defect and advanced towards each other. The resulting shape of wound closure from bilateral unipedicle flaps is referred to as an H- or a T-plasty (*Figures 3, 4*).

Note how H- and O-to-T-plasty advancement flaps utilize two opposing unipedicle flaps to close a primary defect. Burrow's triangles are removed at the base of the flap to correct standing cutaneous deformities.



Figure 5a: A 1.5 cm circular defect of the left cheek. Standing cutaneous deformities marked on the superior and inferior border of the defect



Figure 5b: Bilateral unipedicle advancement flaps used to close defect

H or O-to-T advancement flaps are employed in areas where minimal tissue distortion is imperative such as near the eyebrow, helical rim, and vermilion border. They can also be used to close defects of the cheek, temple, and forehead (*Figures 5ab*).

Bipedicle Advancement Flap

A bipedicle advancement flap advances tissue at a right angle to the linear axis of the flap to close an adjacent defect. The flap is designed to be longer than the defect and with a width equal or slightly greater than that of the defect. A secondary defect is produced with closure of the primary defect and requires closure with a skin graft. Given the creation of a secondary defect, bipedicle advancement flaps are often reserved for repair of large scalp defects and small full thickness nasal defects. A common bipedicle advancement flap involves the vestibular mucosa to repair full-thickness defects of the alae where the mucosa is pedicled medially and laterally. The secondary defect created by the advancement is repaired with a full-thickness skin graft to prevent contraction.

V-Y Advancement Flap

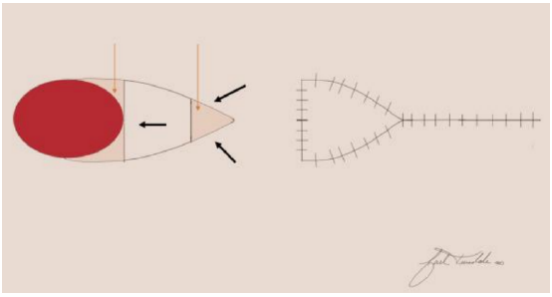


Figure 6: V-Y advancement flap with original configuration in the shape of a V. The flap is advanced in a linear direction while maintaining a subcutaneous pedicle that is at least 1/3 the length of the flap. With closure of the flap, the final configuration is Y-shaped

The V-Y advancement flap relies on a subcutaneous pedicle to supply an island of skin that is advanced in a linear direction to close a defect (*Figure 6*).



Figure 7a: 2 cm skin defect of the upper lip involving the vermillion border



Figure 7b: V-Y advancement flap design with borders along the vermilion border and melolabial crease



Figure 7c: Flap in position after advancement with a final Y-shaped configuration

The flap is designed in a triangular fashion with the leading edge designed to be of similar size to the defect, and the sides parallel to RSTLs or within natural creases or folds. The flap is incised along all edges down to subcutaneous tissue. The surrounding tissue is undermined away from the pedicle to allow for flap mobilization. The leading and tail edges of the flap can be undermined provided that at least 1/3 of the flap is in continuity with the pedicle to ensure adequate blood supply. Closure of the wound forms a Y configuration (*Figures 7a-c*). The maximum point of wound tension is at the apex of the flap. This flap is used to repair defects of the lip, cheek, forehead, and nose.

Rotation Flaps

Rotation flaps are pivotal flaps that recruit adjacent tissue to close a primary defect.



Figure 8a: Planned left cheek defect marked with blue sutures. Design of rotation flap, recruiting skin from lateral cheek. Burrow's triangle marked on inferior aspect of planned check defect to account for correction of standing cutaneous deformity after flap rotation. Arrow indicates direction of flap rotation



Figure 8b: Flap inset. Standing cutaneous deformity removed with inset along nasolabial crease

They are versatile flaps and are best utilized to close triangular-shaped primary defects. The flap is designed in a curvilinear fashion with the defect forming a portion of the flap's arc of rotation. It is best to base the flap inferiorly and medially and bordering a RTSL. The length of the flap should be about four times the width of the triangular defect. The point of greatest wound tension is at the apex of the flap. Rotation of the flap causes a standing cutaneous deformity at the base of the flap, which can be corrected by excising a Burrow's triangle. A primary defect with a height of two times the width minimizes the size of the standing cutaneous deformity. Advantages of rotation flaps include a reliable vascular supply given its broad base, and flexible design that can be placed between subunits of the face (*Figures 8ab*).

Rotation flaps are best suited to repair defects of the scalp but can also be used on the cheek and nose. For scalp defects, it is often helpful to employ more than one rotational flap given the inelasticity of the scalp.

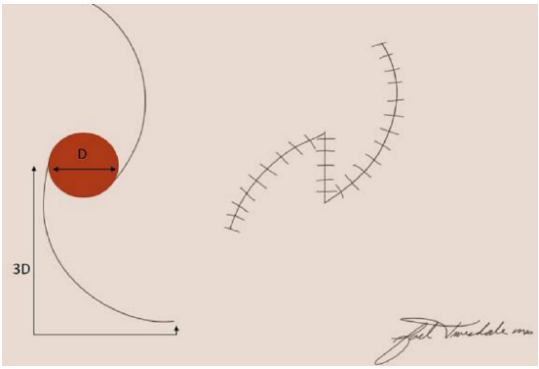


Figure 9: Two rotation flaps positioned on opposite sides of the defect. The length of the flap is three times the diameter of the defect. The final configuration after rotation of the flaps results in a Z-shape

An O-Z repair utilizes two rotational flaps, oriented on opposite sides of the defect, and pivots the flaps in the same direction to close the primary defect (*Figure 9*). When three rotational flaps are rotated in the same direction to close a defect this results in a pinwheel configuration.

Rotation flaps can be used for both small and large cheek defects, though they are often combined with some component of advancement. For large defects of the cheek, cervicofacial flaps are extremely reliable for reconstruction for medial and lateral defects owing to the recruitment of lateral neck skin and positioning of the scar at the borders of aesthetic subunits. For defects of the dorsum, sidewall, and tip of the nose, a dorsal nasal flap, which utilizes skin from the glabella to close defects, is a method of reconstruction.[9] The dorsal nasal flap is primarily a rotation and advancement flap but also has a pivot component.

Transposition flaps

Transposition flaps are pivotal flaps with a linear configuration. The flap can share a border with the primary defect, similar to rotational flaps, but it can also be designed remotely from the primary defect. The base of a transposition flap is always contiguous

with the defect. Placing the flap remotely is advantageous as the surgeon can recruit tissue from areas where there is relative skin laxity. With transposition of the flap, a standing cutaneous deformity is formed at the base of the flap. Excision of the standing cutaneous defect should be away from the base of the flap so not to compromise the flap's blood supply. The area of greatest wound closure tension is at the closure site of the secondary defect. Transposition flaps are reliable methods of reconstruction for small and medium-sized defects of the cheek and nose. Types of transposition flaps include the ***note flap***, ***bilobe flap***, and ***rhombic flap***.

Note flap

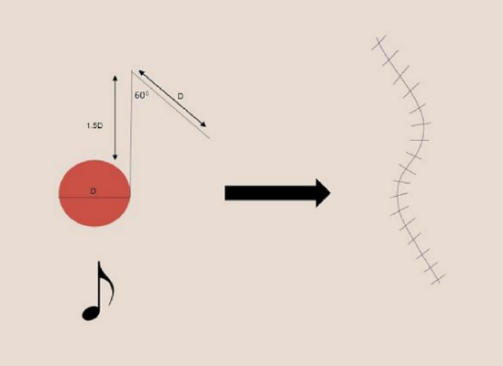


Figure 10: Transposition flap that incorporates a 60°angle triangle placed adjacent to the defect. The flap resembles a musical eighth note

The note flap is a transposition flap designed as a triangle with 50-60° degree angle used to close an adjacent circular defect.[10] The flap is named for its design, which resembles a musical eighth note (*Figure 10*). The limb of the flap adjacent to the defect has a length of 1.5 times the diameter of the defect and is drawn parallel to a RSTL. The second limb of the flap is equal to the diameter of the defect. The triangular flap is transposed to close the primary defect, and the distal tip of the defect is trimmed as needed. The donor site is closed primarily (*Figure 10*).



Figure 11a: Skin defect of left temple



Figure 11b: Note flap design with planned tissue transposition from skin medial to defect. Burrow's triangle marked on superior aspect of defect in order to remove standing cutaneous defect



Figure 11c: Flap inset with removal of standing cutaneous defect superiorly along temporal hairline

The greatest wound closure tension is at the point where the flap tangents the defect. It can be used to close circular defects up to 2 cm in size anywhere on the head and neck. Advantages of the note flap are its versatility, straightforward design, and ability to camouflage the donor site in natural creases or along RSTL. The main disadvantage is the need for skin laxity in order to primarily close the donor site, which limits its use to closure of small defects (*Figures 11a-c*).

Bilobe flap

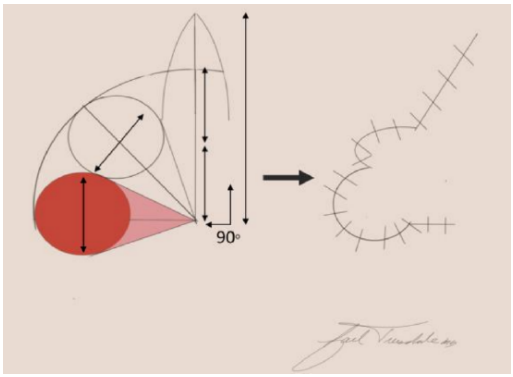


Figure 12: Bilobe flap with 90° axis of rotation. The first lobe is equal in diameter to the defect while the second lobe has a smaller diameter

The bilobe flap is a transposition flap composed of two lobes with a single base around which the flap pivots. The flap was first described with an arc of rotation of 180° with axes of 90° between the defect and 1st lobe as well as between the 1st and 2nd lobes.[11] The flap has undergone modifications by limiting the arc of rotation to 90° to decrease the size of the standing cutaneous deformities and decrease trapdoor deformity (*Figure 12*).[12]

Placement of the flap should be in an area of greater skin elasticity to allow for adequate tissue recruitment.



Figure 13a: Skin defect of nasal tip



Figure 13b: Design of bilobe flap extending over nasal dorsum with Burrow's triangle marked on the lateral aspect of the defect



Figure 13c: The bilobe flap inset with removal of standing cutaneous deformity

Bilobe flaps are most commonly employed for the caudal one-third of the nose, but they can also be a good reconstructive option for large cheek defects. The primary lobe of the flap is designed to be of similar surface area and adjacent to the primary defect. For

cheek defects, the primary lobe may be up to 25% less than the defect size due to the relative increased skin elasticity of the cheek compared to the nose. The size of the secondary lobe is typically smaller than that of the primary lobe (50-100% the size of the primary lobe) and is closed primarily by skin advancement. The main advantage of the bilobe flap is the ability to recruit skin from a distal site where skin redundancy allows primary closure of the tertiary defect (*Figures 13a-c*). The major disadvantages of the flap are the large scar, the tendency for trapdoor deformity, especially in patients with thick sebaceous skin, and difficulty placing the incisions parallel to RSTL due to the complex design.

Rhombic (Limberg) flap

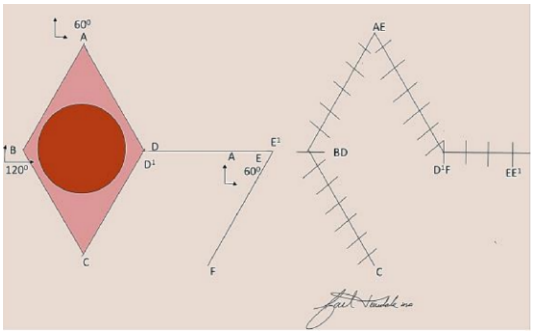


Figure 14: Rhombic flap with internal angles of 60 and 120°

The classic rhombic (Limberg) flap is a transposition flap used to repair defects in the shape of a rhombus with internal angles of 60° and 120°.[13] A rhombus in this configuration can also be thought of as two equilateral triangles; thus all sides of the rhombus are of equal length. If a cutaneous defect does not have a 60°-120° rhombus configuration then additional skin can be removed to create this configuration. The 1st side of the flap is designed by extending a line equal to the length of a short diagonal, which bisects one of the 120° internal angles. The 2nd side is made parallel to the adjacent side of the rhombus and is of equal length to the 1st side. The flap is then transferred by both pivotal and advancement movement with the point of greatest wound tension at the donor site (*Figure 14*).

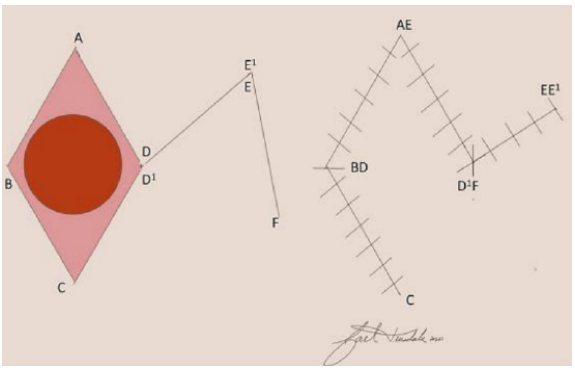


Figure 15: Modification of Limberg rhombic flap with internal angles less than 60 and 120°



Figure 16a: Right temple lesion planned for excision



Figure 16b: Dufourmentel rhombic flap designed on the inferior border of the planned defect

The rhombic flap is versatile and can be used to repair defects of the cheek, temple, chin, and neck. Advantages include minimal tissue distortion, predictable scars, and lower likelihood of trapdoor deformity. Disadvantages are formation of standing cutaneous deformity, need to excise normal skin to create a rhombic defect, and that a portion of the scar does not lie within the RSTL. The ***Dufourmentel flap*** is a modification of the classic rhombic flap and can be used to close rhomboids with any combination of internal angles (*Figure 15*).[14] The advantage of the Dufourmentel flap is a smaller standing cutaneous deformity (*Figures 16ab*).

Interpolated Flap

An interpolated flap is a pivot flap in which the base of the flap is not contiguous with the defect and the pedicle of the flap passes over intervening tissue in order to close the primary defect. Given that the pedicle must pass over intervening tissue, interpolated flaps routinely require a 2nd stage procedure to divide the pedicle and inset the flap. These flaps are used for tissue defects that cannot be closed with adjacent flaps due to insufficient tissue or skin laxity. The paramedian forehead and melolabial flaps are interpolated flaps that can be used to reconstruct nasal defects.

Paramedian Forehead Flap (Figures 17ad, 18)



Figure 17a: Lateral view of skin defect involving right nasal tip and soft tissue triangle. Nasal subunits involving the defect and adjacent to defect outlined



Figure 17b: Bird's eye view of skin defect and outlined nasal subunits of right tip and ala



Figure 17c: Lateral view of paramedian forehead flap inset with reconstruction of right hemi-tip



Figure 17d: Bird's eye view of paramedian forehead flap inset



Figure 18a: Subtotal nasal defect of nasal dorsum, tip, columella, both alae and soft tissue triangles. Right paramedian forehead flap designed over supratrochlear artery



Figure 18b: Bird's eye view of paramedian forehead flap after inset with pedicle attached



Figure 18c: Basal view of nasal defect with grafted cartilage to reconstruct the nasal framework

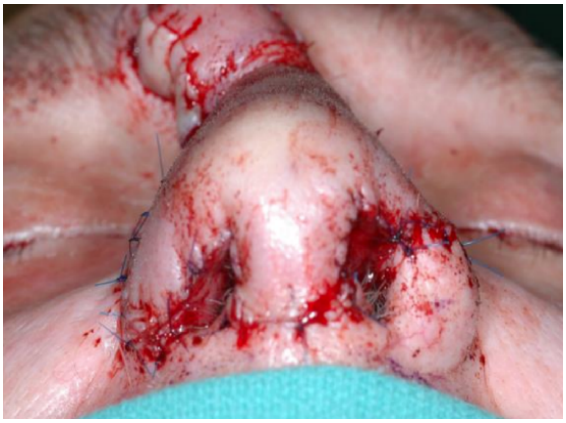


Figure 18d: Basal view after inset of paramedian forehead flap

The paramedian forehead flap is an interpolated flap with an axial blood supply provided by the supratrochlear artery and with some contributions from the supraorbital artery. It is designed over the path of the supratrochlear artery. The supratrochlear artery exits the orbit 1.7 to 2.2 cm lateral to midline, which roughly corresponds to the medial eyebrow. At this level the artery travels under the orbicularis oculi and over the corrugator supercilia. The artery then pierces the orbicularis and frontalis muscles to travel more superficial in the cephalic direction. Due to its reliable blood supply, the length of the flap can be 4 times the width of the pedicle.

There are many reasons why the paramedian forehead flap is the workhorse in reconstruction of large nasal defects – it provides significant tissue for coverage; has a similar skin color and texture to the nose; and it can revascularize cartilage or bone grafts needed to reconstruct the nose.

When planning the design of the flap, it is important to evaluate the nasal skin defect and the nasal subunits involved. ***If the defect involves more than 50% of a subunit, the entire subunit should be excised and reconstructed***. A template is made of the defect and the excised subunits. This template is placed just below the hairline along the course of the supratrochlear artery. If the template is large or more skin/pedicle length is needed, then the template can be placed within the hair with the understanding that hair removal from the flap will be needed postoperatively.

Cephalically, the flap is raised in a subcutaneous plane, which allows for a thin and pliable flap that can easily be contoured to the nasal defect. If more bulk is needed to cover a deep defect, then frontalis muscle can be left on the flap. As dissection proceeds caudally, the course of the artery is deeper and thus dissection should be below the fascia or periosteum to protect the pedicle. The flap is inset into the nasal defect after structural grafting has been undertaken. A full thickness skin graft taken from the supraclavicular fossa can be sewn to the open portion of the pedicle to reduce postoperative oozing. The donor site is closed primarily. If the donor site is too large to be closed primarily, portions can be left to granulate with adequate aesthetic outcomes.

The forehead flap remains attached for approximately 3 weeks to the recipient and donor sites via the skin pedicle containing the supratrochlear artery. After 3 weeks, sufficient blood supply has developed from the periphery of the recipient site, and the vascular pedicle may be safely divided and the recipient and donor sites aesthetically repaired.

After detachment and inset, additional procedures, can be performed to thin and contour the flap as needed.

The main disadvantages of paramedian forehead flaps are the need for at least 2 procedures, a large donor site scar, potential for alopecia at the donor site, and greater risk of postoperative bleeding compared to other local flaps.

Melolabial Flap

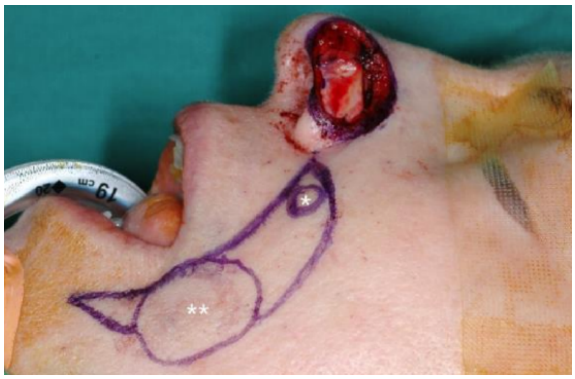


Figure 19a: Skin defect involving left nasal tip, soft tissue triangle, and ala. Melolabial flap designed along melolabial groove. Asterisk marks the pedicle of the flap to be kept intact. Double asterisks mark the skin flap to be transposed onto the defect



Figure 19b: Melolabial flap inset with pedicle intact. The pedicle is taken down 3 weeks later and the lateral aspect of the flap is inset. Asterisk marks pedicle of flap

The melolabial flap is an interpolated flap that transfers tissue from the cheek to reconstruct nasal ala defects. The flap is designed lateral to the melolabial crease. Given the inherent redundancy of tissue in this area, there is usually enough tissue for flap transfer and primary closure of the donor site. The blood supply can be based on cutaneous or subcutaneous pedicles. Advantages of the flap are its ability to recruit tissue from an area with increased skin elasticity, and redundancy and ease of scar camouflage within the melolabial crease. The main disadvantage is the need for a second stage procedure to take down the pedicle (*Figure 19*).

Abbe Flap



Figure 20ab: Abbe flap used to reconstruct the lower lip

The Abbe flap is an interpolated flap used to repair full thickness lip defects that comprise >25% of the lip and cannot be closed primarily or with advancement flaps. The flap is designed from the opposing lip with the height of the flap equal to that of the defect and the width about half the width of the defect (*Figures 20ab*). The labial artery serves as the vascular pedicle and runs between the orbicularis oris and lip mucosa. Once the flap has been designed, it is raised with preservation of the labial artery and pivoted almost 180° into the defect. Inset of the flap requires special attention to reapproximate the vermillion border and the mucosa, muscle, and skin. The secondary defect is closed primarily. While the pedicle is attached, patients consume a liquid and soft diet to limit strain on the pedicle. The pedicle of the flap is divided after 3 weeks and the flap is fully inset.

Postauricular Flap



Figure 21a: Skin and cartilage defect of helical rim and scapha

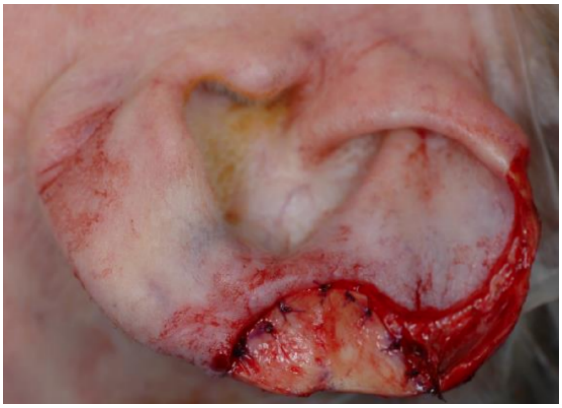


Figure 21b: Conchal cartilage graft used to reconstruct scapha and portion of helical rim

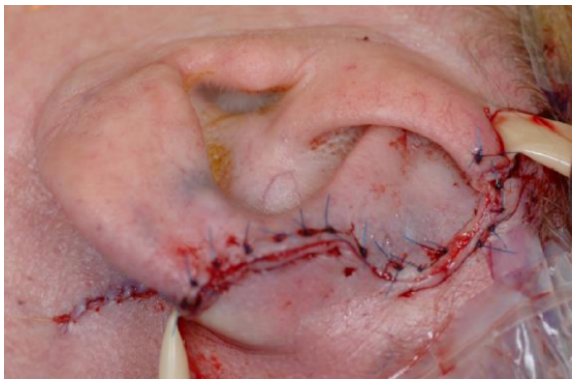


Figure 21c: Postauricular skin flap inset over cartilage framework

The postauricular flap is a two-stage procedure used to reconstruct large defects of the auricle that require both cartilage and soft tissue repair. The first stage involves reconstruction of the cartilaginous framework and a posteriorly based cutaneous advancement flap. The flap is elevated from the medial aspect of the auricular defect and continued posteriorly into the postauricular sulcus and onto the scalp. The width of the flap is equal to the height of the defect. Once the flap is elevated, the cartilaginous framework is reconstructed using harvested conchal or septal cartilage. The cartilaginous framework is laid underneath the flap and the flap is secured to the skin on the anterior aspect of the defect, in order to completely cover the cartilage. The advancement flap remains

attached for 3 weeks. At the 2nd stage, the advancement flap is released from the scalp and used to cover the medial aspect of the defect. A skin graft is used to repair the secondary defect from the advancement flap (*Figures 21a-c*).

References

1. Rogers HW, Weinstock MA, Feldman SR, Coldiron BM. Incidence Estimate of Nonmelanoma Skin Cancer (Keratinocyte Carcinomas) in the U.S. Population, 2012. JAMA Dermatol. 2015; 151(10):1081-6
2. Leiter U, Eigentler T, Garbe C. Epidemiology of skin cancer. Adv Exp Med Biol. 2014;810:120-40
3. Apalla Z, Lallas A, Sotiriou E, Lazaridou E, Ioannides D. Epidemiological trends in skin cancer. Dermatol Pract Concept. 2017;7(2):1-6
4. National Comprehensive Cancer Center. NCCN clinical practice guidelines in oncology; squamous cell skin cancer (V2.2019). Available at: www.nccn. org. Accessed June 17, 2019
5. National Comprehensive Cancer Center. NCCN clinical practice guidelines in oncology; basal cell skin cancer (V1.2019). Available at: www.nccn.- org. Accessed June 17, 2019
6. Kim JYS, Kozlow JH, Mittal B, et al. Guidelines of care for the management of basal cell carcinoma. J Am Acad Dermatol. 2018;78(3):540-59
7. Kim JYS, Kozlow JH, Mittal B, et al. Guidelines of care for the management of cutaneous squamous cell carcinoma. J Am Acad Dermatol. 2018;78(3):560- 78
8. Connolly SM, Baker DR, Coldiron BM, et al. AAD/ACMS/ASDSA/ASMS 2012 appropriate use criteria for Mohs micrographic surgery: a report of the American Academy of Dermatology, American College of Mohs Surgery, American Society for Dermatologic Surgery Association, and the American Society for Mohs Surgery. J Am Acad Dermatol. 2012;67(4):531-50
9. Rieger RA. A local flap for repair of the nasal tip. Plast Reconstr Surg. 1967;40 (2):147-9
10. Walike JW, Larrabee WF. The 'note flap'. Arch Otolaryngol. 1985;111(7): 430-3
11. Esser JFS. Gestielte lokale Nasenplastik mit zweizipfligem Lappen, Deckung des sekundaren Defektes vom ertsen Zipfel durch den zweiten. In. Vol 143. Deutsche Zeitschrift für Chirurgie 1918:385-90
12. Zitelli JA. The bilobed flap for nasal reconstruction. Arch Dermatol. 1989; 125(7):957-9
13. Limberg AA. Modern trends in plastic surgery. Design of local flaps. Mod Trends Plast Surg. 1966;2:38-61
14. Dufourmentel C. [Closure of limited loss of cutaneous substance. So-called "LLL" diamond-shaped L rotationflap]. Ann Chir Plast. 1962;7:60-6

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Deltopectoral flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Also refer to Open Access chapter: Surgical management of skin cancers of the head and neck

Authors

Shiayin F. Yang MD
Center for Facial Cosmetic Surgery
University of Michigan
19900 Haggerty Rd; Suite 103
Livonia, MI 48152
shi1yang@gmail.com

Carl Truesdale MD
Center for Facial Cosmetic Surgery
University of Michigan
19900 Haggerty Rd; Suite 103
Livonia, MI 48152
ctruesda@med.umich.edu

Jeffrey S. Moyer, MD
Center for Facial Cosmetic Surgery
University of Michigan
19900 Haggerty Rd; Suite 103
Livonia, MI 48152
jmoyer@med.umich.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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5.20: Deltopectoral and Cervicodeltopectoral Fasciocutaneous Flaps for Head and Neck Reconstruction

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

DELTOPECTORAL AND CERVICODELTOPECTORAL FASCIOCUTANEOUS FLAPS FOR HEAD AND NECK RECONSTRUCTION

Johan Fagan, Ottie van Zy

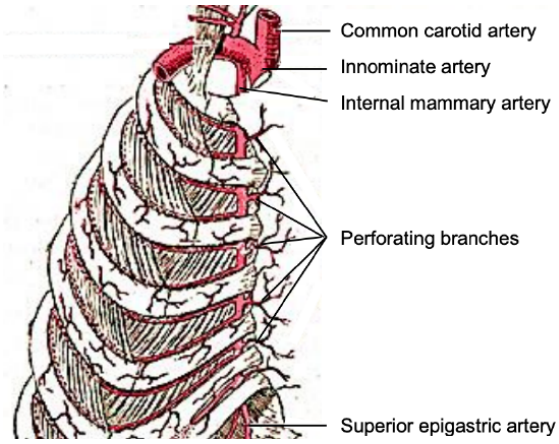


Figure 1: Perforators originate from the internal mammary artery

Fasciocutaneous flaps raised from the anterior chest wall below the clavicle are well suited to reconstructing skin defects in the head and neck region in terms of proximity, skin texture and skin colour. Bakamjian first described the ***deltopectoral (DP) flap*** in 1965 as a head and neck reconstructive option[1]. The DP flap is a pedicled axial fasciocutaneous flap based on the ***internal mammary artery perforator arteries (IMAP)*** (*Figure 1*) although the perforator(s) are usually not identified, dissected, nor mobilized. However, if the flap is raised as an island flap with complete division of the skin pedicle and the perforators are dissected out, it becomes an ***internal mammary artery perforator flap (IMAP flap)***; the IMAP flap will be discussed in a separate chapter.

Surgical anatomy

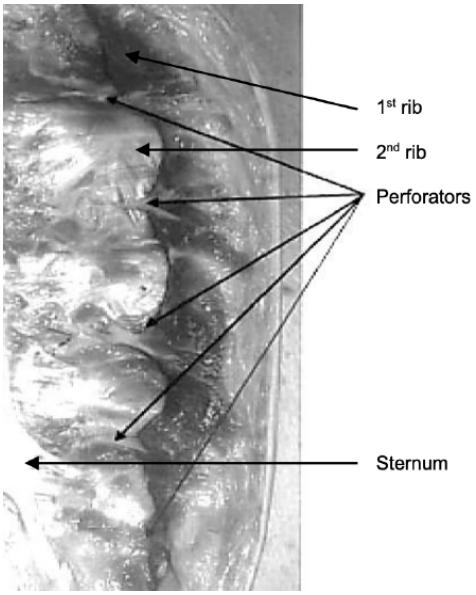


Figure 2: Left half of sternum: Perforators emerge approximately 7 mm lateral to sternum [2]

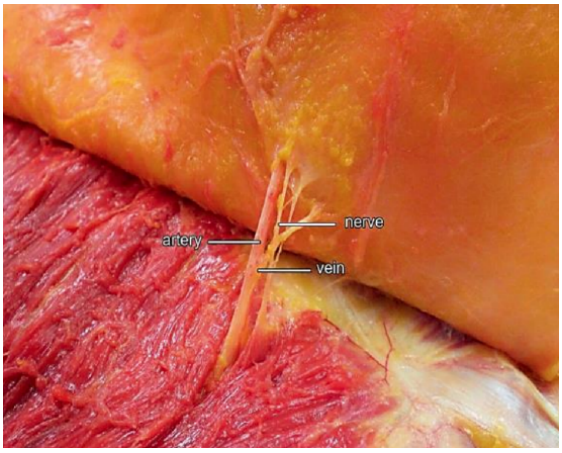


Figure 3: Perforator branch of IMA [3]

Paired internal mammary (IMA) arteries arise from the subclavian artery and course inferiorly on the inside of the rib cage approximately 1 cm lateral to the sternum (*Figure 1*). The perforating branches of the IMA emerge about 7 mm lateral to the sternum through five or six intercostal spaces; they are 0.25-3.5mm in diameter (*Figures 1, 2, 3*). The so-called "principal perforator" traverses the 2nd intercostal space; the mean diameters of this artery and vein are just over 1.8 mm^2. The vessels subsequently course laterally to provide blood supply to the pectoralis major muscle and overlying skin; the 2nd - 4th perforators send branches to the breast.

The blood vessels to the fasciocutaneous flap run in a plane superficial to the fascia that covers the pectoralis major and deltoid muscles; hence the importance of raising these flaps in a plane deep to the deltoid and pectoral fasciae.

The DP flap that is located medial to the deltopectoral groove (junction between pectoralis and deltoid muscles) has a reliable axial blood supply and can be transferred with a high probability of survival.

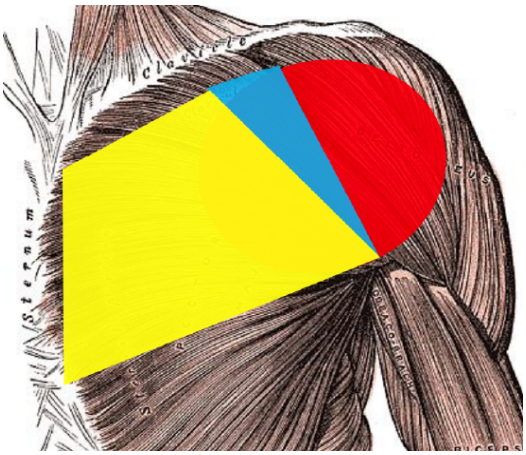


Figure 4a: 1st angiosome: yellow; 2nd angiosome: blue; 3rd angiosome: red

Three angiosomes (arterial/vascular territories) are included when extending a DP flap laterally over the deltoid (*Figure 4a*):

- ***1st Angiosome***: IMA perforators extend from the lateral border of the sternum up to close to the deltopectoral groove (This area also receives some blood supply from musculocutaneous perforators arising from the pectoralis major muscle)
- ***2nd Angiosome***: A small, but variable region of skin below the clavicle and medial to the deltopectoral groove is supplied by the thoracoacromial artery via a small direct cutaneous artery
- ***3rd Angiosome***: The area over the deltoid muscle is supplied by musculocutaneous perforators arising from the deltoid branch of the thoracoacromial artery and the anterior circumflex humeral artery

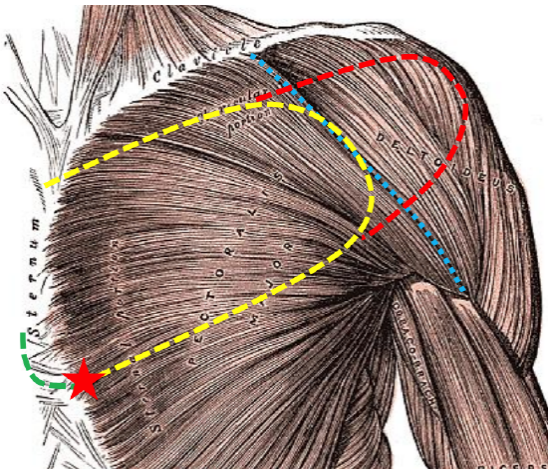


Figure 4b: Typical outline of a DP flap (yellow); deltopectoral groove (blue); lateral extension of flap (red); incision to gain additional length (green); axis of rotation (red star)

As one moves laterally and away from the IMA source-perforators the pressure gradient diminishes. Taylor [4] showed with the angiosome concept that the blood supply of the main angiosome and ***adjacent angiosome*** (2nd angiosome) is reliable, but that an additional angiosome, such as that over the deltoid muscle, is at risk of undergoing ischaemic necrosis. Once a DP flap is extended lateral to the deltopectoral groove, its reliability is therefore diminished (*Figure 4b*).

More dominant supply vessels to the 2nd and 3rd angiosomes increase the risk of necrosis in the 3rd/distal angiosome once these supply vessels are divided and the flap becomes dependent only on the vessels from the 1st angiosome. The further laterally the flap is raised the more random and unreliable the vascular supply and the less reliable the flap becomes. If very large deltoid perforators are therefore encountered when elevating the distal part of the flap, one should be more inclined to delay the flap as ***delaying*** or ***supercharging*** the flap lateral to the deltopectoral groove improves survival of its distal part (see later).

Deltopectoral Flap (Figure 4)



Figures 5a, b: DP flap used to cover skin defect that caused a carotid blowout

The DP flap has largely been supplanted by the pectoralis major, free tissue transfer and, to a lesser extent, latissimus dorsi flaps. It may however be useful in specific situations when other options are unavailable or have been exhausted e.g. reconstruction of cervical skin defects; skin cover of an exposed carotid artery (*Figures 5a*, *b*); closure of a pharyngocutaneous fistula; or (staged) hypopharynx reconstruction (very rarely). Contraindications include an internal mammary artery that has previously been used for coronary artery bypass surgery; and prior trauma or surgery (mastectomy, pacemaker, pectoralis major flap) to the anterior chest wall.

