EUROPEAN SOCIETY OF RADIOLOGY

eBook for Undergraduate Education in Radiology

CHAPTER: Head and Neck Imaging

Preface

Undergraduate teaching of radiology in Europe is provided according to national schemes and may vary considerably from one academic institution to another. Sometimes, the field of radiology is considered as a "cross-cutting discipline" or taught within the context of other clinical disciplines, e.g., internal medicine or surgery.

This e-book has been created in order to serve medical students and academic teachers throughout Europe to understand and teach radiology as a whole coherent discipline, respectively. Its contents are based on the *Undergraduate Level of the ESR European Training Curriculum for Radiology* and summarize the so-called ***core elements*** that may be considered as the basics that every medical student should be familiar with. Although specific radiologic diagnostic skills for image interpretation cannot be acquired by all students and rather belong to the learning objectives of the *Postgraduate Levels of the ESR Training Curricula*, the present e-book also contains some ***further insights*** related to modern imaging in the form of examples of key pathologies, as seen by the different imaging modalities. These are intended to give the interested undergraduate student an understanding of modern radiology, reflecting its multidisciplinary character as an organ-based specialty.

We would like to extend our special thanks to the authors and members of the ESR Education Committee who have contributed to this eBook, to Carlo Catalano, Andrea Laghi and András Palkó who initiated this project, and to the ESR Office, in particular Bettina Leimberger and Danijel Lepir, for all their support in realising this project.

We hope that this e-book may fulfil its purpose as a useful tool for undergraduate academic radiology teaching.

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eBook for Undergraduate Education in Radiology

Based on the ESR Curriculum for Undergraduate Radiological Education

Chapter: Head and Neck Imaging

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Anatomy - Paranasal Sinuses

These are air-containing sacs communicating with the nasal cavity through narrow, and easily occluded, openings. The maxillary and sphenoid sinuses are present in a rudimentary state at birth. The rest develop by the 8th year of life. All are fully formed at adolescence.

Frontal sinuses (Figs. 1 and 2): contained in the frontal bone. They vary greatly in size. Occasionally, one or both may be absent. Their posterosuperior wall lies adjacent to the frontal lobe of the brain. Their floor abuts the ethmoid air cells, the roof of the nasal fossa and the orbit. They drain into the frontal recess, an opening at its inferior aspect and finally drains into the middle meatus via the hiatus semilunaris (**Figs. 1 and 2**). The latter is an opening located in the lateral wall of the nasal cavity (see figure below).

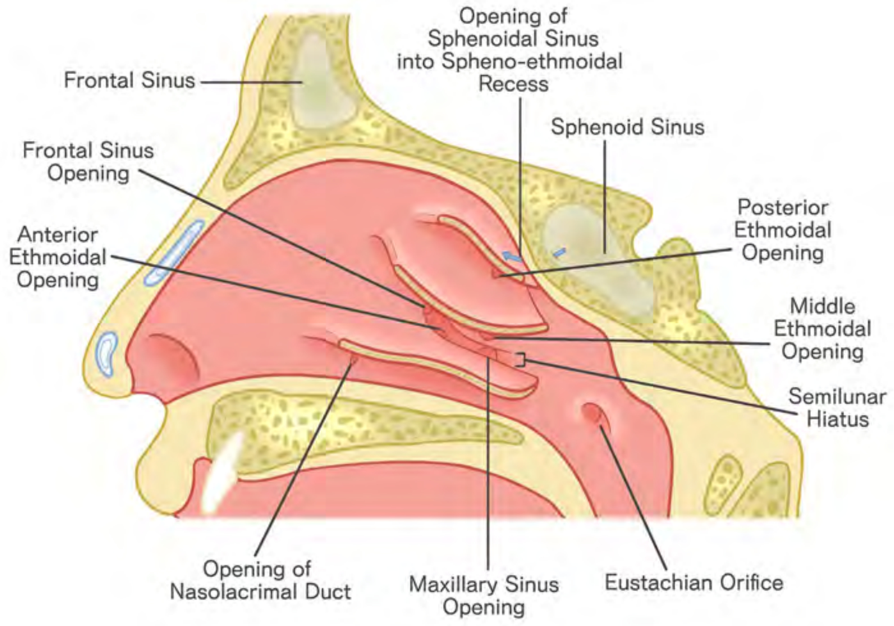

Fig. 1. Schematic diagram of the nasal cavity (sagittal view) with conchae removed to expose the hiatus semilunaris.

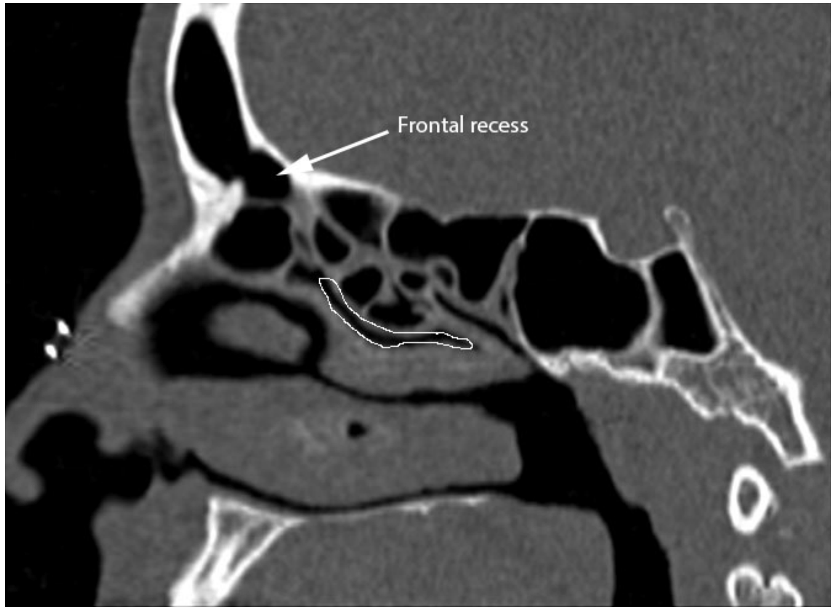

Fig. 2. Sagittal reformatted CT image. The frontal sinus drains into the middle meatus via the frontal recess and then hiatus semilunaris (outlined in white). The latter is an opening located in the lateral wall of the nasal cavity.

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Anatomy - Paranasal Sinuses

Maxillary sinuses (Figs. 3, 4 and 5) : pyramidal shaped sinus occupying the cavity of the maxilla. The medial wall forms part of the lateral face of the nasal cavity and carries the inferior concha. Above this concha is the opening of the maxillary sinus into the middle meatus in the hiatus semilunaris.

Ostiomeatal unit (Fig. 4 and 5): This is a very important anatomical region as it allows drainage of the frontal, anterior ethmoid and maxillary sinuses. It is composed of the superomedial maxillary sinus, maxillary infundibulum, uncinate process, ethmoid bulla, hiatus semilunaris.

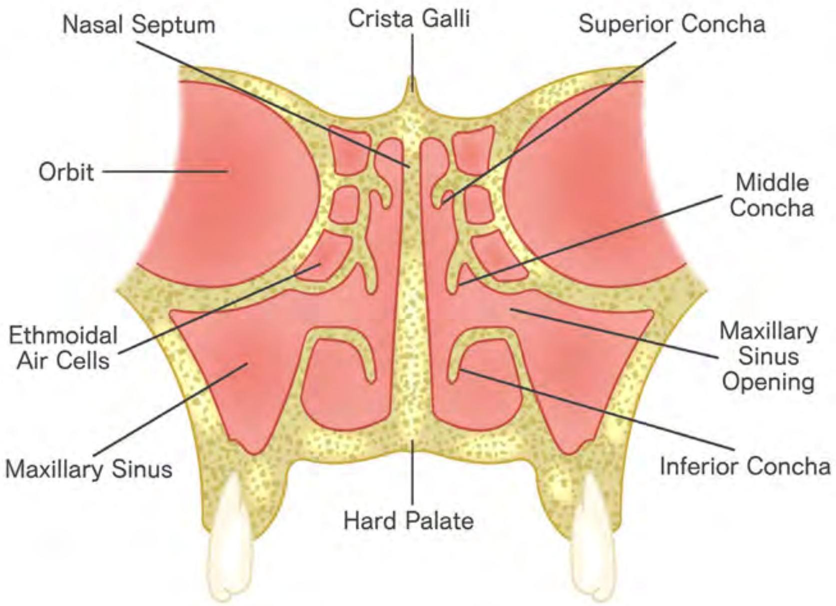

Fig. 3. Schematic diagram of the nasal cavity, maxillary sinus and ethmoid sinuses (coronal view).

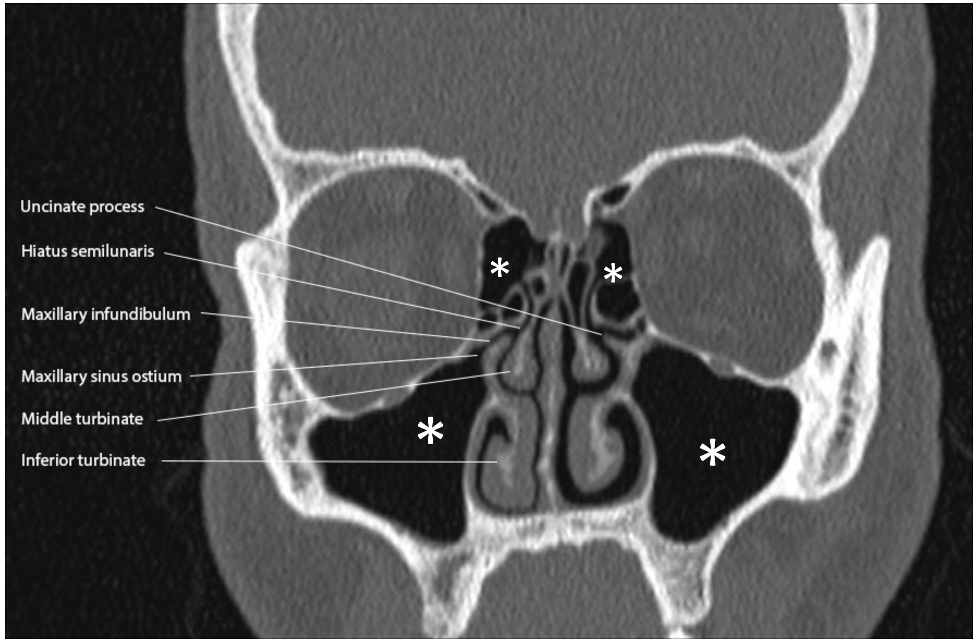

Fig. 4. Coronal CT reformatted image showing the components of the ostiomeatal unit/complex. Maxillary sinuses (large asterisks). Ethmoid sinuses (small asterisks)

Anatomy - Paranasal Sinuses

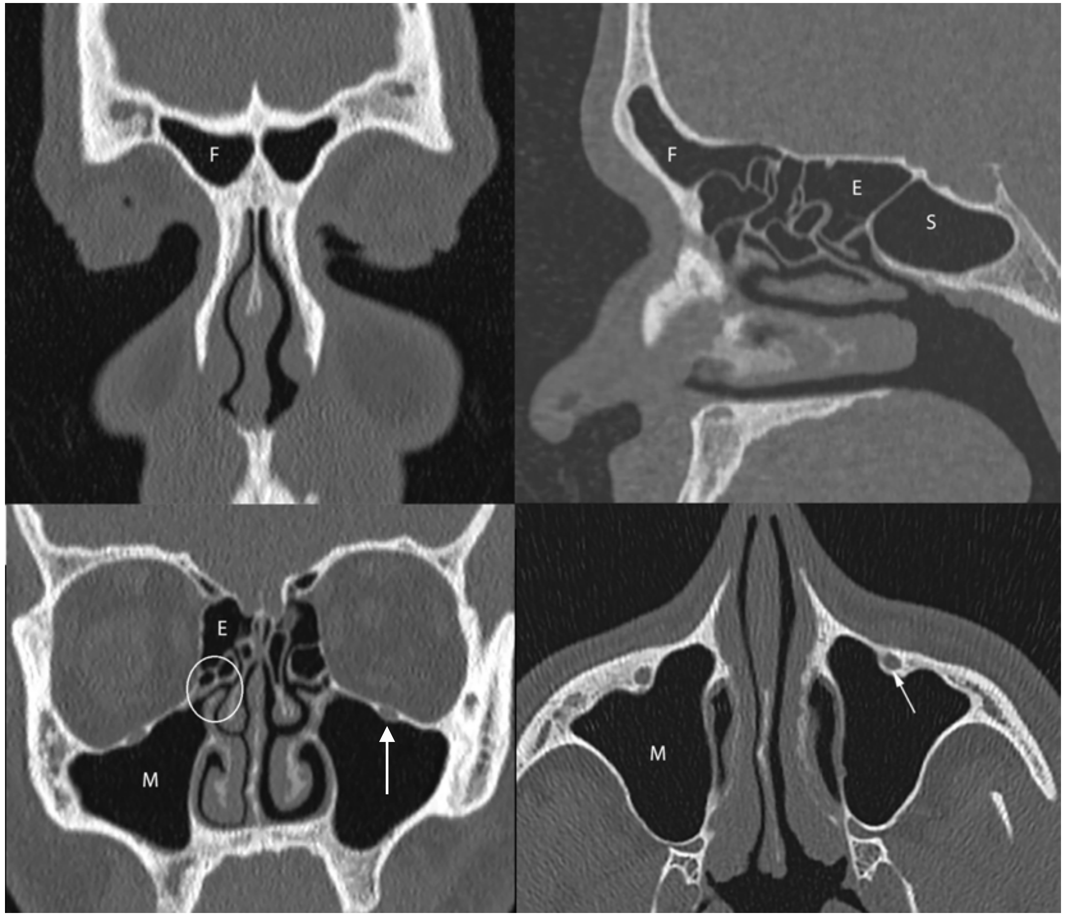

Fig. 5. Multiplanar reformatted CT images of the paranasal sinuses demonstrating the frontal (F), ethmoid (E), maxillary (M) and sphenoid (S) sinuses. The ostiomeatal complex is indicated by a circle. Infraorbital nerve (arrow).

The **infraorbital nerve** lies in a groove which bulges into the roof of the sinus (**Fig. 5**). The floor of the sinus carries the roots of the upper premolar and molar teeth. The floor of the sinus corresponds therefore to the alveolar ridge of the maxilla, not the floor of the nasal cavity.

Ethmoid sinuses: group of 8-10 air cells within the lateral mass of the ethmoid lying between the side-walls of the upper nasal cavity and the orbits (**Figs. 4 and 5**). Superiorly, they lie on each side of the cribriform plate and are located below the frontal lobe of the brain. They drain into the superior and middle meatus.

Sphenoid sinuses: lie within the body of the sphenoid bone on either side of the midline **(Fig. 5)**. They vary in size and may extend laterally into the greater wing of the sphenoid bone or backwards into the basal part of the occipital bone. They drain into the nasal cavity above the superior concha via the sphenoethmoidal recess.

Chapter Outline

Anatomy - *Pharynx*, Larynx & Oral Cavity

Pharynx: Is a musculofascial tube extending from the skull base to the oesophagus. It is made up of three portions (**Figs. 6** and **7**):

- **Nasopharynx (NP)** situated behind the nasal fossae and above the soft palate. It is directly continuous anteriorly with the nasal cavity.
- **Oropharynx** lying behind the mouth, situated between the soft palate and the base of the tongue (it includes the uvula). It forms part of the upper respiratory tract and the gastrointestinal tract. On axial images, the C1/C2 junction is generally accepted as the level of demarcation between NP and oropharynx (Dubrulle et al. 2007).
- **Hypopharynx (also called laryngopharynx)** – lies behind the larynx. It is the inferior continuation of the oropharynx.

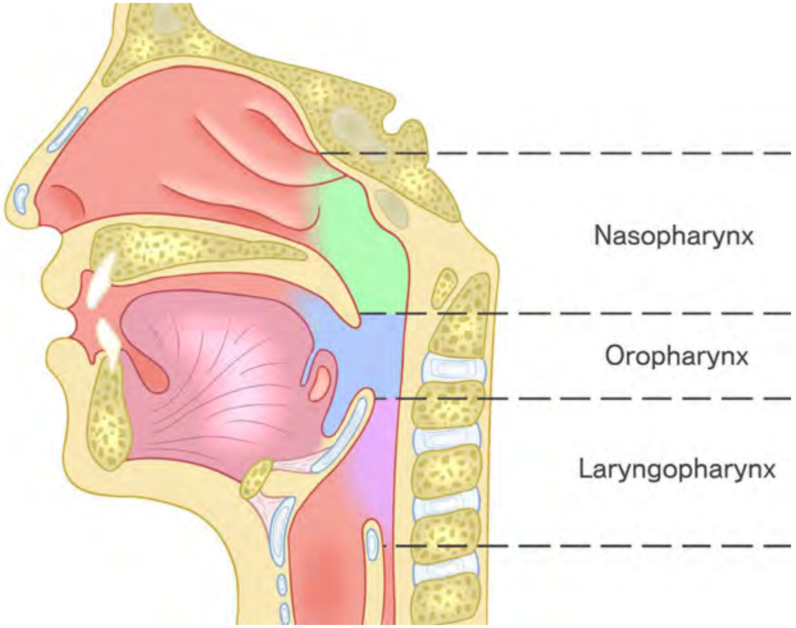

Fig. 6. Schematic diagram of the pharynx and its subdivisions into nasopharynx, oropharynx and laryngopharynx.

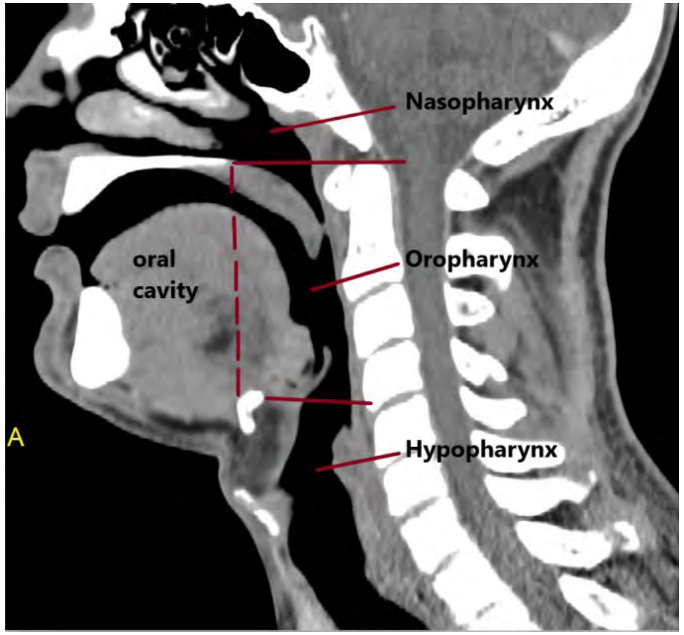

Fig. 7. Sagittal reformatted CT of the neck after contrast administration showing the different subdivisions of the pharynx and the oral cavity.

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Anatomy - *Pharynx*, Larynx & Oral Cavity

The **nasopharynx** (NP) is an inverted J-shaped muscular aponeurotic sling suspended from the central skull base (Teresi et al. 1987).

Superior border: basisphenoid and clivus; Inferior border: lower border of the soft palate (C1); Anterior border: nasal choane; Posterior border: retropharyngeal space and prevertebral space; Lateral border: parapharyngeal space (pharyngobasilar membrane). See **Fig. 8.**

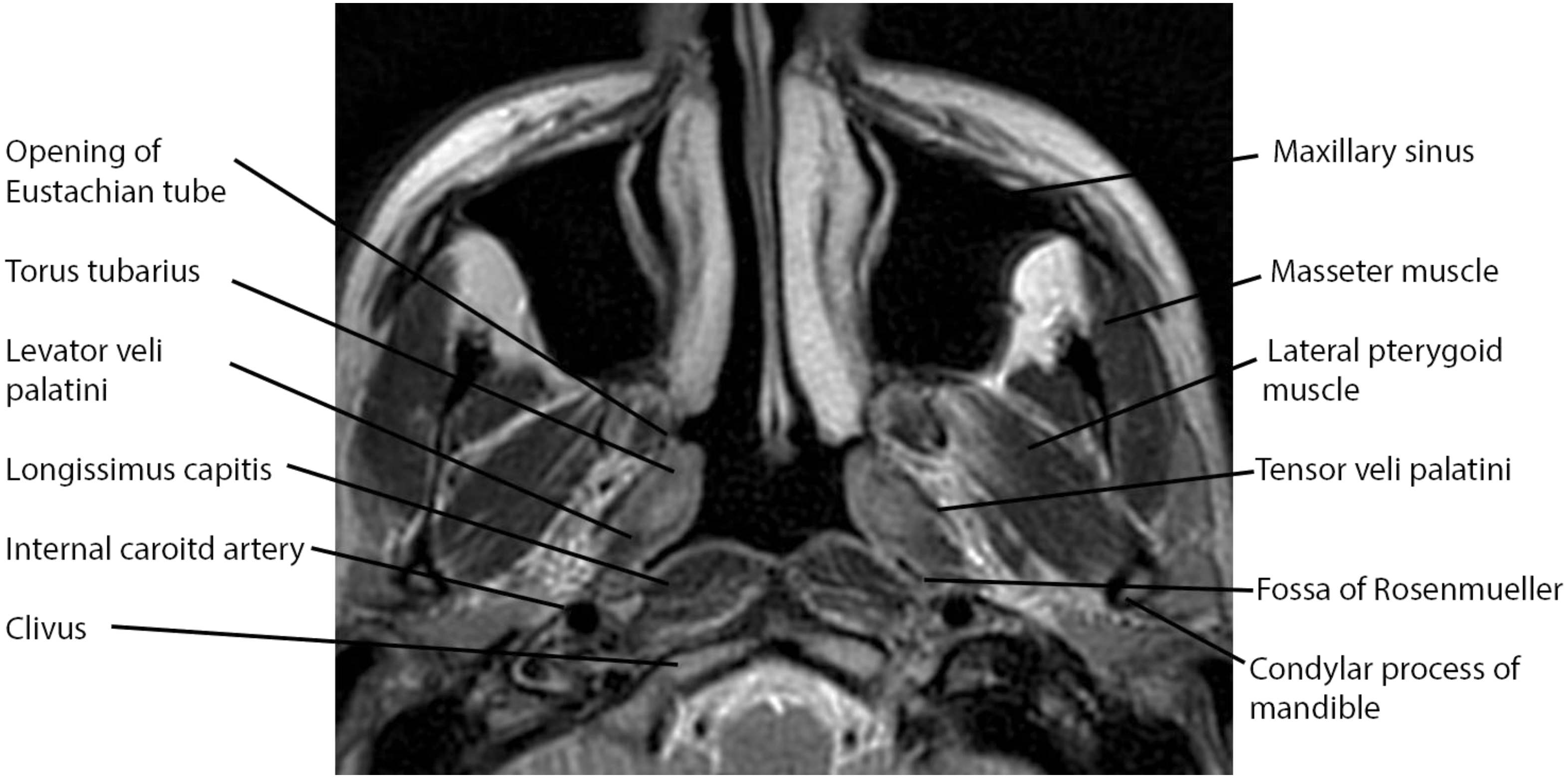


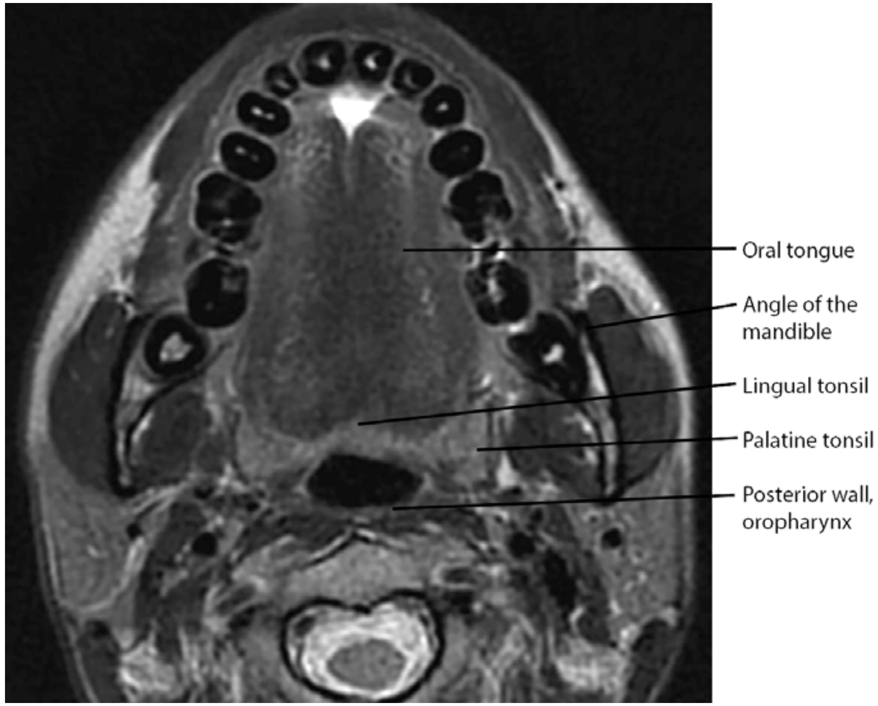
Fig. 8. Axial T2 weighted MR image showing the anatomy of the NP and surrounding structures.

Anatomy - ***Pharynx***, Larynx & Oral Cavity

The **oropharynx (Figs. 6, 7** and **9)** Is the portion of the pharynx between the nasopharynx above and hypopharynx below.

Boundaries: superiorly level of the soft palate, inferiorly level of hyoid bone or tip of epiglottis and laterally tonsillar fossae

The oropharynx includes the base of the tongue (posterior third) and the lingual tonsils, the palatine tonsils, the inferior surface of the soft palate, the uvula, the valleculae and posterior pharyngeal wall.



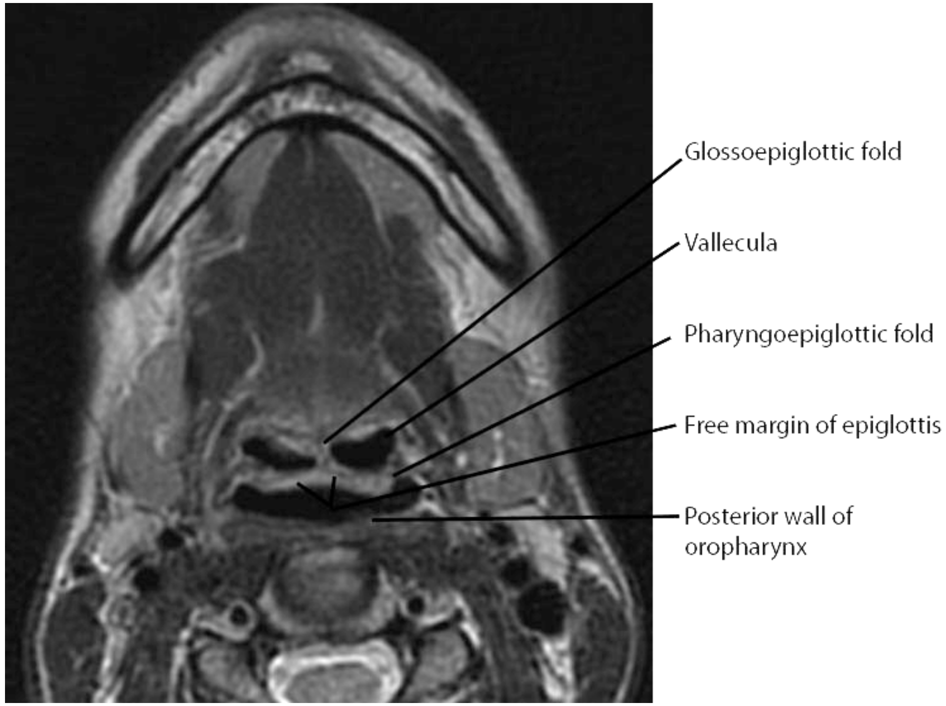


Fig. 9. Axial T2W MR Images at the level of the oropharynx. At the inferior margin of the oropharynx, the free margin of epiglottis, glossoepiglottic fold, and pharyngoepiglottic fold are seen.

Anatomy - *Pharynx*, Larynx & Oral Cavity

The **hypopharynx** is a mucosa-lined, muscular tube which is located posterior to the larynx, medial to the carotid spaces bilaterally, and ventral to the retropharyngeal space (**Figs. 6, 7** and **10**).

The hypopharynx begins as the continuation of the oropharynx at the pharyngoepiglottic fold (which is at the level of the hyoid bone) and extends inferiorly to the level of the inferior aspect of the cricoid cartilage, from where it continues as the cervical esophagus. The hypopharynx has three subsites: the pyriform sinuses, the posterior wall and the retro-cricoid portion.

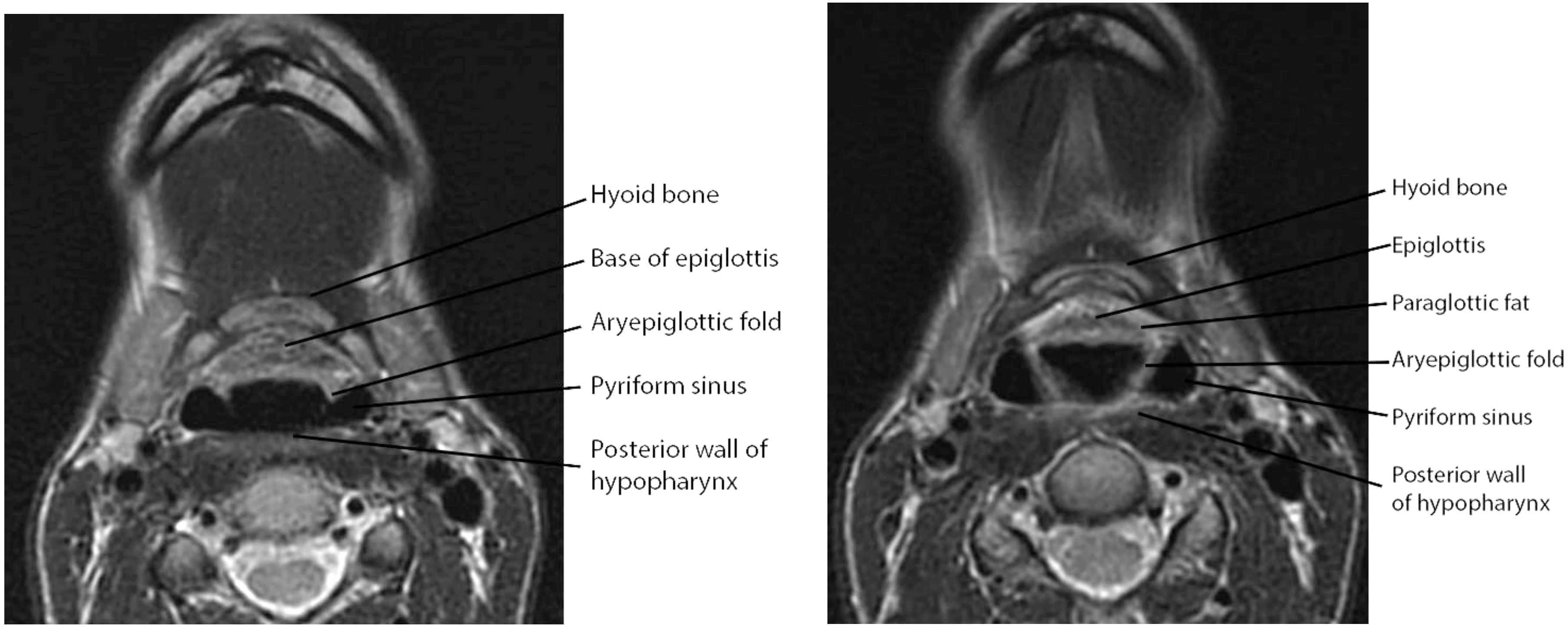


Fig. 10. Axial T2W MR images show the most cranial portions of the hypopharynx. The aryepiglottic folds separate the funnel-shaped vestibule of the larynx (asterisk) from the piriform sinuses.

