Laryngeal Imaging: Anatomy and Pathology

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Abstract

Imaging plays an important role in diagnostic evaluation of laryngeal lesions. The real value of imaging comes when there is a need to decide the feasibility of speech conservation therapy. Cross-sectional imaging allows excellent depiction of the intricate anatomy of the larynx and the characteristic patterns of tumor extension as well as the status of cervical nodal disease. Imaging studies also help in the post-therapeutic follow-up of patients with laryngeal cancers. In this article, we review the currently used laryngeal imaging techniques and protocols, the key anatomic structures relevant to tumor spread and the characteristic patterns of submucosal extension and invasion of laryngeal cancer. The role of CT and MRI in the evaluation of patients with laryngeal SCC and the impact of imaging findings, staging and surgical aspects is also discussed.

Keywords
- larynx
- neck
- cartilage

Introduction

The neck is a complex region that houses many important structures from many different organ systems including the vascular, respiratory, digestive, neurologic, musculoskeletal, and endocrine systems. It is the region between the skull base and the chest. The superior boundary is the inferior/mandibular margin and superior nuchal line, whereas the inferior boundary is demarcated by the suprasternal notch, superior clavicular borders, and T1 vertebral body. The larynx, a midline structure connecting the pharynx with the trachea, supports and protects the vocal cords and prevents aspiration into the trachea. The larynx is composed of several cartilages connected by numerous ligaments and muscles.[1]

The most common indication to perform a computed tomography (CT) or a magnetic resonance imaging (MRI) examination of the larynx and hypopharynx consists in imaging a biopsy-proven, suspected primary, or recurrent neoplasm. Although diagnostic evaluation of the larynx and hypopharynx is primarily done with endoscopy and endoscopic biopsy, cross-sectional imaging either with CT or MRI plays an indispensable complementary role, because it enables evaluation of the deep submucosal structures and spaces.

Anatomy

Larynx is 5- to 7-cm long structure comprised of series of cartilages connected by ligaments, membranes and muscles (►**Figs. 1–5**). Its upper boundary starts at the tip of epiglottis opposite third to fourth cervical vertebra and lower boundary end at the lower end of cricoids cartilage opposite sixth cervical vertebra. The larynx has total nine cartilages, three of them are individual and three of them are paired. Cricoid, thyroid, and epiglottis are unpaired and arytenoids, corniculate, and cuneiform are paired cartilages.[1]

Thyroid Cartilage

It is the largest cartilage which forms anterior and lateral portions of the larynx with no posterior component. Two right and left lamina fuses anteriorly to form laryngeal

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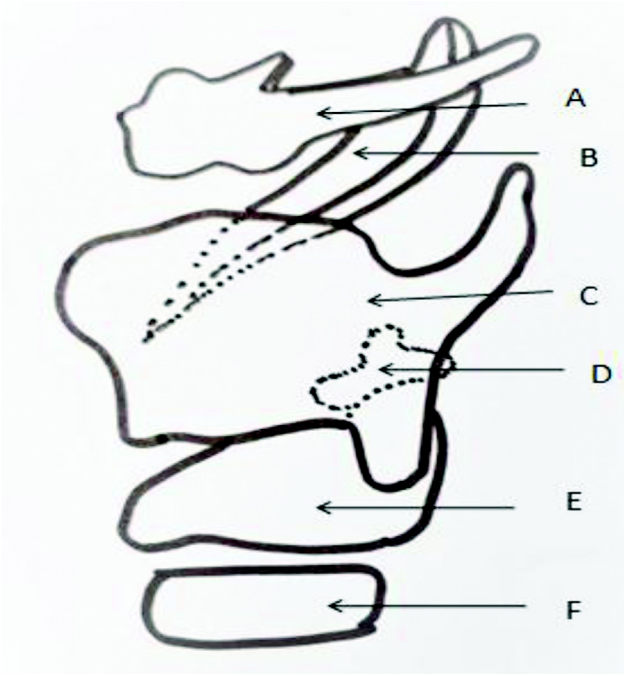

Fig. 1 Lateral demonstration of laryngeal skeleton from upward to downward, hyoid bone (A), epiglottis (B), thyroid cartilage (C), arytenoid cartilage (D), cricoid cartilage (E) and first tracheal ring (F).

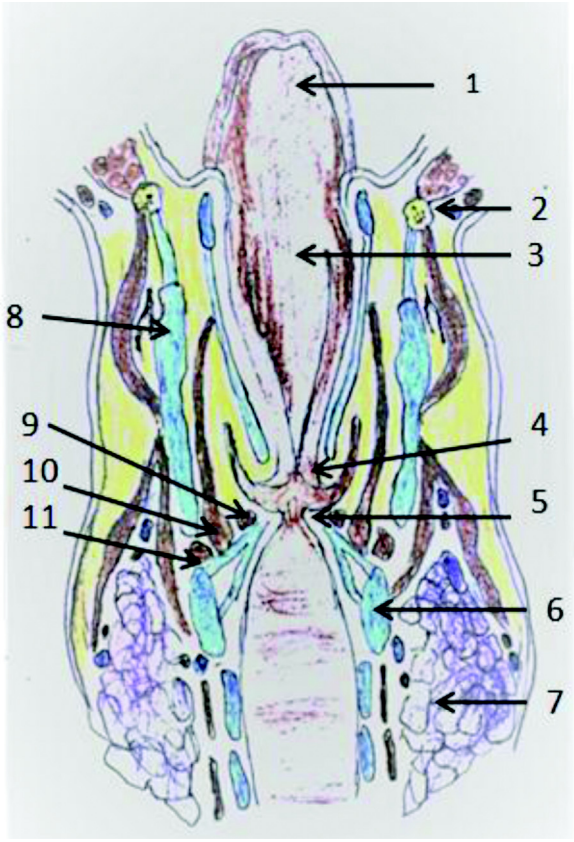

Fig. 2 Coronal section of larynx: (1) epiglottis, (2) hyoid bone, (3) vestibule, (4) vestibular fold, (5) vocal fold, (6) cricoid cartilage, (7) thyroid gland, (8) thyroid cartilage, (9) vocalis muscle, (10) oblique arytenoid muscle, and (11) lateral cricoarytenoid muscle.

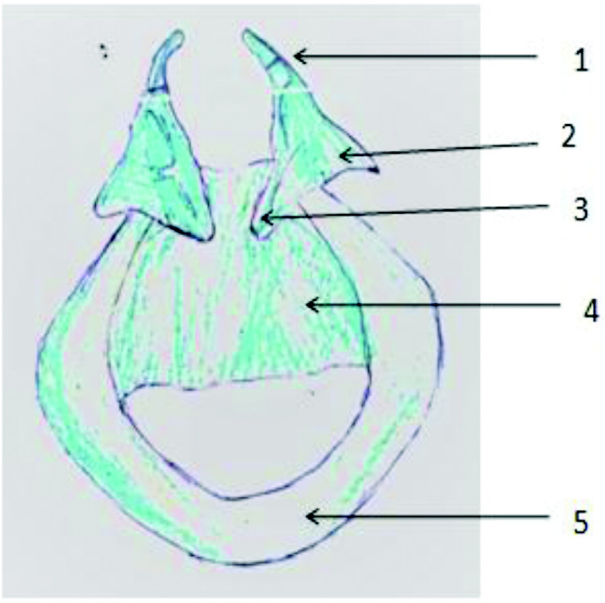

Fig. 3 A drawing of cricoid cartilage and its articulations: (1) corniculate cartilage, (2) muscular process of arytenoid cartilage, (3) vocal process of arytenoid cartilage, (4) lamina of cricoid cartilage, and (5) arch of cricoid cartilage.

prominence called "Adam's apple." Superior aspect of the prominence has a superior thyroid notch and inferiorly a small notch called inferior thyroid notch. The posterior aspects of each lamina are extended upward into superior horn and downward into inferior horn. Superiorly, the thyroid cartilage attaches with hyoid bone by thyrohyoid membrane and inferiorly with cricoids cartilage and form cricothyroid joint.[2]

Cricoid Cartilage

It is the only component that completely encircles the airway. It connects larynx to the trachea by cricotracheal ligament. It has narrow anterior arch and broad posterior lamina. It attaches with trachea through cricothyroid ligament.

