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What the clinician wants to know: surgical perspective and ultrasound for lymph node imaging of the neck

Michiel W M van den Brekel* **and Jonas A Castelijns†**

**Department of Otolaryngology, Head and Neck Surgery, Netherlands Cancer Institute, Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands; †Department of Radiology, VU Medical Center, PO Box 7057, 1007 MB Amsterdam, The Netherlands*

Corresponding address: Michiel W M van den Brekel, Department of Otolaryngology, Head and Neck Surgery, Netherlands Cancer Institute, Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands
E-mail: m.vd.brekel@nki.nl

Abstract

Imaging of lymph node metastases in the neck can have two major indications: (1) prognosis and assisting with choice of treatment; (2) staging and detection of clinically occult metastases in different levels of the neck. Both indications are discussed. The role and limitations of US and US-guided fine-needle aspiration cytology are also reviewed.

Keywords: *Neck; imaging; ultrasound; metastasis; lymph node; prognosis.*

Prognosis

Lymphatic metastasis is the most important mechanism in the spread of most head and neck carcinomas. The presence of lymph node metastases determines to a great extent the chances of locoregional cure or the development of distant metastases. The incidence of distant metastases in head and neck squamous cell carcinoma (HNSCC) ranges from 4% in clinical studies to over 50% in autopsy studies[1–3]. The lungs, the skeletal system, and the liver are the most frequent sites of distant metastases[3]. De Bree *et al.*[4] have shown that in patients with three or more nodal metastases, bilateral or low jugular lymph node metastases, large lymph node metastases ($\geq$6 cm) or second primary malignancies, a search for distant metastases is warranted based on a high incidence. For screening of distant metastases, a chest computed tomography (CT) scan is the first choice modality, more effective than bone scans or ultrasound (US) of the liver[4].

Although lymph node level is used only in *N*-staging of nasopharyngeal carcinomas, several studies have shown its prognostic importance in other sites of the head and neck[5,6]. Accurate depiction of the number and level of neck node metastases becomes important if selective neck dissections are considered or when radiotherapy is the primary treatment and no histopathology will become available[7,8]. The accuracy of CT, US, and magnetic resonance imaging (MRI) for the assessment of the exact number of metastases or levels involved has not been studied. It is likely that imaging is not very accurate for this, as relatively large detectable metastases are very often accompanied by small undetectable micrometastases[9,10]. However, CT and MRI may be helpful for the detection of retropharyngeal and possibly paratracheal and mediastinal lymph nodes. This may lead to a more expanded surgical treatment of the neck or extension of the radiotherapy fields. Furthermore, the presence of these lymph nodes is important for prognosis[11]. Unfortunately, paratracheal and retropharyngeal node metastases are often very small and difficult to detect at CT or US[12,13].

Assessment of tumour volume has been shown to be an important prognosticator in laryngeal, and to a lesser extent, pharyngeal carcinoma[14–16]. Assessment of nodal volume[15,17,18] is studied less, but also has clinical importance in predicting outcome. A volume over 110 ml is a poor prognostic indicator in patients treated with radiotherapy[19].

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Necrosis in lymph nodes, as depicted at CT or MRI can also be important to predict response to radiotherapy or chemoradiation. As nodal necrosis is a sign of tumour hypoxia, it can be anticipated that these lymph nodes respond less to radiotherapy. Indeed, Dietz has shown that diminished vascularity in lymph nodes, as shown with duplex Doppler, is a poor predictive sign for patients treated with chemoradiation[18]. In another study, it was shown that if the lymph node necrosis area at CT encompasses more than one-third of the total volume, the survival rate drops dramatically[19,20]. Recently, it has been shown that with use of functional MRI, tumour hypoxia can be measured and chemoresistance predicted[21]. Another method of assessing tumour hypoxia is Tc-imidazole scintigraphy[22]. Recently, the standardized uptake value of fluorodeoxyglucose positron emission tomography (FDG-PET) was shown to be a predictive marker for patients treated with radiotherapy as well[23].

Extranodal spread is radiologically characterized by ablation of fat planes and irregular nodal borders. For this feature, Close *et al.* have reported that CT could only identify extranodal spread in large nodes[24], and Som reported a sensitivity of 100%[25]. Yousem *et al.* reported an accuracy of CT of 90%, whereas in their study MRI had an accuracy of 78%[26]. On the other hand, Carvalho studied the value of CT in detecting extranodal spread and found a sensitivity of 63% and a specificity of 60%[27]. In a study by Woolgar, in 16% of the cases N0 at CT, extranodal spread (ENS) was present at pathology[28]. Recently, King *et al.* have shown that both CT and MRI have an accuracy in the order of 73%–80% to detect ENS[29]. We have previously looked at the inter- and intra-observer variation in diagnosing ENS histopathologically[30]. From these studies it became clear that even among pathologists there is no consensus on the criteria of ENS and that frequently it is a subtle feature not detectable radiologically. In our opinion, only major macroscopic extranodal spread (infiltration) can be detected with imaging techniques. In a recent study from the VU Medical Center, MRI characteristics of lymph node metastases were evaluated for their predictive value for the development of distant metastases. The mean lymph node metastases volume was 11.4 cm^3 (range 0.3–122 cm^3). Ipsilateral ENS was observed in 28% and central necrosis was observed in 61% of the entire group. In the multivariate analysis, ENS as diagnosed on MRI was the only independent predictor for the development of distant metastases, warranting further screening for distant metastases in these patients. These results confirm that macroscopic ENS is probably more important than microscopic ENS[31].

Assessment of invasion of vital structures can be both prognostically and therapeutically relevant. In this respect, invasion of the common or internal carotid artery is probably most important[32], although invasion of both internal jugular veins, the skull base, or thoracic inlet pose similar therapeutic challenges. The reported accuracy of CT, MRI, and US in detecting tumour invasion into the carotid artery varies widely[33–35]. Palpation simultaneously with real-time US can be helpful to detect carotid wall invasion[36]. In general, a tumour encircling the vessel over 270° on CT or MRI, or a tumour that is immobile from the vessel using sono-palpation, indicates involvement of the vessel wall and often non-resectability.

Staging

The sensitivity and specificity of palpation for neck node metastases are in the range of 60%–70%. The resulting risk of occult neck metastases is to a large extent dependent on the size and site and other characteristics of the primary tumour. Because of this, it is common practice to treat the neck electively by either surgery or radiotherapy in most patients. The ‘acceptable’ risk in refraining from elective treatment is hard to define. In a published meta-analysis, a risk of occult metastases of over 20% was shown to warrant elective treatment[37]. Apart from this risk, a more important question is whether a wait-and-see policy has any prognostic impact. So far, this has not been proven unequivocally, although many retrospective and some prospective studies point towards a survival advantage of elective treatment[38–40]. The prognostic impact is probably related to the delay in treatment of the occult metastases[41]. Many imaging modalities have been used to assess the neck and improve detection of small metastases in head and neck cancer.

In a neck without palpable nodes, imaging can help in detecting occult metastases or in increasing the confidence that the neck is really tumour negative and can be observed[42]. Depiction of suspicious non-palpable lymph nodes can convert selective neck treatment or a wait-and-see policy to more secure comprehensive treatment of all levels of the neck. Negative imaging results, on the other hand, can be used as an argument to refrain from elective treatment of the neck if the risk of radiologically occult metastases is considered to be low enough and close follow-up using either US or US-guided fine-needle aspiration cytology (FNAC) is guaranteed. So far, several authors have shown the applicability and reasonable prognosis using this approach[41,43–47].

Another aspect is the assessment of the exact number of lymph node metastases and the levels involved. This is becoming more important as selective neck dissection and limited image-guided radiotherapy gain popularity. Unfortunately so far no imaging studies have been published relating to this important subject.

Apart from detection of lymph node metastases in untreated necks, imaging is often crucial for the detection of recurrences. Detection of recurrences is clinically most relevant if therapeutic options are still present. In patients treated for the primary tumour only (wait-and-see for the neck) or those treated exclusively with

radiotherapy on the neck, chemoradiation or limited surgery, routine follow-up examinations of the neck using imaging to detect early recurrences seem warranted. Thus far, CT and also MRI have disappointed in the early detection of recurrent or residual disease in the neck. CT, MRI, and US have a poor specificity to distinguish radiation or postsurgical oedema and scarring from recurrent tumour[48,49]. In patients who have a high likelihood of loco-regional recurrence, a baseline MRI or CT can be obtained 2–4 months after the initial treatment. Using the baseline scan, abnormalities that develop later can then be interpreted better with respect to tumour. With respect to the detection of residual neck disease, positron emission tomography (PET) is very likely to be the most accurate technique[50–53]. When the PET scan is negative, further investigations can be obviated according to most authors. The use of US, US-FNAC or duplex Doppler for the follow-up of the treated neck has been shown by several authors[46,54,55]. Westhofen showed that US FNAC was superior to CT in detecting neck recurrences after previous treatment[46]. In our opinion, routine US-FNAC follow-up for at least 1 year is warranted if the neck was not treated electively. We also use it to confirm complete response in patients treated with (chemo)radiation for an N+ neck, 6–8 weeks post treatment. In these cases, however, the cytology is much more difficult to interpret.

US-guided FNAC in experienced hands is a highly specific and quite sensitive technique in detecting palpably occult metastases, and the authors have adapted their policy of elective neck treatment in selected patients[41,43,45]. In selected patients who can be treated with transoral excision for T1 (and T2) oral carcinomas, laser excision of T1–2 supraglottic carcinomas, or selected patients who undergo laryngectomy for laryngeal carcinomas, one can rely on the US-guided FNAC findings and not routinely treat the neck electively. These patients should be followed very meticulously, using US-guided FNAC at 12-week intervals for at least 1 year.

Thyroid cancer

Apart from lymph node metastases from mucosal squamous cell carcinomas, imaging can play a similar role for thyroid cancer, skin cancer and salivary gland cancer. The rate of occult metastases from papillary thyroid carcinoma is reported to be as high as 60%–80%[56,57]. In patients with follicular carcinomas, lymph node metastases are less common. The most important echelons are the paratracheal and level 4 lymph nodes. Although neck node metastases are a risk factor for developing locoregional recurrences, the influence on survival is probably limited[58]. There is little literature on the accuracy of imaging on the detection of paratracheal metastases. Because radioactive iodine can cure small metastases after thyroidectomy, imaging before treatment has relatively few implications in papillary carcinomas without palpable neck nodes. However, to detect metastases early during follow-up, US-guided FNAC is the most reliable technique routinely used for follow-up[59–61]. As no iodine contrast agents should be used, CT is less useful than US-guided FNAC. In medullary carcinomas, the rate of metastases to the neck is also high. Regional lymph nodes metastases are present in over 75% of cases at the time of diagnosis[62,63]. Because of the prognostic significance, in medullary carcinomas elective neck dissection is often recommended but still controversial and imaging can play a pivotal role in decision making. As imaging of the paratracheal nodes is not very reliable, a routine paratracheal dissection is always recommended.

Salivary gland carcinoma

Lymph node metastases are an important prognostic factor in salivary gland cancer[64,65]. The incidence of lymph node metastases from salivary gland cancer is dependent on the size of the primary tumour and the histologic subtype. Overall, some 20% of all parotid carcinomas are pN+, whereas lymph node metastases are rare in low grade acinic cell carcinomas and relatively common in high grade mucoepidermoid cancer[38,65]. However, in a recent study from Stennert *et al.*[66], the reported incidence of (occult) metastases was much higher. Because the incidence of neck node metastases is in general reported to be below 20%, elective neck dissection is controversial[38,66]. A common policy is to perform frozen section of the first echelon nodes in level 2. If these are positive, the parotidectomy will be followed by a neck dissection. This policy has the disadvantage that surgery time is difficult to plan. Therefore, preoperative assessment of the neck, using either MRI or US-FNAC is a logical approach[67]. As the treatment of most parotid carcinomas is surgery with postoperative radiotherapy, there is a tendency to treat the primary with surgery and postoperative radiotherapy, and the neck with elective radiotherapy if staged N0 preoperatively and at frozen section of level 2 nodes.

