

## ARTICLE

# Imaging of tongue carcinoma

Cheng K Ong and Vincent F H Chong

*Department of Diagnostic Radiology, National University Hospital, Yong Loo Lin School of Medicine,  
National University of Singapore, Singapore*

*Corresponding address: Dr Vincent Chong, Department of Diagnostic Radiology, National University Hospital,  
5 Lower Kent Ridge Road, Singapore 119074, Republic of Singapore. E-mail: gdrclfhv@nus.edu.sg*

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### Abstract

The tongue enables taste and plays a critical role in formation of food bolus and deglutition. The tongue is also crucial for speech and the earliest sign of tongue paresis is a change in the quality of speech. Given the importance of the tongue, tongue carcinoma should be accurately staged in order to optimise treatment options and preserve organ function. The intent of this review is to familiarise radiologists with the pertinent anatomy of the tongue and the behaviour of tongue carcinoma so as to map malignant infiltration accurately.

**Keywords:** *TNM staging; tongue carcinoma; computed tomography; magnetic resonance imaging.*

### Introduction

The tongue is the centrepiece of the oral cavity and the oropharynx. It enables taste of food and plays a critical role in formation of food bolus and deglutition. The tongue is also crucial for speech. Speech is impaired by glossectomy, the degree of which depends on the extent of the resection. In fact, the earliest sign of tongue paresis is a change in the quality of speech.

Given the importance of the tongue, tongue carcinoma should be accurately staged in order to optimise treatment options and preserve organ function. The intent of this review is to familiarise radiologists with the pertinent anatomy of the tongue and the behaviour of tongue carcinoma so as to map malignant infiltration accurately. It should be noted that surgical resection of the tongue base often necessitates total laryngectomy to prevent food aspiration.

### Applied anatomy

The tongue has a dorsum, apex, inferior surface and root. The root (base) is attached to the hyoid bone and mandible while the apex forms the tip of the tongue. The sulcus terminalis, a shallow groove with the circumvallate

papillae just anterior to it, divides the tongue into the oral (anterior two-thirds) and pharyngeal (posterior third) parts. As a general guide on axial imaging, a line joining the anterior aspect of the mandibular rami may be used as the dividing line between these two parts, which differ in their developmental origins and hence their nerve supplies.

The mucosa of the oral tongue derives from the ectodermal lining of the midline tuberculum impar and the pair of lateral lingual swellings of the first pharyngeal (mandibular) arch. The sensory supply of this mucous membrane, excluding the region of the circumvallate papillae is by the lingual branch of the mandibular nerve whose trigeminal component mediates common sensation, and whose chorda tympani component mediates taste.

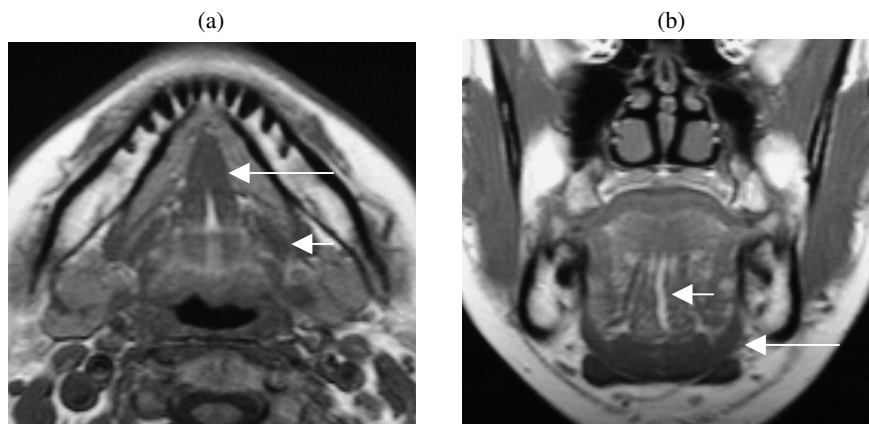
The mucosa of the pharyngeal tongue (base of the tongue) originates from the endodermal lining of the third pharyngeal arch, with a small contribution from the fourth arch. This mucosa, together with the pre-sulcal area of the circumvallate papillae is predominantly supplied by the glossopharyngeal nerve, which mediates both common sensation and taste. The small area of lingual mucosa in the anterior wall of the vallecula, which develops from the fourth pharyngeal arch, is mediated by the internal laryngeal nerve.