Advantages

- Provides large area of skin cover
- Better color and texture match compared to free tissue transfer flaps from distant sites
- Less bulky than pectoralis major flap
- Technical simplicity

Disadvantages



Figure 6: Scarring from skin grafts and flap contracture band of the neck

- Limited arc of rotation
- Fasciocutaneous pedicle limits the reach of the flap
- Unsightly donor defect especially if skin graft is required (*Figure 6*)

Anesthesia and preparation

- General anesthesia
- Paralysis acceptable as there are no major nerves are in the surgical field
- Supine position with padding/bag under the shoulders
- Prepare and drape the anterior chest wall, shoulder and neck
- Prepare and drape the thigh for a possible skin graft

Flap design (Figures 4, 7)



Figure 7: Closing a pharyngocutaneous defect after laryngectomy (pharyngeal mucosa has been closed); positions of the 1st three perforators and the deltopectoral groove have been marked on the skin

- Outline the flap over the anterior chest wall and shoulder (*Figure 7*)
- The DP flap was originally based on the 1st - 3rd perforators but is now is generally based only on the 2nd and 3rd perforators
- Mark the positions of the intercostal perforators on the skin in the intercostal spaces, 1 cm lateral to the sternum
- A Doppler probe may be used to define their positions more accurately (*Figure 7*)
- Measure the required length of the flap from the top of the defect in the neck to the point of rotation which is based at the most inferior perforator to be used
- ***Note that the point of rotation of the DP flap is located closer to the upper side*** of the base of the flap due to the more lax skin along the inferior border of the flap and along the anterior axillary fold

Limits of DP flap

- Above: clavicle (unless cervicodeltopectoral rotation flap is used)
- Below: 5th intercostal space
- Lateral: deltopectoral groove (extension over the deltoid muscle may require delaying the flap)

Flap elevation (Figure 8)

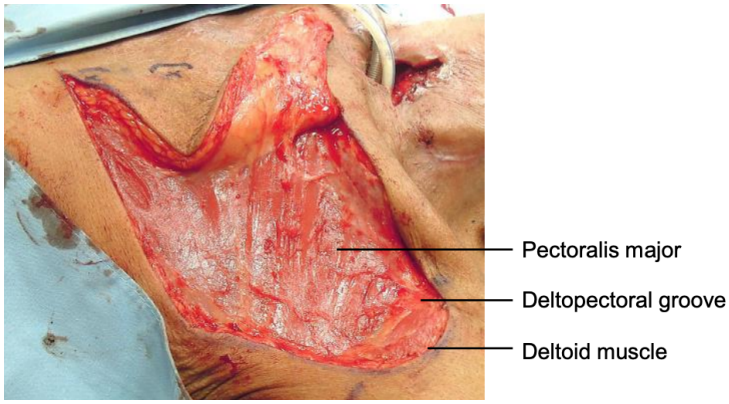


Figure 8: Flap has been elevated in a subfascial plane to expose pectoralis major and deltoid muscles

- Cut through skin and subcutaneous fat and breast tissue onto the (delto)pectoral fascia
- Cut through the (delto)pectoral fascia onto the muscle
- Suture the skin edges to the fascia

- Leave these sutures long at the distal end of flap and hold onto them when elevating the flap
- Use a scalpel (not diathermy) to elevate the pectoral fascia off the muscle in order to protect the suprafascial vascular network
- Elevate the flap from lateral to medial just deep to the (delto)pectoral fascia; this exposes the muscle fibers of the two muscles (*Figure 8*)
- Branches of the thoracoacromial artery which perforate the pectoralis major muscle laterally are severed during elevation
- Stop elevating the flap about 2 cm lateral to the sternum so as not to injure the perforators

Flap Inset

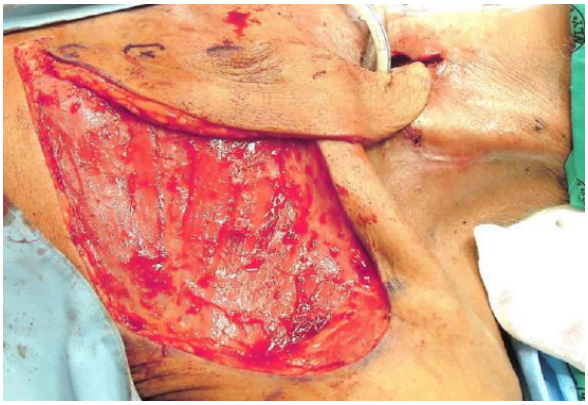


Figure 9a: Flap is positioned in its final position to cover the pharyngocutaneous defect; note the back-cut below the 3rd perforator to increase the length of the flap

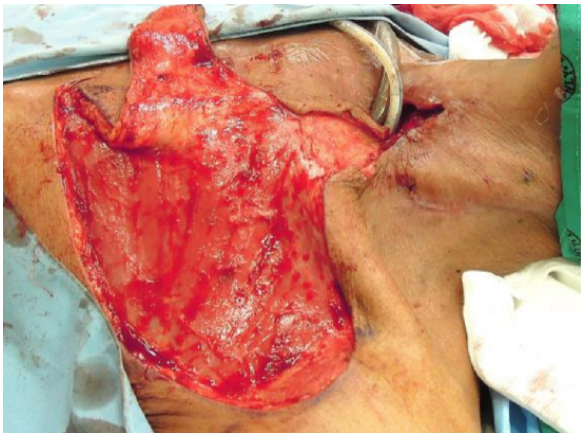


Figure 9b: The skin bridge between the defect and the flap has been divided and elevated to accommodate the flap's pedicle



Figure 9c: Flap has been inset and the donor site has been closed primarily

- The entire flap may be used to cover adjacent defects (*Figures 9a, b, c*)
- The flap may also be tubed and passed over an intact bridge of skin, or fashioned as an island flap by separating the skin off the pedicle in a subcutaneous plane

Closure of donor defect

- Small donor sites can be closed primarily by undermining the surrounding skin and inserting a suction or pencil drain (*Figure 9c*)
- Larger donor sites are covered with a split thickness skin graft (*Figure 6*)

Maximizing flap survival

- Handle the flap atraumatically
- Use a scalpel (not diathermy) to raise the flap
- Use bipolar cautery for hemostasis
- Avoid injury to the perforating arteries
- Avoid tension on the flap during its rotation and inset
- If possible, avoid extending the flap beyond the deltopectoral groove
- Avoid tracheostomy ties around the neck as they may compress the vascular pedicle

Gaining additional length

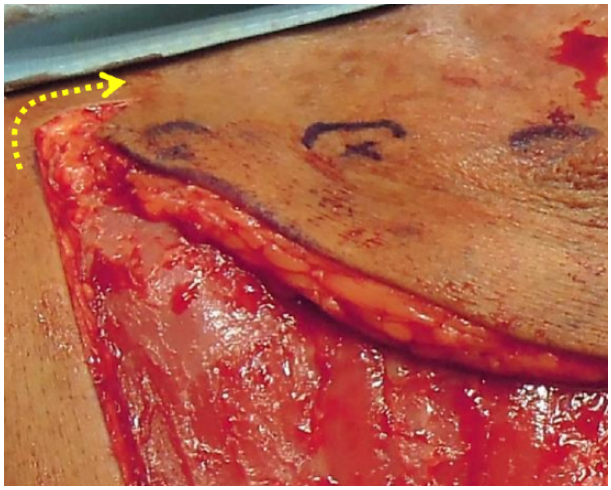


Figure 10: Additional reach obtained by cutting back below and medial to the most inferior IMA perforator

- ***Cut back*** over the sternum below and medial to the most inferior perforator (*Figures 4, 10*)
- ***Extend the flap*** over the deltoid muscle or even include an inferior 90º extension
  - Risk of skin necrosis increases the further laterally the flap is extended over the shoulder
  - A ***delay technique*** may be employed to improve survival of the distal flap (see below)
  - The tip of the flap can be ***supercharged*** (see below)
- ***Use tissue expanders*** (see below)

Delay technique (Figures 11, 12)

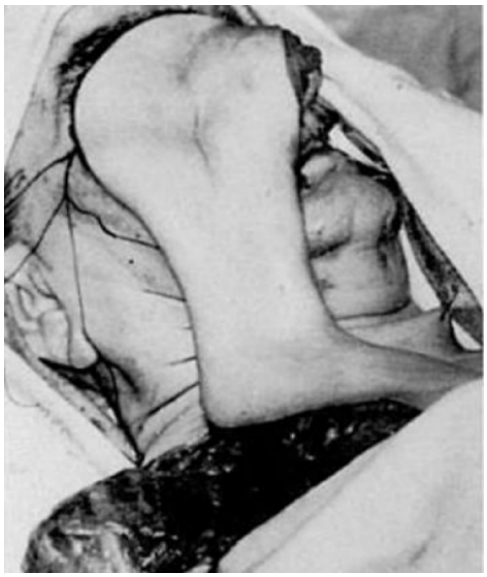


Figure 11: Additional reach obtained by delaying a DP flap (Bakmajian) [5]

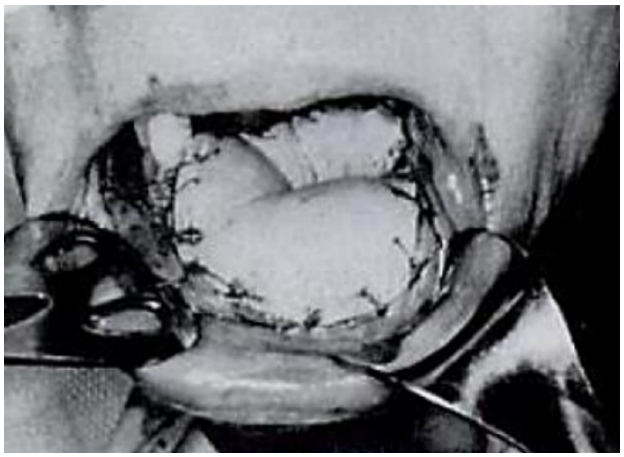


Figure 12: Oral cavity reconstruction is possible following delay of a DP flap (Bakmajian) [5]

Delaying a DP flap may improve flap survival, especially with extension of the flap beyond the deltopectoral groove. Delay is thought to:

- Condition the tissue to ischemia
- Increase vascularity
  - Sympathectomy
  - Reactive hyperaemia
  - Stimulates inflammatory cascade with release of vasodilators
  - Vascular reorganization with opening of choke vessels, increasing vessels in the subdermal plexus and a more longitudinal reorganization of vessels

There are various methods to delay DP flaps

- Elevate the distal ½ of the flap ensuring division of the deltoid perforators as well as the contribution from the thoracoacromial artery
- Return and suture the flap back to its original position
- One may elect to apply a split thickness skin graft at the time of primary elevation to line the deep aspect of the flap to subsequently serve as the inner lining of a pharyngeal reconstruction
- Elevate the flap again 10-14 days later

Supercharging

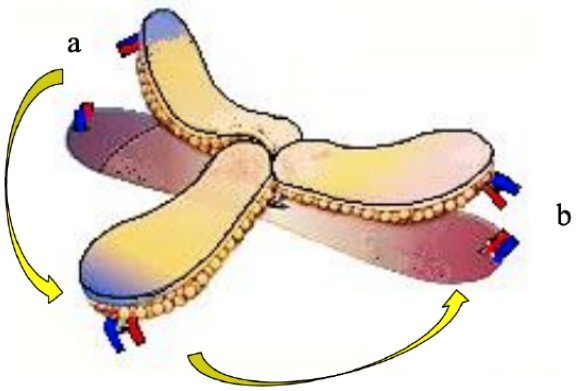


Figure 13: Supercharging tip of DP flap: Vessels at donor site (a) divided and anastomosed to vessels at recipient site (b)

Branches of the thoracoacromial vessels are identified at the superior part of the flap and anastomosed to vessels in the recipient site by microvascular technique (*Figure 13*).

Tissue expanders

Using tissue expanders placed ***deep*** to the pectoral fascia increases the area of skin available for reconstruction of both the recipient area and the donor defect. It permits reconstruction of defects as high up as the cheek and has the added benefit of delaying the flap.

Split skin graft for inner lining

When a DP flap is employed to repair an oro- or pharyngocutaneous fistula, then a split skin graft can be applied to the deep aspect of the flap either at the time of delaying a flap or at the time of definitive repair. This can also be achieved by applying a split skin graft over a tissue expander which is inserted endoscopically, hence allowing the flap to be elevated and inset into a pharyngeal defect with the skin graft already having taken.

Crossing an intact skin bridge

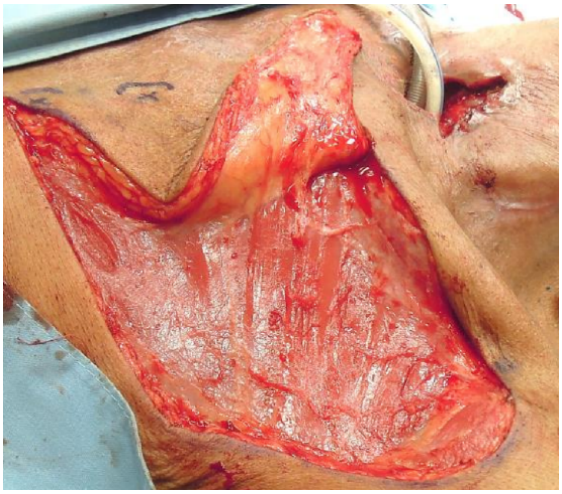


Figure 14: Skin bridge between donor and recipient sites



Figure 15: Staged repair of orocutaneous fistula; the pedicle is subsequently divided, and the proximal end is returned to the donor site [6]

When skin bridge is interposed between the donor and recipient sites (*Figure 14*), the surgeon can opt to divide the skin bridge (*Figure 9b*), discard the interposing skin, de-epithelialize and tunnel the flap below the skin bridge, or tube the flap and subsequently divide the pedicle and return the proximal portion of the flap to the chest wall donor defect after 3-6 weeks (*Figure 15*).

Cervicodeltopectoral rotation flap



Figure 16a: Cervical skin defect; flap has been based on the 1st 3 perforators

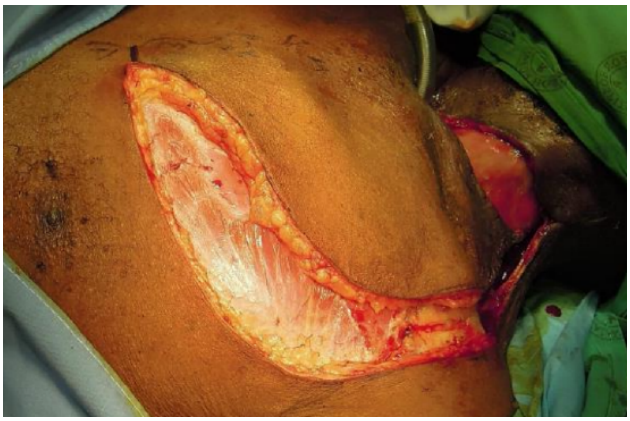


Figure 16b: Incise skin, fat, and pectoralis fascia



Figure 16c: Elevate DP flap deep to pectoralis fascia

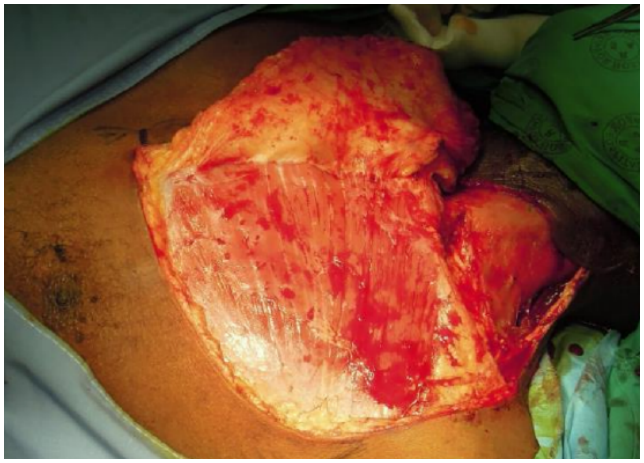


Figure 16d: Fully elevated cervicodeltopectoral flap



Figure 16e: Cervicodeltopectoral flap rotated into cervical defect and donor site closed primarily

When a cervical defect abuts or is in close proximity to the superior margin of a DP flap, then the defect can be covered with a cervicodeltopectoral rotation flap based on the IMA perforators (*Figures 16a-e*).

Combined DP & Pectoralis major flaps

When raising a pectoralis major flap one can elect to retain the option of using an ipsilateral DP flap (either at the same operation or later). This requires that ***when raising the pectoralis major flap, the dissection plane is kept deep to its fascial covering to*** preserve the blood supply to the DP flap. Either the DP flap is first raised as described above and, following pectoralis major flap transposition, is resutured in its original position; or the DP flap is raised through parallel superior and inferior incisions, maintaining its lateral attachment by branches of the acromiothoracic vessels at the deltopectoral groove.

Deltopectoral island flap [7]

A skin island is designed that is placed laterally within the confines of a DP flap. Skin flaps are carefully elevated in a subdermal plane (protecting the underlying deeper suprafascial vascular supply to the skin island) via superior and inferior horizontal incisions. Then elevate the flap in the usual manner and transpose it underneath the intervening skin bridge to reach the defect and thus (usually) avoid a donor site skin graft.

Internal mammary artery perforator island flaps (IMAP flaps)

A DP flap can be converted into an island flap based on one or two perforating branches of the internal mammary artery. It may then be used as a pedicled or a free microvascular tissue transfer flap. This increases its versatility, provides a variety of axes of rotation and additional length[3]. IAMP flaps are discussed in a separate chapter.

Summary

- The most important part of the DP flap for reconstruction is invariably its distal tip; it is this area that may become ischemic and undergo necrosis
- The DP flap was the workhorse of head and neck reconstruction during the 1970's and 80's but has since been replaced by microvascular free flaps
- Although the DP flap may be 1st choice in some situations of external defects in the neck, tubed DP flap to reconstruct internal pharyngoesophageal defects has become obsolete in modern head and neck surgery

References

1. Bakamjian,VY. A two-stage method for pharyngoesophageal reconstruction with a primary pectoral skin flap. Plast Reconstr Surg. 1965;36:173
2. Gedge DR, Holton LH, Silverman RP, Singh NK, Nahabedian MY. Internal mammary perforators: a cadaver study. J Recon Microsurg. 2005;21(4):239-42
3. Schellekens PPA. Proefschrift: Internal Mammary Artery Perforator flap: 2012
4. Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: experimental study and clinical applications. Br J Plast Surg. 1987; 40(2); 113-41
5. Lore JM. General purpose flaps. In: Lore JM, ed. An Atlas of Head and Neck Surgery. 3rd ed. Philadelphia, Pa: WB Saunders Co. 1988:344-57
6. Balakrishnan C. Closure of orocuta nous fistula using a pedicled expanded deltopectoral flap Can J Plast Surg. 2008; 16(3): 178–80
7. Portnoy, WM, Arena S. Deltopectoral island flap. Otolaryngol Head Neck Surg 1994;111:63-9

Other flaps described in The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery

- Pectoralis major flap
- Buccinator myomucosal flap
- Buccal fat pad flap
- Nasolabial flap
- Temporalis muscle flap
- Paramedian forehead flap
- Upper and lower trapezius flaps
- Cervicofacial flaps
- Submental artery island flap
- Supraclavicular flap
- Latissimus dorsi flap
- Local flaps for facial reconstruction
- Radial free forearm flap
- Free fibula flap
- Rectus abdominis flap
- Anterolateral free thigh flap
- Thoracodorsal artery scapular tip (TDAST) flap
- Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Author

JE (Ottie) Van Zyl MBChB, FCS
Plastic & Reconstructive Surgeon
Groote Schuur Hospital
Cape Town, South Africa
ottie@mweb.co.za

Editor & Author

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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5.21: Upper and Lower Trapezius Flaps in Head and Neck Reconstruction

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

UPPER & LOWER TRAPEZIUS FLAPS FOR HEAD & NECK RECONSTRUCTION

Patrik Pipkorn, Ryan Jackson, Jason Rich

Trapezius flaps are a useful reconstructive option for the head and neck. Because of the popularity of microvascular surgery, as well as surgeons' unfamiliarity with back flaps and the need for lateral or prone surgical positioning, trapezius flaps have however decreased in popularity. But, in a setting without microvascular expertise and with other reconstructive options exhausted, these are robust and reliable flaps with low morbidity.

There are ***three types of trapezius flaps*** i.e. ***upper, lower and lateral trapezius island flaps***. The lateral trapezius island flap has a very variable blood supply and is very seldom used and is not covered in this chapter.

Upper trapezius flap

The upper trapezius flap is based on the paraspinous perforators and branches of the occipital artery and is a good option for carotid cover for skin loss after radical neck dissection.

Benefits

- Robust and reliable blood supply
- Can be raised following prior radical neck dissection
- Can provide up to 10 cm width skin and muscle
- Can provide skin cover to the midline

Caveats

- Limited arc of rotation
- Often requires skin graft to cover donor site
- Impaired shoulder function (unless XIn already sacrificed)
- Requires slightly rotated surgical position or a Mayfield headrest for surgical exposure

Lower trapezius island flap

The lower trapezius island flap is based on branches of the transverse cervical artery and provides excellent reconstruction of posterior occipital and scalp defects.

Benefits

- "The pectoralis flap of the back"
- Reliable blood supply
- Provides skin cover up to parietal scalp
- Easy to raise once familiar with back anatomy
- Up to 9 cm of skin width with primary closure
- Low donor site morbidity
- Excellent arc of rotation

Caveats

- Requires lateral or prone surgical position
- Wound prone to seroma
- Questionable vascularity after neck dissection if transverse cervical vessels have been sacrificed

Surgical anatomy

As with any surgical procedure a sound understanding of the anatomy and good judgement are essential.

Muscle anatomy (Figure 1)

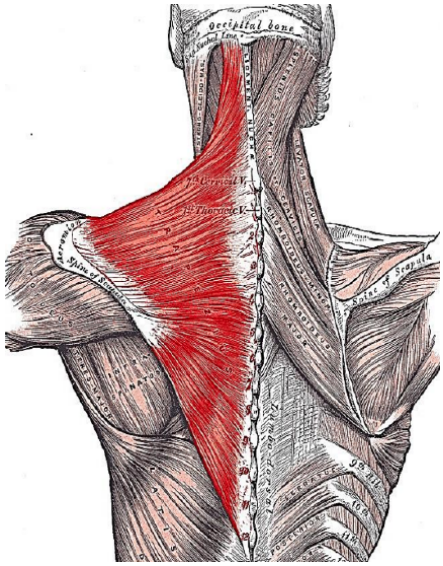


Figure 1: Trapezius, latissimus dorsi, levator scapulae, and rhomboid muscles

The trapezius muscle is the most superficial of the muscles of the upper back and posterior neck. It is a thin trapezoid-shaped muscle with three anatomic and functional components. The upper portion arises from the superior nuchal line and the external occipital protuberance, and it inserts into the lateral third of the clavicle, defining the posterior triangle of the neck. This part of the muscle helps to elevate the scapula and the shoulder. The lower two thirds of the muscle originate from the seven cervical and six upper thoracic spinal processes and inserts into the acromion and spine of the scapula. These fibers help to retract the scapula. The lower part of the muscle overlies the latissimus dorsi muscle. Deep to the trapezius muscle are the thin rhomboid minor and major muscles that originate from C7-T1 and T2-T5 respectively. Superior to the rhomboid muscles is the levator scapulae muscle that arises from the posterior tubercle of the transverse processes of C1-C4 and inserts into the superior and medial borders of the scapula. These muscles retract and elevate the scapula. Superolaterally the trapezius covers the supraspinatus muscle.

Vasculature (Figure 2)

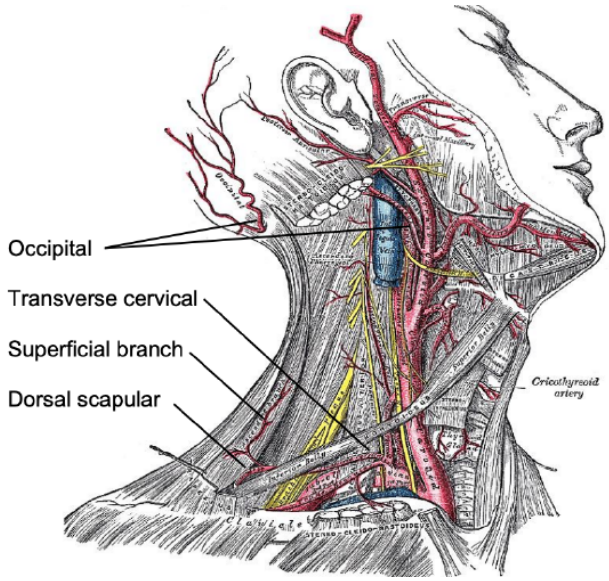


Figure 2: Occipital, transverse cervical and its dorsal scapular and superficial branches

The trapezius muscle has a ***variable blood supply*** that has been debated over the years. When harvesting ***upper trapezius flaps these variations have no relevance***. However, ***with the lower island flap these variations are important***, but only ***if additional***

pedicle length is required.

The main blood supply to the muscle originates from branches of the ***transverse cervical artery (TCA)*** or ***dorsal scapular artery (DSA)***. The muscle has minor blood supply from ***perforating paraspinous perforators*** from posterior intercostal vessels all along its origin from C1-T6. The upper portion of the muscle has additional blood supply from branches of the ***occipital artery*** (*Figure 2*).

The ***transverse cervical artery*** arises from the thyrocervical trunk and crosses laterally low in the neck, superficial to the prevertebral fascia and enters the trapezius from its deep surface (*Figure 2*). Before entering the muscle, it gives off a deep branch, the ***dorsal scapular artery*** which runs deep to levator scapulae, and a ***superficial branch*** to the trapezius most commonly between the rhomboid minor and major muscles; However, occasionally this branch runs between the levator scapulae and rhomboid minor muscles.

Anatomic variations

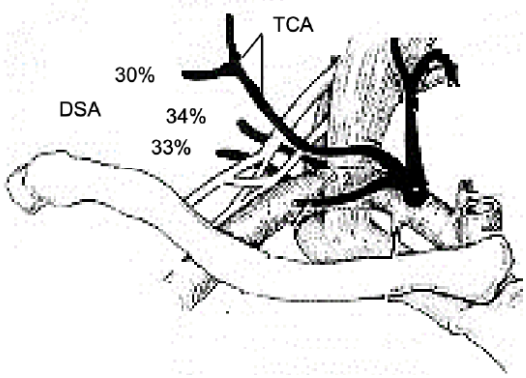


Figure 3: Origin of dorsal scapular artery (DSA)

It was long believed that the transverse cervical artery was the main blood supply to the trapezius flap after reports of distal flap necrosis when the superficial branch of the dorsal scapular artery was ligated to obtain additional length. However, cadaveric studies in the early 1990's shed further light on anatomic variations, and showed that the dorsal scapular and transverse cervical artery (superficial branch) had a reciprocal relationship. In 50% of cases the dorsal scapular artery was dominant and was a branch of transverse cervical artery. In 30% the transverse cervical artery was the main supply with the dorsal scapular artery being a branch from the transverse cervical artery. In 20 % the blood supply was equal, but had separate takeoffs from the subclavian artery. This differed slightly from earlier cadaveric studies with a higher proportion of the dorsal scapular artery having a separate takeoff directly from subclavian artery (*Figure 3*).

Variations of how the vessels are intertwined with the brachial plexus have also been described. These variations are important to understand if additional pedicle length is required when harvesting a lower trapezius island flap. Since it is difficult to know which artery is dominant, it may be safer to not divide the distal dorsal scapular artery to preserve this additional blood supply to not jeopardize the vascular supply. To preserve the proximal dorsal scapular artery, the rhomboid minor muscle must be divided. Additionally, it is ***important to consider the status of the transverse cervical vessels as they may have been sacrificed during the neck dissection***.

Innervation

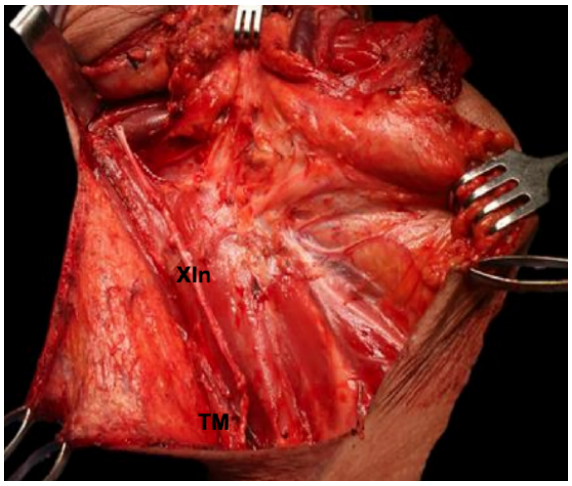


Figure 4: Accessory (XIn) fully exposed in right neck dissection, passing deep to anterior border of trapezius muscle (TM)

The trapezius is innervated mainly by the XIn. It enters the deep surface of the superior edge of the muscle in the lower posterior triangle of the neck after passing through the upper third of the sternocleidomastoid muscle (*Figure 4*). It receives additional innervation from branches of C3 and C4 although the clinical importance of these fibers is unclear.

Upper Trapezius Flap: Surgical steps

The upper trapezius flap is based on the paraspinous perforators and branches of the occipital artery.

Informed consent

Preoperative counseling includes risk of seroma or hematoma, as well as unsightly scars. The patient needs to be informed about shoulder dysfunction (especially if the XIn is still functioning) and the possible need for a skin graft to the donor site.

Surgical preparation and positioning (Figure 5)



Figure 5: Patient slightly tilted away from the side of the flap to expose the upper back, just beyond thoracic spinal processes

The patient's neck and upper back are prepped and draped. Exposure needs to include the upper back, just beyond the thoracic spinal processes. This exposure is obtained by slightly tilting the patient away from the side of the flap, especially if the patient's head is supported in a Mayfield headrest. Alternatively, the patient is positioned in a lateral decubitus position, al-though this makes the oncologic resection in the neck more challenging.

Flap design (Figure 5)

Before raising the flap, the surgeon needs to have a good understanding of the surgical defect.

- The superior edge of the trapezius muscle denotes the anterior edge of the flap
- Pre- or intraoperative ultrasound can be used to better define the superolateral border of the trapezius muscle to plan the incisions

- The lateral extension of the trapezius at the acromion generally marks the lateral extent of the flap
- Skin over the deltoid can be raised if additional length is needed, but any skin beyond the trapezius is supplied randomly through the dermal plexus and is not reliable
- The defect size will dictate the width of the flap, although the wider the flap the more reliable it is
- Up to about 6 cm can be raised without a need for skin grafting; a simple pinch test will give guidance

Raising the flap



Figure 6: Start by identifying the anterior edge of the trapezius muscle



Figure 7: Anteriorly the transverse cervical vessels are encountered



Figure 8: Flap rotated into position



Figure 9: Primary closure of door site

- Start by making the ***anterior incision*** through skin, fascia and fat to the level of the trapezius muscle (*Figure 6*)
- By making this incision anteriorly, adjustments can still be made should it turn out that the edge of the muscle is in a different position than was anticipated
- Once the anterior edge of the trapezius is identified, the remainder of the skin incision is made
- Continue with the ***posterior skin incision***
- Divide the trapezius from its attachment from the spine of the scapula
- Anteriorly the transverse cervical vessels will be encountered and need to be divided to enable rotation of the flap (*Figure 7*)
- Continue with blunt dissection between the deep aspect of the trapezius and the supraspinatus musculature
- Continue the dissection medially towards the spine until the flap can be easily rotated into position (*Figure 8*)
- To gain additional rotation, a back-cut can be made on the contralateral side of the spinal process
- If possible, close the defect primarily (*Figure 9*)
- Otherwise close the defect with a skin graft

Lower Trapezius Island Flap: Surgical steps

The lower trapezius island flap is based on branches of the transverse cervical artery.

Informed consent

Preoperative counseling includes risk of a seroma or hematoma, as well as unsightly scars. The patient needs to be informed about a possible need for a skin graft to the donor site. There is a smaller risk of shoulder dysfunction (especially if the XIn is still functioning), because the upper portion of the muscle which elevates the shoulder is never transected, and shoulder impairment is usually limited to inability to retract the scapula. Patients should avoid lying flat on their backs after surgery to avoid compression of the pedicle.

Surgical preparation and positioning

Position the patient either prone or in a lateral decubitus position on a bean bag. Expose the upper back just beyond the thoracic spinal processes.

Flap design

Before raising the flap, the surgeon needs to have a good understanding of the surgical defect.

- The flap can be raised as a myofascial or myocutaneous flap
- Up to a 9 cm wide skin paddle can be raised and still permit primary closure of the donor site; a pinch test provides guidance



Figure 10: Outline the trapezius muscle

- Outline the trapezius muscle on the patient's back (*Figure 10*)
- The trapezius can seldom be palpated on the back, so the inferior extent of the muscle may be difficult to determine
- However, the skin paddle is generally reliable up to about 5 cm below the tip of the scapula



Figure 11: Outline the trapezius muscle



Figure 12: Lateral incision through skin, fascia and fat, down to latissimus dorsi muscle (*)

- If uncertain, it is wise to extend the skin flap more inferiorly as the distal end can always be trimmed or discarded (*Figure 11*)
- Start by making the ***lateral incision*** through the skin, fascia and fat, down to the ***latissimus dorsi muscle*** (*Figure 12*)
- Bevel the cut slightly laterally to avoid jeopardizing any perforators from the trapezius to the skin

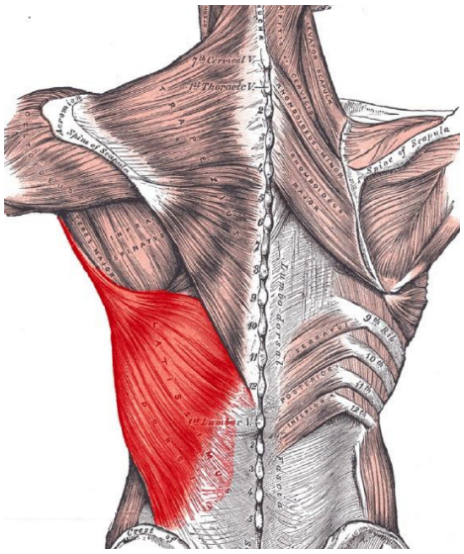


Figure 13: Latissimus dorsi muscle

- The latissimus dorsi can be identified by its more-or-less horizontal fibers (*Figures 12, 13*)
- Raise the lateral flaps to expose parts of the latissimus dorsi muscle and define its anatomy
- Having dissected down to latissimus dorsi, dissect sharply on the surface of latissimus dorsi towards the spine
- By staying strictly on the latissimus dorsi muscle, the more superficial trapezius muscle is raised together with the skin flap

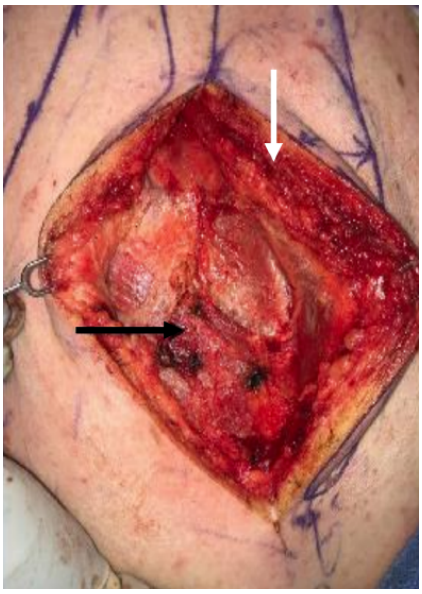


Figure 14: Latissimus dorsi (black arrow) and trapezius (white arrow)



Figure 15: Identify the most inferior extension of the trapezius muscle

- The trapezius muscle is easily identified by its more vertically oriented fibers (*Figures 13*, *14*)
- Follow the trapezius muscle inferiorly and identify the most inferior extension of the muscle (*Figure 15*)
- Once the inferior extension is determined, the design of the inferior skin paddle design can be finalized



Figure 16: Medial skin cuts just lateral to the spine

- Continue with the medial skin cuts just lateral to the spine (*Figure 16*)
- The medial and lateral skin incisions are now carried in a superior direction
- The superior incision of the skin paddle can be made once the exact extent of the trapezius muscle has been defined and it has been confirmed that the skin paddle lies directly over the muscle
- Again, one can err on raising additional skin superiorly, as this can be discarded should it be redundant
- A larger skin paddle is also more reliable as more perforators are incorporated



Figure 17: Expose the mid- and upper trapezius

- Continue to expose the mid- and upper trapezius (*Figure 17*)
- Making a vertical incision beyond the skin flap can greatly facilitate additional exposure



Figure 18: Gentle blunt dissection on the deep surface of the trapezius will expose the thin rhomboid major muscles



Figure 19: Exposed thin rhomboid major muscle (*)

- Gentle blunt dissection on the deep surface of the trapezius will expose the thin rhomboid major muscles (*Figures 18, 19*)
- The lateral and medial incisions through trapezius muscle can now be made



Figure 20: The flap is raised in a distal-to-proximal fashion by dividing the trapezius close to the origin from the spinal processes and laterally towards the scapula



Figure 21: Branch from dorsal scapular artery entering the muscle on its deep aspect between rhomboid major and minor

- By dividing the trapezius close to the origin of the spinal processes and laterally towards the scapula, the flap is raised in a distal-to-proximal fashion (*Figure 20*)
- With careful dissection, the branch from the dorsal scapular artery can now be identified as it enters the muscle on its deep aspect between the rhomboid major and minor muscles (*Figure 21*)
- At this point the reach of the flap is assessed. Usually the flap easily reaches the postauricular level without needing to divide the dorsal scapular artery, which greatly enhances the robustness of the flap
- If ***additional reach*** is needed, the deep dorsal scapular vessels may need to be divided, although this is rarely needed
- An alternative to dividing the dorsal scapular for additional flap length is to divide the rhomboid minor and maintaining the dorsal scapular artery intact
- To ***increase the arc of rotation***, the trapezius muscle can be narrowed superiorly around the pedicle
- However, the safest way is to divide the muscle laterally and medially and to keep the pedicle undissected
- Once the flap has been rotated into position, two suction drains are placed in the back



Figure 22: Closed donor site

- The skin is closed in layers using large absorbable sutures for the deep dermis and nylon/staples for the skin (*Figure 22*)
- Drains are removed once output is <30 mL/24 hours
- Staples are removed at least after two weeks

Clinical examples

Case 1: Upper trapezius flap in a female with a history of parotid cancer following resection, radiation and reirradiation for recurrence.





Case 2: Upper trapezius flap in a male with a history of cutaneous squamous cell carcinoma with previous neck dissection and postoperative radiation, now with regional recurrence.









Case 3: Lower trapezius island flap in a male with a history of multiple recurrent cutaneous squamous cell carcinomas and previous radical neck dissection, radiation therapy, and re-resection with a new single nodal recurrence in posterior neck.







Case 4: Lower trapezius island flap in a female with a history of brain cancer and posterior fossa craniectomy with poor skin quality over a titanium mesh.



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References

1. Netterville JL and Wood DE (1991). "The lower trapezius flap. Vascular anatomy and surgical technique." Arch Otolaryngol Head Neck Surg 117(1): 73-6
2. Urken, ML. Atlas of regional and free flaps for head and neck reconstruction. Raven Press. Ltd. New York. 1995

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Authors

Patrik Pipkorn MD, Assistant Professor, Head & Neck and Microvascular Reconstruction
Washington University
St Louis, MO, USA
pipkorn@wustl.edu

Ryan Jackson MD Assistant Professor, Head & Neck and Microvascular Reconstruction
Washington University in St Louis
St Louis, MO, USA
jackson.ryan@wustl.edu

Jason T. Rich MD Assistant Professor, Head & Neck and Microvascular Reconstruction
Washington University in St Louis
St Louis, MO, USA
richj@wustl.edu

Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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6.1: African Head and Neck Society Clinical Practice Guidelines for Head and Neck Cancers in Developing Countries and Limited Resource Settings

Management guidelines for head and neck cancers such as those of the *NCCN* are often inappropriate for limited resource settings due to lack of access to special investigations, radiation therapy, and even thyroid and calcium replacement. Hence the *AfHNS* has promulgated these management guidelines that are adapted to limited resource settings. These guidelines will assist clinicians to provide appropriate best practice that will benefit patients with head and neck cancers living in developing countries.

These guidelines have been formulated by African head and neck surgeons and oncologists, in consultation with American and European colleagues. Guidelines have been completed for *Thyroid nodules, cancers and large goitres; Parotid Tumours and Cancers; Submandibular tumours and cancers; and Glottic, Supraglottic and Hypopharyngeal cancers.* The *AfHNS Clinical Practice Guidelines for Head & Neck Cancers in Developing Countries and Limited Resource Setting* is a work in progress, and additional tumour sites will be added in the future.

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6.2.1: 1. Introduction

International guidelines for thyroid nodules and cancers require availability of TSH, ultrasound, FNAC, thyroid scans, RAI, thyroid and calcium monitoring and replace-ment, and reliable follow-up. However, frequently not all these interventions are available, and follow-up may be unreliable. The **AfHNS Clinical Practice Guidelines for Thyroid Cancer in Developing Countries and Limited Resource Settings** tailor management of thyroid masses and cancers according to diagnostic and therapeutic resources available to physicians and their patients.

Background

Thyroid nodules are very common (approx. 50% of population), more prevalent in women (reference), >90% are benign (reference), and >90% of thyroid cancers are differentiated i.e. papillary (PTC), follicular (FTC), or Hürthle cell thyroid cancers (HTC). Because differentiated cancers are generally slow-growing and have a good prognosis (reference), treatment of differentiated thyroid cancer has become more conservative with observation being a reasonable option for small (<1.5 cm) papillary thyroid cancers (references), with less extensive surgery and less frequent use of radioactive iodine employed for low risk differentiated cancers (references).

Many thyroid nodules and cancers are diagnosed incidentally by ultrasound (U/S) and other imaging modalities. However, radiological screening for thyroid nodules and cancers is not recommended (reference).

Because the majority of thyroid nodules are not life threatening and hence do not require surgery, investigation of a thyroid nodule is directed at identifying the minori-ty of cases that require thyroid surgery, as opposed to observation or simple reassu-rance. The principal diagnostic tools used for thyroid nodules and cancers and to avoid unnecessary surgery are thyroid U/S and fine needle aspiration cytology (FNAC).

International guidelines for management of thyroid nodules and cancers such as those of the *American Thyroid Association (ATA)* and *National Comprehensive Cancer Care (NCCN)* assume the availability of TSH, U/S, FNAC, thyroid scans, radioactive iodine (RAI), thyroid and calcium monitoring and replacement, and reliable follow-up. However, in low resource settings in developing countries, such investigations, thera-peutic interventions, and even thyroid and calcium monitoring and replacement, are frequently not available or unaffordable, and follow-up may be unreliable. Hence international guidelines for management of thyroid nodules and cancers cannot always be applied in developing countries.

Without resource appropriate guidelines for thyroid nodules and cancers, resident surgeons and volunteer surgeons from developed countries have little to guide them about best practice when working in such resource limited settings. This might lead to inappropriate surgery, over-investigation or, in the worst case scenario, even fatal consequences either directly from surgical complications or from hypocalcaemia or hypothyroidism when patients do not have access to calcium and thyroid hormone monitoring, replacement or reliable follow up.

Methodology of developing AfHNS guidelines

The AfHNS convened a task force (video) to enumerate thyroid surgery guidelines for low resource settings. This collaboration between physicians from African and Developed countries included members of the AfHNS, American Head & Neck Society; American Academy of Otolaryngology Head and Neck Surgery; and French Otolaryngology Society.



The 2018 National Comprehensive Cancer Network (NCCN) algorithms for thyroid nodules and cancers were referenced and adapted for limited resources using the ADAPTE process. Due to paucity of literature about management of thyroid nodules and cancers in low resource settings, much of the recommendations represents expert opinion.

Following a meeting of the task team in Cape Town in December 2018, the guidelines were circulated for comment to all the task team members before being published.

Johan Fagan & *Mark Zafereo* *(Co-Chairs)*

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6.2.2: 2. How to Use The Guidelines

By clicking on the clinical scenario that represents the resources available to you and your patient, you will be directed to clinical practice guidelines appropriate for your patient.

When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

Adherence to these guidelines should therefore applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access a services at a better and more appropriately resourced center.

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6.2.3: 3. Evaluating a Thyroid Nodule

- The **majority** of thyroid nodules are benign and **do not require surgery**
- **Not all thyroid cancers require surgery**; some differentiated thyroid cancers can be monitored with close follow-up
- **Objectives** of evaluation of a thyroid nodule / mass
  - Avoid unnecessary surgery
  - Do appropriate surgery
  - Avoid doing harm e.g. causing RLN injury, hypocalcaemia and/or hypothyroidism when calcium monitoring and replacement therapy are unavailable
- **Ultrasound** is the best imaging modality for thyroid nodules. It has a high sensitivity and specificity for diagnosis of thyroid malignancy
- **When ultrasound is unavailable**, then history and physical examination of the thyroid and neck may yield features suggestive of higher risk of malignancy e.g. rapid growth, firm mass, thyroid asymmetry, cervical lymphadenopathy, recent onset of hoarseness, and vocal cord paralysis. Presence of multiple suspicious features e.g. firm thyroid mass with hoarseness, is associated with a higher risk of malignancy. When ultrasound is unavailable, these features are indications for FNAC
- Only if ultrasound is unavailable, may **CT or MRI** be considered to assess a thyroid nodule with the knowledge that they have **poorer sensitivity and specificity** and are more expensive
- With FNAC, **Bethesda IV** only has a 20 – 30% risk of being a follicular carcinoma
- A **thyroid uptake scan** is not indicated for the workup of a thyroid nodule unless the patient is biochemically or clinically thyrotoxic
- When **TSH is not available**, clinical signs and symptoms may be used to determine the probability of a hyperthyroid vs. euthyroid/hypothyroid state. A clinically validated method is **Wayne's Index**, with reported positive predictive value of 95% and negative predictive value of 90% (Naraintran S et al. Accuracy of Wayne's criteria in diagnosing hyperthyroidism: a prospective study in south Kerala, India. *Int Surg J* 2018; 5:1267-70)
- **Thyroid lobectomy** is the minimum recommended resection but, **diagnostic nodulectomy** may occasionally be necessary in situations where FNAC is not available, where the nodule is in the isthmus or positioned anteriorly within the thyroid and where there is concern about hypothyroidism in a context where thyroid replacement is unavailable.

