3 Significance of Anatomical Versus Surgical Landmarks in Head and Neck Surgery

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3.1 Introduction

Head and neck surgery entails multiple procedures involved with important structures of the head and neck region. The organs for breathing, hearing, taste, vision, and swallowing all reside in the head region. In the neck, there are multiple neural and vascular structures that are at significant risk during surgery. This includes the lower four cranial nerves, carotid artery, internal jugular vein, larynx, oesophagus, thyroid glands, and so forth. In order to perform an effective and safe surgery while minimizing the morbidity, an operating surgeon should have a sound anatomical knowledge as well as refined surgical skills. In addition, the availability of instruments and proactive communications with staffs would facilitate an efficient surgery (Fig. 3.1). Inadvertent injury to aforementioned critical structures could lead to serious and fatal complications. The availability of imaging tools like CT scan (Fig. 3.2) and other diagnostic optical endoscopy allows surgical mapping that would minimize surgery-related morbidity.

A variety of methods are available to enhance the anatomical knowledge of young trainee and junior surgeons practising in head and neck surgery. These range across cadaveric dissection, simulation training, head and neck online courses, and many more. An efficient way to consolidate anatomical knowledge and to link this awareness for better understanding of head and neck surgery is the new interdisciplinary hands-on course [1]. The 3D simulation cadaveric dissection is probably the best way, as the head and neck's detailed anatomical structures could be mapped on virtual reconstructive models. This will facilitate greater understanding of relevant surgical landmarks during the dissection process.

The neck region is a compartmental area with superficial and deep layers of fasciae dividing the region into many small spaces. All of these spaces have clinical and surgical importance. The deep space of the neck is crucial as multiple pathologies such as infection, tumour spread, neck node metastasis, and spread of disease could occur inside these spaces (Table 3.1). For example, the poststyloid compartment of the parapharyngeal space is well known for the occurrence of pleomorphic adenoma of the deep lobe of parotid glands and paragangliomas that originate from the last four cranial nerves or those that arise from sympathetic fibre that overlies the carotid wall. Surgical access to parapharyngeal space is

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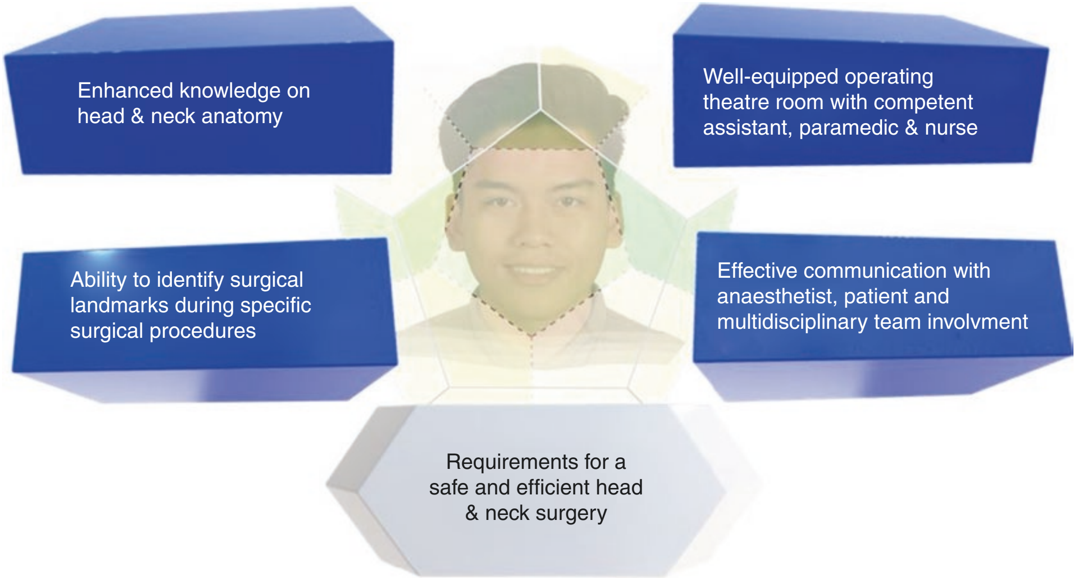


Fig. 3.1 Determining factors for a safe surgery

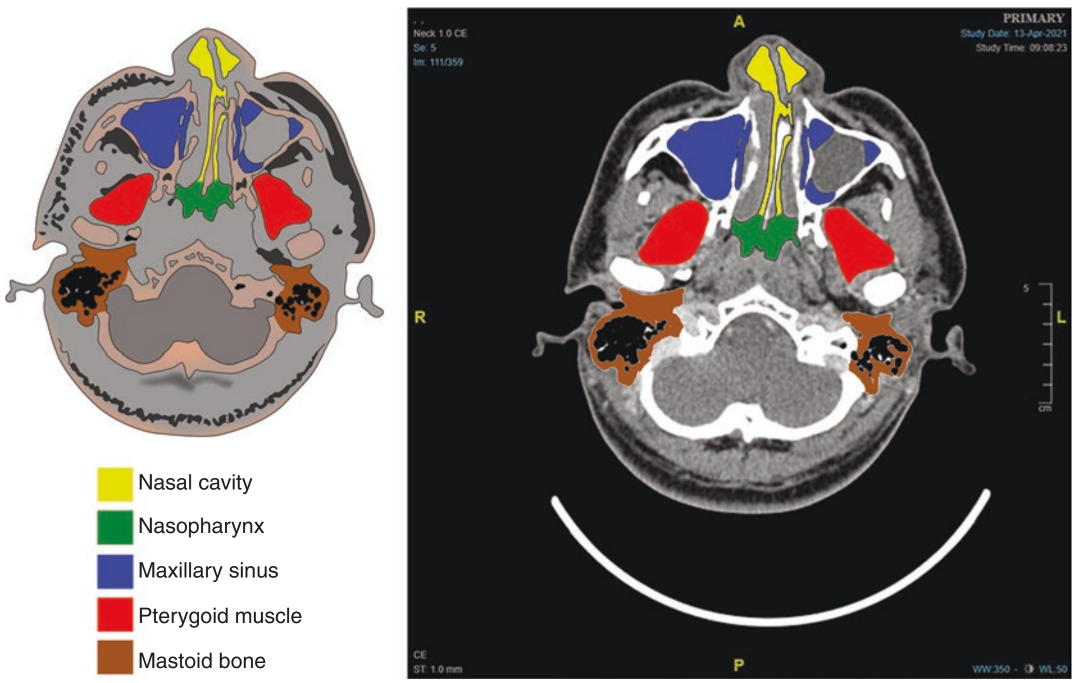


Fig. 3.2 Identification of the structures visualized in the CT scan images such as nasopharynx, pterygoid muscle, maxillary sinus, nasal cavity, mastoid air cells, and adjacent critical structures is vital for preoperative surgical mapping

Table 3.1 Clinical importance of deep spaces of head and neck region

	Deep spaces of head and neck	Clinical and surgical importance
1.	Parapharyngeal space	• Paraganglioma and deep lobe pleomorphic adenoma originate from this space • Abscess formation
2.	Retropharyngeal space	• Collection of abscess and infection • Origin of deep neck infection (DNI) • Nodes of Rouviere/ retropharyngeal nodes impact prognostication of NPC
3.	Danger space	• Spaces posterior to retropharyngeal space • At risk of airway obstruction in extensive cases
4.	Prevertebral space	• Indicative of inoperability if tumour infiltrated this space
5.	Carotid space	• Contains the neck nodes especially on the IJV wall, at risk of neck metastasis recurrence
6.	Submandibular space	• At risk of infection like Ludwig's angina, and in severe cases can cause airway obstruction
7.	Masticator space	• Tumour spread

technically challenging and requires a thorough knowledge of the anatomical and surgical landmarks of these spaces. In addition, a meticulous surgical technique is necessary during dissection with regard to the preservation of the delicate neurovascular structures and its relation to the adjacent tissues, so that complications could be avoided.

The surgical plane is a plane of dissection which is used in relation to the tissues and organs, so that the normal structures can be preserved. In the surgery of malignant mass, the intention is to excise a tumour, leaving the muscles and the neurovascular tissues that are not affected by the tumour intact. In the majority of cases, if the dissection continues in a correct plane, severe tissue damage is avoided, and bleeding can also be minimized. If the surgeon loses the surgical planes during surgery and lacks the detailed knowledge of anatomical structures of the related organs, the vessels, nerves, muscles, and other organs might be injured. Consequently, the risk of surgery will be higher. Many critical tumours are located in the head and neck and need to be addressed according to the principle of oncologic surgery. Therefore, surgeons should have a thorough knowledge of this critical region's surgical anatomy so that the tumour can be excised with free surgical margins and without compromising the adjacent structures. Of note, an inexperienced junior surgeon with fear of causing damage to important structures may lead to inadequate surgical treatment efficacy, with a consequent risk of tumour persistence or recurrence [2].

Fig. 3.3 Skin incision and landmarks have been drawn for a bilateral selective neck dissection. The landmarks include sternocleidomastoid muscle (scm), mandible (m), external jugular vein (ejv), and outline of skin incision (sil)

During a neck surgical procedure, for instance a bilateral selective neck dissection for a tongue carcinoma, the surgeon should identify the landmarks of the neck structures which are ideally marked with a marker pen, before starting a skin incision (Fig. 3.3). This is a good practice in order to orientate the structures or tumoural mass dissection, so as to avoid the unnecessary bleeding or iatrogenic injury to neural structures.

In head and neck surgery, the subplatysmal flap is the simplest flap that is ideal for an illustration for a teaching purpose, especially to the junior trainees in head and neck surgical oncology practice for attaining a right plane of dissection during the surgery. In fact, it is a cornerstone flap for access and removal of significant neck

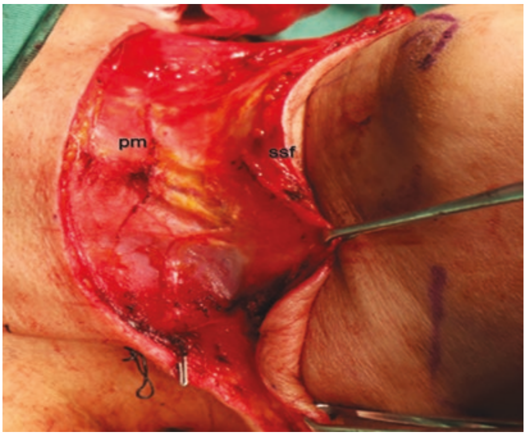


Fig. 3.4 A subplatysmal skin flap (ssf) is raised and reflected superiorly. The thicker the flap, the better it is for flap vascularization in order to avoid flap necrosis. The distal end of cut platysma is also shown (pm)

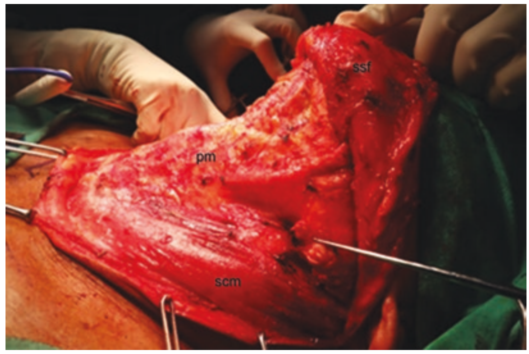


Fig. 3.5 A subplatysmal skin flap (ssf) is raised exposing the sternocleidomastoid muscle (scm) and tissue at levels I, II, III, and IV. This is the extent of exposure required in selective neck dissection. The SCM is retracted laterally, in order to dissect the fibrofatty tissue and fascia overlying IJV (levels II, III, and IV). The distal end of cut platysma is also shown (pm)

tumours such as thyroid tumour, laryngeal cancer, and neck node metastases; submandibulectomy; and most of the excision of the pathology of neck region. All of these surgical procedures require the elevation of subplatysmal flap. Platysma is a superficial thin muscle that spans from the inferior border of mandible to clavicle. It criss-crosses the sternocleidomastoid muscle (SCM) and is deficient at the anterior and posterolateral parts of the neck (Fig. 3.4). The vascular supply to the flap is through the submental artery, a branch of facial artery, and suprascapular artery, a branch from thyrocervical trunk. The thicker the flap, the better the vascular supply, hence less risk of developing flap necrosis.