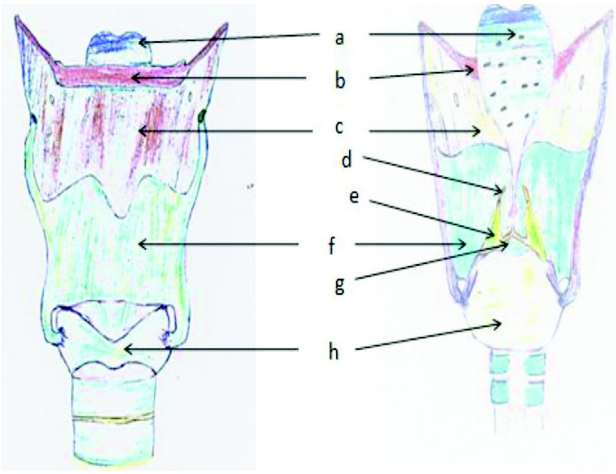

Fig. 4 A drawing of anterior and posterior view of larynx showing, epiglottis (a), hyoid bone (b), thyrohyoid membrane(c), corniculate cartilage (d), arytenoid cartilage (e), thyroid cartilage (f), vocal ligament (g) and cricoid cartilage (h).

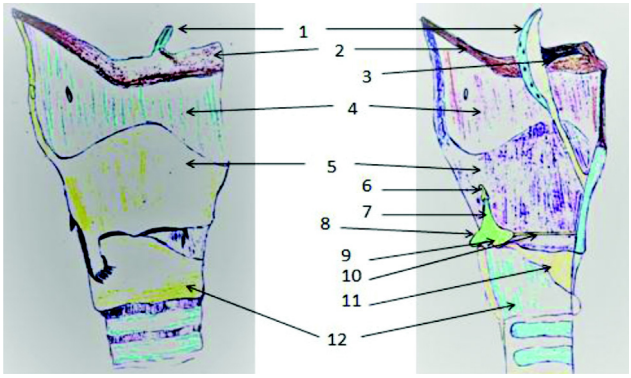

Fig. 5 Sagittal section of larynx: (1) epiglottis, (2) hyoid bone, (3) hyoepiglottic ligament, (4) thyrohyoid membrane, (5) thyroid lamina, (6) corniculate cartilage, (7) arytenoid cartilage, (8) muscular process, (9) vocal process, (10) vocal ligament, (11) cricothyroid ligament, (12) cricoid cartilage.

Arytenoid Cartilage

They are two in number and are situated posteriorly at the upper border of lamina of cricoids cartilage. They are pyramidal in shape with three surfaces, apex, and base. Apex of the cartilage attaches to corniculate cartilage. It has an anterior vocal process which gives attachment to vocal ligament and lateral muscular process which attaches to cricoartytenoideus muscle.[2]

Corniculate Cartilage

They are situated in the posterior part of aryepiglottic folds and articulates with the summits of arytenoids cartilage and prolongs them backward and medially.[2]

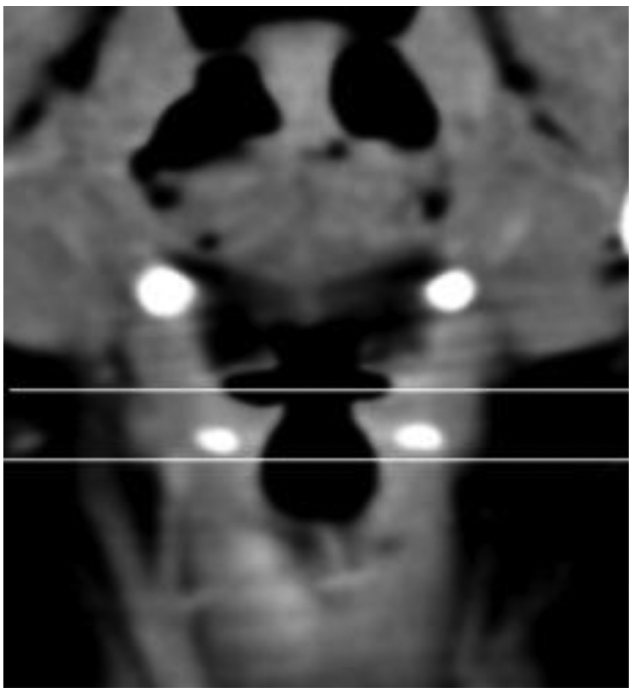

Fig. 6 Laryngeal subdivisions. Supra glottis: from the superior-most tip of the epiglottis to a transverse plane through the laryngeal ventricle. Glottis: from this transverse plane to 1 cm inferiorly and includes the true vocal cords. Sub glottis: from the inferior-most plane of the true cords to the inferior portion of the cricoid cartilage.

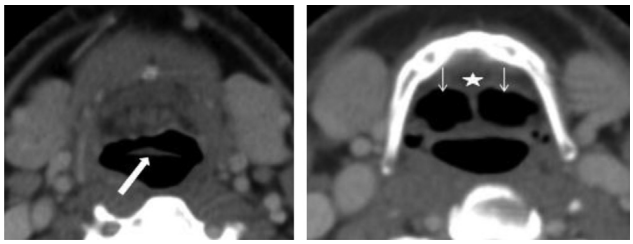

Fig. 7 Axial CT image at supraglottic level showing Tip of epiglottis (thick arrow), paired vallecula (thin arrow) and glossoepiglottic fold (*). CT, computed tomography.

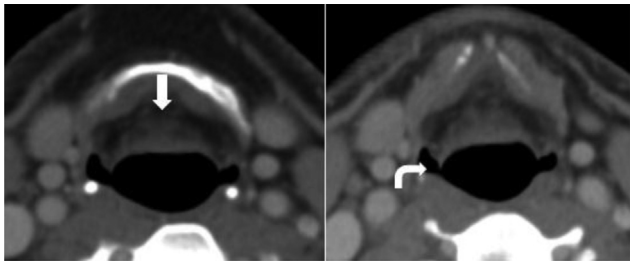

Fig. 8 CT axial image at supraglottic level showing preepiglottic fat (thick arrow), aryepiglottic fold and pyriform sinus (curved arrow). CT, computed tomography.

Cuneiform Cartilage

They are located lateral and superior to corniculate cartilage on either side along the free edge of aryepiglottic folds.[2]

Epiglottis

It is a leaf-like fibroelastic cartilage forms the superior border of larynx. It attaches to the angle formed by two lamella of thyroid cartilage with thyroepiglottic ligament just below the superior notch of thyroid. Superiorly, it also attaches to hyoid bone through hyoepiglottic ligament.[2]

Larynx is divided into three parts: supraglottic region, glottis, and subglottic region (►**Fig. 6**).

Supraglottic Region

It extends up to transverse plane through laryngeal ventricles (►**Figs. 7**–**9**). It contains epiglottis, preepiglottic fat, aryepiglottic folds, false vocal cord, paraglottic space, and arytenoid cartilages. The lateral walls of laryngeal cavity bulges outward

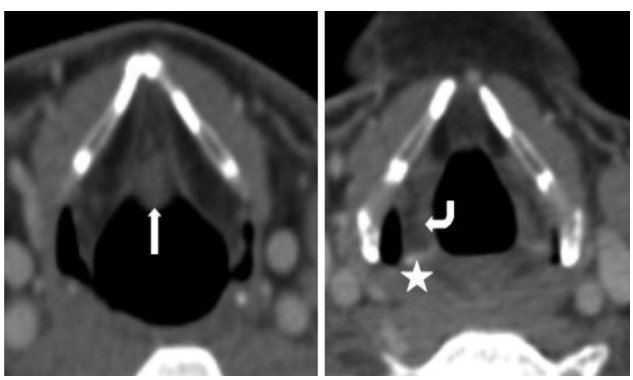

Fig. 9 axial CT cut at supraglottic level showing stem of epiglottis (straight arrow), false vocal cord (curved arrow) and tip of arytenoid (*).CT, computed tomography.