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**Table 1** Tumour Node Metastasis (TNM) classification

T—Primary tumour	
TX	Primary tumour cannot be assessed
T0	No evidence of primary tumour
Tis	Carcinoma <i>in situ</i>
T1	Tumour 2 cm or less in greatest dimension
T2	Tumour more than 2 cm but not more than 4 cm in greatest dimension
T3	Tumour more than 4 cm in greatest dimension
T4a (oral tongue)	Tumour invades through cortical bone, into deep/extrinsic muscle of tongue (genioglossus, hyoglossus, palatoglossus, and styloglossus), maxillary sinus, or skin of face
T4b (oral tongue)	Tumour invades masticator space, pterygoid plates, or skull base, or encases internal carotid artery
T4a (pharyngeal tongue)	Tumour invades any of the following: larynx, deep/extrinsic muscle of tongue (genioglossus, hyoglossus, palatoglossus, and styloglossus), medial pterygoid, hard palate, and mandible
T4b (pharyngeal tongue)	Tumour invades any of the following: lateral pterygoid muscle, pterygoid plates, lateral nasopharynx, skull base; or encases the carotid artery
N—Regional 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 or less in greatest dimension
N2	Metastasis in a single ipsilateral lymph node, more than 3 cm but not more than 6 cm in greatest dimension; or in multiple ipsilateral lymph nodes, none more than 6 cm in greatest dimension; or in bilateral or contralateral lymph nodes, none more than 6 cm in greatest dimension
N2a	Metastasis in a single ipsilateral lymph node, more than 3 cm but not more than 6 cm in greatest dimension
N2b	Metastasis in multiple ipsilateral lymph nodes, none more than 6 cm in greatest dimension
N2c	Metastasis in bilateral or contralateral lymph nodes, none more than 6 cm in greatest dimension
N3	Metastasis in a lymph node more than 6 cm in greatest dimension
M—Distant metastasis	
MX	Distant metastasis cannot be assessed
M0	No distant metastasis
M1	Distant metastasis

Note: Midline nodes are considered ipsilateral nodes.



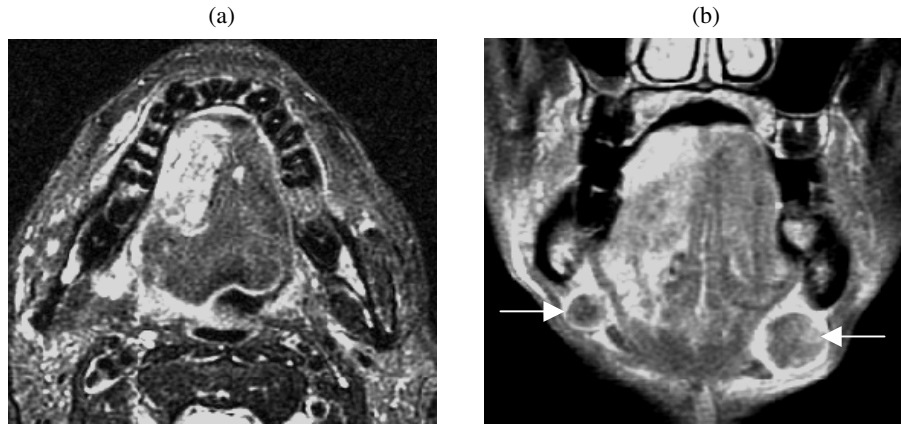
**Figure 1** (a) Axial T1 weighted image shows the tongue muscles, genioglossus (long arrow) and hyoglossus (short arrow). (b) Coronal T1 weighted image shows lingual septum (short arrow) and mylohyoid (long arrow), which forms the floor of the mouth.

The oral tongue has a free margin bounded anteriorly and laterally by the alveolar margins. The pharyngeal tongue, which is really the anterior wall of the oropharynx, extends from the sulcus terminalis to the epiglottis and is bounded laterally by the glossopharyngeal sulci. The valleculae (which are considered as part of the tongue), are 1-cm strips of smooth mucosa that form the transition between the tongue base and the epiglottis.

