Clinical Radiology

The Royal College of Radiologists

Recommendations for cross-sectional imaging in cancer management, Second edition

Head and neck cancers

Faculty of Clinical Radiology

Contents

Head and neck cancers

Clinical background

Cancers of the head and neck mostly arise from the mucosal surfaces of the upper aerodigestive tract (therefore, most are squamous cell tumours). The T-staging which indicates the extent of the primary tumour differs in specific details related to the anatomical site of the primary tumour. The N-staging is uniform for all anatomical sites except for nasopharynx and thyroid because of differing tumour biology and prognosis. The status of regional lymph nodes provides such important prognostic information that nodes should be assessed in detail in terms of location, multiplicity, size, neurovascular involvement and extracapsular tumour spread. Abnormal neck nodes should be described by their anatomical site and classified according to level. These nodal levels conform to surgical landmarks identified at the time of surgical neck exploration.

Magnetic resonance imaging (MRI) is an excellent modality for assessing the soft tissue extent of the primary tumour. Its main advantage is in assessing deep infiltration. Together with the mucosal extent visible on clinical inspection, this is used to determine the T stage. Patients with upper aerodigestive tract tumours may have difficulties with swallowing, coughing and breathing so MRI is sometimes challenging, particularly when imaging the larynx and hypopharynx. There may also be significant degradation of images by susceptibility artefact resulting from previous surgical reconstructions or dental restoration. Sequences are acquired in orthogonal planes with coverage from the skull base to the thoracic inlet, and slice thickness should be a maximum 4 mm. A single protocol may be applied to the staging of most head and neck tumours; although some additional sequences may be required for individual cases (see Table, page 4). Gadolinum is usually used with fat saturation in at least one plane to better define tumour extent, particularly with respect to skull base and perineural extension. In centres where the lymph node status is primarily assessed with other imaging modalities, the protocol may be adapted to focus on the primary tumour. MRI is generally the cross-sectional study of choice for tumours of the suprahyoid neck, although local operational policy will dictate its role in imaging the various tumour sites.

Multislice computed tomography (MDCT) may be used to acquire a rapid, high spatial resolution volume of data. It provides particular benefits in the infrahyoid neck, minimising artefact due to swallowing and movement. MDCT slice thickness is scanner-dependent; however, 1–1.5 mm collimation is generally used with images reformatted at a 2–3 mm thickness. The volume is acquired to cover the superior extent of the primary tumour to the thoracic inlet and the neck should be imaged with arms by the side. The patient should be instructed not to swallow and to breathe gently. Intravenous contrast medium should be always administered (unless allergy or renal function prohibit this). One technique is to use a long bolus (for example, 100 ml at 1 ml/s with imaging commenced at 90–100 sec). CT has the advantage that it may be combined with chest imaging and it is able to detect early cortical bone erosion (such as laryngeal cartilage, mandible or sinonasal). Asking the patient to perform a Valsalva manoeuvre can be useful to demonstrate tumours of the cheek and pyriform sinus.

Values of CT dose index DI_{vol} should normally be below the relevant national reference dose for the region of scan and patient group (see Appendix and Radiation protection for the patient in CT in Section 2).

Ultrasound (US) is an excellent modality for the assessment and surveillance of the cervical nodes. US is cheap, readily available and does not expose the patient to ionising radiation. It can be used to guide fine needle aspiration cytology (FNAC) (including aspiration of small impalpable nodes) and multiple nodes can be aspirated in one visit. It has excellent resolution beyond that of CT and MRI. US also has limitations. It cannot detect retropharnageal, retrotracheal and mediastinal nodes. Correlation with cross-sectional imaging and previous US imaging can be difficult. Both US and FNAC are highly operator-dependent but results improve with experience.