Click on the clinical scenario that reflects the diagnostic tools available to your patient. This will transfer you to a resource appropriate diagnostic pathway.

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations															
Ultrasound	**X**		**X**	**X**	**X**				**X**	**X**	**X**	**X**				
TSH	**X**	**X**		**X**	**X**		**X**	**X**			**X**		**X**			
Thyroid scan	**X**	**X**	**X**		**X**	**X**		**X**	**X**					**X**		
FNAC	**X**	**X**	**X**	**X**		**X**	**X**			**X**					**X**	

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6.2.4: 4. How to Manage a Thyroid Nodule After FNAC and/or Ultrasound

- The majority of thyroid nodules are benign and do not require surgery
- Not all thyroid cancers require surgery
- Most thyroid malignancies are indolent, slow growing papillary carcinomas which may be diagnosed on FNA
- With follicular neoplasms, FNAC cannot distinguish benign (adenomas) and malignant (follicular or Hürthle cell carcinomas) as the latter two require histological evidence of vascular or capsular invasion
- Some differentiated thyroid cancers may be observed with follow-up
- Objectives of management
  - Avoid unnecessary surgery
  - Do appropriate surgery
  - Avoid doing harm e.g. causing hypocalcaemia and/or hypothyroidism in patients without access to monitoring and replacement therapy

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6.2.5: 5. Papillary Carcinoma

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8
	Available treatment							
Thyroid monitoring/ replacement	X		X	X	X			Unavailable or poor follow-up
Ca++ monitoring/ replacement	X	X		X		X		
Radioactive iodine therapy	X	X	X				X	

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6.2.6: 6. Follicular Neoplasm

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8
	Available treatment							
Thyroid monitoring/ replacement	X		X	X	X			Unavailable or poor follow-up
Ca++ monitoring/ replacement	X	X		X		X		
Radioactive iodine therapy	X	X	X				X	

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6.2.7: 7. Hurthle Cell Carcinoma

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8
	Available treatment							
Thyroid monitoring/ replacement	X		X	X	X			Unavailable or poor follow-up
Ca++ monitoring/ replacement	X	X		X		X		
Radioactive iodine therapy	X	X	X				X	

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6.2.8: 8. Medullary Carcinoma

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4
	Available treatment			
Thyroid monitoring/replacement	X		X	Unavailable or poor follow-up
Ca++ monitoring/replacement	X	X		

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6.2.9: 9. Anaplastic Carcinoma

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4
	Available treatment			
Thyroid monitoring/replacement	X		X	Unavailable or poor follow-up
Ca++ monitoring/replacement	X	X		

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6.2.10: 10. Large Symptomatic Goitre

Click on the clinical scenario that reflects the therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4
	Available treatment			
Thyroid monitoring/replacement	X		X	Unavailable or poor follow-up
Ca++ monitoring/replacement	X	X		

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6.2.11: 11. Diagnostic Procedures

Wayne's Index to Determine Hyperthyroidism

Symptoms	Score
Dyspnoea on effort	+1
Palpitations	+2
Tiredness	+2
Preference for heat	-5
Preference for cold	+5
Excessive sweating	+3
Nervousness	+2
Appetite increased	+3
Appetite decreased	-3
Weight increased	-3
Weight decreased	+3

Signs	Present	Absent
Palpable thyroid	+3	-3
Bruit over thyroid	+2	-2
Exophthalmos	+2	-
Lid retraction	+2	-
Lid lag	+1	-
Hyperkineses	+4	-2
Hands hot	+2	-2
Hands moist	+1	-1
Casual pulse rate		
>80/min	-	-3
>90/min	+3	-
Atrial fibrillation	+4	-

Scores

- <11 = Euthyroid
- >19 = Hyperthyroid

Naraintran S et al. Accuracy of Wayne's criteria in diagnosing hyperthyroidism: a prospective study in south Kerala, India. *Int Surg J* 2018; 5:1267-70

- Sensitivity 87%
- Specificity 96%
- PPV 95%
- NPV 90%

FNAC: Bethesda System for Risk of Malignancy

Bethesda	Diagnostic category	Risk of malignancy
I	Nondiagnostic / unsatisfactory	1-4%
II	Benign	0-3%
III	Atypia or follicular lesion of undetermined significance	5-15%
IV	Follicular neoplasm or suspicious for follicular neoplasm	15-30%
V	Suspicious for malignancy	60-75%
VI	Malignant	97-99%

Clinical Indications for FNAC

- **Suspicious clinical findings:** Rapidly growing, firm mass, thyroid asymmetry, cervical lymphadenopathy, recent onset hoarseness/ vocal cord paralysis
- **Palpable firm thyroid nodule:** FNAC of thyroid nodule
- **Palpable firm cervical lymph node:** FNAC of node +/- thyroid nodule
- **Factors that may be considered in addition to above suspicious clinical findings:** Prior thyroid cancer, radiation exposure, 1st degree relative with thyroid cancer of MEN2, FDG avid on PET scan, thyroid cancer associated history e.g. familial adenomatous polyposis, Carney complex, Cowden syndrome.
- **If FNAC not indicated, repeat exam after 6-12 months; if stable for 1-2yrs, then consider review at 3-5 yearly intervals**

Ultrasound Indications for FNAC

U/S can be used to risk-stratify using the Thyroid Imaging Reporting and Data System (TI-RADS) (http://tiradscalculator.com/)

Solid nodule

- With suspicious sonographic features ≥1.0 cm
- Without suspicious sonographic features ≥1.5 cm

Mixed cystic-solid nodule

- With suspicious sonographic features: hypoechoic, microcalcifications, infiltrative margins, taller than wide in transverse plane Solid component >1.0 cm
- Without suspicious sonographic features: Spongiform nodules, isoechoic of hyperechoic solid nodules, mixed solid-cystic nodules without above suspicious features Solid component ≥1.5 cm

Spongiform nodule (multiple microcystic components in >50% of volume of nodule >2.0 cm

Suspicious cervical lymph node: FNAC of node +/- thyroid nodule

If FNAC not indicated, then repeat US after 6-12 months; if stable for 1-2yrs, then consider US at 3-5 yearly intervals

Above criteria are general guidelines: With high risk clinical features, evaluation of smaller nodules may be indicated based on clinical concerns e.g. prior thyroid cancer, radiation exposure, 1st degree relative with thyroid cancer of MEN2, FDG avid on PET

scan, thyroid cancer associated history e.g. familial adenomatous polyposis, Carney complex, Cowden syndrome.

TI-RADS Calculator

Calculates TI-RADS Score

Clinical Indications for Diagnostic Thyroid Surgery in Absence of U/S and FNAC

- **Suspicious clinical mass:** Rapidly growing, firm mass, thyroid asymmetry, cervical lymphadenopathy, recent onset hoarseness/ vocal cord paralysis
- **Palpable firm cervical lymph node**
- **In addition to above suspicious clinical findings:** Prior thyroid cancer, radiation exposure, 1st degree relative with thyroid cancer of MEN2, FDG avid on PET scan, thyroid cancer associated history e.g. familial adenomatous polyposis, Carney complex, Cowden syndrome
- **When referral is not possible for U/S or FNAC**

U/S Indications for Diagnostic Thyroid Surgery in Absence of FNAC

U/S can be used to risk-stratify using the Thyroid Imaging Reporting and Data System (TI-RADS) (http://tiradscalculator.com/)

Solid nodule

- With suspicious sonographic features $\geq$1.0 cm
- Without suspicious sonographic features $\geq$1.5 cm

Mixed cystic-solid nodule

- With suspicious sonographic features: hypoechoic, Solid component $\geq$1.0 cm
  microcalcifications, infiltrative margins, taller than
  wide in transverse plane
- Without suspicious sonographic features: Spongiform Solid component $\geq$1.5 cm
  nodules, isoechoic of hyper echoic solid nodules, mixed
  solid-cystic nodules without above suspicious features

Spongiform nodule (multiple microcystic components >2.0 cm
in >50% of volume of nodule

Suspicious cervical lymph node: May consider biopsy of lymph node

Above criteria are general guidelines: With high risk clinical features, evaluation of smaller nodules may be indicated based on clinical concerns e.g. prior thyroid cancer, radiation exposure, 1st degree relative with thyroid cancer of MEN2, FDG avid on PET scan, thyroid cancer associated history e.g. familial adenomatous polyposis, Carney complex, Cowden syndrome.

Diagnostic Nodulectomy vs. Thyroid Lobectomy

In the absence of a cytologic diagnosis of a thyroid nodule, and when clinically indicated to obtain a histopathologic diagnosis, the question arises whether one should perform a nodulectomy or thyroid lobectomy. Even though thyroid lobectomy is the standard of care, at least 25%* of lobectomy patients will require long-term thyroid replacement therapy.

- **Thyroid lobectomy**
  - Therapeutic for some differentiated cancers
  - Ipsilateral revision surgery not required
- **Nodulectomy**
  - Consider only if patients do not have access to thyroid replacement
  - Nodulectomy ideal for isthmus nodules, or nodules located along the anterior/inferior aspect of the thyroid lobe
  - If nodule situated deeply/posterior in gland, then one should identify the RLN prior to the nodulectomy to avoid injuring the RLN
  - May need to do completion lobectomy depending on histology of nodule, with increased risk to RLN associated with revision surgery

* Ahn D, Sohn JH, Jeon JH. Hypothyroidism Following Hemithyroidectomy: Incidence, Risk Factors, and Clinical Characteristics *J Clin Endocrinol Metab.* 2016 Apr;101(4):1429-36. https://doi.org/10.1210/jc.2015-3997

* Said M, Chiu V, Haigh PI. Hypothyroidism after hemithyroidectomy. *World J Surg*. 2013 Dec;37(12):2839-44 https://www.ncbi.nlm.nih.gov/pubmed/23982782

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6.2.12: 12. Surgery

Surgical Considerations for Thyroid Tumours

- Thyroid lobectomy
  - 25% may require long-term thyroid hormone replacement
  - Thyroid replacement may not be available
  - TSH/T3/T4 monitoring may be unavailable
- Total thyroidectomy
  - Transient hypocalcaemia in 5-60%
  - Permanent hypocalcaemia in 1.5-5%
  - Calcium monitoring and replacement may not be available
  - Hypocalcaemia may be fatal
- Bilateral RLN injury may be fatal
- Central neck dissection increases complication rates (RLN and hypocalcaemia)
- Occasional thyroid surgeons have higher hypocalcaemia and RLN complication rates
- If RAI unavailable
  - Must rely on curative surgical treatment
  - May not require total thyroidectomy
- Follow-up may be unreliable

Surgical Options for Thyroid Tumours

- **Standard of care** for suspected cancer
  - Thyroid lobectomy
  - Total thyroidectomy
- **Lesser surgery** a consideration when
  - Diagnostic tests such as FNAC and U/S are not available
  - Patients cannot access thyroid or calcium monitoring and replacement
  - Surgical options
    - Open biopsy and await histology before planning definitive surgery
    - Nodulectomy (no referral possible, isthmic and anterior placed nodules rather than posterior which makes repeat surgery difficult and dangerous)
    - Subtotal thyroidectomy
- **Neck dissections**
  - Central neck dissection
  - Lateral neck dissection

Diagnostic Nodulectomy vs. Thyroid Lobectomy

In the absence of a cytologic diagnosis of a thyroid nodule, and when clinically indicated to obtain a histopathologic diagnosis, the question arises whether one should perform a nodulectomy or thyroid lobectomy. Even though thyroid lobectomy is the standard of care, at least 25%* of lobectomy patients will require long-term thyroid replacement therapy.

- **Thyroid lobectomy**
  - Therapeutic for some differentiated cancers
  - Ipsilateral revision surgery not required
- **Nodulectomy**
  - Consider only if patients do not have access to thyroid replacement
  - Nodulectomy ideal for isthmus nodules, or nodules located along the anterior/inferior aspect of the thyroid lobe
  - If nodule situated deeply/posterior in gland, then one should identify the RLN prior to the nodulectomy to avoid injuring the RLN

- May need to do completion lobectomy depending on histology of nodule, with increased risk to RLN associated with revision surgery

* Ahn D, Sohn JH, Jeon JH. Hypothyroidism Following Hemithyroidectomy: Incidence, Risk Factors, and Clinical Characteristics *J Clin Endocrinol Metab.* 2016 Apr;101(4):1429-36. https://doi.org/10.1210/jc.2015-3997

* Said M, Chiu V, Haigh PI. Hypothyroidism after hemithyroidectomy. *World J Surg*. 2013 Dec;37(12):2839-44 https://www.ncbi.nlm.nih.gov/pubmed/23982782

Subtotal Thyroidectomy

Subtotal thyroidectomy may be applicable in selected patients with benign thyroid goitres and differentiated cancers who cannot undergo total thyroidectomy due to **lack of access to thyroid or calcium monitoring and replacement**.

The **Dunhill procedure** involves complete removal of one thyroid lobe with preservation of the superior and posterior thyroid on contralateral side. The posterior thyroid tissue near the cricothyroid joint is preserved, with the intent of not disturbing the recurrent laryngeal nerve, although failure to identify the nerve does potentially increase risk of injury. Similarly, the intent of preservation of the superior and posterior thyroid tissue is to increase the likelihood of preservation of the superior parathyroid glands, which are generally located along the posterosuperior aspect of the gland.

Risks (Compared to thyroid lobectomy/total thyroidectomy)

- Haemorrhage
- Potential increased risk of recurrent laryngeal nerve injury (if RLN not identified)
- Parathyroid glands are generally not specifically identified
- Uncertainty whether sufficient functioning thyroid tissue preserved to render patient euthyroid
- Risk of recurrence of a goitre
- Revision surgery more difficult

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6.3.1: 1. Motivation and Methodology

6.3.2: 2. How to Use Guidelines

6.3.3: 3. Evaluation of Parotid Mass- Key Points

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6.3.12: 12. Reccurent Pleomorphic Adenoma

6.3.1: 1. Motivation and Methodology

International guidelines for **parotid tumours and cancers** assume availability of ultrasound, CT, MRI, high quality cytology, high levels of surgical expertise, frozen section, and postoperative radiation therapy. Frequently, not all these interventions are available, and follow-up may be unreliable.

Without resource appropriate guidelines for parotid tumours, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

The *AfHNS Clinical Practice Guidelines for Parotid Tumours and Cancers in Developing Countries and Limited Resource Settings* tailor management of parotid tumours and cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

Methodology

The AfHNS convened a task force to enumerate parotid guidelines for poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS, American, and European colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of salivary cancers in low resource settings, much of the recommendations represents expert opinion.

Contributors to AfHNS Clinical Practice Guidelines for Parotid Masses and Cancers in Developing Countries and Limited Resource Settings were: Johan Fagan (South Africa), Jeff Otiti (Uganda), Joyce Aswani (Kenya), Paul Onakoya (Nigeria), Anna Konney (Ghana), Mohammed Garba (Nigeria), Rajab Mugabo (Rwanda), Innocent Kundiona (Zimbabwe), Melesse Biadgelign (Ethiopia), Chege Macharia (Kenya), Victor Mashamba (Tanzania), Kenneth Baidoo (Ghana), Khaled Twier (Libya), Clare Stannard (South Africa), Julie Wetter (South Africa), Vincent Vander Poorten (Belgium), Patrick Bradley (UK), Mark Zafereo (USA).

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6.3.2: 2. How to Use Guidelines

How to use the AfHNS Clinical Practice Guidelines for Parotid Tumours and Cancers in Developing Countries and Limited Resource Settings

By clicking on Scenario 1-16 depicting the resources available to you and your patient, you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
FNAC	X		X	X	X				X	X	X	X				
CT/MRI	X	X		X	X		X	X			X		X			
Total parotidectomy expertise	X	X	X		X	X		X	X					X		
Radiotherapy	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.3.3: 3. Evaluation of Parotid Mass- Key Points

- Most parotid neoplasms are benign
- **Clinical evaluation, cytology and imaging do not conclusively exclude malignancy**….hence the need for complete resection of the tumour and **histological examination**, or if surgery is not to be done, a core needle biopsy
- **Objectives of preoperative evaluation**
  - To avoid unnecessary surgery for e.g. infective or non-neoplastic masses, lymphoma, unresectable tumour
  - To do appropriate surgery
  - To avoid embarking on surgery that is beyond the scope of a surgeon e.g. deep lobe tumour, tumour extending to parapharyngeal space, tumour requiring neck dissection, or tumour requiring facial nerve reconstruction
- **History and examination** are important means to identify infective causes (e.g. HIV, TB) , benign and malignant primary tumours and metastases to the parotid
- **FNAC** is helpful in selected cases
- **Imaging** is rarely beneficial for clinically benign, mobile parotid tumours as it uncommonly alters surgical management, but may be helpful in other selected cases
- **Histological classification** of primary salivary neoplasms is difficult and complex. Cytological and histological diagnoses should always be treated with caution and viewed in a clinical context, especially if reported from outside centers of excellence

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6.3.4: 4. Clinical Evaluation- History and Examination

- **Objectives**
  - Avoid unnecessary surgery for e.g. infective or non-neoplastic masses, lymphoma, unresectable tumour
  - Do appropriate surgery
  - Avoid embarking on surgery that is beyond the scope of a surgeon e.g. deep lobe tumour, tumour extending to the parapharyngeal space, tumour requiring neck dissection, or tumour requiring facial nerve reconstruction
- **Malignant parotid tumours may have clinically benign features**
- **Consider lymphoma**
  - Past lymphoma
  - HIV +ve
  - Cervical / generalised lymphadenopathy
- **Suspicious for malignancy**
  - Pain
  - Rapid growth
  - Neurological deficits
  - Facial nerve: Facial twitching or weakness
  - Trigeminal nerve
  - Greater auricular nerve
  - Skin invasion
  - Muscle invasion….trismus
  - Cervical nodes
  - Prior skin/conjunctival cancer/melanoma
  - Previous salivary cancer
  - Previous radiation to salivary gland region

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6.3.5: 5. Fine Needle Aspiration Cytology (FNAC)

Limitations

- Because of the highly complex and varied histology of salivary tumours, FNAC has limited accuracy, even in expert hands
- Benign vs malignant: 79%
- Precise histological type: 30%
- Cannot distinguish between high and low-grade mucoepidermoid carcinoma
- Consequently be cautious about making key surgical and radiotherapy decisions based on cytology alone (especially outside cytology centers of excellence) e.g. partial vs total parotidectomy, facial nerve resection, neck dissection, palliative vs curative treatment

Indications

- Only selected salivary neoplasms require FNAC
- Potentially avoid surgery
- Suspected non-neoplastic disease (e.g. HIV lymphoepithelial cyst, TB, benign cyst, lipoma)
- Suspected lymphoma
- Elderly / infirm / refusing surgery
- FNAC indicating Warthin's tumour
- Potentially modify surgery
- Suspected lymphoma….core biopsy / incision biopsy
- Facial nerve weakness…. resect nerve involved by tumour
- Metastatic skin / conjunctival SCC or melanoma….superficial/total parotidectomy with elective/therapeutic neck dissection
- Tumour of parapharyngeal space….may determine surgical approach
- Suspected cervical lymph node metastases from salivary gland malignancy

Technique: FNAC can be done as an office procedure by the surgeon….Ultrasound guidance is rarely required https://onlinelibrary.wiley.com/doi/pdf/10.1111/1744-1633.12315

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6.3.6: 6. Imaging

Minority of parotid tumours require imaging

- Only required if it might change management
- Infrequently indicated for clinically benign, mobile parotid tumours as it rarely alters surgical management

Indications

- **Suspect non-neoplastic disease** e.g. HIV lymphoepithelial cyst, TB, benign cyst, lipoma (US / CT)
- **Deep vs superficial lobe parotid tumour**
- Mobile tumour: Only if surgeon does not have skill to resect a deep lobe tumour (CT with contrast / MRI)
- Reduced mobility/fixed tumour
- Deep lobe tumour (CT with contrast / MRI)
- Extension to parapharyngeal space (CT with contrast / MRI)
- Invasion of local structures (CT / MRI)
- **Recurrence** of benign or malignant tumours (MRI)
- **Neurological deficits** e.g. facial nerve to determine extent of perineural invasion (MRI with Gd)
- **Metastases to parotid gland** (skin, conjunctiva), to plan selective vs therapeutic neck dissection (US / CT / MRI)
- **Exclude lung metastases** with suspected/known malignancy (CXR / CT)

Types of imaging

- **Ultrasound**
  - Cystic vs solid; associated cervical lymph nodes
  - Not good for deep vs superficial lobe, or for parapharyngeal extension
- **CT with contrast**
  - Cystic vs solid; associated cervical lymph nodes
  - Deep vs superficial lobe mass, or for parapharyngeal extension (Need to identify retromandibular vein (Need to identify retromandibular vein)
- **MRI**
  - Tumour “stuck” around stylomastoid foramen area
  - Local invasion (Good soft tissue differentiation)
  - Deep vs superficial lobe mass, or for parapharyngeal extension
  - Perineural invasion

PET-CT: Unhelpful as benign pathology (pleomorphic adenoma, Warthin tumours, TB, abscesses, lymphoma) are PET-avid

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6.3.7: 7. Surgical Considerations in Under-Resourced Settings

Unreliable follow-up: With patients unlikely to attend regular follow-up to detect early recurrence or metastases, a case can be made for more extensive surgery e.g. total (facial nerve sparing) parotidectomy for all malignant tumours as well as elective treatment of the neck by surgery (preferably) or radiation therapy

Unavailability of postoperative radiation therapy (PORT)

- Most patients with salivary malignancy receive PORT (Indications for PORT)
- Not having PORT to treat residual microscopic cancer or nodal metastases in the parotid deep lobe has the following surgical implications:
  - Consider completion total parotidectomy for high risk cancers diagnosed after partial parotidectomy
  - Consider resecting and grafting facial nerve branches adherent to a malignant tumour
  - Consider elective neck dissection for T3 and T4 malignancies
  - Consider who **not** to offer parotid surgery when outcomes without PORT will be poor
- Note that current evidence does not support use of chemotherapy for salivary cancers with either curative or palliative intent. (Vander Poorten V, Meulemans J, Delaere P et al. Molecular Markers and Chemotherapy for Advanced Salivary Cancer. *Curr Otorhinolaryngol Rep* (2014) 2: 85. https://doi.org/10.1007/s40136-014-0040-2)

Palliative surgery

- Patients often present with advanced cancers that might either be treated with surgery and PORT, or palliated with radiation therapy
- In the absence radiation, it raises the issue of surgical palliation for incurable salivary cancers to improve quality of life
- Some patients with adenoid cystic carcinoma with lung and bone metastases at presentation may survive some years (van Weert S, et al. Adenoid cystic carcinoma of the head and neck: A single-center analysis of 105 consecutive cases over a 30-year period. *Oral Oncol*. 2013 Aug;49(8):824-9)
- Hence “palliative parotidectomy” can be recommended for selected patients

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6.3.8: 8. Facial Nerve in Parotidectomy

Always attempt to preserve the nerve: If functioning preoperatively, one should aim to have a functioning nerve postoperatively

Intraoperative facial nerve monitoring

- Reduces immediate postoperative weakness, but does not affect permanent facial nerve weakness (Sood AJ, et al. Facial nerve monitoring during parotidectomy: a systematic review and meta-analysis. *Otolaryngol Head Neck Surg*. 2015) Apr;152(4):631-7)
- Not a substitute for knowledge of surgical anatomy of facial nerve
- Not required for routine parotidectomy
- Advisable for known malignant tumours requiring total parotidectomy, revision surgery or large tumours

Benign salivary tumours

- Displace, but do not invade nerve
- Nerve can always be dissected / peeled off tumours

Malignant tumours

- Functioning, normal looking nerve may be peeled off tumour, and microscopic residuum treated with postoperative radiotherapy
- If nerve is invaded/encased by tumour
- Confirm malignancy on frozen section
- Resect involved segment until free margins on frozen section (perineural spread can extend many centimetres beyond normal looking nerve)
- Be prepared to dissect the mastoid segment of the nerve if positive margin at stylomastoid foramen
- Immediately graft resected nerve, unless a small midface branch (cross-innervation in midfacial branches)

No postoperative radiotherapy or frozen section with known malignancy adherent to, or invading nerve

- May need to be surgically more aggressive
- Reservations about peeling nerve off tumour – but resect nerve only when the remainder of the operation is likely to achieve clear margins
- Resect nerve at least 1cm beyond obvious tumour

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6.3.9: 9. Neck Dissection or Irradiation with Parotid Cancer

- **When neck dissection is indicated and a surgeon lacks the expertise, refer to another centre for neck dissection**
- **Clinically/radiologically apparent cervical metastases:** Modified radical neck dissection (Levels 1-5)
- **Clinically/radiologically N0 neck**
  - Elective treatment of the neck (Levels 2/3/4) for parotid cancer is controversial
  - Elective neck dissection and elective radiotherapy are equally effective
  - Known risk factors for occult neck disease are
    - Tumour size >4cm
    - High-grade histology
    - Extraparotid tumour extension
  - Always sample nodes in Level 2a at the time of parotidectomy, or perform Level 2 selective neck dissection, to avoid having to redissect Level 2
    - If positive on frozen section, proceed to modified neck dissection
    - If frozen section not available, then histological examination guides subsequent treatment planning
  - When performing elective neck dissection (Levels 2/3/4) for skin cancer metastases to the parotid, always include the nodes overlying the sternomastoid along the external jugular vein

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6.3.10: 10. Postoperative Radiation Therapy

High risk requiring radiotherapy

Primary tumour bed for malignancy

- High grade primary salivary malignancy
- High grade mucoepidermoid
- Salivary duct carcinoma
- Ca ex pleomorphic
- Adenoid cystic
- Adenocarcinoma NOS
- T3/4 (>4cms)
- Perineural involvement
- Lymphovascular invasion
- Positive margin / close margin / tumour peeled off nerve
- Extra-parenchymal extension
- Recurrent disease
- Intraoperative tumour spillage
- Previous open / incision biopsy

Neck

- Undissected N0 neck
- T3/4
- Skin/conjunctival cancer metastases to parotid
- Dissected neck
- ≥2 metastases
- ECS

Low risk not requiring radiotherapy

Malignant

- Low grade primary salivary malignancy, completely excised
- <4cms diameter

Benign

- Benign tumour peeled off nerve in a well defined surgical dissection plane
- Controlled intraoperative tumour spillage of benign tumour, with copious irrigation of the wound

Chemotherapy in the absence of radiation therapy? Current evidence does not support use of chemotherapy for salivary cancers with either curative or palliative intent. (Vander Poorten V, Meulemans J, Delaere P et al. Molecular Markers and Chemotherapy for Advanced Salivary Cancer. *Curr Otorhinolaryngol Rep* (2014) 2: 85. https://doi.org/10.1007/s40136-014-0040-2)

Acronym for PORT by Sandro V Porceddu

M	Margins close (<5mm)/positive
U	Undifferentiated/high grade
L	Lymph node involvement
T	T3-4
I	Immunosuppressed
P	Perineural involvement
L	Lymphovascular invasion
I	Invasion into skin/in-transit metastases
E	Extra-parenchymal extension
R	Recurrent disease

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6.3.11: 11. Parotidectomy without Radiotherapy

Unreliable follow-up: With patients unlikely to attend regular follow-up to detect early recurrence or metastases, a case can be made for more extensive surgery e.g. total (facial nerve sparing) parotidectomy for all malignant tumours as well as elective treatment of the neck by surgery (preferably) or radiation therapy

Unavailability of postoperative radiation therapy (PORT)

- Most patients with salivary malignancy receive PORT (Indications for PORT)
- Not having PORT to treat residual microscopic cancer or nodal metastases in the parotid deep lobe has the following surgical implications:
  - Consider completion total parotidectomy for high risk cancers diagnosed after partial parotidectomy
  - Consider resecting and grafting facial nerve branches adherent to a malignant tumour
  - Consider elective neck dissection for T3 and T4 malignancies
  - Consider who **not** to offer parotid surgery when outcomes without PORT will be poor
- Note that current evidence does not support use of chemotherapy for salivary cancers with either curative or palliative intent. (Vander Poorten V, Meulemans J, Delaere P et al. Molecular Markers and Chemotherapy for Advanced Salivary Cancer. *Curr Otorhinolaryngol Rep* (2014) 2: 85. https://doi.org/10.1007/s40136-014-0040-2)

Palliative surgery

- Patients often present with advanced cancers that might either be treated with surgery and PORT, or palliated with radiation therapy
- In the absence radiation, it raises the issue of surgical palliation for incurable salivary cancers to improve quality of life
- Some patients with adenoid cystic carcinoma with lung and bone metastases at presentation may survive some years (van Weert S, et al. Adenoid cystic carcinoma of the head and neck: A single-center analysis of 105 consecutive cases over a 30-year period. *Oral Oncol*. 2013 Aug;49(8):824-9)
- Hence “palliative parotidectomy” can be recommended for selected patients

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6.3.12: 12. Reccurent Pleomorphic Adenoma

- Rare if original surgery is properly performed with preservation of tumour capsule
- Prevention
  - Avoid open surgical biopsy
  - Complete tumour resection
  - Avoid tumour rupture and spillage
  - If ruptures, copiously irrigate wound
- Clinical features
  - Multiple (usually) nodules in previous surgical field
  - Painless
  - Facial nerve function unaffected
- Investigations
  - Details of extent of previous tumour and surgery
  - Imaging (MRI / Ultrasound / CT scan) always indicated
    - Extent and distribution of nodules
    - Residual parotid tissue
    - Relationship to facial nerve (retromandibular vein)
  - FNAC to exclude malignancy if rapid growth, pain, facial weakness, lymphadenopathy
- Treatment
  - Surgery is primary treatment, not radiation therapy
  - Refer to experienced surgeon
    - Commonly requires total parotidectomy +/- soft tissue resection +/- Level 2 neck dissection
    - Facial nerve at significantly greater risk of injury due to scarring in surgical bed and potential for tumour adherence to the nerve
      - Informed consent about risk to facial nerve
      - Use nerve monitor (if available)
      - May require nerve graft
    - May require resection of involved skin and reconstruction with e.g. cervicofacial flap
  - Consider postoperative radiation therapy in unfavorable cases

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6.4.1: 1. Motivation and Methodology

6.4.2: 2. How to Use Guidelines

6.4.3: 3. Evaluation of Submandibular Salivary Gland Mass- Key Points

6.4.4: 4. Clinical Evaluation- History and Examination

6.4.5: 5. Fine Needle Aspiration Cytology (FNAC)

6.4.6: 6. Imaging

6.4.7: 7. Surgical Considerations in Under-Resourced Settings

6.4.8: 8. Facial, Lingual, and Hypoglossal Nerves in Submandibular Salivary Gland Surgery

6.4.9: 9. Neck Dissection or Irradiation with Submandibular Salivary Gland Cancer

6.4.10: 10. Postoperative Radiation Therapy

6.4.11: 11. Histological Classification of Salivary Neoplasms

6.4.12: 12. TNM Classification of Submandibular Salivary Gland Cancers

6.4.1: 1. Motivation and Methodology

Without resource appropriate guidelines for submandibular tumours, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

The *AfHNS Clinical Practice Guidelines for Submandibular Tumours and Cancers in Developing Countries and Limited Resource Settings* tailor management of submandibular tumours and cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of submandibular tumours in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS, American, and European colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of salivary cancers in low resource settings, much of the recommendations represents expert opinion.

Contributors to AfHNS Clinical Practice Guidelines for Submandibular Masses and Cancers in Developing Countries and Limited Resource Settings were: Johan Fagan (South Africa), Paul Onakoya (Nigeria), Anna Konney (Ghana), Mohammed Garba (Nigeria), Innocent Kundiona (Zimbabwe), Melesse Biadgelign (Ethiopia), Kenneth Baidoo (Ghana), Khaled Twier (Libya), Joyce Aswani (Kenya), Rajab Mugabo (Rwanda), Vincent Vander Poorten (Belgium), Patrick Bradley (UK), Mark Zafereo (USA).

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6.4.2: 2. How to Use Guidelines

By clicking on Scenario 1-16 depicting the resources available to you and your patient, you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
FNAC	X		X	X	X				X	X	X	X				
US/CT/MRI	X	X		X	X		X	X			X		X			
Neck dissection expertise	X	X	X		X	X		X	X					X		
Radiotherapy	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.4.3: 3. Evaluation of Submandibular Salivary Gland Mass- Key Points

- 50% are malignant
- Adenoid cystic carcinoma is the most common malignancy
- **Clinical evaluation, cytology and imaging do not conclusively exclude malignancy**….hence complete resection of the tumour and **histological examination** are required, or if surgery is not to be done, a core needle biopsy
- **Objectives of preoperative evaluation**
  - Distinguish between a submandibular lymph node and salivary mass
  - Avoid unnecessary surgery
  - Do appropriate surgery
  - Avoid embarking on surgery that is beyond the scope of a surgeon e.g. tumour requiring neck dissection
- **History and examination** are important means to identify non-neoplastic causes e.g. sialadenitis, sialolithiasis, and benign and malignant primary tumours, although **2/3 of malignant tumours are clinically benign**
- **FNAC** is helpful in **selected** cases
- **Ultrasound** may distinguish a lymph node from a salivary mass, and identify cervical nodal metastases
- **Histological classification** of primary salivary gland neoplasms is difficult and complex. Cytological and histological diagnoses should always be treated with caution and viewed in a clinical context, especially if not reported from centers of excellence

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6.4.4: 4. Clinical Evaluation- History and Examination

Objectives

- Avoid unnecessary surgery
- Do appropriate surgery
- Avoid embarking on surgery that is beyond the scope of a surgeon e.g. tumour requiring neck dissection
- Distinguish between submandibular lymph node and salivary mass

Distinguishing lymph node from SMG mass

- Unlike the parotid, there are no intraglandular lymph nodes
- Lymph nodes are lateral/superficial to the SMG
- Palpate the mass between a finger placed on the floor of mouth and another on the neck: lymph nodes are generally palpable only with the finger on the neck, as opposed to a SMG mass that is palpable between both fingers
- If still uncertain, proceed to U/S or FNAC

Suspicious for malignancy

- Malignant tumours may have benign clinical features in 2/3 of cases
- Rapid growth
- Pain (30% of malignant tumours)
- Extra-glandular extension
  - Adherence to mandible
  - Skin
  - Floor of mouth
  - Neurological deficits
    - Hypoglossal nerve
    - Lingual nerve
    - Marginal mandibular nerve
- Cervical lymphadenopathy
- Previous salivary cancer
- Previous radiation to salivary gland region

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6.4.5: 5. Fine Needle Aspiration Cytology (FNAC)

Limitations

- Because of complex and varied histology of salivary tumours, FNAC has limited accuracy, even in expert hands
- Benign vs malignant: 79%
- Precise histological type: 30%
- Cannot distinguish between high and low-grade mucoepidermoid carcinoma
- Consequently be cautious about making key surgical and radiotherapy decisions based on cytology alone (especially outside centers of cytology excellence) e.g. sacrificing marginal mandibular, hypoglossal, and lingual nerves, neck dissection, palliative vs. curative treatment

Indications

- Only selected salivary neoplasms require FNAC
- Potentially avoid surgery
- Suspected non-neoplastic disease
- Possibly a lymph node
- Elderly / infirm / refusing surgery
- Potentially modify surgery
- Malignancy: Elective neck dissection
- Suspected cervical lymph node metastases from salivary gland malignancy: therapeutic neck dissection
- Nerve weakness…. resect nerve involved by tumour

Technique: FNAC can be done as an office procedure by the surgeon….Ultrasound guidance is rarely required https://onlinelibrary.wiley.com/doi/pdf/10.1111/1744-1633.12315

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6.4.6: 6. Imaging

A minority of submandibular tumours require imaging

Indications

- Suspected non-neoplastic disease e.g. sialadenitis, sialolithiasis (US / CT)
- Distinguish between submandibular lymph node and salivary mass (US)
- Reduced mobility/fixed tumour with invasion of surrounding structures (Panorex / CT / MRI)
- Neurological deficits to determine extent of perineural invasion (MRI with Gd)
- Malignant tumour (clinically / cytologically) to exclude cervical metastases (US / CT)
- Exclude lung metastases with suspected/known malignancy (CXR / CT)

Panorex: For adherence to mandible

Ultrasound

- Sialolithiasis / chronic sialadenitis / neoplasm
- Cervical lymph nodes

CT

- Sialolithiasis / chronic sialadenitis / neoplasm
- Cystic vs solid
- Cervical lymph nodes
- Advanced tumours: Erosion of mandible / invasion of muscles of floor of mouth / tongue

MRI

- Advanced tumours: Erosion of mandible / invasion of muscles of floor of mouth or tongue (Good soft tissue differentiation)
- Perineural invasion

PET-CT: Unhelpful as benign pathology (pleomorphic adenoma, infection), lymphoma are PET-avid

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6.4.7: 7. Surgical Considerations in Under-Resourced Settings

Unreliable follow-up: With patients with malignant tumours and unlikely to attend regular follow-up to detect early recurrence or metastases, electively treat Levels Ia,b, IIa and III of the neck by surgery (preferably) or radiation therapy

Unavailability of postoperative radiation therapy (PORT)

- Most patients with salivary malignancy receive PORT (Indications for PORT)
- Not having PORT to treat residual microscopic cancer or nodal metastases has the following surgical implications:
  - Consider resecting nerves adherent to a malignant tumour
  - Elective neck dissection Levels Ia,b, IIa and III for malignancies
  - Consider who **not** to offer surgery for advanced tumours when outcomes without PORT will be poor

Palliative surgery

- Patients often present with advanced cancers that might either be treated with surgery and PORT, or palliated with radiation therapy
- In the absence of radiation, it raises the issue of surgical palliation for incurable salivary cancers to improve quality of life
- Some patients with adenoid cystic carcinoma with lung and bone metastases at presentation may survive some years (van Weert S, et al. Adenoid cystic carcinoma of the head and neck: A single-center analysis of 105 consecutive cases over a 30-year period. *Oral Oncol*. 2013 Aug;49(8):824-9)

Hence “palliative surgery” can be recommended for selected patients

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6.4.8: 8. Facial, Lingual, and Hypoglossal Nerves in Submandibular Salivary Gland Surgery

If functioning preoperatively, one should aim to have functioning nerves postoperatively

Benign salivary tumours

- Displace, but do not invade nerve
- Nerve can always be dissected / peeled off tumours

Malignant tumours

- Functioning, normal looking nerve may be peeled off tumour and microscopic residuum treated with postoperative radiotherapy
- If nerve is invaded/encased by tumour or has impaired function
- Confirm malignancy on frozen section
- Resect involved segment until free margins on frozen section (perineural spread can extend many centimetres beyond normal looking nerve)
- Immediately graft a resected marginal mandibular nerve if you wish to restore lower lip function or hypoglossal nerve
- Lingual nerve generally not grafted if resected

No postoperative radiotherapy or frozen section with known malignancy adherent to, or invading nerve

- Be surgically more aggressive
- Do not peel nerve off tumour, but resect nerve at least 1cm beyond obvious tumour to achieve clear margins

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6.4.9: 9. Neck Dissection or Irradiation with Submandibular Salivary Gland Cancer

- **Clinically/radiologically N+ neck:** Modified radical neck dissection (Levels I-V)
- **Clinically/radiologically N0 neck**
  - Elective treatment of the neck (Levels Ia,b, IIa and III)
  - Elective neck dissection and elective radiotherapy are equally effective
  - Known risk factors for occult neck disease are
    - Tumour size >4cm
    - High-grade histology
    - Extraglandular tumour extension
  - With a clinically or cytologically malignant tumour, electively clear all nodes in Level I to avoid having to redissect Level I
    - If positive on frozen section, proceed to modified neck dissection
    - If frozen section not available, then histology of lymph nodes guides subsequent treatment

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6.4.10: 10. Postoperative Radiation Therapy

High risk requiring radiotherapy

Primary tumour bed for malignancy

- High grade primary salivary malignancy
- High grade mucoepidermoid
- Salivary duct carcinoma
- Ca ex pleomorphic
- Adenoid cystic
- Adenocarcinoma NOS
- T3/4 (>4cms)
- Perineural involvement
- Lymphovascular invasion
- Positive margin / close margin / tumour peeled off nerve
- Extra-parenchymal extension
- Recurrent disease
- Intraoperative tumour spillage
- Previous open / incision biopsy

Neck

- Undissected N0 neck
- T3/4
- Skin/conjunctival cancer metastases to parotid
- Dissected neck
- $\geq$2 metastases
- ECS

Low risk not requiring radiotherapy

Malignant

- Low grade primary salivary malignancy, completely excised
- <4cms diameter

Benign

- Benign tumour peeled off nerve in a well defined surgical dissection plane
- Controlled intraoperative tumour spillage of benign tumour, with copious irrigation of the wound

Chemotherapy in the absence of radiation therapy? Current evidence does not support use of chemotherapy for salivary cancers with either curative or palliative intent. (Vander Poorten V, Meulemans J, Delaere P et al. Molecular Markers and Chemotherapy for Advanced Salivary Cancer. *Curr Otorhinolaryngol Rep* (2014) 2: 85. https://doi.org/10.1007/s40136-014-0040-2)

Acronym for PORT by Sandro V Porceddu

M	Margins close (<5mm)/positive
U	Undifferentiated/high grade
L	Lymph node involvement
T	T3-4
I	Immunosuppressed
P	Perineural involvement
L	Lymphovascular invasion
I	Invasion into skin/in-transit metastases
E	Extra-parenchymal extension
R	Recurrent disease

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6.4.11: 11. Histological Classification of Salivary Neoplasms

Malignant epithelial tumours

- Mucoepidermoid carcinoma
- Adenoid cystic carcinoma
- Acinic cell carcinoma
- Polymorphous adenocarcinoma
- Clear cell carcinoma
- Basal cell adenocarcinoma
- Intraductal carcinoma
- Adenocarcinoma, NOS
- Salivary duct carcinoma
- Myoepithelial carcinoma
- Epithelial-myoepithelial carcinoma
- Carcinoma ex pleomorphic adenoma
- Secretory carcinoma
- Sebaceous adenocarcinoma
- Carcinosarcoma
- Poorly differentiated carcinoma
- Undifferentiated carcinoma
- Large cell neuroendocrine carcinoma
- Small cell neuroendocrine carcinoma
- Lymphoepithelial carcinoma
- Squamous cell carcinoma
- Oncocytic carcinoma
- Uncertain malignant potential
- Sialoblastoma

Benign tumours

- Pleomorphic adenoma
- Myoepithelioma
- Basal cell adenoma
- Warthin tumour
- Oncocytoma
- Lymphadenoma
- Cystadenoma
- Sialadenoma papilliferum
- Ductal papillomas
- Sebaceous adenoma
- Canalicular adenoma and other ductal adenomas

Non-neoplastic epithelial lesions

- Sclerosing polycystic adenosis
- Nodular oncocytic hyperplasia
- Lymphoepithelial sialaedenitis
- Intercalated duct hyperplasia

Benign soft tissue lesions

- Haemangioma
- Lipoma/sialolipoma
- Nodular fasciitis

Haematolymphoid tumours

- Extranodal marginal zone lymphoma of mucosa-associated lymphoid tissue (MALT lymphoma)

Secondary malignancies

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6.4.12: 12. TNM Classification of Submandibular Salivary Gland Cancers

Primary tumour	
TX	Primary tumour cannot be assessed
T0	No evidence of primary tumour
Tis	Carcinoma in situ
T1	Tumour ≤2 cm in greatest dimension without extraparenchymal extension*
T2	Tumour >2 cm but not more than 4 cm in greatest dimension without extraparenchymal extension*
T3	Tumour >4 cm and/or tumour having extraparenchymal extension*
T4	Moderately advanced or very advanced disease
T4a	Moderately advanced disease Tumour invades the skin, mandible, ear canal, and/or facial nerve
T4b	Very advanced disease Tumour invades skull base and/or pterygoid plates and/or encases carotid artery
*Extraparenchymal extension is clinical or macroscopic evidence of invasion of soft tissues. Microscopic evidence alone does not constitute extraparenchymal extension for classification purposes.	

