

Computed Tomography Evaluation of Oral Cavity and Oropharyngeal Cancers

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Part 1—Oral Cavity

ABSTRACT

Cross-sectional imaging plays a vital role in the diagnostic evaluation of oral and oropharyngeal cancers. This article discusses important technical issues related to CT scan examination, cross-sectional anatomy, patterns of tumor spread and role of imaging in pretreatment staging and post-treatment surveillance.

Keywords: Computed tomography (CT), Oral cavity, Oropharynx.

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INTRODUCTION

By mapping out the extent of disease, cross-sectional imaging completes the picture given by clinical examination and endoscopy. Thus, imaging plays a vital role in accurate staging, formulating appropriate treatment strategies and prognostication of oral cavity and oropharyngeal cancers. The topic is dealt in two parts.

Cross-sectional Imaging of Oral Cavity and Oropharynx

CT and MRI are complementary in the assessment of oral cavity and oropharyngeal pathologies. CT is readily available and offers faster image acquisition and a better assessment of cortical bone involvement whereas MRI has the advantage of better soft-tissue resolution and is particularly useful for staging oral cavity malignancies that involve the floor of the mouth and complex disease processes that extend through multiple anatomic spaces. Marrow involvement and perineural spread of tumors is also better depicted by MR imaging. Both modalities suffer from artefacts in the setting of dental amalgam; however, an angled gantry may aid the reduction of artefacts with CT.

Advantages of MDCT

One of the limitations in MR imaging is artifacts produced by swallowing-related movement. With multidetector CT, imaging of the oral cavity and pharynx can be performed in a single short breath hold or even with the patient breathing normally. Patient movement artifact is virtually eliminated.

Volume acquisition of data allows image reconstruction in any desired plane.

Examination Technique

Image acquisition is done in the axial plane with 'puffed cheek' (Fig. 1) to separate the buccal and gingival surfaces. Puffed cheek technique requires the patient to blow uniformly through pursed lips while breathing normally. The technique can be improved further by pushing the tongue away from the hard palate.

If the patient has dental amalgams (Fig. 2) or other oral cavity metal products that cause severe artefacts, additional scans should be performed through the region of degraded images with a gantry angulation along the plane of the mandible. All studies should be reconstructed in both soft-tissue and bone algorithms.

Coronal and sagittal reformatted images are essential for structures lying in the axial plane.

Intravenous contrast increases the conspicuity of pathology and is essential for evaluating the cervical lymph nodes.

CT Anatomy of the Oral Cavity¹

Knowledge of Anatomy is Critical to Accurate T Staging

Oral cavity comprises of several subsites, which are the lips, buccal mucosa, upper alveolus with gingiva, lower alveolus



Fig. 1: Coronal computed tomography image showing normal anatomy of oral cavity with puffed cheek: tongue (star), upper and lower gingivobuccal sulci (thin arrows), hard palate (block arrow) and buccal mucosa (curved arrow)