Protocol for imaging of most head and neck cancers

Sequence	Plane	Slice thickness	Field of view	Comments
T1W pre- and post-gadolinium	4 mm	Axial or coronal	Small	Identification of primary tumour and survey of neck for pathological nodes
T1W fat saturation post-gadolinium	4 mm	Coronal or axial	Small	Identification of primary tumour and perineural and skull base involvement
T2W	4 mm	Axial or coronal	Small	Identification of primary tumour (particularly in paranasal sinuses) and survey of neck for pathological nodes
Short tau inversion recovery (STIR)	4 mm	Coronal or axial	Small	Identification of primary tumour and survey of neck for pathological nodes
Others				
Diffusion-weighted imaging (DWI) (echo-planar imaging, EPI)	4–5 mm			Evolving role, particularly for determining tumour treatment response
Sagittal sequences	3 mm			Consider for base of tongue, nasopharynx, paranasal sinuses
Thinner section sequences	3 mm			Dedicated laryngeal imaging
Increased matrix (512 x 512 matrix)	4 mm			Paranasal sinuses (T2 coronal), nasopharynx (post-gadolinium axial)
Volumetric post-gadolinium sequence	N/A			For radiotherapy planning
Magnetic resonance angiography (MRA)	N/A			To delineate arterial involvement

In patients who present with a palpable neck mass, US can be used for FNAC and to diagnose the presence of metastatic neck nodes (and, in those with an occult primary, initiate the search for the primary tumour).

US can also be used in the assessment of the clinically N0 neck or the clinically negative contralateral neck, in patients with ipsilateral nodal disease, as well as surveillance of the neck following treatment.

The specificity of US FNAC for neck nodes is very high.[1–4] The sensitivity is dependent on the criteria used in the assessment. In the clinically N0 neck, the 1 cm short axis size criterion has a poor sensitivity for the detection of nodal metstases.[5] Taking account of shape, contour, echogenicity, grouping, internal architecture, necrosis and pattern of Doppler vascularity enhances the accuracy of US for nodal metastases to greater than 90%.[6]

FDG PET-CT is effective for imaging head and neck cancer. It is highly specific for detecting squamous cell carcinoma of the head and neck and more sensitive than CT and MR for detecting small malignant lesions. In up to 30% of patients,[7] FDG PET-CT identifies primary

tumours not detected on usual assessment, including flexible fibre optic naso-endoscopy (FFO), CT and MRI. The majority of these are in the tongue base; the reason being MRI and CT are less sensitive in this area compared with FDG PET-CT. A second major advantage of FDG PET-CT is that, as a single investigation, it can accurately identify patients with disseminated disease and obviates the need for multiple scans for complete and accurate assessment of the full extent of disease. It should be considered before embarking on treatment with curative intent in patients with a high risk of disseminated disease and this includes patients who present with primary head and neck tumours likely to be associated with widespread disease such as the nasopharynx, patients who present with advanced loco-regional disease (T3/4, N2/3) and patients with recurrence. There is growing evidence that FDG PET-CT may be the most accurate method of response assessment when performed three to six months' post-chemoradiotherapy in patients with residual masses following treatment. A further advantage of FDG PET-CT is its ability to more accurately diagnose recurrence compared with CT and MR. It should be used in patients with clinical suspicion of recurrence where a clear diagnosis

cannot be established by usual means. There are two other areas where FDG PET-CT can be effectively used. To confirm the nature of lymph nodes which are suspicious of being cancerous and not accessible to US FNAC or when US FNAC results are equivocal to confirm the nature of indeterminate lesions that cannot be characterised on standard assessment; for example, pulmonary nodules.

In the head and neck, mis-registration of CT to PET even when slight can cause confusion between FDG uptake due to normal structures and FDG uptake due to pathology. Careful correlation of FDG to CT is required to distinguish FDG uptake in brown adipose tissue (brown fat) and skeletal muscle from FDG uptake within lymph nodes and other structures when there is mis-registration. Brown adipose tissue and skeletal muscle FDG uptake can be minimised by providing a relaxed and warm environment for the patient during their visit for PET-CT. Head and neck FDG PET-CT should ideally be acquired with arms on the side of the body to avoid artefact from the arms.

Imaging should always be performed before any biopsy, if possible.