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6.5.1: 1. AfHNS Clinical Practice Guidelines for Glottic Cancers in Developing Countries and Limited Resource Settings

6.5.2: 2. Select Guideline According to Available to Resource Scenarios

6.5.3: 3. Motivation and Methodology

6.5.4: 4. How to Use Guidelines

6.5.5: 5. AfHNS Guidelines for Evaluation for Glottic Cancer- Key Points

6.5.6: 6. Clinical Evaluation- History and Examination

6.5.7: 7. Imaging

6.5.8: 8. TNM/AJCC Staging of Glottic Cancer

6.5.9: 9. Treatment Modifications in Poorly Resourced Settings

6.5.10: 10. Principles of Selecting Treatment

6.5.11: 11. Surgical Options for Glottic Cancer

6.5.12: 12. Indications for Neck Dissection with T3/T4 Glottic Cancers

6.5.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

6.5.14: 14. Requirements for Effective Delivery for Primary Chemoradiation

6.5.15: 15. Anterior Commissure

6.5.1: 1. AfHNS Clinical Practice Guidelines for Glottic Cancers in Developing Countries and Limited Resource Settings

Cancer of the Glottis

Without resource appropriate guidelines for glottic cancers, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

The *AfHNS Clinical Practice Guidelines for Glottic Cancers in Developing Countries and Limited Resource Settings* tailor management of glottic cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of glottic cancers in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS, American, and European colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of glottic cancers in low resource settings, much of the recommendations represents expert opinion.

Contributors to AfHNS Clinical Practice Guidelines for Glottic Cancers in Developing Countries and Limited Resource Settings were: Johan Fagan (South Africa), Paul Onakoya (Nigeria), Anna Konney (Ghana), Mohammed Garba (Nigeria), Innocent Kundiona (Zimbabwe), Melesse Biadgelign (Ethiopia), Kenneth Baidoo (Ghana), Khaled Twier (Libya), Joyce Aswani (Kenya), Rajab Mugabo (Rwanda), Victor Mashamba (Tanzania), Marco Faniriko (Madagascar),Jeff Otiti (Uganda), Chege Macharia (Kenya), Patrick Bradley (UK), Mark Zafereo (USA), and Wayne Koch (USA).

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6.5.2: 2. Select Guideline According to Available to Resource Scenarios

Click on the scenario that reflects the diagnostic tools and therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available Investigations & Treatment															
CT / MRI	X		X	X	X				X	X	X	X				
CO2 laser	X	X		X	X		X	X			X		X			
Chemoradiation	X	X	X		X	X		X	X					X		
Partial laryngectomy surgical expertise	X	X	X	X		X	X			X					X	

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6.5.4: 4. How to Use Guidelines

Click on the scenario 1-16 of resources available to you and your patient, and you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
CT / MRI	X		X	X	X				X	X	X	X				
CO_2 laser	X	X		X	X		X	X			X		X			
(Chemo)radiation package of care	X	X	X		X	X		X	X					X		
Partial laryngectomy expertise	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.5.5: 5. AfHNS Guidelines for Evaluation for Glottic Cancer- Key Points

- **Histological diagnosis is essential**
- Squamous cell carcinoma (SCC) is most common
- Exclude inflammatory causes e.g. TB
- **Principal treatment options** are surgery +/- adjuvant radiation therapy; or (chemo)radiation
- **Objectives of preoperative evaluation**
  - Confirm diagnosis
  - Describe the precise location of the cancer
  - Stage the primary cancer and the neck and exclude distant metastases
  - Decide whether to offer curative or palliative treatment
- **Patient evaluation**
  - Fitness for surgery / chemoradiation
  - Ability to cope with aspiration if partial laryngectomy, chemoradiation considered
  - Ability to complete surgery and postoperative radiation therapy, or chemoradiation
  - Ability to deal with the long-term consequences of treatment e.g. dysphagia, aspiration, tracheostomy, hypothyroidism, voice disturbance/aphonia
- **Surgery**
  - Plan appropriate surgery
  - Avoid inappropriate surgery
  - Avoid surgery beyond the scope of the surgeon e.g. complex salvage surgery

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6.5.6: 6. Clinical Evaluation- History and Examination

Objectives

- Select appropriate surgery
- Avoid unnecessary surgery
- Avoid embarking on surgery that is beyond the scope of a surgeon

Primary tumour

- Site
  - Lateral
  - Anterior commissure
  - Subglottic (>1cm below free edge of glottis)
  - Supraglottic
  - Hypopharynx
  - Vallecula/BOT
- T-stage
  - Vocal cord mobility
  - Cartilage invasion
  - Extralaryngeal extension
    - Through thyroid cartilage
    - Base of tongue
    - Pre-epiglottic space
- Bulk
- Arytenoid involvement
- Laryngeal dysfunction: Stridor, voice, swallowing, aspiration

Cervical nodes

- Palpate the neck
- Consider Ultrasound

Synchronous Primary (upper aerodigestive tract, lungs)

- Current/recent smokers have 5-10% second primary
- History and office examination
- Panendocopy
- CXR / CT / PET

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6.5.7: 7. Imaging

Imaging is only required if it may change management

Imaging of Primary

- **T1 / T2**
  - Minority require imaging
  - Consider for anterior commissure tumours if concern about thyroid cartilage invasion
- **T3/4**
  - CT / MRI rarely helpful if total laryngectomy planned
  - CT / MRI recommended if chemoradiation or partial laryngectomy considered
    - Thyroid cartilage
    - Paraglottic extension
    - Staging of cervical nodes
- **If primary radiation considered:** Ultrasound, CT or MRI of larynx to exclude thyroid cartilage invasion

Cervical metastases

- **N0 neck:** No need to image if elective neck dissection planned or for T1/2 glottic cancers
- **N+ neck:** Image (U/S or CT) if concern about resectability

Distant metastases: CXR / CT chest: T3/4 glottic cancers

Synchronous primary: CXR / CT chest

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6.5.8: 8. TNM/AJCC Staging of Glottic Cancer

T1	Limited to vocal cord(s) with normal mobility (may involve anterior or posterior commissures)
T1a	• Limited to one vocal cord
T1b	• Involves both vocal cords
T2	Extends to supraglottis and/or subglottis, and/or with impaired vocal cord mobility
T3	Limited to larynx with vocal cord fixation and/or invasion of paraglottic space, and/or inner cortex of thyroid cartilage
T4	Moderately advanced or very advanced
T4a	• Moderately advanced local disease. Invades through outer cortex of thyroid cartilage and/or invades tissues beyond larynx (e.g. trachea, soft tissues of neck including deep extrinsic muscle of tongue, strap muscles, thyroid or oesophagus)
T4b	• Very advanced local disease. Invades prevertebral space, encases carotid artery, or invades mediastinal structures

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6.5.9: 9. Treatment Modifications in Poorly Resourced Settings

Postoperative radiotherapy (PORT): when weighing up need with marginal indications, consider:

- Expense
- Morbidity e.g. >25% risk of hypothyroidism from radiating central neck, 80% if radiation after thyroid lobectomy
- Social support and likelihood to complete treatment
- Competing institutional needs for scarce radiation therapy

Primary chemoradiation: when weighing up need with marginal indications, consider:

- Patient's fitness/ finances
- Morbidity and mortality related to treatment
- Social support and likelihood to complete treatment
- Institutional package of care

Unavailability of postoperative radiation therapy (PORT)

- Patients with T4 malignancy normally receive PORT (Indications for PORT)
- Consider who **not** to offer surgery for advanced tumours when outcomes without PORT will be poor (palliate)
- Not having PORT to treat residual microscopic cancer or nodal metastases has the following surgical implications:
  - Wider tumour resection margins
  - More likely to require a flap to reconstruct the pharynx
  - Low threshold to convert a selective neck dissection to modified neck dissection/ extended ND (level VI)

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6.5.10: 10. Principles of Selecting Treatment

- **Should require a lot of thought**
  - Need to individualise treatment
  - Cannot simply base on TNM staging
- Need to balance cure with preservation of function
  - Swallowing
  - Voice
  - Aspiration
  - Airway
- Consider patient's values, beliefs, financial status, socioeconomic support
- Consider available resources
- Tumour factors
  - Site
  - Stage
  - Cartilage invasion
  - Ability to spare the arytenoid complex
- Prior therapy
  - Radiation
  - Partial laryngectomy
- Patient factors
  - Age, fitness, pulmonary status (tolerate aspiration)
  - Cognitive status
  - Values and beliefs
  - Socioeconomic status and social support
  - Access to thyroid replacement therapy
  - Reliability for follow-up
- Institutional support
  - Surgical expertise
  - Availability of CO2 laser transoral microsurgery
  - Radiotherapy package of care
  - Speech and swallowing support
  - Tracheo-oesophageal speaking valves/ electrolarynx

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6.5.11: 11. Surgical Options for Glottic Cancer

As is apparent from the treatment algorithms, many surgical options can achieve clear margins and preserve laryngeal function

Surgical options include:

- Transoral endoscopic microsurgery (cold steel)
- Transoral microscopic CO2 laser surgery
- Laryngofissure cordectomy
- Vertical partial laryngectomy (Hemilaryngectomy)
- Supracricoid laryngectomy
- Near total laryngectomy
- Total laryngectomy

Type of surgery depends on

- Tumour factors
  - Site
  - Cartilage invasion
  - Stage
  - Involvement of arytenoid complex
- Prior therapy
  - Radiation
  - Partial laryngectomy
- Patient factors
  - Pulmonary status (tolerate aspiration)
  - Cognitive status
- Institutional support
  - Surgical expertise
  - Availability of CO2 laser / transoral microsurgery
  - Speech and swallowing support
  - Tracheo-oesophageal speaking valves

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6.5.12: 12. Indications for Neck Dissection with T3/T4 Glottic Cancers

- **Clinically N0 neck**
  - Ipsilateral elective neck dissection Levels II– IV
  - Convert to MND if suspicious nodes in neck (+/- frozen section)
  - Contralateral elective neck dissection Levels II– IV for tumour crossing midline or significant supraglottic extension
  - Level VI (pre- and paratracheal nodes) with subglottic extension or extension to piriform fossa…also requires thyroid lobectomy
- **Clinically N+ neck:** Modified radical neck dissection (MND) / Selective Levels II-IV / Radical neck dissection (RND)

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6.5.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

Commenced within 6 weeks of surgery

Postoperative Radiotherapy

- **Primary tumour bed**
  - Through thyroid cartilage or into extralaryngeal soft tissues
  - Positive margin / close margins
  - Intraoperative tumour spillage
  - Preoperative tracheostomy through tumour
  - Subglottic tumour extension
- **Neck**
  - >1 metastases
  - Extracapsular spread (ECS)
- **Postoperative chemoradiation**
  - Positive margins
  - ECS

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6.5.14: 14. Requirements for Effective Delivery for Primary Chemoradiation

- Primary CRT is an option mainly for selected T3 glottic cancers
  - Not excessively bulky
  - No cartilage destruction
- Patient factors
  - Functional larynx: airway, swallowing, aspiration
  - Likely to complete CRT treatment
    - Fitness, age
    - Social support / financial means
  - Ability to cope with possible sequelae of CRT
    - Aspiration
    - Dysphagia
    - Renal failure
    - Hearing loss/ peripheral neuropathy
    - Tracheostomy
    - Hypothyroidism
- Total laryngectomy often a better option in low resource environments because CRT
  - Complex, sophisticated, toxic treatment
  - Requires complex supportive care, both during and following treatment
- Required package of care for favourable outcomes
  - CT/MRI/PET imaging for planning and surveillance
  - Modern radiation techniques
  - Medical and social support during treatment
  - Speech and swallowing therapy
  - Access to PEG feeding (Short and/or long-term)
  - Cancer surveillance (MRI / PET)
  - Thyroid replacement therapy
  - Complex salvage surgery including pedicled and free flaps

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6.5.15: 15. Anterior Commissure

- More likely to invade thyroid cartilage
  - Proximity
  - Broyle's ligament
- Beware subglottic extension through cricothyroid membrane
- Imaging advisable if considering CO2 laser or RT, except for small tumours
- Treatment options
- CO2 laser / transoral microsurgery
- Radiotherapy: Adapt technique to cover anterior commissure
- Vertical partial laryngectomy (Frontolateral)
- Supracricoid laryngectomy
- Total laryngectomy (extralaryngeal extension)

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6.6.1: 1. AfHNS Clinical Practice Guidelines for Supraglottic Cancers in Developing Countries and Limited Resource Settings

6.6.2: 2. Select Guideline According to Available Resource Scenarios

6.6.3: 3. Motivation and Methodology

6.6.4: 4. How to Use Guidelines

6.6.5: 5. AfHNS Guidelines for Evaluation of Supraglottic Cancer- Key Points

6.6.6: 6. Clinical Evaluation- History and Examination

6.6.7: 7. Imaging

6.6.8: 8. TNM/AJCC Staging of Supraglottic Cancer

6.6.9: 9. Treatment Modifications in Poorly Resourced Settings

6.6.10: 10. Principles of Selecting Treatment

6.6.11: 11. Surgical Options for Supraglottic Cancer

6.6.12: 12. Indications for Neck Dissection with Supraglottic Cancers

6.6.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

6.6.14: 14. Requirements for Effective Delivery of Primary Chemoradiation

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Cancer of the Supraglottis

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6.6.2: 2. Select Guideline According to Available Resource Scenarios

Click on the scenario that reflects the diagnostic tools and therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available Investigations & Treatment															
CT / MRI	X		X	X	X				X	X	X	X				
CO2 laser	X	X		X	X		X	X			X		X			
Chemoradiation	X	X	X		X	X		X	X					X		
Partial laryngectomy surgical expertise	X	X	X	X		X	X			X					X	

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6.6.3: 3. Motivation and Methodology

Without resource appropriate guidelines for supraglottic cancers, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

The *AfHNS Clinical Practice Guidelines for Supraglottic Cancers in Developing Countries and Limited Resource Settings* tailor management of supraglottic cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of supraglottic cancers in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS, American, and European colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of supraglottic cancers in low resource settings, much of the recommendations represents expert opinion.

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6.6.4: 4. How to Use Guidelines

Click on the scenario 1-16 of resources available to you and your patient, and you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations															
CT / MRI	X		X	X	X				X	X	X	X				
CO_2 laser	X	X		X	X		X	X			X		X			
Chemoradiation full package of care	X	X	X		X	X		X	X					X		
Surgical expertise	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.6.5: 5. AfHNS Guidelines for Evaluation of Supraglottic Cancer- Key Points

- **Histological diagnosis is essential**
- Squamous cell carcinoma (SCC) is most common
- Exclude inflammatory causes e.g. TB
- **Principal treatment options** are surgery +/- adjuvant radiation therapy; or (chemo)radiation
- **Objectives of preoperative evaluation**
  - Confirm diagnosis
  - Describe the precise location of the cancer
  - Stage the primary cancer and the neck and exclude distant metastases
  - Decide whether to offer curative or palliative treatment
- **Patient evaluation**
  - Fitness for surgery / chemoradiation
  - Ability to cope with aspiration if partial laryngectomy, chemoradiation considered
  - Ability to complete surgery and postoperative radiation therapy, or chemoradiation
  - Ability to deal with the long-term consequences of treatment e.g. dysphagia, aspiration, tracheostomy, hypothyroidism, voice disturbance/aphonia
- **Surgery**
  - Plan appropriate surgery
  - Avoid inappropriate surgery
  - Avoid surgery beyond the scope of the surgeon e.g. complex salvage surgery

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6.6.6: 6. Clinical Evaluation- History and Examination

Objectives

- Select appropriate surgery
- Avoid unnecessary surgery
- Avoid embarking on surgery that is beyond the scope of a surgeon

Primary tumour

- Site
  - Supraglottic (infra- vs suprahyoid, false cord, arytenoid, pre-epiglottic space, AE fold, epiglottic)
  - Glottic
  - Hypopharynx
  - Vallecula/BOT
  - Can the arytenoid(s) be spared?
- T-stage
  - Vocal cord mobility
  - Cartilage invasion
  - Extralaryngeal extension
    - Through thyroid cartilage
    - Base of tongue
    - Pre-epiglottic space
- Bulk
- Arytenoid involvement
- Laryngeal dysfunction: Stridor, voice, swallowing, aspiration

Cervical nodes

- Palpate the neck
- Consider Ultrasound

Synchronous Primary (upper aerodigestive tract, lungs)

- Current/recent smokers have 5-10% second primary
- History and office examination
- Panendocopy
- CXR / CT / PET

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6.6.7: 7. Imaging

Imaging is only required if it may change management

Imaging of Primary

- **T1 / T2**
  - Minority require imaging
  - Consider for anterior commissure tumours if concern about thyroid cartilage invasion
- **T3/4**
  - CT / MRI rarely helpful if total laryngectomy planned
  - CT / MRI recommended if chemoradiation or partial laryngectomy considered
    - Thyroid cartilage
    - Paraglottic extension
    - Pre-epiglottic space involvement if supracricoid laryngectomy planned
    - Staging of cervical nodes
- **If primary radiation considered:** Ultrasound, CT or MRI of larynx to exclude thyroid cartilage invasion

Cervical metastases

- **N0 neck:** No need to image if elective neck dissection planned or for T1 cancers
- **N+ neck:** Image (U/S or CT) if concern about resectability

Distant metastases: CXR / CT chest: T2 – 4 cancers

Synchronous primary: CXR / CT chest

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6.6.8: 8. TNM/AJCC Staging of Supraglottic Cancer

T1	Tumour limited to one subsite of supraglottis with normal vocal cord mobility
T2	Tumour invades mucosa of >1 adjacent subsite of supraglottis or glottis or region outside the supraglottis (e.g. base of tongue, vallecula, medial wall of piriform sinus) without fixation of the larynx [Subsites: suprahyoid epiglottis, infrahyoid epiglottis, aryepiglottic folds (laryngeal aspect), arytenoids and false vocal cords]
T3	Tumour limited to larynx with vocal cord fixation and/or invades any of the following: postcricoid area, pre-epiglottic space, paraglottic space, and/or inner cortex of thyroid cartilage
T4	Moderately advanced or very advanced
T4a	Moderately advanced local disease. Tumour invades through outer cortex of thyroid cartilage and/or invades tissues beyond larynx (e.g. trachea, soft tissues of neck including deep extrinsic muscle of the tongue, strap muscles, thyroid or oesophagus)
T4b	Very advanced local disease. Tumour invades prevertebral space, encases carotid artery, or invades mediastinal structures

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6.6.9: 9. Treatment Modifications in Poorly Resourced Settings

Postoperative radiotherapy (PORT): when weighing up need with marginal indications, consider:

- Expense
- Morbidity e.g. >25% risk of hypothyroidism from radiating central neck, 80% if radiation after thyroid lobectomy
- Social support and likelihood to complete treatment
- Competing institutional needs for scarce radiation therapy

Primary chemoradiation: when weighing up need with marginal indications, consider:

- Patient's fitness/ finances
- Morbidity and mortality related to treatment
- Social support and likelihood to complete treatment
- Institutional package of care

Unavailability of postoperative radiation therapy (PORT)

- Patients with T4 malignancy normally receive PORT (Indications for PORT)
- Consider who **not** to offer surgery for advanced tumours when outcomes without PORT will be poor (palliate)
- Not having PORT to treat residual microscopic cancer or nodal metastases has the following surgical implications:
  - Wider tumour resection margins
  - More likely to require a flap to reconstruct the pharynx
  - Low threshold to convert a selective neck dissection to modified neck dissection/ extended ND (level VI)

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6.6.10: 10. Principles of Selecting Treatment

- **Should require a lot of thought**
  - Need to individualise treatment
  - Cannot simply base on TNM staging
- Need to balance cure with preservation of function
  - Swallowing
  - Voice
  - Aspiration
  - Airway
- Consider patient's values, beliefs, financial status, socioeconomic support
- Consider available resources
- Tumour factors
  - Site
  - Stage
  - Cartilage invasion
  - Ability to spare the arytenoid complex
- Prior therapy
  - Radiation
  - Partial laryngectomy
- Patient factors
  - Age, fitness, pulmonary status (tolerate aspiration)
  - Cognitive status
  - Values and beliefs
  - Socioeconomic status and social support
  - Access to thyroid replacement therapy
  - Reliability for follow-up
- Institutional support
  - Surgical expertise
  - Availability of CO_2 laser transoral microsurgery
  - Radiotherapy package of care
  - Speech and swallowing support
  - Tracheo-oesophageal speaking valves/ electrolarynx

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6.6.11: 11. Surgical Options for Supraglottic Cancer

As is apparent from the treatment algorithms, many surgical options can achieve clear margins and preserve laryngeal function

Surgical options include:

- Transoral endoscopic microsurgery (cold steel) or extended Bovie via Lindholm
- Transoral microscopic CO2 laser surgery
- Suprahyoid approach and resection (page 9): May be considered to access and resect T1 tumours of suprahyoid epiglottis or arytenoid or aryepiglottic fold
- Supraglottic laryngectomy (Requires swallowing therapy expertise)
- Supracricoid laryngectomy (Requires swallowing therapy expertise)
- Total laryngectomy
- Partial pharyngectomy (may require flap reconstruction)

Type of surgery depends on

- Tumour factors
  - Site
  - Cartilage invasion
  - Stage
  - Involvement of arytenoid complex
- Prior therapy
  - Radiation
  - Partial laryngectomy
- Patient factors
  - Pulmonary status (tolerate aspiration)
  - Cognitive status (To work with Speech and Language Therapist)
- Institutional support
  - Surgical expertise
  - Availability of CO2 laser / transoral microsurgery
  - Speech and swallowing support
  - Tracheo-oesophageal speaking valves

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6.6.12: 12. Indications for Neck Dissection with Supraglottic Cancers

- **Unlike glottic cancer, supraglottic cancers have a high propensity for**
  - Occult cervical nodal metastases
  - Bilateral nodal metastases
- **T2-4 and clinically N0 neck**
  - Bilateral elective neck dissection Levels II– IV
  - Convert to MND if suspicious nodes in neck (+/- frozen section)
  - Level VI (pre and paratracheal nodes) with subglottic extension or extension to piriform fossa…requires thyroid lobectomy
- **Clinically N+ neck**
  - Modified radical neck dissection (MND) / Radical neck dissection (RND)
  - Elective neck dissection Levels II– IV of contralateral N0 neck

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6.6.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

Commenced within 6 weeks of surgery

Postoperative Radiotherapy

- **Primary tumour bed**
  - Through thyroid cartilage or into extralaryngeal soft tissues
  - Positive margin / close margins
  - Intraoperative tumour spillage
  - Preoperative tracheostomy through tumour
  - Subglottic tumour extension
- **Neck**
  - >1 metastases
  - Extracapsular spread (ECS)
- **Postoperative chemoradiation**
  - Positive margins
  - ECS

Note: Postoperative radiation therapy may impair swallowing and increase aspiration following supraglottic or supracricoid laryngectomy

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6.6.14: 14. Requirements for Effective Delivery of Primary Chemoradiation

- Primary CRT is an option mainly for selected T3 supraglottic cancers
  - Not excessively bulky
  - No cartilage destruction
- Patient factors
  - Functional larynx: airway, swallowing, aspiration
  - Likely to complete CRT treatment
    - Fitness, age
    - Social support / financial means
  - Ability to cope with possible sequelae of CRT
    - Aspiration
    - Dysphagia
    - Renal failure
    - Hearing loss/ peripheral neuropathy
    - Tracheostomy
    - Hypothyroidism
- Total laryngectomy often a better option in low resource environments because CRT
  - Complex, sophisticated, toxic treatment
  - Requires complex supportive care, both during and following treatment
- Required package of care for favourable outcomes
  - CT/MRI/PET imaging for planning and surveillance
  - Modern radiation techniques
  - Medical and social support during treatment
  - Speech and swallowing therapy
  - Access to PEG feeding (Short and/or long-term)
  - Cancer surveillance (MRI / PET)
  - Thyroid replacement therapy
  - Complex salvage surgery including pedicled and free flaps

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6.7.1: 1. AfHNS Clinical Practice Guidelines for Hypopharyngeal Cancers in Developing Countries and Limited Resource Settings

6.7.2: 2. Select Guideline According to Available Resource Scenarios

6.7.3: 3. Motivation and Methodology

6.7.4: 4. How to Use Guidelines

6.7.5: 5. AfHNS Guidelines for Evaluation of Hypopharyngeal Cancer- Key Points

6.7.6: 6. Clinical Evaluation - History and Examination

6.7.7: 7. Imaging

6.7.8: 8. TNM/AJCC Staging of Hypopharyngeal Cancer

6.7.9: 9. Treatment Modifications in Poorly Resourced Settings

6.7.10: 10. Principles of Selecting Treatment

6.7.11: 11. Surgical Options for Hypopharyngeal Cancers

6.7.12: 12. Indications for Neck Dissection with Hypopharyngeal Cancers

6.7.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

6.7.14: 14. Requirements for Effective Delivery of Primary Chemoradiation

6.7.1: 1. AfHNS Clinical Practice Guidelines for Hypopharyngeal Cancers in Developing Countries and Limited Resource Settings

Without resource appropriate guidelines for hypopharyngeal cancers, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

The *AfHNS Clinical Practice Guidelines for Hypopharyngeal Cancers in Developing Countries and Limited Resource Settings* tailor management of hypopharyngeal cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of hypopharyngeal cancers in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS, American, and European colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of hypopharyngeal cancers in low resource settings, much of the recommendations represents expert opinion.

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Click on the scenario that reflects the diagnostic tools and therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available Investigations & Treatment															
CT / MRI	X		X	X	X				X	X	X	X				
CO2 laser	X	X		X	X		X	X			X		X			
Chemoradiation	X	X	X		X	X		X	X					X		
Pedicled of free flap expertise	X	X	X	X		X	X			X					X	

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Click on the scenario 1-16 of resources available to you and your patient, and you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
CT / MRI	X		X	X	X				X	X	X	X				
CO_2 laser/TORS	X	X		X	X		X	X			X		X			
Chemoradiation package of care	X	X	X		X	X		X	X					X		
Flap (pedicled or microvascular)	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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- **Histological diagnosis is essential**
  - Squamous cell carcinoma (SCC) is most common (rarely adenoid cystic carcinoma, liposarcoma)
  - Exclude inflammatory causes e.g. TB
- **Principal treatment options** are surgery +/- adjuvant radiation therapy; or (chemo)radiation
- **Objectives of preoperative evaluation**
  - Confirm diagnosis
  - Describe the precise location of the cancer
  - Stage the primary cancer and the neck and exclude distant metastases
  - Decide whether to offer curative or palliative treatment
- **Patient evaluation**
  - Unlike cancers of the larynx, patients are **often malnourished** due to dysphagia and odynophagia
  - Fitness for surgery / chemoradiation
  - Ability to cope with aspiration if partial laryngectomy, chemoradiation considered
  - Ability to complete surgery and postoperative radiation therapy, or chemoradiation
  - Ability to deal with the long-term consequences of treatment e.g. dysphagia, aspiration, tracheostomy, hypothyroidism, voice disturbance/aphonia
- **Surgery**
  - Plan appropriate surgery
  - Avoid inappropriate surgery
  - Avoid surgery beyond the scope of the surgeon e.g. complex salvage surgery

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6.7.6: 6. Clinical Evaluation - History and Examination

Objectives

- Select appropriate surgery
- Avoid unnecessary surgery
- Avoid embarking on surgery that is beyond the scope of a surgeon

Primary tumour

- Site
  - Hypopharynx (subsite: lateral, medial pyriform, postcricoid)
  - Supraglottis
  - Glottis
  - Vallecula/BOT
  - Distant extent (may require flap reconstruction, oesophagectomy)
- T-stage
  - Vocal cord mobility
  - Cartilage invasion
  - Extension to oropharynx, oesophagus
- Mobility related to
  - Prevertebral tissues
  - Thyroid cartilage
- Laryngeal dysfunction: Stridor, voice, swallowing, aspiration

Cervical nodes

- Palpate the neck
- Consider Ultrasound

Synchronous Primary (upper aerodigestive tract, lungs)

- Upper aerodigestive tract, oesophagus, lungs
- History and office examination
- Panendocopy
- CXR / CT / PET

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6.7.7: 7. Imaging

Imaging is only required if it may change management

Imaging of Primary

- **T1 / T2**
  - Minority require imaging
  - CT / MRI to exclude thyroid cartilage or prevertebral tissue invasion if tumour immobile at examination under anaesthesia
- **T3/4**
  - CT / MRI rarely helpful if total laryngectomy planned
  - If total laryngectomy planned: consider CT / MRI if concern about extrapharyngeal extension or prevertebral tissue invasion
  - If chemoradiation considered
    - CT / MRI recommended
    - Thyroid cartilage invasion
    - Staging of cervical nodes

Cervical metastases

- **N0 neck:** No need to image if elective neck dissection planned or for T1 cancers
- **N+ neck:** Image (U/S or CT) if concern about resectability

Distant metastases: CXR / CT chest: T2 – 4 cancers

Synchronous primary: CXR / CT chest

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6.7.8: 8. TNM/AJCC Staging of Hypopharyngeal Cancer

T1	Limited to 1 subsite of hypopharynx; Greatest dimension ≤ 2 cm
T2	Involves >1 subsite of hypopharynx, or adjacent site, or measures 2-4cms in greatest dimension without fixation of hemilarynx or extension to oesophagus
T3	> 4cms in greatest dimension or fixation of hemilarynx or extension to oesophagus
T4	Moderately advanced or very advanced
T4a	Moderately advanced local disease: Invades thyroid/cricoid cartilage, hyoid bone, thyroid gland, oesophagus, or central compartment soft tissue
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- Expense
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- Morbidity and mortality related to treatment
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- Tumour factors
  - Site
    - Lateral may not require laryngectomy
    - Small AE fold / medial may be amenable to transoral excision
  - Stage
  - Mobility
    - Cartilage invasion
    - Prevertebral fascia invasion
  - Distal extent: May need flap reconstruction, oesophagectomy
- Prior radiation therapy
- Patient factors
  - Age, fitness, nutritional status
  - Pulmonary status (tolerate aspiration)
  - Cognitive status
  - Values and beliefs
  - Socioeconomic status and social support
  - Access to thyroid replacement therapy
  - Reliability for follow-up
- Institutional support
  - Surgical expertise
  - Availability of CO2 laser transoral microsurgery
  - Radiotherapy package of care
  - Speech and swallowing support
  - Tracheoesophageal speaking valves/ electrolarynx

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6.7.11: 11. Surgical Options for Hypopharyngeal Cancers

As is apparent from the treatment algorithms, many surgical options can achieve clear margins and preserve laryngeal function

Surgical options include:

- Transoral endoscopic microsurgery (cold steel) or extended Bovie via Lindholm
- Transoral microscopic CO2 laser surgery
- TORS (Transoral robotic surgery)
- Suprahyoid approach and resection (page 9): May be considered to access and to resect high posterior wall hypopharyngeal tumours
- Lateral pharyngotomy
- Supracricoid laryngectomy (Requires swallowing therapy expertise)
- Total laryngectomy

Type of surgery depends on

- Tumour factors
  - Site
  - Cartilage invasion
  - Stage
- Prior therapy
  - Radiation
  - Partial pharyngectomy
- Patient factors
  - Pulmonary status (tolerate aspiration)
  - Fitness, age
  - Nutritional status
  - Cognitive status (To work with Speech and Language Therapist)
- Institutional support
  - Surgical expertise
  - Availability of CO2 laser / transoral microsurgery / TORS
  - Speech and swallowing support
  - Tracheoesophageal speaking valves
  - Oesophagectomy, gastric pull-up, PEG

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6.7.12: 12. Indications for Neck Dissection with Hypopharyngeal Cancers

- **Unlike glottic cancer, hypopharyngeal cancers have a high propensity for**
  - Occult cervical nodal metastases
  - Paratracheal nodal metastases (Level VI)
  - Bilateral nodal metastases
- **T1 (most) and T2-4 clinically N0 neck**
  - Elective neck dissection Levels II– IV
  - Level VI (pre- and paratracheal nodes).…requires thyroid lobectomy
  - Contralateral SND Levels II– IV
    - Medial wall of piriform fossa / aryepiglottic fold
    - Postcricoid
    - Posterior pharyngeal wall
  - Convert to MND if suspicious nodes in neck (+/- frozen section)
  - Level VI (pre- and paratracheal nodes) with subglottic extension or extension to piriform fossa…requires thyroid lobectomy
- **Clinically N+ neck**
  - Modified radical neck dissection (MND) / Radical neck dissection (RND)
  - Contralateral END Levels II– IV
    - Medial wall of piriform fossa / aryepiglottic fold
    - Postcricoid
    - Posterior pharyngeal wall

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6.7.13: 13. Indications for Postoperative (Chemo)Radiation Therapy

Commenced within 6 weeks of surgery

Note: Postoperative radiation therapy may impair swallowing and increase aspiration following hypopharyngeal resection or supracricoid laryngectomy

Postoperative Radiotherapy

- **Primary tumour bed**
  - Through thyroid cartilage or into extralaryngeal soft tissues
  - Positive margin / close margins
  - Intraoperative tumour spillage
  - Preoperative tracheostomy through tumour
- **Neck**
  - >1 metastases
  - Extracapsular spread (ECS)
- **Postoperative chemoradiation**
  - Positive margins
  - ECS

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6.7.14: 14. Requirements for Effective Delivery of Primary Chemoradiation

- Primary CRT is an option mainly for selected hypopharyngeal cancers
  - Not excessively bulky
  - No cartilage destruction
- Patient factors
  - Functional larynx: airway, swallowing, aspiration
  - Likely to complete CRT treatment
    - Fitness, age
    - Social support / financial means
  - Ability to cope with possible sequelae of CRT
    - Aspiration
    - Dysphagia
    - Renal failure
    - Hearing loss/ peripheral neuropathy
    - Tracheostomy
    - Hypothyroidism
- Total laryngectomy often a better option in low resource environments because CRT
  - Complex, sophisticated, toxic treatment
  - Requires complex supportive care, both during and following treatment
- **Required package of care for favourable outcomes**
  - CT/MRI/PET imaging for planning and surveillance
  - Modern radiation techniques
  - Medical and social support during treatment
  - Speech and swallowing therapy
  - Access to PEG feeding (Short and/or long-term)
  - Cancer surveillance (MRI / PET)
  - Thyroid replacement therapy
  - Complex salvage surgery including pedicled and free flaps

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6.8.1: 1. AfHNS Clinical Practice Guidelines for Oral Cancers in Developing Countries and Limited Resource Settings

6.8.2: 2. Select Guideline According to Available Resource Scenarios

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6.8.11: 11. Indications for Neck Dissection with Oral Cancer

6.8.12: 12. Indications for Postoperative (Chemo)Radiation Therapy

6.8.1: 1. AfHNS Clinical Practice Guidelines for Oral Cancers in Developing Countries and Limited Resource Settings

The AfHNS Clinical Practice Guidelines for Oral Cancers in Developing Countries and Limited Resource Settings tailor management of oral cancers according to diagnostic and therapeutic resources available to physicians and to their patients.

International guidelines for oral cancers assume availability of cytology, ultrasound, CT, MRI, high levels of surgical expertise, reconstructive surgery, frozen section, and postoperative (chemo)radiation therapy. Frequently, not all these interventions are available, and follow-up may be unreliable.

Without resource appropriate guidelines for oral cancers, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of oral cancers in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS and American colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of oral cancers in low resource settings, much of the recommendations represents expert opinion.

Contributors to *AfHNS Clinical Practice Guidelines for Oral Cancers in Developing Countries and Limited Resource Settings* were: Johan Fagan (South Africa), Julie Wetter (South Africa), Paul Onakoya (Nigeria), Anna Konney (Ghana), Innocent Kundiona (Zimbabwe), Melesse Biadgelign (Ethiopia), Kenneth Baidoo (Ghana), Khaled Twier (Libya), Joyce Aswani (Kenya), Rajab Mugabo (Rwanda), Victor Mashamba (Tanzania), Marco Faniriko (Madagascar), Evelyne Diom (Senegal), Mark Zafereo (USA), and Wayne Koch (USA).