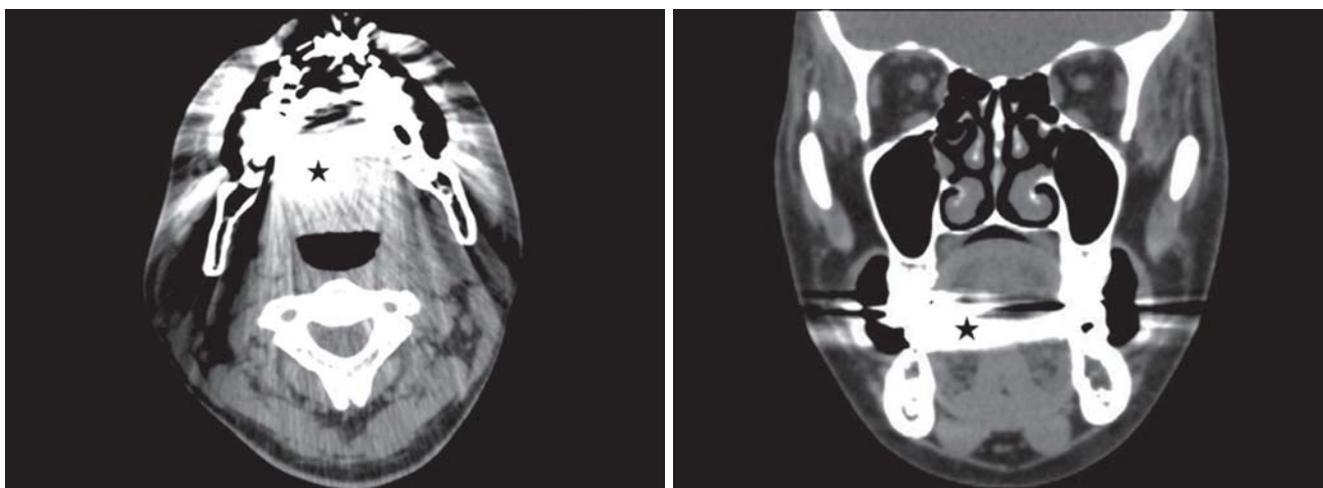


Fig. 2: Dense streak artefacts (stars) caused by dental amalgam

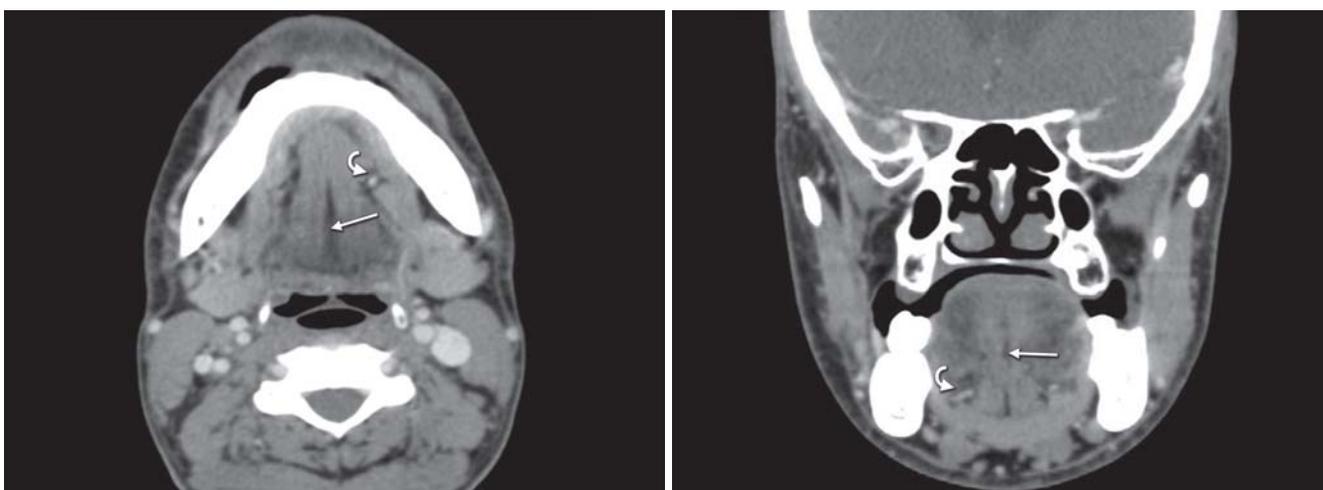
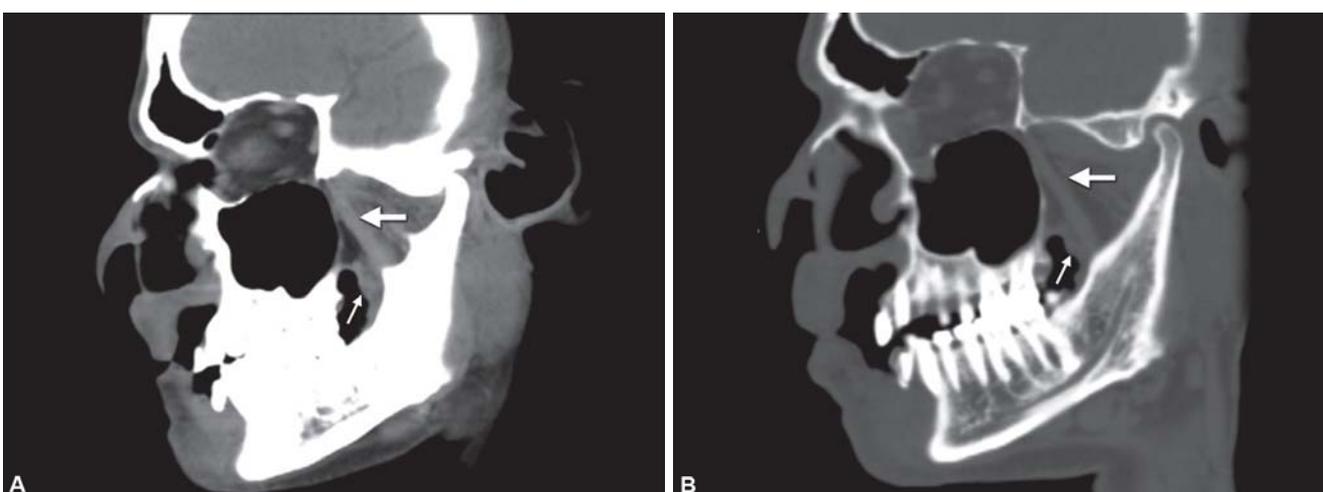


Fig. 3: Axial and coronal images showing the anatomy of oral tongue and sublingual space: midline septum (thin arrows), fat containing sublingual space with the lingual neurovascular bundle (curve arrows)



Figs 4A and B: Oblique reformatted images displaying the anatomy of retromolar trigone. The retromolar trigone (thin arrow) is a triangle-shaped area of mucosa (thin arrow) posterior to the last mandibular molar. (A) Bone window of the same region is shown in (B). The tendency of squamous cell cancers in the RMT to invade the bone and infiltrate the infratemporal fossa (block arrows) is easily understandable from these images

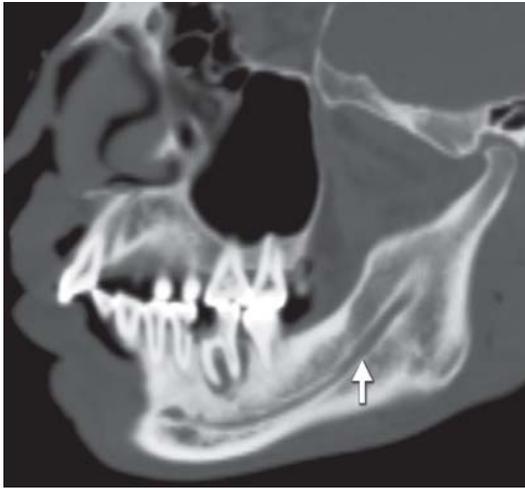


Fig. 5: Oblique reformatted image showing the inferior alveolar nerve canal (block arrow)

with gingiva, retromolar trigone (RMT), oral tongue (anterior two-thirds), floor of mouth and hard palate (Figs 1 and 3).

RMT is a triangle-shaped area of mucosa posterior to the last mandibular molar that covers the anterior surface of the lower ascending ramus of the mandible (Figs 4A and B).

Lateral to the buccal mucosa is the buccal space which is bounded by the buccinator medially and the zygomaticus major laterally while the masseter is located posteriorly. It consists of the buccal fat, vessels, nerves, the terminal part of the Stensen’s duct and the facial node.

The oral tongue located in the central part of the oral cavity is formed by the anterior two-thirds of the tongue up to the circumvallate papillae. The midline lingual septum (Fig. 3) divides the tongue into equal halves, consisting of the intrinsic and extrinsic muscles. These muscles are difficult to appreciate on CT, but are well seen on MR imaging.

The floor of the mouth (FOM) is formed primarily by the mylohyoid which is best seen on coronal planes on CT

and MR imaging. Two other muscles, geniohyoid and anterior bellies of digastric support the FOM. The submandibular gland is located inferior to the mylohyoid. The deep lobe of the submandibular gland wraps around the posterior free border of mylohyoid to lie on the superior surface of the mylohyoid. However, surgically the FOM is the space between the mucous membrane of the FOM and the mylohyoid.

The sublingual space (Fig. 3) is seen superomedial to the mylohyoid and lateral to the genioglossus. It is a fat-filled space and contains the sublingual gland, deep part of submandibular gland, Wharton’s duct, lingual neurovascular bundle and the anterior fibers of hyoglossus. On CT it appears as a low density plane.

The inferior alveolar canal running through the ramus and body of mandible contains the nerve by the same name (Fig. 5).