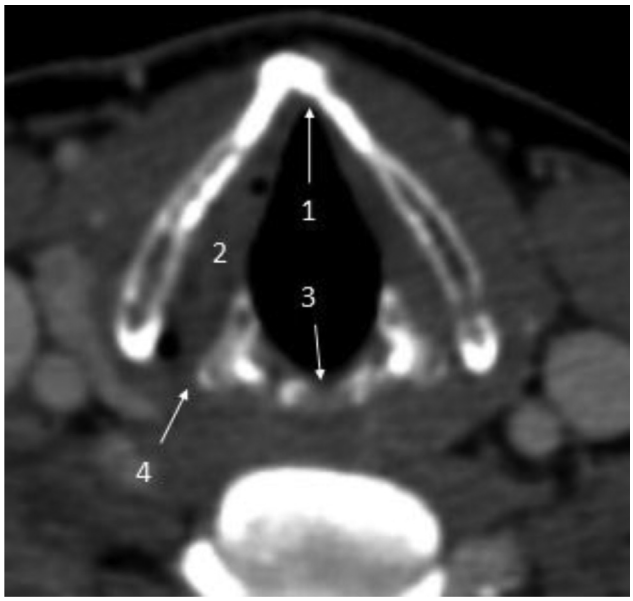

Fig. 10 Axial CT section at the level of glottis; (1) anterior commissure, (2) thyroarytenoid muscle, (3) posterior commissure, (4) cricoarytenoid joints.

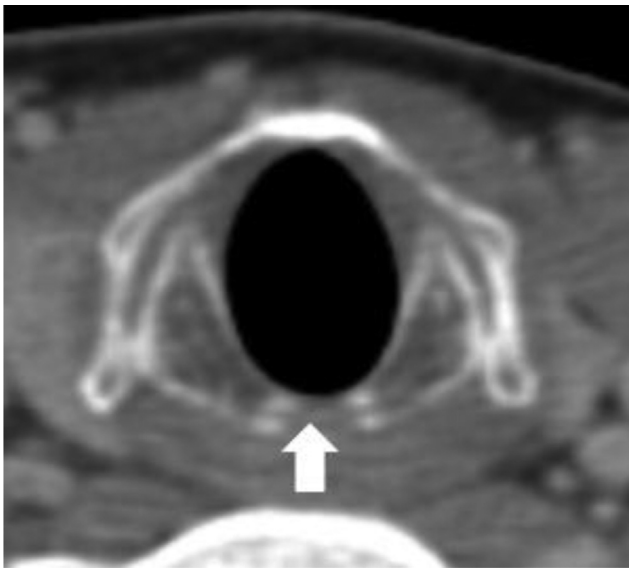

Fig. 12 CT axial image at subglottic level showing cricoid ring (thick arrow). Note that there is no soft tissue at the inner margin of the ring. CT, computed tomography.

to form laryngeal ventricle between the vestibular fold and vocal folds. The laryngeal ventricles has a bling tubular fold called laryngeal saccule, that projects anterosuperiorly between thyroid cartilage and vestibular fold.[3]

- Preepiglottic space: fat-filled space between hyoid bone anteriorly and epiglottis posteriorly (►**Fig. 12**).
- Aryepiglottic folds: projects from cephalad tip of arytenoids cartilages to inferolateral margin of epiglottis. Represents superolateral margin of supraglottis, dividing it from pyriform sinus (hypopharynx).
- False vocal cords: mucosal surfaces of laryngeal vestibule of supraglottis. Beneath them are paired paraglottic spaces.
- Paraglottic spaces: paired fatty regions beneath false and true vocal cords. Superiorly they merge into preepiglottic space and terminates inferiorly at under surface of true vocal cord (►**Fig. 13**).

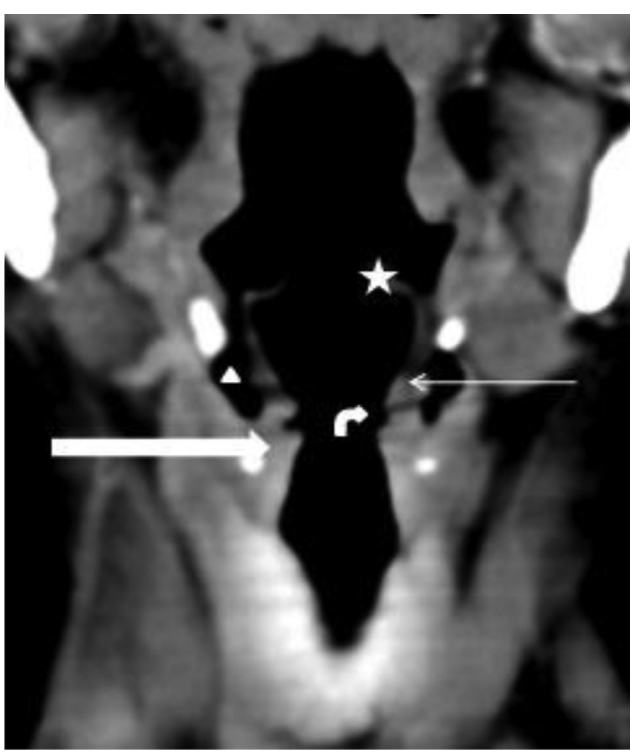

Fig. 11 CT image at the mid coronal section of larynx showing epiglottis (*), vellecula (triangle), false vocal cord (thin arrow),

Glottis

It is narrow zone of larynx, the vocal apparatus forms by true vocal folds and the Rima glottidis. It contains true vocal cords, anterior and posterior commissure, thyroarytenoid muscles (medial fibers are "vocalis" muscles[4]; ►**Figs. 10** and **11**).

- Anterior commissure is midline meeting point of true vocal cord.
- Vocal folds contains vocal ligament and vocalis muscles on either side. True folds that produces sound.

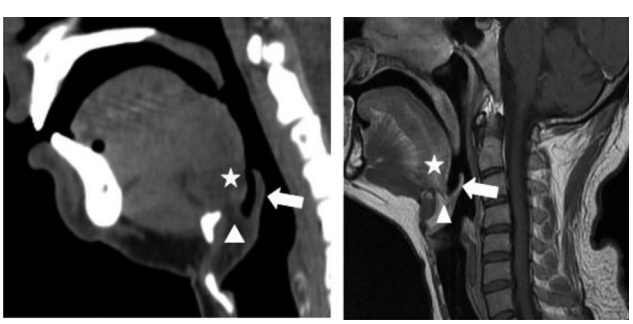

Fig. 13 CT and MRI images at the mid sagittal section of supraglottic region showing epiglottis (thick arrow), pre-epiglottic fat (triangle) and base of tongue (*) better differentiated on MRI images. CT, computed tomography; MRI, magnetic resonance imaging.

- The Rima glottidis is the opening between true vocal folds. The shape of which is depends on the position of vocal folds and rotational movements of the arytenoids cartilage at the cricoarytenoid joints.

Subglottis

It extends from under surface of true vocal cord to inferior surface of cricoid cartilage. Mucosal surface of subglottic area is closely applied to cricoid cartilage (►**Fig. 12**).

- Conus elasticus: fibroelastic membrane extends from medial margin of true vocal cord above to cricoid below.

Vascular Supply

- Superior laryngeal artery (branch of the superior thyroid artery) supplies above the vocal cord and area below the vocal cords is supplied by the inferior laryngeal artery (branch of the Inferior thyroid artery).
- Superior laryngeal vein accompanies its artery and drains into the Superior thyroid vein (a tributary to the internal jugular vein) and inferior laryngeal vein accompanies its artery and drains into the inferior thyroid vein (a direct tributary to the braciocephalic vein).[2]

Lymphatic Drainage

- Supraglottic: the supraglottic lymphatic network follows the superior laryngeal artery, piercing the thyrohyoid membrane, and then draining into the superior deep cervical nodes and the preepiglottic nodes.
- Subglottic: the infraglotttic lymphatic network drains to the inferior deep cervical nodes, following the inferior laryngeal artery, and/or the prelaryngeal (the Delphian) nodes via the conus elasticus (aka the lateral cricothyroid ligaments).
- Both the superior and inferior deep cervical nodes then drain into the right and left jugular trunks which subsequently empty into the right lymphatic duct and the thoracic duct on the left.[2]

Innervation

- Motor: the recurrent laryngeal nerve supplies all the intrinsic muscles of the larynx apart from the cricothyroid muscle which is supplied by the external laryngeal nerve.
- Sensory: above the vocal cords (supraglottic), internal laryngeal nerve (branch of the superior laryngeal nerve).
- Below the vocal cords (infraglottic): recurrent laryngeal nerve.[2]

Imaging Modalities

CT is the preferred imaging method for evaluating the larynx and hypopharynx, whereas MRI is used as a complementary tool in those cases where the CT study does not provide all information needed prior to therapy. Imaging is mostly required for moderate sized laryngeal masses in which proper delineation of margin of mass is needed for voice sparing surgery.