Further dissection and skeletonization of the anterior border of SCM are required, so that it can be retracted laterally, thus exposing the carotid sheath. The dissection overlying the internal jugular vein (IJV) and carotid artery equates level II, III, and IV neck dissection (Fig. 3.5). The assistant nurse or surgeon should retract the mandible superiorly with a cold instrument, while the surgeon applies traction inferiorly on the dissected mass (Fig. 3.6). This technique of countertraction and traction will facilitate neck dissection effortlessly.

The knowledge of anatomy and function of the nerves that innervate neck muscles may enable surgeons to avoid inadvertent injury. For example,

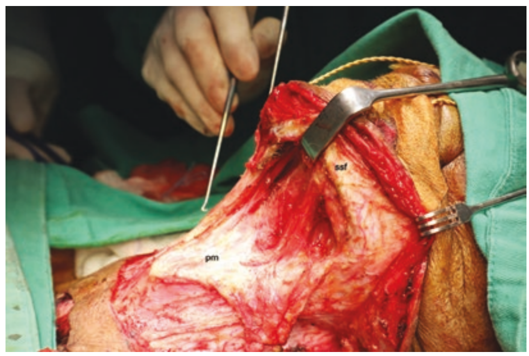


Fig. 3.6 Mandible is retracted with the assistance of a nurse or surgeon to facilitate efficient dissection of fibrofatty tissues and neck node metastases. A good traction and countertraction allow a quick dissection and will shorten the operating time

ansa cervicalis is a loop of nerve that arises from cervical plexus, which lies superficial to the internal jugular vein in the carotid triangle. It is the nerve that innervates the sternohyoid, sternothyroid, and omohyoid muscles. Lesion to this nerve would result in paralysis of these muscles. In addition, the cervical plexus also gives rise to the cutaneous nerves of the neck, which are located superficially on the lateral neck muscles, namely the great auricular, posterior auricular, transverse cervical, and supraclavicular nerves. Lesion to any of these would result in paraesthesia to the skin areas supplied by the respective nerves.

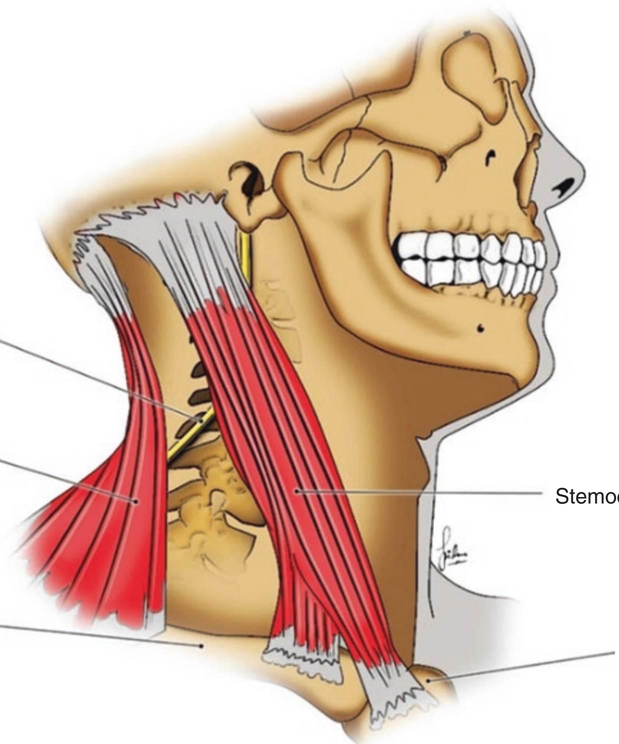


Fig. 3.7 The course of the spinal accessory nerve (SAN) in the posterior triangle or level V is critical for neck dissection. SAN exits at upper two-thirds at the posterior border of SCM and enters the anterior border of trapezius at 5.0 cm above the clavicle. The landmarks for identification of SAN are C2 vertebrae and Erb's point

Another important nerve in the posterior triangle which is of importance is the spinal accessory nerve (SAN). The SAN lies 1–2 cm superior to the exit point of cutaneous nerve branches from cervical plexus at the posterior border of SCM. This nerve runs in the posterior triangle of the neck or level V crossing the carotid sheath, SCM, and trapezius muscle in 45° angles (Fig. 3.7). Several landmarks are being used to identify the SAN. These include

1. Erb's point
2. SCM
3. Trapezius muscle
4. Transverse process of C2 vertebra

These landmarks allow the identification and preservation of SAN during neck dissection at level V region, as this nerve is located superficially (Table 3.2). Injury and traction of the SAN cause significant morbidity like frozen shoulder syndrome, which is characterized by limited arm abduction, painful scapular region, and inability to shrug the shoulder.

In the head and neck region, there is an extensive anastomotic network of the lower cranial nerves. The understanding of the neural intercommunications of the skull base is vital in diagnosing and treating patients with pathology in this critical area [3]. Facial nerve, hypoglossal nerve, and vagus nerve are particularly important nerves that need to be recognized and preserved during the surgery. Injury to these nerves or inadvertent denervation during aggressive dissection causes significant morbidity to patients as these nerves are involved in many critical functions of the facial-neck complex, such as mastication, swallowing, speech, and facial expression. Awareness of the anatomy of these neural connections would be especially useful in facial reconstructive sur-

Table 3.2 Surgical landmarks of the spinal accessory nerves, cranial nerve XI

	Surgical landmarks for SAN (CNXI)	Description
1.	Erb's point	The exit point of cutaneous nerve branches from cervical plexus at the posterior border of SCM. The SAN lies 1–2 cm above this point
2.	Transverse process of cervical vertebra	The SAN can be palpated over the transverse process, at level IIB neck as the nerve runs over this vertebra
3.	Sternocleidomastoid muscle	The SAN pierces through this muscle at its superior one-third. It may also lie deep to this muscle
4.	Trapezius muscle	The SAN runs 5 cm above the clavicle at the anterior border of trapezius, before piercing and supplying the muscle
5.	Great auricular point	The point of exit of great auricular nerve at the posterior border of sternocleidomastoid muscle. The SAN lies 1–2 cm above this point

gery, neck dissection, and various nerve transfer procedures as well as in understanding the pathophysiology of various cranial, skull foundation, and neck disorders [4]. Hypoglossal nerve injury leads to tongue atrophy, fasciculation, and deviation of the tip of the tongue. Vagus nerve injury causes hoarseness of voice and aspiration, whereas facial nerve injury causes facial asymmetry. All of these complications will indefinitely impair the patient's quality of life.

3.2 Importance of Surgical Landmarks

The knowledge on the anatomical and surgical landmarks will assist surgeons to perform the surgery with most minimum complication as possible. During the surgery, dissection is started with the designing and drawing of the skin incision together with other landmarks. For instance, during a tracheostomy, a skin incision drawing is placed at 2.0 cm above the sternal edge. In addition, the cricoid, thyroid, and hyoid cartilage locations are also identified and drawn. This is to ensure that tracheostomy is performed in the midline, thus avoiding the crucial vascular structures such as the carotid artery and the laterally positioned IJV in the carotid sheath. A correct technique of tracheostomy would also prevent the development of post-surgical stenosis, which is due to the recurrence and would be very debilitating.

During the skin incision, surgeons need to anticipate the fascial layer of the neck that would be encountered during the procedure. The superficial cervical fascia is encountered right after the elevation of platysma muscle. The pretracheal fascia layer is the next layer to be incised, exposing the strap muscles. Deep to the strap muscles is the thyroid gland, which needs to be retracted superiorly. Once thyroid gland is retracted, the tracheal ring could be easily palpated and visualized. So, in essence, by knowing the order of the structures of the neck from superficial to deep, it would facilitate a safe dissection and minimize complications such as active bleeding, muscle injury, or nerve transection. The ability to visualize the superficial musculoaponeurotic system and its relationship to crucial neurovascular structures allows surgeons to plan the operation and minimize post-operative complications [2]. As the surgical procedure is performed, crucial neural structure injury should be avoided as it can have a significant impact on patient's functions like swallowing, speech, breathing, and facial expression.

In addition, superficial skin lesion and its related surgery should also be performed with a sound knowledge of anatomical landmarks. Most skin surgical procedures are performed in sun-damaged areas of the face and head because of the development of skin tumour like basal cell carcinoma and malignant melanoma. Surgeons or dermatologists should have a very good knowledge of the important layers of epidermis, dermis, and hypodermis in these areas so that they can perform an aesthetically safe skin surgical procedure.

3.3 Thyroid Surgery and Related Surgical Landmarks

The thyroid mass surgery is one of the most common neck pathologies that are managed by the ear, nose, and throat (ENT) surgeon in selected centres. The surgical management of thyroid tumour is critical as it is involved with the preservation of the recurrent laryngeal nerve (RLN), which innervates the intrinsic muscles of the larynx (except the cricothyroid muscle). The mobility of vocal cord is crucial for the normal voice production. Injury to the RLN will impair the vocal cord mobility, hence resulting in hoarseness of voice. This impairs patient's effective communication and quality of life.