Imaging of Oral Cancers¹⁻³

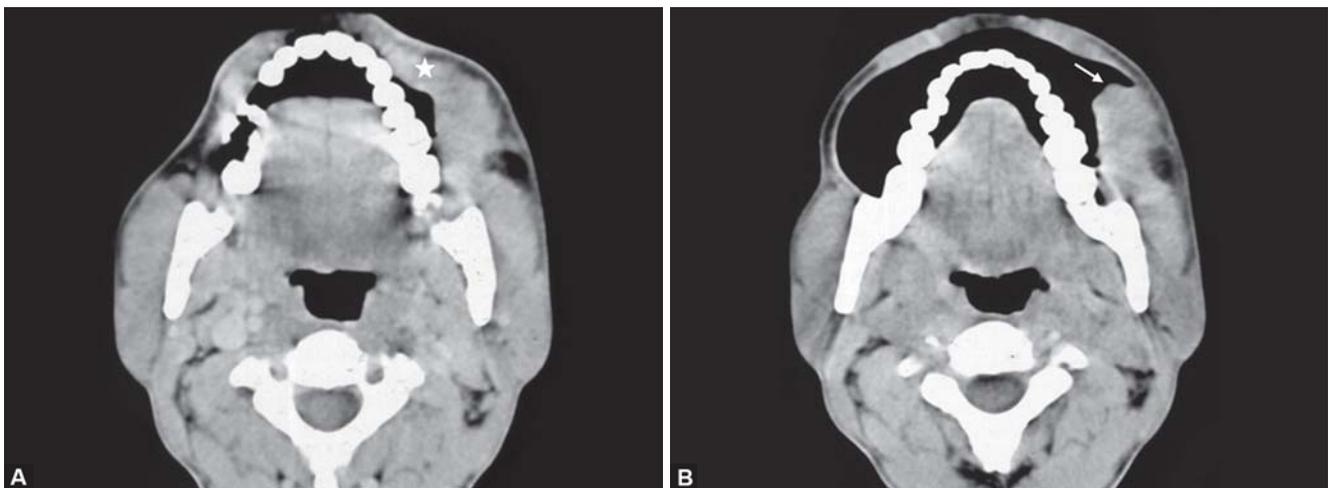
Squamous cancers of the gingivobuccal region, oral tongue and retromolar trigone are the common oral cancers in our country. SCC of the lower gingivobuccal complex due to tobacco chewing has been described as the ‘Indian oral cancer’.

Gingivobuccal and Retromolar Trigone SCC

Important issues in gingivobuccal and RMT SCC that have an impact on management and prognosis are soft tissue spread, bone erosion and nodal involvement.²

Soft Tissue Extension

Gingivobuccal SCC (Figs 6 to 8) can spread laterally into the overlying buccal and subcutaneous fat up to the skin, superiorly into the maxillary sinus, medially erode the mandible and extend across into the lingual musculature all of which are defined as stage T4a. They can extend



Figs 6A and B: Utility of puffed cheek technique is well illustrated in this example. Axial scan obtained without puffed cheek (A) overestimates the anterior extent (star) of the left buccal mucosa mass. The true anterior extent of the mass (thin arrow) is demonstrated in (B)

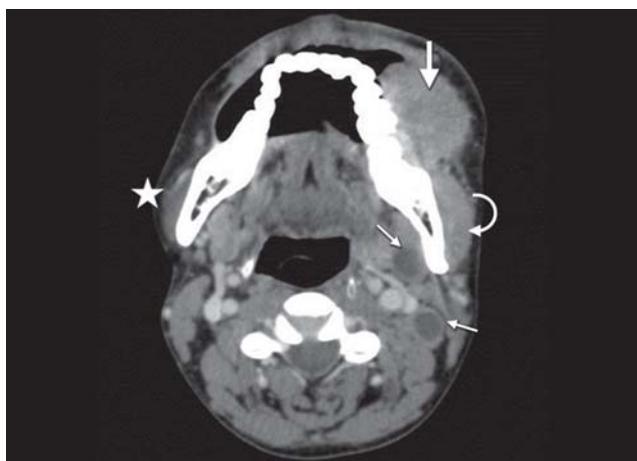
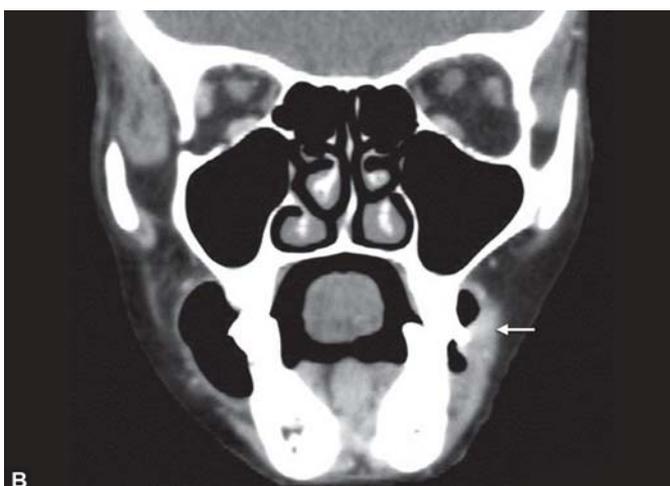
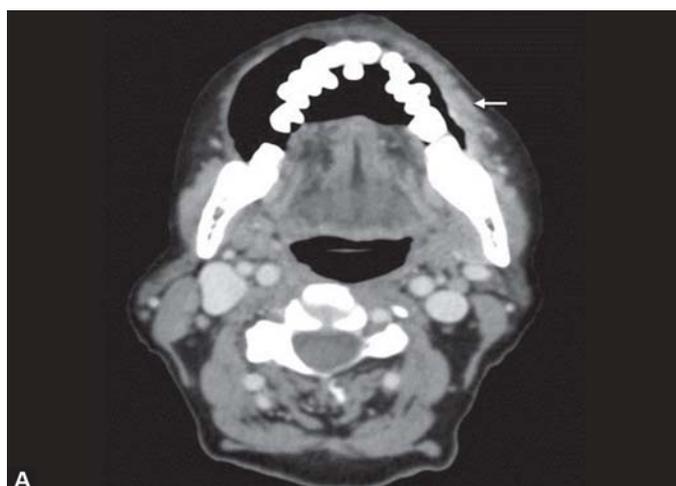


Fig. 7: Axial scan of a bulky left buccal mucosa tumor infiltrating the buccomasseteric space (block arrow). Observe the difference in thickness and enhancement of left masseter muscle (curved arrow) compared to the normal side (star). Necrotic left level 2 nodes (thin arrows) are also observed