Skin cancer

Metastatic patterns from skin carcinomas and melanomas differ and are more variable than metastases from mucosal carcinomas. For all skin carcinomas, lymph node metastases are a dismal prognostic feature[68–72]. The parotid gland is a major nodal echelon for all skin tumours anterior to a vertical plane through the ear. Tumours behind this line mainly spread to the posterior neck nodes and occipital nodes. Metastases to superficial nodes, e.g. along the external jugular vein, occur more frequently than in mucosal squamous cancers. Whereas basal cell carcinomas very rarely

give rise to neck metastases, squamous cell carcinomas, especially when infiltrating deeply, do so in 2%–15% of cases[73–75]. Melanomas give rise to lymph node metastases more often, although the patterns of metastases are less predictable than in squamous cell carcinomas[76]. The incidence of lymph node metastases is in the range of 20% for intermediate thickness melanomas. Because of that, the sentinel node procedure has gained widespread acceptance although it has not yet been clarified with certainty whether early detection of lymph node metastases (and early treatment) has prognostic importance in skin melanoma. For the head and neck area, the accuracy of the sentinel node procedure is less than for other parts of the body, and in over 10% of patients, the sentinel node cannot be identified or renders false negative results[77–79]. To assess the neck non-invasively, several authors have shown that US or US-guided FNAC is the modality of first choice, more reliable than palpation or CT[80–84]. Thus, US-FNAC can be used to stage advanced skin squamous cancers and melanomas. When US-guided FNAC is negative, a sentinel node procedure should be considered in intermediate thickness melanomas. Apart from initial assessment, US-guided FNAC can be used during follow-up[83,85].

Ultrasound

In general, US is reported to be superior to palpation in detecting lymph node metastases[86–88]. Whereas some authors report it to be superior to contrast-enhanced CT and MRI[89], others have found similar accuracies[90,91]. The advantages of US over other imaging techniques are its price and low patient burden. Furthermore, US is the only available imaging technique that can be used for frequent routine follow-up.

Because irregular echogeneity as a sign of metastatic involvement is often not present in small lymph node metastasis, the size of lymph nodes plays an important role in assessing their nature[92]. It is clear that size and shape criteria are not very accurate for the clinically N0 neck. The criteria used in the literature vary between 8 and 30 mm[9,25,93–95]. Several studies have tried to define criteria by evaluating nodal size and the histopathological outcome in neck dissection specimens[9,91,96–98]. Friedman[98] found a maximal axial diameter of 1 cm optimal, whereas Giancarlo[91] found a minimal diameter of 1 cm. By comparing three lymph node diameters we previously found that the minimal axial diameter is a better criterion than the more widely used maximal axial diameter or the longitudinal diameter[9]. Don *et al.*[96] found that 68 of 102 (67%) metastatic nodes had a longitudinal diameter smaller than 1 cm, whereas in our study we found that 102 of 144 (71%) were smaller than 1 cm. As a consequence, the current size criterion of 1 cm or larger misinterprets the majority of all metastases. This is especially the case in clinically N0 patients. In an US study in clinically node-negative patients[99], we found that for level 2 a criterion of 7 mm for the minimal diameter renders the best compromise, whereas for the rest of the neck, lymph nodes with a minimal diameter of 6 mm should be considered suspicious. During follow-up, an increase in size is a strong argument for metastasis[44].

As lymph nodes with metastases tend to become a rounder shape, shape is used as a criterion by several authors. In general, a round shape is considered more suspicious than an oval or flat shape[95]. In reactive nodes, the ratio of the longest diameter over the shortest diameter is 2 or higher in 86% of cases[93]. In stead of diameter or shape, the axial surface might be a better criterion. Umeda *et al.* showed that a surface area of 45 mm^2 correlated better with histopathology than using a minimal or maximal axial diameter[92].

As the size, shape and necrosis criteria are hampered by the fact that they are not very adequate for the clinically N0 neck, researchers keep looking for better criteria. Morphological criteria, such as focal cortical widening or depiction of small tumour areas inside a lymph node, will become more important as the contrast and spatial resolution of imaging techniques increases. Thus far, however, these are not shown to be reliable in lymph nodes measuring less than 1 cm. The potential value of Doppler US criteria (avascular pattern, scattered pattern, peripheral vascularity) as an adjunct to differentiate between benign and metastatic lymph nodes has been the topic of various reports. This technique enables the visualization of small irregularities in vascularization[100,101]; however, these irregularities are seldom visible in lymph nodes smaller than 1 cm. Because of that, it is our opinion that lymph nodes should be aspirated to obtain cells for cytological assessment if management consequences are attached to these radiological findings.

Ultrasound-guided aspiration cytology

Because many authors have found that borderline lymph nodes cannot be reliably characterized on US, CT, and MRI, and because radiological criteria are not as reliable as cytology, US-guided FNAC has gained popularity since its introduction some 20 years ago[102]. In the United States this technique has received less acceptance because it is operator dependent. Although the technique is not difficult, considerable training is required to aspirate from lymph nodes as small as 4–5 mm and still obtain sufficient cells[67], and to select the most suspicious lymph nodes from which to aspirate. For this it is necessary to have clinical information on the primary tumour and knowledge about the patterns of lymphatic spread from this tumour.

It has been shown that US-guided FNAC has a very high specificity, approaching 100% as epithelial cells in lymph nodes are seldom diagnosed falsely. To obtain

a high enough sensitivity, lymph nodes as small as 4–5 mm in the first two echelons should be aspirated. Although aspirating smaller nodes will probably increase the sensitivity, it is difficult to obtain a diagnostic aspirate from nodes of 3 mm or smaller. In a previous report, we found that with use of this US-guided FNAC we obtained a sensitivity of 73% with a specificity of 100% in N0 necks[90,103]. This was significantly better than CT or MRI. Only two other studies have compared US-guided FNAC to CT and MRI and found it to be superior as well[104,105]. Also for melanoma metastasis it was found to be the most accurate technique. Recently, however, in a multicentre study using US-guided aspiration, Takes *et al.* reported a sensitivity of only 42% for the N0 neck[106]. Righi *et al.* found a sensitivity of 50%, which was inferior to the 60% for CT[107]; however, in Righi's study, most false negatives were found at the beginning of the study and some of these were irradiated patients or non-squamous cell carcinoma patients.

False-negative US-guided FNAC results may be the result of aspirating the wrong node or the wrong part of the correct node (=sampling error). Furthermore, the cytopathologist may overlook single tumour cells. A technique which was supposed to increase the accuracy of US-guided aspiration is better selection of the node to aspirate by the sentinel node procedure. The concept of the sentinel node approach is based on the knowledge that nodal metastases progress in an orderly manner with the first site of metastases occurring in the sentinel node. Initial reports on sentinel node biopsy in oral cancer have shown promising results. However, it remains an invasive technique and lymph node metastases close to the primary tumour, e.g. level 1 nodes in oral cancer, can be difficult to detect using scintigraphy[84,108]. The sentinel node detection technique involves injecting around the primary tumour site with Tc-99m-labelled colloid. The localization of the sentinel node is then performed by planar scintigraphy and the use of a hand-held gamma camera. We have tried to combine the non-invasive US-guided FNAC procedure with lymphoscintigraphic detection of the sentinel node[109]. Unfortunately, this combination of the sentinel node procedure and US-guided FNAC has not improved our results obtained without sentinel node scintigraphy[43,110]. In these studies we could also show that the sensitivity of US-guided FNAC for the clinically N0 cases varied widely in relation to the patient population studied. In patients treated with elective neck dissection, the sensitivity was 71%, similar to our previous studies[90]. However, in the group of patients treated with transoral excision only and follow-up of the neck, the sensitivity was only 25%. The reasons for this lower sensitivity might be the unreliability of histopathological examination in the electively treated group. Probably more important is the fact that in the transoral excision group the primary tumours and thus the metastases were smaller and thus more difficult to detect.

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Oral cavity cancer

Vincent Chong

Department of Diagnostic Radiology, National University Hospital, Singapore

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

Abstract

Imaging plays a crucial role in the staging of oral cancers. Imaging information is essential for determining tumour resectibility, post resection surgical reconstruction and radiation therapy planning. The aim of this paper is to highlight the natural history of oral cancer spread and how malignant infiltration can be accurately mapped. It focuses on buccal mucosa, hard palate, tongue and floor of mouth carcinoma.

Keywords: *Buccal carcinoma; hard palate carcinoma; tongue carcinoma; floor of mouth carcinoma; retromolar trigone carcinoma.*

Introduction

The vast majority of oral cancers are squamous cell carcinomas (SCCa). They account for more than 90% of all oral malignant lesions. These lesions are thought to result from multiple genetic alterations that affect cell growth regulation. These alterations may be genetically determined or caused by prolonged exposure to environmental factors such as tobacco and alcohol[1]. Other malignancies that may arise in this area include lymphomas, sarcomas and minor salivary gland tumours.

Oral cavity cancers are classified into the following subsites[2]: (1) buccal mucosa; (2) upper alveolus and gingival; (3) lower alveolus and gingival; (4) hard palate; (5) tongue; and (6) floor of mouth. The T1 to T3 classifications are based purely on the greatest dimension (T1 tumours are less than 2 cm; T2 tumours are more than 2 cm but less than 4 cm; and T3 tumours are more than 4 cm). T4a tumours involve bone, extrinsic muscles of the tongue, maxillary sinus, or skin. T4b tumours involve the masticator space, pterygoid plates, skull base or encase the carotid sheath. The role of imaging, therefore, is to determine whether tumours involve the anatomic structures specified in the UICC staging manual[2].

Buccal mucosa

The buccal mucosa is the mucosa that lines the inner surface of the lips and cheeks. Buccal SCCa are usually low grade cancers and are most commonly found in the lateral walls of the buccal cavity. These lesions spread

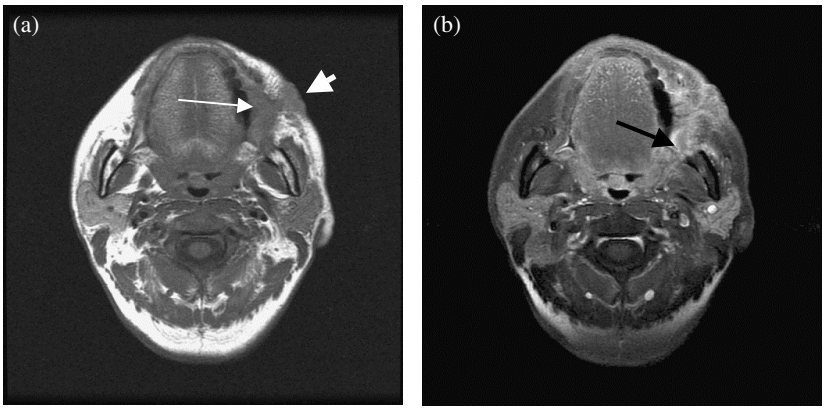

Figure 1 **(a) Axial T1-weighted MRI shows a left buccal mucosa carcinoma (thin arrow) with skin infiltration (thick arrow). (b) Axial contrast enhanced MRI shows tumour enhancement. Note tumour infiltration of the left buccal space (arrow).**

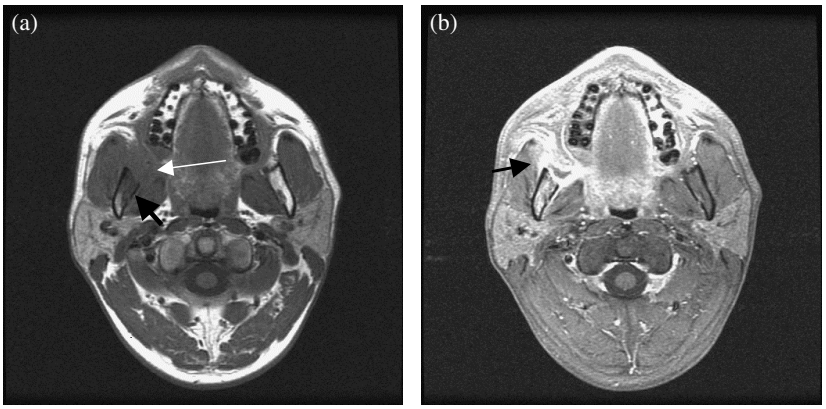

Figure 2 **(a) Axial T1-weighted MRI shows a right intermediate signal intensity retromolar trigone carcinoma (thin arrow). There is adjacent mandibular marrow involvement (thick arrow). (b) Axial contrast enhanced MRI shows tumour enhancement. Note the marrow enhancement and involvement of the right masseter muscle (arrow).**

along the submucosal surface and may eventually involve skin (Fig. 1). Advanced lesions may erode the adjacent alveolar margin. A search for bone or skin involvement is important as infiltration of these structures constitutes T4a disease.