Plain Film Radiography

It uses air present in the larynx and trachea as a contrast to visualize position of laryngeal cartilage and soft tissue masses. Retropharyngeal soft tissue thickness can be appreciated on lateral films.

Barium Swallow

It is used to evaluate pharyngeal wall. Pyriform sinus is seen as sharp marginated structure in frontal view adjacent to filling defect of epiglottis. Irregularity or filling defects in sinus can be seen in case of hypopharyngeal masses or laryngeal paralysis.[5]

Computed Tomography Scan

- Scanning parameters: in supine position, patient is instructed to resist swallowing or coughing. Axial slices are obtained from the base of the skull to the trachea with a scan orientation parallel to the true vocal cords. Iodinated contrast material (total dose, 35–40-g iodine) is given intravenously with an automated power injector. Images are obtained during quiet breathing rather than during apnea because the abducted position of the true vocal cords facilitates evaluation of the anterior and posterior commissures.[6] A slice thickness of 1.5 mm and overlapping reconstructions every 0.75 mm are used routinely by many investigators, including ourselves, allowing high-quality two-dimensional reconstructions in the coronal or sagittal plane.
- Additional dynamic maneuvers during phonation or the modified Valsalva maneuvers are used in selected cases to improve visualization of certain anatomic areas such as laryngeal ventricle or hypopharynx.

Magnetic Resonance Imaging Scan

- Scanning parameters: MRI of the larynx and hypopharynx is done using dedicated surface neck coils in a phased array configuration or with parallel imaging techniques. Two basic pulse sequences are currently used by most investigators, namely, T1-weighted sequences and T2-weighted sequences. Axial T2-weighted fast spin echo (FSE) and T1-weighted spin echo (SE) or T1-weighted FSE images are obtained from the skull base to the thoracic inlet with a scan orientation parallel to the true vocal cords. Additional axial T1-weighted images after intravenous administration of gadolinium chelates are obtained routinely. Fat-saturated T1-weighted images with or without contrast-material enhancement and fat-saturated T2-weighted images are optional. Images in the coronal or sagittal plane may be obtained to evaluate certain anatomic spaces such as the preepiglottic space in the sagittal plane or the paraglottic space and the ventricle in the coronal plane (►**Fig. 13**-**15**).[6]

Laryngeal Pathologies

Laryngeal pathologies are divided into traumatic, inflammatory, congenital, and neoplastic lesion. These are again subdivided into supraglottic, glottic, and subglotic categories.

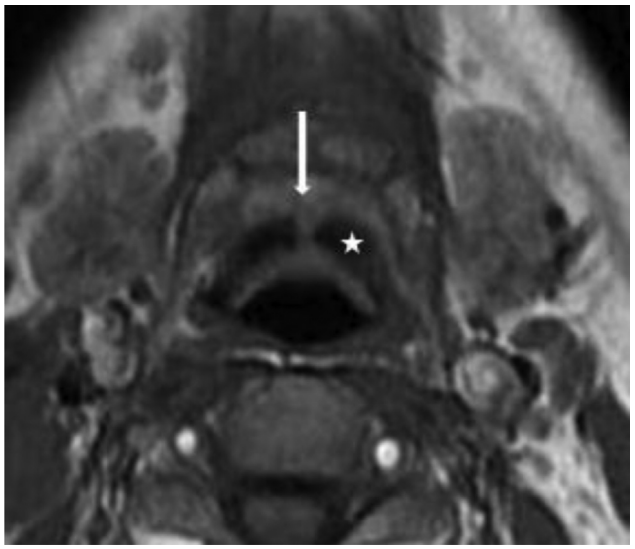

Fig. 14 Axial MRI at the level of upper epiglottis showing paired vallecula (*) and glossoepiglottic fold (arrow). MRI, magnetic resonance imaging.

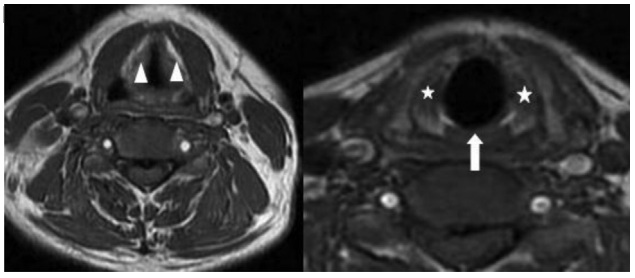

Fig. 15 Axial MRI T1-weighted image showing true vocal cord (arrowhead), posterior wall of cricoid cartilage (arrow) and cricoid ring (*). MRI, magnetic resonance imaging.

Most laryngeal trauma are iatrogenic, following intubation which are mucosal erosions, laryngomalacia, or stenosis. Others are due to direct force on the larynx causing fractures of laryngeal cartilages or dislocation of joints and perforation of mucosa. These fractures and perforation causes further airway compromise by allowing passage of air in adjacent soft tissue (►**Figs. 16** and **17**). A hematoma can develop and seen as a mass obliterating fatty soft tissue, a history of trauma is needed to rule out neoplastic lesions.[7] Different types of cartilage fractures are listed below:

- Thyroid: longitudinal, paramedian, transverse, or comminuted fractures.
- Cricoid: always breaks in two places, the posterior component is often not clinically recognized.
- Epiglottis: may be avulsed posteriorly and superiorly.
- Arytenoids: anterior and posterior dislocation.

Congenital Anomalies

Most congenital anomalies, like laryngeal stenosis, laryngeal web, laryngeal cleft, and laryngomalacia, do not come to imaging and are evaluated clinically with direct endoscopy.

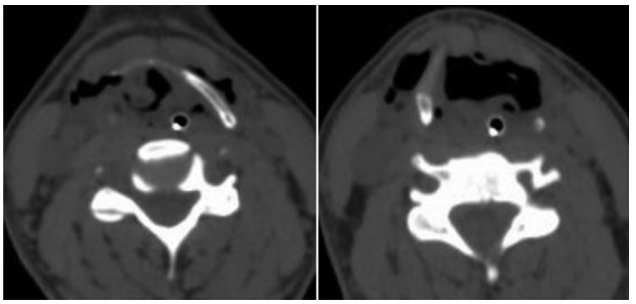

Fig. 16 Case of laryngeal trauma with edema of supraglottic region and glottis with emphysema underneath the anterior strap muscles on both the sides.

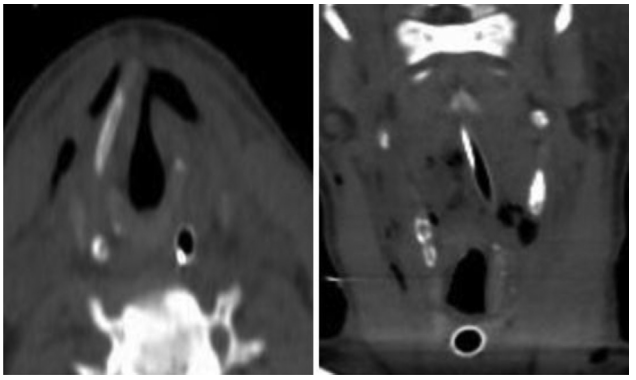

Fig. 17 Case of laryngeal trauma with rupture of laryngeal cartilage anteriorly with emphysema underneath the strap muscles and formation of false tract.