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Anatomy - Pharynx, *Larynx* & Oral Cavity

Larynx (Fig. 11): is an inferior continuation of the oropharynx. It extends from the epiglottis to the inferior aspect of the cricoid cartilage. Inferiorly, it continues as the cervical trachea. The larynx is part of the upper respiratory tract.

The larynx consists of the laryngeal cartilages (thyroid, cricoid, arytenoids and epiglottis, which make up the laryngeal skeleton), the false cords and the true vocal cords with the mucosa overlying them, as well as ligaments and muscles holding these structures together.

The larynx has three subsites: the supraglottis, the glottis and the subglottis (**Figs. 12-14**).

Anteriorly to the larynx are the strap muscles, posteriorly, the oesophagus and the hypopharynx, superiorly the hyoid bone and inferiorly the trachea.

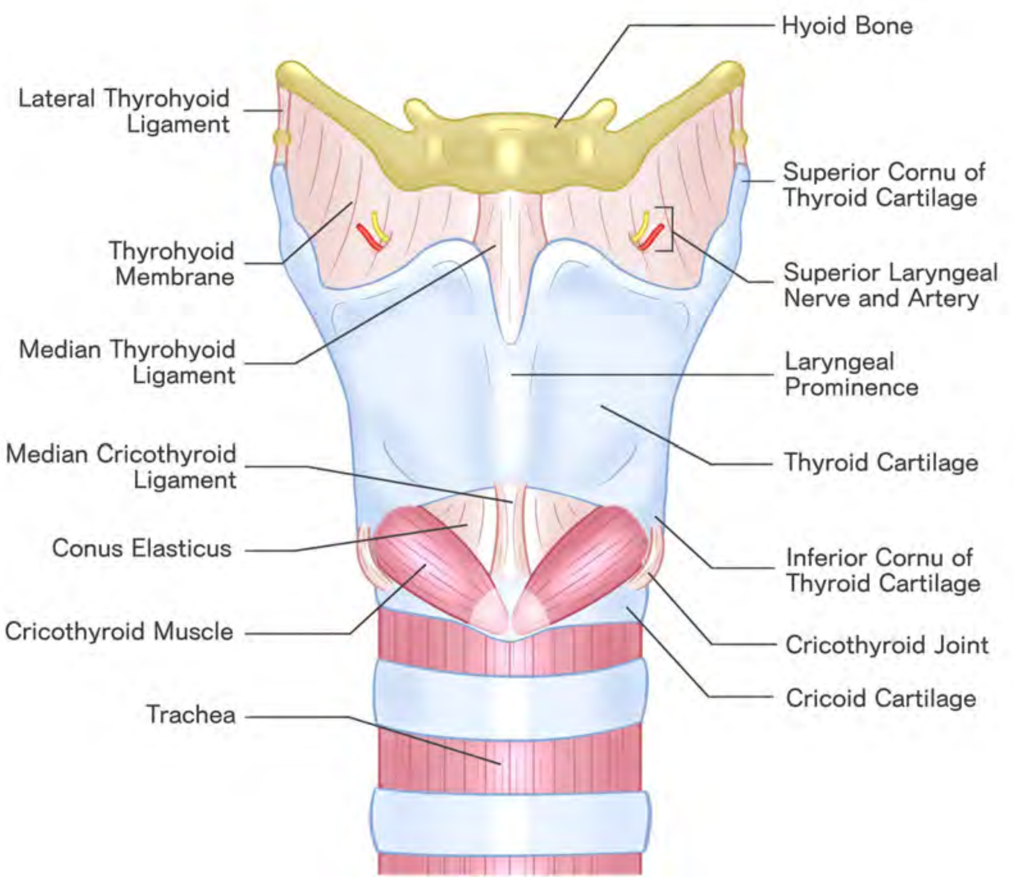

Fig. 11. Schematic drawing of the larynx (anterior view).

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Anatomy - Pharynx, *Larynx* & Oral Cavity

Supraglottis (Fig. 12): extends from the tip of the epiglottis to the laryngeal ventricle and consists of the following:

- Epiglottis with the suprahyoid and infrahyoid portions
- Pre-epiglottic and paraglottic space
- Arytenoid cartilages
- Aryepiglottic folds
- False vocal cords

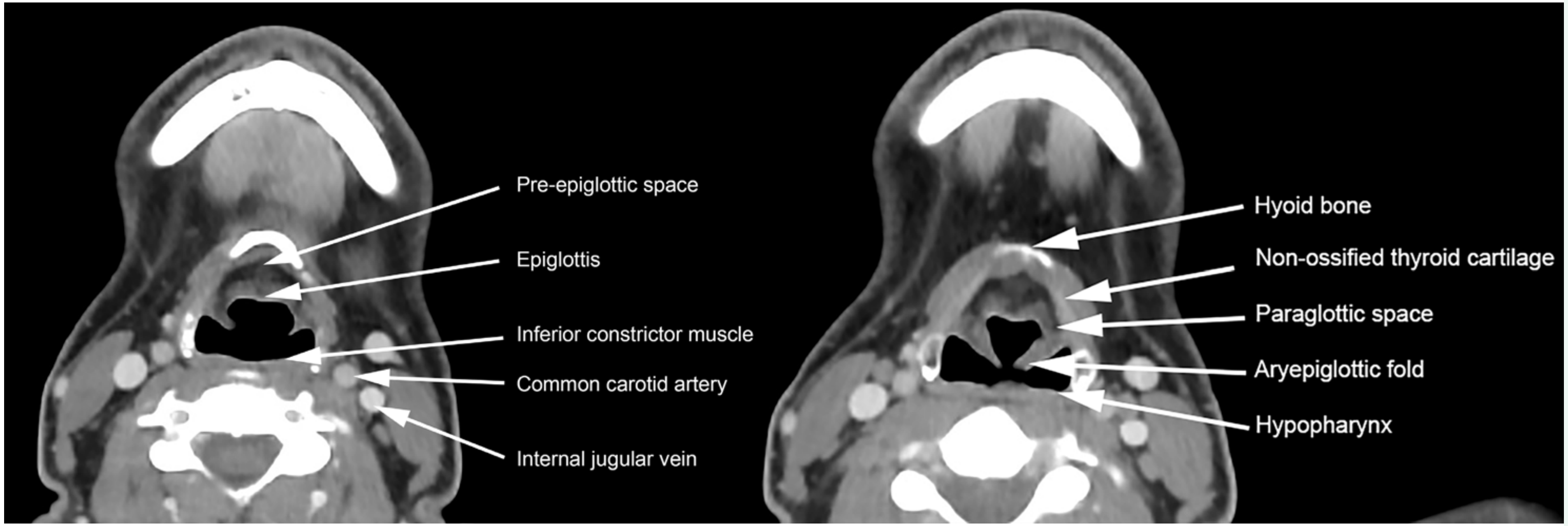

Fig. 12. Axial contrast enhanced CT images at the level of the supraglottis.

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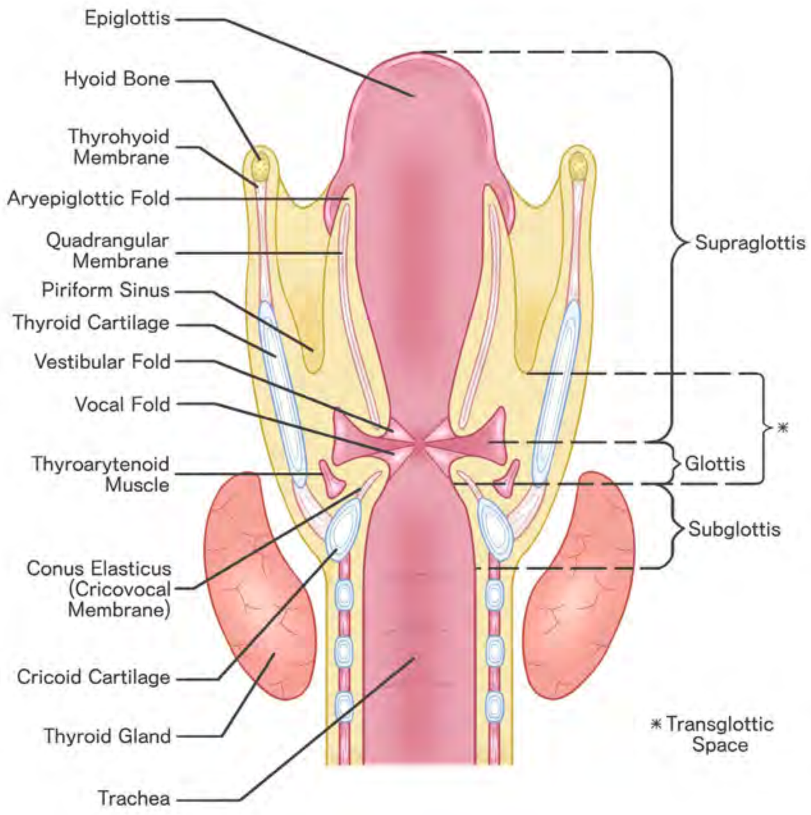
Anatomy - Pharynx, *Larynx* & Oral Cavity

Glottis (Fig. 13): Anatomic subsite of larynx between supraglottis and subglottis. It comprises:
- True vocal cords
- Anterior commissure
- Posterior commissure

The glottis is bound superiorly by upper surface of true vocal cord and laterally by the paired paraglottic spaces. Inferiorly, it extends 1cm below the upper surface of the true vocal cords.



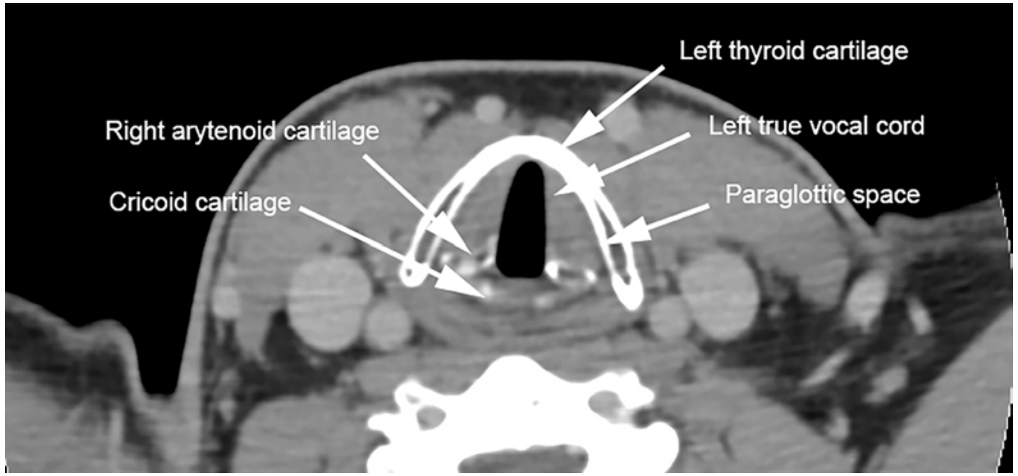
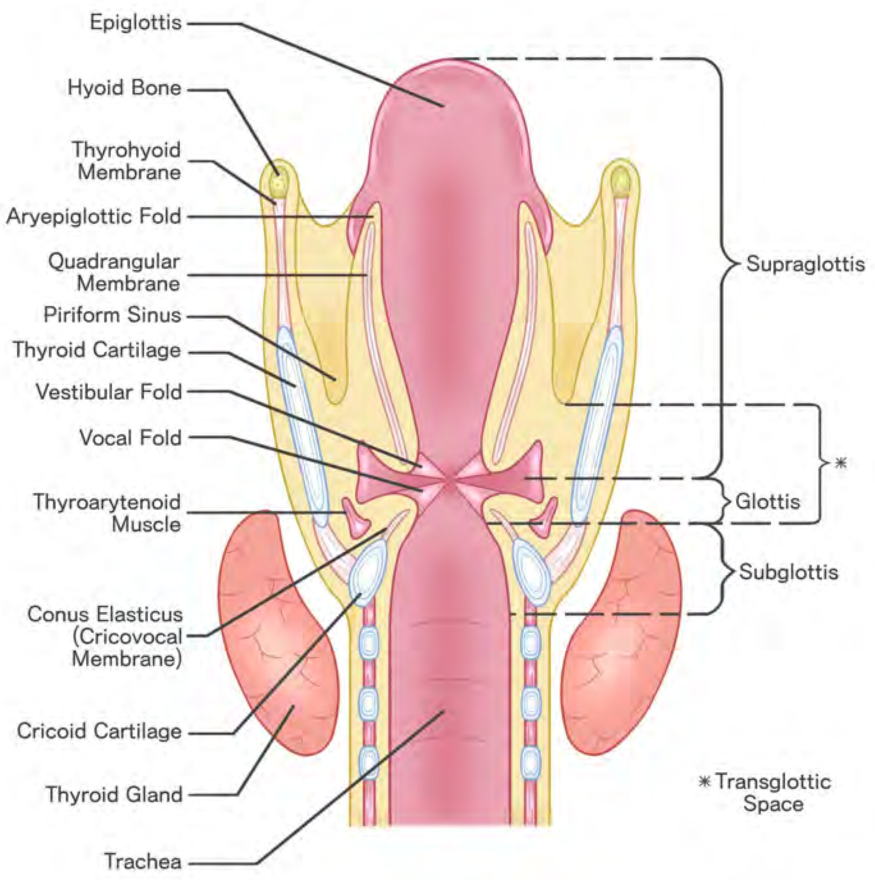


Fig. 13. Schematic drawing of the inner structures of the larynx (coronal view) and axial contrast enhanced CT image at the level of the glottis. This CT image was obtained in quiet breathing (abducted vocal cords).

Anatomy - Pharynx, *Larynx* & Oral Cavity

Subglottis (Fig. 14): Extends from inferior surface of true vocal cords to the inferior surface of cricoid cartilage.



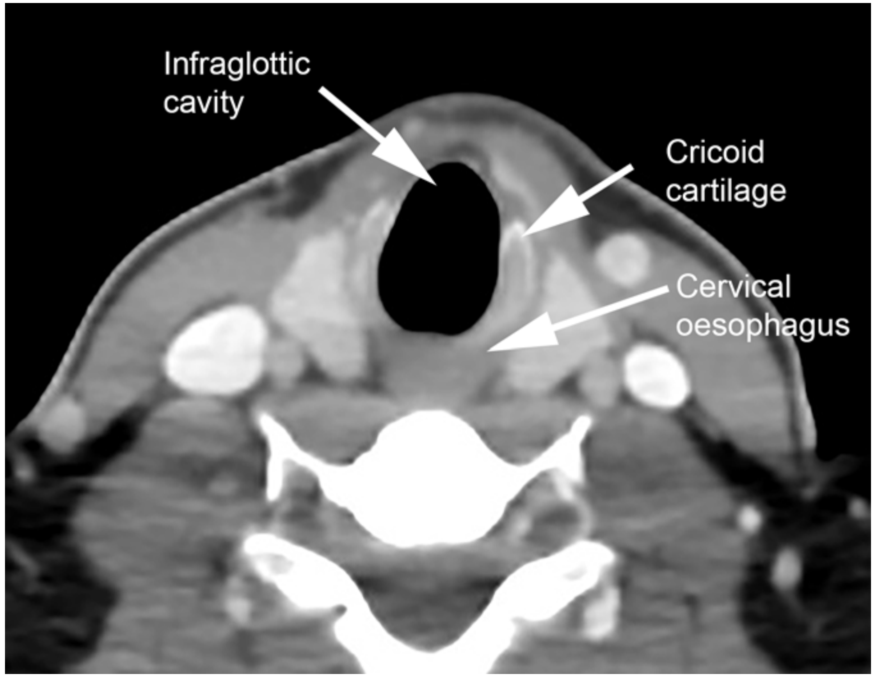


Fig. 14. Schematic drawing of the inner structures of the larynx (coronal view) and axial contrast enhanced CT image at the level of the subglottis (also called infraglottis).

Anatomy - Pharynx, Larynx & ***Oral Cavity***

Oral cavity (Fig. 15): also referred to as the mouth is directly continuous with the oropharynx posteriorly.

It is made of the following anatomical structures:

- upper and lower lip,
- buccal mucosa (cheek),
- upper and lower alveolar ridge (gums),
- hard palate,
- anterior two thirds of the tongue,
- floor of mouth (includes oral cavity mucosa lining the floor of mouth and mylohyoid sling)
- retromolar trigone (mucosal surface behind the lower third molar tooth).

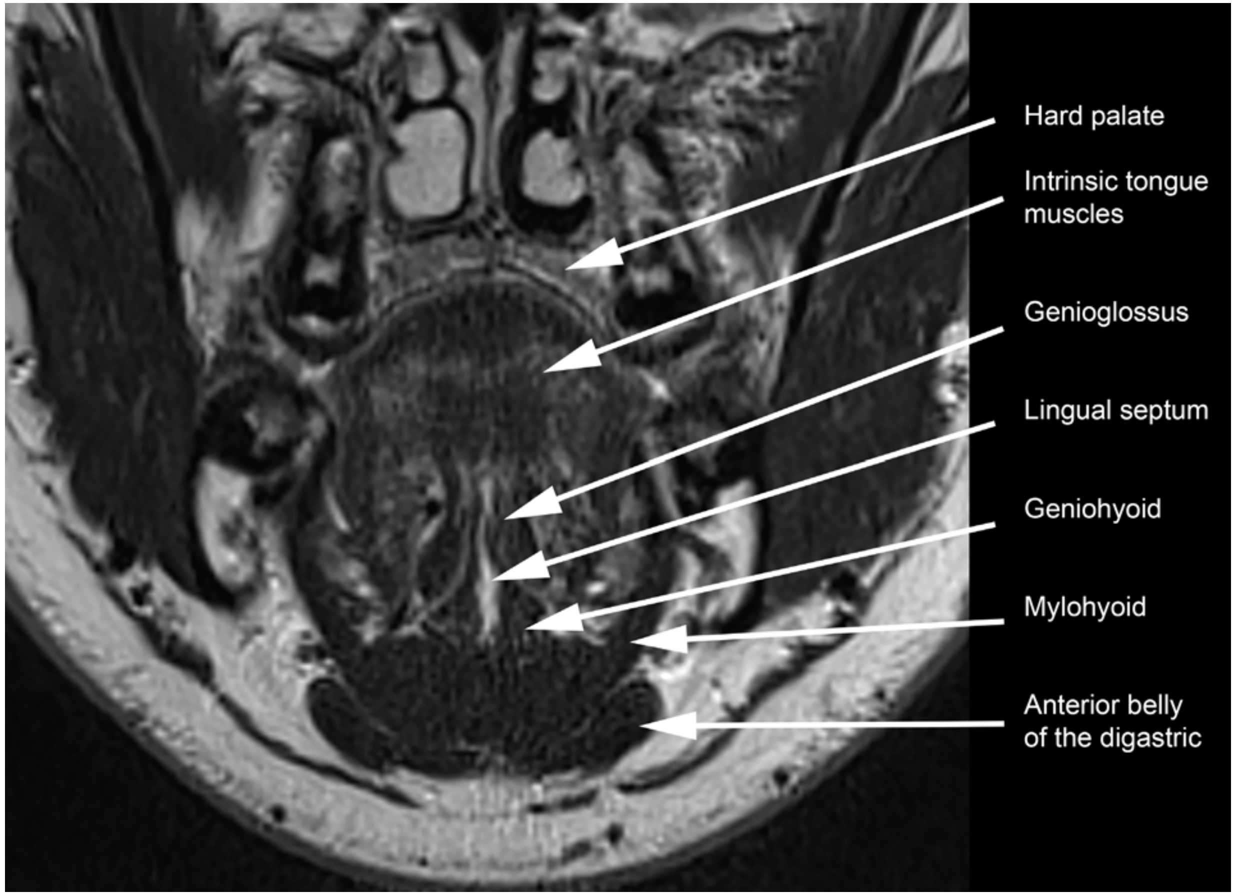


Fig. 15. Coronal T2W MR image of the oral cavity.

Chapter Outline

Anatomy -*Parotid*, submandibular and sublingual glands

Parotid gland (Figs. 16 and **17):** It is the largest salivary gland in the body. It is composed of adipose and glandular tissue in nearly equal portions.

Is located posterolateral to the ascending ramus of the mandible, masseter and medial pterygoid muscle and lateral to the common carotid artery (CCA) and internal jugular vein (IJV).

It contains the facial nerve, auriculotemporal branches of the mandibular nerve (CN V3), lymph nodes, the external carotid artery and retromandibular vein. The parotid duct (Stenson's duct) opens into the mouth on a small papilla, opposite the upper 2nd molar tooth.

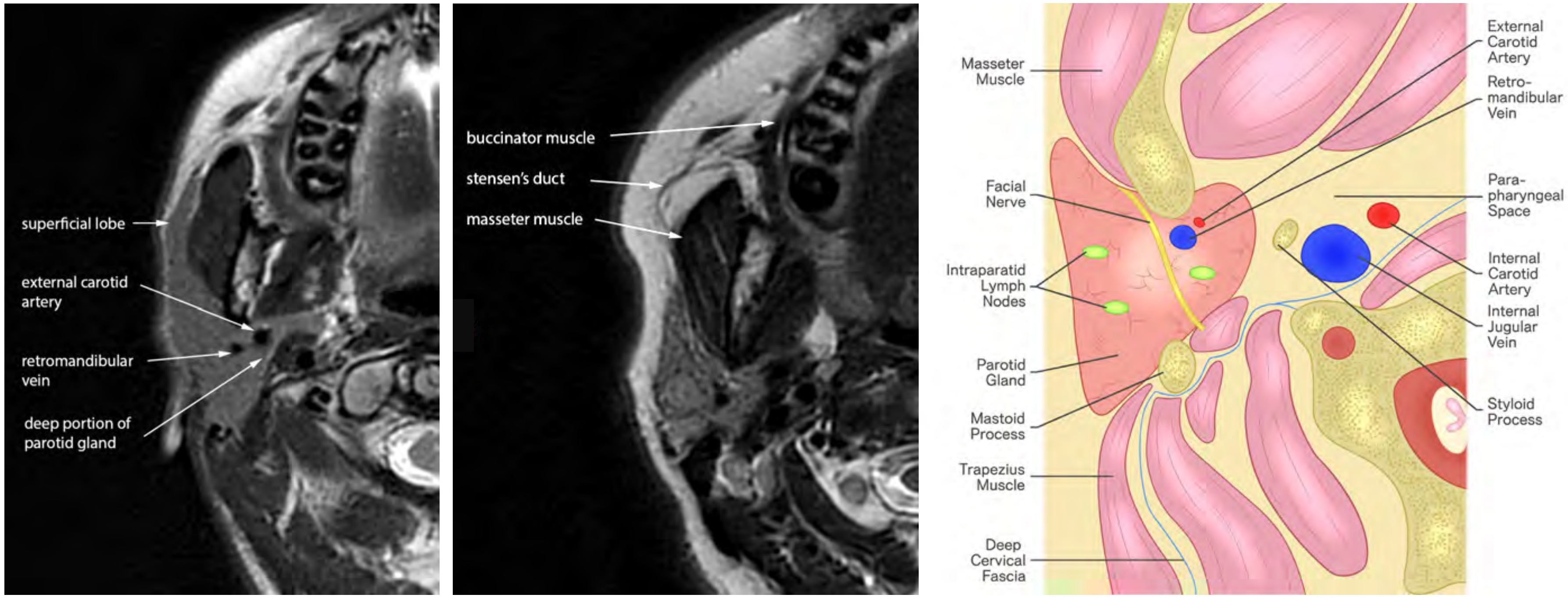


Fig. 16. Axial T2W MR images at the level of the right parotid gland and a schematic illustration of the pertinent anatomic structures within and surrounding the left parotid gland.

Anatomy -*Parotid*, submandibular and sublingual glands

Parotid gland :

It develops before the submandibular and sublingual glands but is the last to encapsulate

Explains why lymph nodes occur in the parotid gland but not in the other salivary glands.

This unique feature of the parotid gland has implications → predilection to develop lymphatic pathology.

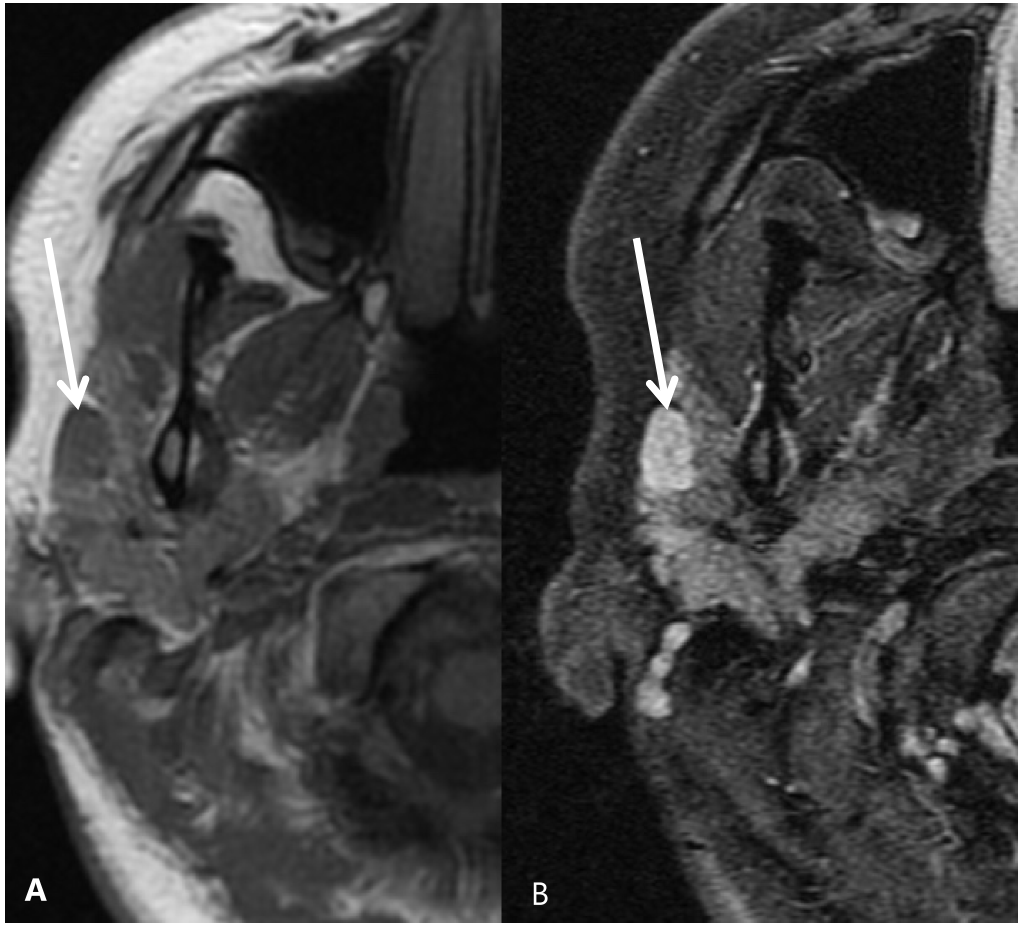


Fig. 17. Axial T1W MR image (A) and corresponding contrast-enhanced fat saturated T1 weighted (T1W FS + C) image (B) show a slightly enlarged, enhancing lymph node (arrows) in the right parotid gland. Histology revealed follicular lymphoma.

Anatomy -Parotid, ***submandibular*** and ***sublingual*** glands

Submandibular glands (Fig. 18): are paired glands located behind and below the ascending ramus of the mandible. They secrete mixed serous and mucous saliva that is excreted into the oral cavity via the submandibular duct (Wharton's duct) that connects the gland to the floor of mouth.

Sublingual glands (Fig. 18): are the smallest of the three major salivary glands. They are situated deep to the body of the mandible in the sublingual space. They are composed of a major sublingual gland and 8–30 small minor sublingual glands. The sublingual duct (duct of Bartholin) drains the major sublingual gland into Wharton's duct. Multiple tiny ducts of Rivinus drain the minor sublingual glands into the floor of the mouth.