The retromolar trigone, as the name suggests, is a small area posterior to the last molar. Retromolar trigone SCCa are therefore classified as buccal mucosa tumours. These tumours often show posterior spread with early involvement of the mandible (Fig. 2). The pterygomandibular raphe can be found beneath the mucosal surface of the retromolar trigone. This ligament (originates in the mandible and inserts into the pterygoid process) is the common insertion of the buccinator muscle, obicularis oris and the superior constrictor muscles. Tumour may extend superiorly along this raphe to erode the pterygoid process or the adjacent maxilla. Alternatively the tumour may extend into the adjacent buccal space or medially into the oropharynx and base of tongue[3].

The choice of imaging modality is often determined by clinical findings. CT is adequate for early mucosal lesions and the staging for lymph node metastasis. As early cortical bone erosion is not well demonstrated on MRI, CT is indicated when bone involvement is clinically suspected.

Hard palate

Primary malignant tumours of the hard palate are rare. The hard palate has one of the highest concentrations of minor salivary glands in the upper aerodigestive tract. It is therefore not surprising that a large number of malignant neoplasms in this location are tumours of salivary gland origin (adenoid cystic carcinoma and mucoepidermoid

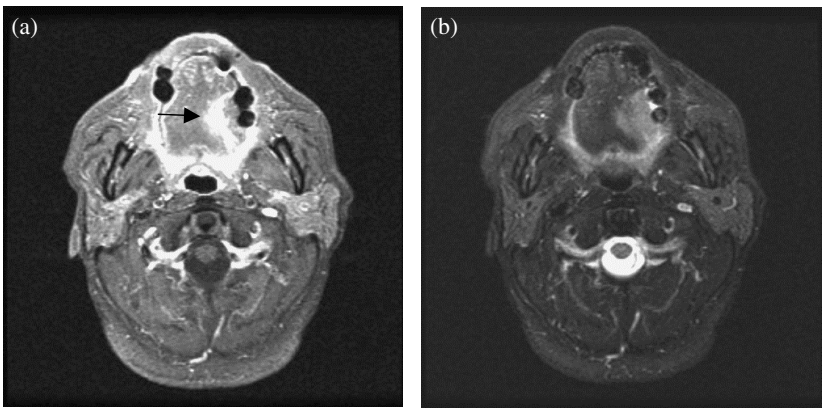

Figure 3 **(a) Axial contrast enhanced MRI shows an enhancing tumour on the lateral aspect of the left hemitongue (arrow). (b) Axial T2-weighted MRI shows a high signal intensity left tongue carcinoma. Fat saturated T2-weighted MRI is particularly useful in separating the lesion from normal tongue tissue.**

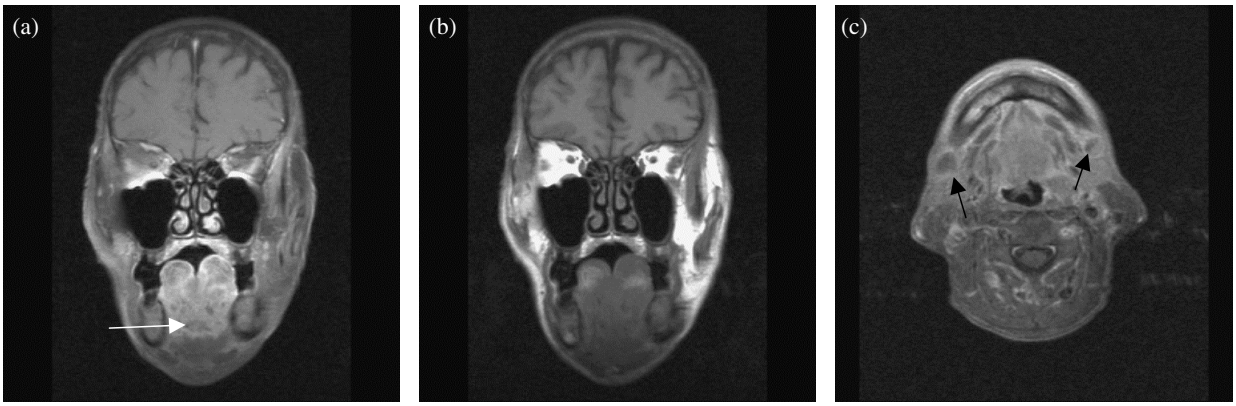

Figure 4 **(a) Coronal T1-weighted MRI shows an intermediate signal intensity mass with extensive involvement of the floor of the mouth. There is complete loss of the normal tissue planes. (b) Coronal contrast enhanced MRI shows heterogeneous enhancement in floor of mouth carcinoma. (c) Axial contrast enhanced MRI shows extensive floor of the mouth malignant infiltration. Note bilateral submandibular lymphadenopathy with central nodal necrosis (arrow).**

carcinoma). As the mucosa of the hard palate is closely applied to the underlying bone, early osseous erosion is often encountered. It is therefore important to obtain coronal CT sections of the oral cavity for adequate staging of hard palate carcinoma.

Tongue

Nearly all tongue tumours occur on the lateral and undersurface (Fig. 3). Tumours tend to remain in the tongue but show well defined routes of infiltration in neglected cases. Anterior third tumours invade the floor of the mouth. Middle-third lesions invade the musculature of the tongue and subsequently floor of the mouth. Posterior-third lesions grow into the musculature of the tongue, the floor of the mouth, the anterior tonsillar pillar, tongue base, glossotonsillar sulcus and mandible.

It is known that the most important factor governing local recurrence is resection margin. Whereas 1 cm is generally considered adequate for most squamous cell carcinoma, for tongue cancer, the margins should be 1.5–2 cm. Tumours with deep margins are often difficult to assess during surgery. Hence, deep margins are frequently the site of positive or inadequate resection margins.

Up to 35% of patients have nodal metastasis on presentation; of these, 5% have bilateral lymph node involvement. It should be noted that in patients with clinically N0 neck, the overall occult metastasis rate is approximately 30%. Various clinical studies have been performed to correlate the depth of tumour invasion to the likelihood of cervical nodal metastasis[4,5]. The first echelon nodes are the submandibular and subdigastric nodes. Submental node involvement is uncommon and these nodes are seen usually in patients with tumour at the tip of tongue.

Tongue carcinomas are sometimes difficult to see on CT. This is especially so when the tongue is obscured by dental streak artefacts. These artefacts are often serious enough to render the imaging study uninterpretable. MRI is better suited to the evaluation of tongue carcinoma. It provides valuable information both within and around the tongue.

Floor of the mouth

Floor of the mouth SCCa most commonly arise within 2 cm of the anterior midline. These carcinomas spread in a manner predictable by the anatomic location of the floor of the mouth. Superior spread may involve the ventral surface of the oral tongue; anterior and lateral spread may erode the mandible; inferior spread may infiltrate the genioglossus or mylohyoid muscles; while posterior spread often involves the tongue base (Fig. 4). The choice of imaging modality depends on clinical assessment. If the primary objective is to demonstrate or to rule out mandibular erosion, CT should be selected. However, the extent of soft tumour infiltration through the floor of the mouth or posteriorly into the tongue base is better achieved with MRI.

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Oropharyngeal cancer

Robert Hermans

Department of Radiology, University Hospitals Leuven, Herestraat 49, B-3000 Leuven, Belgium

Corresponding address: Robert Hermans, MD, PhD, Department of Radiology, University Hospitals Leuven, Herestraat 49, B-3000 Leuven, Belgium. E-mail: robert.hermans@uz.kuleuven.ac.be

Abstract

Imaging studies have an important role in defining the extent of oropharyngeal neoplasms and coming to an accurate staging of these lesions. Besides influencing treatment choice, imaging studies can also be used to monitor tumour response to treatment, and as an adjunct to clinical follow-up in order to detect treatment failure as early as possible.

Keywords: *Squamous cell cancer; head and neck; pharynx.*

Introduction

Head and neck cancer commonly originates from the oropharynx. As in most head and neck sites, squamous cell cancer is the most frequently encountered malignant disease. Cigarette smoking and excessive alcohol consumption are well-known risk factors. The accuracy of pre-therapeutic staging is an important factor in the treatment planning of oropharyngeal neoplasms. High-quality imaging is of considerable help to the clinician examining patients with oropharyngeal cancer, by revealing submucosal tumour spread and detecting subclinical adenopathies.

Squamous cell carcinoma

About 90% of oropharyngeal neoplasms are squamous cell carcinoma. Most patients complain of sore throat,

otalgia or dysphagia; more advanced, invasive tumours may cause severe pain and trismus.

The T-staging is based on tumour size, and involvement of adjacent structures (Table 1). The most common site of origin of oropharyngeal cancer is the anterior tonsillar pillar.

Table 1 T-staging of oropharyngeal carcinoma[12]

Tis	Carcinoma *in situ*
T1	Tumour ≤2 cm in greatest dimension
T2	Tumour >2 cm but ≤4 cm in greatest dimension
T3	Tumour measures >4 cm in greatest dimension
T4a	Tumour invades any of the following: larynx, deep/extrinsic muscle of the tongue (genioglossus, hyoglossus, palatoglossus, and styloglossus), medial pterygoid, hard palate, and mandible
T4b	Tumour invades any of the following: lateral pterygoid muscle, pterygoid plates, lateral nasopharynx, skull base, or encases the carotid artery

Tonsillar cancer

Nearly all tonsillar cancers originate from the anterior tonsillar pillar. These cancers commonly spread antero-inferiorly to the tongue base, and superomedially to the soft palate, both along the palatoglossal muscle. Anterolateral spread, along the pharyngeal constrictor muscle to the pterygomandibular raphe and retromolar trigone, is also often seen (Fig. 1). Advanced lesions may invade the mandible, spread along the pharyngeal wall to the hypo- and/or nasopharynx, or invade the parapharyngeal space through the pharyngeal wall. Spread to the infratemporal space, with involvement of the muscles of mastication and neurovascular structures in this space may be seen in advanced cases.

Lesions originating from the posterior tonsillar pillar are rare; these may spread inferiorly along the palato-pharyngeal muscle.

Tongue base cancer

Cancer in the tongue base tends to grow silently and deeply, and is often larger than suspected at clinical examination. Tumours may spread, along the palato-glossal muscle, cornering the glossotonsillar sulcus, to involve the anterior tonsillar pillar.

Anterior spread into the floor of the mouth and/or tongue body may occur, along the mylo- and/or hyo-glossal muscle, and/or along the lingual neurovascular bundle (Fig. 2). Tongue base cancer may also grow in a retrograde fashion along the lingual vessels towards the external carotid artery[1]. Vascular and perineural tumour spread is associated with reduced local and regional tumour control and reduced patient survival. A tumour mass with a overall diameter of more than 2 cm on imaging predicts vascular and perineural tumour spread[2]. Infiltration of the normal fatty tissue planes in the base of the tongue, of the fat in the sublingual space, as well as irregular tumour margins are also associated with an increased risk of vascular and perineural tumour spread. Such findings are related to overall tumour bulk.