Developmental anomalies frequently discovered incidentally, like thyroglossal duct remnants, while other presents as laryngeal masses interfering with laryngeal function. These are developmental cysts, that is, dermoid, epidermoid, duplication cyst, brachial apparatus, and thyroglossal duct cysts. Brachial apparatus secondarily involves larynx by track leading to pyriform sinus which can get infected and cause obstruction of larynx.[8]

Benign Tumors

These are the vocal cord nodules, papillomatosis, and nonepithelial/mesenchymal tumors.

1. Vocal cord nodules: it is mainly associated with vocal cord abuse. They occurs at the free margin of the true vocal cord and rarely requires imaging consideration.
2. Papillomas: these are wart like lesions generally occurs in children. They are frequently multiple with high chances of recurrence after laser excision.
3. Nonepithelial/mesenchymal tumors: it includes lipoma, dermoid, hemangioma, paraganglioma, chondroma, leiomyoma, and neural origin tumors.

Chondroma

Chondroid tumors of the larynx are uncommon neoplasms and they are comprised up to 1% of all laryngeal neoplasms. However, they are most common mesenchymal tumors of larynx. Some studies supported that the incidence of malignant chondroid tumors is higher than benign types.[9]

Chondroma and low-grade chondrosarcoma are most common types. These tumors are localized in posterior lamina of cricoids cartilage. Malignant forms generally are seen in old and male patients. The most common symptoms are dyspnea, hoarseness, and compression to the neighbor tissues.

Chondroid tumors of larynx can be easily recognized histologically, because of their characteristic features. But morphologic features must be well known for differential diagnosis between subtypes.

Chondrometaplastic nodules are smaller than 1 cm and multiple. This lesion is characterized by loose of lobular pattern, mucochondroid changes in soft tissue matriks, and well-defined nodules.

Differential diagnosis between chondromas and chondrosarcomas can be difficult. Macroscopically chondromas are smaller than 2 cm (average: 1.5 cm) but chondrosarcomas are generally larger than 3 cm size (average: 4.3 cm). Chondromas are rare mesenchymal tumors of larynx. They are benign lesions but incidence of locally recurrence is very high. Histopathologicly, differential diagnosis of laryngeal chondromas should be planned very carefully. Especially differential diagnosis between chondromas and low-grade chondrosarcomas is important for planning of treatment.

Hemangioma

Hemangiomas are more common in adults than in children but in children, it is more likely to cause obstruction because of venous engorgement due to crying. Hemangioma appears to be hyperdense on plain CT and hyperintense on T2-weighted MRIs.[10] It shows marked enhancement following contrast administration. Phleboliths can be seen.

Other than these, schwannoma and paraganglioma can also occur in larynx, usually in supraglottic location.

Cysts of the Larynx

Laryngocele/saccular cyst arises form saccule, a tubular structure which normally arises from anterior ventricle and extends superiorly into paraglottic region of supraglottic. If saccule enlarges, it results into a submucosal mass known as laryngocele. These are seen as fluid-filled smooth-walled cystic lesion on CT and MRI in paraglottic space of false cord to the level of ventricle.[11] Laryngocele is always benign but can be seen in associated with malignant lesions when the tumor obstructs the outflow of saccule.

Thyroglossal duct cyst is, seen just off the midline against thyroid ala, insinuating between the strap muscles. There can be distinguish from laryngocele, because it has more anterior location and remains outside of the larynx.

Squamous Cell Carcinoma of Larynx

Most laryngeal malignancies are squamous cell carcinoma represent approximately 1% of all cancer diagnosed. Most common risk factors are smoking and alcohol. Patients with laryngeal papilloma, associated with human papilloma virus, have also approximately 2% risk of having malignant transformation into squamous cell carcinoma.

Most of the lesions present early with symptoms of hoarseness of voice or difficulty in breathing and can be easily diagnosed with laryngoscope. Imaging is only required to know the extent of the lesion and for surgical planning.

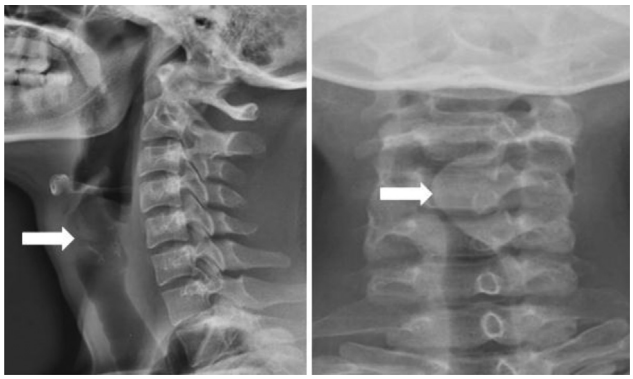

Fig. 18 X-ray cervical spine (AP/lateral) of a 21 years old female shows soft tissue density lesion (arrow) at the level of C4, C5 vertebrae and anterior to tracheal shadow. AP, anteroposterior.

By origin, squamous cell carcinoma are divided into four types: supraglottic, glottic, subglottic, and transglottic (involving two or more spaces; ►**Figs. 18** and **19**).

Supraglottic Carcinoma (30%)

It arises from the epiglottis, aryepiglottic fold, false vocal fold, as well as the deep preepiglottic, and paraglottic space. These lesions do not cause early hoarseness, therefore are discovered in later stages. They may have "HOT POTATO" voice, but hoarseness is only seen when there is involvement of arytenoids cartilage or extension into true cord. Dysphagia and referred otalgia are common presenting complaints. A

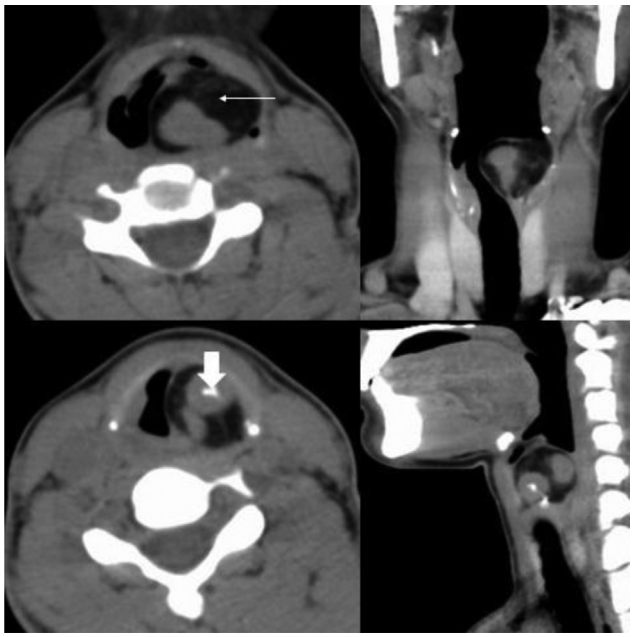

Fig. 19 Axial section on CT scan shows well defined heterogeneous soft tissue density lesion with internal fat (thin arrow) and calcification (thick arrow) along left aryepiglottic fold with effacement of left pyriform sinus. On HPE, it turned out to be Dermoid. CT, computed tomography; HPE, histopathological examination.

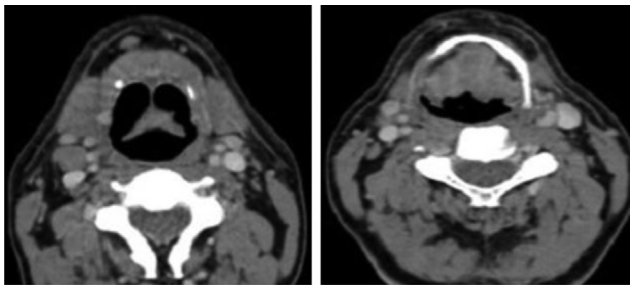

Fig. 20 Supraglottic mass: CT scan of a 56-year-old male in axial view shows heterogeneously enhancing lesion involving epiglottis with preserved preepiglottic fat. CT, computed tomography.