In the identification and safe dissection of the RLN, sufficient knowledge of its surgical anatomy, clinical experience, and meticulous surgical techniques are key factors. The RLN can be identified during a thyroidectomy using four different approaches, depending on the type of thyroid growth and the surgeon's choice. These approaches include the lateral, inferior, superior, and medial approaches [5]. It depends on the surgeon's preference and intraoperative findings in choosing the type of surgical approach. The surgical landmarks that are commonly used during thyroid surgery include the laryngeal cartilages such as the thyroid, cricoid, hyoid bone, and also trachea. The easily palpable parts of laryngeal cartilages are, for instance, the inferior cornua of the thyroid cartilage, the thyroid cartilage inferior tubercle, and the most anterior portion of the cricoid cartilage arch. These palpable landmarks have been recognized as critical landmarks during thyroid surgery (Fig. 3.8). Of note, the distances between these structures and the RLN entry point on the medial aspect of the cricoid cartilage arch have been recognized as a landmark for the identification and preservation of recurrent laryngeal nerves [6].

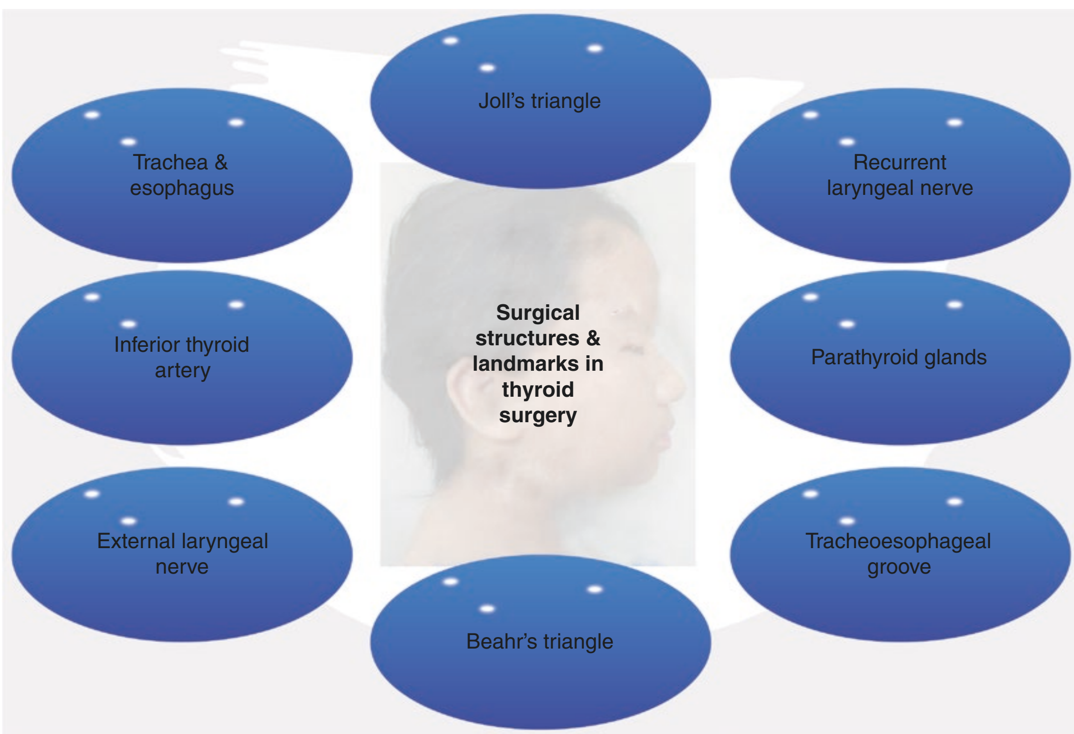


Fig. 3.8 The critical structures encountered during a thyroid surgery

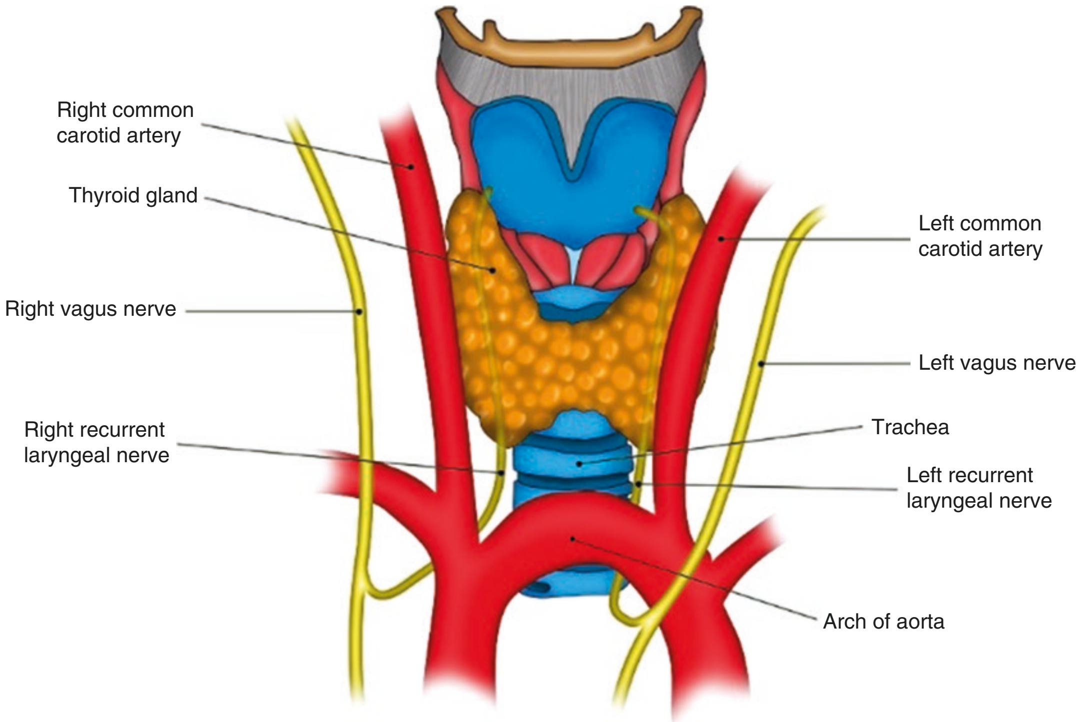


Fig. 3.9 Anatomical relationship between vagus nerves, recurrent laryngeal nerves, arch of aorta, right subclavian artery, common carotid arteries, and thyroid glands

The anatomical course of the RLN is different between the right and the left sides of the neck. At the point where the brachiocephalic artery is divided into two branches, the right RLN, which arises from the vagus nerve, rotates backwards around the right subclavian artery and advances towards the tracheoesophageal groove after passing the trachea at an angle of 15–45° posterior to the carotid artery. While on the left neck, at the level of the ligamentum arteriosum, the left RLN branches out from the vagus nerve, turns posteriorly from the anterior aspect of the aortic arch, and reaches the tracheoesophageal groove from the medial side of the left common carotid artery (Fig. 3.9) [5].

The inferior thyroid artery (ITA) is one of the important structures associated with the RLN. In majority of the cases, the RLN is located anterior or posterior to ITA, or passes within its branches. After passing the ITA level, the RLN usually follows the same anatomical route on both sides, and next runs close to the Zuckerkandl tubercle (ZT) and the Berry's ligament. The Berry's ligament is encountered when the dissection is performed posterior to the thyroid glands. The risk of RLN injury in this area of Berry's ligament is very high [5]. The surgical procedure in thyroid surgery is illustrated in Figs. 3.10, 3.11, 3.12, and 3.13.

During the thyroid surgery, other important neural structures are also at risk. In addition to the recurrent laryngeal nerve (RLN), protection must be provided to the external branch of the superior laryngeal nerve (EBSLN) [7]. This EBSLN supplies the cricothyroid muscle, which tenses vocal cord. This is particularly crucial for a professional voice user like singer, teacher, and tutor. The entry point of the EBSLN into the muscle is usually 1.1 mm from the insertion of the sternothyroid into the oblique line of the thyroid cartilage and 5–12 mm from the muscle's anterior border. There is a classification system by Cernea et al., which highlights the course of the external laryngeal nerve in relation to the upper lobe of the thyroid glands. Ideally, the superior

Fig. 3.10 Important landmarks should be marked before the first skin incision in order to orientate the critical structures that need to be addressed safely during the surgery. Outline of the mass is in dotted lines (big arrow), skin incision (star), anterior border of SCM (small arrow), and hyoid bone (hb)

Fig. 3.11 A midline thyroid mass is visualized on lateral inspection

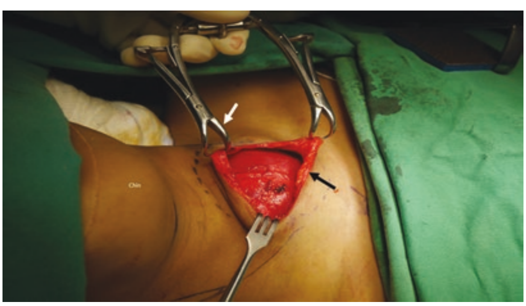


Fig. 3.12 A subplatysmal skin flap has been raised (black arrow), and the strap muscle overlying the thyroid mass is exposed. Classically, the skin flap can be retracted with a Joules retractor (white arrow) or an assistant with a cold retractor instrument

Fig. 3.13 Thyroid mass has been removed exposing the trachea (T). The sternocleidomastoid muscle is visible on either side of the neck, left SCM (L SCM) and right SCM (R SCM)

Fig. 3.14 Intraoperative neural monitoring in thyroid gland surgery is vital for preservation of the recurrent laryngeal nerve. The ground electrode (star) and the electric lead inserted to the intubation tube (arrow) are secured

thyroid artery should be ligated 1.0 cm away from the upper pole of thyroid gland to avoid injury to EBSLN. Before ligating the superior thyroid vessels, these useful landmarks enable the nerve to be consistently located, identified, and preserved during thyroid surgery [8]. Thus, a meticulous dissection needs to identify and preserve these nerves.

In addition to visual identification, the intraoperative neural monitoring (IONM) (Fig. 3.14) is able to assist surgeons to better identify the nerves, both the RLN and ESBLN. The use of IONM application can functionally locate the EBSLN so that muscle twitch, i.e. the cricothyroid muscle, is a reliable evidence of the EBSLN’s functional integrity. In the majority of patients, activation of the EBSLN causes a recordable motor response [7]. Additionally, in order to identify these nerves, a meticulous dissection technique and diligent assistant are crucial for a safe conduct of the surgery (Fig. 3.15).

Fig. 3.15 The right recurrent laryngeal nerve (star) is seen at the tip of the nerve probe (white arrow)

3.4 Salivary Gland Surgery and Surgical Landmark

Salivary gland surgery is another critical head and neck surgery as it involves the facial nerve. The facial nerve and its branches supply the muscle of facial expression. Injury to the nerves will result in facial asymmetry with impairment of facial expression. This results in dysfunction of social integration and affects patient's quality of life (Figs. 3.16 and 3.17).