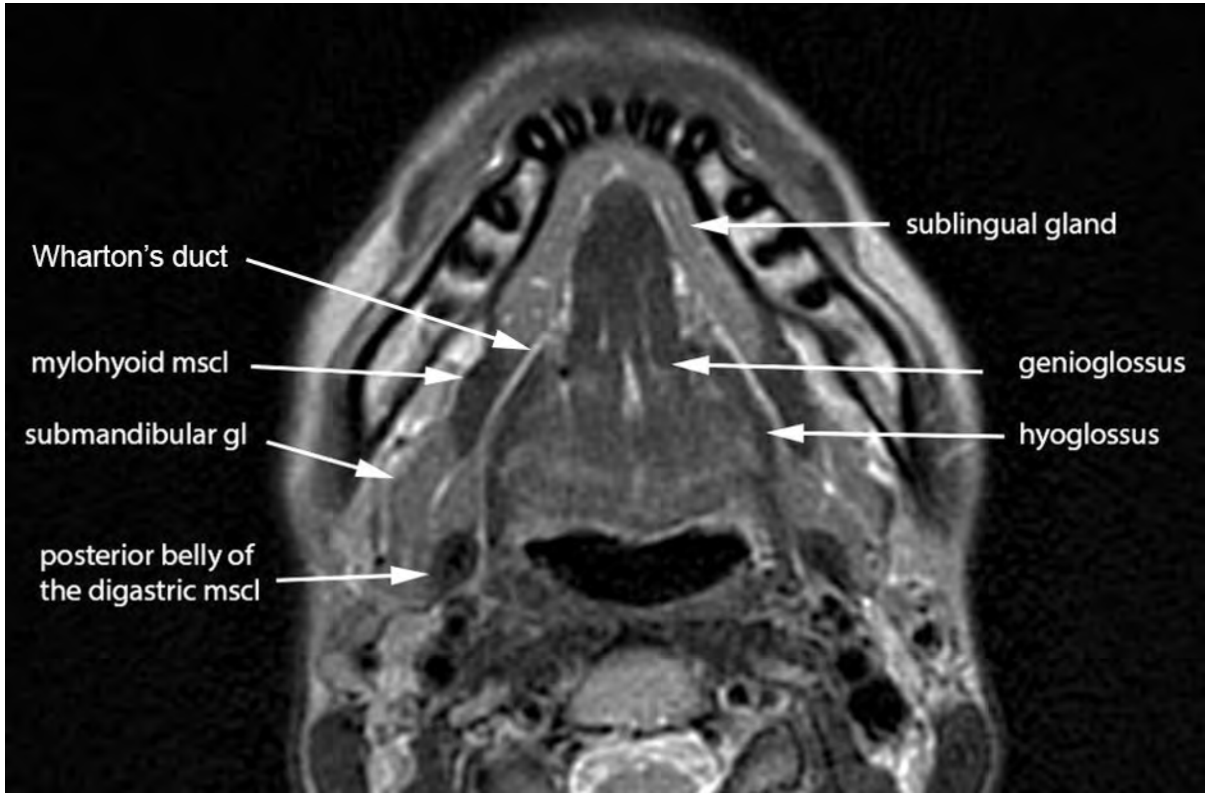
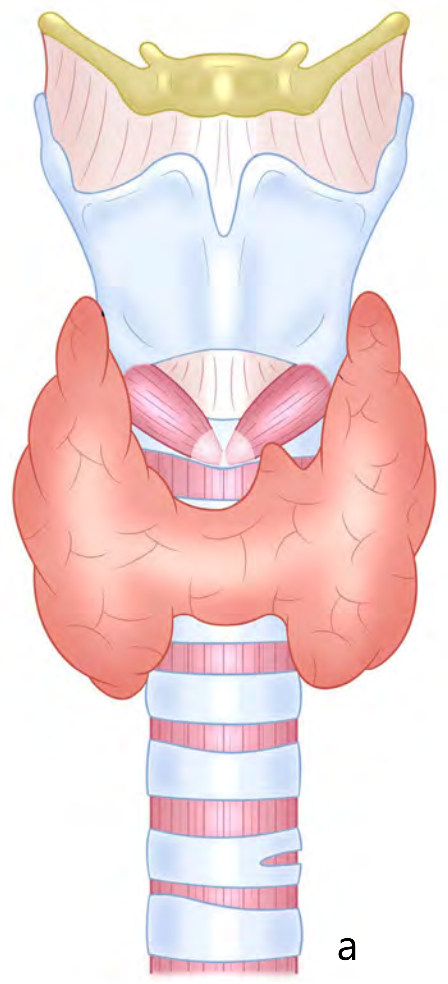


Fig. 18. Axial T2W image shows both the sublingual and submandibular glands.

Anatomy – Thyroid Gland

The thyroid gland (Fig. 19) is a single midline endocrine organ in the anterior neck responsible for thyroid hormone production. It extends from C5 to T1 and lies anterior to the thyroid and cricoid cartilages of the larynx and the first five or six tracheal rings.



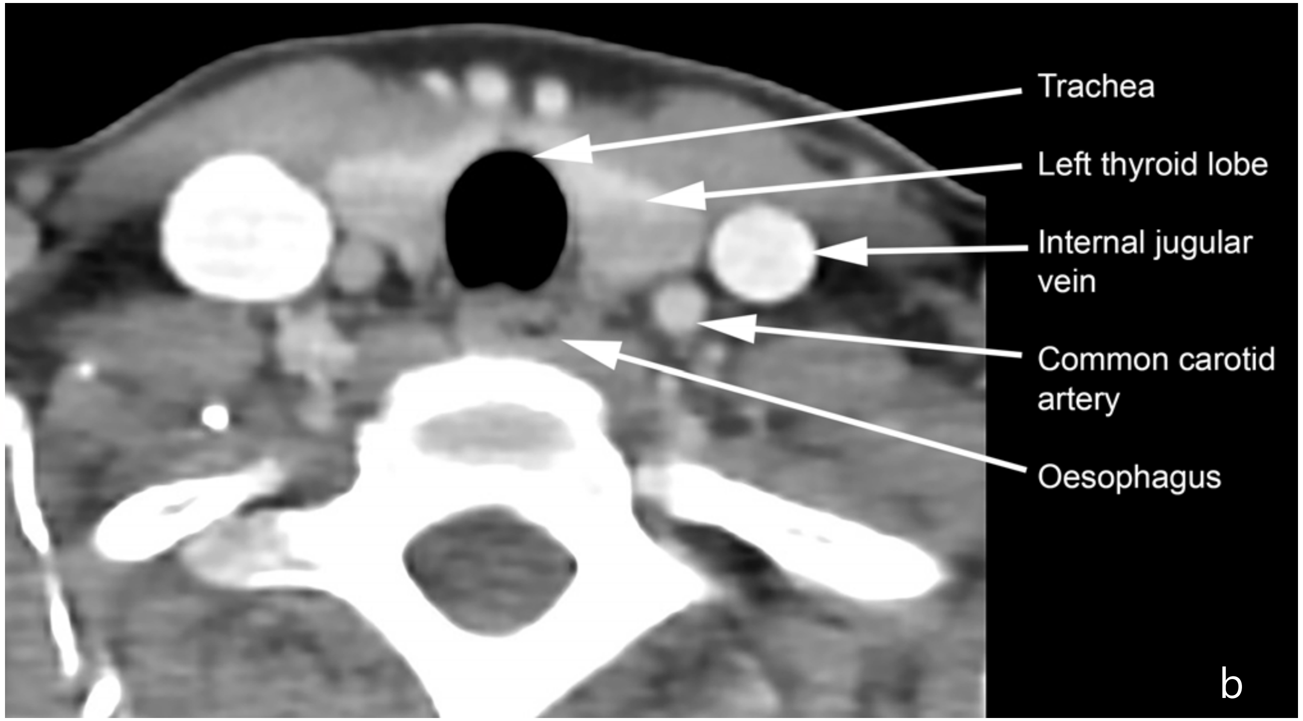


Fig. 19. Schematic illustration of the thyroid gland location and anatomy (a). Normal anatomy of the thyroid gland as depicted on an axial contrast-enhanced CT image at the level of the cervical trachea (b).

Anatomy – Thyroid Gland

Thyroid gland (Fig. 20) : is butterfly-shaped and is composed of two lobes, each with a superior and inferior pole. These lobes are connected in the midline via a narrow isthmus which is adherent to the 2nd to 4th tracheal rings.

The parathyroid glands lie posteromedially and are sometimes intracapsular.

The thyroid gland is related to the strap muscles anteriorly, and to the thyroid cartilage, cricoid cartilage and trachea posteriorly. Posteromedially, it abuts the tracheo-esophageal groove (containing lymph nodes, the recurrent laryngeal nerve, the parathyroid glands), whilst posterolaterally it is related to the common carotid artery and internal jugular vein.

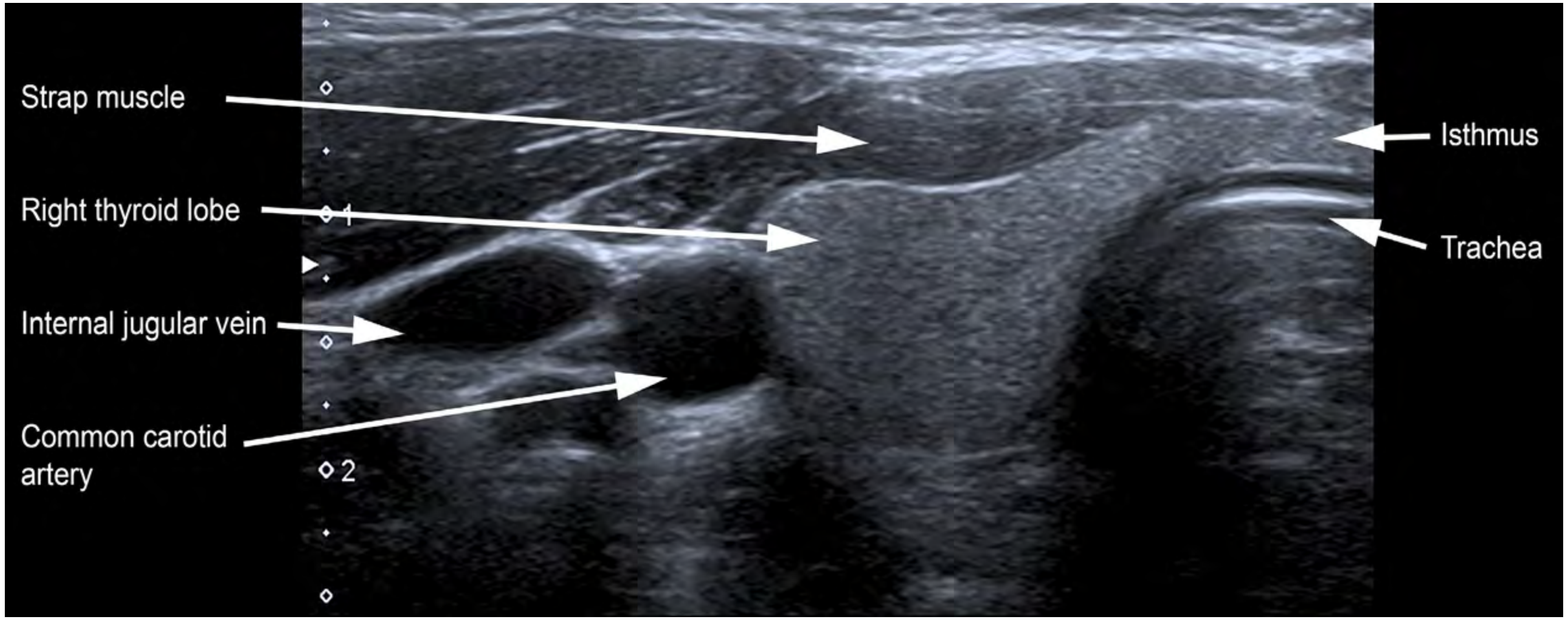


Fig. 20. Axial ultrasound image illustrating the normal anatomy of the thyroid gland. Note that the normal gland has a slightly higher echogenicity compared to the strap muscles.

Anatomy – Lymph Nodes

There are several groups of lymph nodes in the neck divided according to their location **(Fig. 21)** as follows:

Submental/level IA: anteromedial between the anterior bellies of both digastric muscles

Submandibular/level IB: posterolateral to the anterior belly of the digastric muscles

Upper internal jugular (deep cervical) chain/level II:

- Cranio-caudal extent: from the base of the skull at the jugular fossa to the inferior border of the hyoid bone.
- Antero-posterior extent: From the posterior border of the submandibular gland to the posterior border of the sternocleidomastoid muscle.
- Medial extent: to the medial border of the internal carotid artery

Middle internal jugular (deep cervical) chain/level III:

- Cranio-caudal extent: from the inferior border of the hyoid bone to the inferior border of the cricoid cartilage.
- Antero-posterior extent: from the anterior border of the sternocleidomastoid muscle to the posterior border of the sternocleidomastoid muscle.
- Medial extent: to the medial border of the common carotid artery.

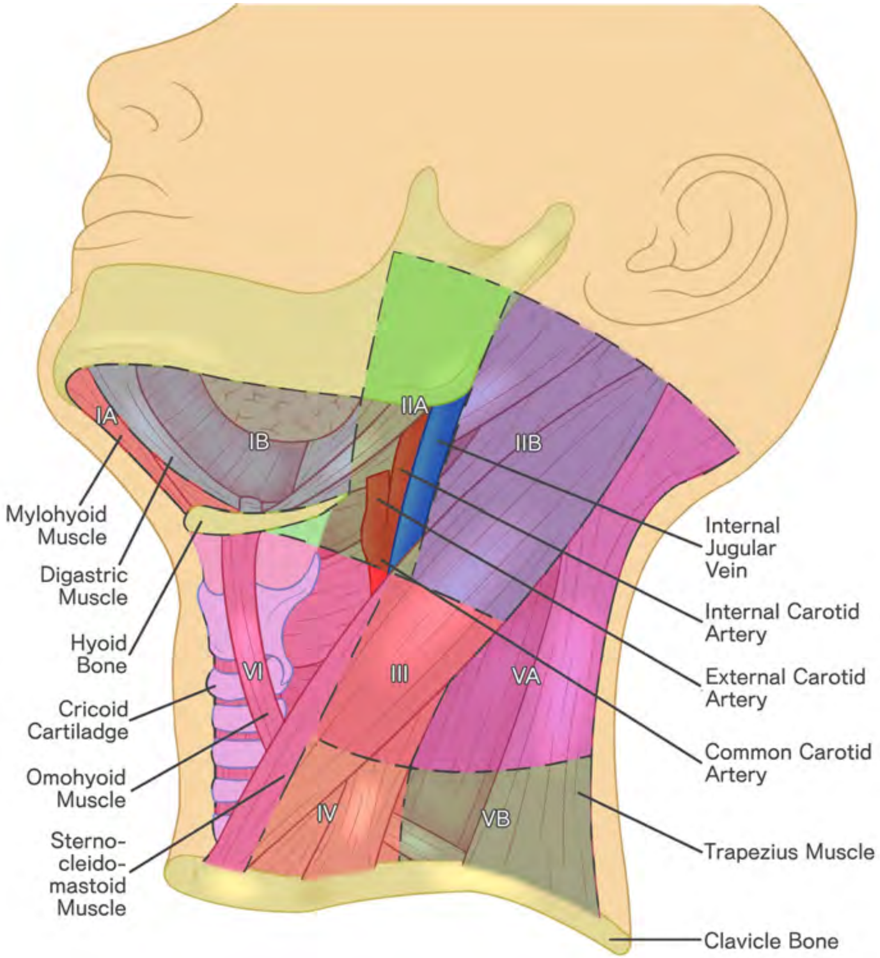


Fig. 21. Schematic diagram demonstrating the cervical lymph node levels in relation to important anatomical landmarks

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Anatomy – Lymph Nodes

Lower internal jugular (deep cervical) chain/level IV:
- Cranio-caudal extent: from the inferior border of the cricoid cartilage to the level of the clavicle.
- Antero-posterior extent: from the anterior border of the sternocleidomastoid to the posterolateral edge of the sternocleidomastoid muscle and lateral edge of the anterior scalene muscle.
- Medial extent: to the medial border of the common carotid artery. This includes the supraclavicular nodes including Virchow node.

Posterior triangle/level V:
- Cranio-caudal extent: from the level of the skull base at the apex of the convergence of sternocleidomastoid and trapezius muscles to the level of the clavicle.
- Antero-posterior extent: from the posterior border of the sternocleidomastoid muscle to the anterior border of the trapezius muscle.

Central (anterior) compartment/level VI:
- Cranio-caudal extent: from the inferior border of hyoid bone to the superior border of manubrium (suprasternal notch).
- Antero-posterior extent: from the the platysma muscle, to the trachea (medially) and prevertebral muscles (laterally.
- Lateral extent: to the medial borders of both common carotid arteries.

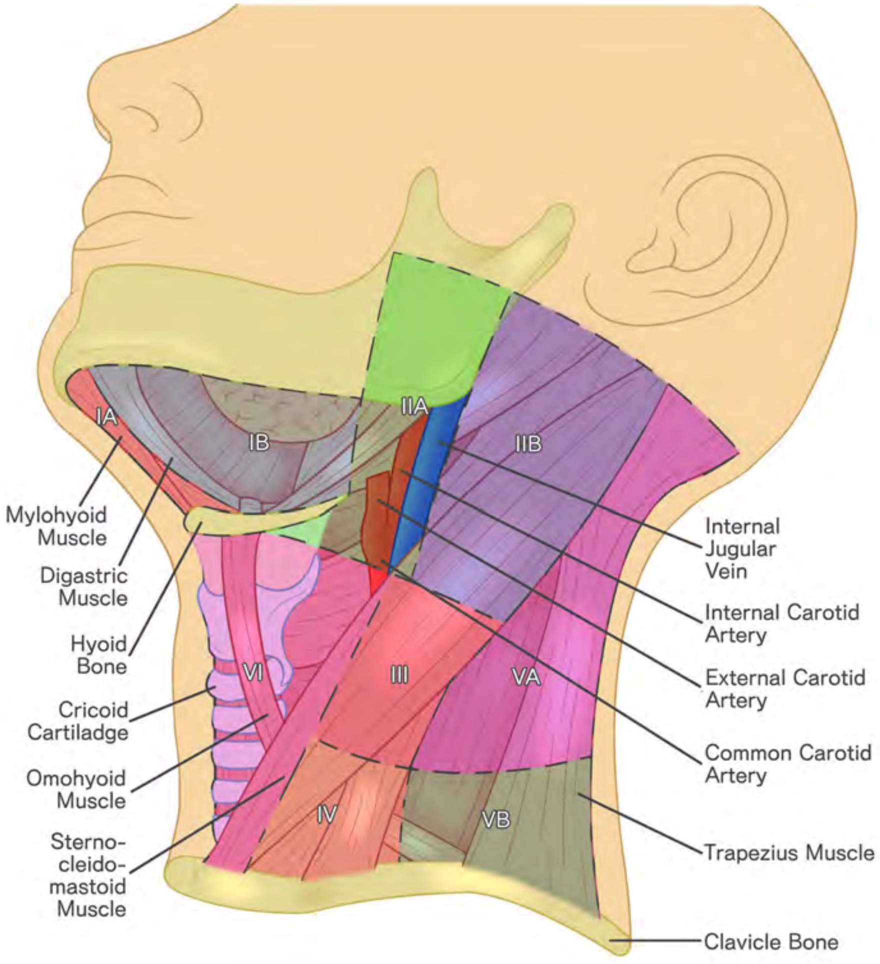
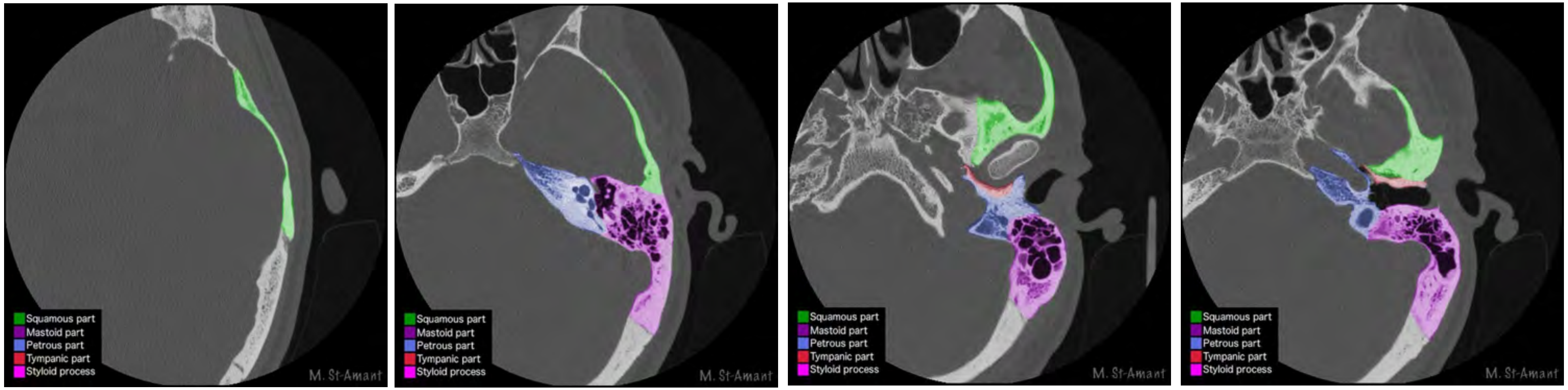


Fig. 21. Schematic diagram demonstrating the cervical lymph node levels in relation to important anatomical landmarks

Anatomy - Temporal Bones

The temporal bone is composed of four parts (**Fig. 22**):



Squamous part (temporal squama): forms the lateral wall of the middle cranial fossa and is separated from the parietal bone by the squamosal suture. Its zygomatic process contributes to the zygomatic arch and the squamosal portion bears the mandibular fossa. This together with the petrous portion of the temporal bone forms the bony portion of the Eustachian tube.

Petrous portion: this is divided into the petrous apex and base. The petrous apex articulates with the posterior part of the greater wing of the sphenoid and basilar occiput. It also houses the internal carotid artery. The base directly fuses with the squamous and mastoid portions. It houses the otic capsule or bony labyrinth which surrounds the membranous labyrinth of the inner ear (cochlea, vestibule, semicircular canals).

Tympanic portion: is situated inferior to the squamous part and in front of the mastoid bone. Its anterior surface forms the posterior part of the mandibular fossa. Anteriorly it is continuous with the squamous part of the temporal bone

Mastoid portion: is usually considered a separate entity but it is formed by both the squamous and petrous parts. It is the posterior component of the temporal bone. The inferior conical part is called the mastoid process. The styloid process passes inferiorly from the base of the petrous bone and the stylomastoid foramen lies behind the styloid process transmitting the facial nerve.

Fig. 22. Axial CT images of the normal temporal bone. Case courtesy of Maxime St-Amant, Radiopaedia.org. From the case rID:55609

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Anatomy – Temporal Bones

The temporal bone can also be divided into three otologic regions: the outer ear, the middle ear and the inner ear (**Figs. 23-29**).

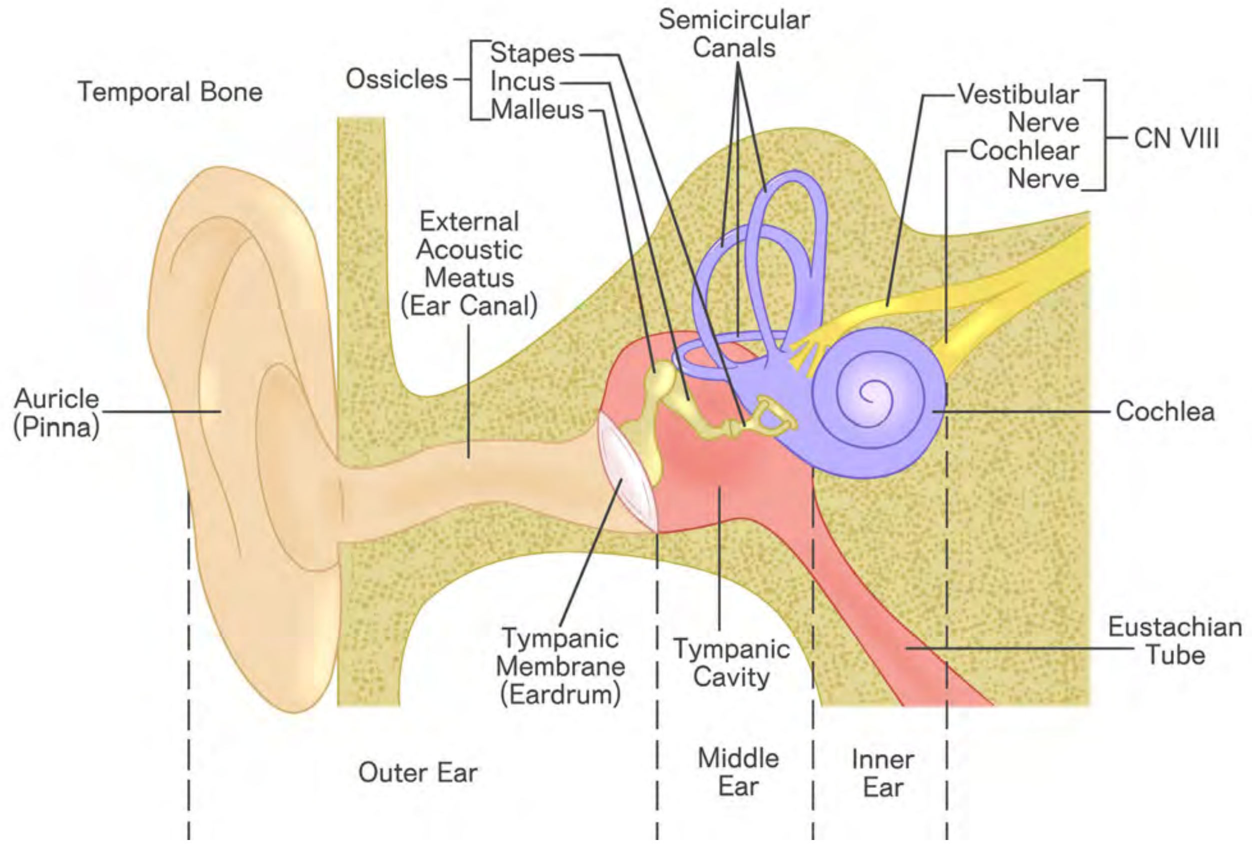


Fig. 23. Schematic drawing of the three otologic temporal bone regions.

Anatomy – Temporal Bones

- **External auditory canal:** It is usually 2.5cm long and S-shaped. The lateral third is bound by a fibrocartilaginous tube continuous with the external ear. The medial two thirds is surrounded by bone and arises from the tympanic and squamous portions of the temporal bone.
- **Middle ear also known as tympanic cavity:** this is an air-filled compartment in the petrous temporal bone, separated from the external ear by the tympanic membrane and from the inner ear by the medial wall of the tympanic cavity. It contains the auditory ossicles.
- **Inner ear and internal auditory canal:** The inner ear refers to the bony labyrinth, the membranous labyrinth and their contents. It is divided into three parts, the cochlea, vestibule and semicircular canals.

Figures 24 a-c illustrate the normal anatomy of the main anatomic structures of the peripheral auditory apparatus.

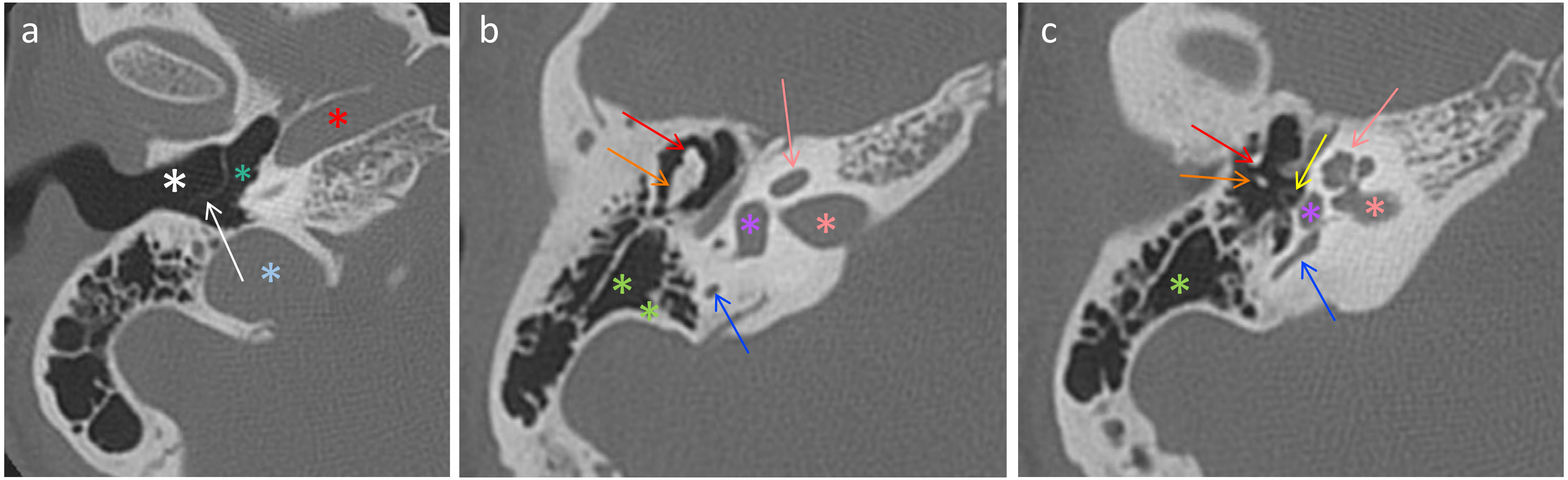


Fig. 24.a-c. Axial high-resolution CT slices of the temporal bone. External auditory canal (white asterisk), tympanic membrane (white arrow), middle ear (green asterisk), internal carotid artery (red asterisk), internal jugular vein (blue asterisk), malleus (red arrows), incus (orange arrows), stapes (yelow arrow), cochlea (pink arrows), vestibule (purple asterisks), semicircular canals (dark blue arrows), mastoid air cells (green asterisks), internal auditory canal (pink asterisk.

Anatomy – Temporal Bones

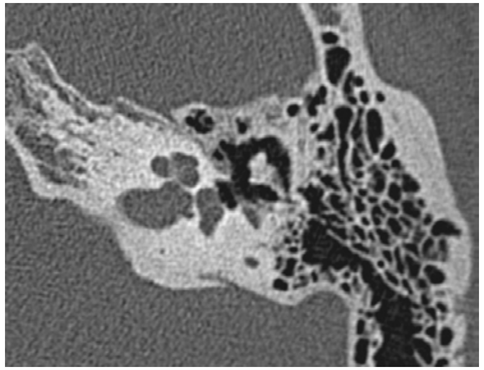


Fig. 25. High resolution CT: depicts the anatomy of the bony labyrinth in exquisite detail

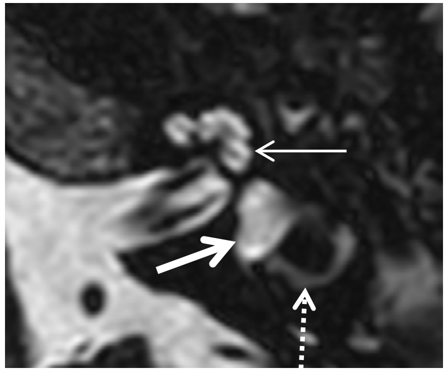


Fig. 26. High resolution MRI. This is a dedicated nerve sequence demonstrating the inner ear. The high signal in the cochlea (arrow), vestibule (thick arrow) and lateral semicircular canal (dashed arrow) s is mainly due to the perilymph.

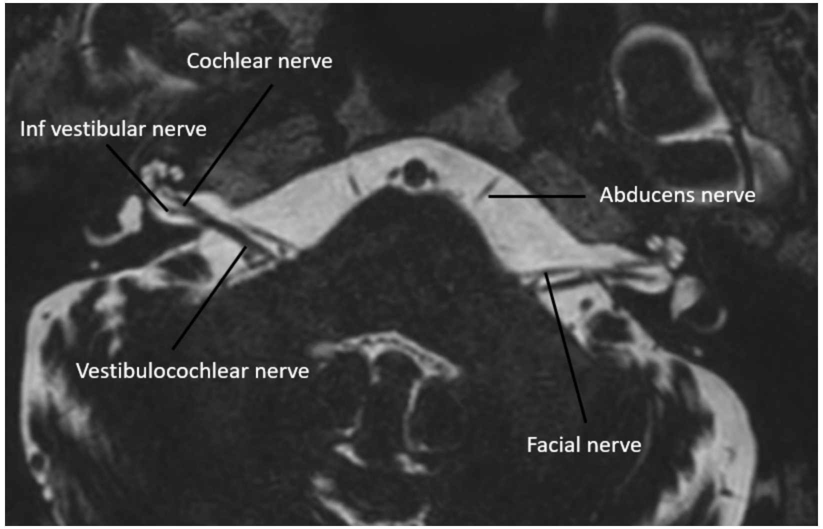


Fig. 27. The Internal auditory canal contains the vestibulocochlear nerve which supplies the vestibulocochlear apparatus.