Spread to the valleculae and piriform sinuses, and into the pre-epiglottic space may be seen. Extension of a tongue base cancer across the midline usually precludes surgical cure, as one lingual neurovascular pedicle needs to be conserved for sufficient functional recovery to allow safe swallowing.

Differentiation of tongue base cancer from normal lymphoid tissue on the surface of the tongue base may be difficult on imaging studies; the only reliable criterion to diagnose cancer is infiltration of the deeper soft tissue structures.

Soft palate cancer

Soft palate cancer may spread laterally and inferiorly along the tonsillar pillars. Superior spread to the nasopharynx occurs in advanced disease (Fig. 3). Carcinoma of the soft palate may occasionally spread perineurally along palatine branches of the maxillary nerve[3].

Posterior oropharyngeal wall cancer

Isolated cancer in the posterior oropharyngeal wall is rare (Fig. 4); more commonly, this wall is invaded by cancers originating from the lateral oropharyngeal wall. Along the posterior wall, mucosal or submucosal spread to the hypopharynx and/or nasopharynx is possible.

Fixation to or direct invasion of the prevertebral fascia precludes the possibility of surgical resection of pharyngeal cancer, and is associated with a poor prognosis. The absence of pre-vertebral space involvement is reliably predicted on CT and MR images by demonstrating the preservation of the retropharyngeal fat plane. The negative predictive value of this sign varies between 82% and 97.5%[4,5]. However, cross-sectional imaging is poor in predicting involvement of the pre-vertebral space. Obliteration of the retropharyngeal fat plane, asymmetric enlargement of the pre-vertebral muscles (on CT studies), and thickening and signal abnormalities (on MR studies) are all unreliable signs to diagnose extension into this space (Fig. 4)[4–6]. Open neck exploration with direct evaluation of the pre-vertebral muscles is superior to CT and MRI and should be considered in these patients. However, the decision to perform surgical resection in these patients is influenced by a number of factors in addition to involvement of the pre-vertebral space, including carotid artery encasement, perineural spread, retropharyngeal adenopathy and overall patient performance status. Also, the majority of lesions on the

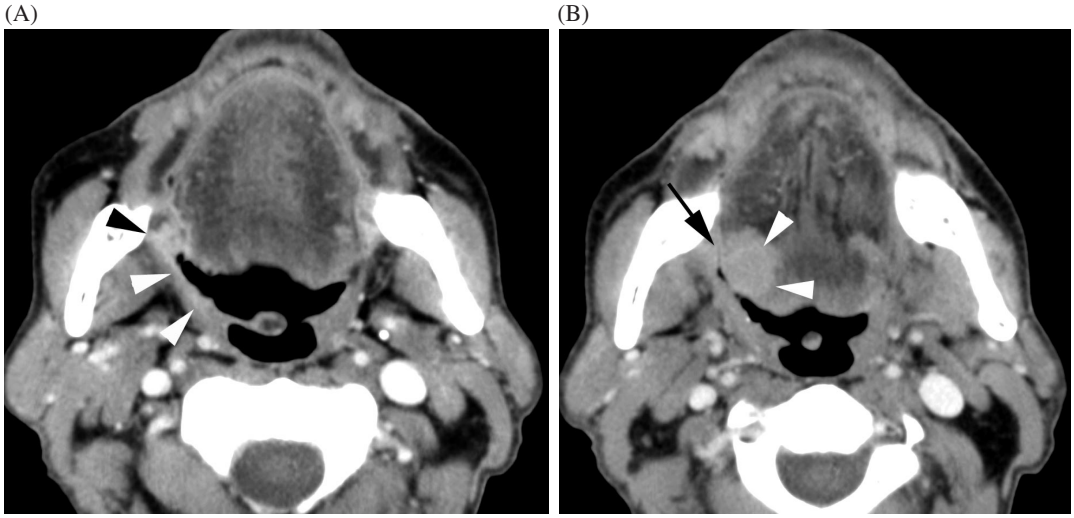

Figure 1 **Axial contrast-enhanced CT images in a patient with right-sided tonsillar cancer. (A) Soft tissue thickening and increased enhancement in the right anterior tonsillar pillar (white arrowhead), extending to the pterygomandibular raphe (black arrowhead). (B) The enhancing soft tissue mass grows along the glossotonsillar sulcus (arrow) into the tongue base (arrowheads).**

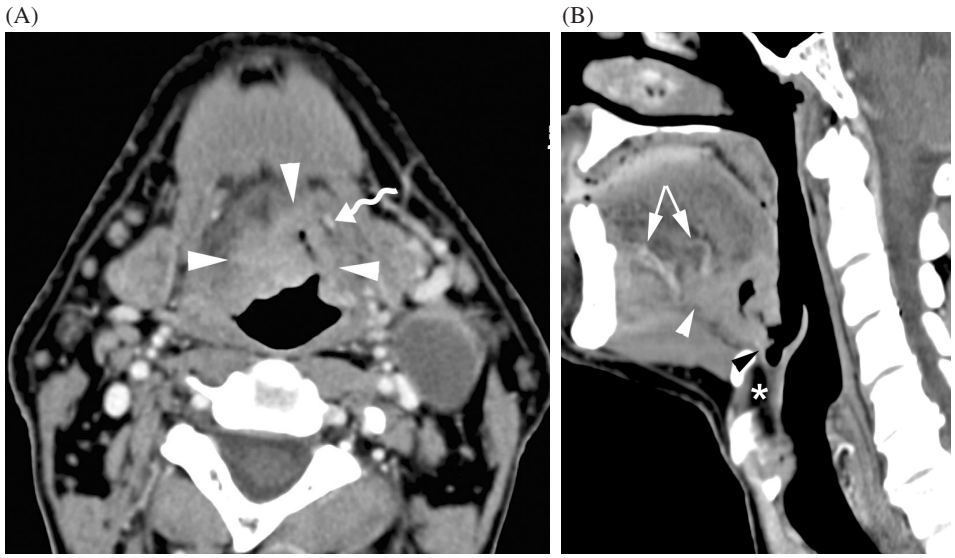

Figure 2 **Contrast-enhanced CT images in a patient with tongue base cancer. (A) Axial image. Ulcerated, contrast-enhancing soft tissue mass in the base of the tongue (arrowheads). Irregular tumour margins are present. The lesion crosses the midline, and approaches the left lingual artery (curved arrow). A large adenopathy is present on left side. (B) Sagittal reformatted image (left paramedian section). Anterior spread in the floor of the mouth (white arrowhead); again, close relationship to the proximal part of the lingual artery is seen (distal branches indicated by arrows). The lesion extends into the vallecula (black arrowhead); the preepiglottic space (asterisk) is not involved.**

posterior pharyngeal wall are treated by radiotherapy or combined chemotherapy and radiotherapy, as the reported cure rates are similar to those of surgery alone or combined surgery and radiotherapy[7]. Nevertheless, as surgical reconstruction methods improve, resection with postoperative radiotherapy can be considered in selected cases[8].

Lymphatic spread

Lymphatic spread usually occurs in a predictable way, from superior to inferior, the upper parajugular lymph nodes (level II) being the first echelon at risk. Retropharyngeal adenopathy is relatively common and usually

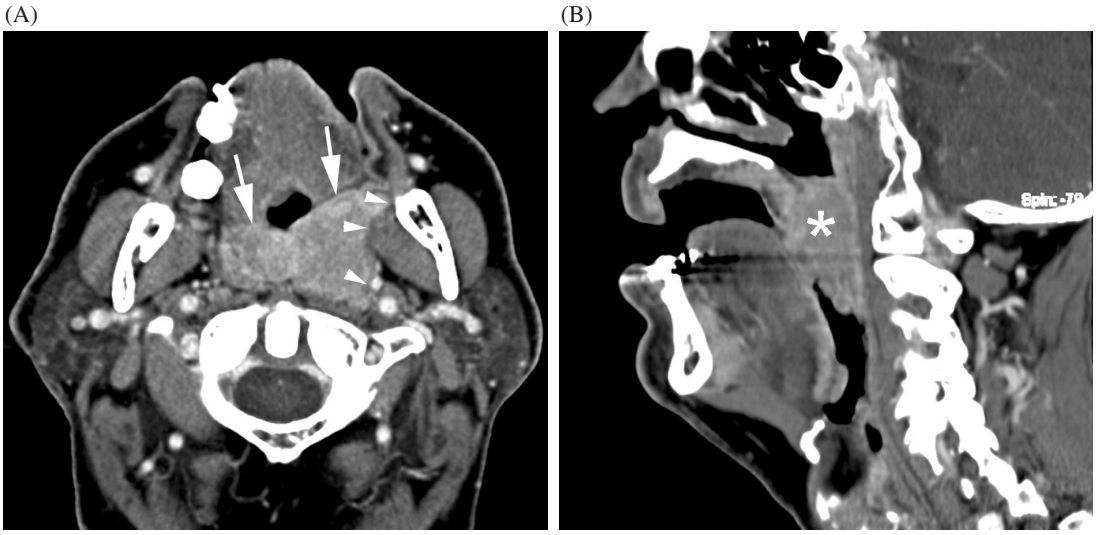

Figure 3 **Contrast-enhanced CT images in a patient with soft palate cancer. (A) Axial image. Pronounced thickening and increased enhancement of the soft palate (arrows); extension is seen into the retromolar trigone; the left lateral pharyngeal wall is displaced towards the parapharyngeal space (arrowheads). (B) Sagittal reformatted image; the soft palate tumour is indicated by an asterisk.**

associated with lymphadenopathy in other neck levels; isolated retropharyngeal adenopathy without involvement of other lymph nodes also occurs, particularly in posterior oropharyngeal wall cancer. Bilateral adenopathies are commonly seen in soft palate cancer, as well in base of the tongue cancer.

Treatment and posttreatment imaging

Oropharyngeal cancer is treated with curative intent by radiotherapy, surgery or a combination of both modalities. Depending on anatomical localisation, small lesions (T1 or T2) are treated by either radiotherapy or surgery; cancer of the soft palate or uvula is treated by irradiation, as surgery of these structures interferes with palatal function. Larger lesions (T3 or T4) are, if possible, surgically treated, with postoperative radiotherapy. Inoperable oropharyngeal cancer is treated by concomitant chemoradiotherapy.

Although currently no hard data are available on the value of surveillance imaging for oropharyngeal cancer after radiotherapy, obtaining a baseline follow-up CT or MR study 3–6 months after the end of therapy can be considered. In a number of cases, local failure can be detected at an earlier stage than by clinical examination alone. Persisting or recurring tissue asymmetry and/or increased tissue enhancement after therapy, are suspect for persisting or recurring tumour (Fig. 5). Such findings need further exploration; when no clinical correlate is apparent, it is safe to perform an additional nuclear imaging study or to obtain a follow-up CT/MR study about 4 months later. In case of persisting or progressive tissue changes, tissue sampling is required.

When an oropharyngeal cancer is treated primarily by surgery, often extensive removal of soft tissues, and possibly also mandibular bone is needed to obtain oncologically safe resection margins. To reconstruct the created tissue defects, and to obtain a better functional and/or cosmetic result, tissue transfer from a body donor site to the oropharyngeal region may be required. These flaps are vascularized by local vessels, anastomosed to the flap by microvascular techniques. Different kinds of free flaps are in use, for example cutaneous flaps to reconstruct defects in the oropharyngeal cavity, or osseous flaps (e.g. fibula) to reconstruct mandibular defects. A CT or MR study, obtained about 4 months after the end of such a complex procedure, may be helpful as a baseline study allowing earlier diagnosis of subsequent tumour recurrence.