The facial nerves and its branches have great variation in their anatomical details. Thus, the surgeon needs to be well versed with the facial nerve anatomical variation and relation to the adjacent structures (Fig. 3.18). This is especially in relation to the facial nerve trunk identification, so that it

Fig. 3.16 One of the common salivary gland tumours is the parotid gland tumour (arrow)

will facilitate the identification and preservation of five main branches of the facial nerve (Fig. 3.18). In most of the cases, the trunk divides into two major branches, the upper cervical and lower cervical branch (Fig. 3.19). Indeed, the anatomy of facial nerve is highly delicate. It displays a highly variable and complex pattern of branching and forms interactions with several other cranial nerves. The facial nerve connects to branches of the trigeminal nerve including branches of the auriculotemporal nerve, buccal nerve, mental nerve, lingual nerve, infraorbital nerve, zygomatic

Fig. 3.17 On clinical examination, a parotid mass will characteristically displace the ear lobule anteriorly

nerve, and ophthalmic nerve [4]. Importantly, the five main branches of the facial nerve should be identified and preserved during any parotid gland's surgery, especially in benign cases.

Several landmarks are commonly used during the parotid gland surgery for the identification of facial nerve trunk and its branches. These include

1. Tragal pointer
2. Upper border of posterior belly of digastric
3. Tympanomastoid suture
4. Styloid process

Tragal pointer is the cartilaginous portion of the external auditory canal. The facial nerve trunk lies 1.0 cm inferior and medial to this pointer. The posterior belly of digastric muscle is an important landmark as the majority of neurovascular structures in the neck are located deep to this muscle. The facial nerve trunk lies about 0.5–1.0 cm above the upper border of the posterior belly of digastric muscle (Figs. 3.20, 3.21, 3.22, and 3.23).

Multiple connections exist between the facial nerve and other nerves in the head and neck

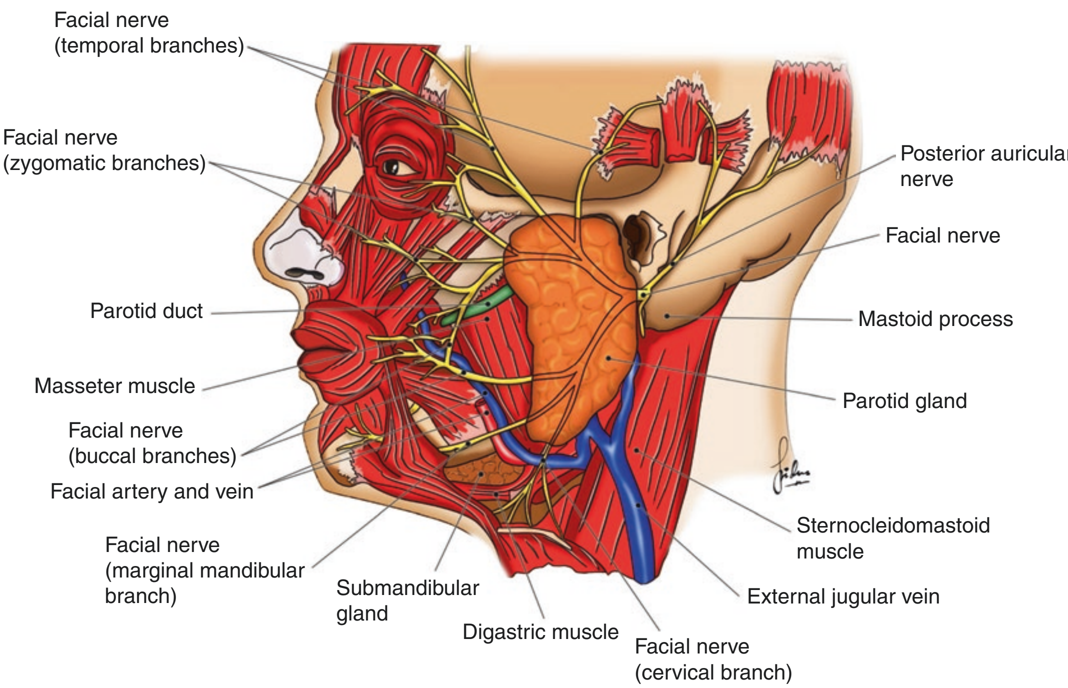


Fig. 3.18 The facial nerve anatomy in relation to parotid glands, EJV, SCM, masseter muscle

Fig. 3.19 The skin flap is retracted anteromedially (sf). The facial nerve trunk (fn) is divided into upper temporal and lower cervical branch. The substance of parotid gland (pg). Masseter muscle (mm) is visible below the lower branch

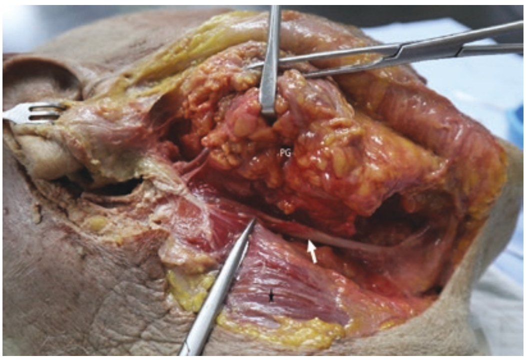


Fig. 3.20 Posterior belly of digastric muscle (arrow) is located deep to parotid glands (PG). This is a critical landmark during a parotid surgery as the facial nerve lies medial to this muscle. The sternocleidomastoid muscle is also shown (star)

Fig. 3.21 Facial nerve trunk (star) divides into two main peripheral branches. The masseter muscle (M) is visualized, and sternocleidomastoid muscle (arrow) is located more inferolaterally

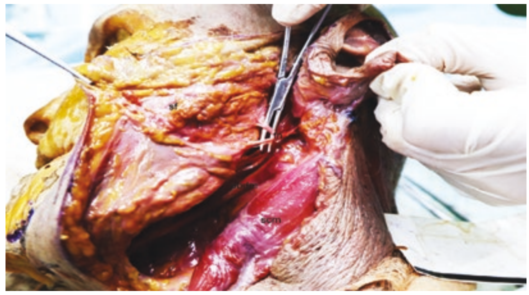


Fig. 3.22 Facial nerve trunk and its division (fn) are lifted with forceps. The posterior belly of digastric (pbdm) is seen deep to the sternocleidomastoid muscle (scm). Tragal pointer (TP) is shown where facial nerve trunk is located 1.0 cm deep and medial to the TP

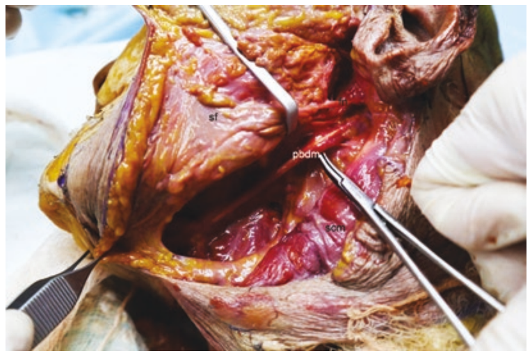


Fig. 3.23 Facial nerve trunk lies 1.0 cm superior and medial to the upper border of the digastric muscle (pbdm). The superficial lobe of parotid gland (sf) and sternocleidomastoid muscle (SCM) are also shown

region. During clinical examination and surgical procedures of the facial nerve, such connections may have significance [4]. This is in the form of assessing the nerve integrity and the possibility for reinnervation. If a branch is sacrificed during the surgery, there is still possibility of reinnervation especially if the nerve has multiple anastomoses with other nerves.

The auriculotemporal nerve is one of the many branches of the mandibular nerve. This nerve hitch-hikes the facial nerve branches and supplies the secretomotor fibres to the parotid gland. The aberrant regeneration of this secretomotor fibre from the parotid bed to the sweat glands will cause Frey's syndrome [9, 10]. Frey's syndrome is characterized by involuntary sweating on the cheek at the parotid bed region upon mastication and eating due to stimulation of the parasympathetic fibre that shares the same neurotransmitter, acetylcholine, which also innervates sweat glands.

Cheek contour deformity, gustatory sweating, and a visible scar on the neck are the three most common problems after a parotidectomy. The face-lift-type incisions that eliminate the neck incision and the temporoparietal fascia interposition at the parotidectomy site that fills the defect and provides a barrier to aberrant neuronal regeneration can potentially avoid these problems [11]. There are a variety of ways to prevent Frey's syndrome [12]. The incidence of Frey's syndrome may be decreased by intra-auricular modification of the facelift incision or by using a traditional lazy-S incision.

Additionally, this critical facial nerve anatomy is also related to facial rejuvenation surgeries [13]. Corrugator originates mainly from the medial supra-orbital rim followed by the medial frontal bone, the medial infraorbital rim, and the upper nasal process. Most of the corrugators are inserted into the middle of the eyebrow or the medial half of the eyebrow but also into the glabella region [13]. The frontalis muscle plays a major role in our everyday social experiences. As the only muscle that raises the eyebrows, its function goes beyond simply keeping the brows out of one's visual field. It is also necessary to convey emotions and non-verbal communication. The antagonist muscles of the frontalis muscle are the procerus muscle, the corrugator supercilii muscle, and the orbicularis oculi muscle [14].

To ensure a safe surgery, facial nerve stimulator is commonly employed during parotidectomy. There are four channels of nerve stimulator that can be applied to identify the main five branches of the facial nerve (Fig. 3.24). A modified Blair skin incision is used, and this will expose the parotid mass and the sternocleidomastoid muscle (Figs. 3.25 and 3.26). During skin flap elevation, care should be taken to identify the greater auricular nerve which lies superficial to the sternocleidomastoid muscle (Fig. 3.27).