Nasopharynx

Clinical background

Cancer of the nasopharynx has an increased prevalence in patients from Southern China where it is consistently associated with high levels of Epstein-Barr virus antibodies.[8] The incidence of nasopharyngeal cancer has remained relatively stable in England between 1990 and 2006. Age standardised rates (per 100,000 population) vary from 0.65 in South East London Cancer Network to 0.21 in Humber and Yorkshire Coast.[9] Nasopharyngeal carcinoma may present late, often with lymph node metastases which can be bilateral and are often present in the retropharyngeal space posterior upper deep cervical (level 2) and posterior triangle (level 5). The presence of pathological nodes in the supraclavicular fossa (low level 4 and 5) confers a poor prognosis (N3). Tumours usually arise in the Fossa of Rosenmuller and often spread submucosally and deeply. Distant metastases in lung, bone and liver are seen more frequently than in most squamous cell cancers of the head and neck. Many cases are detected on routine scanning for non-specific nasal or otalgic symptoms. Radiotherapy, with or without chemotherapy, is the mainstay of treatment and imaging is designed to evaluate patients for this.

Who should be imaged?

MRI is the imaging modality of choice for all patients with suspected nasopharyngeal cancer. CT is often performed as the initial investigation for non-specific sinonasal symptoms. If this demonstrates advanced disease, no further imaging is required. FDG PET-CT is being increasingly used at initial staging to detect metastatic disease and for characterising lesions including lymph nodes and lung lesions, which cannot be characterised by usual assessment. FDG PET-CT is more accurate than CT and MR for detecting recurrence.

The aim of imaging is to document the local extent of the tumour, particularly perineural spread (commonly mandibular division V3) erosion into the skull base, and the presence and extent of nodal metastases and distant metastases. The stage of the disease can significantly alter the choice of radiotherapy technique used. The TNM staging system has been modified to take account of the additional information now available from MRI scanning, and it should be noted that CT generally overstages nasopharyngeal cancer compared to MR.

Staging objectives

- To identify extent of local tumour.
- To identify extent and distribution of lymph node and distant metastases.
- To identify organs at risk for radiotherapy damage.

Staging

MRI
T-staging is best achieved with imaging in multiple planes. Gadolinium-enhanced scans with or without fat suppression, is recommended for demonstration of perineural spread. A combination of axial and coronal imaging is usually required for full assessment and treatment planning. The area from the skull base (top of clinoids) down to supraclavicular fossa should be included in the examination.

CT
Contrast-enhanced CT is not as accurate as MRI for assessing the soft tissue extent of the tumour (T-staging). CT is used to stage metastatic disease and may detect subtle cortical bone involvement at the skull base.

Using MDCT, slice thickness will depend on scanner capability. In general, sections are acquired at 1.25–2.5 mm and reformatted no greater than 3 mm for viewing.

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Reassessment imaging should be performed 3–6 months following completion of radiotherapy. It is advisable to use the same technique employed

for initial staging at follow-up, although there is growing evidence that FDG PET-CT may be the most accurate method of response assessment when performed three to six months' post-chemoradiotherapy in patients with residual masses following treatment. Further imaging follow-up usually depends on disease status and clinical symptoms.

Tips

- The nasopharynx may not revert to normal following radiotherapy. Residual soft tissue effacement is generally seen even after successful treatment.

- US with guided FNA is useful to investigate non-enlarged neck nodes in patients who are to receive focused treatment such as intensity-modulated radiotherapy (IMRT) that will spare these regions.

- FDG uptake is seen in the midline on the normal posterior nasopharyngeal wall due to infection within a Thornwald cyst.

- FDG uptake is seen in prevertebral muscles; the linear appearance helps distinguish FDG uptake due to prevertebral muscle from an FDG-avid prevertebral node.

Larynx

Clinical background

Squamous cell carcinoma of the larynx is the most common head and neck cancer, but its incidence is falling.10 The diagnosis is usually known before imaging referral. The role of imaging is to assess submucosal, paralaryngeal spaces, extalaryngeal spread and cartilaginous framework. Vocal cord fixation upstages all tumours to T3 classification. This is assessed clinically. Cartilage invasion is often clinically occult but upstages tumours to T3 or 4 depending on depth of invasion. Imaging is more accurate than clinical staging and has a major role in directing the choice of primary treatment.

The lymphatic drainage of the larynx is complex. It depends on the site of the tumour and the depth of invasion. The glottis has a very sparse lymphatic network whereas the supraglottic and subglottic larynx both have very rich lymphatic networks. Contralateral nodal involvement is common but it should be noted that midline nodal disease is considered unilateral.