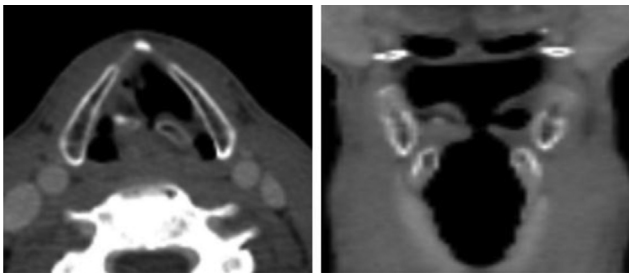

Fig. 21 Glottic mass: CT scan of a 30-year-old male shows polypoidal soft tissue in right vocal cord without extension in to the supraglottic or subglottic region in axial and coronal view. CT, computed tomography.

neck mass due to metastatic adenopathy is a common presenting sign.

Supraglottic lesions are again divided into two categories, suprahyoid and infrahyoid.

The suprahyoid lesions are mostly involving tumors of the free margins of epiglottis. Anteriorly, they spread into vallecula and base of the tongue. Laterally, it extends along pharyngoepiglottic fold to reach lateral wall of pharynx. Anteriorly, the hyoepiglottic ligament acts as barrier to prevent spread of tumor into preepiglottic space[12] (►**Fig. 20**).

Lesions of the infrahyoid epiglottis often shows simultaneous invasion through the thyroepiglottic ligament into the preepiglottic space and ultimately, tumor may spread superiorly within the preepiglottic space, and involve the vallecula and base of the tongue without involving the suprahyoid epiglottis. Cancers of the infrahyoid epiglottis also grow to involve the aryepiglottic folds and the medial wall of the pyriform sinus. Inferolaterally, they grow to reach the false vocal folds and superolaterally extend to the pharyngoepiglottic fold.

On imaging, invasion into preepiglottic fat can be seen easily into CT due to low density of fat and infiltration into high intensity fat on T1-weighted MRIs. In imaging, it is most important to identify inferior extension of the tumor to look for involvement of the ventricle because the resection line of supraglottic laryngectomy is through the ventricle.[13] Ventricles are best seen on coronal sections of larynx and are localized by span of arytenoid cartilage.[14] The upper arytenoid is at the level of false vocal cord and vocal process is at the level of true cord and area in between is the ventricle. If the lesion is seen both above and below the level of ventricle, then it is called transglottic spread. The key imaging feature here is to identify thyroarytenoid muscle. Normally, there is some fat is seen along the superolateral margin of thyroarytenoid muscle.[15] Invading tumor will obliterate this fat and will appear to "pry" the muscle away from thyroid cartilage (this will be best seen on T2-weighted MRI, as the muscle will appear hypointense and tumor will be of hyperintensity).

In the posterior supraglottic larynx, it is important to identify tumor extent in interarytenoid region. Because involvement of this area is considered as a contraindication to supraglottic laryngectomy.

Nodal involvement in supraglottic tumor: the lymphatic drainage of the supraglottic larynx is upper jugular chain (levels II and III). Bilateral involvement is seen if the tumor crosses midline. Deeper tumor extension into the preepiglottic and paraglottic region is generally associated with higher incidence of lymphnodal metastases.

Glottic Carcinoma (65%)

They arise from the true vocal cord. Almost all the tumors present in this region are squamous cell carcinoma. They present in early stage due to hoarseness of voice. It rarely metastasizes due to absence of lymphatic drainage.[16] Glottic squamous cell cancer (SCC) commonly arises from the anterior half of the vocal cord and spreads into the anterior commissure, anterior commissural disease is seen on CT or MRI as soft tissue thickening of more than 1 to 2 mm (►**Figs. 21** and **22**). From the anterior commissure, the tumor may spread further anteriorly into the contralateral cord and the thyroid cartilage or posteriorly into the posterior commissure, the arytenoids, cricoarytenoid joint, and the cricoid cartilage. The tumor may spread superiorly to access the preepiglottic space and the paraglottic space or inferiorly to reach the subglottis, subglottic spreads below the anterior commissure and is seen as an irregular thickening of the cricothyroid membrane, tumor may gain access into the extralaryngeal tissues through the cricothyroid membrane.

Subglottic Carcinoma (5%)

Uncommon as an isolated lesion and usually seen as an extension of glottic tumors, poor prognosis because of early

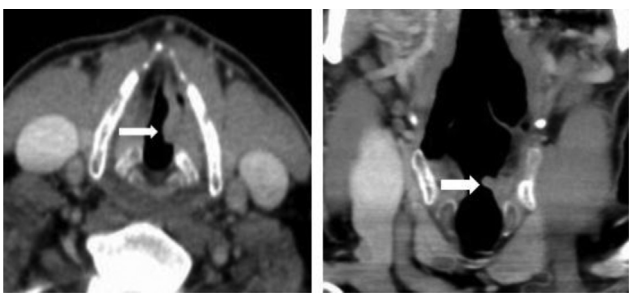

Fig. 22 Glottic mass: CT scan of a 70 years old male patient shows well defined lesion involving left vocal cord in axial and coronal view (white arrow). CT, computed tomography.

nodal metastases and subglottic cancer is diagnosed if any tissue thickening is noted between the airway and the cricoids ring due to their late presentation, invasion of the cricoids cartilage, trachea, and the cervical esophagus with extralaryngeal spread are common findings in these patients at imaging.

Transglottic Squamous Cell Cancer

Laryngeal SCC encroaching on both the glottis and supraglottis, with or without subglottic component and when the site of origin is unclear, is termed as transglottic tumor. This tumor spread is frequently through the paraglottic space and is readily identified on CT or MR imaging, transglottic carcinoma is frequently accompanied by metastatic lymphadenopathy, and coronal images are particularly helpful in assessing transglottic extension of tumor.

Cartilage Involvement in Laryngeal Cancer

Cartilage involvement is more common in glottic and subglottic variety while a tumor confined to supraglottic rarely involves cartilage. Being a radiologist, it is important to identify cartilage invasion because cartilage involvement is considered as a contraindication to radiotherapy and partial laryngectomy. An exception here is involvement of epiglottis and minimal part of arytenoids cartilage.[17] The most reliable sign of cartilage invasion is through and through tumor spread which is visualization of tumor on opposite side of cartilage. Cartilage sclerosis is a reactive phenomenon due to inflammatory reaction by tumor spread to the perichondrium, it does not necessarily indicates cartilage involvement.[18] On MRI images, ossified cartilage appears hyperintense on T1-weighted images. Thus if there is hypointensity of cartilage onT1-weighted image, it indicates either tumor invasion or nonossified cartilage. A T2-weighted image helps here to distinguish them as tumor has intermediate to high signal intensity, while nonossified cartilage appears low signal intensity on T2-weighted image.[18] Other concept to indentify is tumor involving cartilage should follow the signal pattern in soft tissue of larynx (►**Tables 1** and **2**; ►**Figs. 23–30**).[19]

Table 1 Tumor nodal & metastatic staging of laryngeal carcinoma[19]

Primary tumor: supraglottis
• TX: primary tumor cannot be assessed
• Tis: carcinoma in situ
• T1: tumor limited to one subsite of supraglottis with normal vocal cord mobility
• T2: tumor invades mucosa of >1 adjacent subsite of supraglottis or glottis or region outside the supraglottis without fixation of the larynx
• T3: tumor limited to larynx with vocal cord fixation or invades any of the following: postcricoid area, preepiglottic space, paraglottic space or inner cortex of thyroid cartilage
• T4a: moderately advanced local disease: invades through the outer cortex thyroid cartilage or invades tissues beyond the larynx
• T4b: very advanced local disease: invades prevertebral space, encases carotid artery or invades mediastinal structure
Primary tumor: glottis
• TX: primary tumor cannot be assessed
• Tis: carcinoma in situ
• T1: tumor limited to the vocal cord(s) (may involve anterior or posterior commissure) with normal mobility ■ T1a: limited to one vocal cord ■ T1b: involves both vocal cords
• T2: tumor extends to supraglottis or subglottis or with impaired vocal cord mobility
• T3: tumor limited to the larynx with vocal cord fixation or invasion of paraglottic space or inner cortex of the thyroid cartilage
• T4a: moderately advanced local disease: invades through the outer cortex of the thyroid cartilage or invades tissues beyond the larynx
• T4b: very advanced local disease: invades prevertebral space, encases carotid artery or invades mediastinal structures
Primary tumor: subglottis
• TX: primary tumor cannot be assessed
• Tis: carcinoma in situ
• T1: tumor limited to subglottis
• T2: tumor extends to vocal cord with normal or impaired mobility
• T3: tumor limited to larynx with vocal cord fixation or invasion of paraglottic space or inner cortex of the thyroid cartilage
• T4a: moderately advanced local disease: tumor invades cricoid or thyroid cartilage or invades tissues beyond the larynx
• T4b: very advanced local disease: tumor invades prevertebral space, encases carotid artery or invades mediastinal structures