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6.8.2: 2. Select Guideline According to Available Resource Scenarios

Click on the scenario that reflects the diagnostic tools and therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available Investigations & Treatment															
CT / MRI	X		X	X	X				X	X	X	X				
Neck dissection expertise	X	X		X	X		X	X			X		X			
Reconstruction expertise	X	X	X		X	X		X	X					X		
Radiotherapy	X	X	X	X		X	X			X					X	

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6.8.3: 3. Motivation and Methodology

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6.8.4: 4. How to Use Guidelines

Click on the scenario 1-16 of resources available to you and your patient, and you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
CT/MRI	X		X	X	X				X	X	X	X				
Neck dissection expertise	X	X		X	X		X	X			X		X			
Reconstruction expertise	X	X	X		X	X		X	X					X		
Radiotherapy	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.8.5: 5. AfHNS Guidelines for Evaluation of Oral Cancer- Key Points

- Squamous cell carcinoma (SCC) is the most common oral cancer
- Histological diagnosis is essential and to exclude other malignancies like minor salivary cancers , melanoma, and inflammatory (e.g. TB) and traumatic causes
- Surgery +/- adjuvant radiation therapy offers the best chance of cure for SCC of the oral cavity
- Objectives of preoperative evaluation
  - Confirm diagnosis
  - Stage the cancer
  - Decide whether to offer curative or palliative treatment
  - Patient evaluation: Fitness, objectives, ability to complete surgery and postoperative radiation therapy, and ability to deal with the long-term consequences of treatment
  - Surgery
    - Plan appropriate surgery
    - Avoid inappropriate surgery
    - Avoid surgery beyond the scope of the surgeon

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6.8.6: 6. Clinical Evaluation- History and Examination

Objectives

- Select appropriate surgery
- Avoid unnecessary surgery
- Avoid embarking on surgery that is beyond the scope of a surgeon

Primary tumour

- Site
- Diameter
- Depth of invasion (palpation)
  - >4mm, then treat the neck electively
  - 5-10mm: T2
  - >10mm: T3
- Soft tissue invasion
- Tongue mobility
- Trismus
- XIIn, Lingual nerve, mental nerve dysfunction
- Mandible
  - If adherent, then assess mandible invasion
  - Dental caries if to receive radiation therapy

Cervical nodes

- Palpate the neck
- Palpate Level 1b between a finger placed on the floor of mouth and another on the neck
  - To detect nodes
  - To distinguish between SMG and lymph node as nodes are lateral/superficial to SMG are generally palpable only with the finger on the neck, as opposed to a SMG mass that is palpable between both fingers
- Palpable nodes in lymphatic basin: assume metastases
- No palpable nodes
  - T1 <4mm depth: Watchful waiting
  - T1 >4mm depth, T2-4: Electively treat neck
- Nodes outside lymphatic basin e.g. lateral cancer with contralateral nodes, then consider FNAC / nodal biopsy

Synchronous Primary (upper aerodigestive tract, lungs)

- History and office examination
- Panendocopy
- CXR / CT / PET

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6.8.7: 7. Imaging

Imaging is only required if it may change management

Distant pulmonary metastases / synchronous primary: CXR / CT chest

Radiation planned: Panorex to exclude dental disease or bone destruction

Imaging of Primary

- **T1-3 oral cancers**
  - Minority require imaging
  - Abuts mandible to decide re marginal / segmental / hemimandibulectomy
  - Trismus to rule out involvement of masticator space, PPS and ITF
- **T4 oral cancers**
  - Resectable?
  - Abuts mandible to decide re marginal / segmental / hemimandibulectomy
  - Type of bone reconstruction
    - Length of bone resection
    - Mandibular height
    - Will mandibulectomy cross midline?….excludes surgery if cannot reconstruct anterior mandible (Andy Gump deformity)
- **Type of imaging**
  - Soft tissue: CT / MRI
  - Bone: Panorex / CT scan / MRI
  - Perineural spread: MRI

C**ervical metastases**

- **N0 neck:** No need to image if elective neck dissection planned, unless concern re contralateral occult nodes with a midline cancer
- **N+ neck:** Image (U/S or CT) if concern about resectability

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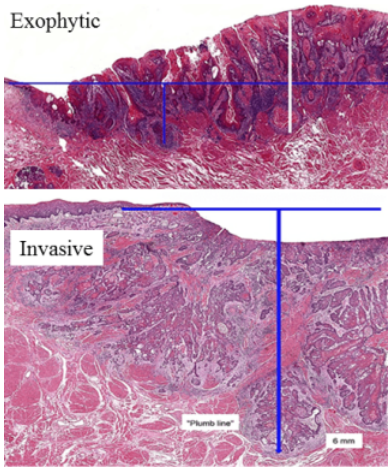
6.8.8: 8. TNM/AJCC Staging of Oral Cancer

TI	<2cm diameter, Depth of invasion (DOI) <5mm
T2	<2cm diameter & DOI >5 mm but <10mm 2-4cm diameter & DOI <10mm
T3	>4cm diameter Any tumour >10mm DOI PNI of large-calibre nerves (≥0.1 mm)
T4a T4a lip T4a oral	Moderately advanced local disease Invades adjacent structures: thru' cortical bone, inferior alveolar nerve, FOM, skin of face Invades adjacent structures: thru' cortical bone of mandible /maxilla / involves antrum of skin (superficial invasion of bone or socket by gingival primary not T4)
T4b	Very advanced local disease: tumour invades masticator space, pterygoid plates, or skull base and/or encases the internal carotid artery

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6.8.9: 9. Oral Cancer - Depth of Invasion

- Distance from adjacent normal basement membrane to deepest point of cancer (Blue *plumb* lines)
- Correlates with prognosis and occult nodal metastases
- Preoperative assessment
  - Palpation +/- imaging
  - Must distinguish exophytic from invasive cancers (see adjacent figures)
- T-stage increases with every 5mm
  - T1: Less invasive (≤5 mm)
  - T2: Moderate depth (>5 to ≤10mm)
  - T3: Deeply invasive (>10 mm)
- Extrinsic muscle infiltration no longer a staging criterion for T4 because
  - Superseded by DOI
  - Limited extrinsic muscle invasion difficult to assess



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6.8.10: 10. Treatment Modifications in Poorly Resourced Settings

Postoperative radiotherapy (PORT): when weighing up need with marginal indications, consider:

- Expense
- Morbidity e.g. 25% risk of hypothyroidism from radiating central neck
- Social support and likelihood to complete treatment
- Competing institutional needs for scarce radiation therapy

Platinum based adjuvant therapy: when weighing up need with marginal indications, consider:

- Patient's fitness
- Morbidity and mortality related to treatment
- Social support and likelihood to complete treatment
- Only 4% lifetime survival advantage by addition of chemotherapy to radiation therapy in an adjuvant setting

Unavailability of postoperative radiation therapy (PORT)

- Most patients with T3 and T4 malignancy normally receive PORT (Indications for PORT)
- Consider who **not** to offer surgery for advanced tumours when outcomes without PORT will be poor
- Not having PORT to treat residual microscopic cancer or nodal metastases has the following surgical implications:
- Wide tumour resection margins
- Low threshold to convert a selection neck dissection to modified neck dissection
- Palliative surgery can be recommended for very select patients

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6.8.11: 11. Indications for Neck Dissection with Oral Cancer

Clinically/radiologically N+ neck: Modified radical neck dissection (MND) / Radical neck dissection (RND)

Clinically/radiologically N0 neck

- >20% risk of occult nodes
  - T1 <4mm depth: Watchful waiting
  - T1 >4mm depth, T2-T4: Electively treat neck
- Elective SND Levels I – IV of ipsilateral neck
- Convert to MND if suspicious nodes in neck (+/- frozen section)
- Elective contralateral neck dissection for tumour approaching/crossing midline

D'Cruz AK, Vaish R, Kapre N et al. Elective versus Therapeutic Neck Dissection in Node-Negative Oral Cancer. 2015. *N Engl J Med*;373:521-9

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6.8.12: 12. Indications for Postoperative (Chemo)Radiation Therapy

Postoperative Radiotherapy

- **Should be commenced within 6 weeks of surgery**
- **Primary tumour bed**
  - T3/4
  - Perineural invasion: PNI of nerves > 0.1mm upstaged to pT3 (AJCC 8th Ed 2017)
  - Lymphovascular invasion
  - Positive margin / close margin
  - Intraoperative tumour spillage
  - Significant bone destruction
  - Bone marrow invasion
- **Neck**
  - ≥2 metastases
  - Extracapsular spread (ECS)

Postoperative chemoradiation

- Indications
  - Positive margins
  - ECS
- **Added expense and toxicity of chemoradiation**
  - Only 4% lifetime survival advantage by addition of chemotherapy to radiation therapy in an adjuvant setting
  - Therefore carefully consider indications especially in
    - Poor patient
    - Poor socioeconomic support
    - Poor general health
    - Aged

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6.9: Cancer of Oropharynx

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6.9.1: 1. AfHNS Clinical Practice Guidelines for Oropharyngeal Cancers in Developing Countries and Limited Resource Settings

Cancer of the Oropharynx

The AfHNS Clinical Practice Guidelines for Oropharyngeal Cancers in Developing Countries and Limited Resource Settings tailor management according to diagnostic and therapeutic resources available to physicians and to their patients.

International guidelines for oropharyngeal cancers assume availability of cytology, p16, ultrasound, CT, MRI, high levels of surgical expertise, CO2 laser or transoral robotic surgery (TORS), reconstructive surgery, frozen section, and (chemo)radiation therapy. In developing countries these interventions are frequently not available, and follow-up may be unreliable. Management is further complicated by inclusion of P16 status in the 8th Edition of *AJCC* and *UICC* staging, thus excluding patients from being staged when testing is unavailable or unaffordable.

Without resource appropriate guidelines for oropharyngeal cancers, both resident and volunteer surgeons from developed countries have little to guide them about best practice when working in resource limited settings. This might lead to inappropriate investigations, inappropriate treatment, and may compromise patients.

Methodology

The AfHNS convened a task force to enumerate resource appropriate guidelines for management of oropharyngeal cancers in poorly resourced settings. This collaboration between physicians from African and developed countries included members of the AfHNS and American colleagues. International guidelines were referenced and adapted for limited resources. Due to paucity of literature about management of oral cancers in low resource settings, much of the recommendations represents expert opinion.

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Johan Fagan and Julie Wetter (Co-chairs)

Index: Clinical Practice Guidelines for Oropharyngeal Cancer

Resource Appropriate Oropharyngeal Cancer Guideline Scenarios

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6.9.2: 2. Select Guideline According to Available Resource Scenarios

Select appropriate management guideline for Oropharyngeal Cancers according to limited resource scenario

Click on the scenario that reflects the diagnostic tools and therapy available to your patient. This will transfer you to a resource appropriate management pathway.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available Investigations & Treatment															
CT / MRI	X		X	X	X				X	X	X	X				
Neck dissection expertise	X	X		X	X		X	X			X		X			
Reconstruction expertise	X	X	X		X	X		X	X					X		
(Chemo)radiation	X	X	X	X		X	X			X					X	

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6.9.3: 3. Motivation and Methodology

Cancer of the Oropharynx

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6.9.4: 4. How to Use the Guidelines

How to use the AfHNS Clinical Practice Guidelines for Oropharyngeal Cancers in Developing Countries and Limited Resource Settings

Click on the scenario 1-16 of resources available to you and your patient, and you will be directed to clinical practice guidelines appropriate for your patient.

Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Available investigations and treatment															
CT/MRI	X		X	X	X				X	X	X	X				
Neck dissection expertise	X	X		X	X		X	X			X		X			
Reconstruction expertise	X	X	X		X	X		X	X					X		
(Chemo)radiation	X	X	X	X		X	X			X					X	

Adherence to these guidelines should be applied taking into account the local medical, surgical, and financial resources available to the individual patient, as well as the ability to access services at a better and more appropriately resourced center. When key resources are unavailable, the authors recommend referral to a center where optimal management is available.

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6.9.5: 5. Evaluation of Oropharyngeal Cancer- Key points

Evaluation of Oropharyngeal Cancer: Key points

- Squamous cell carcinoma (SCC) occurs most commonly
- Etiology includes smoking and HPV infection
- Histological diagnosis is essential, also to exclude malignancies like minor salivary cancers, melanoma, lymphoma, and inflammatory causes (e.g. TB)
- Surgery +/- (chemo)radiation, or primary chemoradiation offers the best chance of cure
- Objectives of preoperative evaluation
  - Confirm diagnosis
  - Staging
  - Patient evaluation: Fitness, objectives (cure vs palliation), ability to undergo surgery +/- (chemo)radiation, or primary (chemo)radiation, and ability to deal with the long-term consequences of treatment
  - Decide whether to offer curative or palliative treatment
  - Surgery
    - Plan appropriate surgery
    - Avoid inappropriate surgery
    - Avoid surgery beyond the scope of the surgeon
  - Primary chemoradiation
    - Ability to complete treatment
    - Ability to deal with long-term consequences of treatment

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6.9.6: 6. HPV-Related Oropharyngeal Cancer

HPV-related Oropharyngeal cancer

- HPV 16 & 18 are associated with oropharyngeal cancer
- Sexually transmitted
- Mostly non-smoking, healthy young adults, more common males
- P16 is a surrogate marker for HPV (sensitivity 100%, has false +ves)
- May present with a small primary and large, often cystic, cervical metastases
- HPV status has prognostic value
  - Different biological behaviour from tobacco-induced oropharyngeal cancer
  - Better prognosis, even with advanced-stage disease
  - Volume and extent of nodal metastases do not have same negative impact on outcome
  - HPV + patients with a significant smoking history probably have same prognosis as HPV –
  - Prognostic value of p16 status may not apply to suboptimally treated patients in resource constrained settings
- Affects staging
  - Different N-staging for HPV+ vs HPV-
  - Same T-staging for HPV+ and HPV-
  - Stage IV only assigned to patients with distant metastases
- HPV status does not influence choice of primary treatment at this time

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6.9.7: 7. Staging Oropharyngeal Cancers- P16-

TNM/AJCC Staging Classification of p16-ve Oropharyngeal Cancers (AJCC 8th ed. 2017)

- Staging differs for p16 - and p16 +
- T-staging is divided into p16 + and p16 -/p16 not done
- Accurate staging is not possible if p16 testing is not available/affordable ("Is AJCC/UICC Staging Still Appropriate for Head and Neck Cancers in Developing Countries?")
- Prognostic value of p16 status may not apply to suboptimally treated patients in resource constrained settings
- T4 is a single entity in p16 + cancers whereas it is divided into T4a and T4b in p16 - cancers

T1	≤2cm
T2	>2 and ≤4cm
T3	>4cm or extension to lingual surface of epiglottis
T4a	Moderately advanced local disease; invades larynx, extrinsic muscles of tongue, medial pterygoid, hard palate, or mandible. Mucosal extension to lingual surface of epiglottis from primary base of tongue cancer or vallecula does not constitute invasion of larynx
T4b	Invasion through lateral pterygoid, pterygoid plates, lateral nasopharynx, skull base or encases carotid artery

N0	No metastases
N1	Single ipsilateral <3cm, ENE -ve
N2a	Single ipsilateral >3cm, but < 6cm, ENE –ve
N2b	Multiple ipsilateral, <6cm, ENE –ve
N2c	Contralateral or bilateral <6cm, ENE –ve
N3a	>6cm, ENE -ve
N3b	Any node, clinically ENE +ve

	N0	**N1**	**N2a,b,c**	**N3a,b**
T1	I	III	IVA	IVB
T2	II	III	IVA	IVB
T3	III	III	IVA	IVB
T4a	IVA	IVA	IVA	IVB
T4b	IVB	IVB	IVB	IVB
Any M1 is stage IVC				

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6.9.8: 8. Staging Oropharyngeal Cancers- P16+

TNM/AJCC Staging Classification of p16+ve Oropharyngeal Cancers (AJCC 8th ed. 2017)

- Staging differs for p16 - and p16 +
- T-staging is divided into p16 + and p16 -/p16 not done
- Accurate staging is therefore not possible if p16 testing is not available/affordable ("Is AJCC/UICC Staging Still Appropriate for Head and Neck Cancers in Developing Countries?")
- Prognostic value of p16 status may not apply to suboptimally treated patients in resource constrained settings
- T4 is a single entity in p16 + cancers whereas it is divided into T4a and T4b in p16 - cancers

T1	≤2cm
T2	>2 and ≤4cm
T3	>4cm or extension to lingual surface of epiglottis
T4	Tumour of any size invading adjacent organ(s) e.g. larynx, extrinsic muscles of tongue, medial pterygoid, hard palate or mandible

N0	No metastases
N1	Single/multiple ipsilateral <6cm
N2	Contralateral or bilateral <6cm
N3	>6cm

	N0	**N1**	**N2**
T0	NA	I	II
T1	I	I	II
T2	I	I	II
T3	II	II	III
T4	II	II	III
Any M1 is stage IV			

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6.9.9: 9. Clinical Evaluation- History and Examination

Oropharyngeal Cancer: History & Exam

Objectives

- Select appropriate treatment
- Avoid unnecessary surgery
- Avoid surgery that is beyond the scope of the surgeon

Primary tumor

- Location and extent by visual inspection, palpation
- Mobility of tumor with swallowing and on palpation: if mobile it suggests that PPS is not involved
- Trismus
- Fixation to prevertebral fascia: Gently rock soft tissue of tonsil fossa medially and laterally using bimanual palpation with one finger intraorally and opposite hand extra-orally
- Function of lingual, inferior alveolar, mental and hypoglossal nerves
- Position of internal carotid artery (inspection and palpation)

Mandible

- If adherent, then assess for mandible invasion
- Check for dental caries if to receive radiation therapy

Neck

- Palpable nodes in Levels 1-3: assume metastases
- Nodes outside lymphatic basin e.g. lateral cancer with contralateral nodes: Consider FNAC / nodal biopsy

Distant metastasis: CXR / CT / PET

Synchronous Primary (upper aerodigestive tract, lungs)

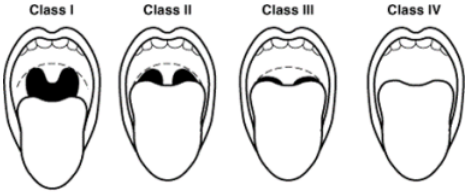
- History and office examination
- Panendocopy
- CXR / CT / PET

Functional impairment resulting from treatment

- Pharyngeal function is complex (Swallowing/speech/aspiration)
- Will soft palate resection cause significant nasal regurgitation and rhinolalia aperta?
- Can function be maintained with reconstruction with a flap?
- Will nonsurgical treatment ensure better swallowing and speech?

Access for transoral resection (incl. TORS)

- Mouth opening
- Trismus (possible medial pterygoid and/or infra-temporal involvement)
- Dentition
- Cervical spine extension
- Mallampati score



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6.9.10: 10. Imaging

Imaging for Oropharyngeal Cancer

Imaging only required if it may change management

Distant pulmonary metastases / synchronous primary: CXR / CT chest

If radiation planned

- Panorex to exclude dental disease or bone destruction
- Imaging (CT/ MRI) to plan radiation

Imaging of Primary

- **T1:** Rarely require imaging
- **T2:** Consider CT scan prior to transoral resection to determine position of carotid artery
- **T3**
  - Trismus: Rule out involvement of masticator space, PPS and ITF (CT scan)
  - If abuts mandible to decide about marginal / segmental / hemimandibulectomy (CT / Panorex)
- **Choice of imaging**
  - Soft tissue: CT / MRI
  - Bone: Panorex / CT scan / MRI
  - Perineural spread: MRI

Cervical metastases

- **N0 neck:** No need to image if elective neck dissection planned, unless concern about occult contralateral (base of tongue, soft palate) or retropharyngeal nodes
- **N+ neck:** Image (U/S or CT) if concern about resectability

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6.9.11: 11. Optimal Therapeutic Approach Not Easily Defined

Oropharyngeal cancer: Optimal therapeutic approach not easily defined

- No valid comparative studies
  - Surgery +/- postoperative (chemo)radiation
  - Primary chemoradiation
- No single therapeutic regimen offers clear-cut, superior survival advantage
- Optimal approach aims for
  - Single modality treatment for early tumors
  - Minimum treatment morbidity and mortality
  - Optimal functional outcome (swallowing, speech)
  - Cost-efficiency
- Therapeutic choice therefore requires
  - Careful review of each case
    - Staging
    - General physical condition
    - Emotional reserves
    - Social and financial support
    - Likelihood of regular follow-up
  - Availability of supportive care (including nutrition), speech and swallowing rehabilitation and salvage treatment
  - Experience of treating team

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6.9.12: 12. Indications for Neck Dissection or Irradiation

Oropharyngeal cancer: Indications for treatment of Neck

- **Neck can be treated surgically or with primary CRT**
- **Clinically/radiologically N0 neck**
  - Electively treat neck for all T-stages (other than very early/superficial lesions)
  - Tonsil, lateral oropharynx: Ipsilateral elective RT / SND Levels II – IV
  - Base of tongue, posterior oropharynx wall, soft palate: Bilateral elective RT / SND Levels II – IV
  - Convert to MND if suspicious nodes in neck at time of surgery (+/- frozen section)
- **Clinically/radiologically N+ neck:** CRT / Modified neck dissection (MND) / Radical neck dissection (RND)
- **Salvage neck dissection following primary CRT**
  - Planned neck dissection or for incomplete response (clinically/CT/MRI/PET) at 6 -12 weeks
  - Recurrence

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6.9.13: 13. Indications for Postoperative (chemo)radiation Therapy

Oropharyngeal cancer: Indications for postoperative (chemo)radiation therapy

Postoperative Radiotherapy

- ***Ideally* commenced within 6 weeks of surgery**
- **Primary tumour bed**
  - T3/4
  - Perineural invasion (PNI)
  - Positive / close margin
  - Intra-operative tumour spillage
  - Bone marrow invasion
  - Note: Lymphovascular invasion is more an indication of risk for spread to nodes rather than for recurrence and so it is not an indication on its own for adjuvant RT
- **Neck**
  - ≥2 metastatic nodes
  - Extranodal extension (ENE)

Postoperative Chemoradiation

Indications

- Positive margins
- ENE

Added expense and toxicity

- Only 5% lifetime survival advantage with addition of chemotherapy to radiation therapy in an adjuvant setting
- Therefore carefully consider indications especially in
  - Poor patient
  - Poor socioeconomic support
  - Poor general health
  - Elderly

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6.9.14: 14. Administration of Chemoradiation Therapy

Oropharyngeal cancer: Administration of Chemoradiation

Radiotherapy (RT)

- The most important part of the treatment
- 66 to 70 Gy to tumour bed and metastatic nodal disease over 6 to 7 weeks

Chemotherapy given with radiation

- Acts as a radiosensitizer *i.e.* increases radiation-induced DNA damage
- Increases radiation dose effect by 7-8 Gy
- When chemotherapy is added to RT to treat OPC, there is an overall *survival* benefit of 5.3% at 5 years
- Addition of chemotherapy gives an *absolute benefit* of 4.5% at 5 years
- Addition of chemotherapy increases acute side-effects of RT – as well as adding unique toxicities
- Addition of chemotherapy should not compromise ability of patient to complete RT
- **"Gold standard":** Single-agent, high-dose Cisplatin 3 weekly x 3 cycles *
- **Alternative regimens ***
  - Single-agent, high-dose Carboplatin 3 weekly x 3
  - Single-agent, low-dose Cisplatin / Carboplatin weekly x 6
  - Carboplatin & Paclitaxel 3 weekly x 3
  - Cetuximab
  - Hydroxyurea

Patients should be carefully selected for this treatment

- Performance status 0 to 1, and at least fair nutrition
- Normal / near-normal hearing especially if Cisplatin used
- Normal renal function
- Availability of supportive care: patients often need iv fluids / admission / feeding tubes / transfusions / antibiotics
- Careful monitoring throughout as well after treatment to ensure patients regain pre-treatment weight, swallowing function etc.
  - Performance status 0 to 1, and at least fair nutrition
  - Normal / near-normal hearing especially if Cisplatin used
  - Normal renal function
  - Availability of supportive care: patients often need iv fluids / admission / feeding tubes / transfusions / antibiotics
  - Careful monitoring throughout as well after treatment to ensure patients regain pre-treatment weight, swallowing function etc

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6.9.15: 15. Treatment Modifications in Poorly Resourced Settings

Oropharyngeal cancer: Treatment modifications in poorly resourced settings

Inability to stage cancers due to unavailability P16 testing: "Is AJCC/UICC Staging Still Appropriate for Head and Neck Cancers in Developing Countries?"

Postoperative radiotherapy (PORT): when weighing up need with marginal indications, consider:

- Expense
- Morbidity e.g. 25% risk of hypothyroidism from radiating central neck
- Social support and likelihood of completing treatment
- Competing institutional needs for radiation therapy or for operating time

Platinum-based adjuvant chemotherapy: when weighing up need with marginal indications, consider:

- Patient's fitness
- Morbidity and mortality related to treatment
- Social support and likelihood of completing treatment
- Only 4% lifetime survival advantage with addition of chemotherapy to radiation therapy in an adjuvant setting

Unavailability of postoperative radiation therapy (PORT)

- Most patients with T3/T4 malignancies normally receive PORT (Indications for PORT)
- Consider who **not** to offer *surgery* for advanced tumors when outcomes without PORT will be poor
- Not having PORT to treat residual microscopic cancer or nodal metastases has the following surgical implications:
- Wider than usual tumour resection margins
- Low threshold to convert a selective neck dissection to modified neck dissection

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OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan & Wayne Koch

In developed countries, early (T1/2) tonsil cancers are commonly resected by lateral oropharyngectomy (radical tonsillectomy) employing transoral CO_2 laser microsurgery or transoral robotic surgery (TORS) techniques. Yet most surgeons in the world do not have access to CO_2 laser or TORS. In such centers early tonsil cancers are often resected by simple tonsillectomy. However, dissecting along the tonsillar capsule and not including the pharyngeal constrictors as the deep margin often results in close or involved deep margins necessitating adjuvant (chemo)radiation.

Because cancers of the tonsil are in a direct line-of-sight for the surgeon when using a simple tonsillectomy gag, there is little reason why the surgical principles that apply to lateral oropharyngectomy by transoral CO_2 laser or TORS techniques should not be employed to lateral oropharyngectomy performed with headlight/diathermy, or microscope/diathermy, or loupes/headlight/diathermy techniques to secure adequate resection margins.

Regardless of the surgical tools being used, lateral oropharyngectomy requires a detailed understanding of the “inside-out” 3D anatomy of the oropharynx, and of the parapharyngeal (PPS) and retropharyngeal spaces. Without such an understanding one is less likely to achieve adequate resection margins and more likely to encounter bleeding, nerve damage and injury to the internal carotid artery.

This chapter details the surgical anatomy of the oropharynx, PPS and retropharyngeal spaces, and discusses principles and techniques relating to transoral resection of tonsil cancers regardless of the surgical tools being used.

Surgical anatomy

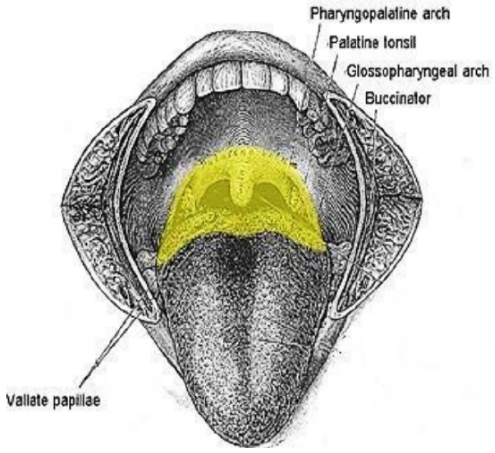


Figure 1a: Oropharynx

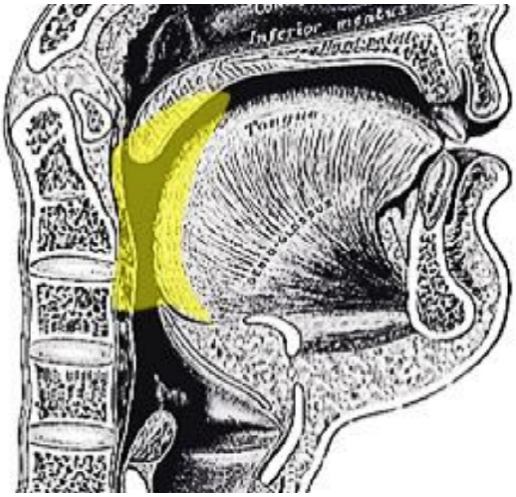


Figure 1b: Oropharynx

The oropharynx encompasses the base of tongue, tonsils, soft palate, and lateral and posterior walls of the pharynx between the levels of the hard palate and hyoid bone (*Figures 1a, b*).

Ligaments and fasciae	Pterygomandibular raphe Buccopharyngeal fascia
Muscles	Buccinator Superior constrictor Middle constrictor Medial pterygoid Stylopharyngeus Muscles of soft palate
Nerves	Lingual Glossopharyngeal (IX)
Arteries	Internal carotid Dorsalis linguae Ascending pharyngeal Tonsillar and ascending palatine branches of facial artery Descending palatine
Spaces	Prestyloid PPS Poststyloid PPS Retropharyngeal space

Table 1: Key anatomy for lateral oropharyngectomy

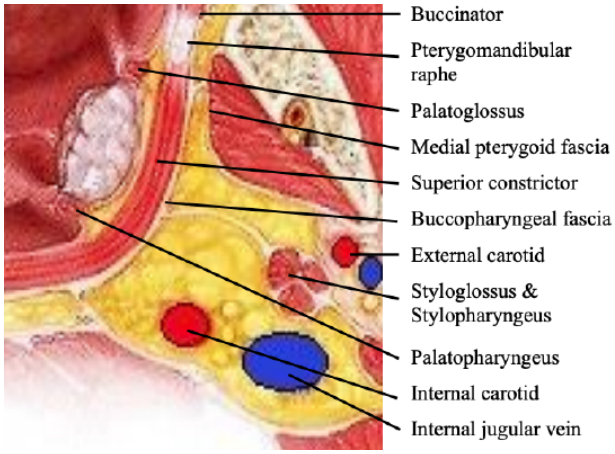


Figure 2: Key anatomical structures for lateral oropharyngectomy at level of tonsil; yellow tissue is parapharyngeal fat

Key anatomical structures relevant to lateral oropharyngectomy are listed in *Table 1* and illustrated in *Figure 2*.

Base of tongue (BOT)

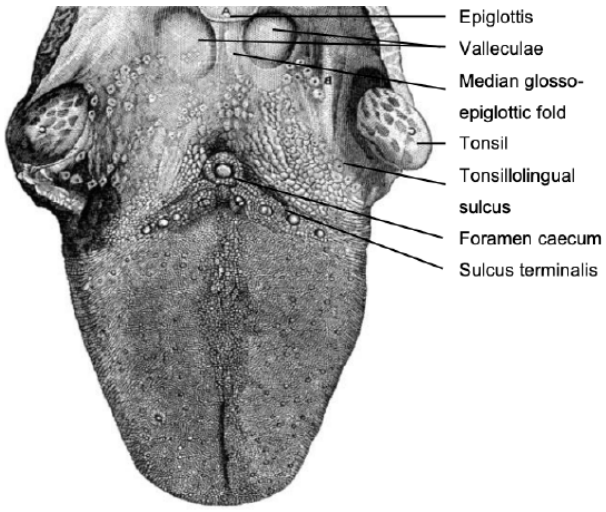


Figure 3: Topography of BOT

This comprises the posterior 1/3 of the tongue behind the ***foramen caecum*** and ***sulcus terminalis*** (*Figure 3*). The mucosa is rough, thick and fixed to the underlying muscle and contains lymphoid follicles (lingual tonsil); this makes it difficult to identify the edges of a BOT tumor; hence frozen section is especially useful to assess resection margins. Posterolaterally the ***tonsillolingual sulci*** separate the tongue from the tonsillar fossae. The ***valleculae*** separate the BOT from the lingual surface of the epiglottis and are separated in the midline by the median glossoepiglottic fold (*Figure 3*).

Soft palate

Soft palate	Tensor veli palatini	V_3
	Levator veli palatini	X
	Palatoglossus	X
	Palatopharyngeus	X
	Musculus uvulae	X
Lateral pharyngeal wall	Salpingopharyngeus	X
	Superior constrictor	X
	Middle constrictor	X
	Stylopharyngeus	IX

Table 2: Muscles of soft palate and oropharynx and cranial nerves which innervate them

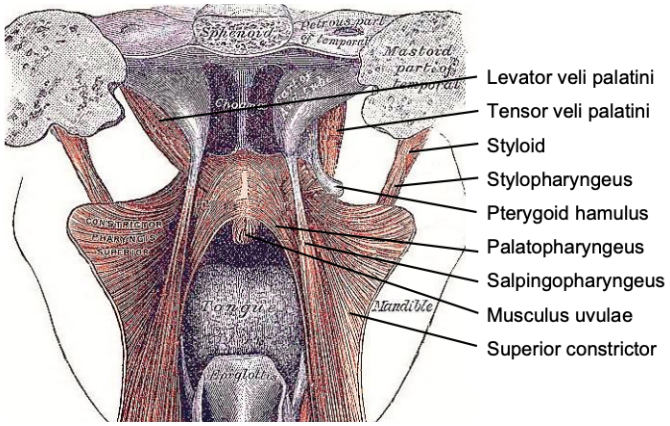


Figure 4: Posterior view of soft palate and pharynx with superior constrictor splayed open

The soft palate has a complex muscular structure and innervation. It has key functions relating to speech and swallowing. Resection and inadequate reconstruction of the palate results in loss of nasal separation which manifests clinically as nasal regurgitation of fluids and food, and hypernasal speech which can be quite disabling. The complex muscular anatomy of the soft palate and lateral pharyngeal wall is illustrated in *Figure 4*. Muscles that contribute to the soft palate and lateral pharyngeal wall are summarized in *Table 2*.

Lateral and posterior pharyngeal walls

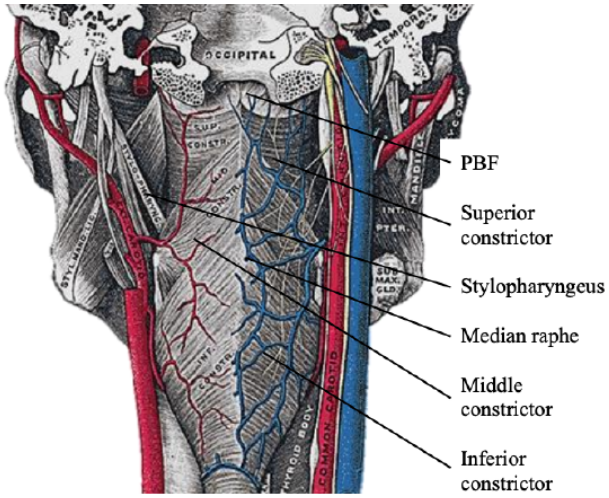


Figure 5: Posterior view of pharynx illustrates attachment of the superior constrictor to pharyngobasilar fascia (PBF) above and the median raphe to which pharyngeal constrictors attach; note close anatomical relationships of internal and external carotid artery systems to pharynx

Lateral oropharyngectomy involves dissecting along the outer aspect of the pharyngeal constrictors. The oropharynx has several layers i.e. mucosa, submucosa, muscle and ***buccopharyngeal fascia***. The submucosa is represented by the ***pharyngobasilar fascia*** that lines the inner aspect of the constrictor muscles. It thins as it extends inferiorly from its attachment to the skull base and bridges the gaps between the skull base and the superior constrictor, the superior and middle constrictors, and the middle and inferior constrictors (*Figure 5*). Posteriorly it forms a ***median raphe*** to which the pharyngeal constrictors attach (*Figure 5*).

The ***buccopharyngeal fascia*** invests the pharyngeal constrictor muscles and is continued forward from the superior constrictor over the buccinator (*Figure 2*). It is loosely attached to the prevertebral layer by connective tissue, with the retropharyngeal space between them.

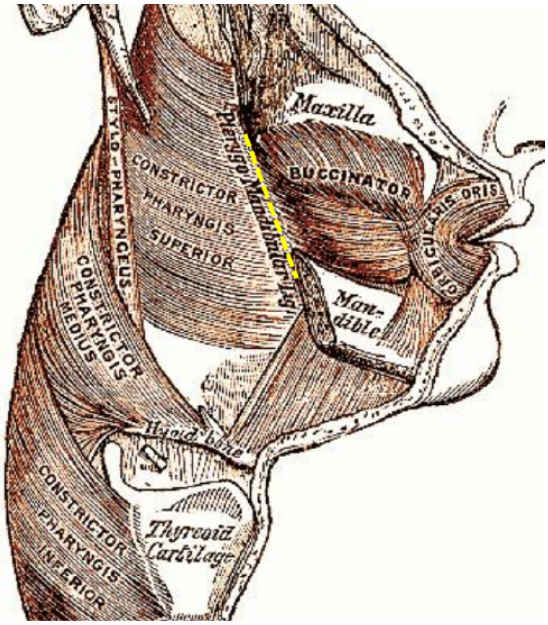


Figure 6: Note how buccinator and superior constrictor muscles attach to the pterygomandibular raphe (yellow line)

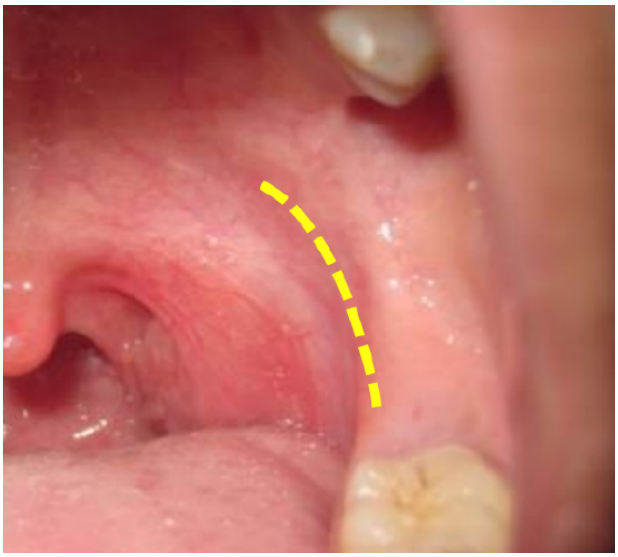


Figure 7: Pterygomandibular fold represents the surface marking of pterygomandibular raphe

The ***pterygomandibular raphé/ligament*** is a ***tendinous band of buccopharyngeal fascia*** and is a key structure to identify initially in lateral oropharyngectomy to gain access to the correct lateral dissection plane. It is attached at one end to the hamulus of the medial pterygoid plate, and at the other end to the posterior end of the mylohyoid line of the mandible (*Figures 6, 7*).

It is interposed between the buccinator muscle which is attached to its anterior edge, and the superior constrictor muscle which is attached to its posterior edge (*Figures 2, 6*). Medially it is covered only by buccal mucosa. Laterally it is separated from the ramus of the mandible and medial pterygoid muscle and fascia by adipose tissue (*Figure 2*). The pterygomandibular fold represents the surface marking of the pterygomandibular raphe (*Figure 7*).

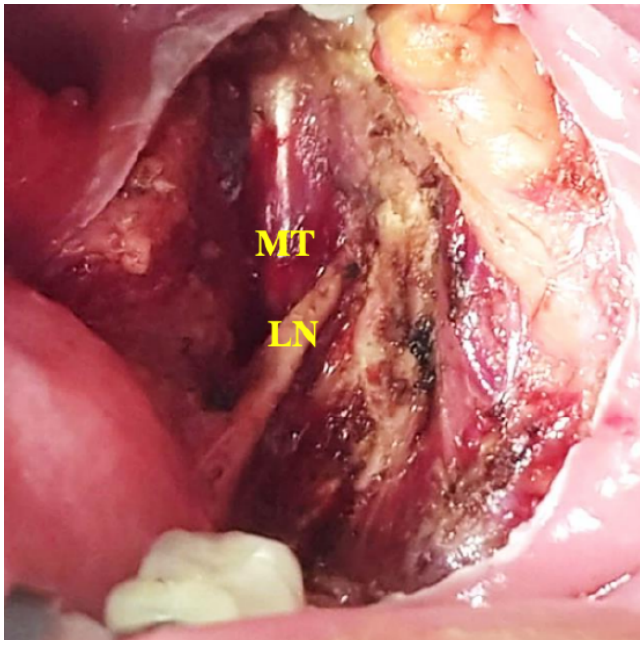


Figure 8: The lingual nerve (LN) courses lateral to the medial pterygoid muscle (MT)

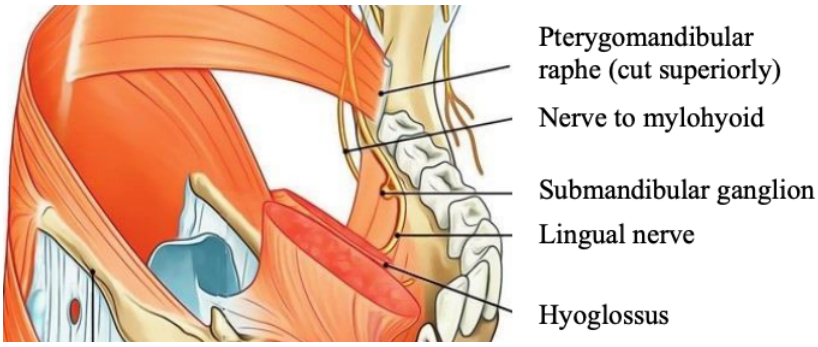


Figure 9: Lingual nerve emerging between lower attachment of raphe to the mandible and the mylohyoid muscle

The ***lingual nerve*** emerges anteriorly between the medial pterygoid and the vertical ramus of the mandible (*Figure 8*). It is therefore protected by the medial pterygoid muscle during lateral oropharyngectomy. However, it is vulnerable to injury when dissecting inferiorly where it courses above the mylohyoid muscle (*Figure 9*).

The ***buccinator muscle*** is transected during lateral oropharyngectomy just anterior to the pterygomandibular raphe. It is a thin, quadrilateral muscle in the cheek, and originates from the outer surfaces of the alveolar processes of the maxilla and mandible. Posteriorly it attaches along the length of the pterygomandibular raphe (*Figures 2, 6*).