Who should be imaged?

The diagnosis of laryneal cancer is made on laryngoscopy. The contribution of imaging is to complement endoscopy by assessing the presence and volume of paraglottic spread, the cartilages, the subglottic space and the tongue base.

Cross-sectional imaging is recommended for T2 lesions or above. Lower stage tumours may not be detectable on imaging, but imaging may be indicated where clinical assessment is difficult, or early subglottic disease or involvement of the anterior commissure is suspected.

CT is generally preferred as the imaging technique of choice because of speed of acquisition and patient tolerance. MRI is the best technique for assessing pre-epiglottic space and tongue base invasion. MRI is helpful at demonstrating cartilage involvement when CT is indeterminate. FDG PET-CT is usually only considered in patients with advanced loco-regional disease for detecting distant metastases.

It is also used to characterise the nature of abnormal lymph nodes and indeterminate visceral lesions including in the lungs when they cannot be characterised by usual assessment. FDG PET-CT is more accurate than CT and MR for distinguishing recurrent disease from laryngeal oedema due to radiotherapy.

Staging objectives

- To identify extent of local tumour and volume of paraglottic disease.
- To identify extent and distribution of lymph node metastases.
- To identify evidence of cartilage invasion.

Staging

CT
Using MDCT, slice thickness will depend on scanner capability. In general, sections are acquired at 0.625–1.25 mm and reformatted no greater than at 2.5 mm for viewing. Scans should be performed during quiet respiration with arms down by the patient's side. The patient should be instructed not to swallow during data acquisition which lasts only a few seconds.

MRI
MRI is useful in specific situations such as assessing possible pre-epiglottic space and tongue base invasion, and possible early cartilage invasion. Degraded images from swallowing motion artefacts are a problem that occurs particularly in patients whose airways are compromised by tumour. A combination of axial, sagittal and coronal T1W and T2W sequences may be required to assess the region of the larynx in question. Contrast medium enhancement with spectral fat suppression is useful for evaluating the extent of soft tissue involvement and cartilage invasion. Slice thickness of 3 mm is recommended for the assessment of laryngeal cartilage.

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Imaging three to four months after completion of radiotherapy is useful in documenting tumour response and serves as a baseline for future comparisons. The same imaging technique should be used as for the pretreatment evaluation.

Tips

- Swallowing artefact and cord palsy can both mimic tumour. Repeating the study immediately is possible without the need for further contrast administration if it is apparent that the images are degraded by swallowing artefact.

- It is essential to scan and or reformat the larynx in the correct plane to avoid misinterpretation.

- Patients are advised not to talk during the period between the administration of FDG and imaging to minimise FDG uptake in the normal intrinsic laryngeal muscles, including vocalis, crico-arytenoid and interarytenoid muscles; symmetrical FDG uptake is usual but uptake may occasionally be asymmetric and normal. Palsy of the left recurrent laryngeal nerve results in no FDG uptake in the left intrinsic laryngeal muscles and FDG uptake is present only in the right intrinsic laryngeal muscles; this pattern of FDG uptake should not be mistaken for pathology. Injection of vocal cords with Teflon and collagen for treatment of vocal cord palsy results in a granulomatous reaction and in intense and focal vocal cord FDG uptake.

- Following radiotherapy, FDG PET-CT should ideally not be carried out for at least eight weeks following completion of treatment. Up to about 12 weeks following radiotherapy, oedematous mucosa shows mild diffuse FDG uptake and this should not be mistaken for residual disease. The neck usually shows no FDG uptake more than eight weeks after radiotherapy.

Paranasal sinuses

Clinical background

Tumours of the paranasal sinuses are the least common (3–4%) of all head and neck malignancies.[11] They are often advanced tumours at presentation and hence have a generally poor prognosis. Early disease often presents clinically as infection and may well have co-existent inflammatory change visible on imaging. The majority (80%) are squamous cell tumours and the maxillary antra are the most common sites of involvement.[12] Other tumour histologies suggest minor salivary gland origin. Tumour spread is by direct infiltration and by perineural extension. Bone destruction is common. In contrast to other head and neck tumours, lymph node spread is uncommon. Distant spread is also uncommon (10%) and, when present, involves spread to the lungs and bones. Treatment for paranasal sinus tumours is usually a combination of primary surgery and adjuvant radiotherapy. The main cause of treatment failure is local recurrence.

