Imaging modalities in head and neck pathology and trauma

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Imaging modalities

Intraoral radiographs including peri-apical, bitewing and occlusal radiographs are often the only imaging technique required for most dental pathology. Usually, these are performed and reviewed by the general dentist. Intra-oral radiographs have higher spatial resolution (of the order of 20 line pairs per millimeter (lp/mm)) than panoramic radiographs, which have about 5 lp/mm (Boeddinghaus & White, 2008). Small carious lesions and peri-apical radiolucencies that cannot be detected on panoramic radiographs can be detected on intra-oral radiographs because of this higher resolution.

Dental panoramic tomography is a specialized tomographic technique used to produce a flat representation of the curved surfaces of the jaws. It gives an overview of the dentition and shows up generalized pathology such as cysts or generalized periodontitis as well as an assessment of the osseous status of the temperomandibular joint. However, it is subject to geometric distortion, and has relatively low spatial resolution compared to intra-oral radiographs. Lateral and antero-posterior cephalograms are standard extra-oral radiographs performed in a cephalostat using film-screen or digital techniques. They are used for orthodontic assessment and in assessing the dental and skeletal relationships of the jaws, as well as asymmetric deformity (Boeddinghaus & White, 2008).

Multi-detector row computed tomography (MDCT), using 16–64 detector rows, is the current state-of-the-art CT technique. Very thin slice profiles are obtained and data can be presented at equal resolution in any plane including curved planes. Three-dimensional reconstructions and thick, slab-like multi-planar reformats (MPRs) can also be derived from this data. This gives excellent “bone detail” and is the imaging of choice in most maxilla-facial pathology. Assessment of soft tissues including articular disc is possible by using a “soft tissue” reconstruction algorithm. CT may be impaired by beam-hardening artefact from dental amalgam, and it results in a relatively high radiation dose (Boeddinghaus & White, 2008). Cone-beam computed tomography (CBCT) uses a cone-shaped X-ray beam (unlike the fan-shaped X-ray beam used in conventional CT), to acquire projection data via a flat detector during a 360-degree rotation. It results in a lower radiation dose than conventional CT by an order of one magnitude or more (Ludlow et al, 2006). It suffers from significant image noise, and is not suitable for soft tissue assessment. Scanning time is comparable to that of conventional CT (10–40 s). As with conventional CT, the volume data set can be used to create multi-planar and three-dimensional reconstructions. CBCT units are generally smaller
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and cheaper than conventional CT scanners, and the patient sits upright, like in a dental panoramic tomography unit. Using multi-planar reconstructions, lateral and frontal cephalometric images can be produced. Some current CBCT units are also capable of acquiring panoramic tomograms and cephalometric projections directly.

The excellent soft tissue contrast resolution of the MRI makes it useful in the assessment of temperomandibular joint pathology such as internal derangement, effusions, synovitis, erosions and associated bone marrow oedema. It is useful in assessing the extent of soft-tissue invasion by maxillofacial tumors. It provides greater specificity than CT in distinguishing between odontogenic cysts and tumors (Boeddinghaus & White, 2008).

Maxillofacial Trauma

Plain radiographs (occipitomental views) and panoramic radiographs are useful in the initial evaluation of suspected mid-facial and mandibular fractures. CT is an excellent tool for detecting radiographically occult fractures, fractures suspected on the basis of secondary signs such as sinus fluid level and to determine the extent of displacement of fractures prior to surgical reduction and displacement (Boeddinghaus & White, 2008). Nasal bone fractures can be determined clinically or by using plain radiographs. Naso-orbito-ethmoidal fractures require CT for optimal evaluation, particularly of the attachment of the medial canthal ligament (Hopper et al, 2006)

Fig 1: Zygomatic complex fracture. Axial CT image shows a minimally displaced fracture of the zygomatic process of the temporal bone (large arrow). The 3-d reconstruction on the left shows displacement well and reveals the orbital floor fracture but is less sensitive for showing
fracture line on zygomatic process (Boedinghaus & White, 2008).

Mandibular fractures are common. They may be subtle or inapparent on panoramic tomography. Condylar fractures are frequently bilateral or associated with a contralateral body fracture. Fractures of the condylar neck or head can result in a characteristic post-traumatic deformity and are often best detected by a CT scan. Frontal sinus fractures are best assessed using CT scans particularly so as one-third of fractures involve the inner table and thus extend intra-cranially.