Fig. 3.24 A four-channel facial nerve monitoring has been applied (star). The branches that are monitored are the frontalis (purple), orbicularis oculi (blue), orbicularis oris (red), and mentalis (orange)

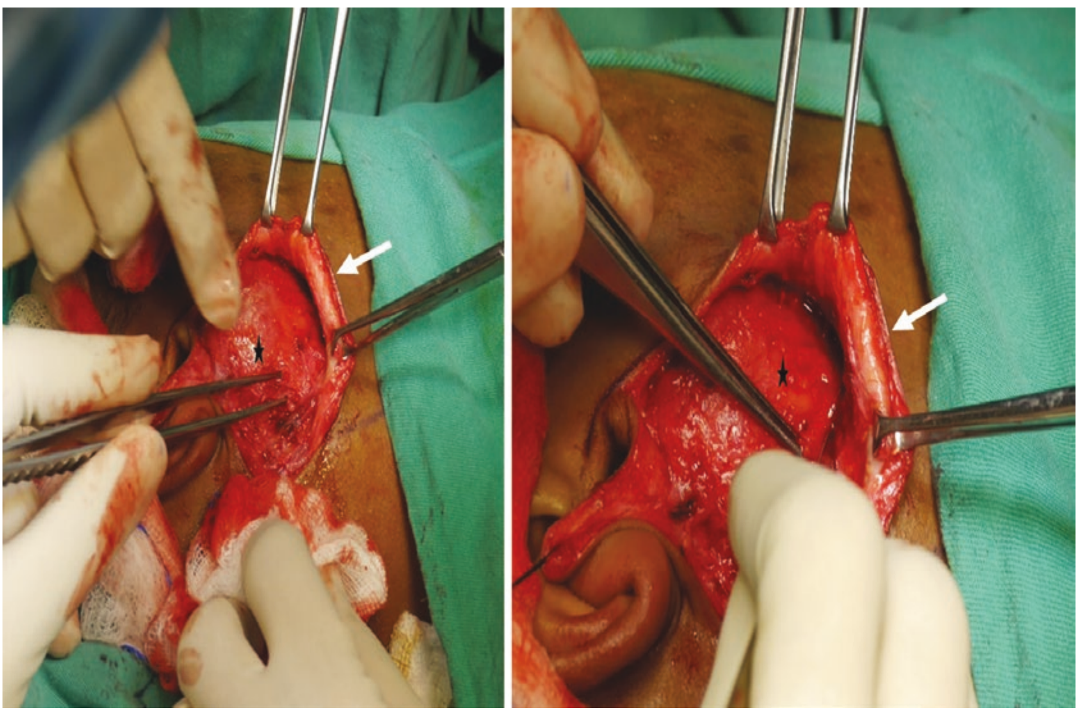


Fig. 3.25 A good traction on the skin flap (arrow) allows exposure of parotid tumour (star). This facilitates dissection around the tumour

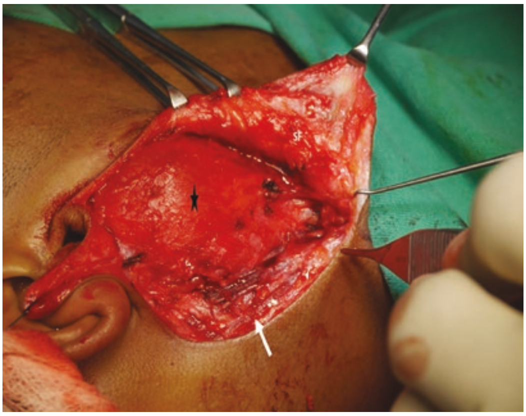


Fig. 3.26 The anterior border of sternocleidomastoid muscle needs to be skeletonized to expose the lateral margin of parotid mass (star). The skin flap (sf) is retracted to allow a good dissection

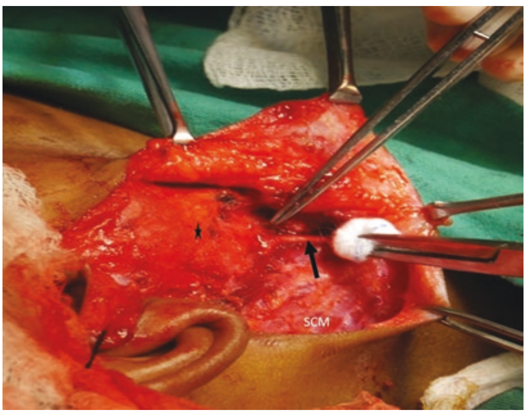


Fig. 3.27 A greater auricular nerve GAN (arrow) is visualized as it traverses superficial to sternocleidomastoid muscle (SCM) before entering the parotid capsule overlying the parotid tumour (star)

3.5 Oral Cavity and Oropharyngeal Surgery

Oral cavity is critical as it harbours many structures and is affected by significant pathology like squamous cell carcinoma. Pertinent consideration of the oral cavity and its subsites and adjacent structures is vital for a safe surgery. The subsite of oral cavity includes lip, teeth, gum, floor of mouth, tongue, buccal mucosa, hard palate, and retromolar trigone. The tongue is a highly muscular organ, composed of extrinsic muscle and intrinsic muscle, which form an easy route for spread of cancer. The adjacent mandible can be infiltrated by cancerous cell, especially in T3 and T4 tumours, which needs to be addressed with proper surgical excision, either marginal mandibulectomy, segmental mandibulectomy, or hemimandibulectomy.

The knowledge of precise course of the mandibular canal, from the mandibular foramen to the mental foramen, and its variations is necessary to perform dental implants and pre-implant surgery in selected cases of oral cavity pathology. Similarly, mandibular sagittal osteotomies are increasingly commonly performed and require optimal knowledge of intramandibular structures to improve the surgical approach to tongue tumour. If not performed correctly, mandibulotomy will result in serious sequelae that are challenging to treat especially in patients with medical comorbidity.

The soft-tissue characteristics can be assessed via an image-guided method like a narrowband imaging. This allows the detection of suspicious areas that are highly likely to be malignant [15] (Fig. 3.28).

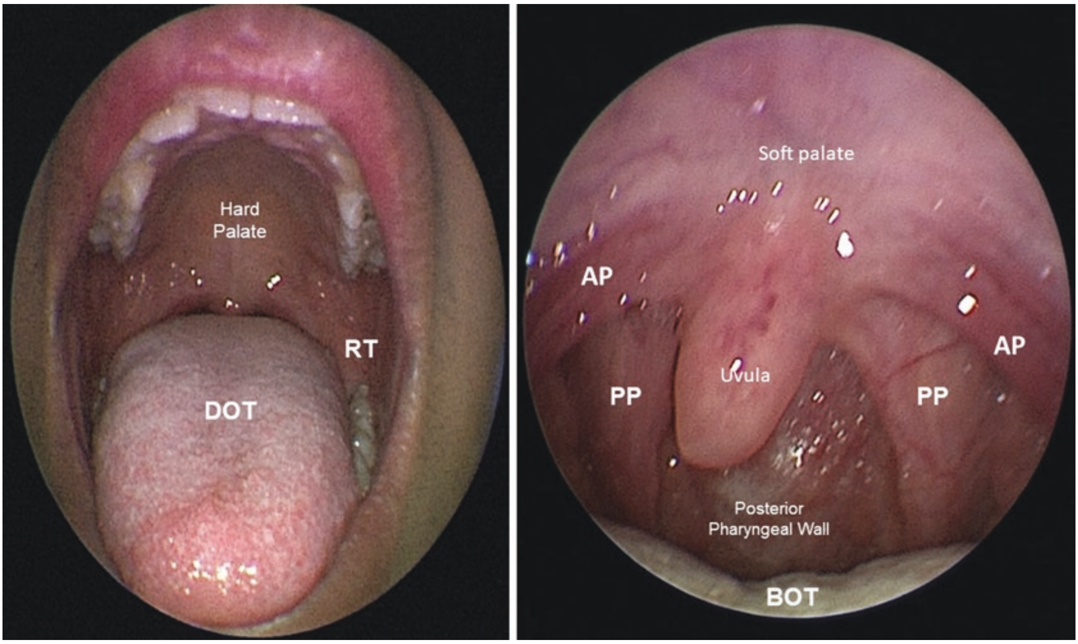


Fig. 3.28 The oral cavity and oropharynx structures are critical for tumour assessment and selected surgical approach. The dorsum of tongue (DOT), retromolar trigone (RT), and base of tongue (BOT) are the common sites for a malignant growth. Anterior pillar (AP) and posterior pillar (PP) harbour the tonsils, which can be affected by tonsillar carcinoma or lymphoma

3.6 Laryngeal and Pharyngeal Surgical Landmark

The laryngeal cartilage and structures play an important role in maintaining adequate airway, humidification, and vocalization. The major cartilaginous larynges are epiglottis, thyroid cartilage, cricoid cartilage, and trachea (Fig. 3.29). The other small cartilages make up the aryepiglottic folds like the cuneiform, corniculate, and arytenoid cartilage (Fig. 3.30). This cartilage is stabilized by muscles and ligaments (Fig. 3.31).

The physiological and anatomical function of larynx is based on a classification system. The larynx is divided into supraglottic larynx, glottic larynx, and subglottic larynx. The supraglottic larynx consists of vestibular fold, aryepiglottic fold, epiglottis, and false cord. The glottic larynx mainly comprises the vocal cord and anterior and posterior commissures. The subglottic larynx refers to an area 1.0 cm below the inferior border of the vocal cord.

The supraglottic view during the direct laryngoscopy allows the assessment of vocal cord, false cord, anterior commissure, laryngeal surface of epiglottis, postcricoid area, and posterior pharyngeal wall (Figs. 3.32 and 3.33).

Identification of this anatomical structure plays a critical role in ensuring that a safe surgical procedure can be performed. Details of boundaries of structures need to be verified to facilitate a correct plane of excision and instrumentation. For instance, endoscopic microlaryngoscopy surgery, EMLS, utilizes multiple instruments which occupy a limited space area of pharynx and larynx. The laryngoscopy and bronchoscopy in paediatric patients pose significant challenges. In selected cases, excision of the tumour or procedure to relieve airway is necessary. Hence, a refined knowledge of airway anatomy and its differences in children and adults is of utmost importance. Laryngeal cancer surgical treatment modalities encompass transoral surgery, open partial resection, and laryngectomy. Transoral surgery of larynx especially poses dif-