Who should be imaged?

Imaging is indicated in all patients with biopsy-proven paranasal sinus cancer. A combination of CT and MRI is generally required for complete staging before treatment. CT is often performed as the initial investigation for non-specific symptoms. If advanced disease is demonstrated, which is not appropriate for surgical management, no further imaging is required. CT provides the detail regarding the bone margins of the sinus at risk, while MRI yields important information about the extent of soft tissue and perineural spread. The radiologist should be familiar with the pathways of spread and those critical areas of potential tumour spread that influence operability and the choice of surgical technique. Images should be reviewed in sagittal and coronal planes in addition to axial plane. Paranasal sinus squamous cell cancers are usually visualised on FDG PET-CT. Notwithstanding, FDG PET-CT is not routinely required for staging. It is applied in patients with extensive disease at the primary site when the precise local extent of disease needs to be determined for planning treatment. It is also used in patients with suspected disease recurrence and usual cross-sectional imaging has not provided sufficient clinical information or certainty.

The role of imaging is to help plan the surgical approach and to define the radiation fields subsequently. The anatomy is complex and an interactive review of imaging in multidisciplinary team (MDT) meetings is recommended before surgery.

Staging objectives

- To determine extent of local tumour.
- To identify evidence of perineural spread.
- To identify evidence of skull base invasion.
- To identify lymph node metastases.

Staging

CT
Axial sections of 2–3 mm using spiral technique following injection of intravenous contrast medium through the skull base and primary tumour. Using MDCT, slice thickness will depend on scanner capability. In general, sections are acquired at 1.25–2.5 mm and reformatted no greater than 3 mm for viewing. Axial sections are obtained through the whole neck to assess lymph nodes. Coronal reformatted images are useful for pre-surgical planning.

MRI
MRI is best for assessing skull base invasion, soft tissue intracranial extension and perineural spread.

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Routine follow-up three to four months after completion of treatment is useful for establishing a baseline for future comparison. MRI is more helpful than CT, and evaluating radiologists

should be familiar with the expected post-surgical changes.

Tips

- Differentiation of tumour from retained secretions can be difficult, and is best achieved with contrast-enhanced MRI.

- The pterygopalatine fossa should be carefully assessed. Replacement of fat by tumour at this site can alter management and make the tumour inoperable.

- Retained secretions show mild FDG uptake in contrast to malignant tumour which shows intense FDG uptake.

Hypopharynx

Clinical background

The hypopharynx extends from the hyoid bone superiorly down to the postcricoid region inferiorly. It includes the posterior pharyngeal wall, the pyriform sinuses and the postcricoid region. Over 95% of tumours arising here are of squamous cell type.[13] Bulky submucosal spread is typical (resulting in clinical understaging at endoscopy) and the majority have lymph node metastases to the neck at presentation. Definitive treatment may involve surgery or radiotherapy.

Who should be imaged?

All patients with biopsy-proven hypopharynx cancer should be imaged. Multi-slice intravenous contrast-enhanced CT or MRI pre- and post-gadolinium enhancement is used to assess primary tumour extent and size. FDG PET-CT is useful for confirming the extent of the primary site and especially the inferior extent of the primary site in postcricoid cancers and for re-staging post-treatment disease recurrence.

Staging objectives

- To determine extent of local tumour.
- To identify evidence of midline involvement.
- To identify evidence of cartilage invasion.
- To identify lymph node metastases.
- To identify involvement of apex of pyriform sinus.

Staging

CT
Using MDCT, slice thickness will depend on scanner capability. In general, sections are acquired at 0.625–1.25 mm and reformatted no greater than at 2.5 mm for viewing. Scans should be performed during quiet respiration with arms down by the patient's side. Instruct patient not to swallow during data acquisition which lasts only a few seconds.