The tongue has a supporting fibrous framework consisting of the lingual septum (Fig. 1) and the hyoglossus

membrane. The midline fibrous lingual septum divides the tongue into two symmetrical muscular halves.

The tongue is essentially a mass of skeletal muscles covered by mucous membrane. Its muscles are divided into intrinsic and extrinsic groups. The intrinsic muscles are entirely within the tongue with no bony attachment, and are organised into superior and inferior longitudinal, vertical and transverse bands. Their principle function is altering the shape of the tongue. The extrinsic muscles consist of genioglossus, hyoglossus, styloglossus



**Figure 2** (a) Axial T2 weighted fat-suppression image shows a right-sided tongue cancer extending more than 5 mm from the lateral margin of the tongue. (b) Coronal T2 weighted fat-suppression image shows bilateral submandibular lymphadenopathy (arrows), a result of the lymphatic drainage pathways of the inner two-thirds of the oral tongue.



**Figure 3** (a) Axial T1 weighted, (b) post-contrast T1 weighted fat-suppression and (c) T2 weighted fat-suppression images show a left-sided oral tongue carcinoma. Note that the tumour is most conspicuous on T2 weighted fat-suppression sequence.

and palatoglossus. These extrinsic muscles stabilise the tongue and alter its position, as well as its shape.

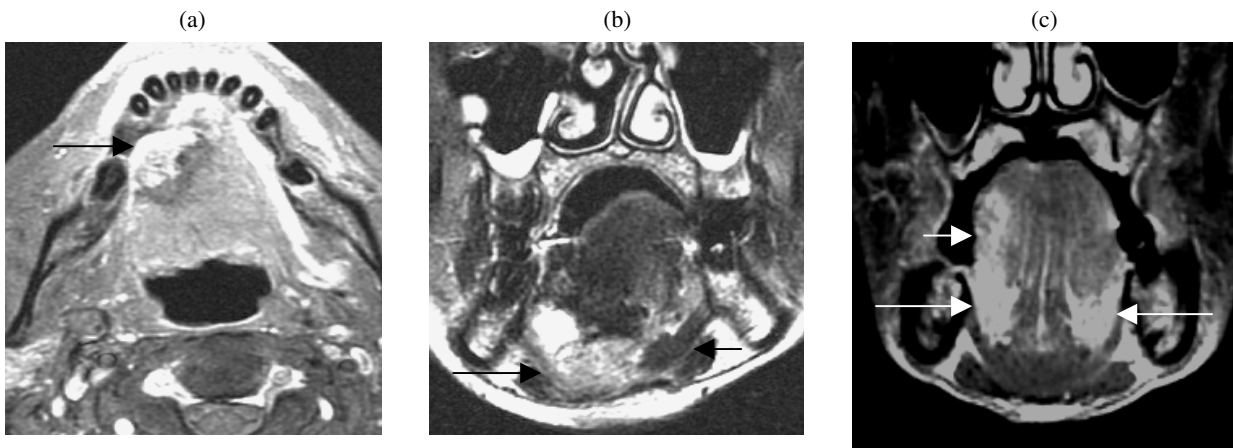
The anatomy of the tongue is well demonstrated on magnetic resonance imaging (MRI). On axial T1-weighted images, fat with high signal intensity can be seen interspersed between the muscles of intermediate signal intensity (Fig. 1).

Genioglossus is the largest of all the tongue muscles and forms the bulk of the tongue. It arises from the genial tubercle and is easily seen on computed tomography (CT) and MRI (Fig. 1). It fans out widely and inserts inferiorly into the hyoid bone; posteriorly into the tongue base; and superiorly into the entire ventral surface of the tongue. Hyoglossus is a thin quadrilateral sheet of muscle arising from the hyoid bone. It ascends superiorly, interdigitating with the fibres of the styloglossus, and attaches to the side of the tongue. The hyoglossus muscles define the lateral margins of the tongue and are readily identified on CT and MRI (Fig. 1). Both the styloglossus (which