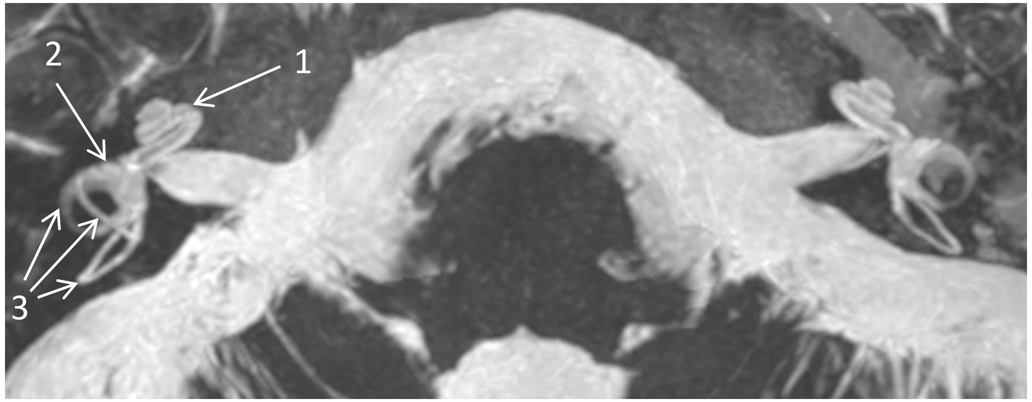


Fig. 28. Volume rendered axial T2 sequence (Maximum Intensity Projection, MIP) clearly depicts of the vestibulocochlear apparatus, which is divided into three parts: cochlea (1), vestibule (2), semicircular canals (3).

MRI is the imaging technique of choice for the assessment of the inner as it depicts its anatomy in exquisite detail (**Figs. 26-29**).

High resolution CT is indicated for the assessment of the middle ear in the context of trauma or inflammatory conditions to look for any fluid in the tympanic cavity and mastoid air cells, and to assess the integrity of the ossicular chain and walls of the middle ear.

Chapter Outline

Anatomy – Temporal Bones

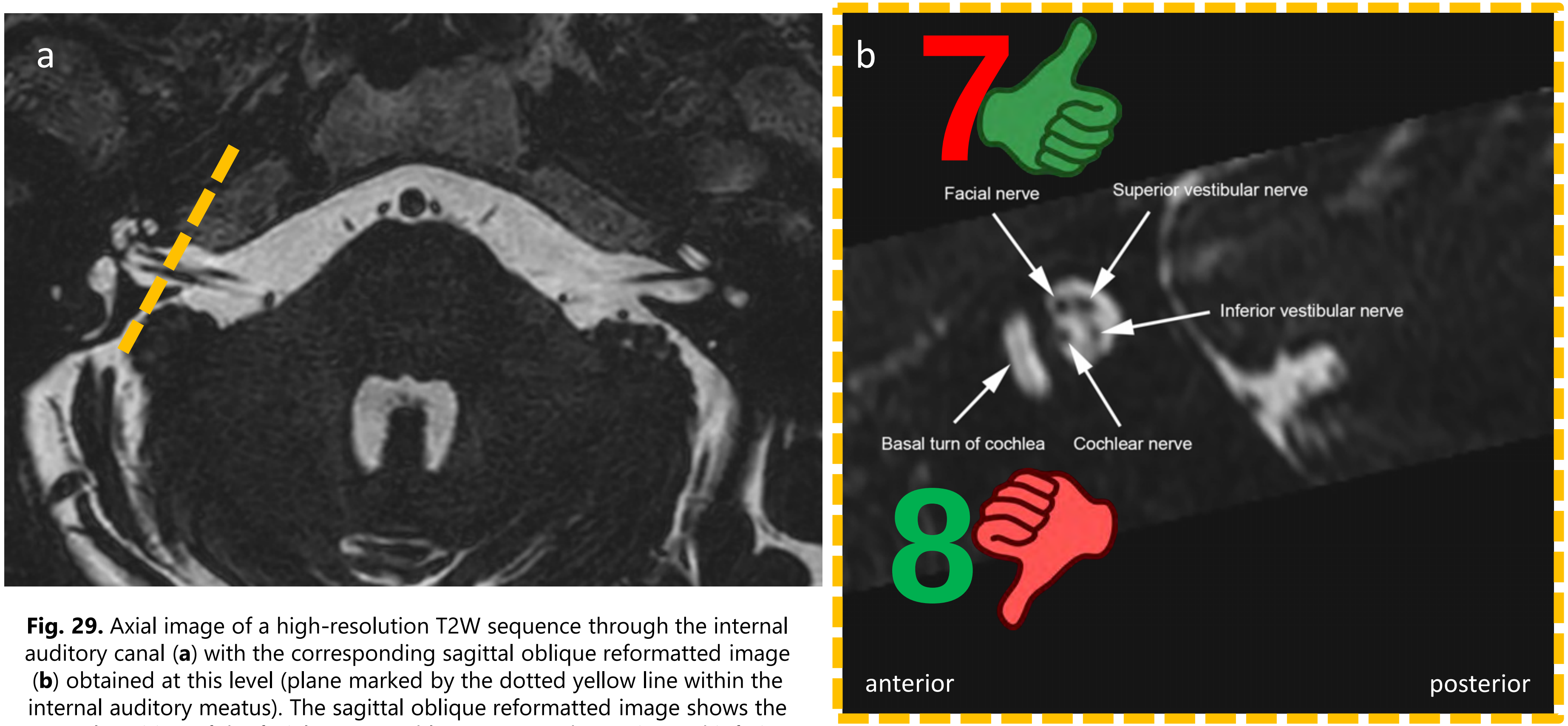


Fig. 29. Axial image of a high-resolution T2W sequence through the internal auditory canal (**a**) with the corresponding sagittal oblique reformatted image (**b**) obtained at this level (plane marked by the dotted yellow line within the internal auditory meatus). The sagittal oblique reformatted image shows the normal position of the facial nerve, cochlear nerve, and superior and inferior vestibular nerves. Note that the facial nerve lies superiorly (thumbs up sign) and the cochlear nerve lies below it (thumbs down sign). The superior and inferior vestibular nerves lie posteriorly to the facial and cochlear nerves, respectively.

Anatomical variants - Vascular

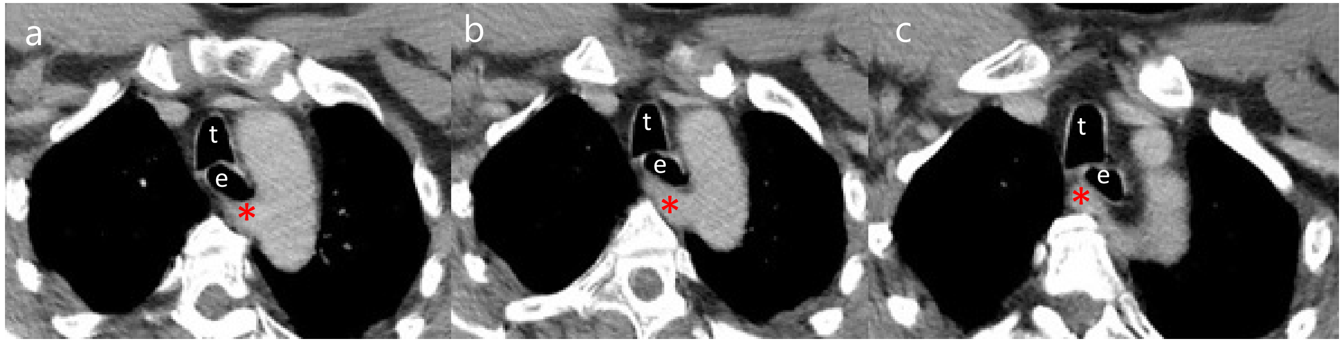


Fig. 30. Axial CT images (a)-(c) depict an **arteria lusoria** (asterisk). Trachea (t). Esophagus (e).

Aberrant right subclavian artery (**Fig. 30**) also known as arteria lusoria: is the commonest aortic arch anomaly with an estimated incidence of 0.5-2%. If there is a retro-oesophageal course, it can get compressed between the oesophagus and the vertebrae. Arteria lusoria is often asymptomatic but about 10% of people may complain of dysphagia.

Medialised course of the internal carotid artery (Fig. 31): this case demonstrates bilateral tortuous medialised internal carotid arteries known as "kissing carotids". This must not be confused with a submucosal pharyngeal mass as biopsy here could result in life-threatening haemorrhage. This vascular anomaly also poses surgical risk during a tonsillectomy. Damage to the ICA during tonsillectomy was first described in the 1780s.

Fig. 31. Axial contrast enhanced CT images (**a-c**) depict a **retropharyngeal course of the internal carotid arteries** (arrows), which almost come to lie next to each other in (c), sometimes referred to as "kissing carotids".

https://radiopaedia.org/articles/aberrant-right-subclavian-artery

Wasserman JM, Sclafani SJ, Goldstein NA. Intraoperative evaluation of a pulsatile oropharyngeal mass during adenotonsillectomy. Int J Pediatr Otorhinolaryngol. 2006 Feb;70(2):371-5. doi: 10.1016/j.ijporl.2005.07.002. Epub 2005 Aug 19. PMID: 16112205.

Chapter Outline

Anatomical variants – Ectopic thyroid

Ectopic thyroid tissue (Fig. 32) : The thyroid gland normally migrates down from the foramen cecum at the posterior aspect of the tongue to its permanent location in the infrahyoid neck. Ectopic thyroid tissue refers to thyroid tissue found along this embryological course

=> see also e book chapter on pediatric radiology.

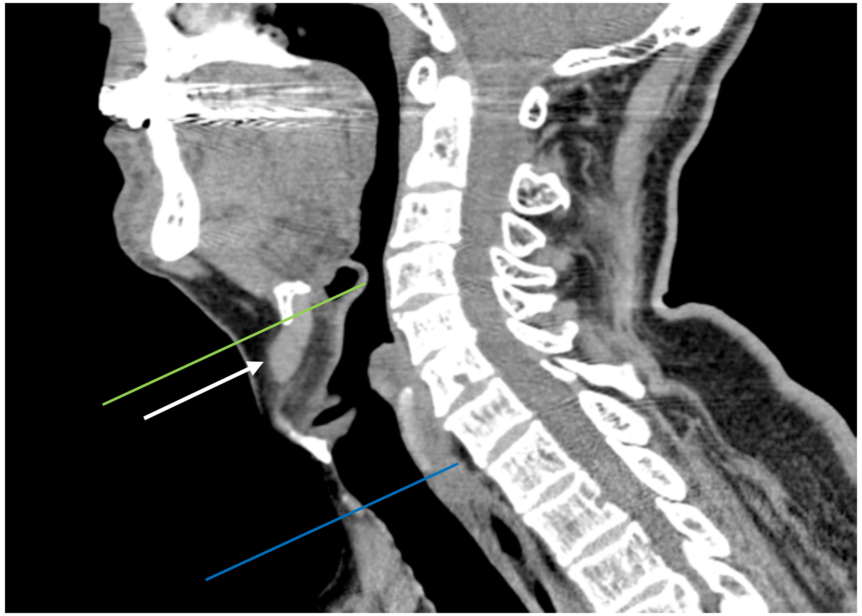


Fig. 32. Ectopic thyroid tissue below the hyoid bone (imaging plane indicated with green line) protruding into the preepiglottic space (arrow) as seen on CT. Normal thyroid gland (imaging plane with blue line) in normal anatomic position (asterisks). *Images courtesy of Lorenzo Ugga, MD (University of Naples Federico II, Naples, Italy).*

Chapter Outline

Anatomical variants - Paranasal Sinuses

Onodi cell also known as sphenoethmoidal cell, is a posterior ethmoidal cell. This is pneumatised far laterally and superiorly to the sphenoid cell. Optic nerve and carotid artery often found lateral to the Onodi (instead of sphenoid)

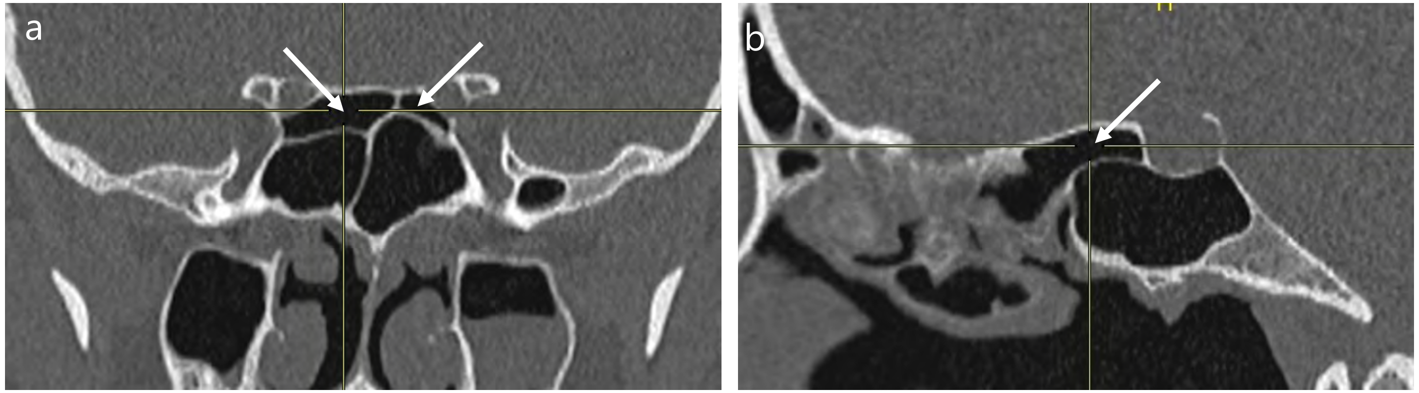


Fig. 33. Bilateral Onodi cells (arrows) as seen on (a) coronal and (b) sagittal CT images.

Nasal septal spurs can be associated with nasal septal deviation. In this case the spur is arising from the left side of the nasal septum and is displacing the middle turbinate superiorly.

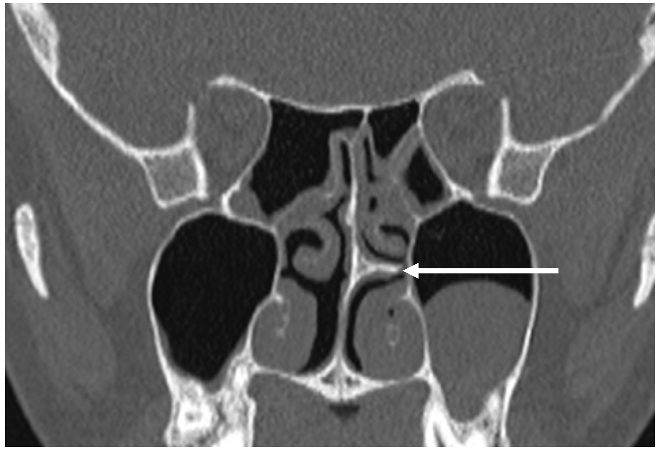


Fig. 34. Nasal septal spur (arrow) as seen on a coronal CT image.

Diagnostic Imaging Techniques - Conventional X-Ray

Applications of conventional radiography in head and neck imaging:

- Emergency setting – retropharyngeal or prevertebral space abscess, suspected acute supraglottitis (**Fig. 35**)
- Paranasal sinuses/facial bones in the context of trauma
- Dental pathology
- Bony pathology of the maxilla and mandible, e.g., osteonecrosis (**Fig. 36**), cherubism, fibrous dysplasia.
- Conventional sialography (rarely used as mainly replaced by MR sialography)
- Salivary glands to identify calculi (now largely superseded by CT or CBCT)

Advantages:
- Is a cheap, simple and quick imaging modality.
- Useful to diagnose calcified sialoliths or Ca2+ within the gland
- Can identify adjacent osseous lesions
- Superior spatial resolution

Disadvantages:
- Radiation penalty
- Cannot identify soft tissue masses
- One-fifth of salivary ductal calculi are radiolucent (Rastogi R et al 2012)

Fig. 35. Lateral conventional X ray of the neck obtained in the emergency setting showing narrowing of the supraglottic larynx (arrow) due to acute supraglottitis.

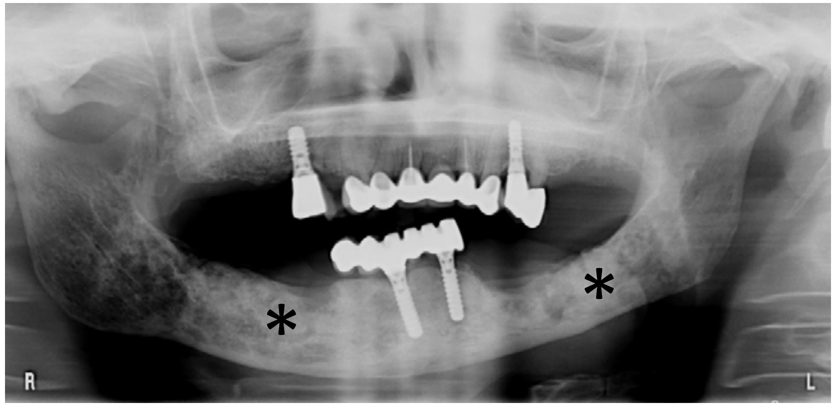


Fig. 36. Orthopantomography (OPT) showing an irregular mandibular bony structure with areas of sclerosis and lysis due to osteoradionecrosis (asterisks) in a patient with previous radiotherapy for a head and neck cancer.

Chapter Outline

Diagnostic Imaging Techniques - Conventional X-Ray

Paranasal sinuses/facial bones x-ray:

On plain radiographs the normal sinuses are transradiant because they contain air. Plain films can show mucosal thickening, fluid levels, bone destruction and fractures. High resolution CT is however the preferred imaging modality for the assessment of sinus disease due to its multiplanar capability, high sensitivity and high specificity.

X ray projections that are normally used include:

Waters view (Fig. 37): best to assess the maxillary and frontal sinuses, the floor of the orbit, orbital rim and infraorbital foramen.

Lateral view (Fig. 38): best for assessment of the sphenoid sinus, sella turcica. The frontal, ethmoid, and maxillary sinuses are superimposed on each other. Other structures that can be visualized include clivus, nasopharynx, hard palate, soft palate, and mandible.

Sialography (Fig. 39) uses a digital subtraction method and relies on retrograde intra-ductal injection of a water-soluble, iodinated, contrast medium into Stenson's/Wharton's duct opening.

Fig. 37. Waters view

Fig. 38. Lateral view

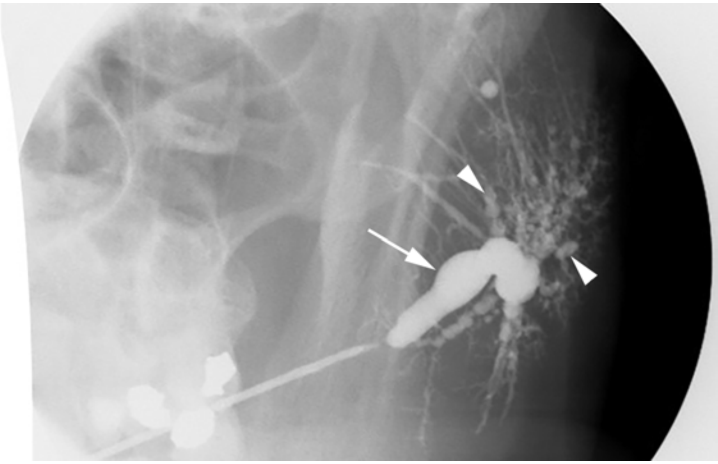


Fig. 39. Conventional sialography showing dilatation of the left Stensen's duct (arrow) associated with globular dilatation of the intraparenchymal ducts (arowheads) consistent with advanced sialectasis

Chapter Outline

Diagnostic Imaging Techniques - CT

INDICATIONS

Non-contrast high-resolution CT or CBCT:

1. Paranasal sinuses: prior to functional endoscopic sinus surgery (FESS). It provides information about the pathology itself and also highlights important anatomical variants/landmarks which the surgeons needs to know in order to avoid post-operative complications.
2. Temporal bones: Inflammatory conditions such as otits media and cholesteatoma. It identifies the pathology and assesses the severity in terms of ossicular erosion/destruction. In the context of trauma, it detects temporal bone fractures, ossicular dislocations, involvement of the otic capsule.
3. Sialolithiasis: Non-contrast CT is highly specific in detecting calcified calculi however it is not indicated in the assessment of salivary gland duct system.
4. Any pathology of the bony structures, e.g., fibrous dysplasia (**Fig. 40),** osteoradionecrosis (**Fig. 41),** fractures, etc.

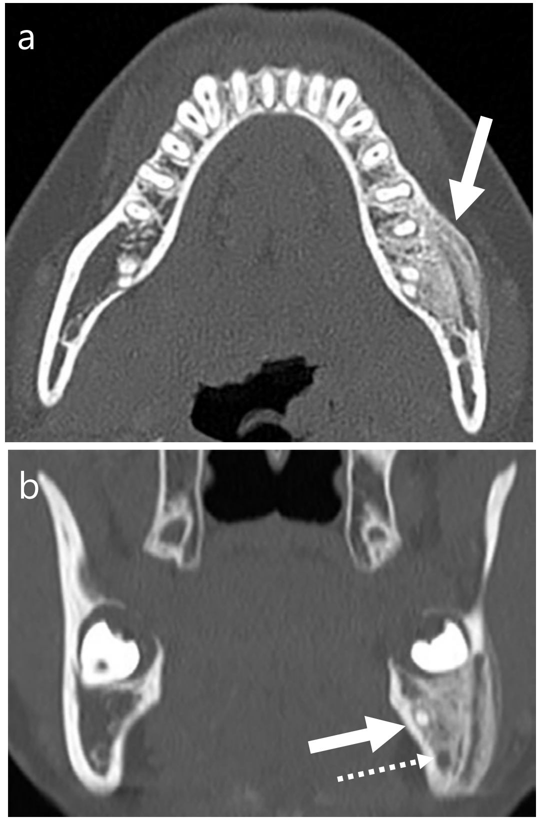


Fig. 40. Axial (a) and coronal (b) images from a high-resolution CT demonstrating the presence of fibrous dysplasia involving the left hemimandible (arrow) and clearly delineating its relationship to the inferior alveolar nerve (dashed arrow).

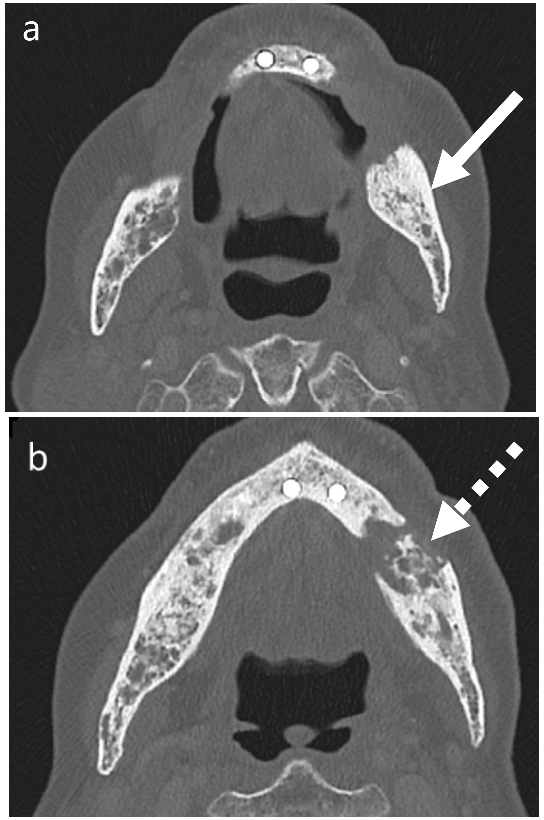


Fig. 41. Axial images from a non-contrast high resolution CT demonstrating osteonecrosis of the left mandible (arrow) in (a) with massive bone destruction and sequestrum formation (dashed arrow) in (b) as a complication of radiotherapy for oral cavity SCC.

Chapter Outline

Diagnostic Imaging Techniques - CT

INDICATIONS

Post-contrast CT scan:

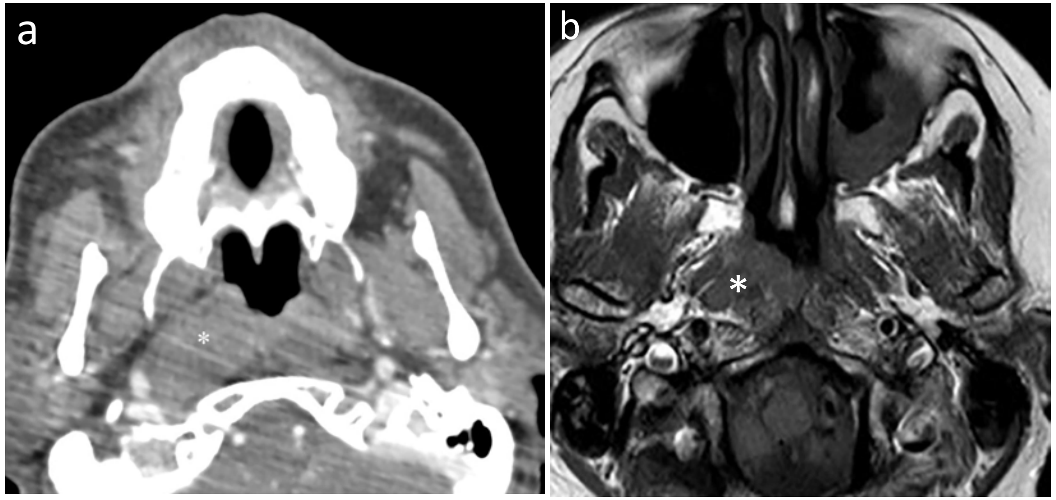
1. Acute neck space infections for instance acute epiglottitis, tonsillar abscess, peritonsillar abscess, Ludwig's angina, masticator space abscess after dental extraction, deep neck space infection complicating malignant otitis externa, complicated otomastoiditis, etc.
2. Post-trauma: Carotid or vertebral artery dissection, laryngeal trauma,
3. Staging of head and neck malignancies particularly when MRI is contraindicated.
4. Osteonecrosis of the mandible or maxilla : following radiotherapy or bisphosphonate therapy. To rule out associated abscesses or disease recurrence in the context of known malignancy.

Advantages:
- Quick and better tolerated by patients. This is particularly useful in trauma and in patients with extensive neck malignances (especially oropharyngeal and laryngeal) who are unable to spend prolonged periods of time in the supine position.
- Multiplanar and volume rendering capability (especially useful to the surgeons when dealing with complex facial/LeFort fractures for surgical planning).
- Demonstrates the osseous lesions/extension and calcification/calculus better than MRI.

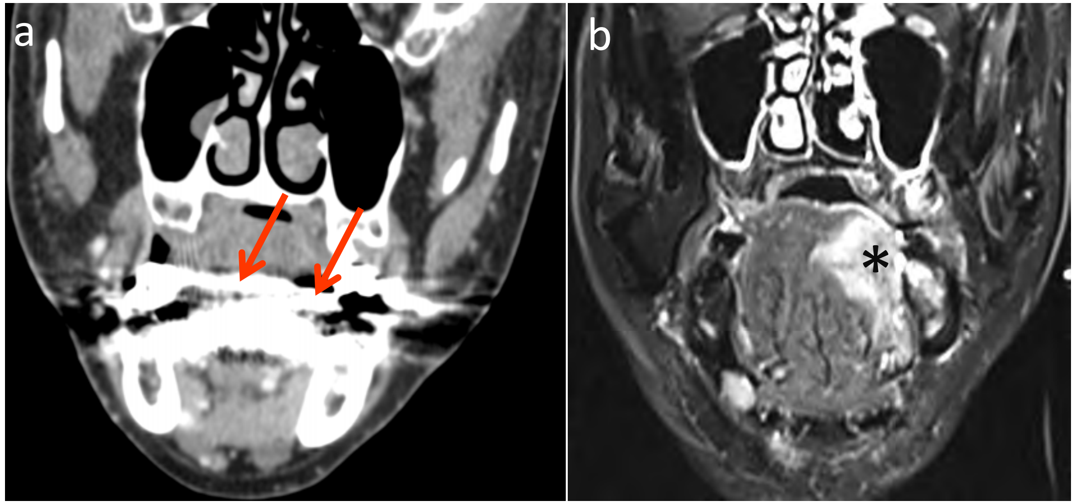
Disadvantages:
- Uses ionizing radiation with its inherent risks
- Limited soft tissue contrast resolution when compared to MRI limiting its value for locoregional staging of certain head and neck malignancies such as nasopharyngeal, oral cavity and oropharyngeal cancer.
- Certain artefacts from dental restoration may obliterate the region of interest, significantly limiting its diagnostic accuracy.

Chapter Outline

Diagnostic Imaging Techniques - CT



<= **Fig. 42.** Same patient, different imaging modality. **a.** CT is fast, well tolerated, and readily available but has lower contrast resolution and requires iodinated contrast material. Asterisks indicate nasopharyngeal cancer. **b.** Note improved lesion conspicuity on the MR image.



<= **Fig. 43.** Patient with a left-sided oral tongue cancer, which was obscured by the artefacts arising from dental fillings on CT in **a**. (arrows) but was then picked up on MRI (asterisk) in **b**. MRI is less affected by dental fillings than CT.

MRI has a higher contrast resolution than CT (**Fig. 42**).

MRI is less affected by dental artifacts than CT (**Fig. 43**).

Chapter Outline

Diagnostic Imaging Techniques - CBCT

INDICATIONS

(Some are identifical to those of high-resolution non-contrast CT)

Paranasal sinuses: prior to functional endoscopic sinus surgery. It provides information about the pathology itself and also highlights important anatomical variants/landmarks which the surgery needs to know in order to avoid post-operative complications.
Temporal bones: Inflammatory conditions such as otomastoiditis, otits media and cholesteatoma. It identifies the pathology and assesses the severity in terms of ossicular erosion/destruction.
Dental imaging: Extensively used prior to dental implantation or dental extraction to help localize the inferior alveolar nerve. Also helps for volume measurement of odontogenic lesions pre- and post-operatively.

Advantages:
- Quick and well-tolerated by patients.
- Higher spatial resolution compared to conventional multidetector CT.
- Lower radiation dose compared to conventional CT.
- Multiplanar and volume rendering capability.