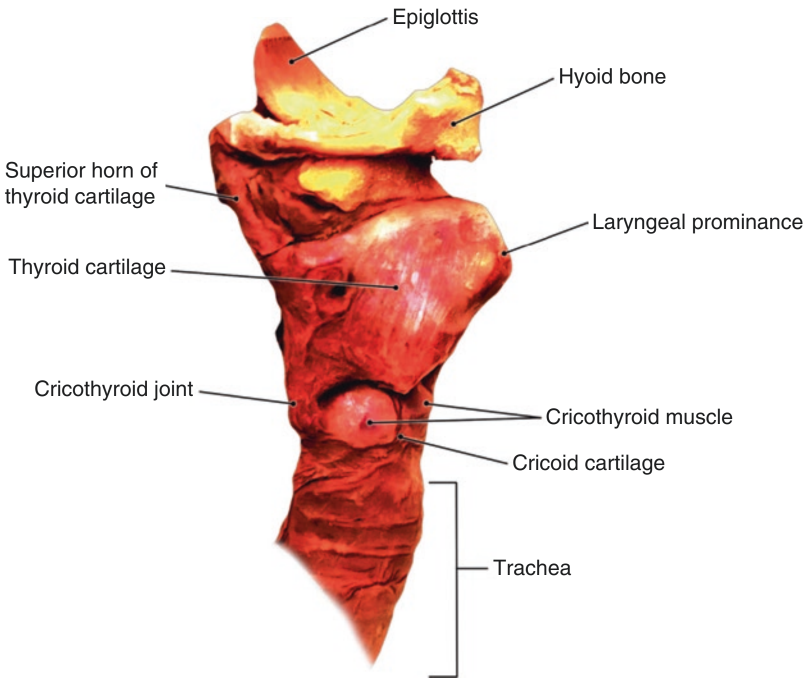


Fig. 3.29 The laryngeal structures are made up of cartilage and muscle

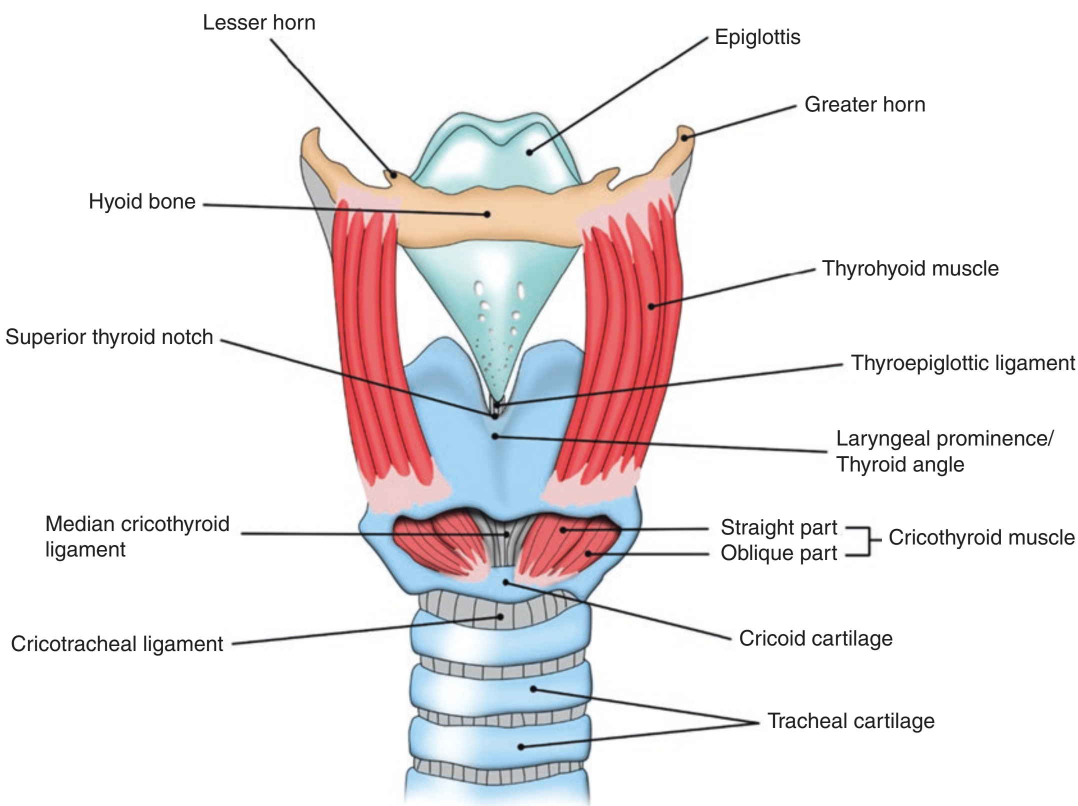


Fig. 3.30 The anterior view of the laryngeal structures. The muscles and ligaments bind the cartilaginous part of hyoid, epiglottis, thyroid cartilage, and trachea

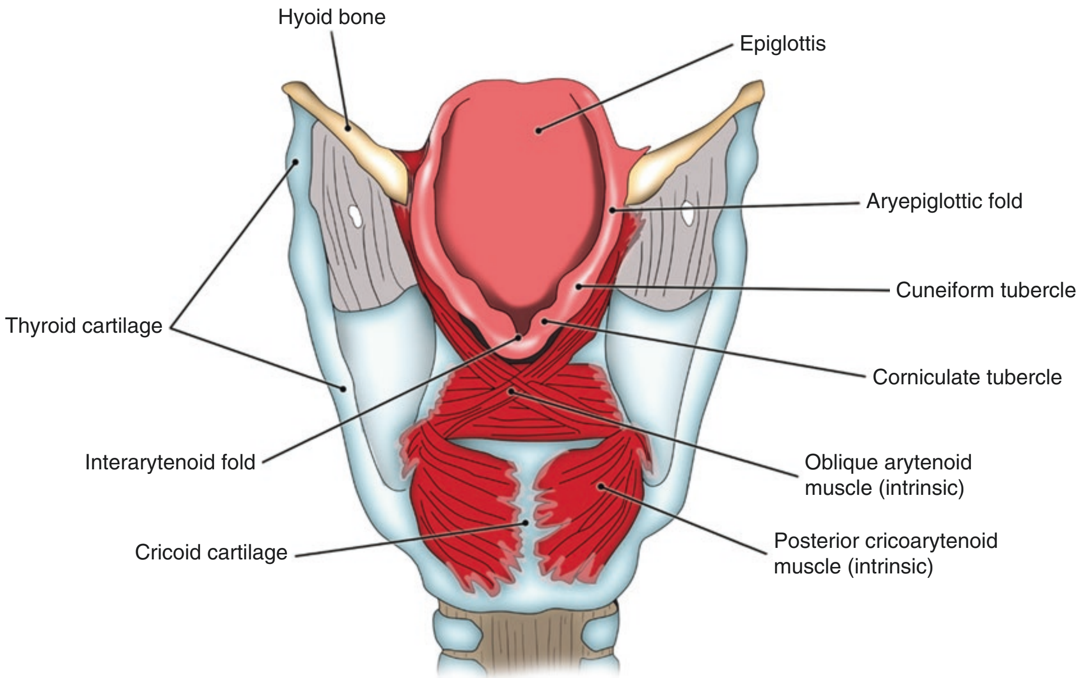


Fig. 3.31 The posterior view of the laryngeal structures shows the muscles that control the vocal cord movement

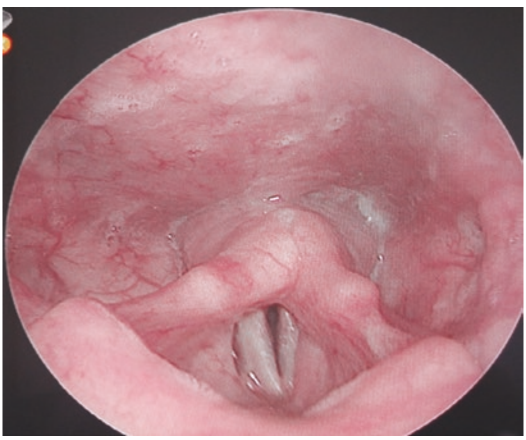


Fig. 3.32 The normal appearance during rigid laryngoscopy examination showing structures of importance like laryngeal surface of epiglottis (LE), aryepiglottic fold (AF), left vocal cord (LVC), right vocal cord (RVC), pyriform fossa (PF), posterior pharyngeal wall (PPW)

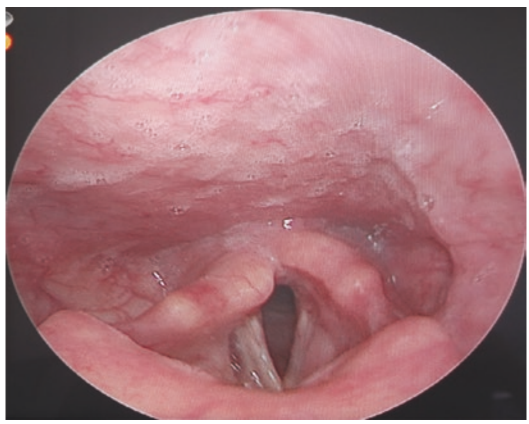


Fig. 3.33 The same figure shows abducted vocal cord during inspiration. The vocal cord will be adducted during the vocalization

ferent challenges, especially in the setting where laser is used for excision. Safety precautions should also be practised with vigilance to avoid unnecessary complications that can endanger the staff and the patients.

The cartilages thyroid cricoid and hyoid bone are the most prominent landmarks that are commonly used during laryngeal surgery. Features of these cartilages plus the associated vascular supply, neural innervation, and lymphatic drainage are vital to consider during the decision-making of appropriate surgical approach for each case. Early glottic carcinoma, T1 or limited T2 tumours, can be treated with transoral approach, whereas T3 and T4 tumours necessitate partial, hemilaryngectomy, or total laryngectomy. For patients with T3 tumours and selected T4 tumours, open partial laryngectomy may be an alternative to primary radiochemotherapy or total laryngectomy. The treatment of T1 and T2 tumours, if the larynx is difficult to expose, if transoral therapy is not possible or sufficient safety margins may not be maintained, or if the anterior commissure is involved, is another indication of open surgery [16].

Laryngectomy types can be further classified into supracricoid laryngectomy or vertical hemilaryngectomy and so forth. The techniques will be different, and different anatomical and surgical landmarks are used during the surgery. Radiotherapy alone in cases of early stages of laryngeal cancer as well as combined radiochemotherapy and induction chemotherapy followed by radiotherapy are concepts of non-surgical curative therapy [16].

3.6.1 Pharynx

Pharyngeal area can be affected by pathology such as chronic inflammatory disease, tumour, or effects of chemoradiation that causes persistent dysphagia. For instance, oropharynx can be affected by lymphoma or tonsillar carcinoma. Management of lymphoma is vastly different from management of tonsillar squamous cell carcinoma. Part of the pharynx also contributes to the airway functioning other than swallowing (Fig. 3.34). Knowledge of the critical parts of pharynx plays a key role in determining the success of surgery in this area. The successful planning of treatment for the correction of upper airway anatomical abnormalities by surgical progression of the mandible depends on extensive knowledge of the space of the pharyngeal airway [17].

Selected cases of tongue base tumour, lateral pharyngeal wall, soft palate, and tonsillar mass can also be addressed by using a robotic system to excise the tumour. Transoral robotic surgery (TORS) is a new approach, which uses a powerful robotic arm and magnifying optics to perform a minimally invasive procedure in the pharynx. TORS provides an excellent approach to benign pharyngeal lesions [18]. Many head and neck surgical oncology centres globally have performed pharyngeal surgery via TORS with different outcomes and success rates. Additionally, the surgeon needs to master the detailed anatomy of pharynx and use the consoles and buttons to manoeuvre the system efficiently.

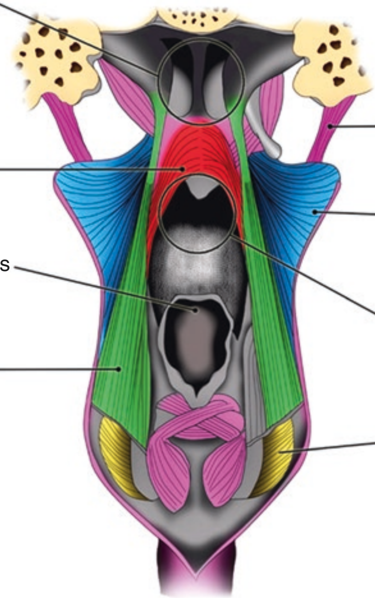
Transoral robotic surgery is a popular treatment method used to treat cancers of the larynx and pharynx, but the effect is limited. Although TORS has been used in the treatment of cancer in the tongue and pharynx, its application in the larynx is still limited. Laryngectomy has been the most common method for performing the surgery, with some practice in total laryngectomy and cordectomy [19].