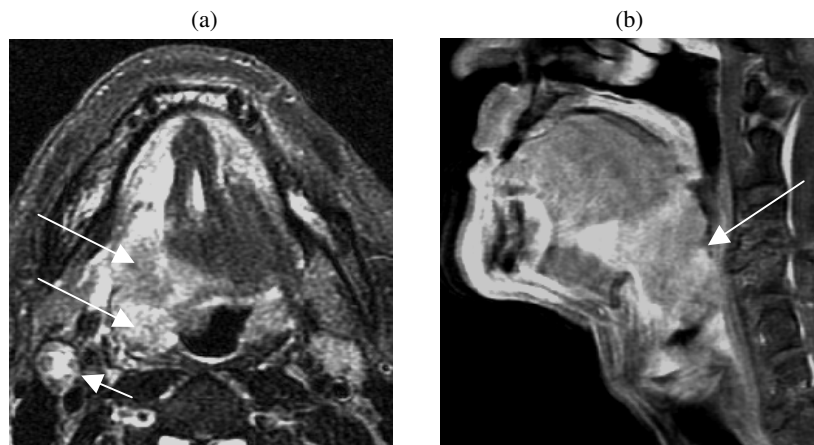
arises from the styloid process and stylohyoid ligament) and the palatoglossus (which originates from the palatine aponeurosis) cannot be seen with certainty on imaging studies.

Tongue muscles are derived from the myotomes of the occipital somites, which migrate anteriorly carrying their nerve supply. All the muscles of the tongue, intrinsic and extrinsic, are thus innervated by the hypoglossal nerve. The exception being palatoglossus, which being essentially a palate muscle, is supplied by the pharyngeal plexus.

The lingual artery, a branch of the external carotid artery, supplies the bulk of each half of the tongue. There are small contributions from the tonsillar branch of the facial artery and from the ascending pharyngeal artery. The fibrofatty lingual septum restricts any significant vascular anastomosis across the midline except the tip of the tongue. One lingual artery may be sacrificed, but sacrificing both arteries leads to high risk of anterior



**Figure 4** (a) Axial post-contrast T1 weighted fat-suppression image shows a right-sided oral tongue carcinoma (arrow). (b) Coronal T2 weighted fat-suppression image shows tumour infiltration of the floor of the mouth (long arrow). Note the normal contralateral mylohyoid muscle (short arrow). (c) Coronal T2 weighted fat-suppression image of another patient shows a right-sided oral tongue cancer (short arrow). Note the sublingual glands (long arrows), which should not be confused as tumour infiltration.



**Figure 5** (a) Axial T2 weighted fat-suppression image shows a right-sided tongue base cancer (long arrows). An enlarged right jugulodigastric node is also seen (short arrow), the first echelon node of tongue base carcinoma. (b) Sagittal T2 weighted fat-suppression image of the same patient shows the extent of pharyngeal invasion of the tongue base tumour (arrow).

tongue necrosis and almost certain loss of the tongue base<sup>[1]</sup>.

The tongue has a rich lymphatic network. Unlike the vascular supply that remains largely unilateral, lymph from one side, particularly from the tongue base, drains into nodes on both sides of the neck. Lymph from the tip of the tongue may drain to the submental nodes. Marginal lymphatics from the outer third of the rest of the oral tongue are directed to ipsilateral submandibular and jugulodigastric nodes. Central lymphatics of the inner two-thirds of the oral tongue have pathways to nodes of both sides of the neck. As a clinical guide, tumour extending more than 5 mm from lateral tongue margin has an increased risk of bilateral metastatic lymphadenopathy<sup>[2]</sup> (Fig. 2).

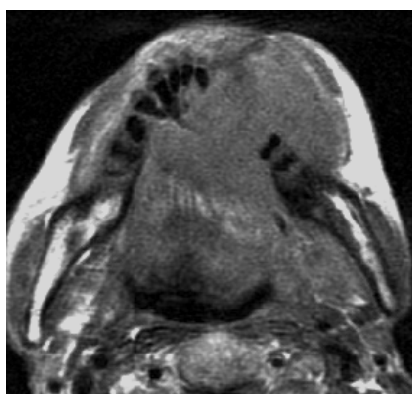
## Pathological anatomy

### Staging

Accurate tumour staging is crucial in cancer management because it (i) aids treatment planning; (ii) gives some indication of prognosis; (iii) assists the evaluation of treatment outcomes; (iv) facilitates the exchange of information between treatment centres; and (v) contributes to the continuing research and study of human cancer.