MRI
MRI is useful in specific situations such as possible early cartilage invasion. Degraded images from swallowing motion artefacts are a problem that occurs particularly in patients whose airway is compromised by tumour. A combination of axial, sagittal and coronal T1W and T2W sequences may be required to assess the region of the hypopharynx in question. Contrast medium enhancement with spectral fat suppression is useful for evaluating the extent of soft tissue involvement and cartilage invasion. Slice thickness of 3 mm is recommended for the assessment of laryngeal cartilage.

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Follow-up imaging two to three months after treatment is useful to establish a baseline for future comparison.

Tip

- Remember to assess retropharyngeal nodes in patients with tumours involving the posterior wall of the hypopharynx.

Salivary glands

Clinical background

The major salivary glands are the three-paired parotid, submandibular and sublingual glands. Generally, the smaller the salivary gland, the more likely it is that any tumour arising within it will be malignant. Tumours in the parotid glands arise from a variety of tissue elements, but superficial lobe tumours are more likely to be benign, while deep lobe tumours are often malignant. Malignant parotid tumours tend to be painful, rapidly growing and associated with facial nerve paralysis. The most common benign parotid tumours are the pleomorphic adenoma (usually solitary) and Warthin's tumour (frequently multiple and bilateral). Mucoepidermoid and adenocystic carcinomas are the most common malignant tumours. Lymph node spread is less common than with other head and neck tumours, and distant spread is usually to the lungs. Perineural spread is seen in adenoidcystic carcinoma with potential extension through the skull base. The parotid has a rich network of lymphatic vessels and intra-parotid nodal involvement is often the site of metastatic disease, particularly from scalp tumours. Parotid nodal enlargement may also be seen in lymphoma. Treatment of malignant disease is usually a combination of surgery and adjuvant radiotherapy.

Who should be imaged?

All patients with biopsy-proven or suspected salivary gland tumours require imaging with MRI.

Staging objectives

- To determine extent of local tumour.
- To identify lymph node metastases to the neck.
- To identify perineural spread.

Staging

MRI
MRI is the imaging modality of choice for staging salivary gland tumours. The soft tissue resolution and multiplanar imaging are necessary for surgical planning and radiation field planning.

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Follow-up MRI is useful two to three months after completion of treatment to establish a baseline for future comparison.

Tips

- Intraparotid lymph nodes can mimic primary salivary tumours on imaging.
- Tumour characterisation is usually not required for management.
- The normal salivary glands usually demonstrate modest and diffuse FDG uptake. Intense symmetrical FDG uptake is usually associated with sequelae of systemic treatment.
- Intraparotid lymph node enlargement due to other malignancies such as lymphoma is clearly shown on FDG PET-CT.
- Benign salivary gland tumours such as pleomorphic adenoma and Warthin's tumour are FDG-avid.
- Recurrent disease can be difficult to diagnose on FDG PET-CT and especially to detect perineural infiltration and when there are islands of recurrence within treatment sequelae.

Oral cavity and oropharynx

Clinical background

Squamous cell tumours are the most common histological subtype of tumours of the oral cavity and oropharynx and are associated with tobacco and alcohol exposure.[14] The incidence of these tumours rose in England between 1990 and 2006. The cause for this in oropharyngeal tumours is thought to be due to human papilloma virus (rather than alcohol and/or tobacco) which is affecting a younger population group.[15] Staging systems are based more on superficial tumour size than on depth or extent, although it is the depth and site of invasion that determines the primary therapeutic approach. Tumours may arise from oral cavity subsites (lip, floor of mouth, retromolar trigone, oral tongue, hard palate, gingival or buccal mucosa) and oropharyngeal subsites (tongue base, vallecula, soft palate, posterior wall and tonsillar fossa/pillars). The lips, floor of mouth, retromolar trigone and ventrolateral tongue are the most frequent oral cavity tumour sites, whereas the anterior tonsillar pillar is the most frequent oropharyngeal tumour site. These tumours often demonstrate well-defined patterns of spread. Occult tonsillar and base of tongue carcinomas are common sources of metastatic lymph nodes in the setting of an 'unknown primary'.

Depending on anatomical site, surgery and radiotherapy may be used alone for low-stage tumours while combined modality therapy (surgery, radiotherapy or chemotherapy) is required for higher stage tumours. Tissue reconstruction is often required following surgery for larger lesions.