Medially, it is covered by submucosa and mucosa of the cheek. Laterally it is related to the ramus of the mandible, the masseter and medial pterygoid muscles, the buccal fat pad and the buccopharyngeal fascia.

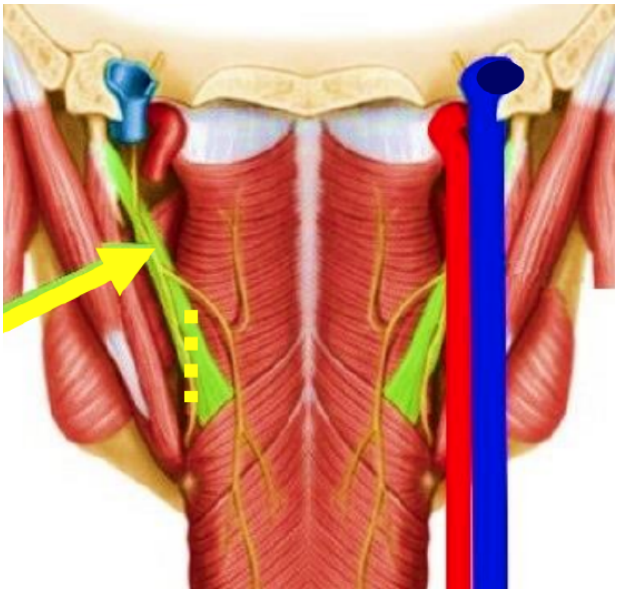


Figure 10: Relationships of stylopharyngeus muscle (green) and internal carotid artery and internal jugular vein. Yellow arrow points to IX nerve. Yellow broken line indicates division of stylopharyngeus muscle during lateral oropharyngectomy

The ***superior*** and ***middle constrictor muscles*** form the lateral and posterior walls of the oropharynx (*Figures 4, 5, 6, 9, 10*), with lesser contributions from the ***salpingopharyngeus*** (*Figure 4*), ***stylopharyngeus*** (*Figures 4, 5, 6, 10*) and ***palatopharyngeus*** (*Figure 4*) muscles.

The ***stylopharyngeus*** arises from the medial side of the base of the styloid process, passes downward through the fat of the PPS along the side of the pharynx, then between the superior and middle constrictors, and fans out beneath the mucosa (*Figures 2, 5, 6, 10*). The glossopharyngeal (IX) nerve innervates the stylopharyngeus. It runs on the lateral side of the muscle and crosses over it to reach the base of the tongue (*Figure 10*).

The deep dissection plane during lateral oropharyngectomy is between the buccopharyngeal fascia/fat of the prestyloid, retrostyloid and retropharyngeal spaces, and the constrictors. Because the stylopharyngeus crosses the PPS to join the pharynx, it must be transected to enable the surgeon to follow the plane along the constrictors towards the retropharynx (*Figures 2, 10*).

The muscles of the ***soft palate*** are not individually dissected and identified but are simply transected with the primary tumor.

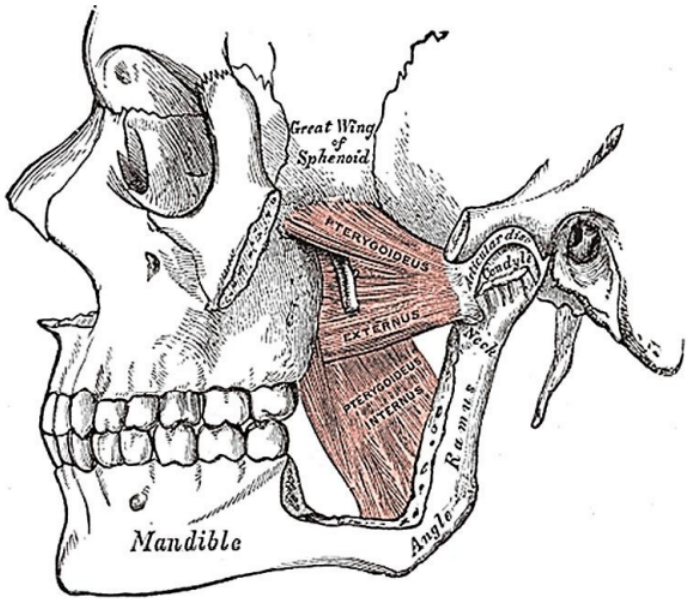


Figure 11: Medial and lateral pterygoids

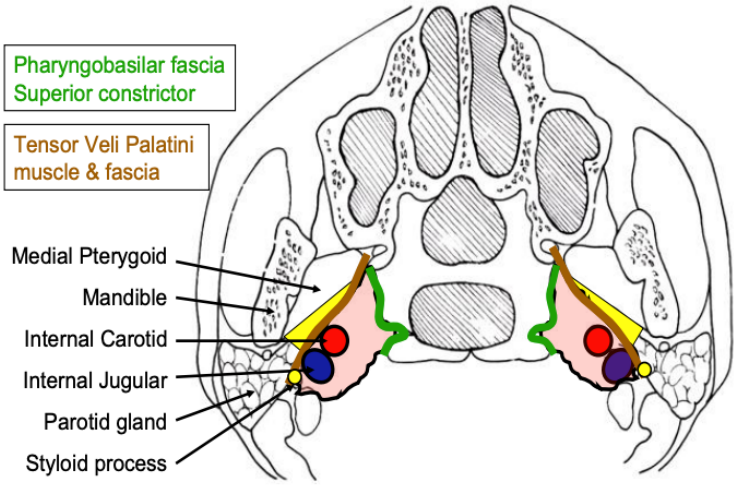


Figure 12: Axial view of prestyloid (yellow) and poststyloid (pink) PPS

The ***medial pterygoid*** (*Figures 2, 8, 11, 12*) constitutes the anterolateral border of the prestyloid PPS and is exposed early in the dissection. It has two heads: the larger deep head arises from just above the medial surface of the lateral pterygoid plate; the smaller superficial head arises from the maxillary tuberosity and the pyramidal process of the palatine bone (*Figure 11*). The muscle passes inferolaterally to insert onto the inferomedial surface of the ramus and angle of the mandible.

Parapharyngeal space (PPS)

The pharyngeal constrictor muscles form the medial border of the PPS, and the dissection therefore proceeds alongside, or within the fat of the PPS (*Figures 12, 13*). Therefore, the surgeon must be familiar with the anatomy of the PPS to anticipate the location of blood vessels, the stylopharyngeus muscle and the ICA.

The PPS extends as an inverted pyramid from the base of the skull superiorly, to the hyoid bone inferiorly. *Figures 2 and 12* illustrate axial views of the prestyloid and poststyloid components of the PPS, separated by the styloid process, tensor veli palatini muscle and its fascia (brown). The prestyloid PPS is bordered anterolaterally by the medial pterygoid muscle, and posterolaterally by the deep lobe of the parotid gland (*Figures 2, 12*) and contains mainly fat. It is traversed by the arteries and veins supplying the pharynx and tonsil. The poststyloid PPS is confined medially by the pharyngobasilar fascia above, and the superior and middle constrictor muscles of the pharynx and contains the internal carotid artery and the internal jugular vein, as well as lower cranial nerves IX -XII, and the sympathetic trunk.

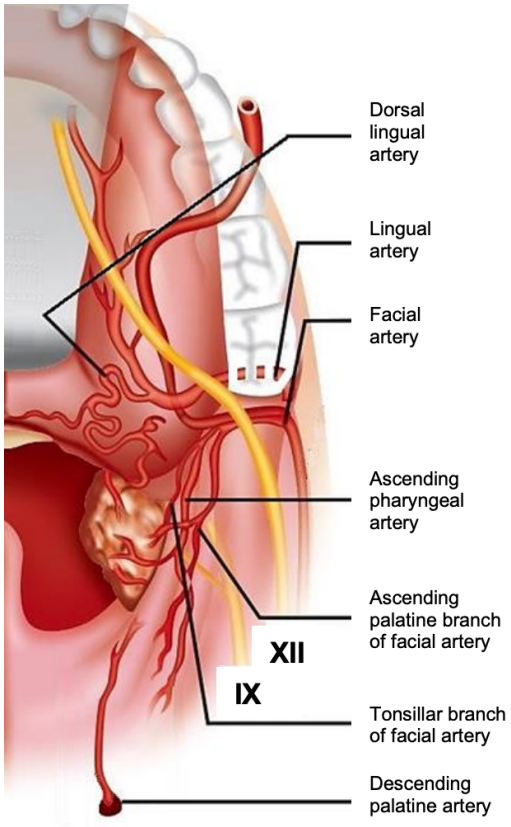


Figure 13: Arterial supply of tonsil and lateral oropharyngeal wall

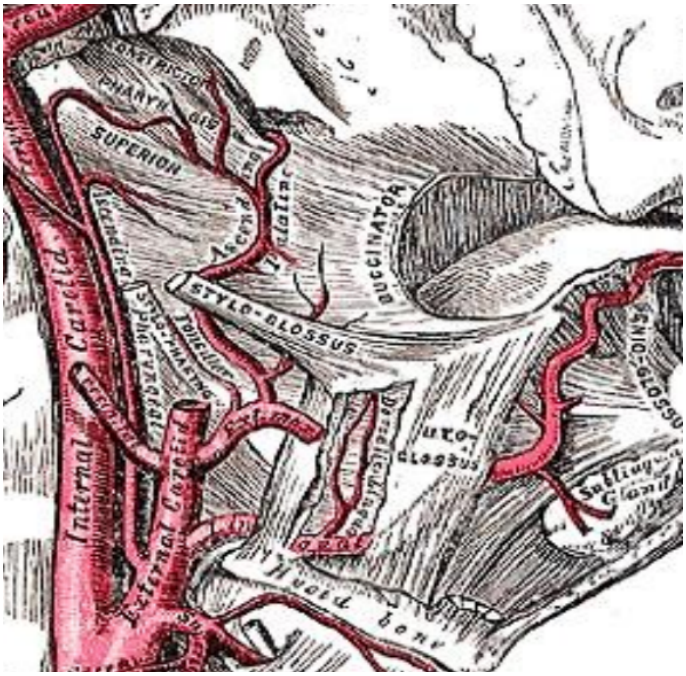


Figure 14: The ascending pharyngeal and ascending palatine and tonsillar branches of the facial (external maxillary) artery lie on the pharyngeal constrictor in the PPS

Knowledge of the vascular anatomy enables the surgeon to anticipate where arteries will be encountered and to minimize blood loss. Depending on the surgical procedure, vessels that may be encountered include the ***tonsillar and ascending palatine branches of the facial artery*** that arise in Level 1 of the neck, and the ***ascending pharyngeal artery***, a branch of the external carotid artery (*Figure 13*). If the dissection includes BOT, the ***dorsalis linguae branches of the lingual artery*** may be encountered (*Figures 13,*

14). If the dissection is extended superiorly, the ***descending palatine artery*** may be encountered at the junction of the soft and hard palates (*Figure 13*).

Venous drainage is via the ***pharyngeal venous plexus*** to the internal jugular vein (*Figure 5*). The ***internal jugular vein*** is located posterolateral to the carotid and is hence not a concern (*Figures 2, 5, 10*).

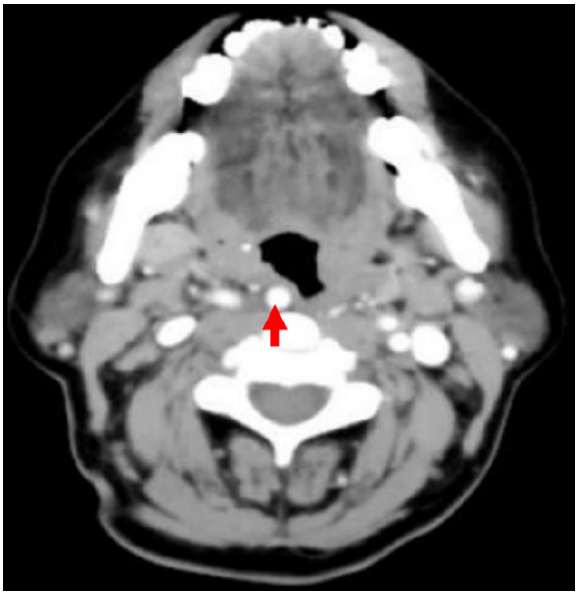


Figure 15: Retropharyngeal internal carotid artery

The ***internal carotid artery*** is generally not exposed, although pulsations of the vessel through the surrounding fat should be looked out for. Dividing the stylopharyngeus muscle gives direct access to the poststyloid PPS and artery (*Figures 2, 5, 10, 14*). The artery is normally located about 20-30 mm posterolateral to the outer aspect of the constrictors but may be ectatic (*Figure 15*) in up to 40% of the cases. A retropharyngeal ICA must be recognized preoperatively and protected and may be a relative contraindication to transoral resection.

Glossopharyngeal nerve (IXn)

Somatic sensory	Tonsils, base of tongue, pharynx, middle ear
Visceral sensory	Carotid bodies Carotid sinus
Parasympathetic fibres	Parotid gland via otic ganglion
Motor fibres	Stylopharyngeus muscle

Table 3: IXn functions

Figures 10 and 13 show the course of the XIn in the PPS. The main trunk of the nerve curves anteromedially around the lateral border of stylopharyngeus and courses between the superior and medial pharyngeal constrictors. Of the functions of the IXn listed in *Table 3*, injury to the nerve during lateral oropharyngectomy would only affect taste and sensation to the base of tongue.

Lateral Oropharyngectomy

Lateral oropharyngectomy for cancer of the tonsil and lateral pharyngeal wall may be performed with a headlight and monopolar electrocautery, operating microscope and electrocautery, transoral CO_2 laser microsurgery or TORS. The latter two techniques provide superior visual detail of tissue planes, tumor margins, vasculature and nerves. The description of the surgical steps that follow apply equally to all these techniques.

Indications

- Tumors of the lateral pharyngeal wall and tonsil that can be resected transorally with clear margins
- The ideal tumor is a T1/2 tonsil cancer in which the constrictor muscles have not been invaded

Contraindications [1]

General

- Poor transoral surgical access
- Coagulopathy
- Cervical spine pathology
- Poor fitness for surgery

Oncologic

- Cancer invading beyond pharyngeal constrictors to involve tissues and structures in PPS, medial pterygoid muscle, mandible or maxilla (requires combined transoral and transcervical approaches)
- Clinical evidence of perineural extension along major nerves e.g. lingual / V3
- Posterolateral fixation of cancer to prevertebral fascia
- Substantial extension into tongue base beyond unaided transoral exposed view

Vascular

- Retropharyngeal carotid artery
- Cancer adjacent to ICA or carotid bulb which will result in exposure of vessel
- Tumor encasement of carotid artery

Functional

- Resection of >50% deep tongue base
- Resection of >50% of posterior pharyngeal wall
- Resection of up to 50% of tongue base as well as entire epiglottis
- Resection of soft palate causing debilitating velopharyngeal insufficiency

Clinical evaluation

- Location and extent of primary tumor determined by visual inspection, palpation (and ultrasound2 evaluation)
- Mobility of tumor with swallowing and on palpation: if mobile it suggests that the PPS is not involved
- Fixation to prevertebral fascia: assessed by gently rocking soft tissue of tonsil fossa medially and laterally using bimanual palpation with one finger intraorally and opposite hand extraorally
- Function of lingual, inferior alveolar, mental, and hypoglossal nerves
- Position of ICA (inspection and palpation)
- Cervical and distant metastasis
- Synchronous primaries

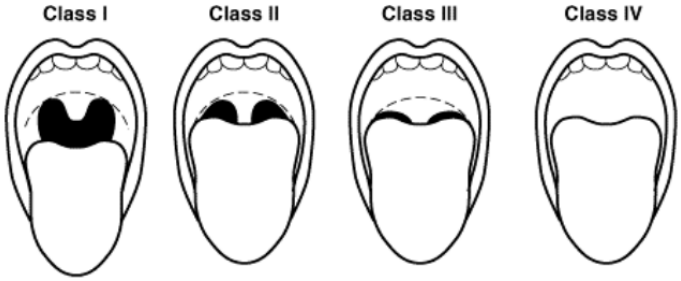
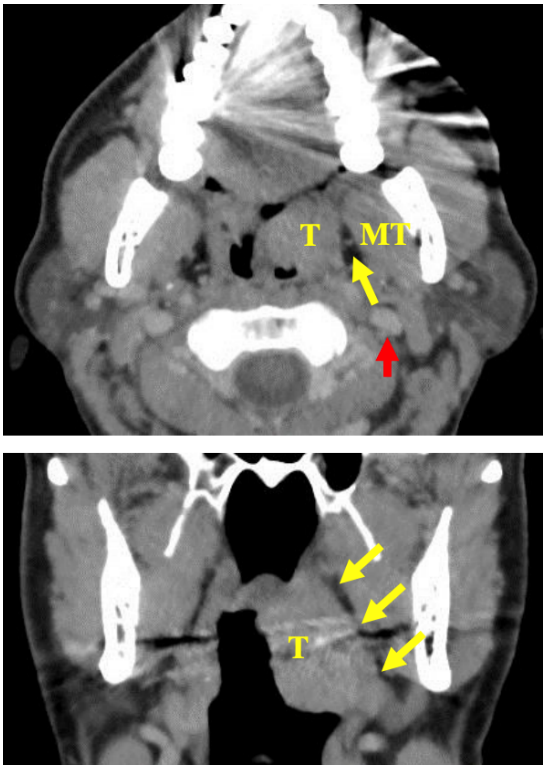


Figure 16: Mallampati scoring system

- Access
  - Mouth opening
  - Trismus (possible medial pterygoid and infratemporal involvement)
  - Dentition
  - Cervical spine extension
  - Mallampati score (*Figure 16*)



Figures 17ab: Axial and coronal CTs illustrate PPS fat (yellow arrows) separating tumor (T) from medial pterygoid muscle (MT), and the position of internal carotid artery (red arrow)

- Primary tumor
  - CT / MRI / US2 (*Figures 17ab*)
  - Not always required
  - Mainly for advanced tumors if concern about extension to PPS and adjacent structures
  - To determine position of internal carotid artery with larger resections
- Neck
- Chest

Informed consent

- Trauma
  - Dental
  - Lips, soft tissue
  - Traction injury of lingual and hypoglossal nerves due to prolonged tongue depression
- Failure to complete transoral resection
- Possible conversion to combined transcervical approach
- Flaps
  - Oropharynx defect
  - Cervical communication
- Neck dissection
- Tracheostomy
- Postoperative
  - Feeding
  - Analgesia
  - Primary or secondary hemorrhage
  - Healing time
  - Anticipated functional outcomes

Anesthesia

- General anesthesia
- Orotracheal or nasotracheal intubation
- Nasogastric feeding tube contralateral to tumor (not always)
- Perioperative antibiotics if combined neck dissection

Surgical instrumentation (minimum)

The minimum instruments required for transoral lateral oropharyngectomy using a headlight +/- loupes include the following:

- Tonsillectomy instrument set



Figure 18: Dingman retractor

- Tonsil / Dingman retractor (*Figure 18*)
- Lindholm or other broad laryngoscope for reaching inferior extension, lateral wall or tongue base



Figure 19: Long-tipped insulated blade extension for monopolar cautery

- Standard or extended length monopolar electrocautery with insulated blade (for blunt dissection in PPS) (*Figure 19*)
- Bipolar long-tipped insulated electrocautery

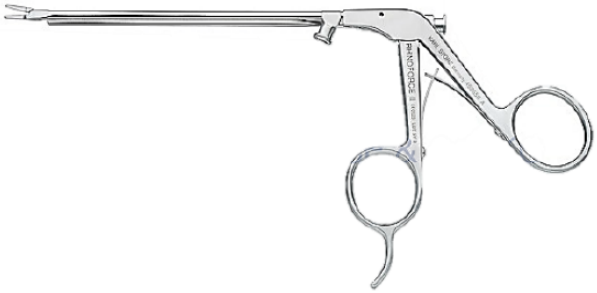


Figure 20: Liga clip applicator

- Liga clip applicator and clips, as used for transoral laryngeal microsurgery (*Figure 20*)

Surgical steps

- Perform panendoscopy to exclude synchronous tumors
- Inspect and palpate the tumor to determine mobility and extent
- Palpate tumor to ascertain extension to tongue base, fullness to superolateral aspect of pterygomandibular fold, soft palate, mobility with respect to pterygomandibular ligament
- Insert Dingman or tonsil retractor and place in suspension

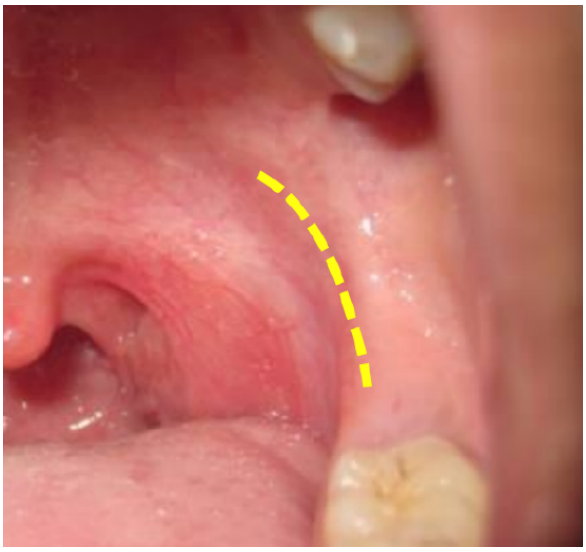


Figure 21: Pterygomandibular fold represents the surface marking of pterygomandibular raphe

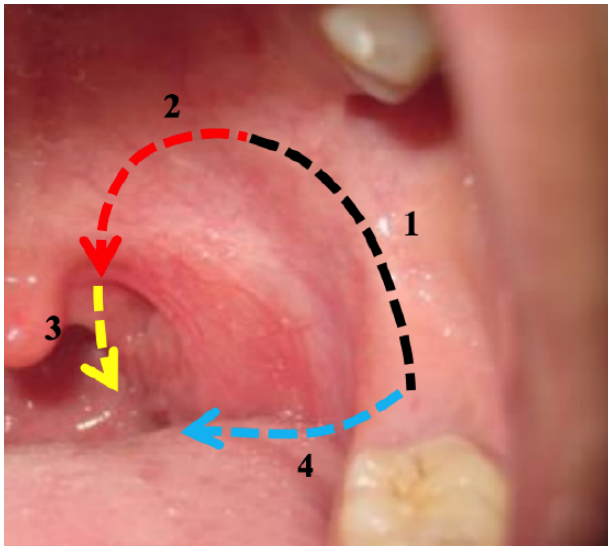


Figure 22: Typical sequence of incisions

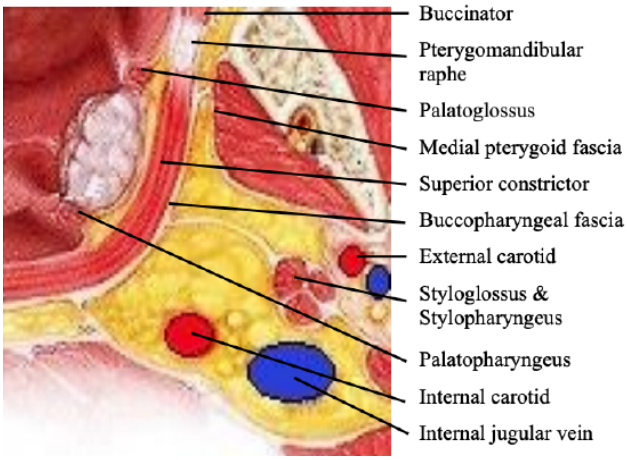
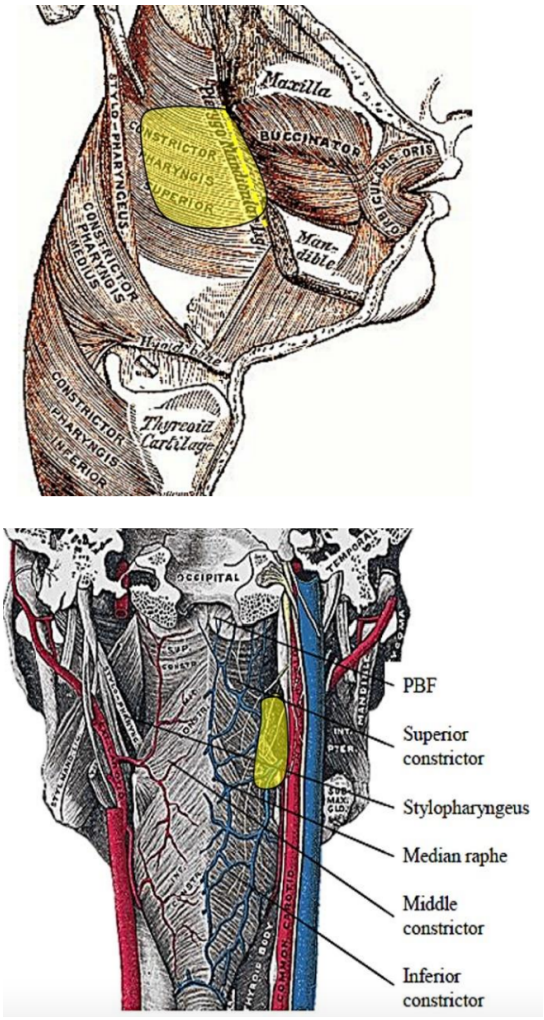




Figure 23: Key anatomical structures for lateral oropharyngectomy and typical dissection lines and planes for lateral oropharyngectomy

- Identify the pterygomandibular fold; it can be located by palpation (*Figure 21*)
- Incise the oral mucosa over the pterygomandibular fold to expose the pterygomandibular raphe; it is a key anatomical landmark to establish the correct lateral dissection plane (*Figure 22*)
- Transect the buccinator muscle along its attachment to the pterygomandibular raphe (*Figures 22, 23*)
- Identify the fascia overlying medial pterygoid muscle (*Figure 23*)
- Dissect posteriorly along the medial pterygoid fascia while retracting the tumor and tonsil medially
- If possible, preserve the buccopharyngeal fascia to seal the oropharynx from structures in the PPS
- Free the superior pole of the specimen by incising through the pterygomandibular raphe, and soft palate mucosa and muscles (*Figure 22*)
- Free the tumor posteriorly by extending this incision inferiorly through the palatopharyngeus muscle (posterior tonsillar pillar) and pharyngeal mucosa and superior pharyngeal constrictor; this prevents the surgeon excising the posterolateral pharyngeal wall too far medially during the final steps of resection (*Figures 20, 21*)
- Free the tumor inferiorly by cutting below the tumor, including the tonsillolingual sulcus and lingual tonsil if required (*Figures 22, 23*)
- Continue the lateral dissection, taking care to remain medially in the dissection plane on the superior pharyngeal constrictor, palatoglossus, and palatopharyngeus muscles, using blunt dissection with the blade of the cautery
- Multiple branches of the facial, lingual and ascending pharyngeal arteries are seen to enter the specimen and are clipped, cauterized or tied and divided
- The facial or lingual arteries may have to be clipped or tied
- Identify the oblique-running styloglossus and vertically running stylopharyngeus muscles inferiorly in the surgical field
- The IX nerve may be seen coursing anterolaterally between these muscles (*Figures 10, 13*)
- The styloglossus and stylopharyngeus muscles obscure the internal carotid artery from the surgeon superiorly in the field (*Figure 10*). Transmitted pulsations, also from the external carotid artery, can be observed through the muscles, parapharyngeal fat and buccopharyngeal fascia
- Dissect bluntly when freeing the styloglossus and stylopharyngeus muscles inferiorly to avoid injury to the lingual artery
- Transect the styloglossus and stylopharyngeus muscles inferiorly as they course between the superior and middle pharyngeal constrictors



Figures 24 a,b: Typical resection (yellow)

- Release the specimen with final inferior cuts at the tonsillolingual sulcus and medial cuts through the superior pharyngeal constrictor (*Figures 24 a,b*)
- Carefully orientate and mark the specimen for the pathologist before removing it from the mouth
- If concern remains about inferior extension to lateral wall or tongue base, remove mouth retractor and examine with wide laryngoscope. Limited resection of residual disease may be undertaken with cup forceps and extended monopolar cautery using telescope for improved visualization and evacuating suction for smoke
- Obtain hemostasis
- If there has been a concurrent neck dissection, check for a direct communication with the neck

Postoperative care

- Analgesia
- Feeding: Commence when comfortable
- Airway
- Bleeding
- Antibiotics only if concomitant neck dissection

Complications

- Postoperative hemorrhage (1.5 - 13% of TORS)
  - Up to a month postoperatively
  - Potentially life-threatening
  - Multiple large vessels are ligated and are left exposed to the pharynx to scar over by secondary intention

    - With large resections one may elect to ligate the facial and lingual arteries or the ECA during the neck dissection to reduce the severity of postoperative bleeding
    - Management depends on severity
        - Minor: Observe in hospital
        - Major
- Intubate/ tracheostomy
- Ligate/clip bleeders
- Ligate ECA
- Embolisation
- Airway obstruction
    - Bleeding
    - Edema
    - Flaps
    - Secretions
    - If in doubt, do a tracheostomy or keep intubated
- Dental trauma
- Lip or tongue lacerations
- Taste disturbance due to prolonged traction or surgical injury to the lingual nerve…recovers with time
- Hypoglossal nerve traction injury… recovers with time

Other issues

Can the specimen be removed piecemeal?

- It is a well-established, safe practice with transoral CO_2 laser microsurgery to transect tumor to determine depth of invasion and to remove a tumor piecemeal, or to debulk the tumor to facilitate resection
- When a large oropharyngeal tumor prevents adequate exposure of the margins, it is therefore acceptable to transect the tumor and remove it piecemeal, taking care to accurately orientate the specimens for the pathologist

What constitutes a clear margin?

- It is not possible to achieve wide deep margins with cancers of the lateral pharyngeal wall without having to resect the contents of the PPS
- However, a 99% 5-year estimated local control was reported by Hinni (2013) following transoral resection of 128 tonsil cancers with average deep resection margins of only 1.98mm [3]
- Therefore, favorable outcomes can be achieved provided microscopically clear margins are achieved

When is reconstruction required?

- An exposed carotid artery must be covered with a flap (note: full thickness removal of the pharyngeal constrictor muscle with extension into PPS fat is an indication for a combined open and transoral approach. This approach also provides access for flap inset, and is a natural extension of neck dissection, management of ECA)
- Significant resection of soft palate can cause palatal incompetence that manifests as nasopharyngeal reflux and impaired speech
- Function does improve as the tumor bed scars and contracts with time
- It remains a judgement call when reconstruction of the palate is required to prevent these sequelae

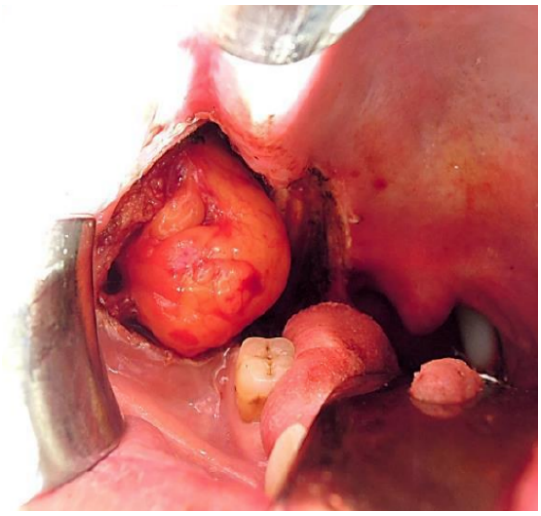


Figure 25: Buccal fat pad flap used to augment the palate or to close a pharyngocervical communication

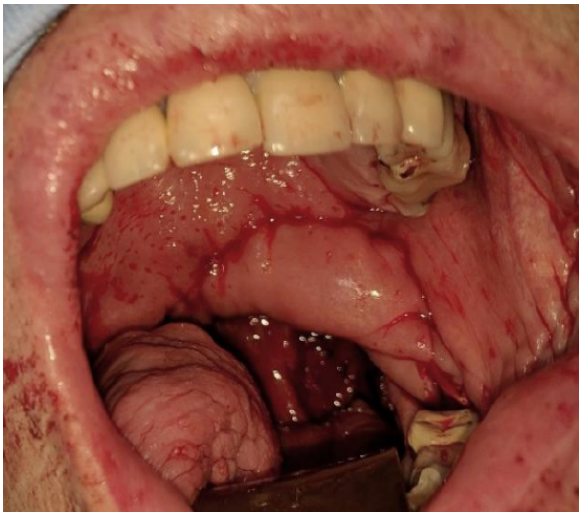


Figure 26: Soft palate and tonsil fossa defect reconstructed with buccinator flap

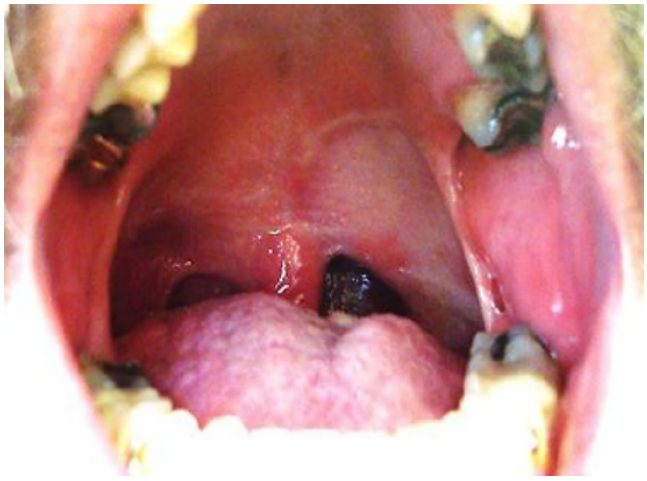


Figure 27: Radial free forearm flap reconstruction of oropharynx and soft palate defect

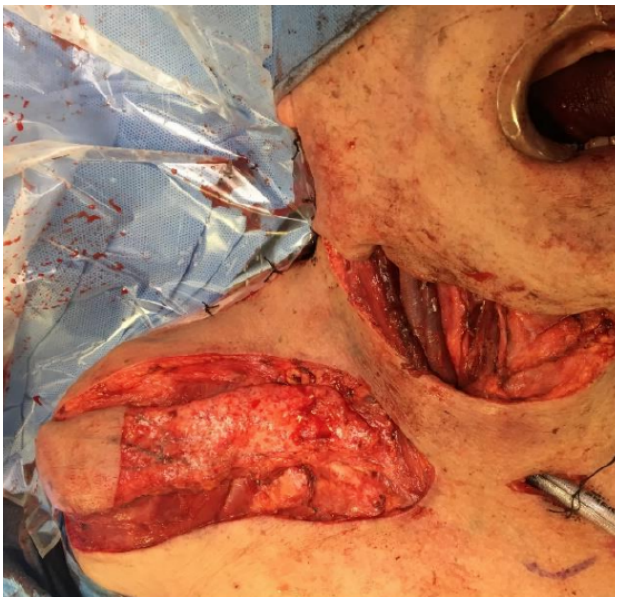


Figure 28: Supraclavicular flap



Figure 29: Submental artery island flap

- Options include
  - Local palatal flaps e.g. rotating uvula into the defect
  - Buccal fat pad flap (*Figure 25*)
  - Buccinator myomucosal flap (*Figure 26*)
  - Radial free forearm flap (*Figure 27*)
  - Supraclavicular flap (*Figure 28*)
  - Submental artery island flap (*Figure 29*)
  - Pectoralis major flap
  - Anterolateral free thigh flap

Neck dissection

- Oropharyngeal squamous carcinomas generally need to have the N0 neck treated either surgically or with (chemo) radiation
- Neck dissection is ideally done at the same operation, but may be staged
- There is a risk of causing a communication between the pharynx and submandibular triangle at the tonsillolingual sulcus
- A communication can be avoided by
  - Cutting through the submandibular gland with cautery, leaving the deep portion of the gland in situ
  - Leaving the whole submandibular gland in situ, taking care to clear the facial nodes (there are no intraglandular lymph nodes)

- Should a communication occur, then it can be dealt with by
  - Suturing the free margin of the mylohyoid to the posterior belly of digastric and avoiding placing the tip of the suction drain close to Level 1
  - Repairing the defect with a flap
    - Buccal fat pad flap (*Figure 25*)
    - Buccinator myomucosal flap (*Figure 26*)
    - Radial free forearm flap (*Figure 27*)
    - Supraclavicular flap (*Figure 28*)
    - Submental artery island flap (*Figure 29*)
    - Pectoralis major flap
    - Anterolateral free thigh flap

Feeding tube

It is simpler to remove a nasogastric feeding tube the day following surgery, than to have to insert it should the patient struggle to swallow.

Tracheostomy

Tracheostomy may be considered for two reasons i.e. concerns about the airway (oedema, soft tissue reconstruction, patient factors) or when there are concerns about postoperative bleeding. It remains a judgement call by the surgeon in consultation with the anesthetist.

Salvage surgery

Salvage surgery may be considered following previous transoral resection and/or chemoradiation. It requires a higher level of surgical skill and experience, and a very detailed radiological assessment of resectability via a transoral approach. When concerns exist about injuring the ICA, the ICA may first be exposed via Level 2 of the neck and gauze packed anterior to the ICA in the PPS to protect it during the transoral phase of the dissection.

References

1. Weinstein GS, O'Malley BW, Rinaldo A et al. Eur Arch Otorhinolaryngol 2015; 272 (7): 1551-2 https://doi.org/10.1007/s00405-014- 3331-9
2. Faraji F, Coquia SF, Wenderoth MB, Padilla ES, Blitz D, DeJong MR, Aygun N, Hamper UM, Fakhry C. Evaluating oropharyngeal carcinoma with transcervical ultrasound, CT, and MRI. Oral Oncology. 2018: 78:177-85
3. Hinni ML, Zarka MA, Hoxworth JM. Margin mapping in transoral surgery for head and neck cancer. Laryngoscope. 2013 May;123(5):1190-8

Additional reading

- Chapter in Open Access Atlas of Otolaryngology Head and Neck Operative Surgery: Oropharyngeal cancer resection
- Gun R, Durmus K, Kucur C, et al. Transoral Surgical Anatomy and Clinical Considerations of Lateral Oropharyngeal Wall, Parapharyngeal Space, and Tongue Base. Otolaryngol Head Neck Surg. 2016 Mar;154(3):480-5

Author

Wayne M. Koch, MD
Professor of Otolaryngology-Head & Neck Surgery
Johns Hopkins University
Baltimore, MD 21287 USA
wkoch@jhmi.edu

Author & Editor

Johan Fagan MBChB, FCS (ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

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6.9.17: 17. Surgical Approaches - Oropharynx Cancer Resection- External Approaches

OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

Johan Fagan, Eugene Myers

Management of cancer of the oropharynx has undergone a paradigm shift in recent years following the realization that HPV infection is both an etiologic and prognostic factor for a subset of oropharyngeal squamous cell carcinoma; the introduction of transoral robotic surgery (TORS) to resect oropharyngeal tumors; as well as attempts to reduce the morbidity of chemoradiation by accepting smaller resection margins when combined with postoperative irradiation.

This chapter describes transoral and transmandibular resection of cancer of the oropharynx; it does not address the debate of the relative merits of chemoradiation vs. transoral excision using electrocautery, CO_2 laser or robotics vs. open resection. Readers are referred to other chapters in the Open Access Atlas of Otolaryngology, Head & Neck Operative Surgery for detailed descriptions of Transoral laser microsurgery (TLM), Transoral lateral oropharyngectomy/radical tonsillectomy, and Resection of cancers of the base of tongue.

Surgical anatomy

The oropharynx is comprised of the base of the tongue, tonsils, soft palate, and the lateral and posterior walls of the pharynx between the levels of the hard palate and hyoid bone.

Base of the tongue (BOT)

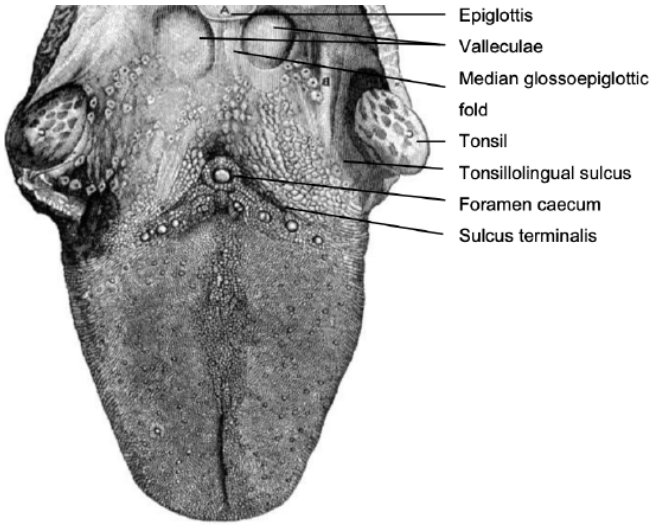


Figure 1: Topography of BOT

This comprises the posterior 1/3 of the tongue behind the ***foramen caecum*** and ***sulcus terminalis*** (*Figure 1*). The mucosa is rough, thick and fixed to the underlying muscle and contains lymphoid follicles (lingual tonsil); this makes it difficult to identify the edges of a BOT tumor; hence frozen section is especially useful to assess resection margins. Posterolaterally the ***tonsillolingual sulci*** separate the tongue from the tonsillar fossae. The ***valleculae*** separate the BOT from the lingual surface of the epiglottis and are separated in the midline by the median glossoepiglottic fold (*Figure 1*).