At present, the Tumour Node Metastasis (TNM) classification is the most commonly used system for describing malignant tumours, their regional involvement and distant metastases<sup>[3]</sup>. The TNM and stage grouping are presented in Tables 1 and 2. This TNM staging system

should be the guide for every radiologist when reporting studies performed for assessment of tongue carcinomas.



**Figure 6** Axial T1 weighted image shows a tongue cancer with mandible invasion. However, early involvement of cortical bones is better seen on CT images.

**Table 2** Stage grouping

Stage 0	Tis	N0	M0
Stage I	T1	N0	M0
Stage II	T2	N0	M0
Stage III	T1, T2 T3	N1 N0, N1	M0 M0
Stage IVA	T1, T2, T3 T4a	N2 N0, N1, N2	M0 M0
Stage IVB	Any T T4b	N3 Any N	M0 M0
Stage IVC	Any T	Any N	M1

### Imaging

MRI is the preferred modality in the evaluation of tongue carcinomas (Fig. 3). The abnormal signals seen on MRI are well correlated with pathological findings<sup>[4]</sup>. Tumour invasion of the floor of the mouth is particularly well seen on coronal images (Fig. 4). Sagittal images provide information on tongue base involvement and the extent of pharyngeal infiltration that cannot be seen on CT (Fig. 5). However, cortical bone involvement, notably the mandible is diagnosed with a higher level of certainty on CT (Fig. 6).

### Oral tongue carcinoma

Nearly all tumours of the oral tongue occur on the lateral and under surface. Dorsal tumours are uncommon but when they do occur, they are usually located near the midline and more posteriorly. Oral tongue tumours tend to remain in the tongue. Tumours in the anterior third of the oral tongue invade the floor of the mouth

(Fig. 7). Middle-third lesions infiltrate the musculature of the tongue and later, the lateral floor of the mouth (Fig. 8). Carcinomas involving the posterior third of the oral tongue grow into the musculature of the tongue, the floor of the mouth, the anterior tonsillar pillar, the tongue base, the glossotonsillar sulcus and the mandible (Fig. 9).

MRI provides valuable information both within and without the tongue. The tongue carcinoma may extend far beyond the gross tumour margin seen on surgery, which is often deceiving. It is known that the most important factor governing local recurrence is the resection margin<sup>[5]</sup>.

Whereas 1 cm is generally considered adequate for most squamous cell carcinomas, the margins for tongue cancer should be 1.5–2 cm. Tumours with deep margins are often difficult to assess during surgery. In addition, these tumours are technically more difficult to resect. Hence, deep margins are frequently the site of positive or inadequate resection margins.

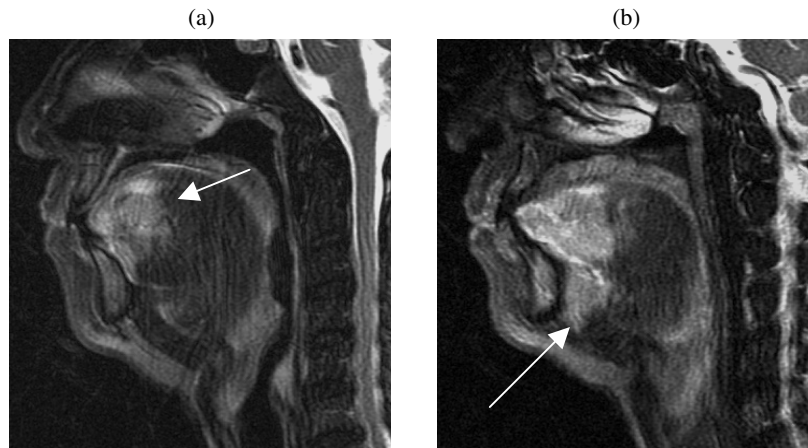
Up to 35% of patients have nodal metastasis on presentation (Fig. 8(a)). Five percent of these patients have bilateral lymph node involvement (Fig. 2(b)). The first echelon nodes are the submandibular and jugulodigastric nodes. Submental node involvement is uncommon except in patients with tumour at the tip of tongue. It should be noted that in patients with clinically N0 neck, the overall occult metastatic rate is approximately 30%. Various clinical studies have been performed to correlate the depth of tumour invasion with the likelihood of cervical nodal metastasis<sup>[6–8]</sup>. These studies reveal that the single most important factor in predicting lymph node metastasis is the depth of tumour invasion.