Who should be imaged?

Imaging is performed in clinically detected cancers to determine deep extension, invasion of adjacent structures as well as nodal and metastatic spread.

Staging objectives

- To determine dimensions and volume of local tumour.

- To identify evidence of deep invasion particularly of the extrinsic tongue muscles and submandibular space (oral cavity tumours) or masticator space and prevertebral space (oropharyngeal tumours).
- To identify evidence of bone invasion of the mandible (where cortical and marrow involvement should be distinguished) and maxilla.
- To identify lymph node metastases to the neck.

Staging

CT
CT may be used as the primary imaging modality and frequently provides the answers to the important clinical questions. It is superior in detecting early cortical bone involvement and may be combined with chest imaging. Unfortunately it may be degraded by artefact from dental restoration. CT is performed with intravenous contrast enhancement from the skull base to the thoracic inlet. Around 1–1.5 mm collimation is generally used with a field of view of 16–20 cm. Images are reformatted at a 2–3 mm thickness and frequently viewed in multiple planes. Asking the patient to perform a Valsalva manoeuvre can be useful to demonstrate buccal tumours. Bone windows are required to inspect for cortical bone invasion of the facial skeleton. Cone beam CT may also be used to specifically address this issue.

MRI
MRI may be used as the preferred imaging modality or for problem-solving following a CT study. It is superior in the detection and delineation of these tumours and better demonstrates perineural spread and mandibular marrow involvement. The images may be degraded by artefact from swallowing and that from metallic implants. Images should cover the neck and the primary site.

PET-CT
The normal palatine tonsils are almost always identified on [18]FDG PET-CT, show uptake of [18]FDG which decreases with age. There is an

overlap between these physiological appearances and uptake observed in primary malignancy, but asymmetrical uptake (in the absence of a tonsillectomy) in the correct clinical context should raise suspicion. [18]FDG PET-CT may be useful for nodal staging. Intense uptake of [18]FDG can be observed in inflammatory conditions.

Follow-up

Follow-up imaging maybe performed 3–6 months after completion of treatment to establish a baseline for future comparison. This is particularly relevant following complex soft tissue reconstructions and following radiotherapy for larger tumours. There is no consensus for the role of surveillance imaging, and subsequent imaging follow-up depends on disease status and clinical suspicion. Radiologists should be aware of expected post-treatment appearances.

Tips

- Changes secondary to diagnostic biopsy, normal mucosal and lymphoid enhancement, together with bulky or irregular lymphoid tissue, may mimic tumour in the oral cavity and oropharynx.
- Superficial mucosal tumours can be difficult to visualise.
- Use the fat planes on CT and T1W MR imaging to help detect and delineate tumour.
- The orthopantomogram is an important complementary imaging technique for assessment of bone involvement of the mandible. It is also useful to demonstrate dentition, and the size and configuration of the mandible for resection and reconstruction planning.
- Intense uptake of FDG due to inflammatory conditions such as dental abscesses and caries should not be mistaken for mandibular involvement.
- Extensive FDG uptake in normal intrinsic muscles of the tongue such as due to gum chewing and tardive dyskinesia mimic pathology.
- FDG uptake in intrinsic muscles of the floor of the mouth including the mylo-hyoid muscle which extends from the genu of the mandible to the hyoid bone is often seen and is distinguished by their linear appearance from malignancy – a distinction that requires special consideration in the post treatment patient.
- Following radiotherapy, atrophy of the intrinsic muscles of the tongue results in asymmetric FDG uptake in the floor of the mouth.
- FDG uptake, which decreases with age, is seen in lymphoid tissue within Waldeyer's ring including palatine tonsil. Asymmetrical uptake occurs as normal variation but in the correct clinical context and in the absence of an explanation for asymmetric uptake such as tonsillectomy or radiotherapy to one side of the oropharynx, it should raise suspicion of pathology (see also Carcinoma of unknown primary origin).
- FDG uptake seen in the floor of mouth in the vicinity of dental amalgam is most likely due to attenuation correction artefact.