(*Continued*)

Table 1 (*Continued*)

Primary tumor: supraglottis
Pathological lymph nodes
• NX: regional lymph nodes cannot be assessed
• N0: no regional lymph node metastasis
• N1: metastasis in a single ipsilateral lymph node ≤3 cm in greatest dimension and extranodal extension (ENE) -
• N2a: single ipsilateral lymph node ≤3 cm and ENE+ or single ipsilateral lymph node >3 cm but ≤6 cm in greatest dimension and ENE-
• N2b: metastases in multiple ipsilateral lymph nodes, none >6 cm in greatest dimension and ENE−
• N2c: metastases in bilateral or contralateral lymph node(s), none >6 cm in greatest dimension and ENE−
• N3a: metastasis in a lymph node that is >6 cm in greatest dimension and ENE−
• N3b: metastasis in either single ipsilateral lymph node, >3 cm and ENE+ or multiple ipsilateral, contralateral or bilateral lymph nodes, any with ENE+ or single contralateral lymph node of any size and ENE+
Distant metastasis (M)
• M0: no distant metastasis
• M1: distant metastasis

Table 2 AJCC prognostic stage grouping

Stage 0	Tumor in situ	N0	M0
Stage I	T1	N0	M0
Stage II	T2	N0	M0
Stage III	T3	N0	M0
	T1–3	N1	M0
Stage IVA	T4a	N0–1	M0
	T1–4a	N2	M0
Stage IVB	Any T	N3	M0
	T4b	Any N	M0
Stage IVC	Any T	Any N	M1

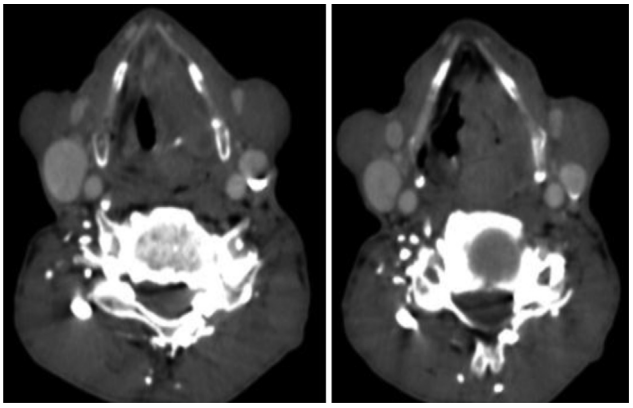

Fig. 24 Glottic carcinoma with supraglottic spread. CT scan of a 56-year-old male shows left vocal cord mass lesion extending in to the supraglottic region in axial view. CT, computed tomography.

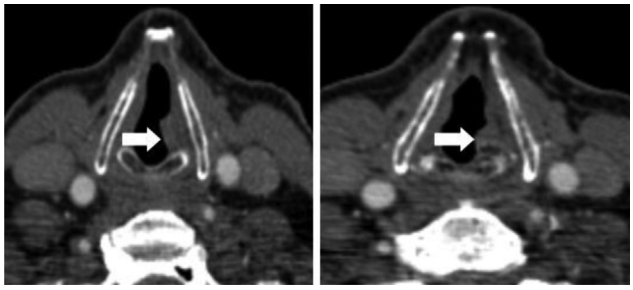

Fig. 23 Glottic mass: CT scan of an 80-year-old male shows a polypoidal soft tissue mass in left vocal cord with extension and abutting the cricoid cartilage on left side in axial view (white arrow). CT, computed tomography.

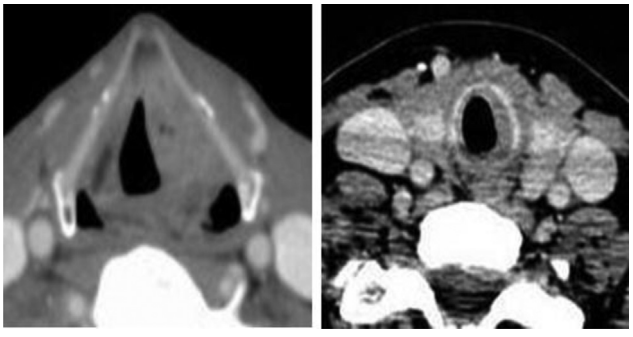

Fig. 25 Glottic carcinoma with subglottic spread. True vocal cord carcinoma with involvement of anterior commissure and extension in subglottic region.

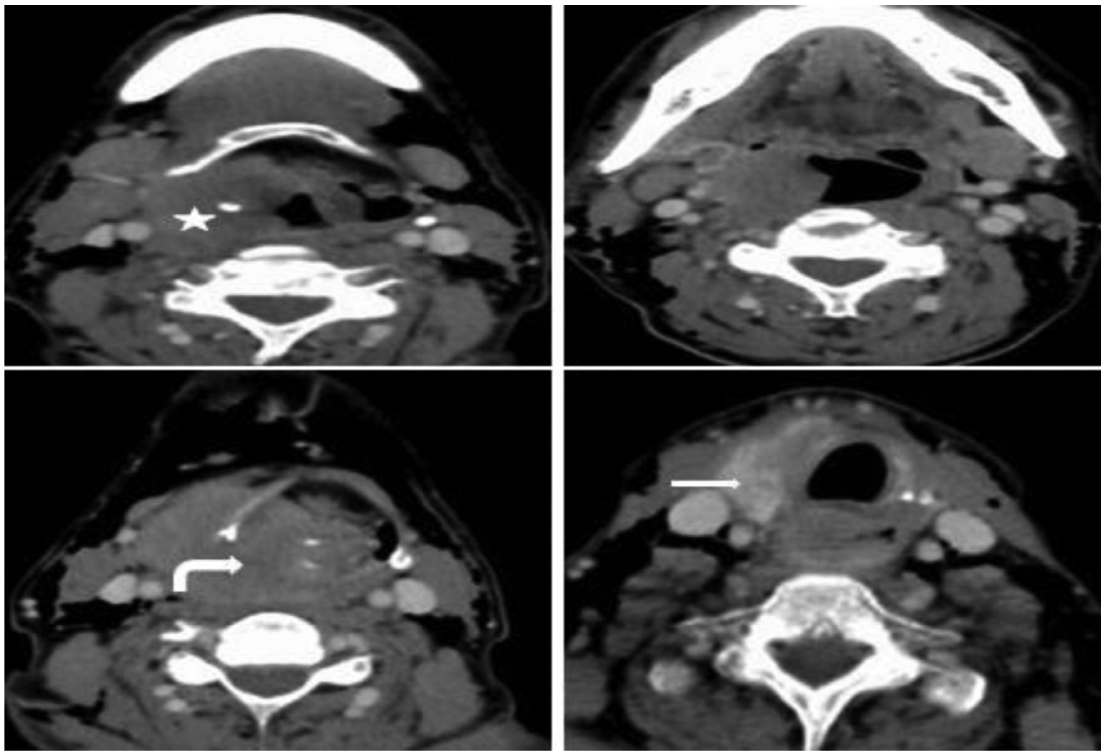

Fig. 26 Contrast axial CT images of larynx showing right parapharyngeal soft tissue mass (*) with supraglottic (curved arrow) and glottic spread (straight arrow). CT, computed tomography.