### Tongue base carcinoma

This is a clinically silent region and tumours tend to spread with deep infiltration. As a general rule, the extent of these tumours is underestimated during clinical examination. Tongue base tumours tend to remain in the tongue except for laterally placed lesions or late cases<sup>[1]</sup>. Under such circumstances, tongue base tumours may extend into the tonsillar fossa (Fig. 10). Tonsillar carcinomas, on the other hand, have a tendency to invade the tongue base.

Vallecular lesions are relatively exophytic (Fig. 11) and spread along the mucosa to the lingual surface of the epiglottis, laterally along the pharyngoepiglottic fold and then to the lateral pharyngeal wall and anterior wall of the pyriform sinus<sup>[1]</sup>. Anterior infiltration involving the floor of the mouth and sublingual space, as well as invasion of the pre-epiglottic space is best evaluated with imaging<sup>[9]</sup>. The true extent of tumours in these regions is difficult to ascertain by clinical examination.

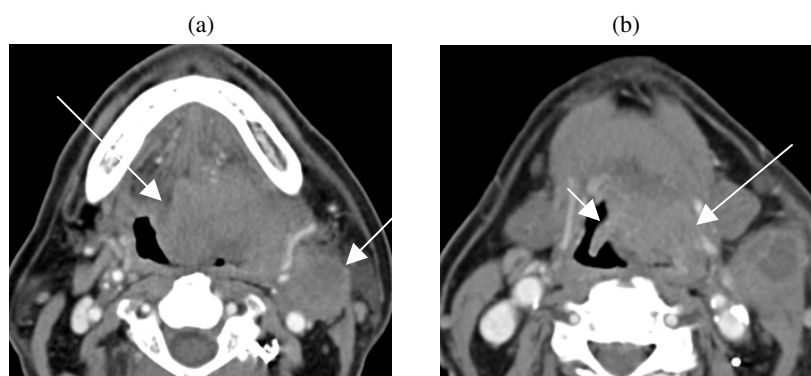
For tongue base carcinoma, the first echelon nodes are the jugulodigastric nodes (Fig. 11), followed by mid and lower jugular nodes. Retropharyngeal nodes are occasionally involved. Submandibular nodes may be



**Figure 7** (a) Sagittal T2 weighted fat-suppression image shows carcinoma in the anterior third of the oral tongue (arrow). (b) Sagittal T2 weighted fat-suppression image (same patient) shows tumour invading the floor of the mouth (arrow).



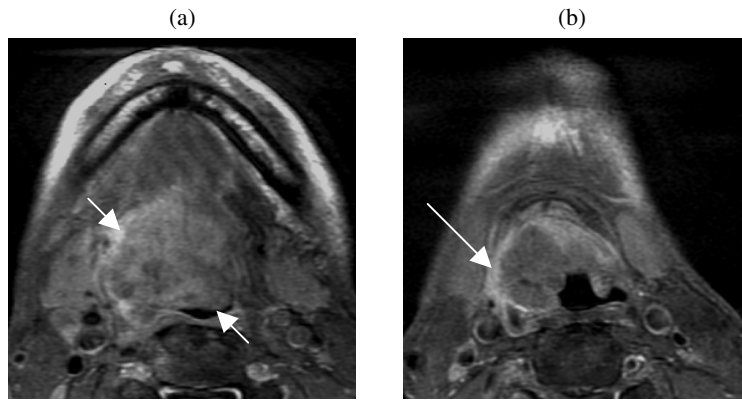
**Figure 8** (a) Coronal T2 weighted fat-suppression image shows a carcinoma in the middle third of the oral tongue with early infiltration (long arrow) of the tongue musculature (genioglossus). Note the ipsilateral submandibular lymphadenopathy (short arrow). (b) Coronal post-contrast T1 weighted fat-suppression image of a more advanced case shows the tumour invading the lateral floor of the mouth (arrow).