Thyroid cancer

Clinical background

Clinical thyroid cancer is uncommon (0.5% of all cancer deaths),[16] although there is a high frequency of occult tumours identified at post-mortem. Most thyroid cancers are relatively indolent tumours that have a chronic clinical course with infrequent metastatic disease. Papillary cancer is the most common histological type and is more frequent in iodine-rich areas.[17] It is the main cancer induced by radiation exposure in childhood and characteristically has low-grade malignant potential. Lymph node spread is a feature but often remains localised to the nodes without further spread. Distant spread is uncommon and the prognosis is generally excellent. Follicular cancer tends to occur in iodine-deficient areas. Unlike papillary cancer, follicular cancer rarely spreads to the nodes but can metastasise to the lungs, bones and liver. Anaplastic cancer is the most aggressive type with a poor prognosis. Medullary cancer can be sporadic or familial, and the serum calcitonin levels are usually elevated.

Treatment depends on the histological type of tumour. Papillary cancers are treated surgically and radioiodine ablation can only be used postoperatively when all residual thyroid tissue has been removed. Follicular cancers are managed by total thyroidectomy and radioablation. Anaplastic cancers usually require radiotherapy. Medullary cancers are treated by surgery and/or radiotherapy in the early stages with chemotherapy for advanced disease.

Who should be imaged?

Patients with differentiated thyroid cancer are usually diagnosed and staged by ultrasound which is the optimum technique for assessing the nodes as well as the primary tumour. For low volume and early-stage disease, further preoperative imaging is seldom required as surgery is the primary management. MRI or CT scanning is indicated when there is suspicion of extracapsular tumour extension to assess the larynx, trachea and retrosternally into the mediastinum.

MRI is the preferred imaging technique because the iodine contrast used for CT scanning may delay postoperative radioiodine therapy. Non-contrast enhanced CT can be performed to stage pulmonary metastatic disease. FDG uptake is not usually observed in the normal thyroid gland. Well-differentiated thyroid cancer shows high iodine uptake and low FDG uptake. Moderately and poorly differentiated thyroid cancer demonstrate paucity of iodine uptake and high FDG uptake. The predominant indication for the use of FDG PET-CT in thyroid cancer is in patients who have clinical suspicion of recurrence such as elevated serum thyrogobulin and a negative 131-Iodine scan. FDG PET-CT permits the detection and localisaton of non-iodine avid metastases.

Staging objectives

- To determine extent of local tumour.
- To identify lymph node metastases to the neck.
- To identify evidence of metastatic spread.

Staging

MRI
MRI is the preferred imaging of choice for determining the local extent of thyroid cancer. Axial and coronal sequences with gadolinium enhancement are used as for other head and neck tumour sites.

CT
The chest should be staged by CT without intravenous contrast but for patients who are claustrophobic and cannot tolerate MRI, CT imaging with intravenous iodinated contrast enhancement should be performed for staging, while recognising its potential impact on subsequent radioiodine therapy. The entire neck should be scanned to include the supraclavicular fossae and it should be discussed with the referring clinician whether iodine contrast enhancement can be used.

Using MDCT, slice thickness will depend on scanner capability. In general, sections are acquired at 1.25–2.5 mm and reformatted no greater than 5 mm for viewing.

Values of $CTDI_{vol}$ should normally be below the relevant national reference dose for the region of scan and patient group (see Appendix and Radiation protection for the patient in CT in Section 2).

PET-CT
Please see the section on Positron emission tomography CT (PET-CT).

Follow-up

Follow-up MRI is useful two to three months after completion of treatment to establish a baseline for future comparison.

Tips

- Most imaging is performed in the post-surgical setting to detect recurrences in patients with rising serum thyroglobulin.
- Careful review of the retrotracheal and retrosternal regions is required.
- May need to avoid contrast-enhanced CT if radioiodine ablation is under consideration.
- Diffuse increased FDG uptake by the thyroid gland is most usually observed in inflammation (thyroiditis) and not malignancy.
- Incidental focal intense FDG uptake in the thyroid gland usually represents a benign nodule, occasionally an occult primary thyroid malignancy, and very rarely an intra-thyroid metastasis. When focal increased FDG uptake is observed in the thyroid, an ultrasound with or without FNA may be indicated.

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