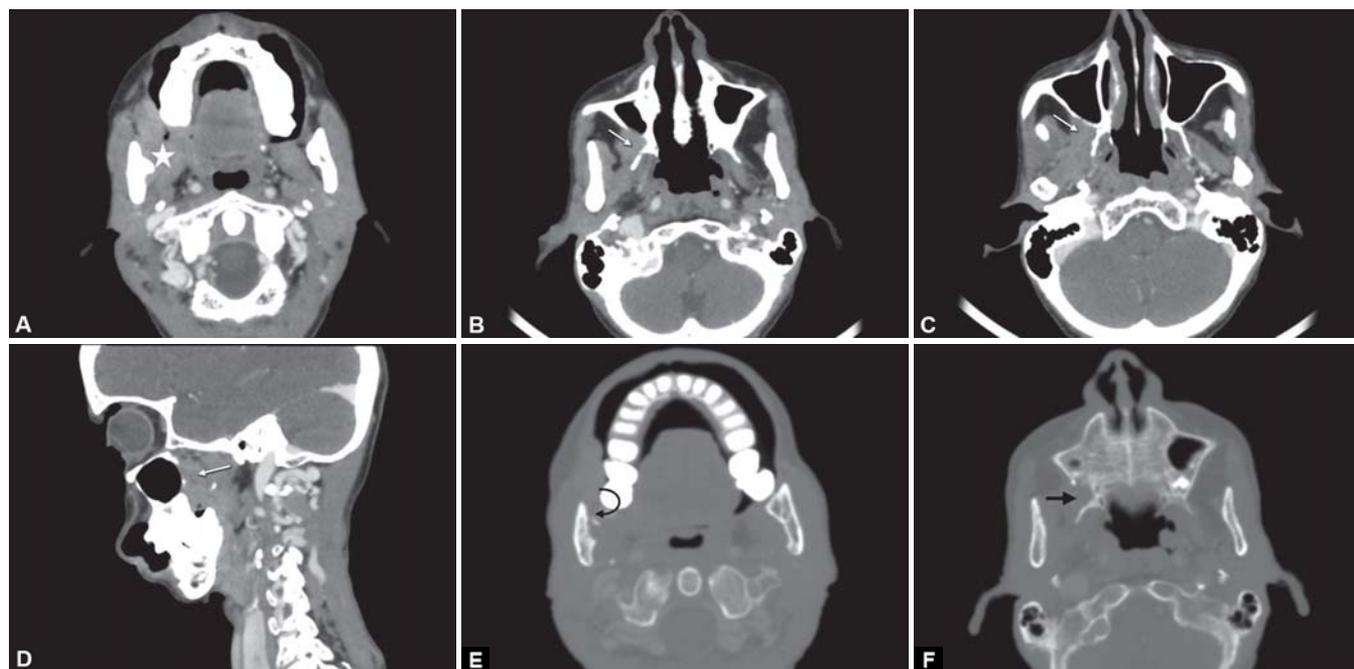
anteriorly into the lips and occasionally spread perineurally through the mental foramen. Postero-superior spread into the masticator space is classified as T4b (Figs 9A to F).

It is important to precisely convey the craniocaudal extent of disease spread. Spread of disease into the upper part of the masticator space closer to skull base has poor prognosis. The mandibular notch between the coronoid and condyloid process is used as a line of demarcation and the masticator space is classified as high (supranotch) and low (infranotch). Disease involving low masticator space has favorable surgical outcomes and most clinicians prefer to operate this group.

Perineural spread through the foramen ovale may occur and causes foraminal widening on CT. Perineural spread is, however, best imaged on MRI.



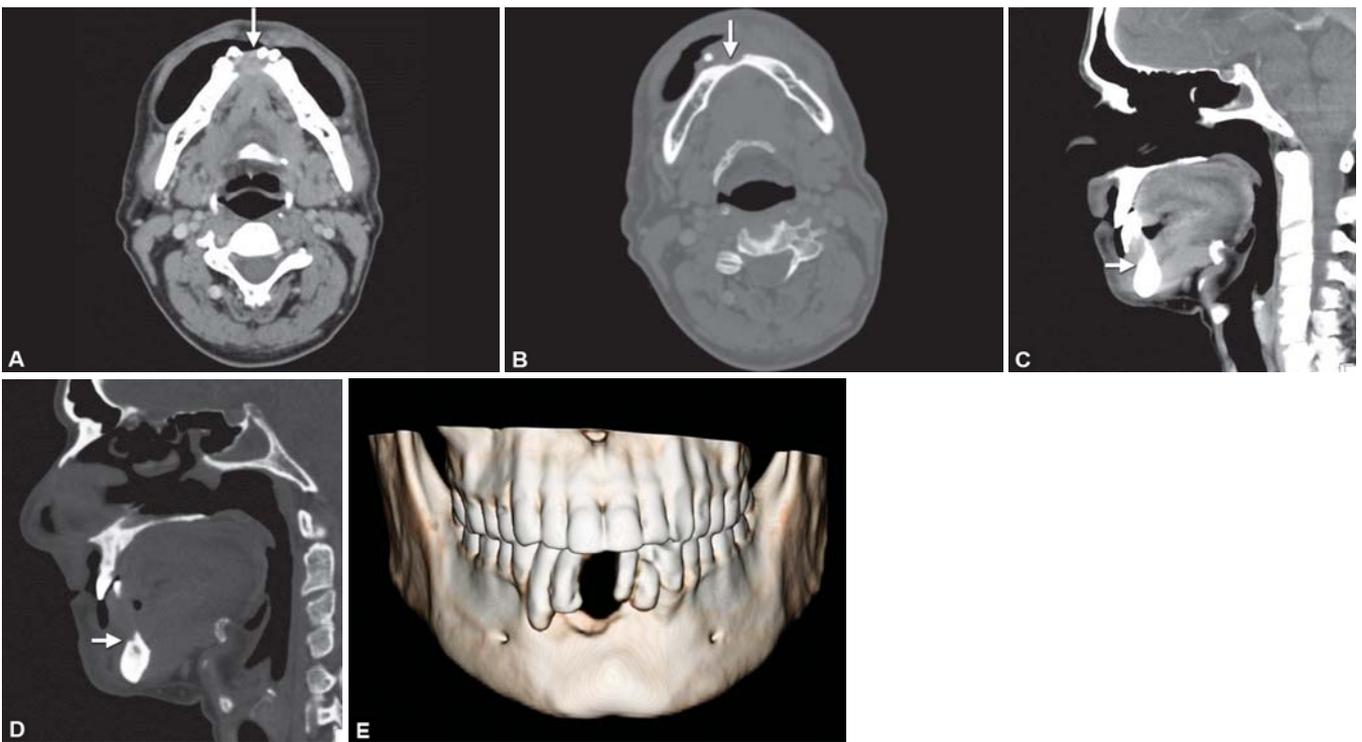
Figs 8A and B: Axial (A) and coronal (B) images of left buccal mucosa malignancy involving the lower gingivobuccal sulcus (arrows)



Figs 9A to F: Axial (A to C) and oblique images (D) of right retromolar SCC (star) infiltrating the high infratemporal fossa (thin arrows). Bone windows (E and F) show mandibular (curved arrow) and maxillary (block arrow) bone destruction



Figs 10A to C: Axial and coronal soft tissue and coronal bone images of a lower alveolar squamous cell carcinoma (block arrows) with gross bone destruction (curved arrow). Tumor is also involving the floor of mouth (thin arrows)



Figs 11A to E: Case of midline lower alveolar SCC destroying the bone (block arrows) in axial (A and B), sagittal (C and D) and 3D bone reconstruction (E) images. This ability to display the anatomic information in the form that the surgeon desires to see is one of the significant advancements given by MDCT technology

Bone Invasion (Figs 10 and 11)

In evaluating bone invasion, CT scan has highest specificity compared to all other imaging modalities.³ Bone erosion, marrow infiltration and involvement of inferior alveolar canal can be identified. Three-dimensional images provided by MDCT are valuable in planning bone resections and reconstructive surgeries.