Disadvantages:
- Uses ionizing radiation.
- Unable to assess the soft tissues, only bones.

Chapter Outline

Diagnostic Imaging Techniques - MRI

INDICATIONS

Pre- and post-contrast MRI:
1. Locoregional staging of head and neck malignancy: Certain parts of the head and neck are much better delineated with MRI such as the nasopharynx, oropharynx and oral cavity. MRI has the capability of demonstrated the presence of local invasion of the nerves (perineural spread) which is critical for staging. Intracranial extension is also clearly depicted on MRI.
2. Pediatric head and neck emergencies: For instance, subperiosteal abscesses complicating acute sinusitis to delineate any intraorbital extension, cavernous sinus thrombosis or subdural abscess formation
3. Detection of tumor recurrence after treatment: MRI is superior to CECT.

Non-contrast MRI
1. Cholesteatoma imaging: essential in detecting chlesteatoma recurrence after surgery.
2. MR Sialography: used to study the ductal system precluding the need for direct contrast injection into the duct.

Advantages:
- No ionizing radiation
- Multiplanar and volume rendering capability (especially useful to the surgeons for surgical planning
- Superior soft tissue contrast resolution allowing better characterization of the lesion based on its signal characteristics and enhancement pattern.
- Certain artefacts from dental restoration may obliterate the region of interest limiting the diagnostic MRI accuracy, however, in most cases MRI allows superior lesion delineation in comparison to CT (**Fig. 43** from page 38).
- MR sialography can be performed in patients with acute sialadenitis, which is a contraindication to X-ray sialography (page 35)

Disadvantages:
- Standard contraindications to MRI (claustrophobia, certain types of pace-makers, neurostimulators, ferromagnetic foreign bodies)
- Longer exam when compared to US and CT.
- More susceptible to motion artefacts (swallowing, breathing and pulsation artefacts).
- Patients with extensive neck malignances (especially oropharyngeal and laryngeal) or tracheostomies are unable to spend prolonged periods of time in the supine position.

Diagnostic Imaging Techniques - Ultrasound

INDICATIONS

- Assesment and classification of thyroid lesions
- Suspected salivary gland tumours
- Sialolithiasis
- Acute sialadenitis
- Helps distinguish solid from cystic lesions in the neck
- High specificity and sensitivity for pathological lymph nodes (**Figs. 44, 45**). Can distinguish between benign and malignant lymph nodes based on their shape, size and pattern of vascularity.

Advantages:

- Quick and cheap
- Noninvasive
- No ionizing radiation
- Helps in diagnosing sialolithiasis
- Differentiates cystic from solid lesions
- Aids in guiding the exact site of FNA or biopsy in suspected salivary gland lesions or lymph node metastases
- In experienced hands, it helps differentiate intra-parotid nodes from true intraparenchymal lesions,
- Excellent spatial resolution

Disadvantages:

- Operator dependent
- No standardized, reproducible imaging documentation
- Unable to assess retrosternal, retropharyngeal, skull base or any other deep-seated lesions.
- Cannot evaluate the deep lobe of the parotid gland.

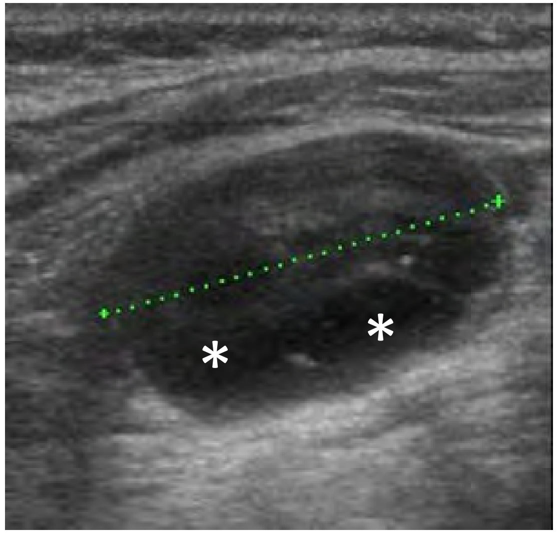


Fig. 44. Targeted US image demonstrating a morphologically abnormal lymph node which has cystic portions (asterisks) and has no central fatty hilum. FNA was performed and confirmed the presence of metastatic non-keratinizing SCC from a nasopharyngeal primary.

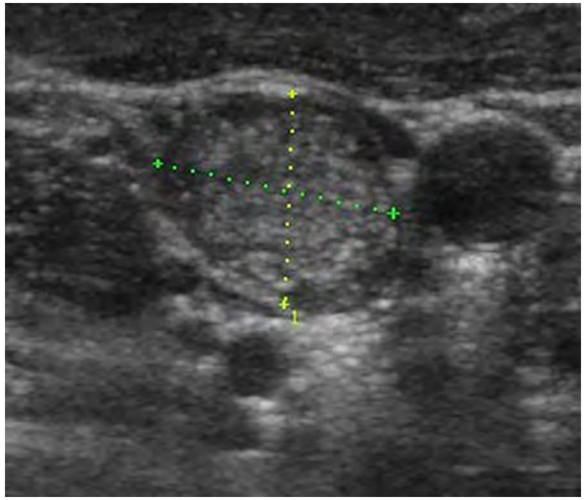


Fig. 45. US shows a pathological lymph node. It is round, with no fatty hilum and contains several microcalcifications (small hyperechoic areas). Findings are pathognomonic of metastatic papillary carcinoma.

Chapter Outline

Diagnostic Imaging Techniques - PET CT

INDICATIONS
- Staging of malignancies affecting the head and neck, e.g., , head and neck squamous cell carcinoma, lymphoma (**Fig. 46**), melanoma, some forms of thyroid cancer
- Baseline imaging before commencement of treatment
- Assessing response to therapy
- Evaluation of disease recurrence
- As a problem-solving tool in cases of tumour of unknown origin
- Suspected malignant transformation in plexiform neurofibromata (NF type 1).

Advantages:
- Enables acquisition of both functional and anatomical information in a single study.
- May have diagnostic value detecting metastatic lesions which might be missed with conventional imaging
- Can assess locoregional lymph node spread more precisely than CT

Disadvantages:
- Ionizing radiation
- Long acquisition times
- Limited spatial resolution

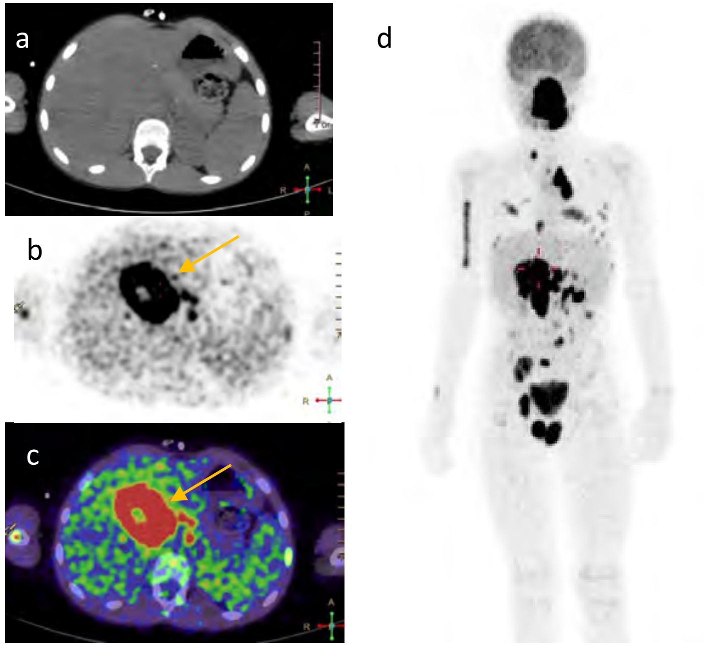


Fig. 46. Extensive nodal, skeletal, liver, and testicular metastatic disease with possible lung involvement in a pediatric patient with non-Hodgkin's lymphoma of the mandible and maxilla. a. Axial CT image through the liver. b Corresponding PET image showing a large hypermetabolic lesion (arrow.). c. PET CT fused image. Arrow points at liver metastasis. d. 3D PET whole body projection showing multiple FDG avid lesions.

Lecchi M, Fossati P, Elisei F, Orecchia R, Lucignani G. Current concepts on imaging in radiotherapy. Eur J Nucl Med Mol Imaging. 2008 Apr;35(4):821-37. doi: 10.1007/s00259-007-0631-y. Epub 2007 Oct 31. PMID: 17972074.

Clinical indications for positron emission tomography. Oxford University Hospitals. 2003. National Health Service, UK

Chapter Outline

Inflammatory and infectious lesions

Sinusitis & Complications

In inflammatory conditions of the paranasal sinuses, the imaging modality employed depends on the clinical situation.

As plain radiography is non-sensitive and non-specific, it has been largely replaced by CT (higher definition, superior detail and multiplanar capability).

General rules :

Chronic sinusitis and nasal polyposis:
Non-contrast multidetector low dose CT or cone beam CT (CBCT)

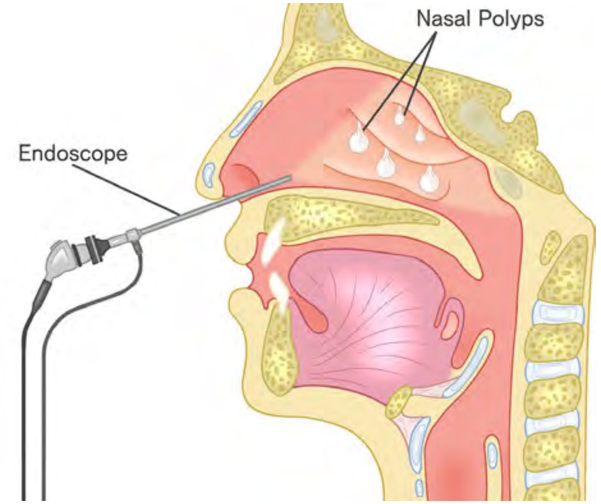
Prior to FESS (functional endoscopic sinus surgery):
Non-contrast low dose CT/CBCT (**Fig. 47**)

Evaluation of congenital anomalies (cherubism, fibrous dysplasia)
Non-contrast CT/CBCT

Acute sinusitis with suspected orbital or intracranial complications:
Contrast enhanced CT (emergency situation). If CT diagnosis is not clear, further evaluation with MRI is required to rule out intraorbital extension, subdural/ epidural abscess formation and cavernous sinus thrombosis .

Should CT or CBCT be used?

- CT: Can be used with or without iv. contrast. Allows assessment of soft tissues especially in the emergency setting
- CBCT: Useful pre-FESS to highlight important anatomical landmarks and variants. Allows assessment of dental pathology. Not suitable for assessment of the soft tissues



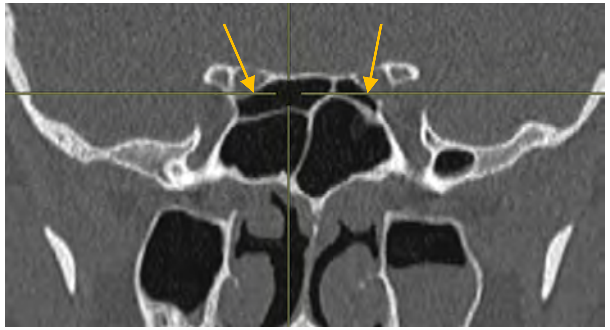


Fig. 47. Coronal reconstructed image from a high-resolution CT. Bilateral Onodi cells (arrows). This puts the optic nerves at risk of damage during FESS and can only be identified at pre-operative imaging with CT or CBCT.

Inflammatory and infectious lesions - Sinusitis & Complications

In the emergency setting, if there is suspicion of acute sinusitis with potential intraorbital or intracranial complications (**Figs. 48 and 49**.), one must first start by requesting a contrast enhanced CT of the brain and sinuses.

CT with contrast allows precise abscess localization and volume measurements, which aid surgical decision making.

MRI is used to search for cavernous sinus thrombosis or any other intracranial complications especially in cases with unclear CT features. In addition, MRI is superior to CT for distinguishing between cellulitis and abscess, a distinction which has therapeutic implications.

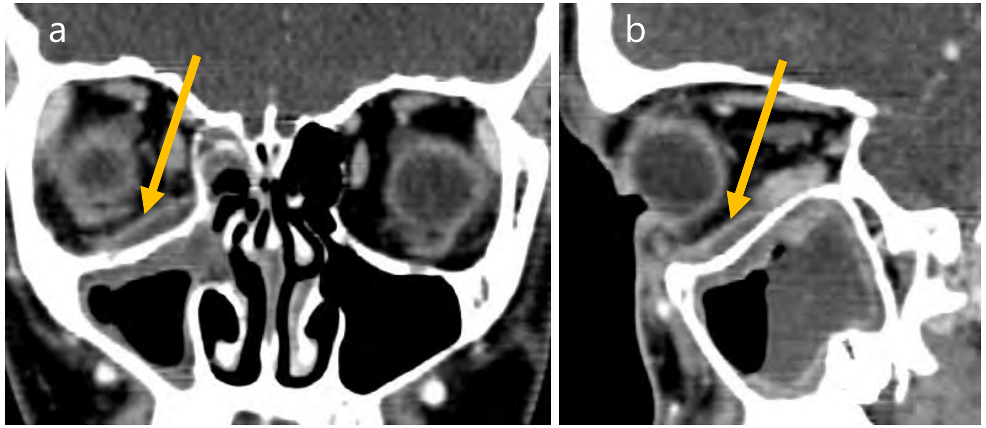


Fig. 49. 8-year-old boy presenting with severe left orbital cellulitis associated with diplopia. Contrast enhanced CT reconstructed in the coronal (a) and sagittal planes (b) confirms the presence of a subperiosteal abscess in the floor of the right orbit (yellow arrow). This was a complication of ipsilateral ethmoid and maxillary sinusitis.

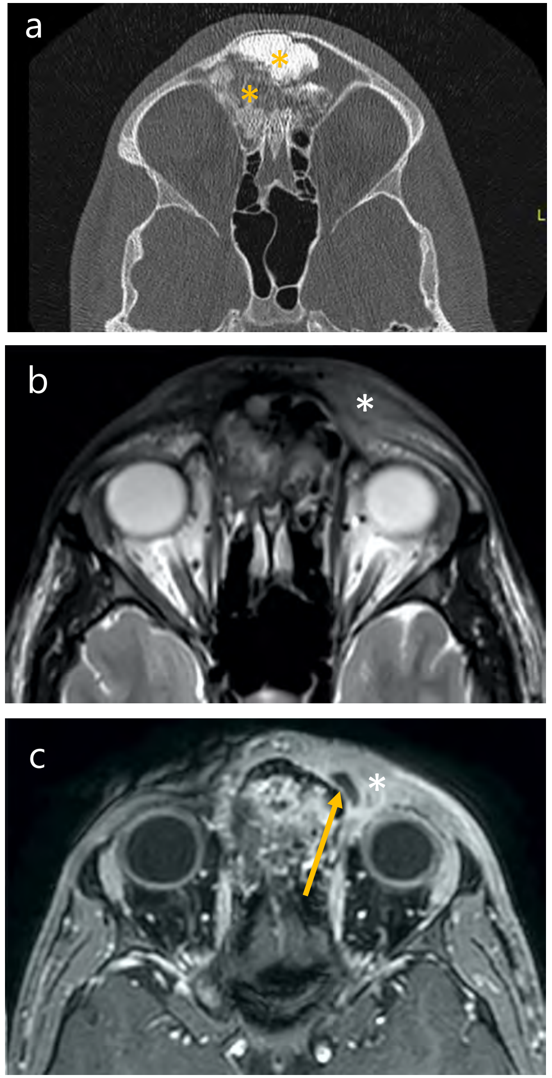


Fig. 48. 18-year-old patient presenting with pre-septal cellulitis secondary to a large sinonasal osteoma (yellow asterisks) in (a), showing a characteristic "Aunt Minnie" appearance on CT (a) with "popcorn" calcifications.
Further evaluation with MRI was performed. (b) Axial T2W sequence confirms the presence of extensive pre-septal cellulitis (white asterisks in b and c). (c) Axial fat suppressed T1 post-contrast confirms small abscess formation in the medial pre-septal soft tissues (arrow).

Chapter Outline

Inflammatory and infectious lesions - Sinusitis & Complications

Acute Invasive Fungal Rhinosinusitis

In an immunocompromised patient (elderly diabetic or receiving chemotherapy), acute sinusitis is a medical emergency. Mucormycosis may rapidly progress to dry gangrene (**Fig. 50**).

Contrast enhanced CT (CECT) with soft tissue & bone windows allows to evaluate soft tissue infiltration & bone erosion in the emergency situation..

However, MRI is superior for evaluating intraorbital & intracranial extension of mucormycosis, defining the extent of affected areas. Affected areas present as nonenhancing lesions at MRI

Admission and urgent MRI **is a must**. CT may only show the tip of the iceberg!

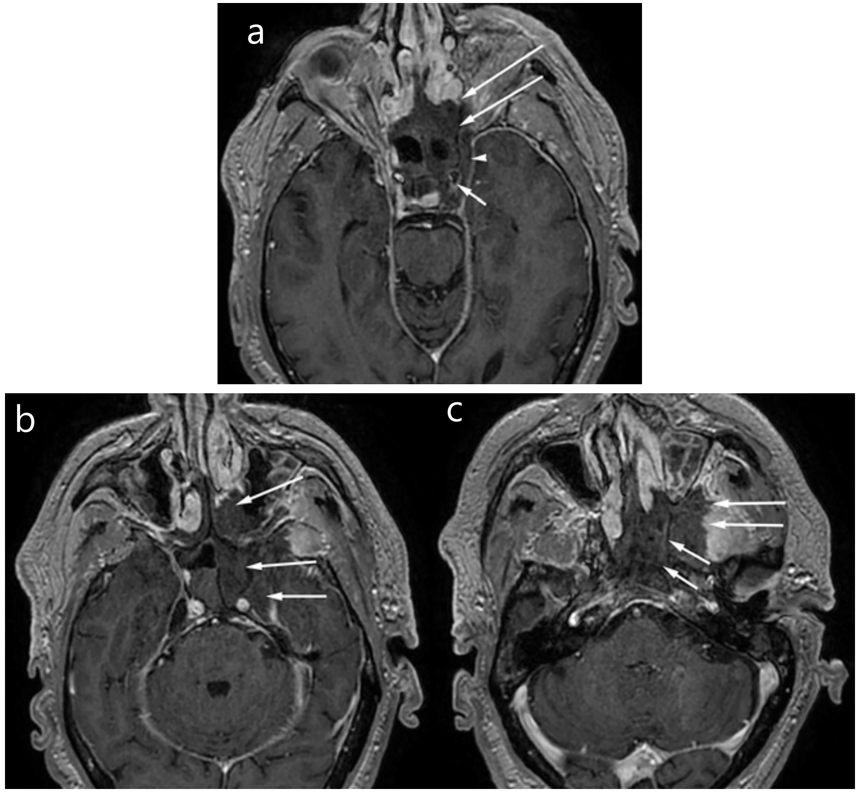


Fig. 50. 64 y/o male with h/o acute leukemia presents with severe frontal headache and facial paresthesia post-tooth extraction. **Acute invasive fungal rhinosinusitis**: rapidly progressive (hours to days) transmucosal fungal sinus infection with vascular, bone, soft tissue, orbit, & intracranial invasion → "dry gangrene". Axial post-contrast T1W images demonstrate (a) absent mucosal enhancement of the sphenoid sinuses and superior turbinates (long arrows), left cavernous sinus thrombosis (arrowhead), thrombus in the left internal carotid artery (short arrow). (b) Dry gangrene in the superior turbinate, sphenoid sinus and cavernous sinus on the left (arrows), and (c) has spread to the nasal septum and left masticator space. The lack of enhancement over the nasal turbinate has been named the "**black turbinate sign**".

Chapter Outline

Inflammatory and infectious lesions - *Tonsillitis* and Peritonsillar Abscess

Tonsillitis: refers to inflammation of any of the tonsils and is the most common head and neck infection in adolescents and young adults. Patients present with dysphagia, fever, tender cervical lymph nodes, ear pain and occasionally trismus (depending on the severity). Usually caused by group A beta-hemolytic streptococci but may be viral in origin (adenovirus, CMV or herpes).

Imaging is **not** indicated in uncomplicated cases and is a clinical diagnosis.

If left untreated this may spread to the peritonsillar space and form a peritonsillar abscess (see next page). Infection can spread to the adjacent neck spaces including (amongst others) the supraglottis (**Fig. 51**). Epiglottitis may sometimes ensue. It is a life-threatening condition especially in children due to the risk of airway compromise. Diagnosis is clinical. CT is only obtained when diagnosis is uncertain however extreme caution should be exercised as placing a child in the supine position can precipitate respiratory arrest.

Fig. 51. Axial contrast enhanced CT in a 31-year-old female patient presenting with painful facial and submandibular swelling. CRP 400. There is oedema of the epiglottis (asterix) and fluid in the submandibular space (double arrows)

Inflammatory and infectious lesions - Tonsillitis and *Peritonsillar* Abscess

Peritonsillar abscess (also known as quinsy) is the most common deep neck space infection complicating acute or recurrent tonsillitis. Usually caused by beta-hemolytic streptococci. Unilateral odynophagia, altered voice quality, trismus and excessive drooling are highly indicative of a peritonsillar abscess.

Imaging modality:

- CT scan of the neck after contrast administration (CECT) is 75% specific and 100% sensitive for this diagnosis (**Fig. 52**). It is also useful to exclude the presence of other associated complications such as septic thrombophlebitis of the internal jugular vein (Lemierre syndrome).
- US is unable to delineate the true extent of the infection.
- Treatment is always by surgical aspiration or incision and drainage. Conversely tonsillitis is managed with antibiotics.
- An important differential diagnosis is an intratonsillar (also known as tonsillar) abscess.

Tonsillar abscess is an uncommon complication of tonsillitis occurring in both children and adults presenting with sore throat and fever for several days. CECT is indicated depending on the clinical situation. It easily demonstrates an abscess within the palatine tonsil. Medical management is usually undertaken in the acute setting. This may be followed by an elective tonsillectomy at a later stage.

Fig. 52. Axial contrast-enhanced CT scan at the level of the tongue base shows early abscess formation caudal to the right tonsil in the oropharynx - peritonsillar (short arrow). Fluid is noted beneath the platysma overlying the right hemimandible (long arrow).

Capps EF, Kinsella JJ, Gupta M, Bhatki AM, Opatowsky MJ. Emergency imaging assessment of acute, nontraumatic conditions of the head and neck. Radiographics. 2010 Sep;30(5):1335-52. doi: 10.1148/rg.305105040. Erratum in: Radiographics. 2011 Jan-Feb;31(1):316. PMID: 20833854.

Inflammatory and infectious lesions – Sialolithiasis

Sialolithiasis Is the most common disease of the salivary glands. 80-90% of stones occur in the submandibular gland with the remaining 10-20% affecting the parotid gland. Uric acid stones may form in gout - the only systemic disease known to produce salivary stones.

Imaging modalities

- Plain film with up to 80% of submandibular and 60% of parotid stones visible on this modality.
- Non-contrast CT or CBCT is highly sensitive for small stones not otherwise visible on plain films. Non-calcified stones and duct dilatation are best observed with sialographic studies.
- US is able to visualize the stone (**Fig. 53**) and the gland itself. It can also identify radiolucent stones. Small stones (<2mm) may however be missed on US. US can also confirm the presence of acute sialadenitis if present.
- Conventional sialography: Main indication is **chronic** parotid or submandibular sialadenitis. **Acute** sialadenitis is a contraindication. Irregular pooling of contrast and ductal obstruction without calculi are indirect signs of malignancy. Disadvantages include radiation exposure, non-visualization of gland parenchyma, allergic reactions to iodinated contrast material (=> see chapter on contrast materials).
- MR sialography (MRS): no contrast injection is necessary for ductal assessment as MRS uses fluid-sensitive sequences with saliva appearing as hyperintense on heavily T2W sequences (**Fig. 54**). Acute sialadenitis is **not** a contraindication to MRS. MRS can also diagnose incidental gland pathology.

> Although MRS has a poorer spatial resolution compared to conventional sialography, it has a similar diagnostic performance as conventional sialography for calculi, ductal stenoses and autoimmune pathology (Sjögren's). In many institutions, it has entirely replaced conventional sialography.

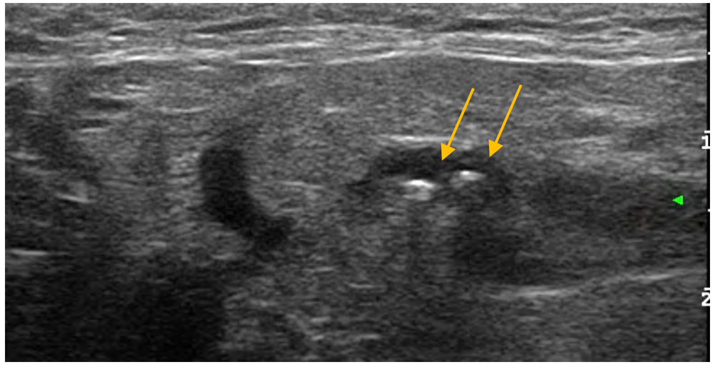


Fig. 53. Targeted US scan of the submandibular gland in a lady with swelling and pain of the right submandibular region after eating. US shows stones (arrows) impacted within a dilated duct.

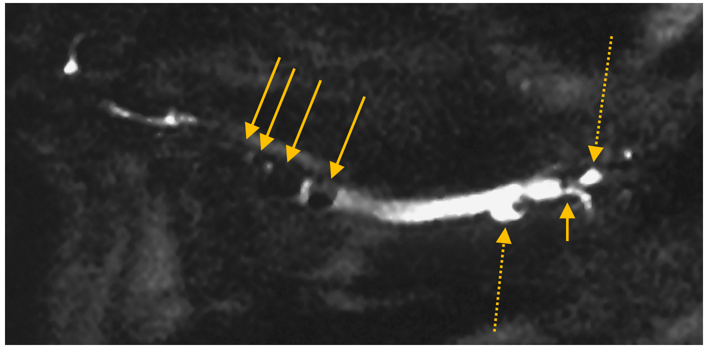


Fig. 54. MR sialography (sagittal view) of the right submandibular gland showing multiple calculi (arrows) in Wharton's duct. Note dilatation of the duct, formation of small sialoceles (dashed arrows) and strictures (short arrow) typical of chronic sialadenitis. Saliva is strongly hyperintense while calculi appear as hypointense filling defects.

Chapter Outline

Inflammatory and infectious lesions – Sialadenitis

Sialadenitis is inflammation of the salivary glands. It can be acute or chronic.
Acute sialadenitis is a clinical diagnosis which can be treated medically. The role of imaging is to exclude complications such as intraglandular abscess or to exclude obstructing calculi.
Chronic sialadenitis needs further evaluation by imaging to determine the cause and assess the ductal system. Sialectasis is dilatation of the ducts which is due to a variety of causes including infective and autoimmune (such as Sjögren's syndrome, **Fig. 55**)

Imaging modalities:

- US can assess the size and architecture of gland parenchyma. In Sjögren's syndrome the gland is coarse and heterogenous with multiple dilated peripheral ducts.
- Conventional sialography: depicts the presence of sialectasis and helps determine its severity. Disadvantages include radiation dose, allergic reactions to iodinated contrast material, and that sometimes the radiologist might not be able to cannulate or opacify the ducts due to severe stenoses.
- MR sialography: Is highly sensitive for the detection of sialectasis even during very early stages. It can identify concurrent/incidental pathology within the gland. MR sialography can be combined with routine contrast-enhanced MRI sequences for improved lesion assessment.

- There is no role for CT in this clinical scenario.

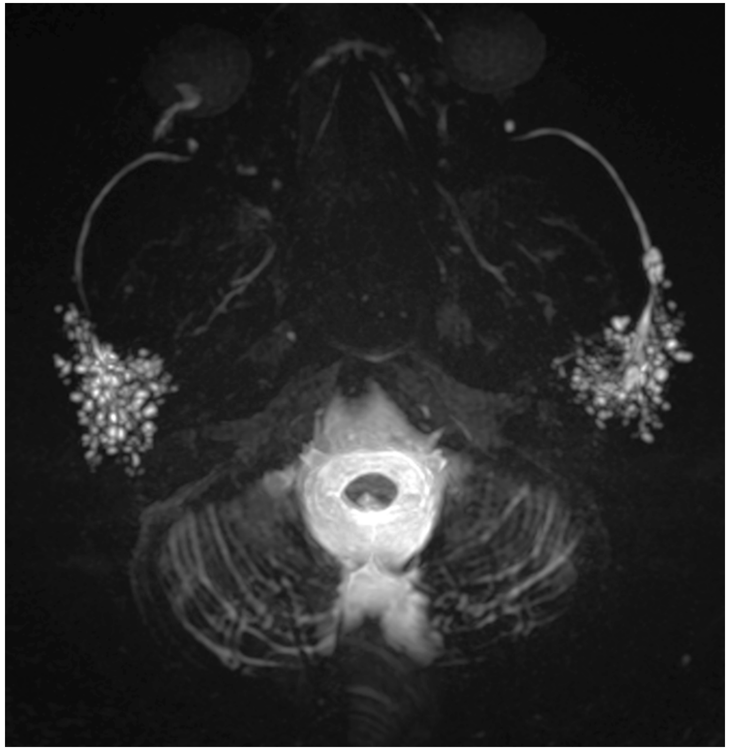


Fig. 55. Gentleman in his 30's, poorly controlled diabetic, presenting with recurrent episodes of sialadenitis. Axial image from a volume rendered MR sialography showing multiple dilated peripheral ducts presenting as "microcysts" typical of Sjögren's syndrome.

Chapter Outline

Inflammatory and infectious lesions – TB Lymphadenitis

Tuberculous (TB) cervical lymphadnitis (sometimes referred to as scrofula) is the commonest manifestation of extrapulmonary TB in endemic areas, as well as in the immunocompromised population and intravenous drug abusers.

In contrast to suppurative bacterial lymphadenitis, these lymph nodes are not tender have less inflammatory changes in the overlying skin. If left untreated, they may discharge spontaneously.

Imaging modalities:
Contrast enhanced CT. If TB is suspected a CT of the neck and chest should be obtained in order to look for evidence of pulmonary disease.

Appearance of this disease entity is quite characteristic on CT and MRI **(Fig. 56)** and manifests as a conglomerate of neck nodes with central necrosis and thick, peripheral enhancement along with regional inflammatory changes.

Ultrasound allows sampling for bacteriology.

TB lymph nodes should not be confused with necrotic metastatic lymphadenopathy from squamous cell carcinoma which may look similar (**Fig. 57**.) . The clinical history is extremely important including history of smoking, alcohol abuse and ethnicity (is the patient coming from a country where TB is endemic?).