3.6.2 Nasopharyngeal Surgery

Surgery to nasopharynx is mainly involved with limited tumour such as benign tumours or recurrent NPC. Benign tumour such as papilloma or adenoma is very rare. Juvenile nasoangiofibroma may sometimes extend posteriorly to involve the nasopharynx region, and it needs to be addressed appropriately. There are many structures located around the nasopharynx that can be critically injured during the surgical procedures. These include skull base and cranial nerves superiorly and internal carotid artery laterally.

Surgery of the paranasopharyngeal space is very hazardous due to the position of the internal carotid artery, which is surrounded by soft tissue with few anatomical landmarks. The stylopharyngeal groove, longus capitis, and Eustachian tube canal are the main surgical landmarks of the internal carotid artery. The artery can be found along the Eustachian tube, the foramen ovale, and the lateral pterygoid plate. The carotid artery remains an extremely dangerous area, only millimetres away from the pharyngeal recess [18] (Fig. 3.35).

Fig. 3.34 Posterior superior view of the pharynx



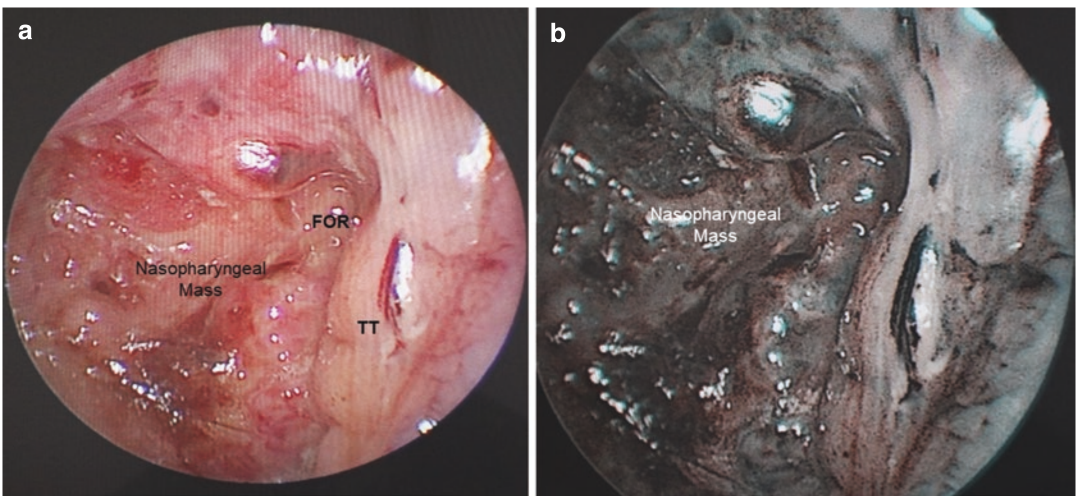


Fig. 3.35 The nasopharyngeal area showing a suspicious mass (**a**), which could be a carcinoma. The vascular change can be observed on the narrowband imaging photos (**b**). *FOR* fossa of rosenmuller, *TT* torus tubarius

3.6.3 The Importance of Surgical Landmark During Neck Dissection

Details of neck node region and its relevant structures are crucial for performing a safe neck dissection. The boundary, floor, roof, and content of each neck node level area are vital as they contain multiple structures that can sustain complications like neurovascular structure injury, which is difficult to manage. Inadvertent injury to the major cranial nerve like transection necessitates immediate repair. The majority of critical structures in the neck are located deep to the posterior belly of digastric muscle (Fig. 3.36).

Fig. 3.36 The neck dissection exposes major neurovascular structures of the neck including common carotid artery (cca), internal carotid artery (ica), external carotid artery (eca), internal jugular vein (ijv), spinal accessory nerve (san), sternocleidomastoid muscle (scm), and posterior belly of digastric muscle (pbdm)

The common carotid artery bifurcates at the level of hyoid bones. The external carotid contains multiple branches, whereas internal carotid artery does not have any branches in the neck. The vagus nerve lies in between the common carotid and IJV and should always be preserved.

The omohyoid is the main landmark for identification of the IJV. IJV lies just deep or inferior to the omohyoid muscle. During dissection at level IV, once the omohyoid muscle is visualized, the IJV is already exposed. Meticulous dissection is necessary in order to avoid injury or puncture to IJV wall, which can cause profuse bleeding.

3.6.4 Sinus and Paranasal Sinus Surgery

Endoscopic sinus surgery represents the gold standard for surgical treatment of chronic sinus diseases. Four main pairs of sinuses, the maxillary, ethmoid, sphenoid, and frontal sinuses, are equally important as each can be affected by different pathologies and necessitate different surgical approaches. For instance, maxillary sinus is mostly involved with carcinoma and requires external approach in late-stage disease. Ethmoid sinusitis and polyps on the other hand are suffice with endoscopic approach. Frontal sinus tumour may necessitate a combination of approaches. There are many factors to consider in order to select the optimal approaches for these patients and that need to be judiciously discussed with patient and the managing teams.

Fig. 3.37 Lower cheek flap for access of mandibulotomy or maxillary swing

The development of minimally invasive surgical methods in rhinology has been aided by the introduction of endoscopic sinus surgery (ESS). Poorly managed bleeding, which limits the sight of the surgical field, can hamper the proficiency of ESS procedures (VSF). This can result in more time spent operating and, more critically, a higher risk of major and minor problems [20]. Thus, detailed knowledge of the anatomy of critical structures like osteomeatal complexes, sinus and its drainage pathway, and surrounding soft tissues and neurovascular structures is highly important for ensuring the success of a surgery.

Nasopharyngeal carcinoma is the most common malignancy affecting the pharyngeal regions. This attributes to multiple risk factors such as dietary and environmental carcinogens [21]. The availability of narrowband imaging may assist in the identification of suspicious area that might harbour malignancy [22].

Maxillectomy can cause numerous complications if not performed meticulously. The principle of bony cut and the steps of disarticulation of maxilla are prerequisites for the success of maxillectomy. Types of maxillectomy, whether to perform partial maxillectomy, medial maxillectomy, subtotal maxillectomy, or total maxillectomy, will depend on the extent of tumour involvement in the surrounding tissues, i.e. stage of the tumour (Figs. 3.37, 3.38, and 3.39).

Fig. 3.38 Lower cheek flap exposes the infraorbital nerve

Fig. 3.39 Maxillectomy cut during maxillectomy

3.6.5 Skull-Based Surgery and Landmarks

Skull-based surgery is critical as many important structures located in the skull base can be injured during the surgery. There are many approaches used and currently in practice by skull-based surgeons in order to address the tumours and pathology more efficiently. Endoscopic endonasal surgery is one of the common and important techniques in skull base surgery due to limited surgical areas that require angled endoscopes for a better visualization of the structures. The expertise of surgeons with multiport multisystem endoscope is crucial to ensure the success of surgery. Endoscopic endonasal surgery provides an optimum access to anterior skull base, spheno-ethmoidal area, and other paranasal sinuses. It allows resection of intradural and extradural tumours. With the advent of a more refined system of 3D endoscopes, distal chip cameras, and robotic surgery, the techniques allow a surgeon to perform a complex surgery with minimally invasive skull base surgery [23].

A skull base tumour represents a wide cohort of tumours with different locations, extension, and histology. Different size and location of tumours require different surgical approaches. Image reconstruction with 2D or 3D techniques will allow accurate assessment of the tumours. The images can be mapped to help with the surgical planning preoperatively. One of the most promising surgical planning technologies is virtual reality. Under virtual reality conditions, it can conduct quick three-dimensional reconstruction of computed tomography, magnetic resonance imaging, and other imaging data sets. Surgical simulation allows for a more intuitive understanding of the anatomical relationship of the surgical area [24]. The visualization and identification of structures like cribriform plate, sellar area, fovea ethmoidalis, and optic prominence are enhanced by using the 3D multi-angle endoscopes. These endoscopic techniques minimize the complications since they reduce the brain and nerve traction, reduce incision size, and hasten the patient's recovery [25].

A versatile method is the endoscopic endonasal transpterygoid approach, providing direct access through an anterior surgical corridor to the petrous apex [26]. In cadavers, the endoscopic endonasal transpterygoid route has been widely evaluated and is currently used for specific diseases involving the lateral skull base during surgery [27]. The gateway for lateral skull base exposure has been the endoscopic endonasal transmaxillary transpterygoid (TMTP) approach. The endoscopic endonasal approach is being used for anatomical regions, which can be quite complex. The use of the Eustachian tube as a landmark for the identification of the petrous internal carotid artery has recently been reported. Removal of the Eustachian cartilaginous tube (ET) and lateral internal carotid artery mobilization (ICA) are technically demanding adjunctive steps used to access the petroclival region [28].

Although this approach is a useful strategy for many petrous apex lesions, extension of the disease into lateral, upper, or posterior compartments may limit the extent of resection provided solely by an anterior approach [26]. A key step during this approach is the identification of the petrous segment of the internal carotid artery (ICA), and the vidian nerve (VN) has been described as the main landmark for the safe endonasal localization of the petrous ICA at the level of the foramen lacerum [27].

By resection of the cartilaginous ET and mobilization of the paraclival ICA, the transpterygoid corridor into the petroclival region is maximally expanded. These additional manoeuvres extended the deep window almost six times and gave the petroclival region more lateral access [28]. In order to avoid injury in skull base surgery through the endoscopic endonasal route, the Eustachian tube is a consistent and reliable landmark of the internal carotid artery. By an intranasal endoscopic approach, the bony-cartilaginous junction of the Eustachian tube was just anterior to the first genuine internal carotid artery [29].

The Eustachian tube and sphenoid spine have been previously described as landmarks for endonasal surgical identification of the most distal segment of the parapharyngeal internal carotid artery (PhICA). A novel and palpable bony landmark, the inferomedial edge of the tympanic bone, referred to as the tympanic crest, was identified, leading from the sphenoid spine to the lateral carotid canal. Variable anatomy is present in the sphenoid spine and the pericarotid space. In an endoscopic transmasticator approach to the infratemporal fossa, the tympanic crest, sphenoid spine, and vaginal process of the tympanic bone represent the closest landmarks leading to the PhICA [30].

To describe the various anatomical structures surrounding the anterior genuineness of the petrous ICA, the endoscopic endonasal transpterygoid approach was used. The VN, the Eustachian tube, the foramen lacerum, the petroclival fissure, and the pharyngobasilar fascia have been identified and described as five key anatomical structures [27].

3.6.6 Temporal Bone Surgery

The temporal bone is separated into the squamous, petrous, styloid, tympanic, and mastoid portions of the skull base. The most medial aspect of the temporal bone is the petrous portion, which encloses the vestibule, semicircular canal, facial canal, carotid canal, and cochlea. It consists of three surfaces and margins, a base and an apex, and is between the sphenoid's larger wing and the occipital bone [31].