Other neoplastic disease

Non-Hodgkin's lymphoma

Due to the abundant lymphoid tissue in the oropharynx (lingual and palatine tonsils), non-Hodgkin's lymphoma occurs in this region as extranodal lymphatic disease. The diagnosis of lymphoma can often be suggested based on the imaging findings, as these tumours frequently appear large and homogenous on imaging studies. Also, adenopathies may be present at sites unusual for an untreated carcinoma, or the oropharyngeal lesion may be associated with another extranodal neck lymphoma localisation[9,10]. Such findings, occurring in patients with no risk factors for head and neck carcinoma, are suggestive for lymphoma.

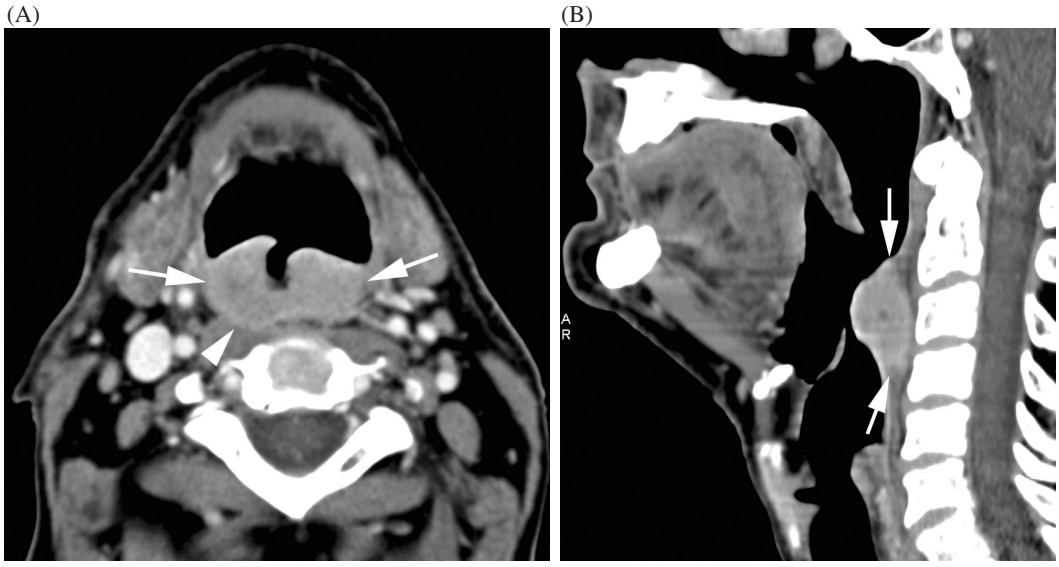

Figure 4 **Contrast-enhanced CT-images in a patient with cancer of the posterior oropharyngeal wall. (A) Axial image. Contrast-enhancing soft tissue mass (arrows), showing ulceration. On the right side, the lesion obliterates the retropharyngeal fat plane and reaches the pre-vertebral muscle (arrowhead); invasion of this muscle cannot be excluded. (B) Coronal reformatted image, showing the craniocaudal extent of the lesion (arrows).**

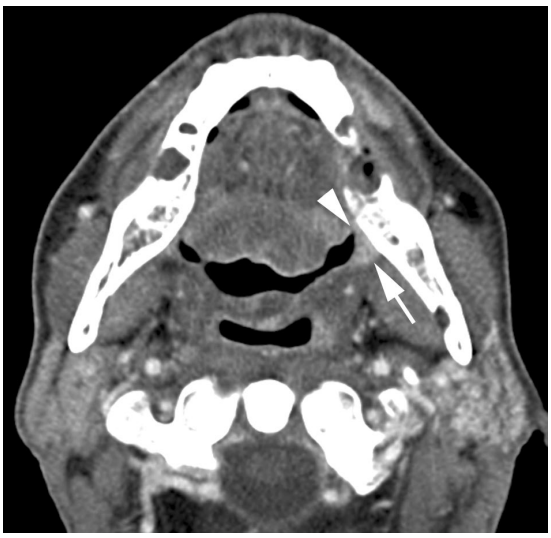

Figure 5 **Axial contrast-enhanced CT image, obtained 6 months after completion of radiotherapy for oropharyngeal cancer, because of left sided odynophagia and otalgia. Slight soft tissue thickening and increased enhancement is seen in the left anterior tonsillar pillar (arrow) extending into glossotonsillar sulcus (arrowhead). Clinically, this abnormality corresponded to a small granulomatous lesion. Biopsy revealed squamous cell cancer.**

Salivary gland tumours

These oropharyngeal neoplasms originate from minor salivary glands. In the soft palate, these are often benign pleiomorphic adenomas, but in other oropharyngeal sites malignant tumours, such as mucoepidermoid and adenoid cystic carcinoma, predominate[11].

Conclusion

The clinical examination and imaging studies are complementary in precisely evaluating oropharyngeal tumour extent and staging the lesion. As an adjunct to clinical surveillance, imaging can be used to monitor tumour response and to detect recurrent or persistent disease as early as possible.

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Lymph node imaging: multidetector CT (MDCT)

Paul M Silverman

Department of Radiology, University of Texas M. D. Anderson Cancer Center, Houston, TX, USA

Corresponding address: Paul M Silverman, MD, Department of Radiology, University of Texas M. D. Anderson Cancer Center, Houston, TX, USA
E-mail: `psilverman@mdanderson.org`

Abstract

Advances in cross-sectional imaging, including conventional and helical (spiral) CT and multidetector (MDCT) and MR imaging, now allow detailed evaluation of the anatomy and pathology of the neck and thoracic inlet. The major structures are identified by their appearance and that of contrasting fatty tissue planes surrounding the soft tissues. These structures include the larynx, trachea, thyroid, and parathyroid glands as well as the vessels, lymph node chains, nerves, and supporting muscles. A thorough understanding of the normal cross-sectional anatomy is fundamental to properly interpret pathologic processes. Pathologic processes include both solid and cystic masses. Most solid masses are enlarged lymph nodes. In contrast, cystic masses are of variable pathology, and their characteristic appearances and locations with respect to normal neck anatomy allow a confident diagnosis to be made from a brief differential diagnostic spectrum.

Keywords: *Neck; computed tomography (CT); lymph nodes.*

Technique

Computed tomography (CT) is performed with the patient supine in quiet respiration[1–4]. A pad placed beneath the patient's scapulae produces mild hyperextension of the neck and provides consistent images perpendicular to the long axis of the neck, minimizing dental artifacts. Scans are obtained using 3–5 mm or thinner contiguous slices. Multidetector CT (MDCT) affords optimal imaging in a single breath-hold, maximizing contrast enhancement and minimizing misregistration which improves visualization of small anatomic structures without rescanning or additional radiation. Intravenous contrast material is a prerequisite for enhancement of vascular structures. Its use facilitates differentiation of vessels from lymph nodes and the characterization of pathology.

Normal anatomy

The classic surgical approach divides the neck into two spaces, the anterior and posterior triangles (Fig. 1). The anterior triangle contains the major structures of the neck: hypopharynx, larynx, trachea, esophagus, thyroid, parathyroid, and salivary glands as well as the carotid sheath, nerves, and lymph nodes. Each anterior triangle

Table 1 1997 AJCC nodal (N) staging systems for cervical lymph nodes

Level	Classification criteria
NX	The regional lymph nodes cannot be assessed (clinically)
N0	There are no regional metastatic lymph nodes present
N1	There is metastasis to a single ipsilateral lymph node that is 3 cm or less in greatest dimension
N2	There is metastasis in a single ipsilateral lymph node that is between 3 and 6 cm in greatest dimension; there are multiple ipsilateral lymph nodes, none of which are greater than 6 cm in greatest dimension; or there are bilateral or contralateral lymph nodes, none of which are greater than 6 cm in greatest dimension
N2a	There is metastasis in a single ipsilateral lymph node that is between 3 and 6 cm in greatest dimension
N2b	There are multiple ipsilateral lymph nodes, none of which are greater than 6 cm in greatest dimension
N2c	There are bilateral or contralateral lymph nodes, none of which are greater than 6 cm in greatest dimension
N3	There is metastasis in lymph nodes that are more than 6 cm in greatest dimension

is bordered posterolaterally by the sternocleidomastoid muscle and superiorly by the mandible. The anterior triangle is subdivided by the hyoid bone into suprahyoid and infrahyoid portions. The suprahyoid provides support for the floor of the mouth and contains sublingual, submandibular salivary glands and associated nodes. The infrahyoid portion contains the remaining components (Fig. 2). The posterior triangle is bounded anteriorly by the sternocleidomastoid muscle and posteriorly by the trapezius and is subdivided by the posterior belly of the omohyoid muscle. The space is primarily filled with fat and includes the hypoglossal nerve, vessels, and nodes.

Normal lymph nodes of the neck

The location of the various lymph node groups of the neck is most succinctly understood using a simplification of the Rouviere classification. Nodal classification is critical for staging tumor extent[6–18]. Lymph nodes of the neck may be divided into 10 major groups[7–18].

The first six groups (I–VI) form a lymphoid collar at the junction of the head and neck (Fig. 2). These nodes are quite superficial, are usually accessible to palpation on physical examination and are commonly referred to as collar nodes: occipital, mastoid, parotid, submandibular, and facial submental.

Two groups of nodes lie deep within this lymphoid collar and are not accessible to clinical examination. Pathologic enlargement (>1.5 cm) allows detection. These nodes—groups VII, sublingual, and VIII, retropharyngeal—are often the site of metastases from carcinoma of the nasopharynx, the base of the tongue, and the tonsils (Fig. 3).

The anterior cervical group (IX) consists of superficial (Fig. 4B) and deep components (Fig. 4C). These nodes may be the site of metastases from primary tumors in the thyroid, larynx, and lung.

The lateral cervical nodes (group X) are also composed of superficial and deep chains (Fig. 5). This important deep group of nodes consists of three chains that form a triangle. The anterior portion is the internal jugular chain, the posterior portion is the spinal accessory chain, and the inferior component is the transverse cervical chain. Of these groups, the most important in staging head and neck tumors are the nodes along the internal jugular chain. A classification used by our surgical colleagues is shown in Table 1. Although the table is useful, the classification can easily be integrated into our system by carefully describing in reports the anatomic location of the nodes.

A new imaging-based classification for abnormal nodes

Recently, the results of a study produced an imaging-based nodal classification for the evaluation of metastatic neck adenopathy. Imaging landmarks were identified to create a nodal classification similar to that of the American Joint Committee on Cancer and the American Academy of Otolaryngology—Head and Neck Surgery[9–11,18–24] (Table 2). This system was defined to ensure a more consistent nodal classification and to eliminate confusion with existing clinically based classifications. Imaging was chosen as a pivotal study because it identifies clinically silent nodes. Table 2 summarizes this new imaging-based classification (Figs. 6–19). A roman numeral is used to define the levels referenced to anatomic names, such as supraclavicular, retropharyngeal, carotid, facial, occipital, postauricular, and other superficial nodes; these anatomic terms are still widely used. This classification brings some improved precision and reproducibility to the staging of head and neck diseases.