Soft palate

The soft palate has a complex muscular structure and innervation. It has key functions relating to speech and swallowing.

Resection and inadequate reconstruction of the palate results in loss of nasal separation which manifests clinically as nasal regurgitation of fluids and food, and hypernasal speech which can be quite disabling. The complex muscular anatomy of the soft palate and lateral pharyngeal wall is illustrated in *Figure 4*.

Soft palate	Tensor veli palatini	V_3
	Levator veli palatini	X
	Palatoglossus	X
	Palatopharyngeus	X
	Musculus uvulae	X
Lateral pharyngeal wall	Salpingopharyngeus	X
	Superior constrictor	X
	Middle constrictor	X
	Stylopharyngeus	IX

Table 1: Muscles of the soft palate and oropharynx and cranial nerves which innervate them

Muscles that contribute to the soft palate and lateral pharyngeal wall are summarized in *Table 1*.

Lateral and posterior pharyngeal walls

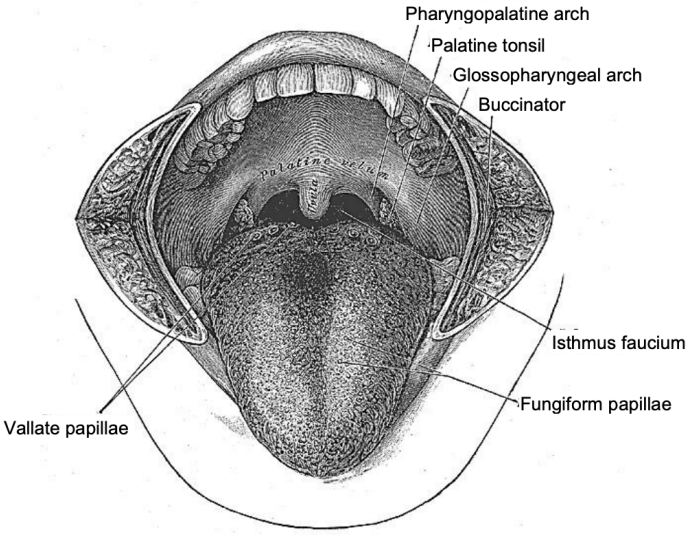


Figure 2: Anterior view of soft palate

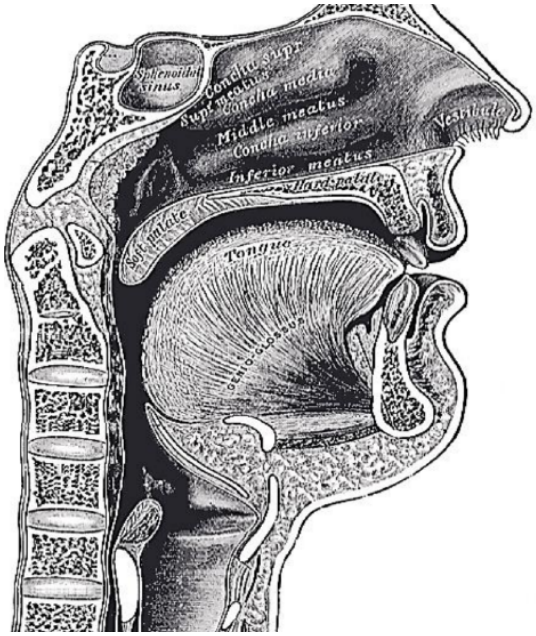


Figure 3: Lateral view of soft palate and its attachment to the hard palate

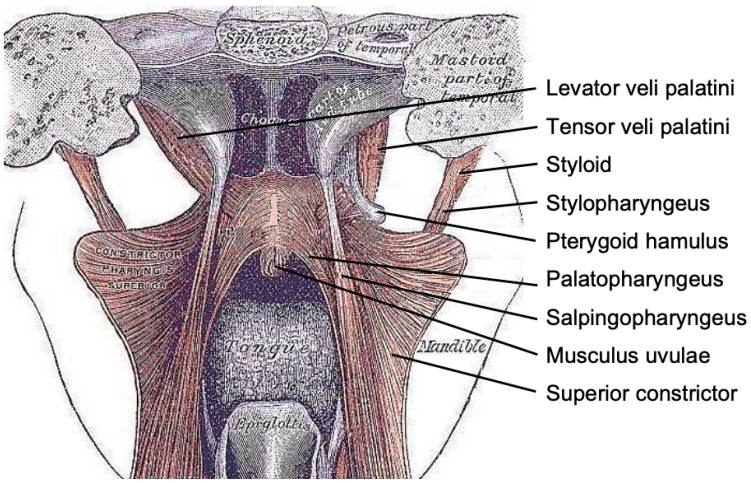


Figure 4: Posterior view of the soft palate and pharynx with the superior constrictor splayed open

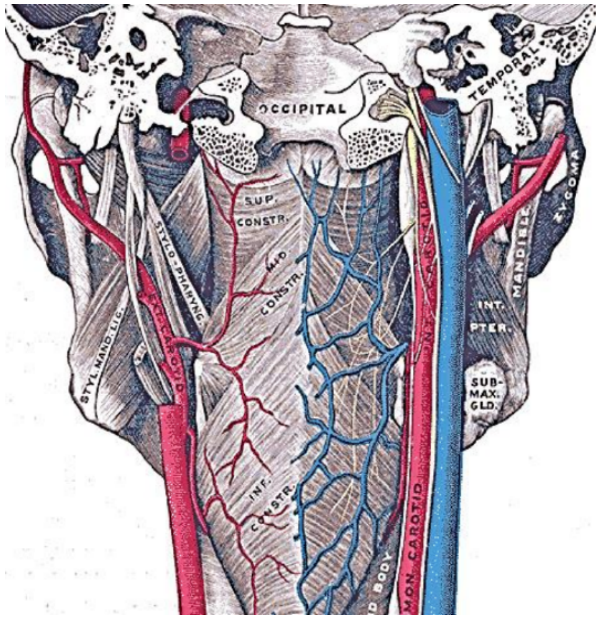


Figure 5: Posterior view of the pharynx illustrates the attachment of the superior constrictor to the pharyngobasilar fascia above and the median raphe to which the pharyngeal constrictors attach; note the close anatomical relationships of the internal and external carotid artery systems to the pharynx

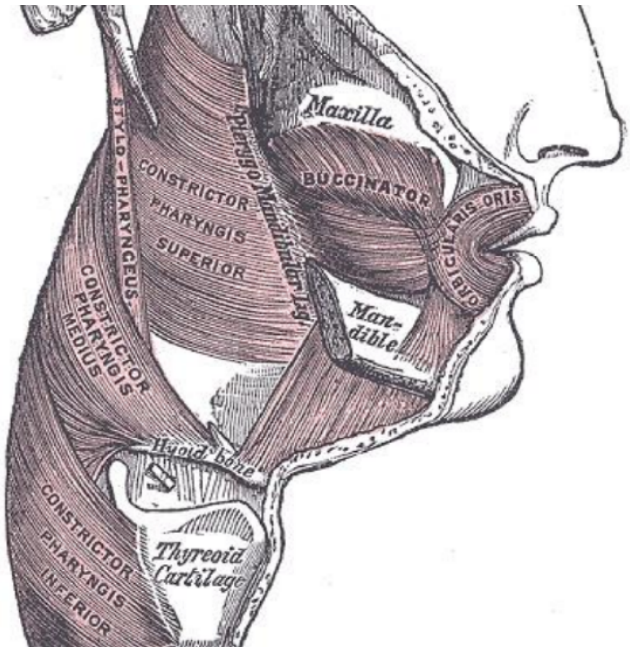


Figure 6: Note how buccinator and superior constrictor muscles attach to the pterygomandibular raphe

The pharynx has a number of layers i.e. mucosa, submucosa, muscle and serosa. The ***submucosa*** is represented by the ***pharyngobasilar fascia***; it thins as it extends inferiorly from its attachment to the skull base and lines the inner aspect of the constrictor muscles. It fills the gaps between the skull base and the superior constrictor, the superior and middle constrictors, and the middle and inferior constrictors (*Figure 5*). Posteriorly it forms a median raphe to which the pharyngeal constrictors attach (*Figure 5*). The anterior faucial/tonsillar pillars are formed by the palatoglossus muscles with a thin mucosal covering and constitute the anterior limit of the oropharynx, behind which it is encircled by the ***superior and middle constrictor muscles*** (*Figures 2, 4, 5, 6*). The ***palatopharyngeus muscles*** constitute the posterior faucial/tonsillar pillars. The tonsils are situated between the anterior and posterior pillars, with the pharyngeal constrictor muscle lateral to the tonsil. The ***buccopharyngeal fascia*** constitutes the s***erosal layer***; it is the outermost coat of the pharynx and is a thin layer of connective tissue that forms the anterior wall of the prevertebral space.

Nerves

The only notable nerves encountered at surgery are the ***lingual, inferior alveolar and mental nerves***, and possibly the ***XIIn*** if resection includes the lateral tongue.

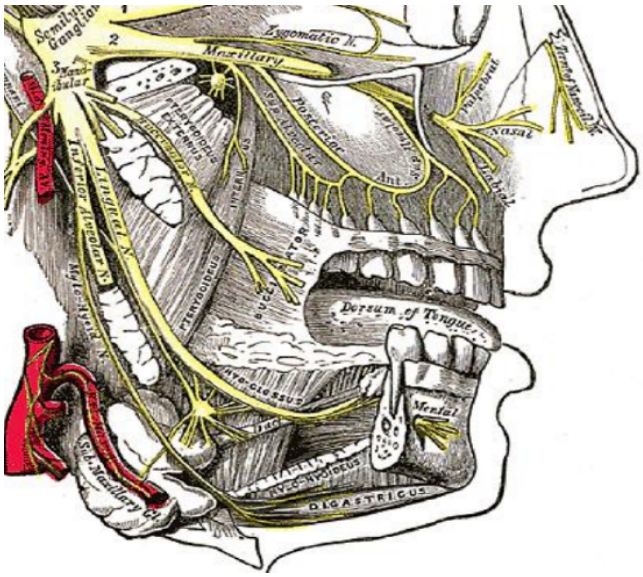


Figure 7: V3, lingual, inferior alveolar and mental nerves

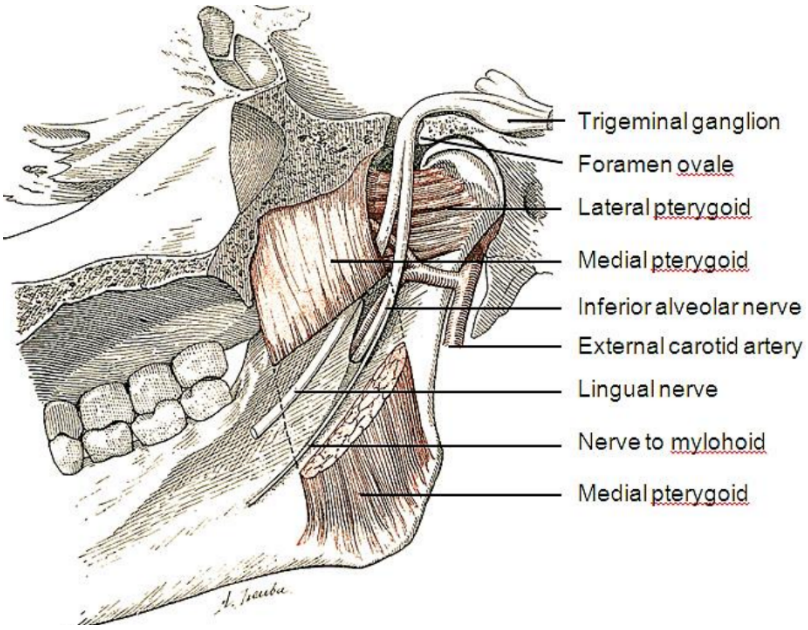


Figure 8: V3, lingual, inferior alveolar and mental nerves

The ***lingual nerve*** is a branch of V3 and provides sensory innervation to the floor of the mouth (FOM). The nerve crosses deep to the submandibular duct in the lateral FOM; in the anterior FOM it is located posterior to the duct (*Figures 7, 8*). It is worthwhile attempting to preserve the nerve when resecting smaller tumors in the tonsillar region.

The ***inferior alveolar nerve*** and its accompanying vessels enter the mandibular canal at the lingula and innervate the inferior alveolus and teeth (*Figures 7, 8*). The nerve is transected whenever a segmental mandibulectomy is done. The ***mental branch*** of the nerve exits the mandibular canal at the mental foramen to innervate the skin of the lower lip and should be preserved when doing a mandibulotomy by placing the osteotomy anterior to the mental foramen (*Figure 7*).

Arteries

Knowledge of vascular anatomy enables the surgeon to anticipate where arteries will be encountered and helps to minimize blood loss. Depending on the surgical procedure, vessels that may be encountered include the ***inferior labial, facial, lingual, inferior alveolar, mental, palatal and tonsillar*** arteries and the ***pterygoid venous plexus***.

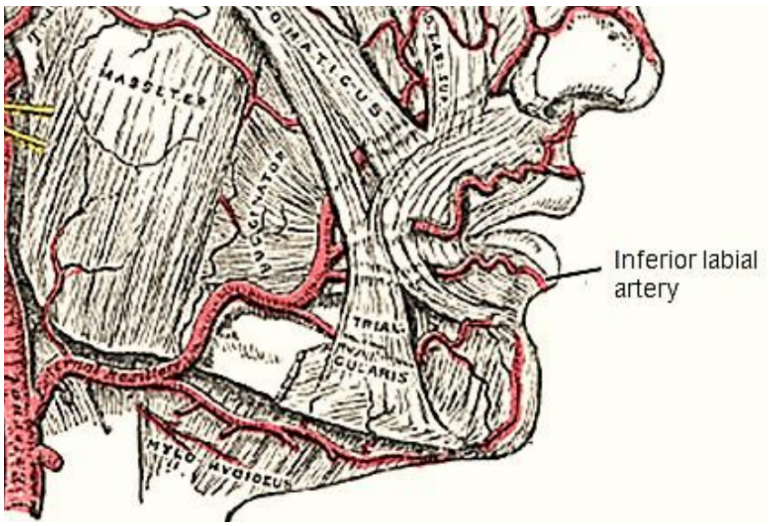


Figure 9: Inferior labial artery

The ***inferior labial artery*** is transected when the lower lip is divided in the midline. A branch of the facial artery, it is located superficially, just deep to the surface of the lip, and is controlled with bipolar cautery (*Figure 9*).

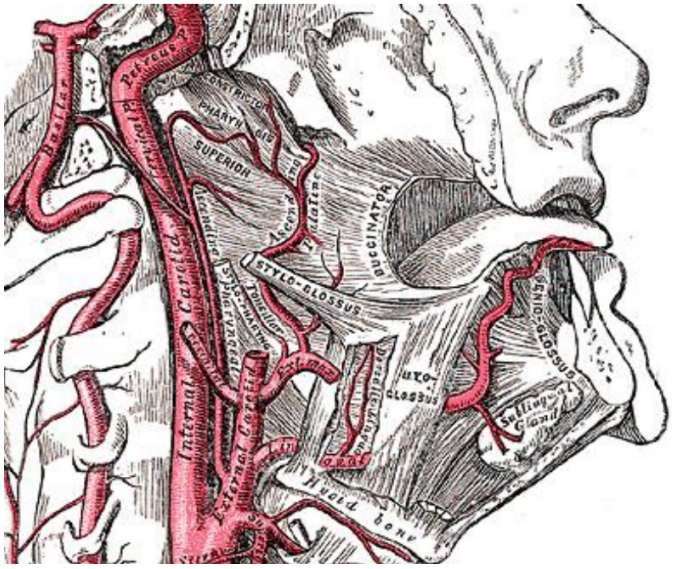


Figure 10: The ascending pharyngeal and ascending palatine and tonsillar branches of the facial (external maxillary) artery lie on the pharyngeal constrictor deep to the medial and lateral pterygoid muscles

The ***facial artery*** is generally not a problem as it is reflected laterally in the cervicofacial flap that is raised when exposing the lateral surface of the mandible (*Figure 9*). It is commonly used as a donor vessel for free microvascular transfer flap reconstruction. The ***tonsillar and ascending palatine arteries*** are branches of the facial artery (*Figure 10*). The ***lingual artery*** is only encountered when resection includes the posterolateral tongue (*Figure 10*).

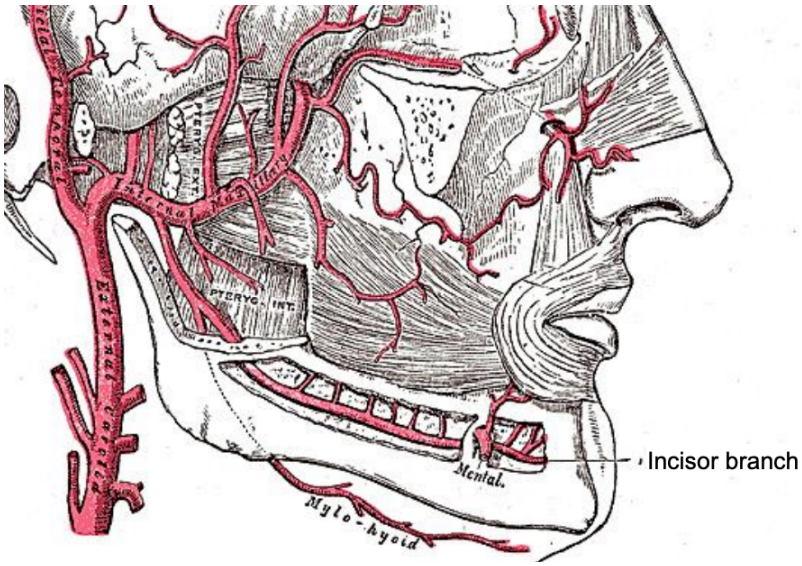


Figure 11: Buccinator, inferior alveolar and mylohyoid arteries

The ***inferior alveolar artery*** is a branch of the internal maxillary artery, and courses between the medial pterygoid muscle and mandible where it enters the mandibular canal at the lingula accompanied by the inferior alveolar nerve and vein (*Figures 5, 8, 11*).

The mental artery accompanies the mental nerve and exits the mandible at the mental foramen (*Figure 11*). If a mandibulotomy is to be done for access just anterior to the mental foramen, avoid dissecting right up to the foramen so as not to cause bleeding requiring cautery, as this might injure the nerve. The ***arterial supply to the soft palate*** is derived mainly from the ***ascending pharyngeal artery***, which anastomoses with the ***greater palatine artery*** at the junction of the hard and soft palate; additional supply is derived from the ***ascending palatine*** and ***tonsillar arteries*** (*Figure 10*). Despite transecting the soft palate with diathermy, one may encounter troublesome bleeding which is controlled with diathermy.

Muscles

The muscles of the soft palate, the pharyngeal constrictors and the palatopharyngeus and palatoglossus are generally not individually dissected and identified but are simply resected with the primary tumor using electrocautery and scissors. Muscles that are encountered depending on the surgical approach and that are individually identified include ***orbicularis oris, masseter, temporalis, mylohyoid, and the medial and lateral pterygoids***.

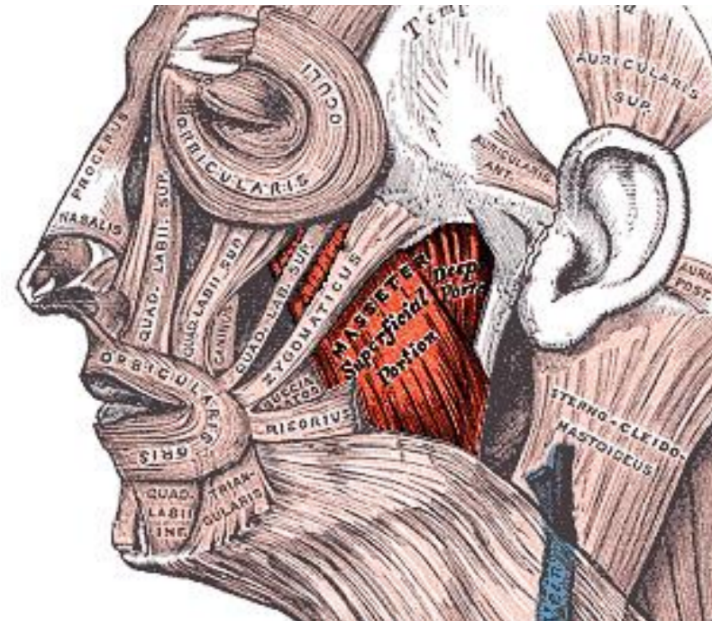


Figure 12: Orbicularis oris and masseter

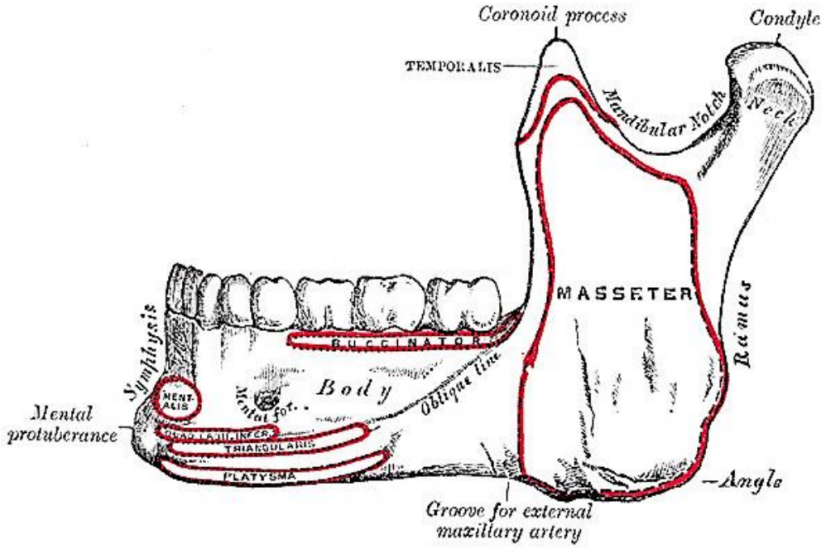


Figure 13: Muscle attachments to outer aspect of mandible and location of mental foramen

The ***orbicularis oris*** is transected with a lip-split incision and has to be carefully reapproximated at conclusion of surgery (*Figure 12*). Dissecting along the lateral surface of the mandible, one next encounters the ***masseter muscle*** (*Figure 12*). It is a thick quadrilateral muscle with superficial and deep portions, the fibers of which converge at the insertion to the lateral aspect of the vertical ramus of the mandible (*Figure 13*). Both the superficial and deep portions arise from the zygoma. Laterally the muscle is covered by the parotid gland. It is innervated by V_3.

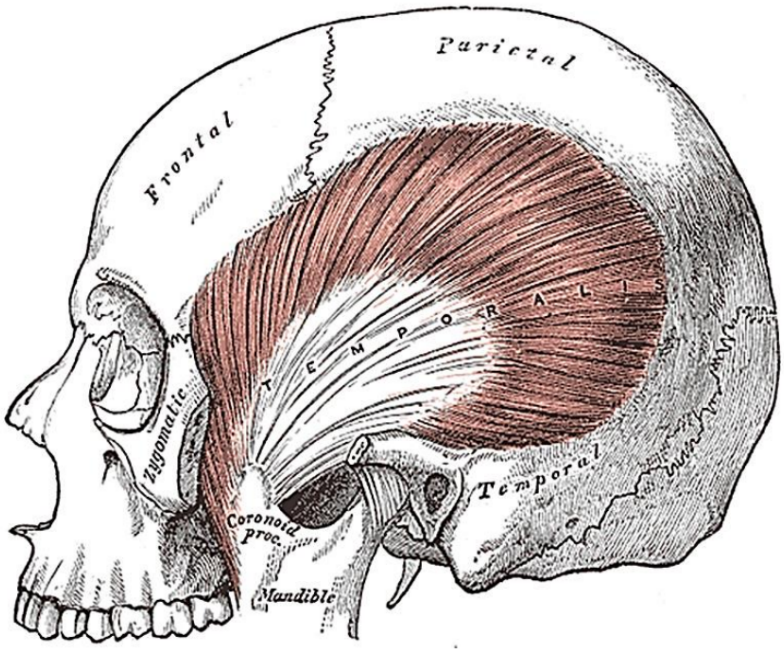


Figure 14: Temporalis muscle inserts into coronoid and anteromedial surface of vertical ramus of mandible

The next muscle one encounters as one dissects along the lateral surface towards the coronoid process of the mandible is the ***temporalis muscle*** (*Figures 13, 14*).

The temporalis muscle arises from the temporal fossa and temporalis fascia and passes behind the zygomatic arch to insert onto the coronoid process and anteromedial surface of the vertical ramus (*Figures 13, 14*). It is innervated by V_3. It receives its blood supply from the deep temporal arteries; preserving these arteries is crucial if a temporalis muscle flap is to be used to reconstruct a surgical defect.

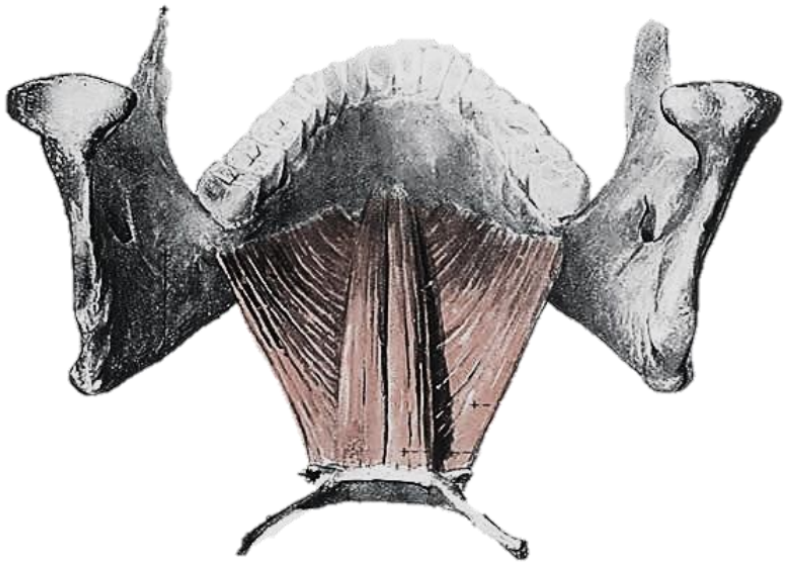


Figure 15: Geniohyoid and mylohyoid

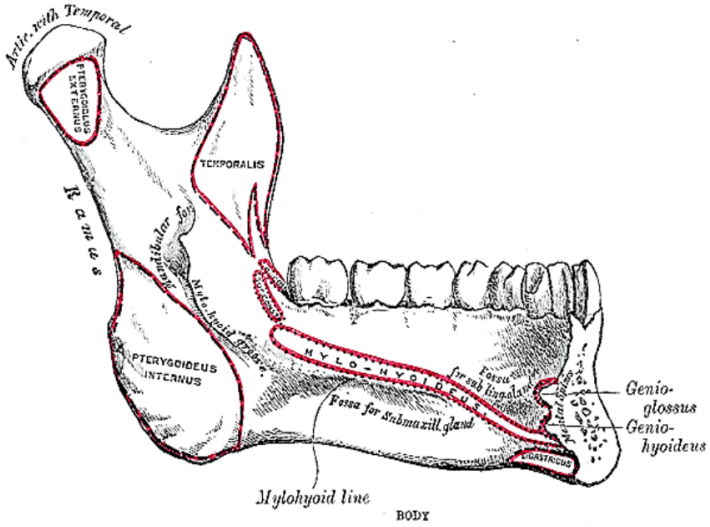


Figure 16: Attachments of mylohyoid, geniohyoid, genioglossus and digastric muscles to inner aspect of mandible

The ***mylohyoid muscle*** is the "diaphragm" of the mouth, and is transected along the medial margin of the mandible when doing a mandibular swing approach to the oropharynx (*Figures 15, 16*).

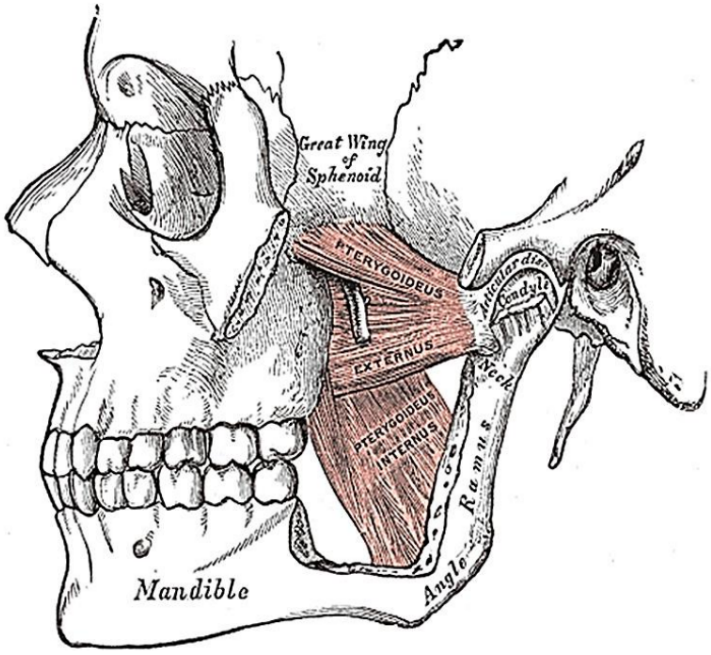


Figure 17: Medial and lateral pterygoids

The next muscle encountered along the medial aspect of the mandible is the ***medial pterygoid*** (*Figures 8, 17*). It has two heads (*Figure 17*): the larger deep head arises from just above the medial surface of the lateral pterygoid plate; the smaller superficial head arises from the maxillary tuberosity and the pyramidal process of the palatine bone (*Figure 17*). The muscle passes inferolaterally to insert onto the inferomedial surface of the ramus and angle of the mandible (*Figures 16, 17*). It is innervated by V_3.

The final muscle that may be encountered is the ***lateral pterygoid***; its superior head originates from the infratemporal surface and crest of the greater wing of the sphenoid, and the inferior head from the lateral surface of the lateral pterygoid plate (*Figure 17*). It inserts onto the neck of mandibular condyle and the articular disc and capsule of the temporomandibular joint (*Figures 16, 17*). It is innervated by V_3.

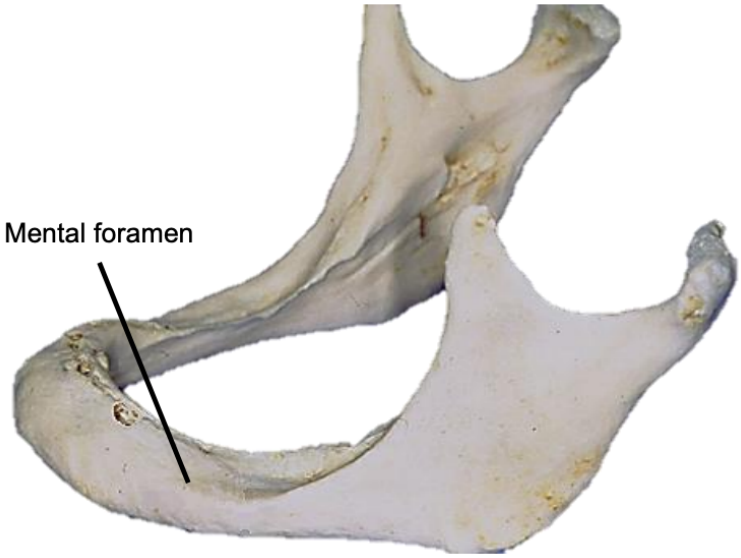


Figure 18: Position of mental foramen in a resorbed mandible

The ***mandible*** may need to be divided (mandibulotomy) to gain access to the oropharynx, or the angle and vertical ramus of the ***mandible*** may be included in the tumor resection (marginal, segmental or hemimandibulectomy). Important surgical features are the position of the mental foramen through which the mental nerve exits to innervate the lower lip, the mylohyoid line to which the mylohyoid muscle attaches, and when planning a marginal mandibulectomy, the height of the body of the mandible and the depth of the dental roots (*Figures 13, 16*). The mental foramen and inferior alveolar nerve may be very close to the superior surface of a resorbed mandible such as is seen in older, edentulous patients (*Figure 18*). A marginal mandibulectomy may not be possible in such a resorbed mandible due to the lack of residual bone.

Surgical Objectives

- Adequate tumor ***resection margins***; this requires a surgical approach that permits good exposure
- ***Surgical morbidity*** relating to palatal function (nasal regurgitation and speech), swallowing, mandible, lingual nerve function and cosmesis should be kept to a minimum; prevent pharyngocutaneous fistulae
- ***Control occult cervical metastasis; the neck is electively treated*** when there is significant risk of occult cervical metastases; the author generally does elective neck dissection (END) levels I-III for squamous cell carcinoma; and bilateral END with cancers of the soft palate and/or base of tongue

The remainder of this chapter focuses on surgical treatment of the primary tumor.

Preoperative evaluation

1. ***Are there synchronous primaries, cervical or distant metastases?*** CXR or CT chest, and panendoscopy
2. ***Is the tumor resectable?*** Since local control and ultimately cure depend upon complete resection of cancer with clear margins, there is little point in doing an incomplete tumor resection. It may be difficult to assess the extent of the primary due to pain, tenderness or trismus. If in doubt, a patient requires imaging such as CT/MRI, or examination under anesthesia. Examples of irresectable tumors include posterior extension to involve the carotid sheath and parapharyngeal space, superior extension to the infratemporal fossa and skull base, perineural extension to the trigeminal ganglion, and irresectable node metastases. A key consideration is surgical morbidity; this in turn is dependent on the range and reliability of reconstructive surgery and prosthodontic support services
3. ***Is there clinical evidence of perineural invasion (PNI) of major nerves?*** Examine the patient for neurological deficits of the hypoglossal, mental, inferior alveolar, lingual, and trigeminal nerves and of the sympathetic trunk (Horner's syndrome). Widening of the mandibular canal on mandibular orthopantomography (Panorex) may be seen. MRI may demonstrate PNI. Should there be evidence of PNI then the affected nerve should be dissected proximally until a clear tumor margin is obtained on frozen section. In the case of the inferior alveolar nerve, this would require a hemi- or segmental mandibulectomy that encompasses the entire inferior alveolar canal Mental foramen
4. ***Is a tracheostomy required?*** Most patients with resections requiring any form of reconstruction with a flap are at risk of airway obstruction and should have a temporary tracheostomy. Oral or transnasal intubation may be difficult or impossible due to

tumor and/or trismus; a tracheostomy is then done under local anesthesia and the patient is intubated through the stoma

5. ***What type of surgical approach is required?*** Select surgical approaches that ensure adequate exposure; transoral access is often inadequate
6. Does the mandible have to be resected? Tumor may involve the medial pterygoid muscle at its insertion onto the mandible (clinically manifested by trismus), extend onto periosteum, invade only the inner cortex, involve medullary bone, or manifest PNI of the inferior alveolar nerve. Panorex only shows gross involvement of bone (*Figure 19*). *Figure 19*: Panorex shows mandibular destruction by tumor Invasion of cortical bone is better assessed with CT; MRI is superior for assessing medullary invasion. In the absence of CT scans the surgeon may elect to strip tumor off bone at the time of resection taking care not to seed tumor, inspect the bone for evidence of periosteal and bony infiltration, and then decide how to proceed. If only the periosteum is involved, then a marginal mandibulectomy (removal of cortical bone) may suffice. Should marginal mandibulectomy be considered, then the vertical height of the mandible should be assessed clinically or by Panorex so as to predict whether a free bony composite flap would be required to strengthen the remaining mandible. Once the cortex is invaded, then either marginal or segmental mandibulectomy is required. Medullary invasion requires segmental or hemimandibulectomy that includes at least a 2 cm length of mandible on either side of the tumor
7. ***Status of dentition?*** Carious teeth are removed at the time of the surgery to reduce the risk of osteoradionecrosis
8. ***What type of reconstruction is required?*** This can often only determined once the resection has been done and the defect can be assessed

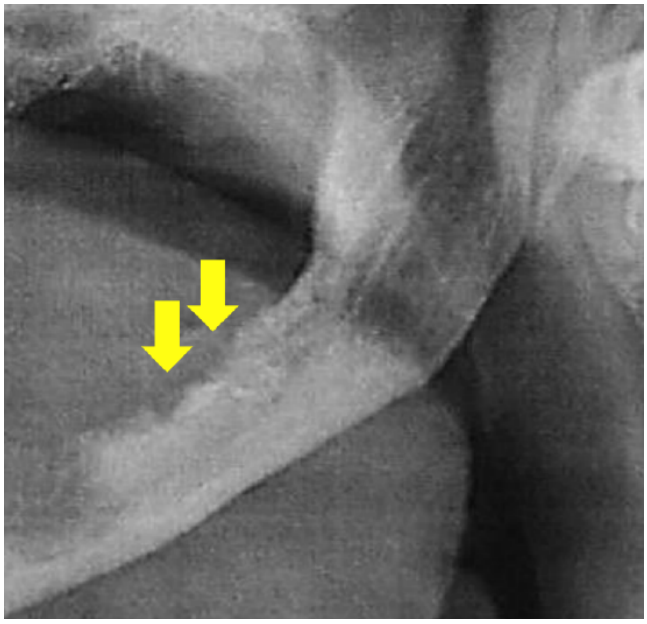


Figure 19: Panorex shows mandibular destruction by tumor

Key surgical points

- ***Preserve function***
  - Attempt to preserve the lingual and hypoglossal nerves
  - Reconstruct soft palate defects
  - Reconstruct mandibular defects
- ***Do not compromise margins to preserve function***
- Employ ***frozen section*** (if available) to ensure clear resection margins
- Have a low threshold for performing a ***tracheostomy***

Anesthesia

The ***surgeon always stands by the patient's side during induction*** of anesthesia as it may be difficult or impossible to intubate a patient who has a bulky tumor, or who has trismus. Should the anesthetist be unable to intubate the larynx, the surgeon may be able to intubate through a laryngoscope or do an emergency tracheostomy or cricothyroidotomy; it is prudent to inject the tracheostomy or cricothyroidotomy site with local anesthetic (with adrenaline) prior to induction. Nasal intobation facilitates resection of pharyngeal tumors and is converted to a tracheostomy during the course of the operation.

Perioperative antibiotics are prescribed for 24 hours.

Surgical access

Good surgical access is essential in order to attain adequate resection margins, to control bleeding, and for reconstruction. A combination of surgical approaches can be used and will now be discussed. ***Level 1 of the neck should first be dissected*** before proceeding to address the primary tumor if neck dissection is indicated.

Transoral resection with electrocautery (Bovie)

Transoral access varies considerably. Edentulous patients are generally better suited to transoral resection. A useful way to predict whether transoral resection is likely to be possible is to pull on the anterior tongue with a cotton swab during preoperative clinical evaluation and to then see how accessible the tumor is. Note that ***tumors become more visible and accessible as the resection proceeds***, especially once the thick BOT lining has been incised around tumor.