Tongue and Floor of Mouth SCC (Fig. 12)

Majority of oral tongue cancers arise from the lateral border with few from the ventral surface.

Imaging findings which have a significant impact on management are the following:

- Tumor thickness
- Extension to the extrinsic muscles of neurovascular bundle

- Invasion of the FOM and base tongue
- Extension of primary tumor up to or across the midline
- Extension to valleculae, pre-epiglottic space and hyoid bone.

MRI is the modality of choice because it can depict intrinsic and extrinsic muscles, the FOM and the lingual vascular bundle. CT has insufficient soft tissue characterization and is frequently hampered by dental artifacts.

Bone erosion can occur in tongue SCC extending to FOM or primary FOM cancers although seen less frequently than in buccal cancers.

Neck Node Metastases²

Lymphatic dissemination is most accurately assessed with imaging. In cases of SCC within the oral cavity, the level I



Fig. 12: Coronal CT image showing a SCC of the right dorsal tongue (curved arrow). Vertical extent of spread (thin arrows) as well as extension across the midline (block arrow) can be evaluated

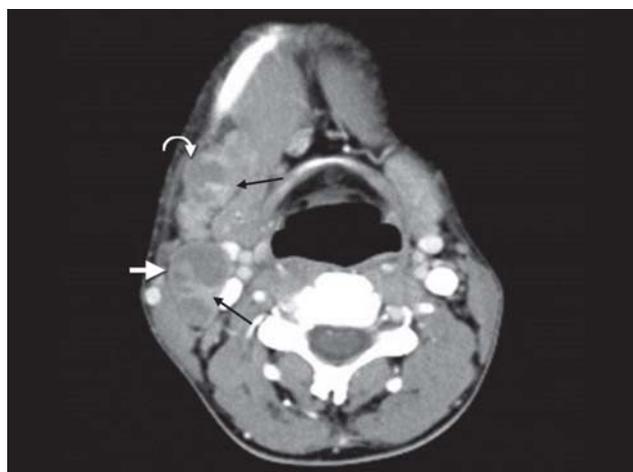
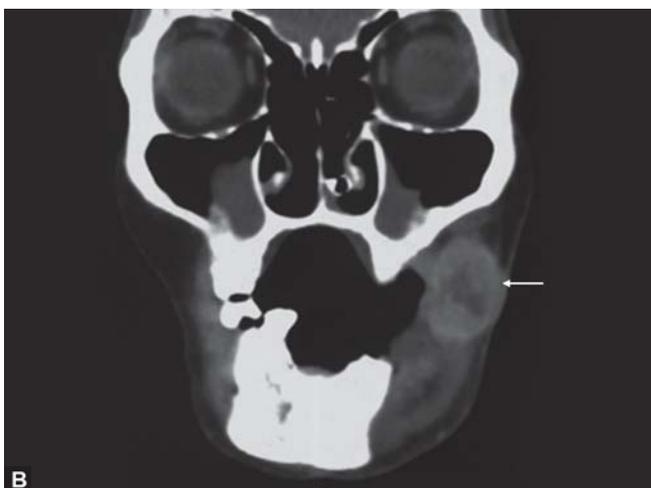


Fig. 13: Presence of central necrosis is the hallmark of metastatic nodes. Thickened enhancing rim (thin arrows) of right level 1b (curved arrow) and level 2 (block arrow) nodes is highly predictive of extracapsular spread



Figs 14A and B: In this case, the metastatic left level 1b nodal mass has infiltrated the submandibular gland. Both superficial and deep lobes have been infiltrated as seen on the coronal (A) and sagittal (B) images



Figs 15A and B: Nodular enhancing mass (thin arrows) seen within the flap (star) on axial (A) and coronal (B) images represents tumor recurrence. There was no mucosal lesion seen on clinical examination

and II lymph nodes are often the first to be involved. In tongue cancers, skip metastases with to level III and IV and to contralateral I and II levels are also known.

Reported sensitivity of CT scan for assessing neck node metastases varies from 55 to 95% and specificity is reported to vary from 39 to 96%.

Two major imaging criteria are nodal size and presence of central necrosis. Regardless of lymph node size, the most reliable imaging finding of metastatic disease is the presence of nodal necrosis (Fig. 13).

For non-necrotic homogeneous nodes, various size criteria using maximum longitudinal diameter and minimum axial diameters have been specified, but false-positive and false-negative rates of 15 to 20% are still seen as metastasis can occur in subcentimeter nodes. The usual size criterion is a maximal longitudinal diameter of more than 15 mm for jugulodigastric lymph nodes and more than 10 mm for other nodes (except retropharyngeal lymph nodes, which are considered pathologic at a diameter of more than 8 mm). However, if the minimal axial diameter is the parameter measured, a size of 11 mm for jugulodigastric (level II) nodes and 10 mm for other nodes is considered indicative of abnormality. The latter criterion changes to more than 8 or 9 mm when more than three enlarged nodes are seen in the same lymphatic drainage area.

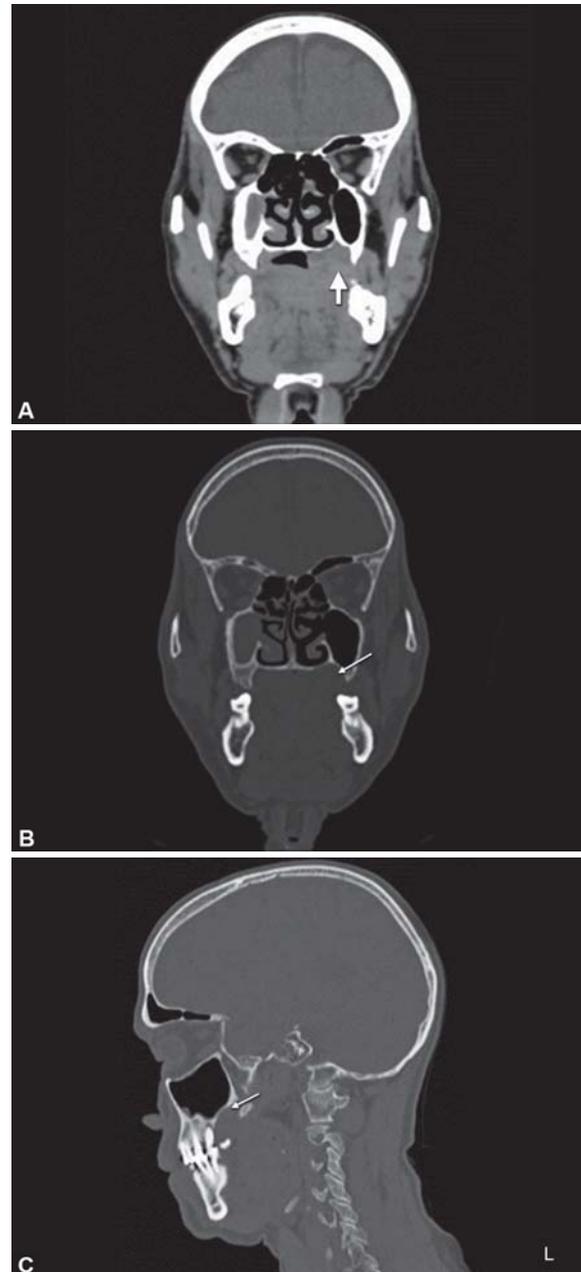
Extranodal tumor extension (macroscopic extracapsular tumor spread) is identified on contrast CT as an enhancing often thickened nodal rim, usually with infiltration of the adjacent fat planes (Figs 13 and 14). Risk of recurrence is ten-times greater in these patients. It has been observed that extranodal spread overall is less reliably identified on MR than on CT, especially when present to only a minimal degree. It may be that the low attenuation of fat is the best background to identify such early nodal changes.