Nodal disease

Clinical examination alone is highly inaccurate in staging nodal disease in patients with head and neck tumors. Therefore, prophylactic X-ray therapy can be used to treat

Table 2 Clinical classification of neck nodes

t	Definition of nodes
I	Above hyoid bone Below mylohyoid muscle Anterior to back of submandibular gland
IA	Between medial margins of anterior bellies of digastric muscles Previously classified as submental nodes
IB	Posterolateral to level IA nodes Previously classified as submandibular nodes
II	From Skull base to level of lower body of hyoid bone Posterior to back of submandibular gland Anterior to back of sternocleidomastoid muscle
IIA	Anterior, lateral, medial, or posterior to internal jugular vein Inseparable from internal jugular vein (if posterior to vein) Previously classified as upper internal jugular nodes
IIB	Posterior to internal jugular vein with pat plane separating nodes and vein Previously classified as upper spinal accessory nodes
III	From level of lower body of hyoid bone to level of lower cricoid cartilage arch Anterior to back of sternocleidomastoid muscle Previously known as mid jugular nodes
IV	From level of lower cricoid cartilage arch to level of clavicle Anterior to line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle Lateral to carotid arteries Previously known as low jugular nodes
V	Posterior to back of sternocleidomastoid muscle from skull base to level of lower cricoid arch From level of lower cricoid arch to level of clavicle as seen on each axial scan Posterior to line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle Anterior to anterior edge of trapezius muscle
VA	From skull base to level of bottom of cricoid cartilage arch Posterior to back of sternocleidomastoid muscle Previously known as upper level V nodes
VB	From level of lower cricoid arch to level of clavicle as seen on each axial scan Posterior to line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle Previously known as lower level V nodes
VI	Between carotid arteries from level of lower body of hyoid bone to level superior to top of manubrium Previously known as visceral nodes
VII	Between carotid arteries below level of top of manubrium Caudal to level of innominate vein Previously known as superior mediastinal nodes
Supraclavicular	At or caudal to level of clavicle as seen on each axial scan Above and medial to ribs
Retropharyngeal	Within 2 cm of skull base and medial to internal carotid arteries

patients with occult metastases, which are estimated to occur in 15%–20% of these individuals.

Because normal nodes in the neck may be identified on high-quality scans, criteria have been established to define lymphadenopathy: (1) a discrete mass great than 1.0–1.5 cm; (2) an ill-defined mass in a lymph node area; (3) multiple nodes of 6–15 mm; and (4) obliteration of tissue planes around vessels in a nonirradiated neck. A nodal mass with central low density is specifically indicative of tumor necrosis[5–8].

Less common, nonnodal solid masses include neurovascular tumors (paraganglioma, neurofibroma, hemangioma), primary neoplasms (fibroma, sarcoma), congenital lesions (teratoma, ectopic thyroid), trauma (hematoma), lesions of the bone (plasmacytoma, aneurysmal bone cyst), and infection. Specific imaging features aid the differential diagnosis. Paragangliomas (carotid body tumor) occur in the carotid space and consistently show early and persistently dense enhancement after the administration of contrast material. Acute hematomas are characterized by an intrinsically high CT attenuation and high intensity on T1-weighted magnetic resonance (MR) imaging. Metastases are located in the expected site of the major lymph node chains of the neck. Many investigators now use 1.0 cm as an effective size criteria for positive nodes in a patient

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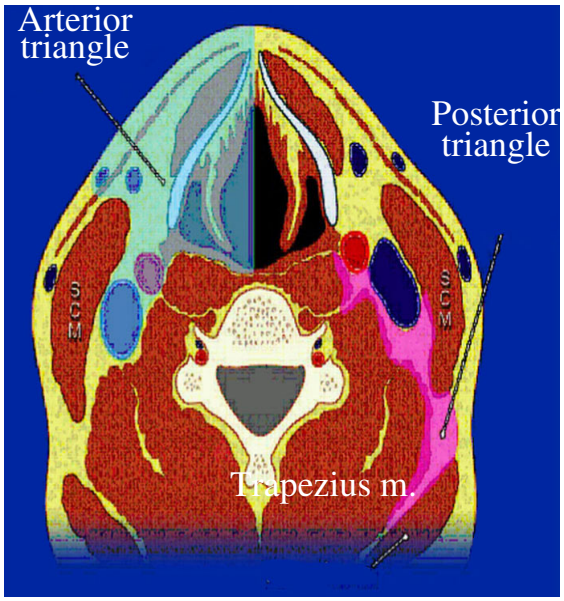

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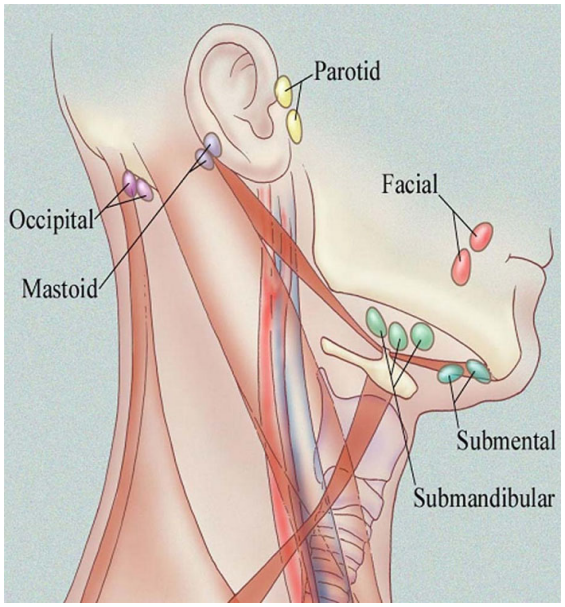

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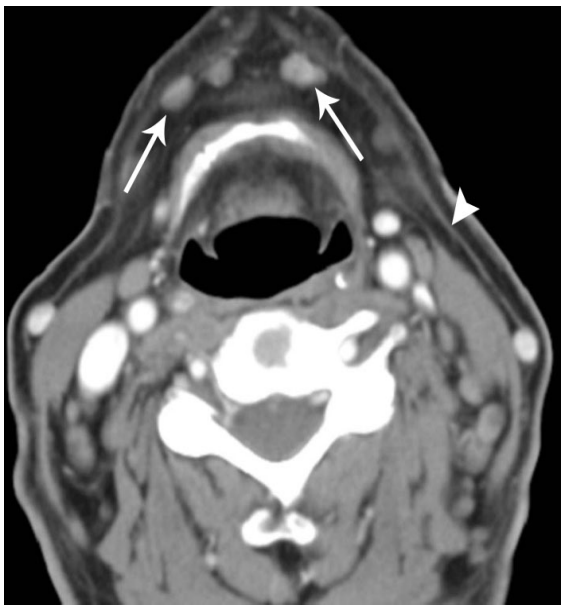

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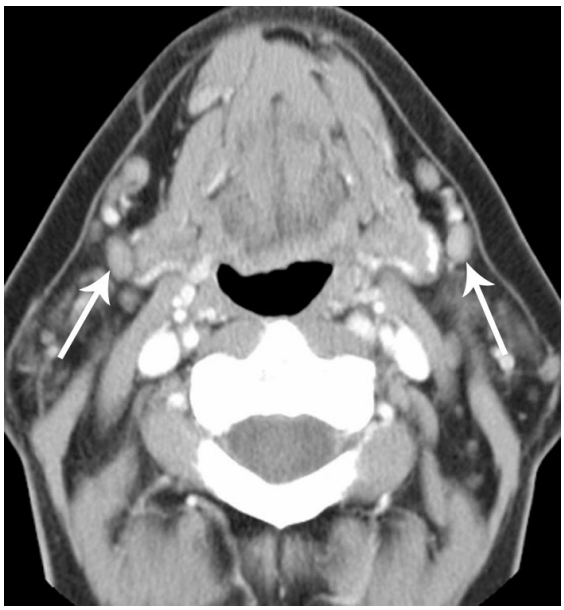

Figures 1–2. **(1) Cross-sectional diagram. Anterior and posterior triangle of the neck. (2) (A) Collar nodes. There are six (I–VI) major nodal groups at the junction of the head and neck. The posterior group consists of the carotid, occipital, and mastoid group while the anterior group consists of the facial, submental, and submandibular nodes. They form a collar of rather superficial nodes. (B) CT scan at the level of the hyoid. Multiple non-specific submental nodes (arrow) deep to the platysmal muscle (arrowhead). (C) Scattered submandibular sub-centimeter nonspecific nodes seen lateral to the submandibular glands (arrows).**

population at high risk. Nodes in the upper neck tend to be large because of repeated respiratory infections; therefore, more liberal size criteria should be accepted. With the use of more liberal criteria, 80% of nodes will be metastatic and 20% will be benign hyperplastic. Important caveats include the follow: (1) regardless of primary site, a single ipsilateral node decreases survival by 50% and a contralateral node halves survival again; (2) extranodal extension is the best indicator of treatment failure and decreases survival by 50%; (3) posterior triangle nodes, with the exception of lymphoma, indicate a poor prognosis; and (4) nodes in the low internal jugular chain have a poor prognosis because proximal spread has often occurred. These caveats are helpful when dealing with the assessment of lymphadenopathy in this region.

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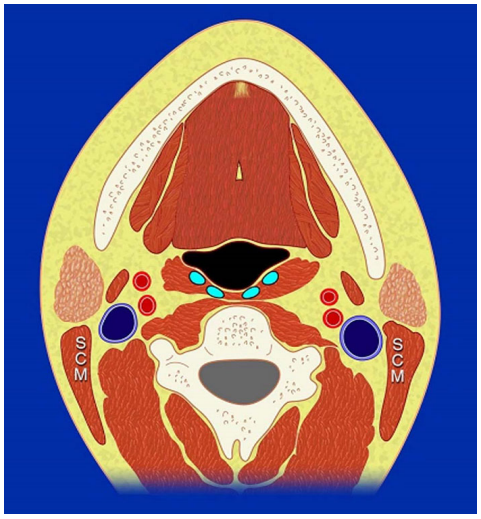

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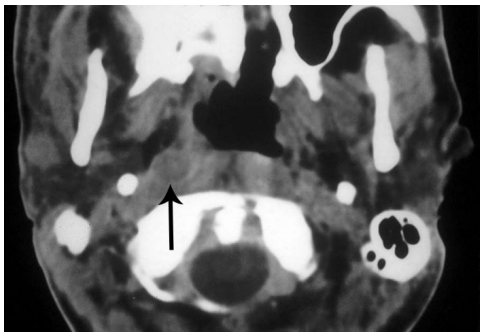

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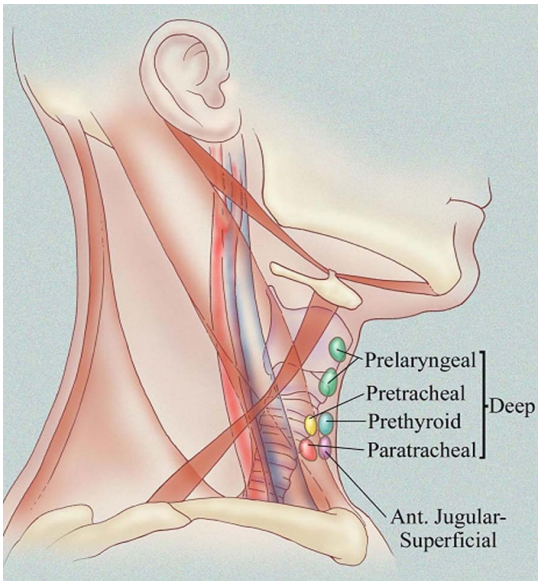

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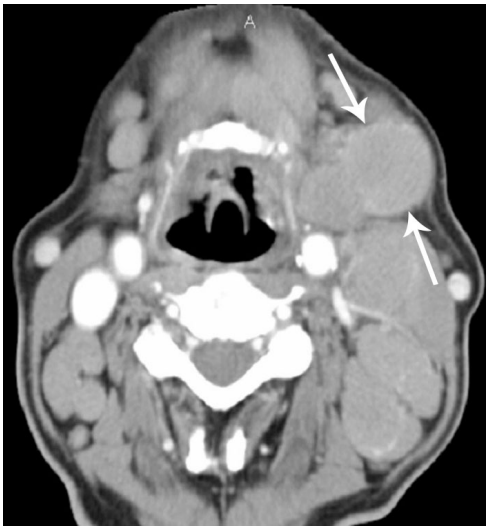