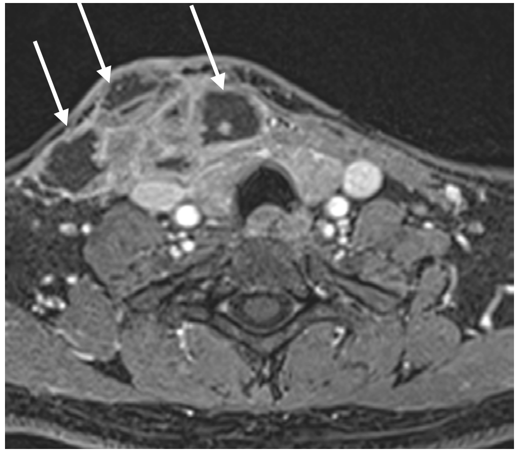


Fig. 56. Axial, contrast enhanced, fat-suppressed T1W sequence obtained in a 37-year-old lady who presents with a right sided neck lump. There is a multiloculated mass in the right lower neck (arrows) extending anterior the thyroid gland, demonstrating solid and cystic components and reaching the skin. This was biopsy proven tuberculous lymphadenitis.

Fig. 57. 53 y/o man presenting with a 2-month history of neck swelling, progressive dysphagia, weight loss and hemoptysis. Contrast enhanced CT scan of the neck at the level of the epiglottis demonstrating extensive metastatic right cervical lymphadenopathy (asterisks).

Chapter Outline

Inflammatory and infectious lesions

Suppurative Lymphadenitis and Reactive Lymph nodes

Suppurative lymphadenitis is inflammation of the lymph nodes which undergo liquefactive necrosis if left untreated, which may require drainage. This is commoner in children although it can occur in elderly diabetics or immunocompromised patients. Bacterial infection is the commonest cause of suppurative cervical adenitis (due to Staph aureus and group A Streptococcus).

Imaging modalities:
Ultrasound: to identify the presence of abscess formation and guide drainage. If deep neck space involvement is suspected, then contrast enhanced CT is warranted. This will help determine the epicenter of the lesion and its extent prior to aspiration or surgical drainage.

Reactive lymph nodes: the commonest cause in children includes viral illnesses of the upper respiratory tract; in young adults one should consider EBV (infectious mononucleosis). The lymph nodes maintain an oval shape albeit enlarged. They may exceed 2cm in size.

Imaging modality:
Ultrasound to assess the internal architecture. It can be difficult to distinguish reactive lymph nodes from low-grade lymphoma and when in doubt US guided core biopsy is indicated. If there is suspicion of malignancy, contrast enhanced CT or MRI should be performed.

If the lymph nodes are supraclavicular or in the posterior triangle of the neck, they should raise the suspicion of malignancy.

Chapter Outline

Inflammatory and infectious lesions - Otomastoiditis and Complications

Otomastoiditis can be acute or chronic and refers to inflammation of the middle ear and mastoid air cells. The chronic type is due to Eustachian tube dysfunction. The diagnosis of acute mastoiditis remains clinical.

The **acute** type is usually due to bacterial infection and is the commonest complication of acute otitis media (**Fig. 58**). Incipient otomastoiditis can progress to acute coalescent mastoiditis which can be complicated by the following:

- Subperiosteal abscess
- Bezold abscess
- Labyrinthitis
- Epidural abscess
- Subdural empyema
- Cerebral abscess
- Dural venous sinus thrombosis

Imaging modalities:
Contrast enhanced CTallows assessment of erosion of the bony structures (including of the mastoid air cell bony septae – coalescent mastoiditis, and of the lateral wall of the mastoid process) and identification of subperiosteal and Bezold abscesses, as well as intracranial abcesses (epidural, subdural or intracerebral)

=> see e book chapter on neuroradiology

Contrast enhanced MRI of the temporal bone is more sensitive for assessing intracranial complications and to identify the presence of labyrinthitis.

Fig. 58. Post-contrast CT shows (a) right coalescent mastoiditis (black arrowhead) and ipsilateral sigmoid sinus thrombosis (black arrow) – both complications of otomastoiditis. CT with bone window settings (b) better depicts the right coalescent mastoiditis (black arrow). Note contralateral mastoid effusion.

Chapter Outline

Malignant Tumours – Squamous Cell Carcinoma: Nasopharynx

Squamous cell carcinoma (SCC) is the most common malignant primary in the head and neck and is classified and staged according to its location (nasopharynx, oropharynx, larynx, oral cavity and sinonasal) and following the **TNM manual** of the UICC (Union Internationale contre le Cancer).

Nasopharyngeal carcinoma:

- Best imaging modality for this region is MRI (**Fig. 59**). One of the reasons is that this type of cancer is staged according to the degree of locoregional spread and many of the soft tissues are better delineated with MRI particularly in the presence of skull base invasion and intracranial extension.
- MRI also allows staging of cervical lymph node involvement.
- PETCT is employed to identify the presence of distant metastatic spread. Nasopharyngeal carcinoma can metastasize to the liver, lungs and bones.

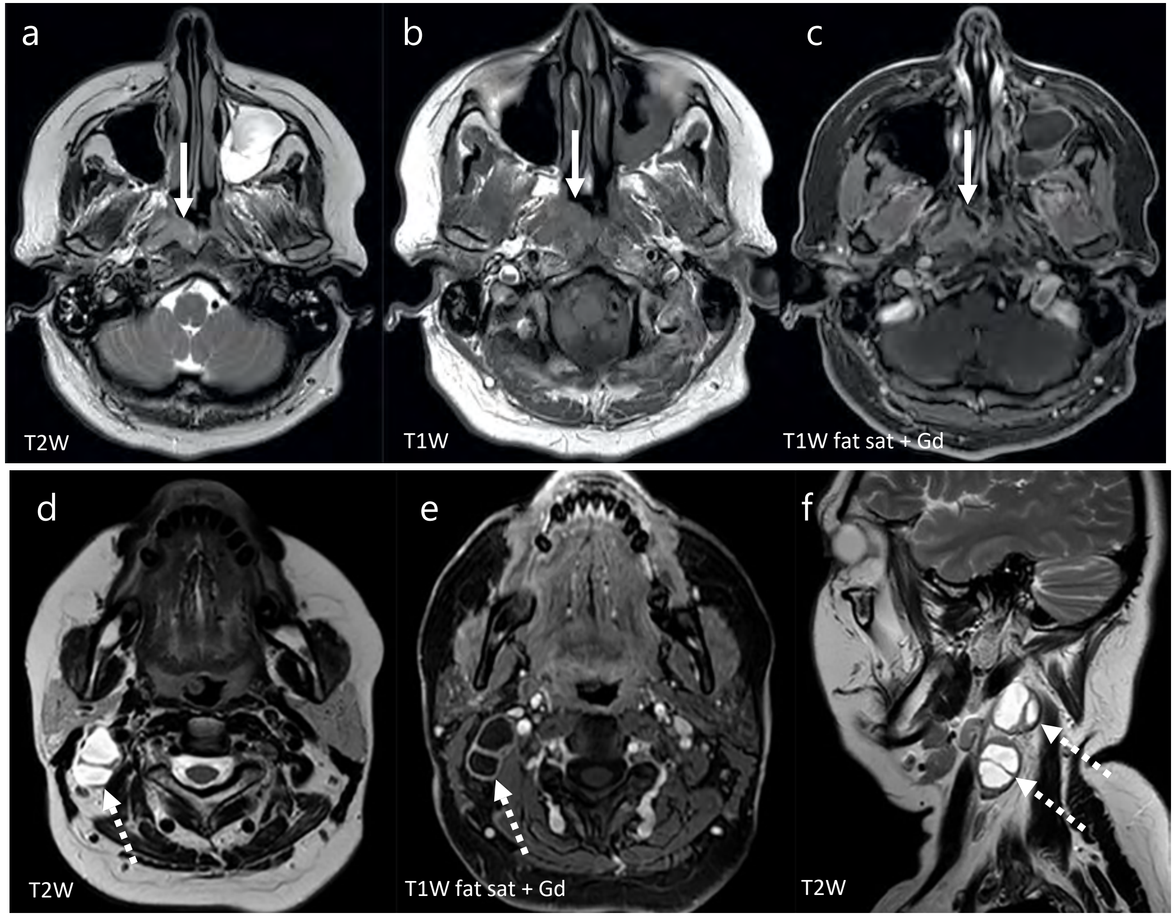


Fig. 59. Axial MRI showing a small SCC of the right nasopharynx (white arrows), exhibiting intermediate signal on the T2W sequence (a), low signal on T1W (b), and homogenous enhancement on the fat suppressed T1W sequence (c). Ipsilateral necrotic lymph nodes (dashed arrows) are seen on the axial T2W (d), and fat suppressed T1W (e) and on the sagittal T2 sequence (f). Patient (40-year-old lady) presented with a painless right sided neck lump.

Chapter Outline

Malignant Tumours - Squamous Cell Carcinoma: Oral Cavity

Oral cavity squamous cell carcinoma (SCC) (Figs. 60-63.) :

- Best imaging modality for this region is MRI. MRI is also be able to pick up lesions which would otherwise be obscured by dental streak artefacts if imaged with CT (see page 38).
- MRI also allows also staging of cervical lymph nodes.
- In cases of advanced disease, PETCT may also be employed to identify the presence of distant metastatic spread.

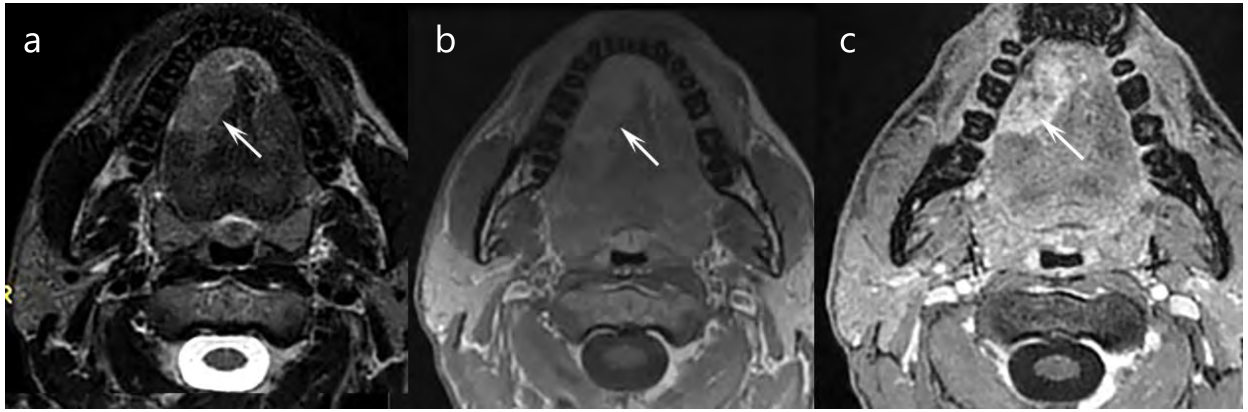


Fig. 60. Axial MRI of an oral cavity SCC shows a solid mass involving the left lateral border of the tongue showing intermediate signal intensity on T2 sequence (a), and homogenous enhancement on the non-fat suppressed T1 (b) and fat suppressed T1 (c) indicated by the white arrow in each case.

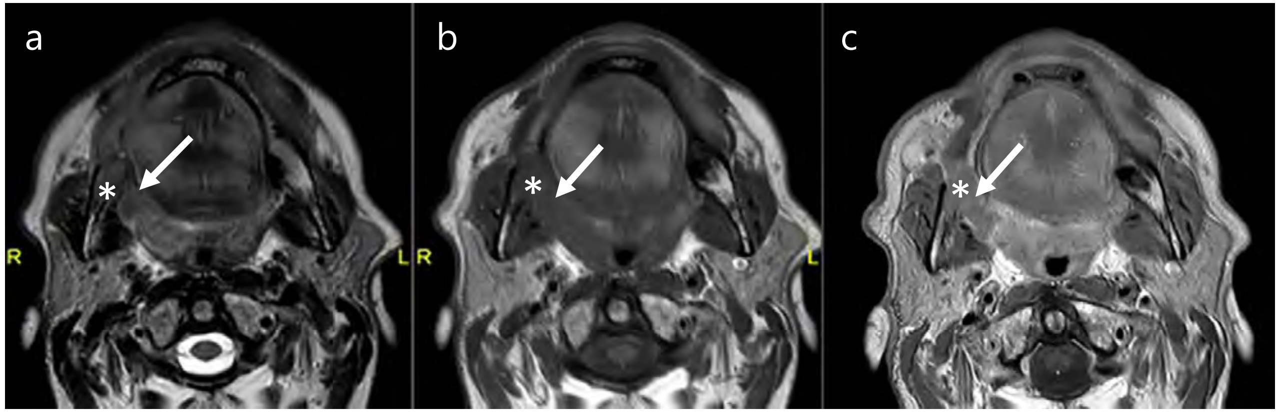


Fig. 61. Axial MRI of a right retromolar trigone lesion – here MRI is crucial for accurate locoregional staging. (a) T2W (b) pre-contrast T1 and (c) post-contrast T1, each show an infiltrative mass originating in the retromolar trigone (white arrow) and invading the adjacent angle of the mandible (asterisk).

Chapter Outline

Malignant Tumours - Squamous Cell Carcinoma: Oral Cavity

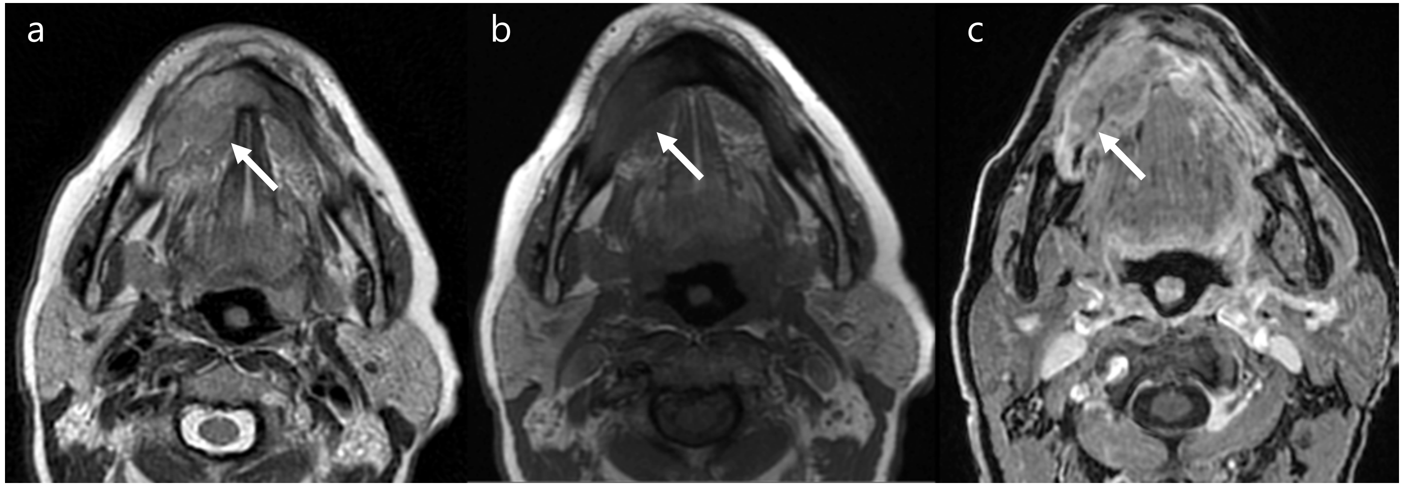


Fig. 62. Axial MRI in a 69y/o patient shows an extensive lesion in the right mandibular alveolar mucosa with bone invasion and involving the floor of mouth and buccal mucosa. (a) It has an intermediate signal on T2, with profoundly low signal in the affected marrow on T1 (b, arrow). (c) The lesion enhances homogenously on the fat suppressed T1 sequence (arrow). This case delineates how MRI can clearly show marrow invasion precluding the need for CT particularly in advanced cases. Conversely integration with CT would be useful in instances where the presence of cortical erosion is equivocal.

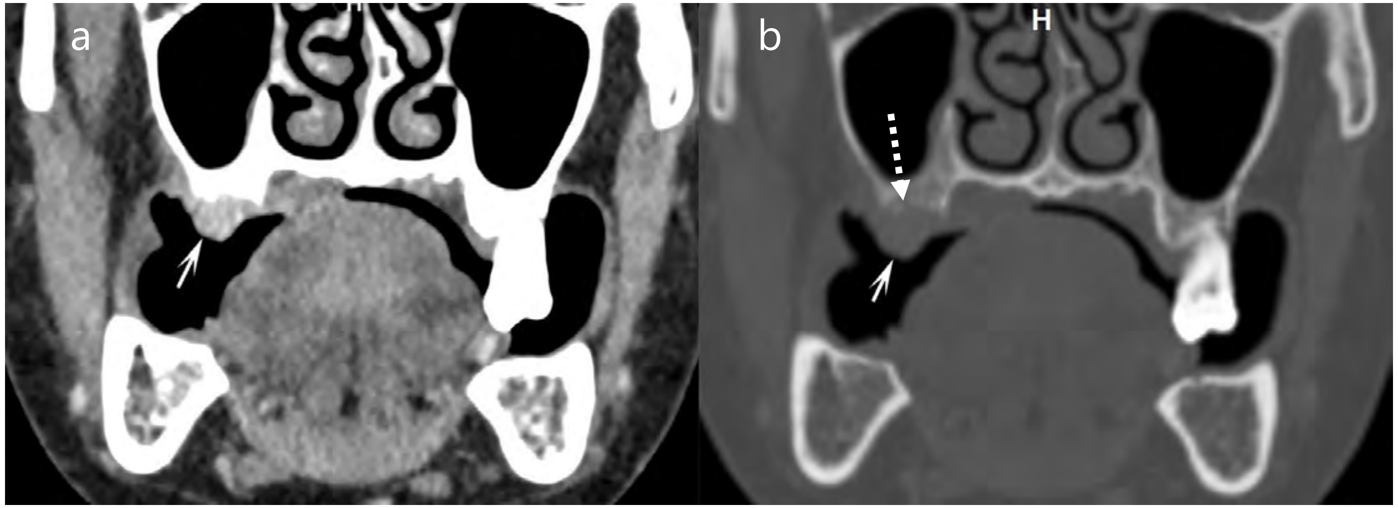


Fig. 63. Superficial neoplasms may be associated with cortical invasion which is subtle and this is best assessed with CT as in this case. (a) Coronal reformatted image from a post-contrast CT with soft tissue window settings shows a small superficial lesion involving the gingiva of the right hemimaxilla (arrow). (b) Same image with bone window settings highlights subtle cortical erosion (dashed arrow) which might be more difficult to identify on MRI.

Chapter Outline

Malignant Tumours - Squamous Cell Carcinoma

Squamous cell carcinoma (SCC) is by far the most common (98%) primary tumor of the larynx.

It occurs in men over 50 and is associated with smoking and alcohol abuse;

Classification is based on the subsite involved: supraglottic (20–30%), glottic (50–60%), subglottic (5%), and transglottic (spanning two or more subsites). The subsite will determine the clinical presentation, as well as management.

Glottic carinomas (**Fig. 64)** often present earlier with dysphonia. They rarely metastasise due to the poor lymphatic drainage of the glottis.

Supraglottic carcinomas (**Fig. 65)** are often asymptomatic, thus usually present later purporting a much poorer prognosis. Symptoms are due to lymphadenopathy or trans-spatial spread, such as tender neck mass, sore throat, dysphagia/odynophagia, or referred ear pain.

Subglottic carcinomas typically present with dyspnea and/or stridor..

Imaging modalities: best choice contrast-enhanced CT (CECT) or MRI. CT has less motion artefacts. CT needs to be obtained with thin slices and dedicated reformats. MRI is superior to CT to assess cartilaginous and extra-laryngeal invasion; however, MRI may be problematic if the patient is non-compliant because of dyspnea.

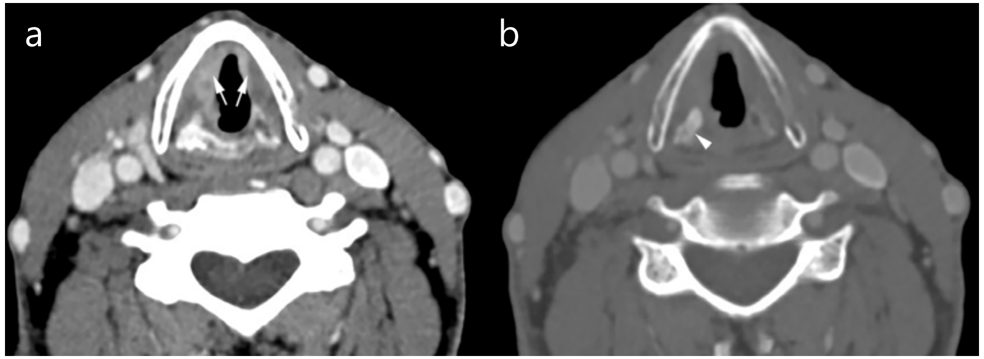


Fig. 64. 61y/o M presenting with irregular ulcerated lesions along both true vocal cords at endoscopy. (a) Axial contrast enhanced CT image (soft tissue window settings) shows a lesion centered on the glottis bilaterally larger on the right (arrows). (b) Same image in bone window settings shows sclerosis of the right arytenoid cartilage (arrowhead), which can indicate cartilage invasion.

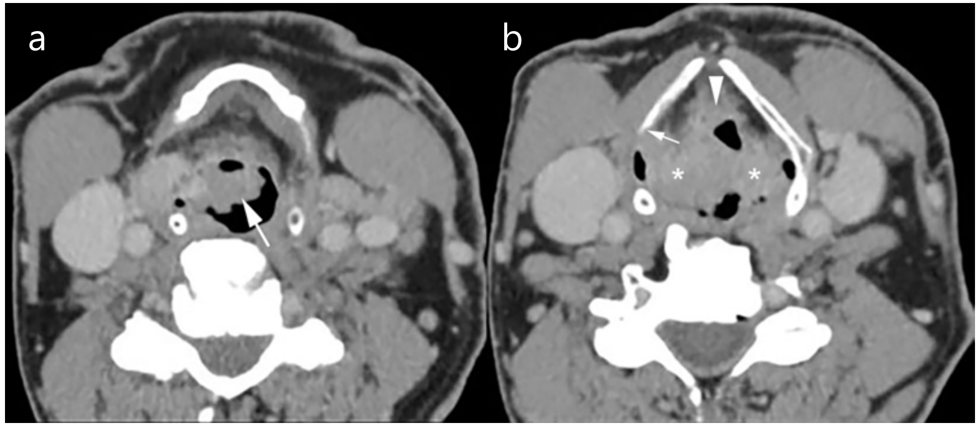


Fig. 65. 64 y/o M, with right sided throat pain and hoarseness. A supraglottic tumour was seen endoscopically. Contrast enhanced CT shows a lesion partly exophytic (arrow in a), involving both aryepiglottic folds (asterisks in b), invading the pre-epiglottic fat (arrowhead) and coming into contact with the inner margin of the right thyroid cartilage (arrow in b).

Chapter Outline

Other Malignant Tumours - Sinonasal Tumours

For the evaluation of sinonasal tumors, CT and MRI are complementary. Both imaging modalities must be obtained as MRI allows distinction between tumor and associated peri-tumoral inflammation while CT allows improved assessment of subtle bone erosion / destruction.

Fig. 66 and 67 illustrate a histologically proven carcinosarcoma. This is a highly malignant tumor.

This case highlights the importance of multimodality imaging (CT and MRI, particularly the latter) for better tissue characterization and anatomical delineation. There is much overlap between different malignant entities and histological correlation is crucial.

Important findings to look for include:

- Bone destruction
- Intracranial invasion
- Intraorbital invasion
- Perineural spread

Hasnaoui J, Anajar S, Tatari M, et al. Carcinosarcoma of the maxillary sinus: A rare case report. Ann Med Surg (Lond). 2017).

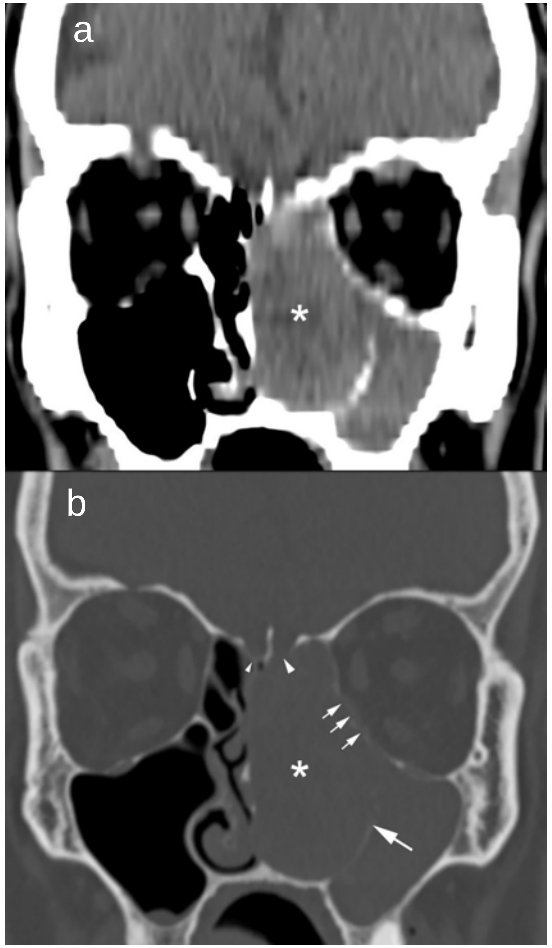


Fig. 66. Coronal reformatted images from a non-contrast CT in soft tissue window (a) and bone window settings (b). The mass (asterisk) causes resorption of the cribriform plate (arrowhead) and lamina papyracea (short arrows) and lateral bowing of the medial wall of the left maxillary sinus.

Fig. 67. Coronal MRI shows a solid mass in the left nasal cavity (asterisk in a & b). (a) T2W: the lesion abuts the left cribriform plate which is still intact (arrowhead) and pushes the lamina papyracea laterally. (b) it enhances avidly after contrast with a small area of central necrosis. Retained secretions in the left maxillary sinus are indicated by arrow.

Chapter Outline

Malignant Tumours - Lymphoma

Lymphoma (Fig. 68.) can be subdivided into Hodgkin's and Non-Hodgkin's lymphoma.

Hodgkin's lymphoma (HL) primarily involves the lymph nodes with only 5% arising in extranodal sites. It most often affects the lymph nodes of the neck and chest.

Non-Hodgkin's lymphoma (NHL) presents at extranodal sites in up to 30% of cases. Marginal zone lymphoma (a subtype of NHL) has an affinity for the orbit, salivary glands, larynx and thyroid gland. Diffuse large B cell lymphoma is commonly encountered in the paranasal sinuses, mandible, maxilla and Waldeyer ring.

The imaging modality of choice includes CT, PET CT and MRI (**Fig. 68**). These can suggest the diagnosis of a lymphoproliferative disorder but cannot distinguish HL from NHL. Furthermore, different subtypes of both HL and NHL exist which will dictate the treatment needed. A histological diagnosis is always warranted via core biopsy (normally ultrasound guided), in order to provide this information.

Contrast enhanced CT (CECT) is indicated for evaluation of cervical lymph nodes; the chest, including the mediastinum; the pelvic cavity; paranasal sinuses; and orbits. CT is also useful for detection of bone destruction involving the base of the skull, paranasal sinuses, and the mandible or maxilla.

MRI is useful to assess extranodal lymphoma, particularly when there is involvement of the orbit, thyroid, salivary glands, larynx, skull base, and to detect intracranial extension. It is also useful to demonstrate marrow infiltration of the spine which may not be apparent on a CT scan.

PETCT is used for pretreatment staging and to monitor treatment response.

Fig. 68. Axial T2W MR sequence shows left sided pathological lymph nodes (arrows) spanning levels II and VA in a patient with histologically confirmed diffuse large B cell lymphoma.

Weber AL, Rahemtullah A, Ferry JA. Hodgkin and non-Hodgkin lymphoma of the head and neck: clinical, pathologic, and imaging evaluation. Neuroimaging Clin N Am. 2003 Aug;13(3):371-92. doi: 10.1016/s1052-5149(03)00039-x. PMID: 14631680.

Chapter Outline

Malignant Tumours – Thyroid Cancer

Malignant thyroid lesions (Figs. 69-70) are classified as follows:
- Primary thyroid cancers
- Thyroid lymphoma (primary thyroid lymphoma or secondary thyroid involvement with lymphoma)
- Metastases to the thyroid (1%)
- Squamous cell carcinoma (rare)

Primary thyroid cancer can be subclassified into papillary, follicular, medullary and anaplastic carcinoma. Papillary is the commonest type accounting for 60-80% of carcinomas and anaplastic the rarest form (1-2%).

The **best imaging modality** for assessment of the thyroid gland is **ultrasound (US) followed by MRI**.

US:

Advantages:
- Non-invasive
- Widely available
- Helps guide minimally invasive procedures such as fine needle aspirations and core biopsies

Disadvantages:
- Operator dependent
- Unable to identify deep seated metastatic lymph nodes lying behind the manubrium sterni or behind the clavicle
- Unable to characterize retrosternal thyroid goiters

MRI: is useful for the assessment of deep spread & lymph node staging.

https://radiopaedia.org/articles/thyroid-malignancies

Read More: https://www.ajronline.org/doi/full/10.2214/ajr.13.11673?mobileUi=0

Fig. 69. 16-year-old lady presenting with hard right neck lump confirmed to be papillary ca on cytology. US shows strongly hypoechoic lesion with microcalcifications (arrows) in the right thyroid lobe breaching the capsule and invading the strap muscles

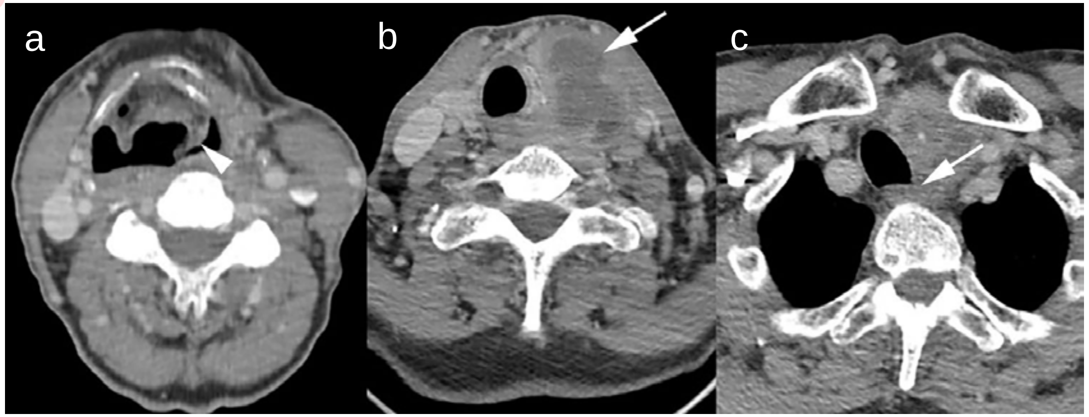


Fig.70. 66 y/o lady presenting with a rapidly growing mass over the left side of her neck and hoarseness. Axial CECT images show a medialized left aryepiglottic fold with effacement of the pyriform sinus indicative of vocal cord paralysis (arrowhead in a), a large necrotic mass replacing the left thyroid lobe and invading the strap muscles (arrow in b) and infiltrating the region of the left recurrent laryngeal nerve in the trachea-oesophageal groove (arrow in c). This was a histologically proven anaplastic thyroid carcinoma

Chapter Outline

Malignant Tumours – Thyroid Cancer

=> See also e book chapter on imaging of endocrine disorders

CT is necessary in the presence of metastases, which are more common in follicular thyroid cancer (which tends to spread haematogenously to the bones and liver), as well as in medullary and anaplastic carcinomas. It can also be helpful to assess the degree of local extension, particularly when there is intrathoracic extension.