Arterial encasement is a grave prognostic finding. From an oncologic view point, invasion of adventitia is as important as greater degree of arterial invasion. As microscopic adventitial tumor infiltration is beyond the scope of current imaging detection, best one can do is to describe the degree of artery's circumference that is potentially involved by tumor.

In general, greater the tumor extension around the artery, the more likely it is that the artery is involved. When more than 270° of artery circumference is surrounded by tumor, it is very likely that arterial wall is invaded.

Role of CT Scan in Post-treatment Disease Surveillance

Imaging plays a key role in the surveillance of postoperative head and neck malignancies. Postoperative and



Figs 16A to C: A case of minor salivary gland tumor of the mucosa overlying hard palate. Coronal soft tissue image (A) shows a nodular lesion in the left side of hard palate (block arrow). Coronal (B) and sagittal (C) bone windows show erosion of the underlying bone (thin arrows)



Fig. 17: Coronal CT image shows a cystic intraoral lesion (curved arrow) extending into submandibular space (thin arrow)—plunging ranula



Figs 18A to C: Axial (A), coronal (B) and sagittal (C) images showing inflammatory air-containing collection in the submandibular space (curved arrow), floor of mouth (star), soft palate (block arrow) and left parapharyngeal space (thin arrow)

post-irradiation necks are often difficult to examine clinically because of the bulky tissue of the flaps and postradiation thickening of skin and subcutaneous tissues. CT scan can easily detect recurrence in flaps where clinical examination is greatly hindered by the bulkiness of the flap tissue (Figs 15A and B).

Nonmalignant pathologies of oral region (Figs 16 to 18) include congenital lesions (like lingual thyroid and thyroglossal duct cysts, dermoid, vascular and lymphatic malformations), inflammatory pathologies, retention cysts of the sublingual or minor salivary glands (ranula) and benign neoplasms (minor salivary gland tumors of the hard palate) and jaw lesions.

Part II—Oropharynx

IMAGING ANATOMY OF OROPHARYNX

The oropharynx is the part of the pharynx that is posterior to the oral cavity, between the nasopharynx superiorly and the hypopharynx inferiorly.

The junctions between the hard palate and soft palate, the oral tongue and base of the tongue, and the floor of the mouth and tonsil are the demarcation between oral cavity and oropharynx. The demarcation between the nasopharynx and oropharynx is the plane of the soft palate. The plane of the hyoid bone and pharyngoepiglottic fold separates the oropharynx and hypopharynx.^{1,2}

Contents of the oropharynx include the base of the tongue, the valleculae, the soft palate and uvula, the lateral pharyngeal walls including the palatine tonsils and tonsillar pillars, and the posterior pharyngeal wall (Figs 19A to C).

OROPHARYNGEAL MALIGNANCIES

The majority of tumors involving the oropharynx are squamous cell carcinomas.⁴ The tonsil and tongue base are the most common sites of origin of oropharyngeal squamous cell carcinomas. SCC of the oral cavity and oropharynx may spread in three general ways:

- By direct extension over mucosal surfaces, muscle and bone
- By dissemination via lymphatic drainage pathways and
- By extension along neurovascular bundles.

For accurate staging, evaluation of these three routes of spread is mandatory.²

As the spread patterns and lymphatic drainage vary with the site of origin, tumors arising in the anterior tonsillar pillar, posterior tonsillar pillar, tonsillar fossa, soft palate and tongue base need to be discussed individually.⁴

Anterior Tonsillar Pillar

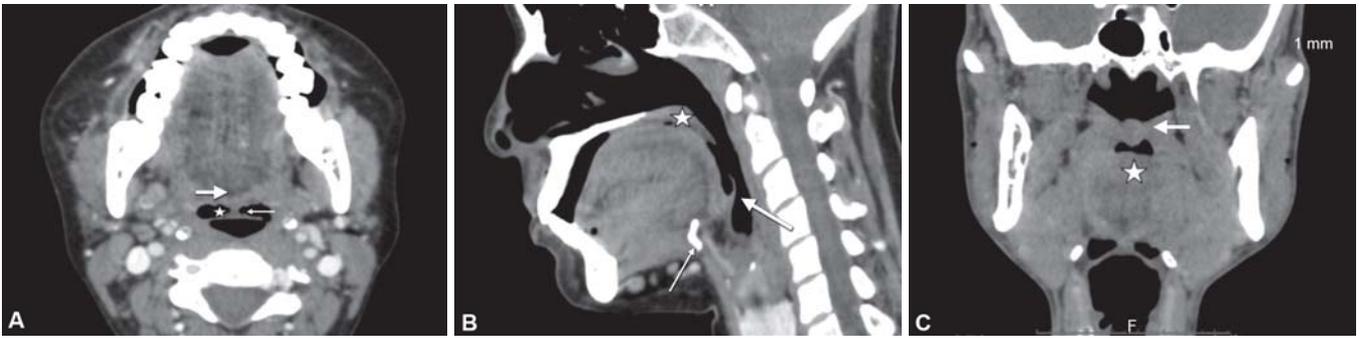
The anterior tonsillar pillar (ATP) is a mucosal fold over the palatoglossus muscle, and tumors arising on the ATP tend to spread along this muscle and its fascial attachments. Thus, tumors may extend superiorly to involve both the soft and hard palates. From the palate, the tumor may continue to extend superiorly along the tensor and levator veli palatini muscles and the pterygoid muscles to the skull base.

Anteriorly and medially, ATP lesions may also spread along the superior constrictor muscle to the pterygomandibular raphe and from there to the buccinator muscle.