The Eustachian tube is divided into the osseous and cartilaginous parts into the bones and cartilage. Based on its relationship to the skull base, the cartilaginous portion can be further subdivided into the posterolateral, middle, and anteromedial sections. The Eustachian tube is closely associated with the pterygoid process of the sphenoid bone, the foramen lacerum, and the petrosal apex, and nearly perpendicular to the oblique sagittal line [32] (Figs. 3.40, 3.41, 3.42, and 3.43).

The petrous apex is a complex temporal bone region that can harbour surgically difficult-to-access lesions. Petrous apex pathology is divided into extradural and intradural aetiology. Cholesterol granulomas, cholesteatoma, or epidermoid cysts and osteomyelitis are included in extradural pathology [31].

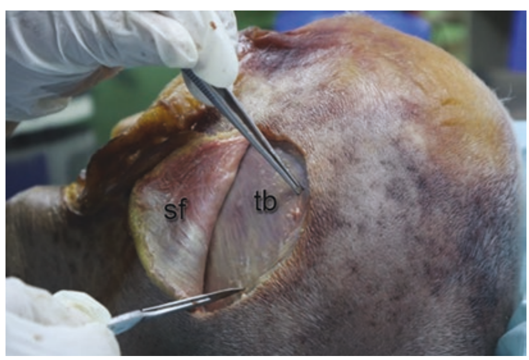


Fig. 3.40 The skin flap (sf) has been elevated, and temporalis muscle is visible with overlying temporalis fascia (tb)

Fig. 3.41 The temporalis fascia is harvested meticulously using micro instruments

Some lesions can be managed with drainage, such as cholesterol granulomas, while neoplastic lesions must be fully resected. Open, endoscopic, and combined techniques are used for surgical options and are categorized into anterior, lateral, and posterior approaches. The approach is determined by the nature of the pathology and location relative to vital structures and extension into surrounding structures and requires thorough preoperative evaluation and discussion with the patient regarding surgical objectives [31] (Fig. 3.44).

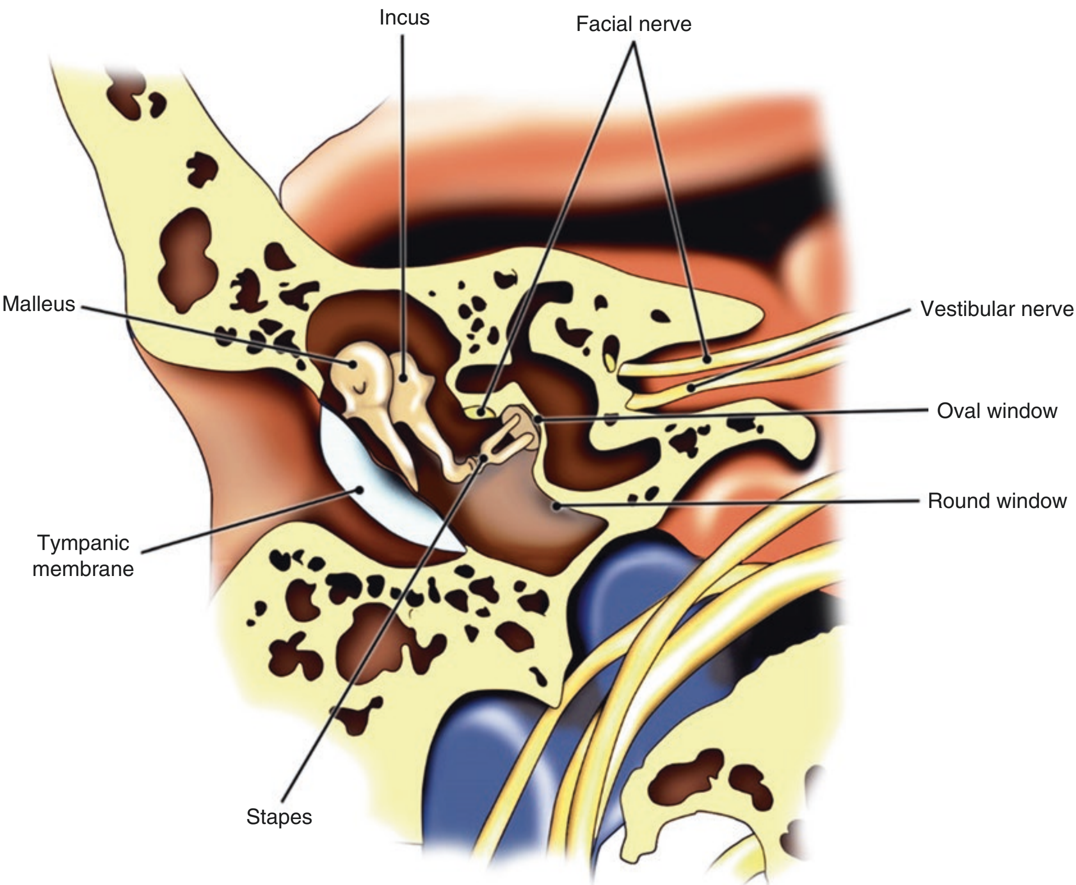


Fig. 3.42 The middle-ear and inner-ear structures and facial nerves are commonly encountered during a mastoidectomy

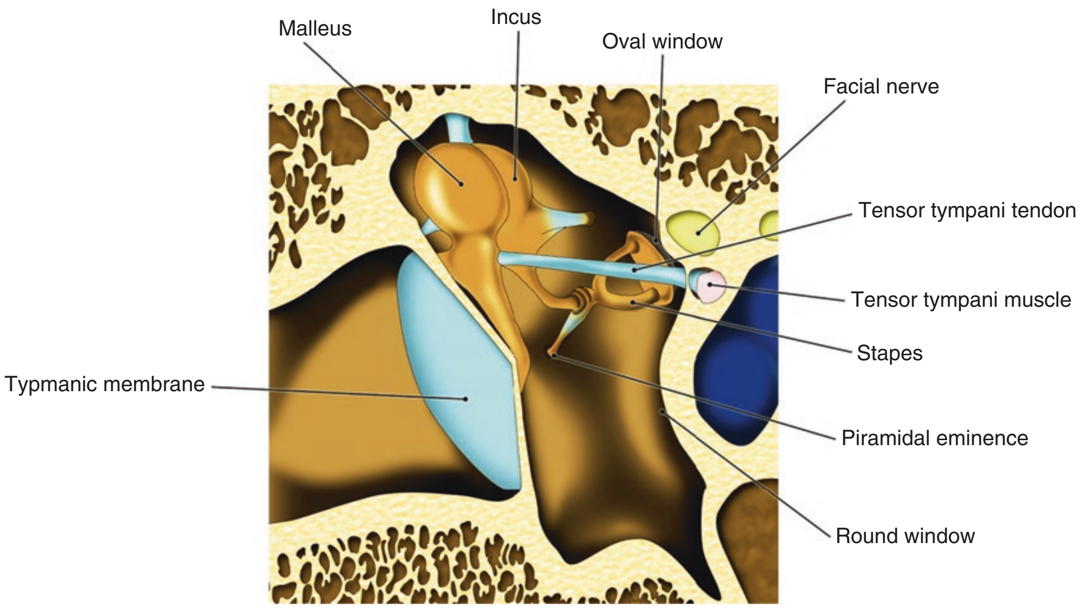


Fig. 3.43 The relation of facial nerve to middle-ear structures like stapes, tensor tympani muscle, and incus is an important landmark for the identification of facial nerve during ear surgery

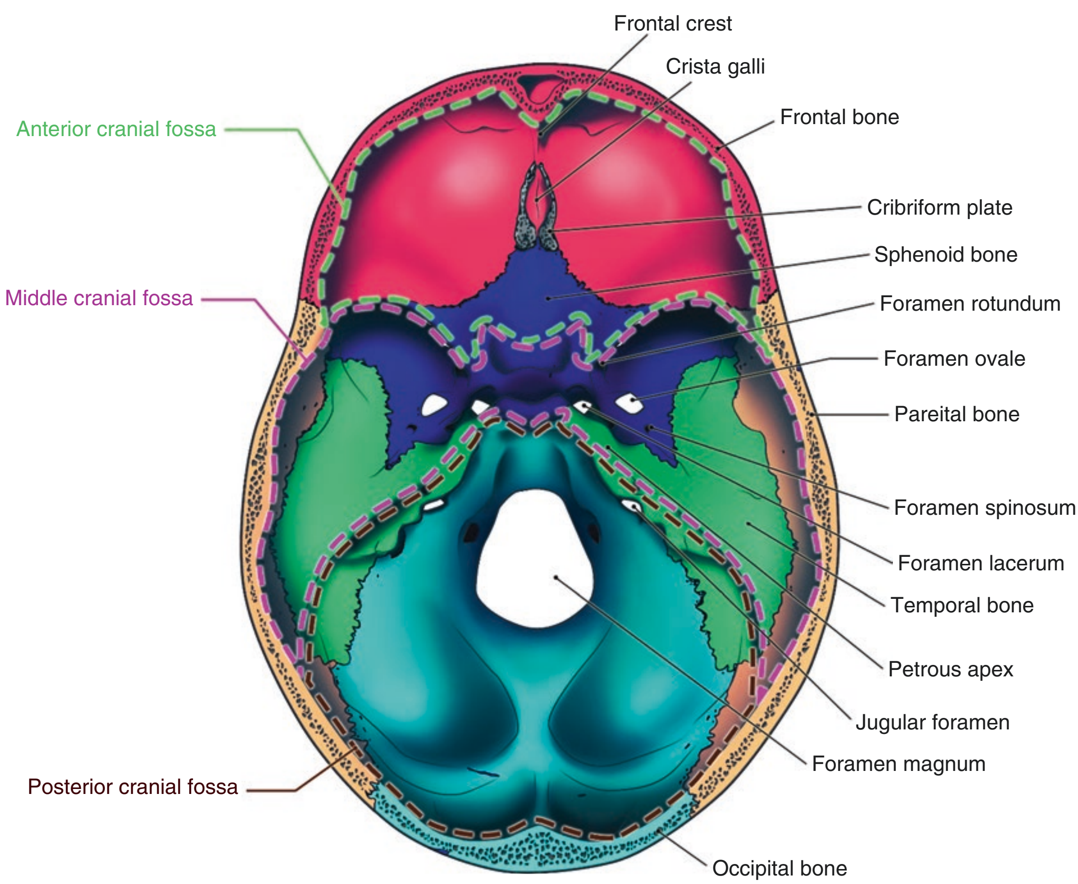


Fig. 3.44 The cranial fossa is divided into three segments and harbours different organs and structures that pass through the skull base to the neck region

3.7 Conclusion

Anatomical structures play an important role in defining the surgical landmarks of any types of head and neck surgery to ensure a safe and effective surgery. Refining techniques of surgery in addition to enhanced surgical landmarks' knowledge will avoid unwanted hazards that can arise from the surgical procedures. The outcome of surgery influences the patient's post-operative quality of life and may reduce the cost on the health institution due to shortened hospital stay and reduced usage of medications, staff, and facility.

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