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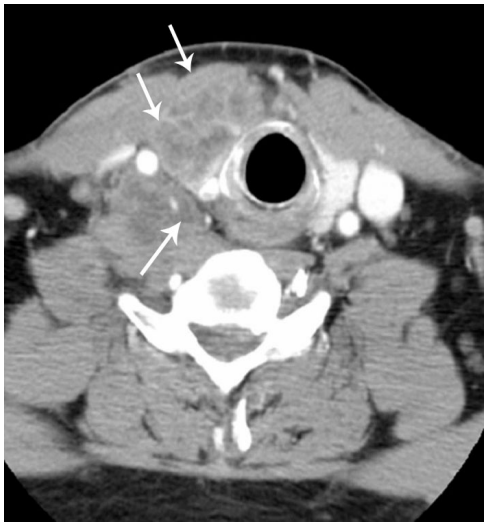


Figures 3–4. **(3) (A) Groups VII and VIII are the sublingual and retropharyngeal nodes. The sublingual nodes are not specifically accessible by cross-sectional imaging but the retropharyngeal nodes are blind to clinical assessment and dependent on radiologic imaging. Diagram at the level of the posterior pharynx demonstrates retropharyngeal nodes in light blue. (B) CT scan showing low attenuation, necrotic node in the right retropharyngeal region (arrow). (4) (A) Anterior cervical nodes (IX). This consists of superficial and deep components. The superficial group is along the anterior jugular vein and the deep group consists of the pre-laryngeal, pre-tracheal, pre-thyroid, and paratracheal nodes. (B) CT scan showing lymphadenopathy including the anterior jugular region (arrow) in a patient with lymphoma. (C) CT scan demonstrating numerous deep nodes along the thyroid gland from metastatic disease.**

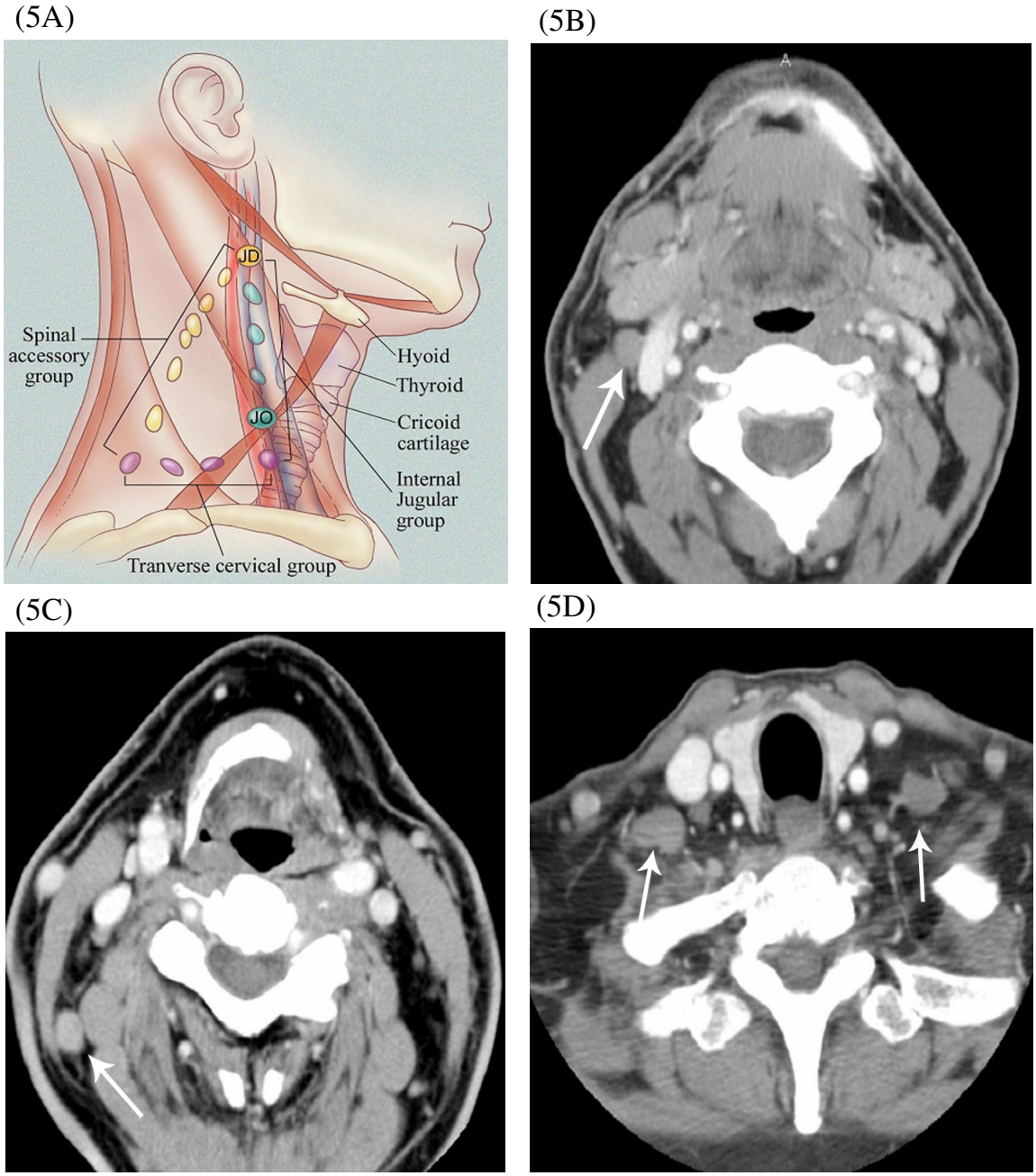
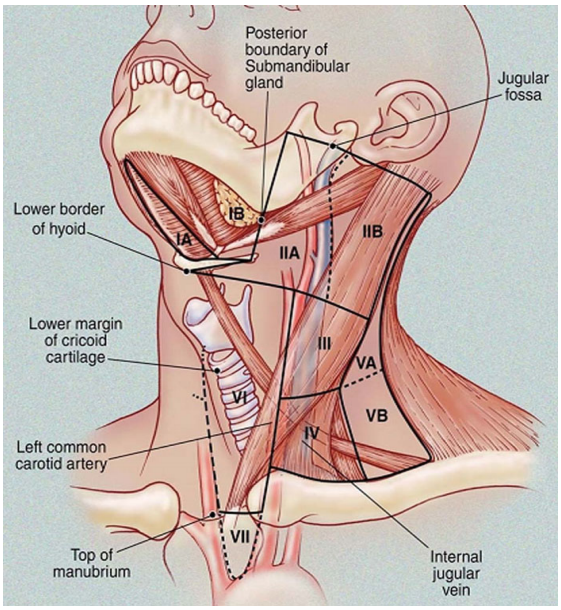


Figure 5. **(A) Lateral cervical nodes (X). The lateral cervical nodes are composed of three chains: the spinal accessory chain in the posterior triangle of the neck, the internal jugular chain along the internal jugular vein, and transverse cervical chain along the base of this triangle. The internal jugular chain represents the major site of metastatic disease for head and neck primary tumors. JD, jugulodigastric node; JO, juguloomohyoid node. (B) CT scan showing node (arrow) seen just lateral to the right internal jugular vein within the right internal jugular group. (C) Small node seen in the distribution of the spinal accessory group (arrow). (D) Enlarged nodes in the transverse cervical chain at the base of the neck (arrows).**

(6)



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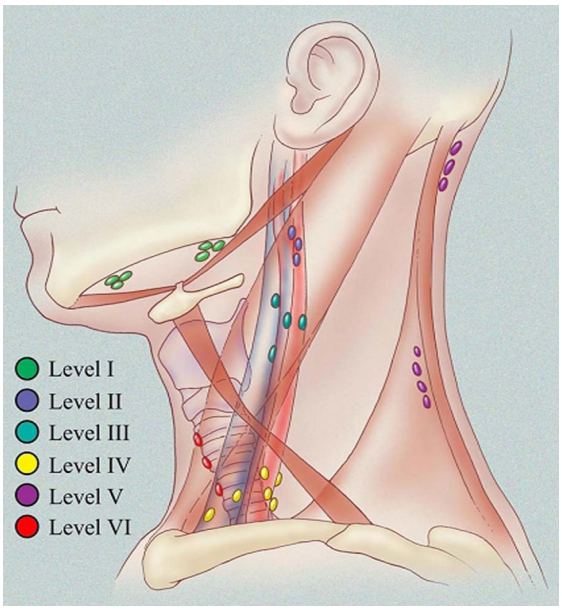

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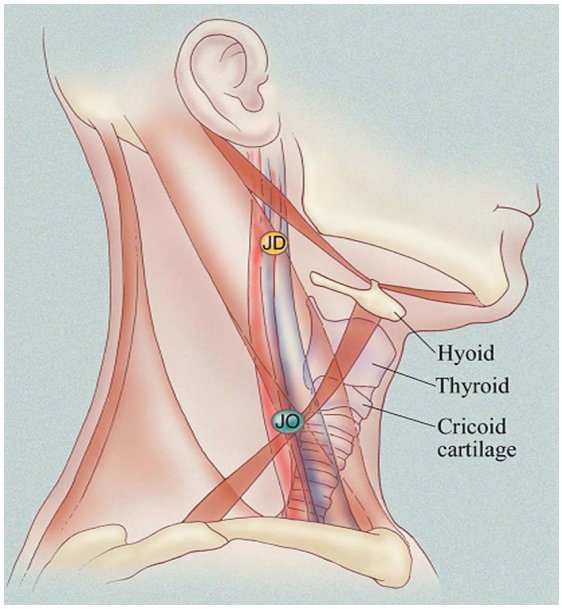
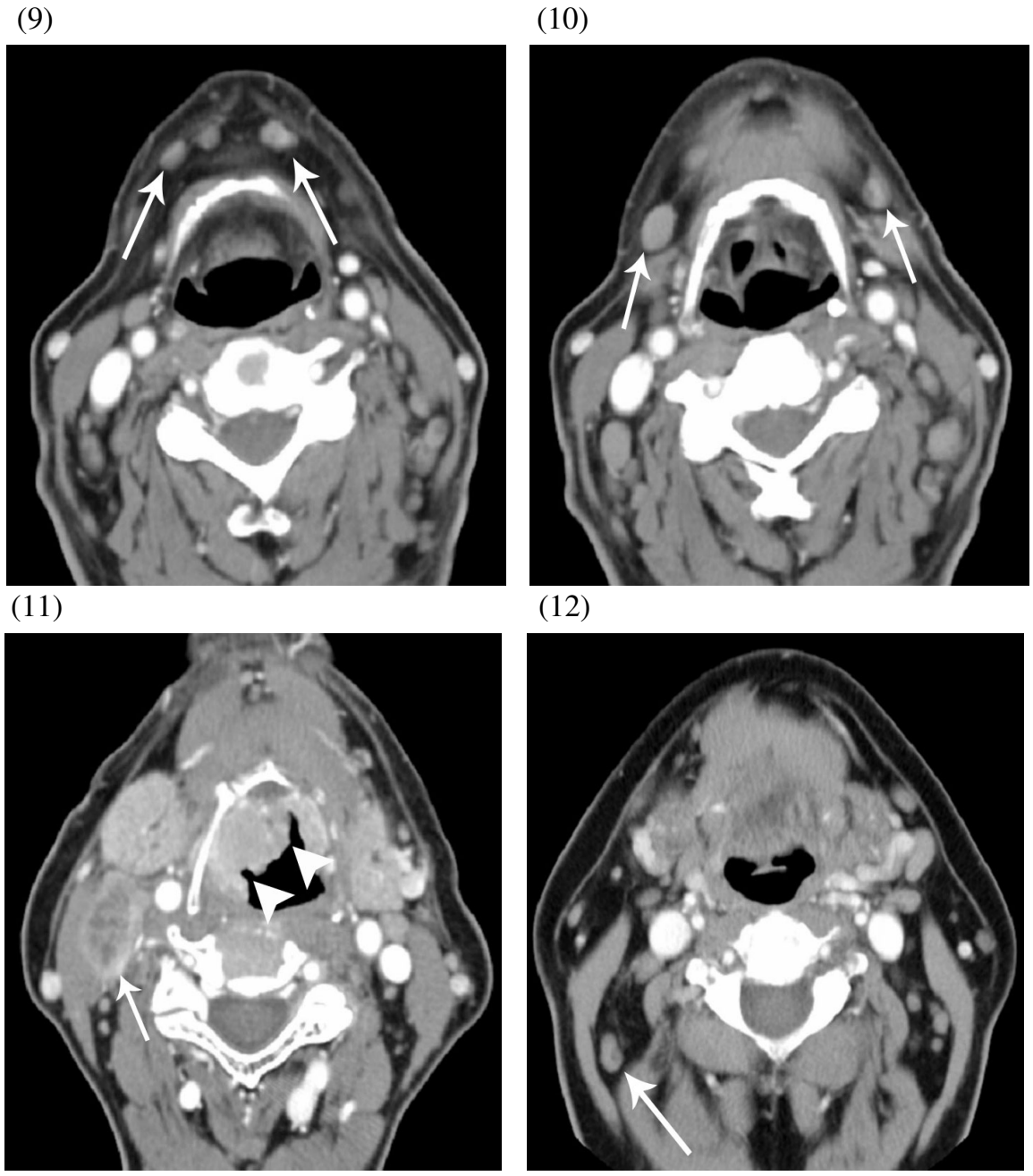
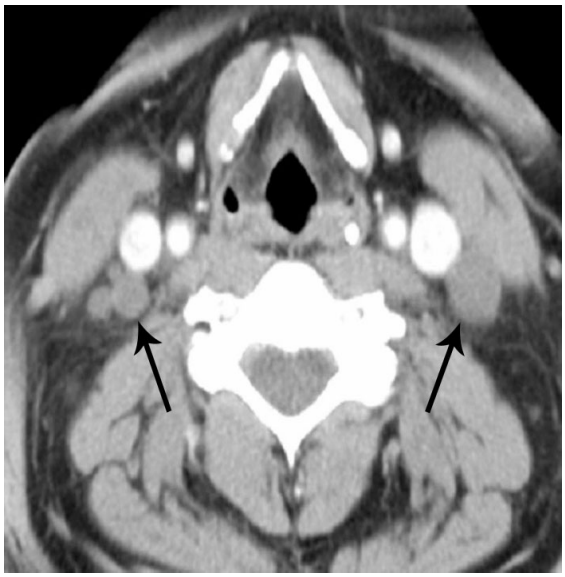