Thyroid imaging reporting and data system (TI-RADS) is a classification system based on US features to help categorize thyroid lesions into benign, borderline and malignant lesions (TI-RADS 1 being a normal thyroid gland, TI-RADS 6 representing biopsy proven malignancy).

Fine needle aspiration is a minimally invasive procedure which involves obtaining a sample from the thyroid nodule of concern, which can then be examined by the pathologist. US is performed to guide the needle. The procedure is contraindicated in patients with coagulopathy, which is refractory to treatment or who have a platelet disorder.

Radioiodine scan: There are two types, the diagnostic and post-therapy studies.

- **Whole-body scan (WBS)** with radioiodine (131I) is the most effective method for tumor detection, staging, and treatment planning. Iodine-131-WBS is useful for determining tumor differentiation on the basis of its avidity to iodine, identifying remnant thyroid tissue, and evaluating for distant metastatic disease. This scan is usually obtained before radioiodine therapy.
- The **therapeutic scan** again uses radioiodine – I-131- as ablation therapy for patients post-thyroidectomy. This is because normally a surgeon performs a near total-thyroidectomy in order to preserve parathyroid function and because of the difficulty in location deeply seated thyroid tissue. The radioiodine scan can then be used to ablate the residual thyroid tissue.

PET CT: Most well-differentiated thyroid carcinomas (DTC) are relatively slowly growing and can be FDG negative. Therefore, the role of FDG PET/CT in the management of patients with DTC is primarily limited to postoperative follow-up. Because only 4–7% of patients with DTC present initially with distant metastasis, the routine use of an initial staging PET is not indicated. Although FDG PET does not provide information beyond that yielded by ultrasound for local preoperative assessment of thyroid cancer, several studies have reported that it has a sensitivity of up to 85% and specificity of up to 95% for distant metastases in patients with DTC (i.e., papillary and follicular carcinoma).

TIRADS=> refer to https://radiopaedia.org/articles/thyroid-imaging-reporting-and-data-system-ti-rads.

Malignant Tumours – Multidisciplinary Tumour Boards

The **importance of multidisciplinary tumour board (MDTB) meetings** (**Figs. 71-72**) cannot be overemphasized. They comprise a number of specialists including:

- Otorhinolaryngologist / head and neck surgeon
- Maxillofacial surgeon
- Medical oncologist
- Pathologist
- Radiologist & nuclear medicine physician
- Radiation oncologist

Fig. 71. The various medical specialists meet and discuss imaging and pathology findings, as well as patient management.

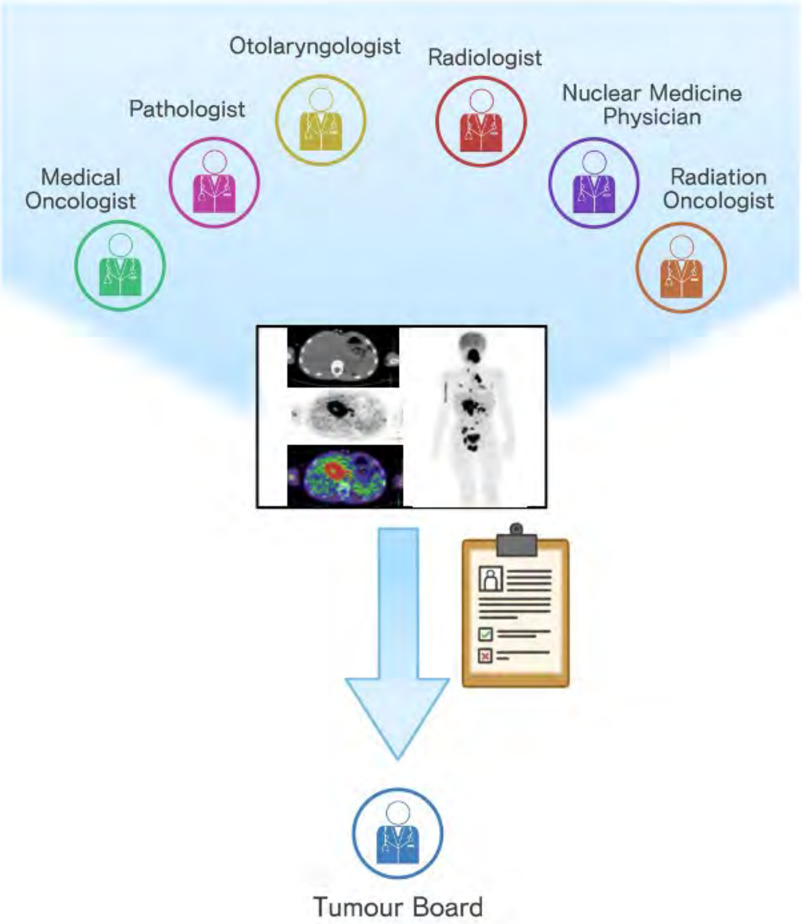


Fig. 72. Schematic diagram depicting the members of a head and neck oncology multidisciplinary tumour board.

Malignant Tumours – Multidisciplinary Tumor Boards

Tumour boards (MDTBs) constitute the **gold standard management strategy** for head and neck squamous cell carcinoma patients but not only. They are successfully implemented in the management of other non-malignant head and neck pathologies including indeterminate thyroid lesions, neurogenic tumours of the head and neck, odontogenic tumours, vascular malformations of the neck and face and many more!

Clinical radiologists are **pivotal members of MDTB meetings**. Radiology incorporates both diagnostic and interventional radiologists, It is central to the diagnostic process along with the histopathologist and is thus crucial in reaching a diagnosis, thereby actively guiding management and treatment options.

A study published in 2002 already showed that when head and neck cancer patients referred from tertiary centers were rediscussed at the MDTB and their cross-sectional imaging studies were re-assessed by a specialized head and neck radiologist, this **significantly impacted tumor staging and prognosis** (Loevner et al, 2002).

Another more recent study published in 2020 demonstrated a positive impact of MDTBs on head and neck cancer patients with **improved overall survival and disease specific survival** (Liu et al, 2020).

Loevner LA, Sonners AI, Schulman BJ, Slawek K, Weber RS, Rosenthal DI, Moonis G, Chalian AA. Reinterpretation of cross-sectional images in patients with head and neck cancer in the setting of a multidisciplinary cancer center. AJNR Am J Neuroradiol. 2002 Nov-Dec;23(10):1622-6. PMID: 12427610; PMCID: PMC8185819.

Liu JC, Kaplon A, Blackman E, Miyamoto C, Savior D, Ragin C. The impact of the multidisciplinary tumor board on head and neck cancer outcomes. Laryngoscope. 2020 Apr;130(4):946-950. doi: 10.1002/lary.28066. Epub 2019 May 16. PMID: 31095740; PMCID: PMC7868105.

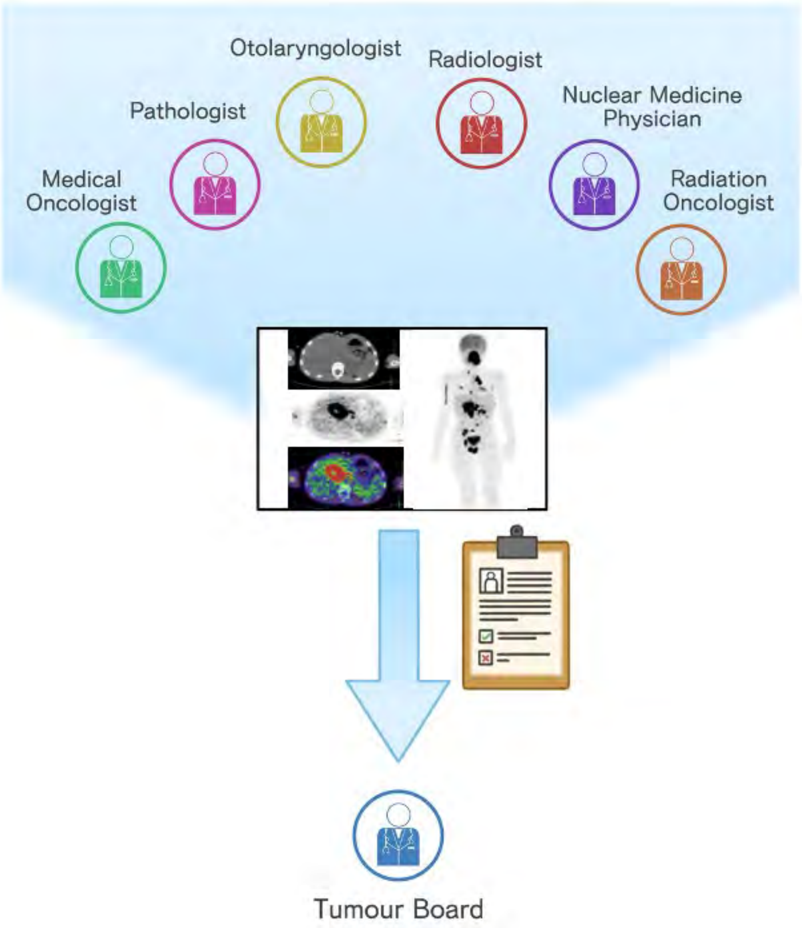


Fig. 72. Schematic diagram depicting the members of a multidisciplinary tumour board.

Chapter Outline

Benign Tumours - Lipoma

Lipomas are benign neoplasms composed of mature fat. 15% occur in the head and neck and up to 5% can be multiple.

US can be used as the initial investigation to assess these lesions. This will demonstrate a well-defined, compressible mass with no internal vascularity.

US should be integrated with CT or MRI as the latter two modalities are superior at demonstrating fat content and excluding complex internal features, i.e., enhancing solid tumour components or thick internal septations. In addition, they identify deep spread. The presence of solid or enhancing components at imaging suggest a liposarcoma.

CT and MRI **(Fig.73)** are also necessary for anatomical lesion delineation when surgery is being considered, particularly to identify the relationship to key structures, e.g., the accessory nerve in the case of posterior triangle lipomas.

PET CT has no role in imaging a lipoma and will not show any uptake. The presence of uptake on PET should raise the concern of a liposarcoma.

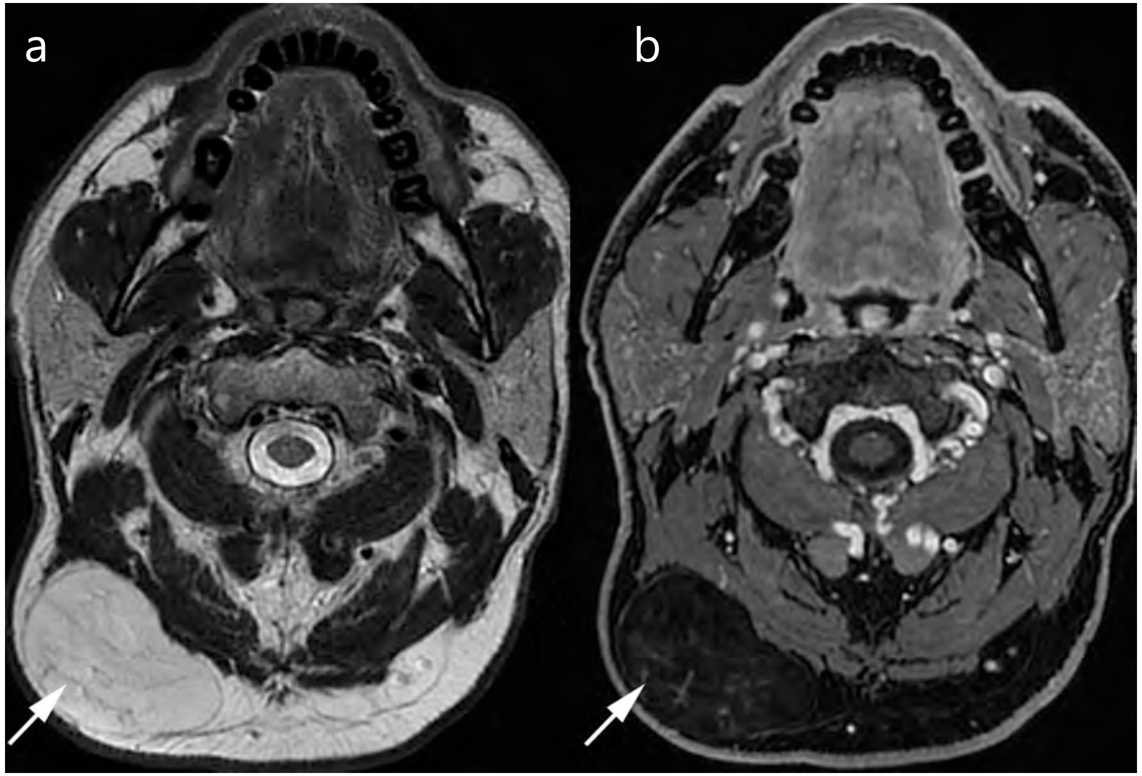


Fig.73. Axial T2W **(a)** and fat suppressed T1 post-contrast **(b)** MR images show a lipomatous mass (arrows) in the right posterior neck with no complex features such as suspicious internal enhancement or nodularity. Features are in keeping with a subcutaneous lipoma.

Chapter Outline

Benign Tumours - Schwannoma

Vestibular schwannomas, also called acoustic neuromas (**Figs. 74-76**) represent 75% - 90% of cerebellopontine angle masses. Their yearly incidence is about 1 in 100,000 population.

Most solitary lesions are sporadic. The presence of **bilateral** vestibular schwannomas is pathognomonic for **neurofibromatosis type 2.**

> Vestibular schwannomas typically present with adult-onset sensorineural hearing loss or non-pulsatile tinnitus.
>
> MRI with contrast is the examination method of choice.

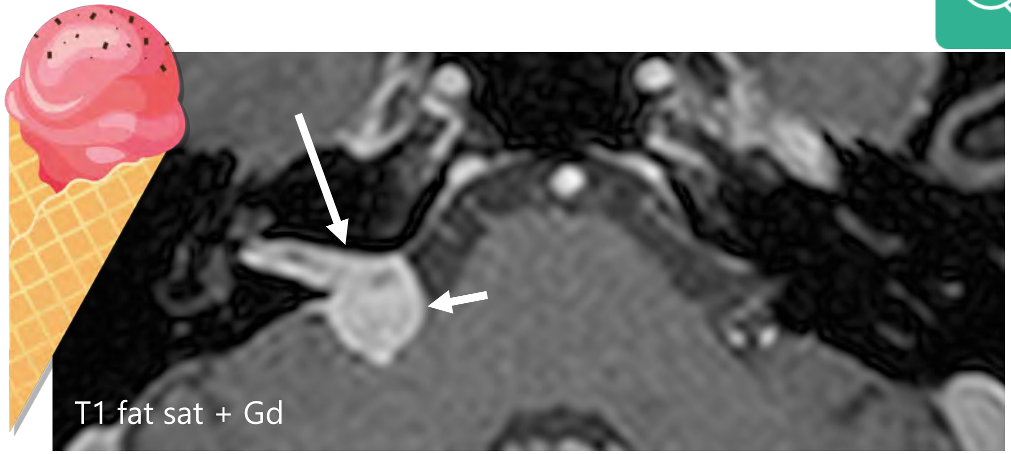


Fig. 74. Vestibular schwannoma presenting as an enhancing internal auditory canal mass (long arrow) extending into the cerebello-pontine angle (short arrow) with a characteristic **ice-cream-on-cone appearance**.

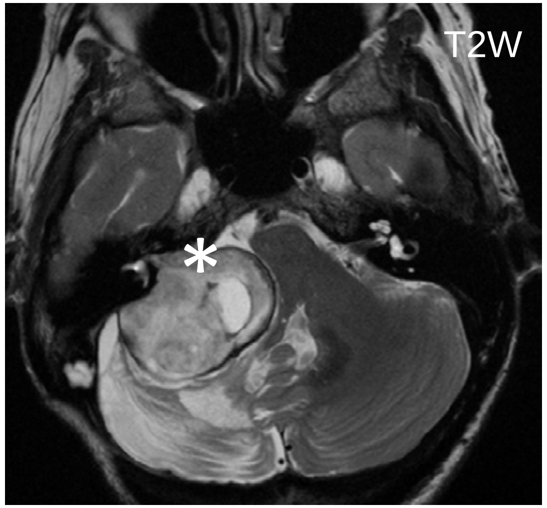


Fig. 75. Large vestibulocochlear schwannoma (asterisk) causing severe compression of the cerebellum and pons

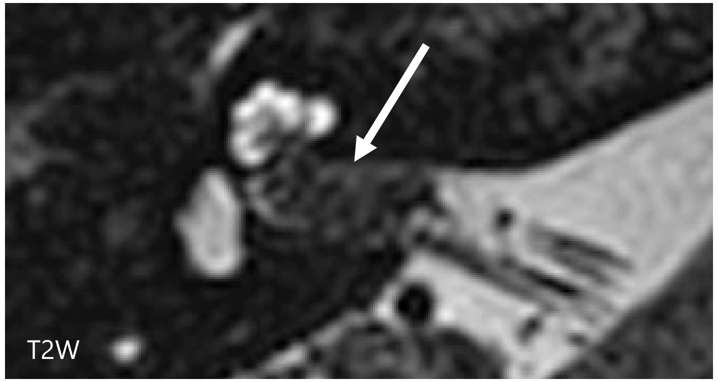


Fig. 76. Intracanalicular schwannoma limited to the internal auditory canal.

Chapter Outline

Benign Tumours - Schwannoma

Schwannomas (**Figs. 77- 79**) can be located anywhere in the head and neck, some examples including:

- **Oral cavity** arising from the lingual nerve. **(Fig. 77).**
- **Posterior triangle** of the neck (involving the brachial plexus **(Fig. 78).**
- **Carotid space** (involving any of the cranial nerves IX-XII and the sympathetic chain) at the level of the oropharynx or nasopharynx or more caudally at the level of the thyroid gland **(Fig. 79).**
- **Parotid gland** (arising from the facial nerve)

The best imaging modality for the assessment of schwannomas and for distinguishing them from other lesions is MRI before and after iv. contrast administration.

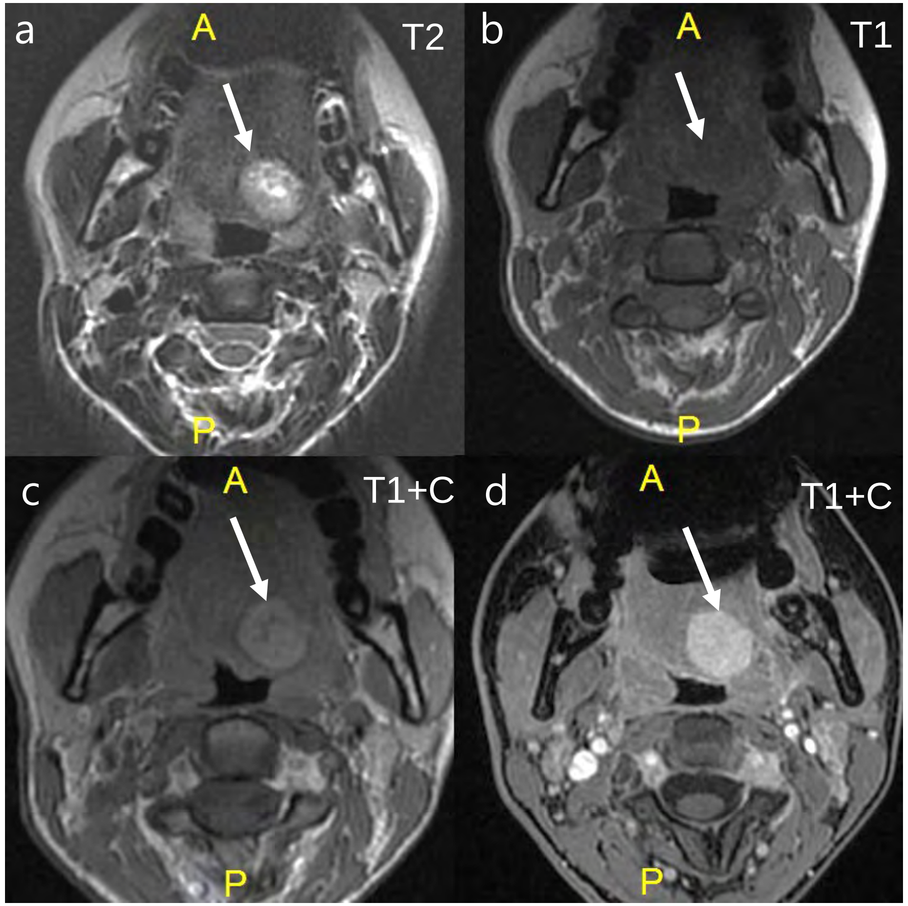


Fig. 77. Lingual nerve schwannoma **(a)** Axial T2W, **(b)** T1, **(c)** T1 post-contrast and **(d)** fat suppressed T1 post-contrast, demonstrating a lingual schwannoma (arrows) on the left side of the tongue. A = anterior. P= posterior.

Chapter Outline

Benign Tumours - Schwannoma

Fig. 78. Brachial plexus schwannomas. Also sometimes referred to as peripheral nerve sheath tumours, the lesions appear as well-circumscribed fusiform masses (arrows) along the course of the brachial plexus and can also exhibit neural foraminal extension. This patient had neurofibromatosis type 2.

Fig. 79. Schwannoma of the cervical sympathetic chain is a benign mass. The above image is an axial T2W MR image demonstrating a typical target sign (characteristic of neurogenic tumours) of the schwannoma (arrow).

Benign Tumours - Paraganglioma

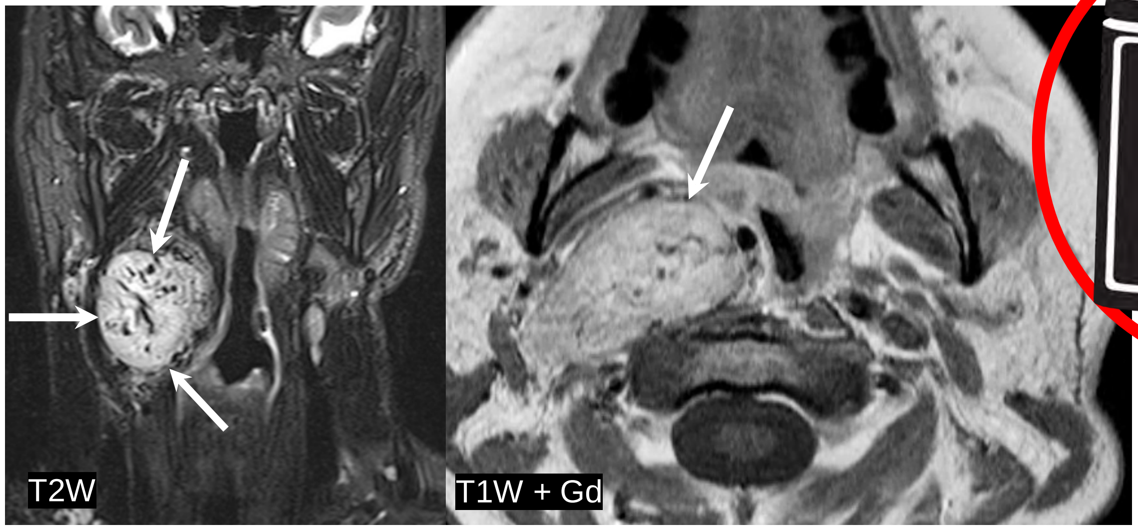
Paragangliomas are tumours originating from neuroendocrine cells which are distributed throughout the body. Being related to the **autonomic nervous system** they can exhibit sympathetic or parasympathetic function depending on their location in the body and whether they have secretory function. They are mainly located in the adrenal medulla, the paravertebral space and the head and neck.

Paragangliomas in the head and neck may present with cranial nerve palsies due to mass effect, a neck mass or tinnitus.

Parasympathetic paragangliomas are predominantly found in the head and neck. They are typically non-secretory. They include:

- **Carotid body** paraganglioma (**Fig. 80**)
- **Glomus vagale** paraganglioma
- **Glomus tympanicum** paraganglioma

=> See also e book chapter on imaging of endocrine disorders



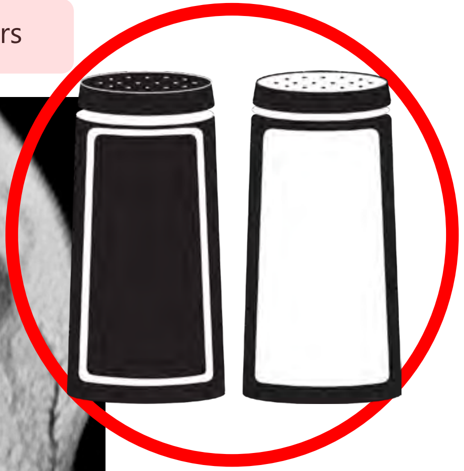


Fig. 80. MR images show a paraganglioma (arrows) in the right carotid space with a very bright signal on T2, avidly enhancing after administration of contrast and with numerous internal low signal areas (flow-voids) due to enlarged intratumoural vessels giving it a characteristic **salt and pepper appearance.**

Chapter Outline

Benign Tumours - Paraganglioma

- **Carotid body tumours** arise from the paraganglion cells of the carotid body. Also known as chemodectomas, the tumours present as a slowly growing, painless, pulsatile masses. Catecholamine–secreting paragangliomas are rare.

- The CT and MR appearances are **pathognomonic** because carotid body tumours characteristically **splay** the external and internal carotid arteries causing the "**lyre sign**" (**Fig. 81.**). Carotid body paragangliomas are exquisitely vascular, thus demonstrating avid enhancement and flow voids on MRI (**Fig. 80**). Flow voids correspond to flow-related signal loss at MRI due to flowing blood with high velocity in patent vessels.

- **Bilateral lesions** may occur in 5-10% of cases and are common in inherited endocrine syndromes.

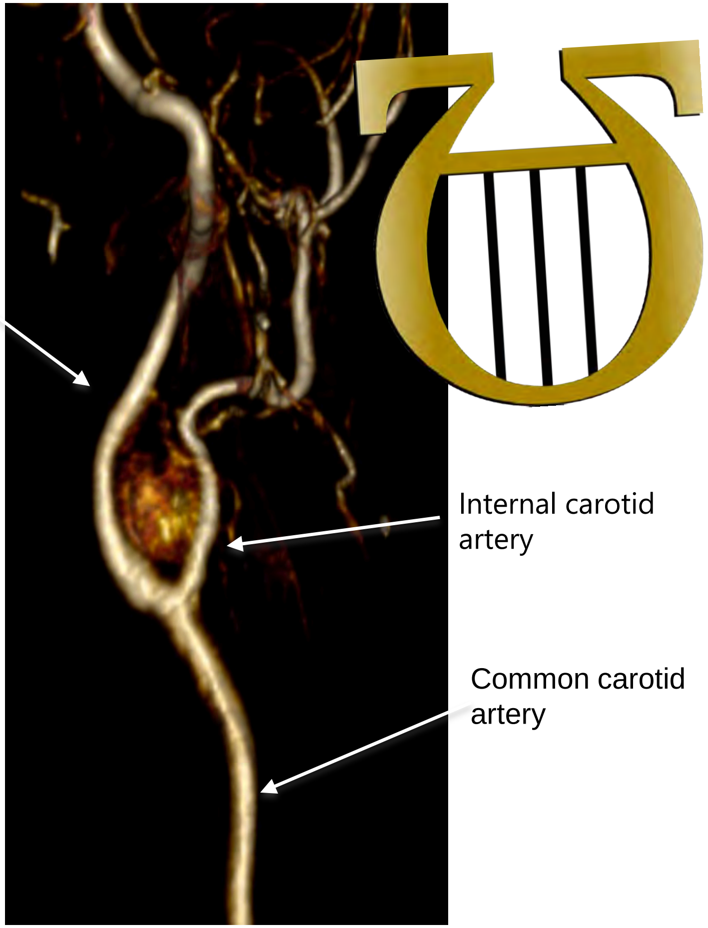


Fig. 81. Carotid body tumours have a characteristic appearance on angiographic studies often described as the "lyre" sign as shown on this MRI angiography image.

Benign Tumours – Pleomorphic Adenoma

These are **the most common salivary gland tumours**. They also account for 70-80% of benign salivary gland tumours. The parotid gland is the most commonly affected gland. The are less common in the smaller salivary glands (the letter having a higher predilection for malignant lesions).

Patients usually present with a smooth, painless, enlarging mass. They are associated with a small risk of malignant transformation into a carcinoma ex-pleomorphic adenoma, the risk rising to 9.5% after 15 years, therefore surgical excision is necessary.

While US can be used to identify the presence of an intraparotid lesion, the imaging findings are non-specific however it is useful in guiding fine needle aspiration cytology or biopsy.

MRI is the gold standard imaging modality for the following reasons:

1. It allows better characterization of the lesion (**Fig. 82.**) and identification of any malignant features
2. Can identify whether there is involvement of the deep lobe of the parotid gland, which would imply a total parotidectomy with potential risk of damage to the facial nerve.
3. It has a high diagnostic performance to detect recurrent disease. While the risk of recurrence is small if total parotidectomy is performed, the risk is high if only enucleation was done initially.

Fig. 82. Axial MR image shows a lobulated lesion which is very bright on T2, involving both deep and superficial lobes. The bright signal on T2 is characteristic of pleomorphic adenomas, although schwannomas and haemangiomas can also have a high signal on T2.

Chapter Outline

Trauma – Temporal Bone

Approximately 14-22% of patients with fractures of the skull will suffer from fractures of the temporal bone. About 90% of adults with temporal bone fractures also have intracranial injuries.

Temporal bone fractures (**Fig. 83.**) may either run parallel to the long axis of the petrous bone (**longitudinal fracture**) or they may run perpendicular to it (**transverse fracture**). Longitudinal fractures are more common than transverse fractures. A combination of both fracture types may also occur (**comminuted fractures**).