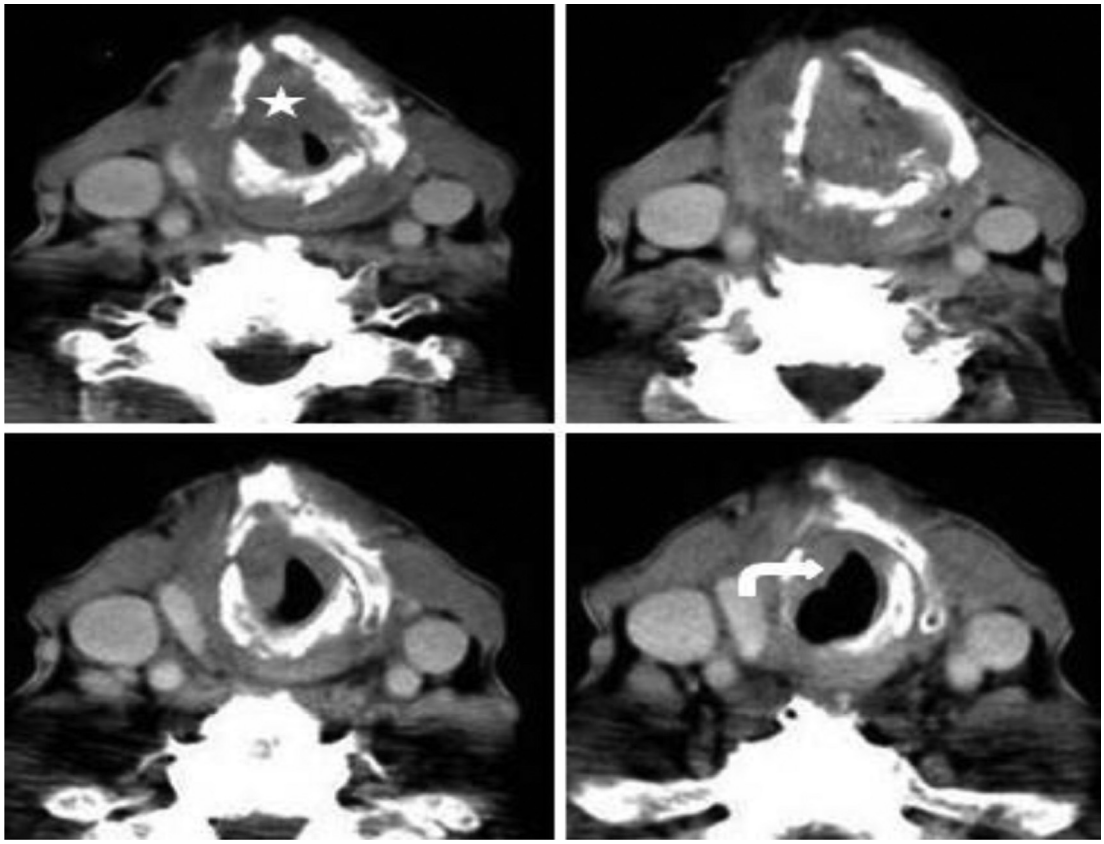

Fig. 27 CT scan on axial view shows heterogeneously enhancing lesion involving both vocal cords and destruction of thyroid cartilage with supraglottic component. CT, computed tomography.

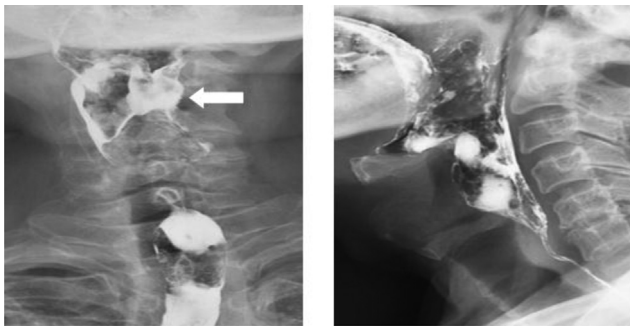

Fig. 28 Barium swallow of a 95-year-old male patient shows non opacification of left pyriform sinus with filling defect (arrow).

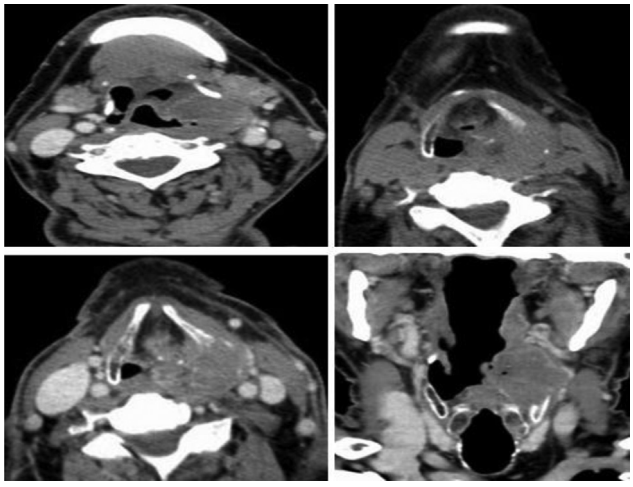

Fig. 29 On CT scan in axial view, soft tissue density lesion noted with few specks of calcifications in left pyriform sinus with adjacent destruction of posterior part of left thyroid cartilage. On coronal view it seems to be extending in glottis and supra glottis region. CT, computed tomography.

Indications of Laryngectomy[20,21]

1. Hemilaryngectomy:
   - No more than 1-cm subglottic extension anteriorly or 5-mm posteriorly.
   - Affected cord but mobile.
   - Minimal anterior contra–lateral cord involvement.
   - No cartilage invasion.
   - No neck soft tissue invasion.
2. Supraglottic laryngectomy:
   - T1, T2 stage masses, or T3 (only if preepiglottic space invasion).
   - Mobile cords.
   - No anterior commissure involvement.
   - Force expiratory volume in 1 second 1 >50%.
   - No tongue base disease beyond circumvallate papillae.
   - Apex of pyriform sinus not involved.

Contraindications to Supraglottic Laryngectomy

- Extension into glottis or impaired vocal cord mobility.

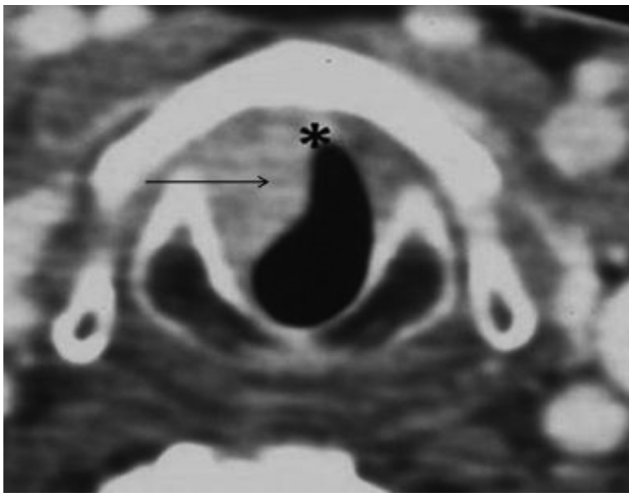

Fig. 30 Subglottic SCC, axial contrast CT image through the subglottis shows a smooth well-defined enhancing mass is seen on the right side (thin black arrow) reaching anteriorly just below the anterior commissure (black asterisk). CT, computed tomography; SCC, squamous cell cancer.

- Fixation of arytenoids cartilage.
- Tumor extension into cricoid or thyroid cartilage.
- Bilateral arytenoids involvement.
- Involvement of the apex of the pyriform sinus or post-cricoid region.
- Involvement of the base of tongue more than 1 cm posterior to circumvallate papillae.

1. Supracricoid laryngectomy: it involves resection of true vocal cords, supraglottis, thyroid cartilage leaving arytenoids, and cricoid ring intact. Half of patients remain dependent on tracheostomy.
   - Indications for the procedure are carcinomas of the glottis that spread beyond the confines of the membranous portion of the true vocal cord or present with limitation of true vocal cord mobility.
2. Total laryngectomy:
   - T3 or T4 stage and unfit for partial laryngectomy.
   - Extensive involvement of thyroid and cricoid cartilages.
   - Invasion of neck soft tissues.
   - Tongue base involvement beyond circumvallate papillae.

Conflict of Interest
None declared.

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