Figure 20: Dental bite block is interposed between lateral teeth to keep mouth open

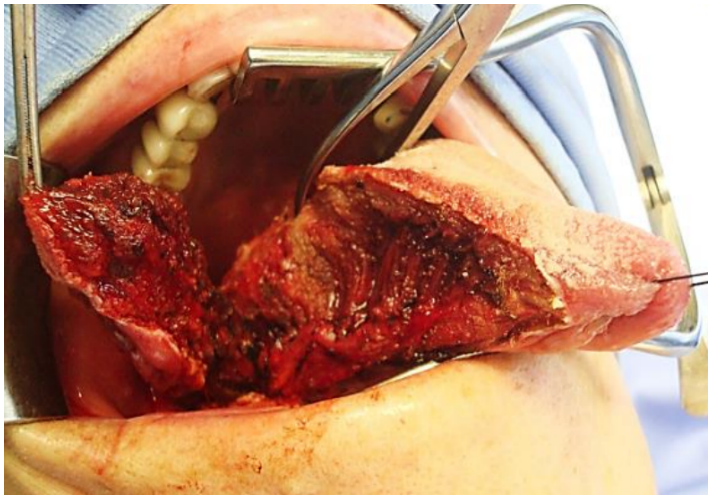


Figure 21: Self-retaining retractor; lateral oral and BOT tumor being resected

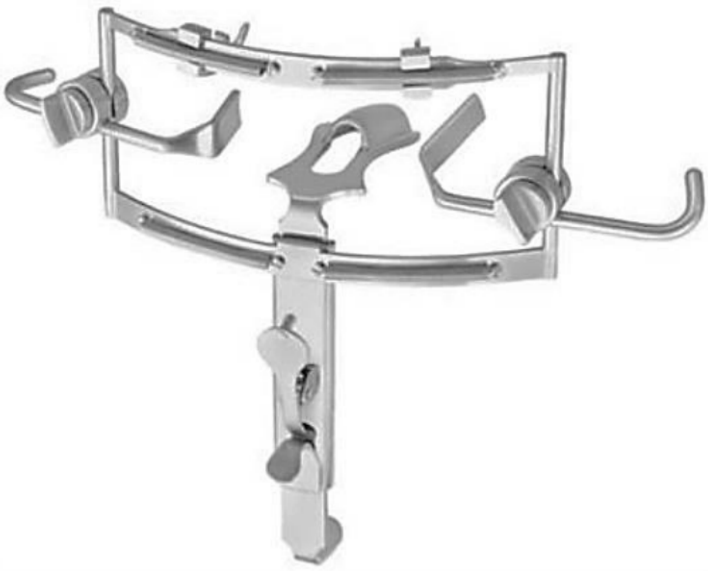


Figure 22: Dingman retractor

The mouth is kept wide open either with a dental bite block (*Figure 20*), or with a self-retaining retractor, taking care to protect the teeth from injury (*Figure 21*), or with a tonsil gag or Dingman retractor (*Figure 22*).

Apply traction to the tongue and the tumor with silk traction sutures or with tissue forceps (*Figure 21*). Resect the tumor with at least a 1 cm margin of normal tissue using electrocautery (Bovie). As the resection proceeds, insert new silk traction sutures or reapply the tissue forceps to facilitate delivery of the tumor.

Mandibulotomy with mandibular swing

This affords ***excellent access*** to the oropharynx. It does however leave a facial scar; it may cause deformity of the lower lip; there is a risk of complications relating to the mandibulotomy and dental malocclusion; and the lingual nerve is at risk of injury.



Figure 23: Skin incisions for Level 1 neck dissection and mandibulotomy approach



Figure 24: Scoring the vermillion border

Having completed the Level 1 neck dissection, the vermillion border is scored or marked so as to ensure an accurate repair (*Figures 23*, *24*).

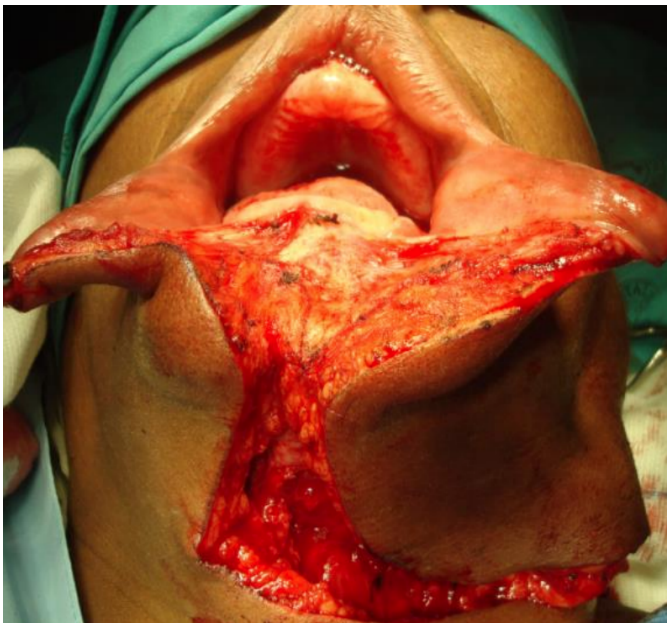


Figure 25: The lower lip is divided vertically in the midline onto bone after Level 1 neck dissection has been completed

The lower lip is vertically divided in the midline (*Figure 25*). Bleeding from the inferior labial artery is controlled with bipolar cautery. At this point, some surgeons prefer to do a ***median mandibulotomy***; it is however the authors' preference to do a ***paramedian mandibulotomy***.

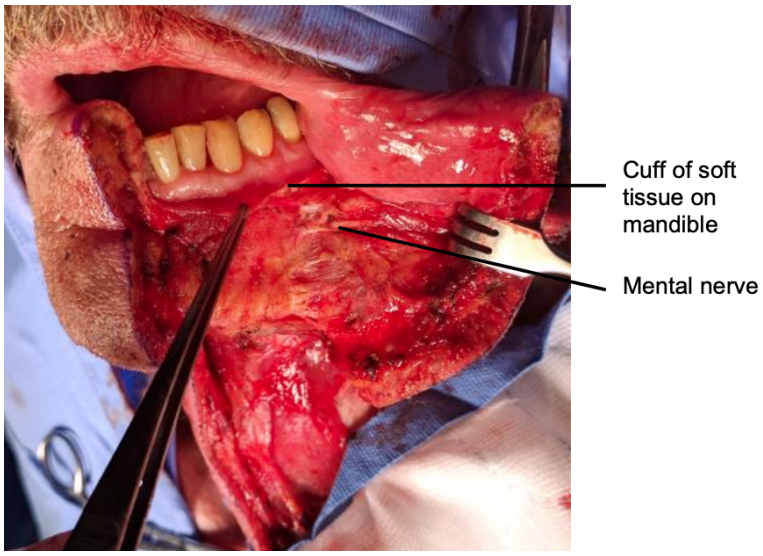


Figure 26: Mental nerve and cuff of soft tissue

Incise the gingivolabial and gingivobuccal mucosae >0.5 cm from the bone to leave a cuff of soft tissue on the bone to facilitate subsequent soft tissue closure (*Figure 26*).

Strip soft tissue off the mandible with monopolar cautery or with a periosteal elevator stopping just short of the mental foramen so as not to injure the mental nerve or mental artery where it exits the foramen (*Figure 26*).



Figure 27: Gigli saw

A ***paramedian mandibulotomy*** is done just anterior to the mental foramen. Compared to median mandibulotomy, the advantages are that it is closer to tumor, it does not disturb the genioglossus, geniohyoid, and digastric muscles, there is less disruption of the FOM, and should segmental mandibulectomy be required, then only the lateral mandible is sacrificed. The mandible is divided just anterior to the mental foramen with a Gigli or a powered saw (*Figure 27*).

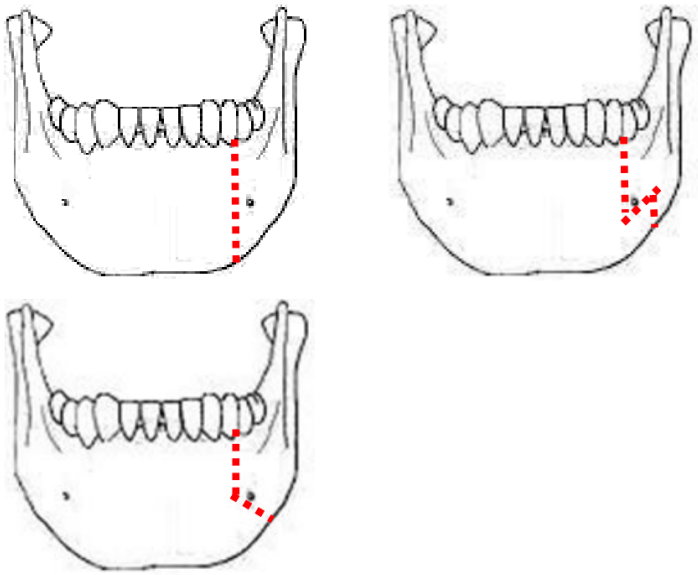


Figure 28: Examples of osteotomies

The osteotomy may be made vertically or alternatively in a step- or V-shaped fashion to achieve a more stable repair (*Figure 28*). It is advisable to extract a tooth and make the osteotomy through the dental socket to avoid devitalizing adjacent teeth.

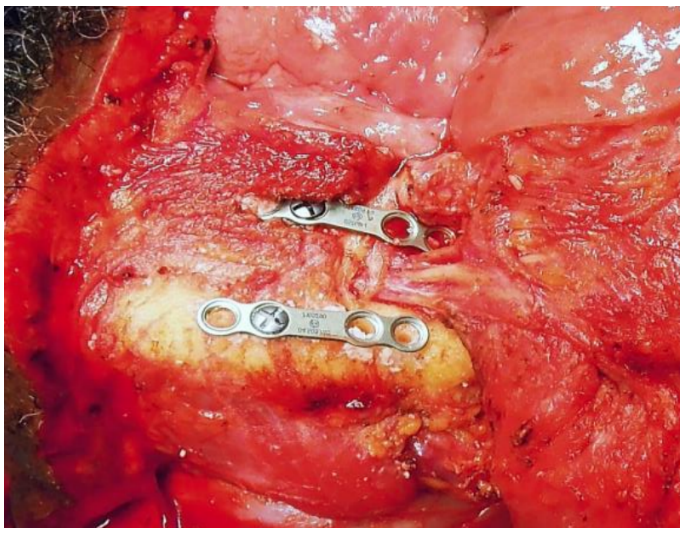


Figure 29: Preplating with 4-holed miniplates above and below mental nerve

In dentate patients the mandible is preplated with titanium miniplates contoured to the mandible to ensure perfect dental alignment. Two 4-holed, non-compression, 2 mm mandibular plates, one placed along the inferior border of the mandible and the other placed more superiorly, are used (*Figure 29*). Once the plates have been contoured and the holes drilled, they are removed, and the bone cut is made.

The surgeon then distracts the cut ends of the mandible to gain access to the oral cavity and proceeds to divide the FOM mucosa and mylohyoid muscle about 1 cm from, and parallel to, the mandible, so as to leave soft tissue on the mandible for FOM repair at conclusion of the surgery. Continue the incision posteriorly along the FOM until the tumor comes into view; the lingual artery (medial to the hyoglossus muscle) and the XIIn course medial to the FOM incision and are not at risk of injury at this stage of the dissection.

The ***tumor is resected using electrocautery***. Posteriorly the ***lingual nerve*** extends from the skull base, passes behind medial pterygoid and crosses the incision line from lateral to medial to course along the lateral FOM; preserve the nerve if possible.

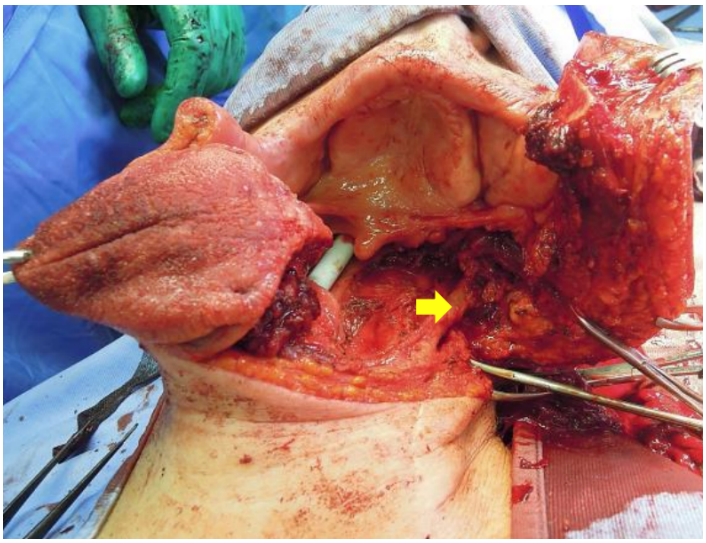


Figure 30: Note the excellent access afforded by mandibulotomy approach (Arrow points to internal carotid artery)

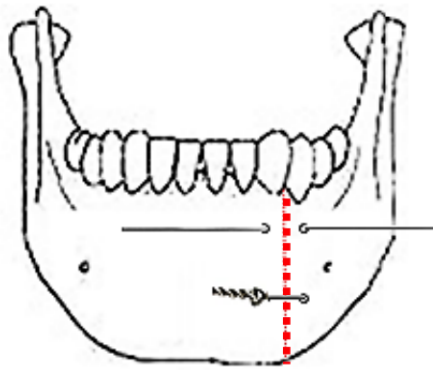


Figure 31: Mandible wired together with stainless steel wire

At ***the conclusion of surgery***, the FOM is closed with a running vicryl suture, and the osteotomy is plated; when plating sets are not available, opposing holes are drilled on either side of the osteotomy and the mandible is wired together with stainless steel wires (*Figure 31*).

Marginal and segmental mandibulectomy

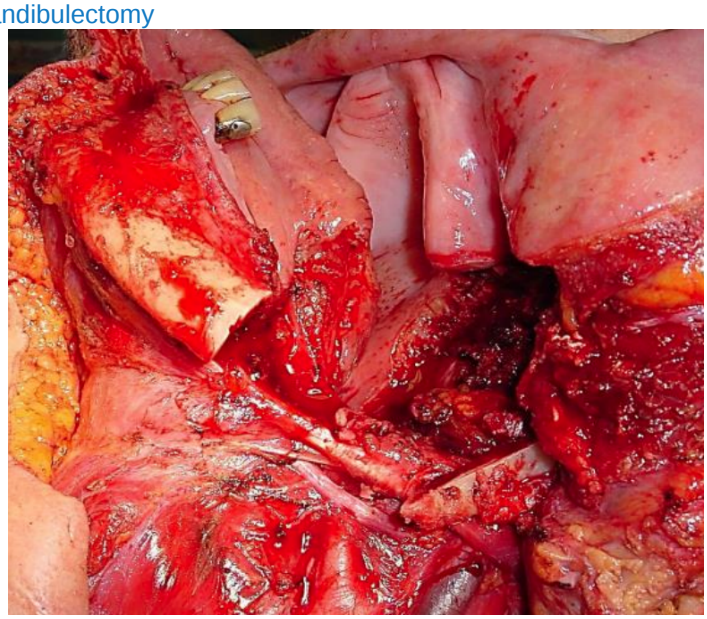


Figure 33: Segmental mandibulectomy preserving only posterior rim of vertical ramus (note preplating holes)

Marginal mandibulectomy is done for access, for securing adequate oncologic resection margins, or to facilitate mucosal repair by suturing gingivolabial to gingivobuccal mucosa (*Figure 32*). Segmental mandibulectomy is done to secure adequate oncologic margins (*Figure 33*).

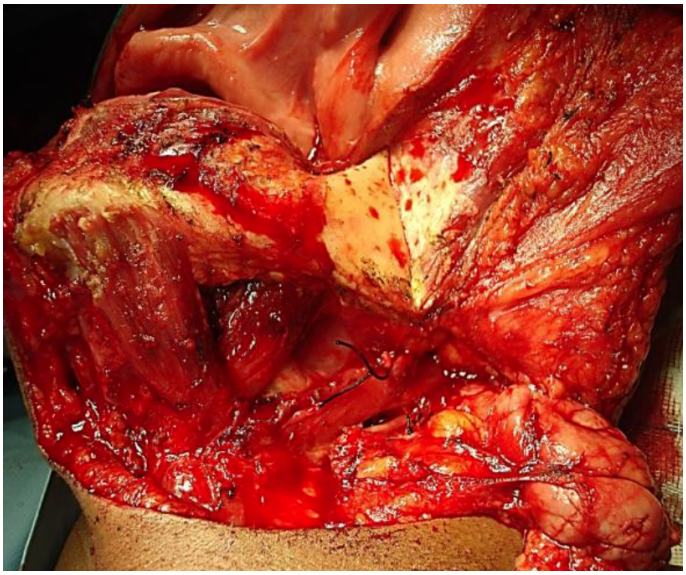


Figure 34: Stripping masseter off bone

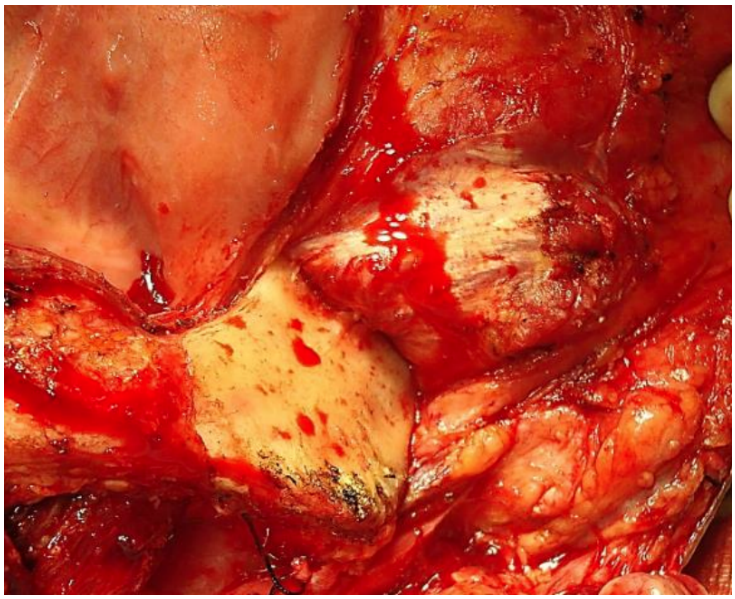


Figure 35: Exposing vertical ramus of mandible up to coronoid process, mandibular notch and neck of condyle

The initial surgical steps are as described for paramedian mandibulotomy (up to *Figure 26*). Transect the mental nerve and artery with cautery and continue to strip soft tissue off the lateral aspect of the mandible up to the masseter muscle; then strip the masseter off its mandibular insertion using electrocautery (*Figures 34*, *35*).

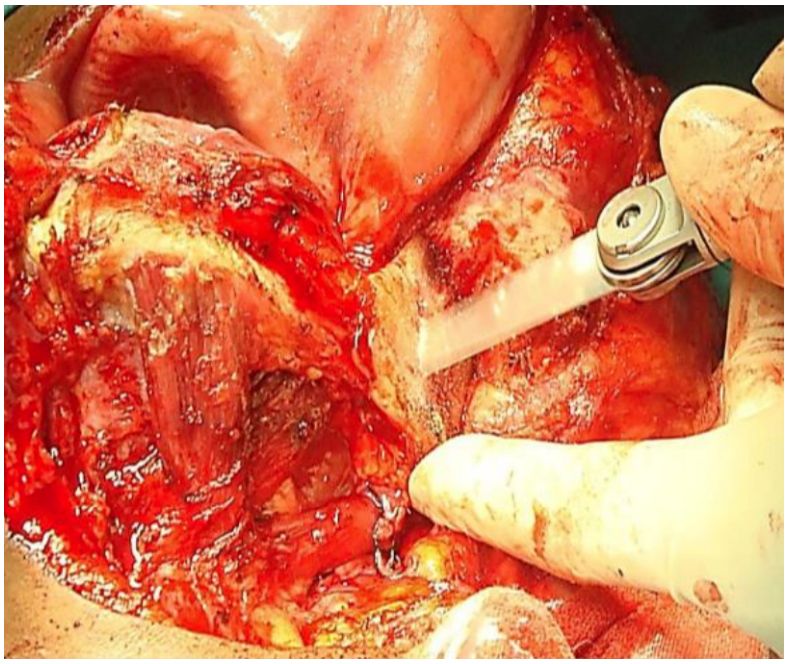


Figure 36: Osteotomy with oscillating saw

Inspect the tumor, and decide as to whether marginal, segmental or hemimandibulectomy is required to obtain clear margins and then plan the osteotomies. Use an oscillating/reciprocating saw or a Gigli saw for the osteotomies (*Figure 36*). Beware of the close proximity of the external carotid artery and its branches to the vertical ramus when making the osteotomies (*Figures 5, 11*).

With segmental mandibulectomy in dentate patients one should preplate the mandible with a reconstruction plate to ensure accurate repair and perfect dental occlusion.

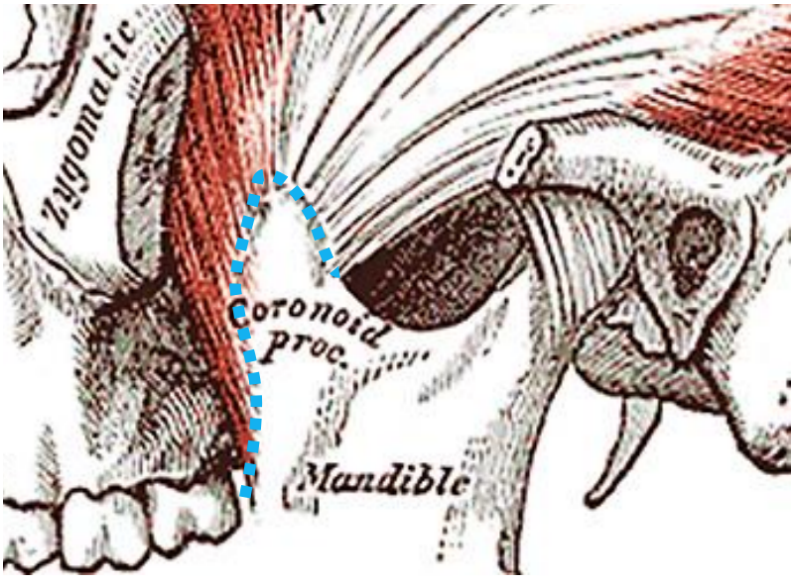


Figure 37: Broken blue line indicates where insertion of temporalis muscle is freed with cautery

To resect the ***coronoid process***, strip the masseter off the entire length of the vertical ramus, identify the mandibular notch, and while pulling caudad on the mandible, free the insertion of the temporalis muscle from the coronoid with cautery, keeping close to bone throughout to avoid blood vessels situated medially; this step is simpler if the distal osteotomy has already been done (*Figure 37*).

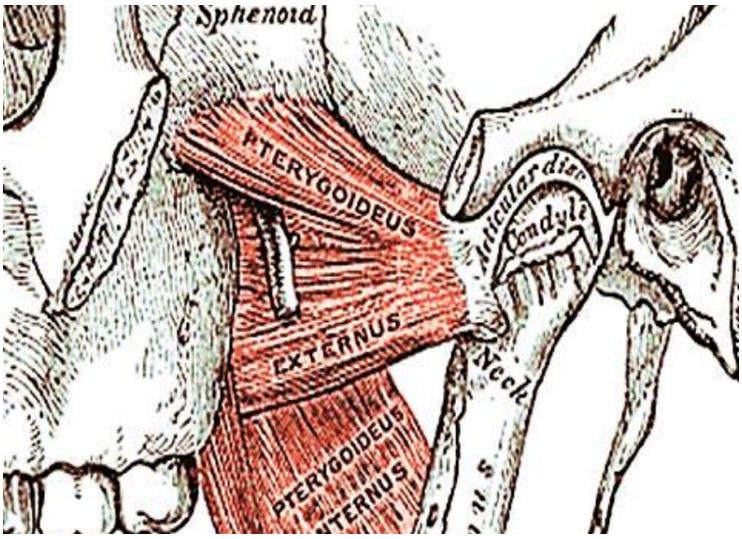
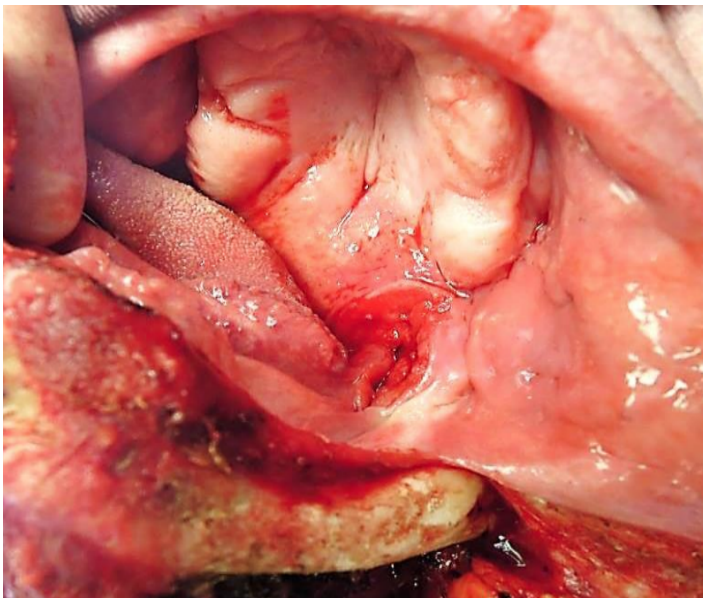


Figure 38: To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule

It is generally not necessary to resect the ***condyle***; rather carefully transect the condylar neck bearing in mind the proximity of the internal carotid artery. To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule (*Figure 38*).

Tumor resection


Figure 39a: Cancer of the tonsil fossa, soft palate & BOT fully exposed

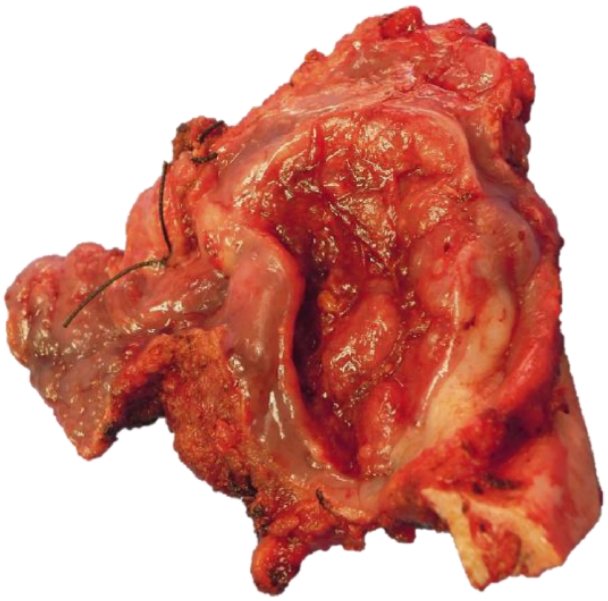


Figure 39b: Marginal mandibulectomy with cancer attached

With adequate exposure, resecting the tumor is generally quite straightforward using electrocautery (*Figures 39 a, b*). The surgeon must remain aware of the locations of the internal and external carotid arteries; palpating the styloid process is useful as the internal carotid artery lies medial to the bone.

Orientate the tumor for the pathologist with a silk suture (*Figure 39b*); obtain frozen section of the margins if available.

Repair / Reconstruction

Obtain meticulous hemostasis using ties, monopolar and bipolar cautery before closing the defect.

The ***lip*** is carefully repaired in layers to approximate the muscles as well as mucosa and skin.

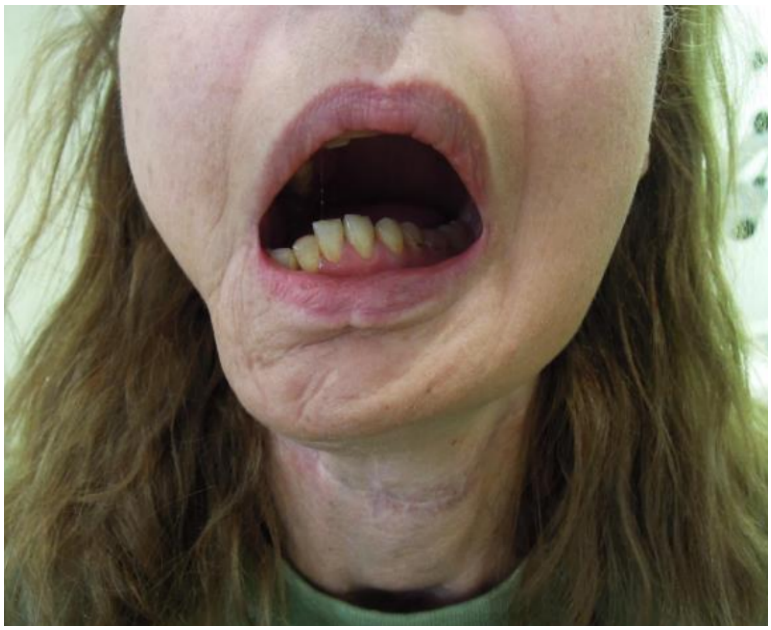


Figure 40: Missing lateral mandibular segment causes mandible to “swing” towards the side of the resection

The ***pharynx*** is a complex functional unit. Whether and how to repair or reconstruct oropharyngeal defects requires that a surgeon critically follows his/her patients and learns from successes and failures. Poor repairs and reconstructions cause hypernasal speech and nasal regurgitation. Failure to reconstruct a lateral mandibular segmental defect (allowing mandible to “swing”) may have significant cosmetic and functional consequences (*Figure 40*).

Healing by secondary intention is not utilized frequently enough with BOT resections, but is of course commonly employed with tonsillectomy, TLM and TORS.

Primary closure of BOT defects yields the best swallowing results, although inadequate bulk impairs speech if the BOT cannot approximate the soft palate. Primary closure of palatal defects may cause hypernasal speech and nasal regurgitation.

Pedicled and free tissue transfer flaps may be used to reconstruct oropharyngeal defects. Simply shaping a flap to match the resected tissue may well restore form yet have a poor functional result. Therefore, one must carefully assess the defect to determine how best to optimize function.

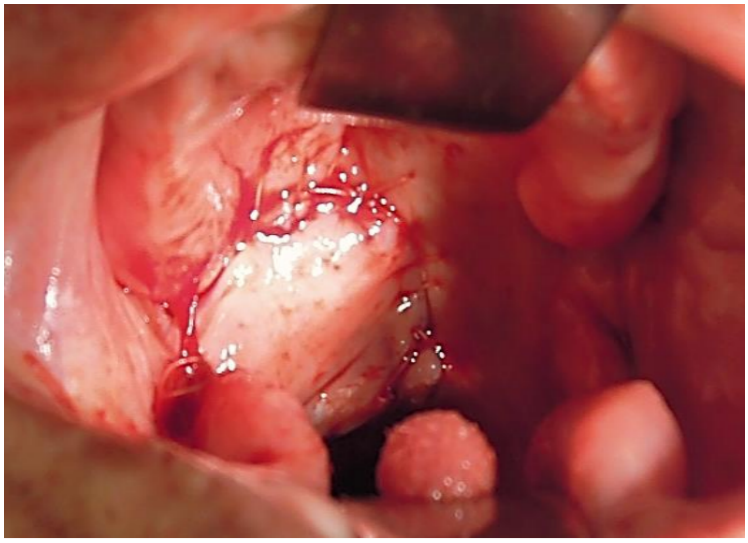


Figure 41: Buccinator myomucosal flap used to restore soft palate and tonsil fossa defects

Buccinator myomucosal flap: (See chapter: Buccinator myomucosal flap) A posteriorly-based buccinator flap can be used to repair defects of the soft palate, lateral pharyngeal wall and BOT. It is an excellent choice as it has the same physical qualities as tissues of the oropharynx, has a reasonable amount of bulk, and preserves mobility (*Figure 41*).

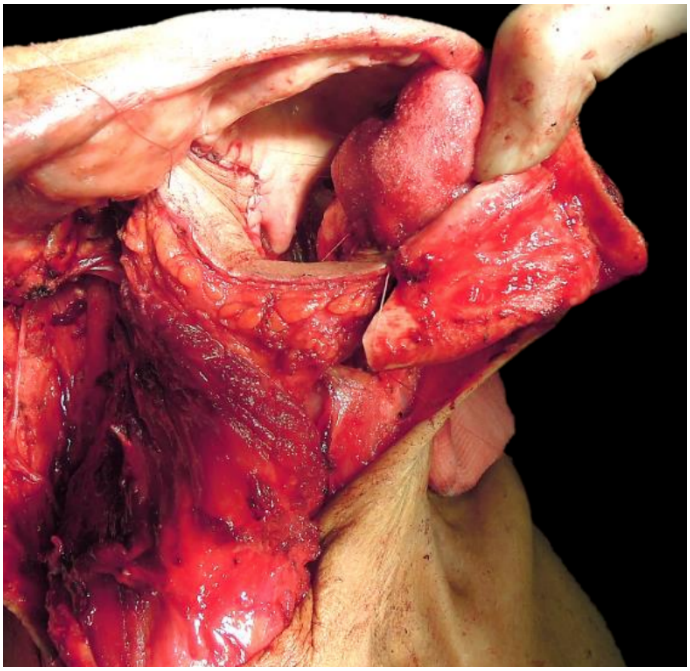


Figure 42: Pectoralis major flap used to reconstruct an oropharyngeal defect and to fill in the bony defect of a segmental mandibulectomy

Pectoralis major flap: (See chapter: Pectoralis major flap) Although this is a reasonable option to use, it may drag down on the soft palate causing palatal incompetence. It is a useful soft tissue filler of a lateral segmental mandibular defect (*Figure 42*).

Buccal fat pad flap: (See chapter: Buccal fat pad flap) This is a useful flap to cover exposed mandible or maxillary bone, or to augment a thinned out soft palate, or to close a small soft palate defect.

Temporalis muscle flap: (See chapter: Temporalis muscle flap) This is commonly used in some centers for oropharyngeal defects. The muscle is pedicled on the coronoid process which is immediately adjacent to the oropharynx. It requires that the deep temporal arteries be preserved.

Other pedicled flaps to consider are the Submental artery island flap and Supraclavicular flap



Figure 43: Soft palate and lateral pharyngeal wall reconstruction with RFFF

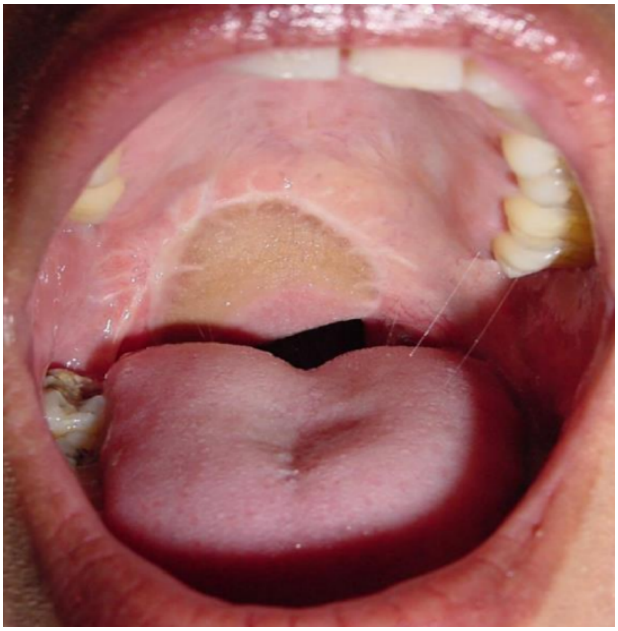


Figure 44: Soft palate reconstruction with RFFF

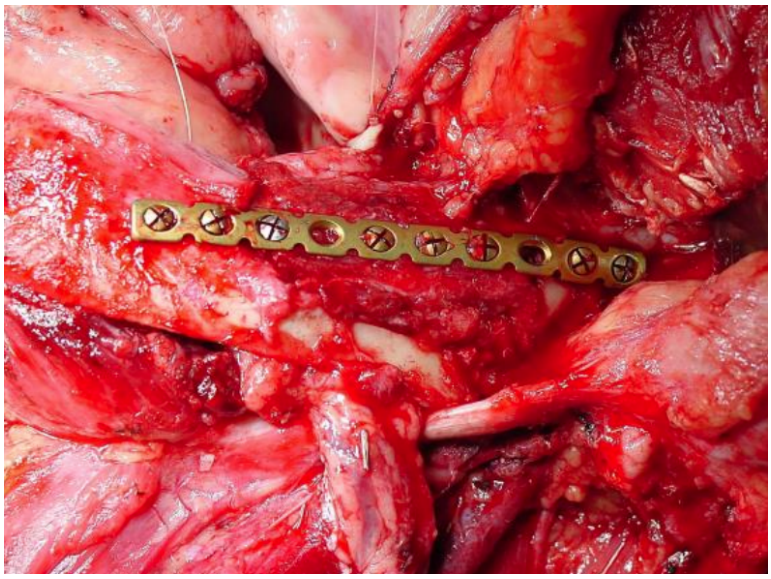


Figure 45: Marginal mandibulectomy with onlay radial osseocutaneous flap

Radial free forearm flap (RFFF): (See chapter: Radial free forearm flap) This is a thin, pliable flap and is therefore an excellent option for oropharyngeal repair (*Figures 43-45*). It can also be used as an onlay osseocutaneous flap following marginal mandibulectomy.

Anterolateral free thigh flap: (See chapter: Anterolateral free thigh flap) Muscle harvested with the flap can be tailored to conform to the volume of the defect to be filled. However, it is less pliable than the radial free forearm flap and is therefore less suited to soft palate reconstruction.

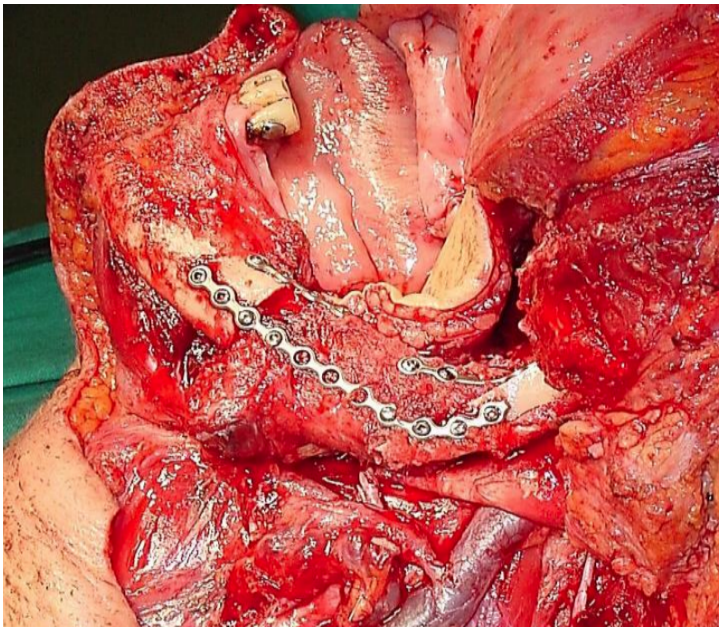


Figure 46: FFF graft following segmental mandibulectomy; skin of leg used to reconstruct oropharynx defect

Free fibula flap (FFF): (See chapter: Vascularized free fibula flap). This is the workhorse flap for patients requiring reconstruction of mandible (*Figure 46*).

Postoperative management

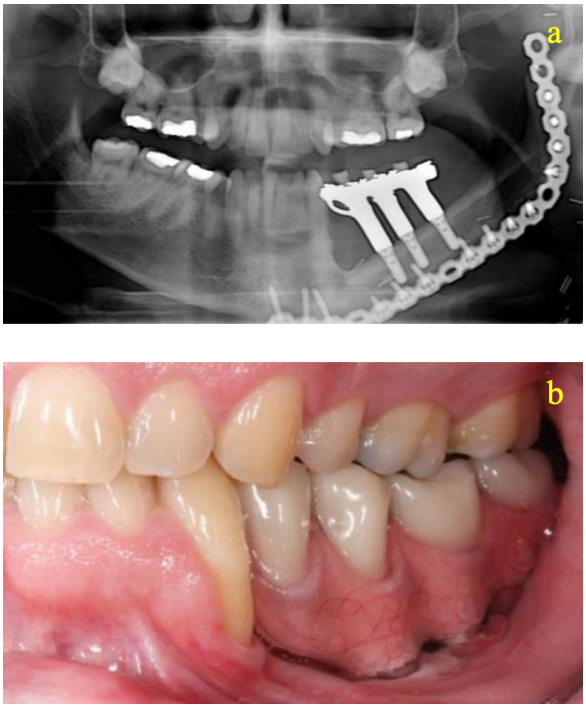
- ***Antibiotics*** are administered for 24hrs
- A ***temporary tracheostomy*** is done; once the airway appears adequate, an uncuffed tracheostomy tube is inserted, the tracheostomy tube is corked for 24hrs and if tolerated, is removed
- A ***nasogastric feeding*** tube is inserted; oral feeding is commenced on Day 5

- ***Suction drains*** are removed when drainage is <50mL/24hrs



Figure 47: Palatal prosthesis

- ***Prosthetic devices*** can be used to correct palatal incompetence (*Figure 47*)
- ***Dental rehabilitation*** may involve new dentures or implants (*Figures 48a, b*)



Figures 48a, b: Dental implants and rehabilitation following FFF reconstruction

Final comments

Resecting tumors of the oropharynx is challenging particularly in terms of access and optimizing swallowing and speech. One should not compromise resection margins for function. The surgical team must master an array of surgical approaches and reconstructive techniques to ensure the best oncological and functional outcomes.

Author and Editor

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town

Cape Town, South Africa
johannes.fagan@uct.ac.za

Author

Eugene N Myers MD, FACS, FRCS Edin (Hon)
Distinguished Professor & Emeritus Chair
Department of Otolaryngology Eye and Ear Institute, Suite 519
200 Lothrop Street
Pittsburgh, PA 15213, USA
myersen@upmc.edu

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- Buccinator myomucosal flap
- Buccal fat pad flap
- Temporalis muscle flap
- Submental artery island flap
- Supraclavicular flap
- Radial free forearm flap
- Free fibula flap
- Anterolateral free thigh flap

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