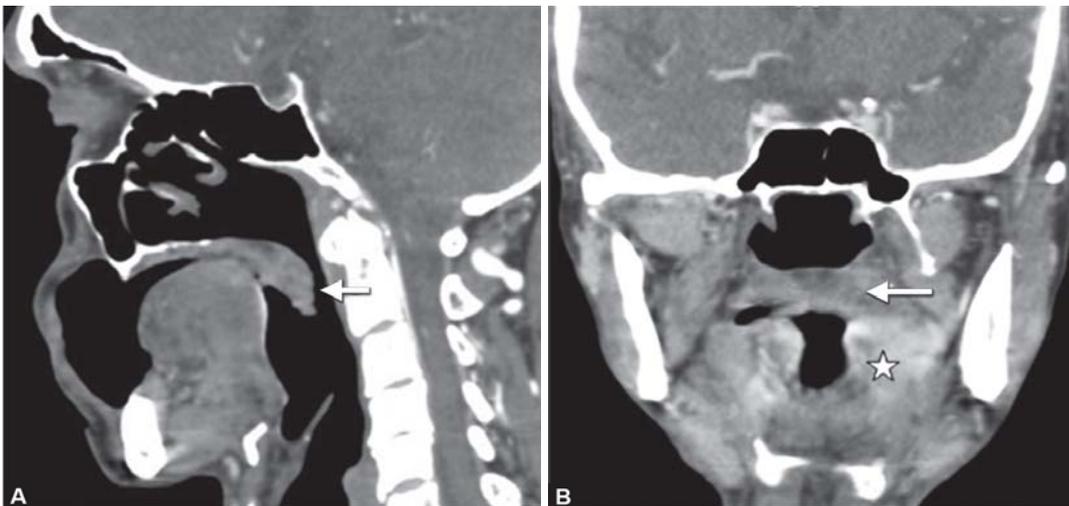
Tongue base invasion may also be present in large lesions and is most likely a result of inferior tumor growth along the palatoglossus muscle.

Posterior Tonsillar Pillar

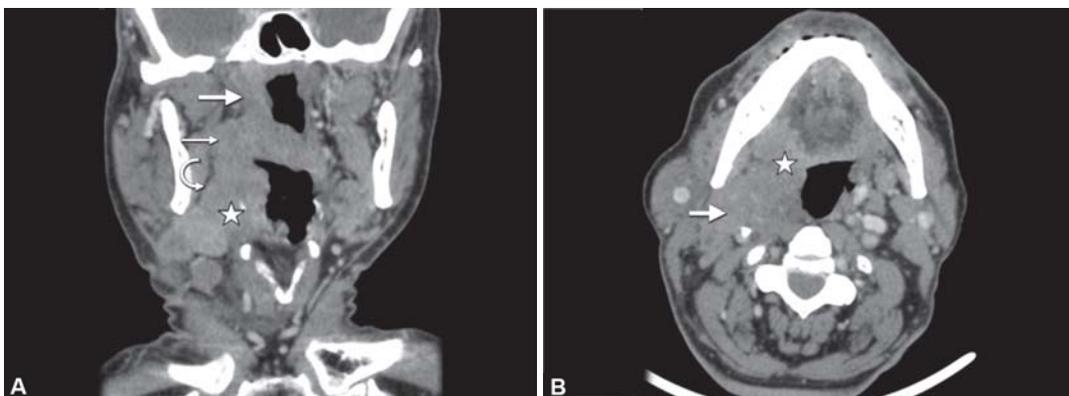
The posterior tonsillar pillar (PTP) is a mucosal fold over the palatopharyngeus muscle. Isolated PTP lesions are rare, and when present are usually small. PTP lesions may spread along the course of the palatopharyngeus muscle, and superior extension may involve the soft palate, while inferior growth may involve the posterior aspect of the thyroid



Figs 19A to C: Normal anatomy of the oropharynx. (A) Axial image demonstrates the base of the tongue (block arrow) with the valleculae (star) being the air space anterior to the epiglottis and posterior to the base of the tongue. The valleculae is split in the center by the median glossoepiglottic fold (thin arrow), (B) mid sagittal image showing the boundaries of the oropharynx. Soft palate (star) and the hyoid bone (block arrow) mark the superior and inferior extent of the oropharynx. Epiglottis (thick arrow), (C) coronal image shows the base of tongue (star) and soft palate (block arrow)



Figs 20A and B: Carcinoma of the left tonsillar region and soft palate. (A) Sagittal image shows thickening and enhancement of the soft palate (arrow), (B) coronal image shows enhancing mass in the left tonsillar area (star) and soft palate thickening (arrow)



Figs 21A and B: (A) Coronal image showing involvement of the lateral oropharyngeal wall (star) and soft palate (thin arrow) extending into the nasopharynx (thick arrow). The parapharyngeal is uninvolved and is shown by the curved arrow; (B) Axial image shows involvement of right lateral oropharyngeal wall, base of tongue (star) and ipsilateral level 2 lymph node mass (thick arrow)

cartilage, the middle pharyngeal constrictor and the pharyngoepiglottic fold.

Tonsillar Fossa (Figs 20A and B to 22A to C)

Tumors in this location often are clinically occult and present with cervical nodal metastases without an obvious

primary tumor. These lesions may spread anteriorly or posteriorly to involve the adjacent tonsillar pillars, thereby acquiring the potential spread patterns associated with these sites. These lesions may also extend deeply and invade the superior constrictor muscle, thus gaining access to the parapharyngeal space and skull base.

Soft Palate (Figs 23A to C)

The majority of soft palate malignancies are SCCA; however, minor salivary gland cancers also have their highest frequency in the posterior hard palate and soft palate.

Carcinomas of the palate usually affect the oral aspect, tend to be well differentiated, and have the best prognosis of all of the oropharyngeal carcinomas. The nasopharyngeal side of the soft palate is rarely involved, even when the tumors are extensive. Although tumor extension of palatal cancer

can occur in any direction, the tonsillar pillars and hard palate are usually affected first. Deep lateral invasion occurs along the levator or tensor veli palatini muscles and into the parapharyngeal space, nasopharynx and base of the skull.

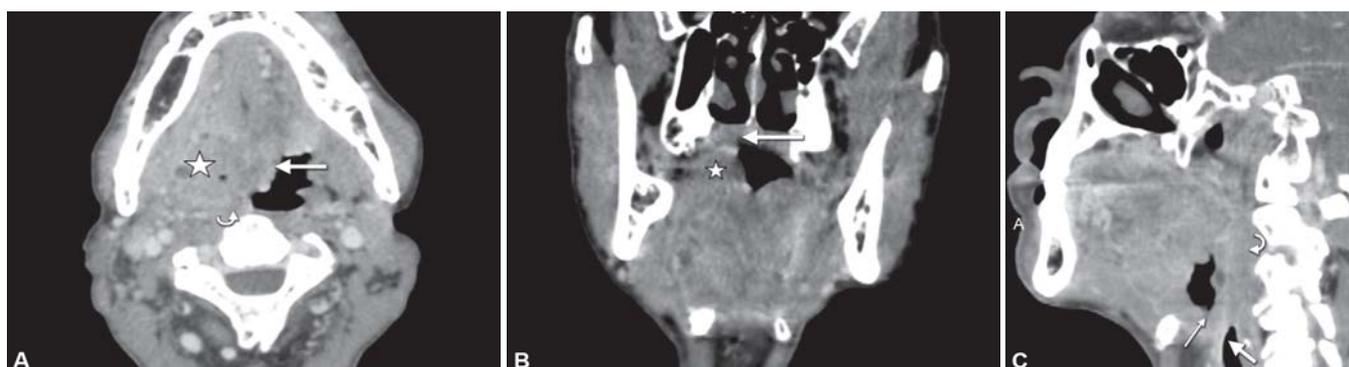
Tumor extension up the greater and lesser palatine nerves can also occur, allowing spread into the pterygopalatine fossa and then via the foramen rotundum to the cavernous sinus.