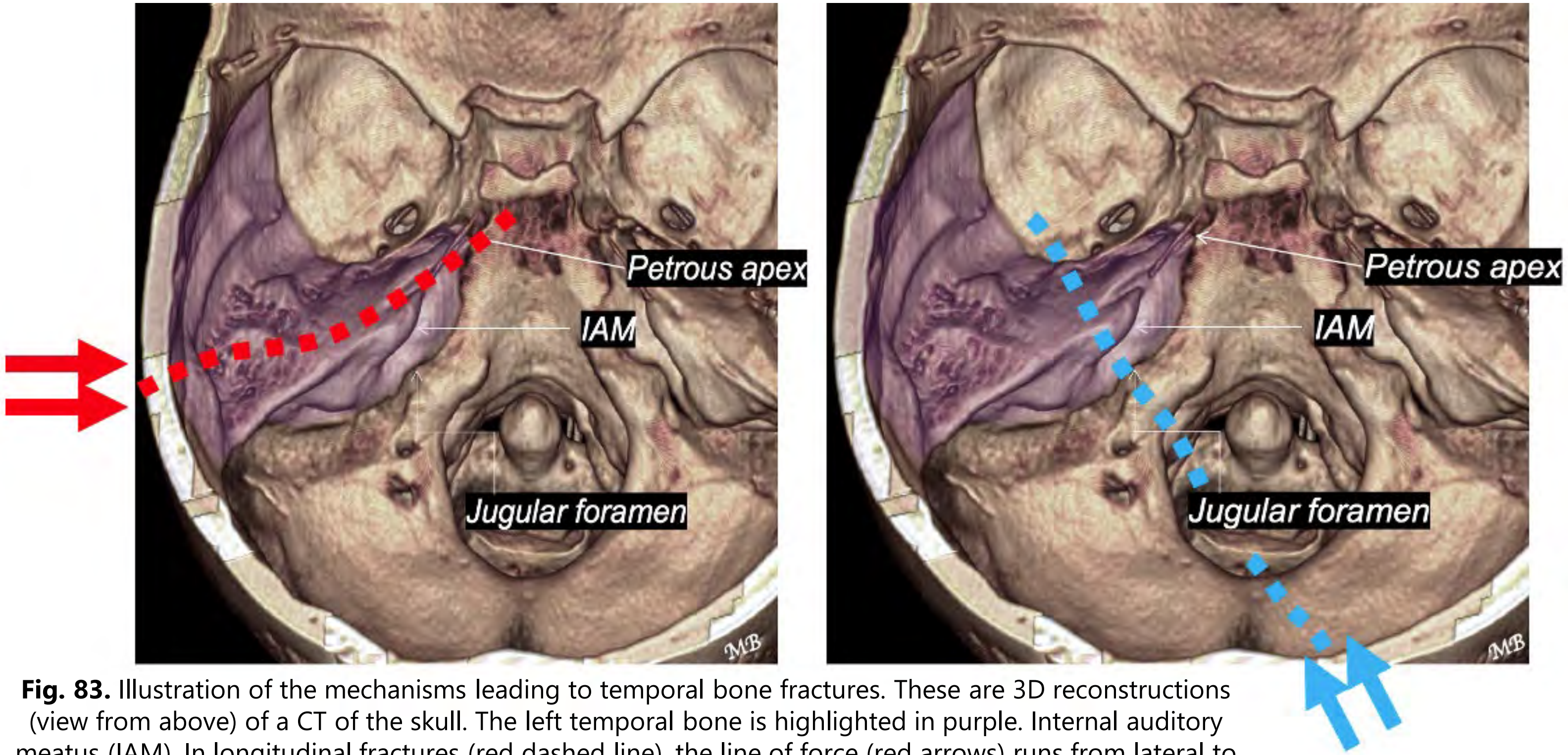


Fig. 83. Illustration of the mechanisms leading to temporal bone fractures. These are 3D reconstructions (view from above) of a CT of the skull. The left temporal bone is highlighted in purple. Internal auditory meatus (IAM). In longitudinal fractures (red dashed line), the line of force (red arrows) runs from lateral to lateral. In transverse fractures (blue dashed line), it runs roughly from posterior to anterior (blue arrows).

Chapter Outline

Trauma - Temporal Bone

Temporal bone fractures can also be classified depending on **involvement of the bony labyrinth** (otic capsule). When the fracture involves the ossicles, inner ear and facial nerve, the patient may present with hearing loss, vertigo and or facial nerve paralysis.

High resolution (thin slice) non-contrast CT scan (**Figs. 84-85**) is indicated for:

- Delineation of the fracture line in relation to the bony labyrinth (cochlea, semicircular canals and vestibule) and facial nerve
- Detection of ossicular dislocation
- Identification of air in the cranial cavity (pneumocephalus), temporal fossa and temporomandibular joint.
- Identification of fluid in the mastoid air cells, middle ear and external auditory canal.

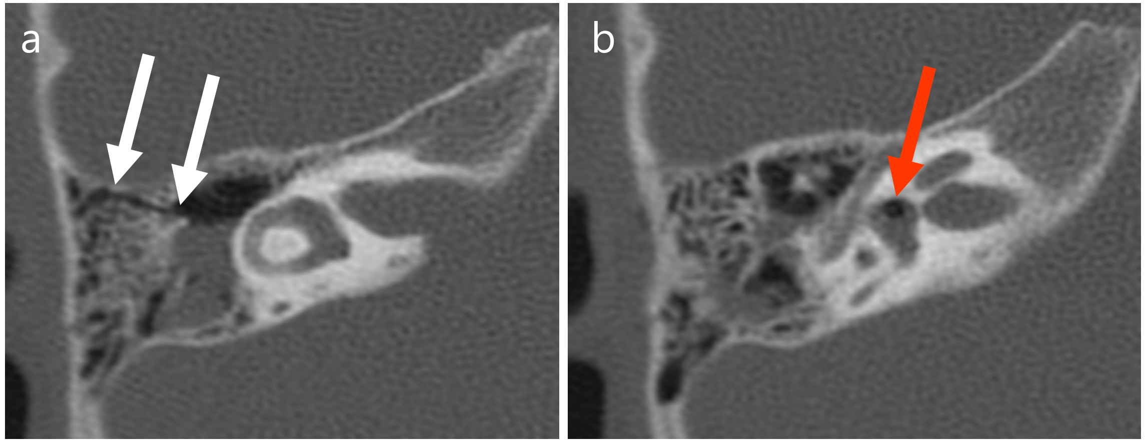


Fig. 84. High resolution unenhanced CT of the temporal bones. **(a)** Longitudinal fracture (white arrows) of the right temporal bone with involvement of the otic capsule and pneumolabyrinth in **(b)**. The red arrow points at an air bubble in the vestibule.

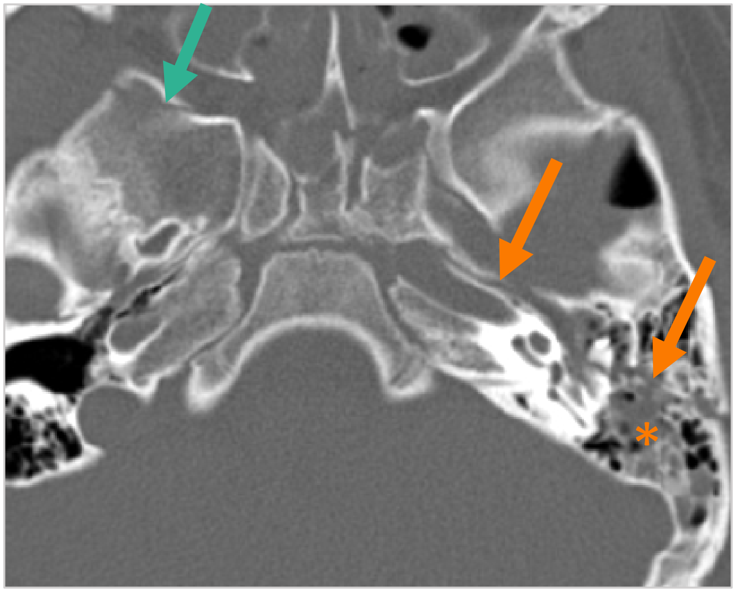


Fig. 85 Longitudinal fracture of the left temporal bone (orange arrows) extending into the contralateral sphenoid bone (green arrow). Note fluid (asterisk) in the mastoid air cells and in the middle ear cavity due to hemotympanum.

Chapter Outline

Trauma Larynx

Laryngeal trauma is uncommon but when encountered, it usually occurs in the following settings:

- Following blunt trauma (particularly motor vehicle accidents)
- Strangulation or hanging
- Penetrating injury, such as knife or gunshot wound
- Post-endotracheal intubation.
- After sneezing with a closed mouth

It can occur in association with other injuries such as fractures of the skull base and cervical spine, as well as thoracic and abdominal injuries.

Symptoms include hoarseness, laryngeal pain, dyspnoea, dysphagia, stridor, haemoptysis and subcutaneous emphysema.

Post-contrast CT (Fig. 86) is the best imaging modality in this regard. It enables assessment of the laryngeal cartilages and great vessels of the neck. The presence of a haematoma is highly suggestive of laryngeal fractures. CT is also necessary to grade the laryngeal injury (Schaefer system) for prognostication and management purposes.

A history of trauma is key to reach the correct differential diagnosis and injury may be subtle, so a high index of suspicion is of paramount importance.

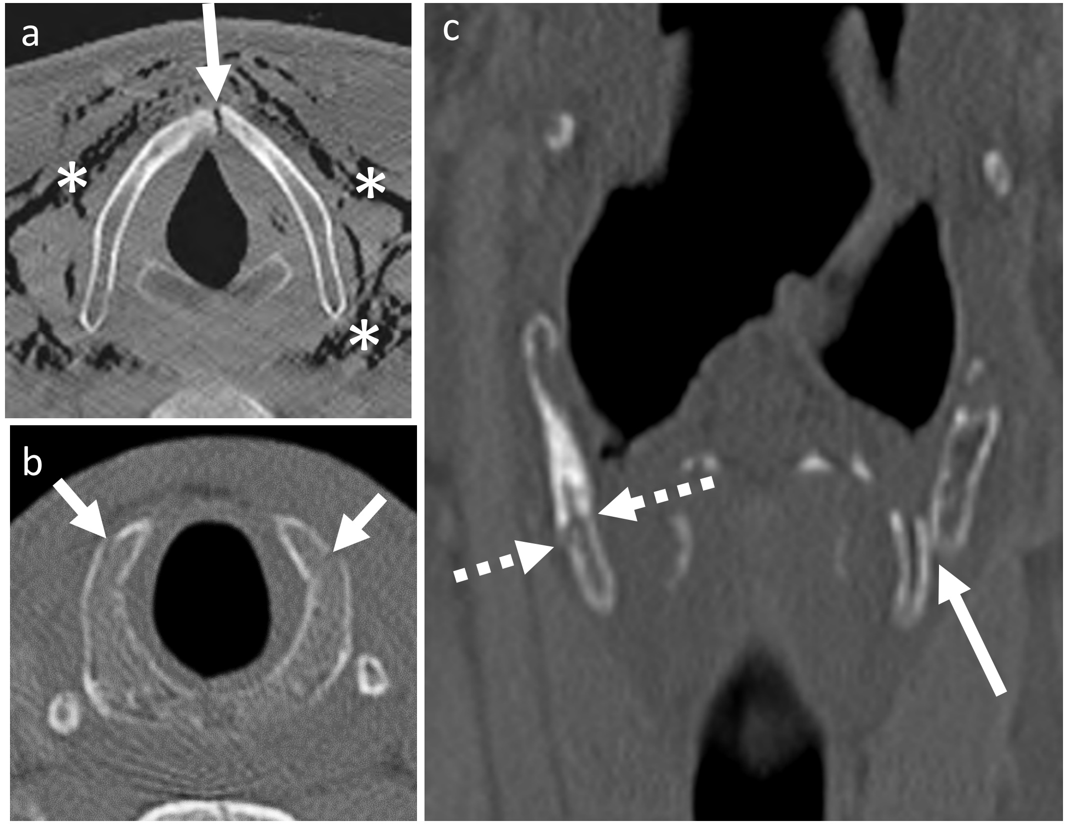


Fig. 86. Three different patients with laryngeal trauma detected by CT. (**a**). Unstable midline fracture of the thyroid cartilage. Note massive soft tissue emphysema (air in the soft tissues of the neck indicated by asterisks). (**b**). Subtle, non-displaced bilateral fractures of the cricoid cartilage (arrows). (**c**). Bilateral fracture of the thyroid cartilage with a left inferiorly displaced fragment (solid arrow) and a right non-displaced fracture line (dashed arrows)

Congenital Lesions - Branchial Cleft Cysts

Branchial cleft anomalies are congenital lesions resulting from persisting branchial clefts or pouches.

=> see also e book chapter on pediatric radiology.

Branchial cleft anomalies comprise **cysts, fistulae or sinuses**. Cysts are the most common branchial cleft anomalies, and second branchial cleft cysts are the most common of all (>90%).

Second branchial cleft cysts (**Fig. 87)** can occur anywhere along the course of the second branchial arch (tonsills, parapharyngeal space, between the internal and external carotid arteries, along the anterior border of the sternocleidomastoid muscle, and skin opening). The most common location is posteriorly to the submandibular gland below the mandibular angle (**Fig. 88).**

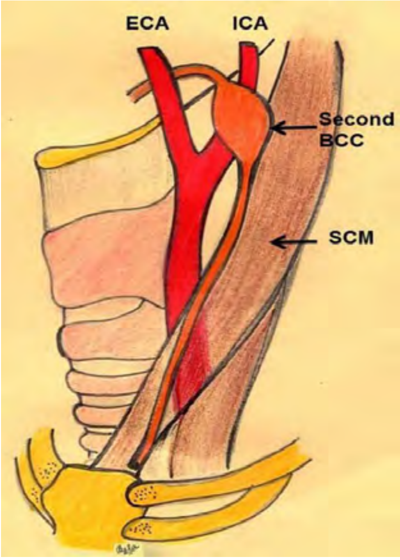


Fig. 87. Schematic illustration of the anatomic location of 2nd branchial arch anomalies. *Drawing courtesy: Bela Purohit, MD, National Neuroscience Institute, Singapore.*

Fig. 88. Well-circumscribed cystic lesion with low attenuation values and thin walls on axial **(a)** and coronal reconstructed images **(b)** from a CECT (arrows) in typical location for a 2nd branchial arch cyst. Submandibular gland (SMG). Sternocleidomastoid muscle (*).

As most branchial cyst anomalies are seen in **children and young adults**, the identification of a purely cystic lesion at ultrasonography, CT or MRI in the appropriate clinical context is pathognomonic.

However, **in patients > 40 years,** the differential diagnosis includes a cystic metastasis (e.g., from squamous cell carcinoma, especially HPV positive oropharyngeal cancer)

Chapter Outline

Congenital Lesions - Thyroglossal Duct Cysts

Thyroglossal duct cyst (TGDC) is a cystic remnant of the embryologic thyroglossal duct (**Figs. 89 - 90**). It is the most common type of congenital neck cyst and pediatric neck mass. TGDCs typically present as midline neck masses in young patients (characteristically < 10 years of age). Patients tend to present with recurrent, intermittent swelling, usually following an upper respiratory tract infection.

If there is a rapidly enlarging mass, think of infection or rarely differentiated thyroid carcinoma (<1% of cases).

Imaging modalities: In children, US is performed to confirm the presence of TGDC and of a normal thyroid gland. MRI is used in the context of infection or if the diagnosis is equivocal.

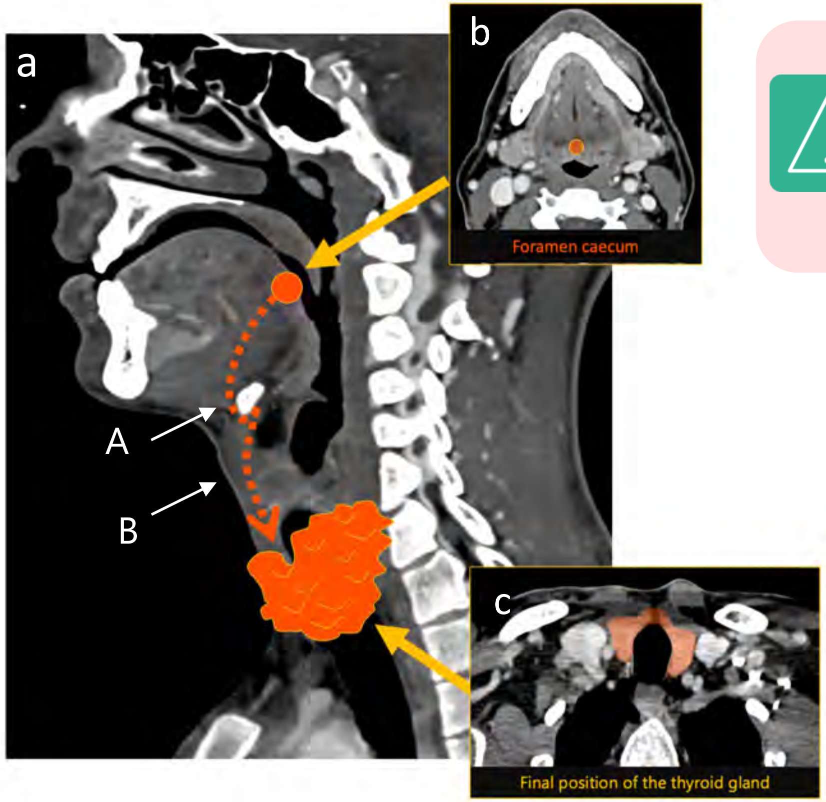


Fig. 89. (a) Schematic illustration of the anatomic location of TGDCs. The anatomic position of the cyst extends from the area of the foramen caecum (b) to the area around the final position of the thyroid gland (c). A and B indicate the anatomic locations of the TGC shown in **Fig. 90.**

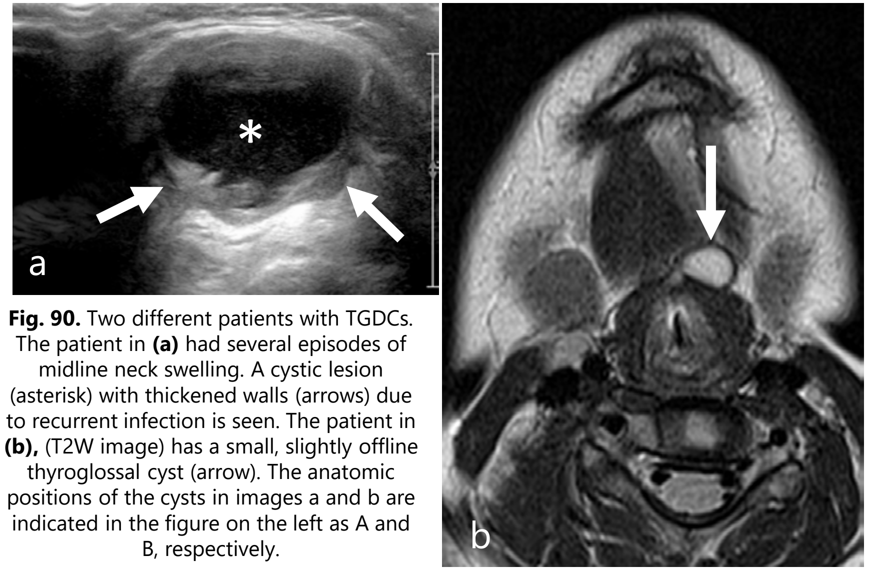


Fig. 90. Two different patients with TGDCs. The patient in **(a)** had several episodes of midline neck swelling. A cystic lesion (asterisk) with thickened walls (arrows) due to recurrent infection is seen. The patient in **(b),** (T2W image) has a small, slightly offline thyroglossal cyst (arrow). The anatomic positions of the cysts in images a and b are indicated in the figure on the left as A and B, respectively.

Chapter Outline

Take-Home Messages

- Head and Neck Radiology is an exciting and rewarding subspecialty of radiology
- A thorough knowledge of the radiological anatomy is crucial to understand pathology and to formulate differential diagnoses.
- Knowledge and familiarity with all imaging modalities and their respective roles is crucial. Like other radiological specialties, radiation protection principles need to be adhered to.
- CT, MRI, ultrasonography (US) and PET CT are essential in a variety of clinical situations as they allow not only a precise diagnosis but also a detailed assessment of the anatomical location facilitating treatment planning and follow-up.
- Head and Neck radiologists work closely with ENT surgeons, oncologists, maxillo-facial surgeons, pathologists, radiation oncologists, dentists and other medical and para-medical specialties.
- Head and neck radiologists are pivotal within multidisciplinary teams and play an important role in the holistic management of benign and malignant ENT conditions.

References

1. Mahmood F. Mafee, Galdino E. Valvassori, Minerva Becker (2005). Imaging of the Head and Neck 2nd edn. Thieme Medical Publishers; Stuttgart, Germany.

2. Bernadette Koch, Bronwyn E. Hamilton, Patricia Hudgins, H. Ric Harnsberger (2017). Diagnostic Imaging: Head and Neck, 3rd edn. Elsevier, Philadelphia.

3. Wolfgang Dähnert. (2003). Radiology Review Manual 7th edn. Wolters Kluwer.

4. Harold Ellis, Vishy Mahadevan (2010). Clinical Anatomy: Applied Anatomy for Students and Junior Doctors 12th edn. Wiley-Blackwell.

5. Paul Butler, Adam Mitchell, Jeremiah C. Healy (2012). Applied Radiological Anatomy 2nd edn. Cambridge University Press.

6. Slide 31: https://radiopaedia.org/articles/aberrant-right-subclavian-artery

7. Slide 31: Wasserman JM, Sclafani SJ, Goldstein NA. 2006. Intraoperative evaluation of a pulsatile oropharyngeal mass during adenotonsillectomy. Int J Pediatr Otorhinolaryngol. 70(2):371-5. doi: 10.1016/j.ijporl.2005.07.002. Epub 2005 Aug 19. PMID: 16112205.

8. Slide 42: Lecchi M, Fossati P, Elisei F, Orecchia R, Lucignani G. 2008. Current concepts on imaging in radiotherapy. Eur J Nucl Med Mol Imaging. 35(4):821-37. doi: 10.1007/s00259-007-0631-y. Epub 2007 Oct 31. PMID: 17972074.

9. Slide 42: Clinical indications for positron emission tomography. Oxford University Hospitals. 2003. National Health Service, UK. https://www.ouh.nhs.uk/services/referrals/radiology/documents/clinical-indications-PET-CT.pdf

10. Slide 47: Capps EF, Kinsella JJ, Gupta M, Bhatki AM, Opatowsky MJ. 2010. Emergency imaging assessment of acute, nontraumatic conditions of the head and neck. Radiographics. 30(5):1335-52. doi: 10.1148/rg.305105040. Erratum in: Radiographics. 2011 Jan-Feb;31(1):316. PMID: 20833854.

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References

11. Slide 57: Hasnaoui J, Anajar S, Tatari M, et al. (2017). Carcinosarcoma of the maxillary sinus: A rare case report. Ann Med Surg (Lond).

12. Slide 58: Weber AL, Rahemtullah A, Ferry JA. (2003). Hodgkin and non-Hodgkin lymphoma of the head and neck: clinical, pathologic, and imaging evaluation. Neuroimaging Clin N Am. 13(3):371-92. doi: 10.1016/s1052-5149(03)00039-x. PMID: 14631680.

13. Slide 59: Marcus C, Whitworth PW, Surasi DS, Pai SI, Subramaniam RM. (2014). PET/CT in the management of thyroid cancers. AJR Am J Roentgenol. 202(6):1316-29. doi: 10.2214/AJR.13.11673. PMID: 24848831.

14. Slide 59: https://radiopaedia.org/articles/thyroid-malignancies

15. Slide 60: TIRADS=> refer to https://radiopaedia.org/articles/thyroid-imaging-reporting-and-data-system-ti-rads.

16. Slide 62: Loevner LA, Sonners AI, Schulman BJ, Slawek K, Weber RS, Rosenthal DI, Moonis G, Chalian AA. (2002). Reinterpretation of cross-sectional images in patients with head and neck cancer in the setting of a multidisciplinary cancer center. AJNR Am J Neuroradiol. 23(10):1622-6. PMID: 12427610; PMCID: PMC8185819.

17. Slide 62: Liu JC, Kaplon A, Blackman E, Miyamoto C, Savior D, Ragin C. (2019). The impact of the multidisciplinary tumor board on head and neck cancer outcomes. Laryngoscope.130(4):946-950. doi: 10.1002/lary.28066. Epub May 16. PMID: 31095740; PMCID: PMC7868105.

Chapter Outline

Test Your Knowledge

1 – The ostiomeatal complex is a critical anatomical region in the paranasal sinuses which drains the:

- Frontal sinus
- Sphenoid sinus
- Posterior ethmoid sinus
- Anterior ethmoid air cells

(multiple answers can be correct)

Chapter Outline

Test Your Knowledge

1 – The ostiomeatal complex is a critical anatomical region in the paranasal sinuses which drains the:

- ✓ Frontal sinus
- Sphenoid sinus
- Posterior ethmoid sinus
- ✓ Anterior ethmoid air cells

Test Your Knowledge

2 – Regarding salivary gland tumours, which of the following is correct?:

- most neoplasms within the parotid gland are malignant
- pleomorphic adenoma is mostly found within the submandibular glands
- facial palsy is invariably present in parotid pleomorphic adenoma
- tumours of the sublingual glands are mostly malignant

Test Your Knowledge

2 – Regarding salivary gland tumours, which of the following is correct?:

- most neoplasms within the parotid gland are malignant
- pleomorphic adenoma is mostly found within the submandibular glands
- facial palsy is invariably present in parotid pleomorphic adenoma
- ✓ tumours of the sublingual glands are mostly malignant

Chapter Outline

Test Your Knowledge

3 – With respect to the role of a staging fully body CT in the diagnostic work-up of patients with thyroid cancer:

- Is indicated in all thyroid cancer cases irrespective of tumour size
- Is not indicated in assessment of anaplastic thyroid cancer
- Is indicated in cases of advanced follicular thyroid cancer
- Has a sensitivity and specificity comparable to US for assessment of discrete malignant thyroid nodules

Test Your Knowledge

3 – With respect to the role of a staging fully body CT in the diagnostic work-up of patients with thyroid cancer:

- Is indicated in all thyroid cancer cases irrespective of tumour size
- Is not indicated in assessment of anaplastic thyroid cancer
- ✓ Is indicated in cases of advanced follicular thyroid cancer
- Has a sensitivity and specificity comparable to US for assessment of discrete malignant thyroid nodules

Chapter Outline

Test Your Knowledge

4 – Regarding imaging of lipomas:

- US should be integrated with CT or MRI to allow more accurate assessment.
- May demonstrate internal vascularity at US during Doppler assessment.
- Accurate anatomical delineation of lipomas can be adequately achieved with US even when large.
- Solid or enhancing components at CT or MRI suggest a liposarcoma

(multiple answers can be correct)

Test Your Knowledge

4 – Regarding imaging of lipomas:

- ✓ US should be integrated with CT or MRI to allow more accurate assessment.
- May demonstrate internal vascularity at US during Doppler assessment.
- Accurate anatomical delineation of lipomas can be adequately achieved with US even when large.
- ✓ Solid or enhancing components at CT or MRI suggest a liposarcoma

Test Your Knowledge

5 – Which of the following anatomical levels refer to pathological lymph nodes in the posterior triangle of the neck:

- level I
- level II
- level V
- level VI

Test Your Knowledge

5 – Which of the following anatomical levels refer to pathological lymph nodes in the posterior triangle of the neck:

- level I
- level II
- ✓ level V
- level VI

Test Your Knowledge

6 – Regarding sinonasal pathology:

- In cases of acute, complicated sinusitis, CT is sufficient to exclude intracranial complications.
- When dealing with sinonasal malignancy, MRI is superior to CT for tumour characterisation because of its superior contrast resolution.
- CBCT and conventional CT are equally useful in the work-up of patients with chronic rhinosinusitis.
- Plan radiographs are still routinely employed for the diagnosis of sinonasal pathology.

(multiple answers can be correct)

Chapter Outline

Test Your Knowledge

6 – Regarding sinonasal pathology:

- In cases of acute, complicated sinusitis, CT is sufficient to exclude intracranial complications.
- ✓ When dealing with sinonasal malignancy, MRI is superior to CT for tumour characterisation because of its superior contrast resolution.
- ✓ CBCT and conventional CT are equally useful in the work-up of patients with chronic rhinosinusitis.
- Plan radiographs are still routinely employed for the diagnosis of sinonasal pathology.

Chapter Outline

Test Your Knowledge

7 – Onodi cell

- is an anterior ethmoid air cell.
- is often symptomatic.
- is intimately related to the carotid artery and optic nerve.
- is usually associated with nasal septal deviation

Test Your Knowledge

?

7 – Onodi cell

- is an anterior ethmoid air cell.
- is often symptomatic.
- ✓ is intimately related to the carotid artery and optic nerve.
- is usually associated with nasal septal deviation

Test Your Knowledge

8 – Paragangliomas of the head and neck region:

- are mostly parasympathetic (as opposed to sympathetic)
- are generally secretory
- often display flow voids at MRI
- have a characteristic salt and pepper appearance

(multiple answers can be correct)

Test Your Knowledge

8 – Paragangliomas of the head and neck region:

- ✓ are mostly parasympathetic (as opposed to sympathetic)
- are generally secretory
- ✓ often display flow voids at MRI
- ✓ have a characteristic salt and pepper appearance

Chapter Outline

Test Your Knowledge

9 – Regarding thyroglosal duct cysts:

- they are rare congenital neck cysts
- typically present in adulthood
- are typically located in the midline
- the majority are located in the foramen caecum.

Chapter Outline

Test Your Knowledge

9 – Regarding thyroglosal duct cysts:

- they are rare congenital neck cysts
- typically present in adulthood
- ✓ are typically located in the midline
- the majority are located in the foramen caecum.

Test Your Knowledge

10 – Regarding imaging of vestibulocochlear schwannomas

- Vestibular schwannomas have to be evaluated with CT and MRI.
- MRI is unable to distinguish the vestibulocochlear nerve from the seventh cranial nerve.
- Contrast enhanced MRI is the gold standard imaging technique.
- The presence of bilateral vestibulocochlear schwannomas is pathognomonic for neurofibromatosis type 1.

Chapter Outline

Test Your Knowledge

10 – Regarding imaging of vestibulocochlear schwannomas

- Vestibular schwannomas have to be evaluated with CT and MRI.
- MRI is unable to distinguish the vestibulocochlear nerve from the seventh cranial nerve.
- ✓ Contrast enhanced MRI is the gold standard imaging technique.
- The presence of bilateral vestibulocochlear schwannomas is pathognomonic for neurofibromatosis type 1.

Chapter Outline

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