Figures 6–8. **(6) Imaging-based classification of neck nodes as defined in Table 1. These nodes are labeled I–VII with an additional notation of supraclavicular and retropharyngeal nodes. Adapted from: Som and Brandwein[24]. (7) Diagrammatic representation showing the distribution of nodes and their levels. Adapted from: Som and Brandwein[24]. (8) Internal jugular chain nodes. Diagrammatic demonstration of the superior and inferior extents of the internal jugular chain. The largest node superiorly in the internal jugular chain is the jugulodigastric node just posterior to the posterior belly of the digastric muscle. The largest inferior node is the jugulo-omohyoid node which lies along the intersection of the sternocleidomastoid muscle and the omohyoid muscle. Adapted from: Som and Brandwein[24].**



Figures 9–12. **(9) Level IA, submental nodes. CT scan at the level of the hyoid bone showing multiple nodes superficially (arrows). (10) Level IB, submandibular nodes. CT scan at the level of the body of the hyoid demonstrates nodes just lateral to the hyoid bone (arrow). (11) Level IIA, upper internal jugular chain. CT scan at the level of the hyoid bone. Necrotic node in the area of the high internal jugular chain (arrow). Necrotic node is the result of metastasis from pyriform sinus cancer (arrowheads). (12) Level IIB, upper spinal accessory chain. CT scan at the level of the upper neck demonstrating nodes (arrow) which were previously classified as upper spinal accessory nodes in the posterior triangle.**

(13)



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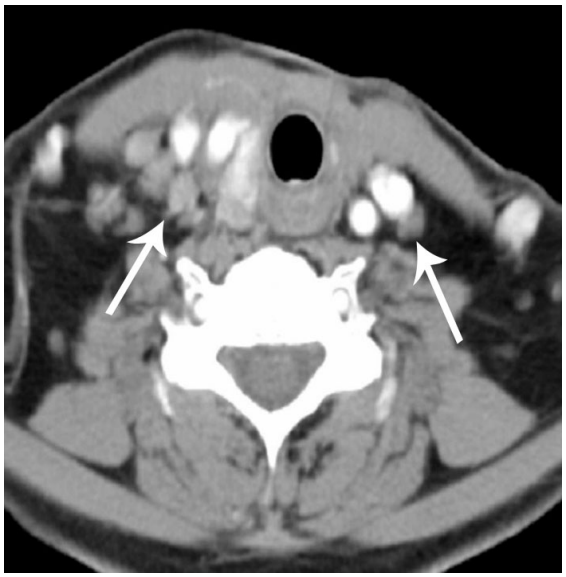

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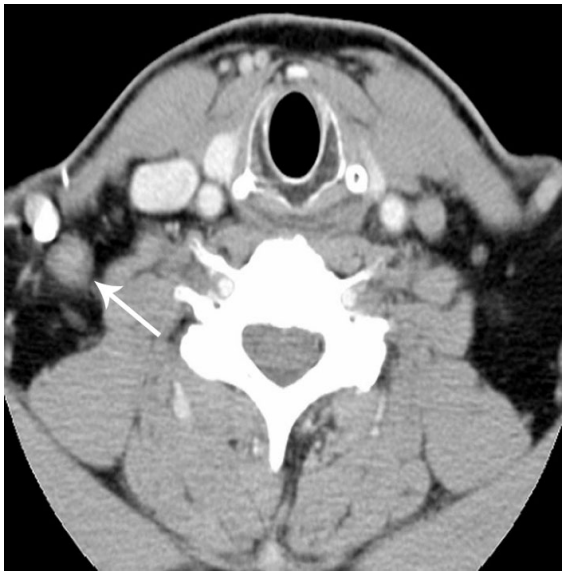

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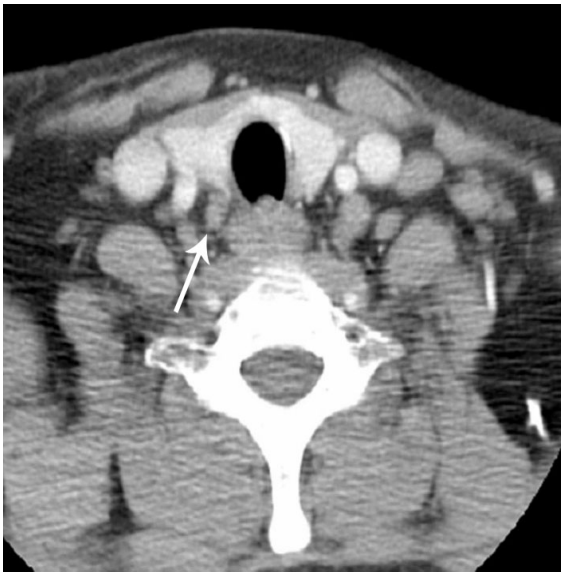
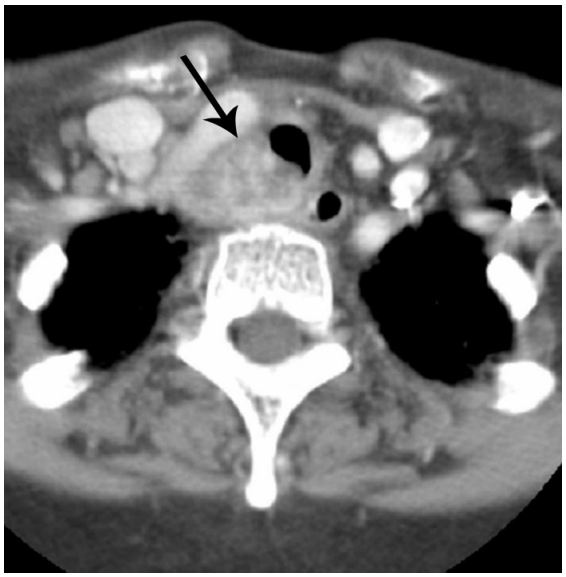
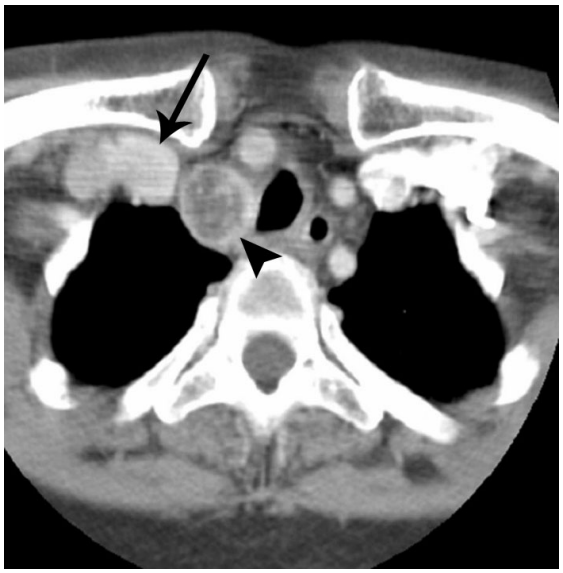


Figures 13–16. **(13) Level III. Nodes previously described as mid-internal jugular chain nodes. CT scan at the level of the mid-internal jugular (arrows). (14) Level IV. Low internal jugular chain. CT scan demonstrating adenopathy in the low internal jugular chain (arrows). (15) Level V. Low spinal accessory chain. CT scan demonstrating node in the low posterior triangle region on right (arrow). (16) Level VI. Nodes previously described as juxtavisceral nodes. CT scan demonstrating small nodes (arrow) along the area of the thyroid gland.**

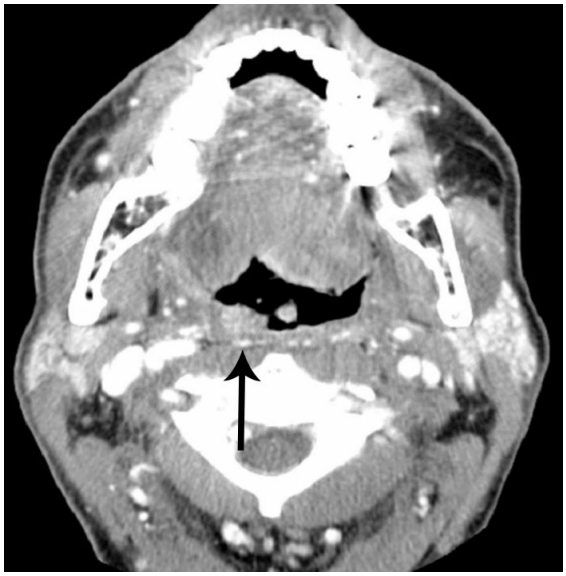
(17)



(18)



(19)



Figures 17–19. **(17) Level VII. Superior mediastinal nodes. CT scan demonstrating nodes in the superior mediastinum from head and neck primary (arrow). (18) Supraclavicular nodes. CT scan at the level of the medial aspect of the clavicles demonstrates an enlarged node in the right paratracheal region (arrowhead) and right supraclavicular node (arrow). (19) Retropharyngeal nodes. CT scan at the level of the base of the tongue demonstrates a small enhancing node in the right retropharyngeal area (arrow), a region blinded to clinical examination because of its location deep to the mucosa.**

In summary, careful analysis of nodes in the neck and knowledge of the various compartments is critical in the assessment and staging of primary head and neck malignancies.

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