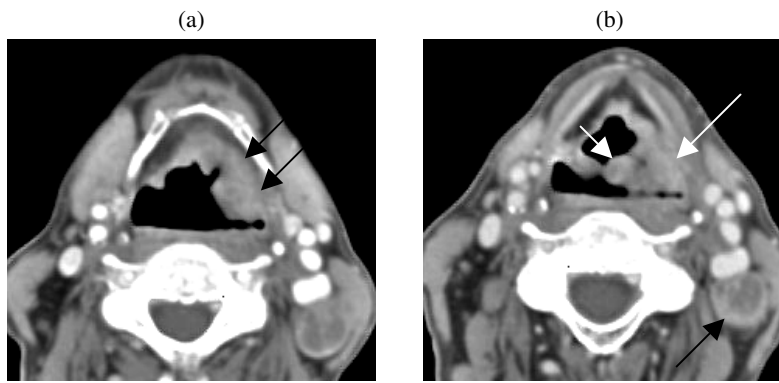
**Figure 9** (a) Axial post-contrast CT image shows a large left-side tongue base carcinoma. Note the extension across the midline (long arrow) and the ipsilateral enlarged jugulodigastric node (short arrow). (b) Axial post-contrast CT image shows tumour extension into the aryepiglottic (short arrow) and hypopharynx (long arrow).

involved if there is anterior tumour extension. Submental nodes are rarely involved. Seventy-five percent of

patients have positive nodes on presentation while 30% have bilateral nodal metastases (Fig. 12). Patients with



**Figure 10** (a) Axial post-contrast T1 weighted fat-suppression image shows a large tongue base tumour (opposing arrows). (b) Axial post-contrast T1 weighted fat-suppression image shows inferior extension into the right pyriform fossa (arrow).



**Figure 11** (a) Axial post-contrast CT image shows an exophytic a left-sided vallecular cancer (arrows). (b) Axial post-contrast CT image shows tumour involving the ipsilateral aryepiglottic fold (short white arrow) and the pyriform sinus (long white arrow). Note the enlarged necrotic left jugulodigastric node (black arrow).

clinically N0 neck have a 30%–50% rate of occult metastases.

### Treatment

In general, radiation therapy and surgery have similar results for similar stages. Total glossectomy is associated with severe speech and deglutition dysfunction. It is poorly tolerated and the procedure is thus rarely performed<sup>[1,2]</sup>. Hemiglossectomy preserves some speech and swallowing ability. The option between surgery and radiation therapy also depends on the practice and preference of a particular head and neck oncology service.

Radiation therapy is often used as the first modality while surgery is reserved for recurrence. Surgical salvage is good for small lesions but the effectiveness drops with progressively larger lesions. Hence, partial glossectomy followed by radiation therapy is the method of choice in many centres.

In view of the high incidence of occult metastases in clinically N0 neck, several studies have recommended elective neck dissection in this group of patients.



**Figure 12** Axial post-contrast CT image shows a tongue base carcinoma (black arrow) with bilateral malignant lymphadenopathy (white arrows), which occurs in up to 30% of patients on presentation.

Investigations have demonstrated the prognostic value of tumour volume measured on CT and tumour thickness (determined on ultrasound or MRI) in predicting occult metastases<sup>[10]</sup>. These studies suggest that tumours with thickness exceeding 4–6 mm or a tumour volume exceeding 13 ml have significant risk of occult metastases.

Recently, segmentation techniques were introduced to measure carcinoma tumour volume on MR images<sup>[11]</sup>.

In conclusion, MRI is the imaging modality of choice for evaluation of tongue carcinomas. Coupled with an in-depth understanding of the anatomy of the tongue and behaviour of the tongue carcinoma, this will allow accurate staging of the tumour, which in turn is crucial in optimising the treatment options.

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