Figs 22A to C: Carcinoma of left tonsil spreading to the nasopharynx with skull base involvement. (A) Axial image shows enhancing mass in the left lateral oropharyngeal wall with retropharyngeal lymphadenopathy (star), (B) the coronal reformatted image demonstrates the mass in the left half oropharynx (star) with superior extent of the growth into the left half of nasopharynx (thick arrow), (C) coronal image in bone windows reveals erosion of the body and greater wing sphenoid (thick arrow) due to adjacent tumor. Sclerosis and thickening of these bones are also observed



Figs 23A to C: Mass in right pharyngeal mucosal space/tonsil and adjacent soft palate. (A) Axial image shows mass in the right pharyngeal mucosal space (star), (B) axial image at a cranial level shows superior extension of the mass (star), (C) coronal image shows infiltration of right parapharyngeal fat (double arrows). Pterygoid muscles are marked with thick arrow. The left parapharyngeal space is shown by curved arrow for comparison. The mass was submucosal in location (star) with intact overlying mucosa (thin arrows) on endoscopy. Possibilities include minor salivary gland tumor, lymphoma or mesenchymal tumor



Figs 24A to C: Carcinoma of base of tongue across the midline and involving the soft palate, epiglottis and posterior pharyngeal wall. (A) Axial image shows heterogeneously enhancing soft tissue in the right half of base of tongue (star), extending across the midline (arrow). Posterior pharyngeal wall extension is also seen (curved arrow), (B) coronal image shows an enhancing mass in the base of tongue (star) on the right side extending to the soft palate (arrow), (C) parasagittal image shows extension of the mass into vallecula (thin arrow), epiglottis (thick arrow) and posterior pharyngeal wall (curved arrow)

Base of the Tongue (Figs 24A to C)

Tongue base carcinomas are often clinically silent. Because of this, these lesions often have progressed to an advanced stage at the time of initial presentation.

Imaging detection of subtle lesions in this area is difficult on CT because this region consists mostly of dense tongue musculature and minimal fat planes.

Malignancies of the tongue base often are limited to one side of the tongue, crossing the midline only when the tumor becomes large. These tumors may also spread to the tonsillar pillar, pharyngeal wall, anteriorly into the sublingual space, and submucosally under the valleculae into the supraglottic larynx.

Lesions may also grow inferiorly and laterally to spread into the deep soft tissues of the neck, eventually involving the styloid musculature and the internal carotid artery.

IMPORTANT ISSUES IN DIRECT TUMOR INFILTRATION OF ADJACENT TISSUES¹

Bone Invasion

The most commonly affected bones are the mandible and the maxilla. The presence of osseous involvement is indicative of a T4 lesion. CT findings of osseous involvement include cortical erosion adjacent to the primary lesion, aggressive periosteal reaction, abnormal attenuation in bone marrow and pathologic fractures.

Pterygopalatine Fossa Invasion

Extension to the pterygopalatine fossa or to other avenues of the fifth cranial nerve raises the possibility of perineural spread of the cancer to the skull base.

MR imaging is superior to CT in showing abnormal enlargement and enhancement of the nerve. Foraminal enlargement is a reliable finding on CT. If one sees infiltration of the fat of the pterygopalatine fossa, atrophy of the muscles innervated by the trigeminal nerve, or abnormal enhancement in Meckel's cave on CT, perineural invasion is implied. Perineural spread of tumor may be antegrade or retrograde and may show skip lesions on imaging.

Bilateral or Deep Invasion of the Tongue Base

Nowhere else in the head and neck is bilaterality of disease more important with respect to patient quality of life. With base of tongue cancers, the difference between a hemiglossectomy and total glossectomy is critical to a patient's quality of life.

If the midline of the base of the tongue has been violated to any significant degree by cancer, the possibility of having

a complete resection with adequate margins while maintaining a functioning tongue is remote. Therefore, a total glossectomy is often recommended.

MRI is superior to CT scan in determining the extent of tumor within the tongue.

Prevertebral Muscle Invasion

If a cancer is fixed to the prevertebral musculature the patient is deemed unresectable. Although the imaging findings of obliteration of the retropharyngeal fat stripe, contrast enhancement of the muscles or nodular infiltration of the muscles are suggestive of neoplastic infiltration, these findings have not been very reliable.

PERINEURAL SPREAD

Because perineural invasion is often clinically silent and cannot be detected at physical examination, it is particularly important that the radiologist be alert to this possibility. Perineural spread is more common in subsites such as the floor of the mouth, where the neurovascular bundles are particularly accessible. Perineural invasion is thought to be characteristic of aggressive SCCs.

Imaging features of perineural spread include foraminal enlargement and replacement of normal fat within the neural foramen. The nerve may appear enlarged on contrast-enhanced MR images, a change that cannot be seen on CT images.

LYMPHATIC SPREAD

Nodal drainage of the oropharynx is to the submandibular chain (level 1) and the high jugular (levels 2 and 3) chains. One might also see retropharyngeal lymph nodes with more superior oropharyngeal carcinomas or advanced disease. The palatine tonsil can also drain to the parotid nodes.

The tongue base has a rich lymphatic network with a significant amount of cross-drainage, which is why nearly 30% of patients have bilateral cervical metastases at initial presentation. The primary lymphatic drainage is to levels II to IV nodes, with occasional involvement of level V nodes. Tumor spread to the floor of the mouth may also involve level I nodes.

The imaging assessment of cervical lymphadenopathy has been discussed in detail in the section on oral cavity.

OTHER NEOPLASMS

Lymphomas may occur in the lymphoid tissue of the base of the tongue or tonsil and may simulate proliferative lymphoid hyperplasia. The coexistence of large lymphadenopathy and systemic symptoms suggests lymphoma over benign lymphoid hyperplasia; however, often the imaging characteristics are identical.

Rhabdomyosarcomas may also occur within the tongue.

Hemangiopericytomas may occur in the oropharynx.

Soft palate minor salivary gland neoplasms tend to be more benign in their histology and growth than hard palate ones.

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