Head Injury

CT scanning is the first imaging technique to be used after head injury. Using CT scalp, bone, extra-axial hematomas and parenchymal injury can be demonstrated. Magnetic resonance imaging is more sensitive for all posttraumatic lesions, except skull fractures, but scanning time is longer, and the problem with the monitoring of patients outside the MRI field is present. If CT does not demonstrate pathology adequately, MRI is warranted. Follow-up is done best with MRI, as it is more sensitive to parenchymal changes (Besenski, 2007).

Cervical Injury

Conventional imaging (Harris & Mirvis, 1996; Eustace, 1999) can be used which is essentially antero-posterior, lateral, oblique and open mouth views. A technically sound lateral cervical X-ray should include all seven cervical vertebrae and T1 to T4 (thoracic vertebrae). CT including 3 dimensional reformats can be used for confirming diagnosis. Disc herniation and cord compression are better detected with MRI
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Fig 2: Multiple in-driven bones with retained shell fragments with diffuse edema and pneumocephalus (arrow) in case with penetrating type of open head injury (Besˇenski, 2007).

Cysts of the maxilla and mandible

The common cysts of the jaw such as the radicular, residual and dentigerous cysts can be detected using panoramic radiographs. Relationships of cysts or associated impacted teeth with the inferior alveolar canals are best assessed using CT scans.

![Dentigerous cyst](image)

Fig 3. Dentigerous cyst (white arrows) related to an unerupted mandibular third molar, shown on a panoramic reconstruction from a CT of the mandible. Note the mild inferior displacement of the inferior alveolar canal (black arrowheads) by the cyst (Boeddinghaus & White, 2008).

The odontogenic keratocyst can have thick cheesy contents due to desquamated keratinizing squamous cells. These contents can occasionally increase the radiographic attenuation of the lesion at CT, but this is not appreciable on panoramic radiographs.
Imaging of odontogenic tumors

Most odontogenic tumors appear as cysts and are found on routine radiography mostly panoramic radiographs. MDCT has the advantage over CBCT of demonstrating soft-tissue detail. This allows detection of dense keratin debris in keratocystic odontogenic tumours (see Fig. 4) and allows distinction between cysts and solid tumours. The extent of a lesion’s relationship to teeth, root resorption, internal structure, cortical expansion and erosion, the boundary of a lesion and the presence of multiple lesions can all be evaluated. MRI further increases the specificity in diagnosis by allowing distinction of solid and cystic lesions on the basis of signal characteristics. The keratin-rich debris in a parakeratinising type of odontogenic keratocyst shows characteristic central drop in signal on MRI images (Janse Van Rensburg et al, 2003). It is difficult to distinguish an ameloblastoma from an odontogenic keratocyst or other odontogenic lesions by plain radiography and CT. Ameloblastoma is better diagnosed with an MRI and features such as multilocularity, mixed solid and cystic components, mural and septal enhancement, irregular thickened walls and papillary projections are better appreciated (Janse Van Rensburg et al, 2003).
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Imaging of acute maxillofacial infection

Intraoral peri-apical X Rays and panoramic radiography provides excellent visualization in dental infections, but for optimal evaluation of complicated maxillofacial infections such as Ludwig’s angina with involvement of bilateral and multiple facial spaces CT imaging (optimally post-contrast MDCT) is preferable (Bridgeman et al, 1995).

Imaging for acute osteomyelitis and osteoradionecrosis

Bone density has to be reduced by 30-50% before it becomes visible on plain radiographs and this takes 2 to 3 weeks. CT (CBCT or MDCT) can better show cortical lysis, sequestrate, periosteal new bone formation. Multiple studies show high sensitivity for MRI in detecting cancellous bone marrow abnormalities. Mixed sclerosis and lysis, pathological fractures, gas bubbles, sequestrate were the radiological features seen in established osteoradionecrosis in radiography and CT scans (Hermans, 2003).

Fibroosseous lesions

This group mainly encompasses 3 types of lesions; fibrous dysplasia, cement-osseous dysplasia and cemento-ossifying fibroma. Radiographically, lesions of fibrous dysplasia vary
from radiolucent to radio-opaque, frequently with a ground-glass texture, depending on the
degree of mineralization. The margins of the lesion are frequently ill defined in the jaws
(although usually well defined in other parts). The underlying morphology of the bone is
preserved and this feature helps to distinguish it from a cemento-ossifying fibroma. CT is
useful to assess the precise extent of the lesion in the complex facial skeleton, especially when
there is orbital involvement, or involvement of the neurovascular foramina of the skull (White
& Paroah, 2004). Cemento-ossifying fibroma is focal, round or oval, and often causes
resorption or displacement of tooth roots. It has well defined margins and a thin radiolucent
line, separating the lesion from surrounding bone. The concentric growth pattern also
distinguishes it from FD, the latter tending to expand bone while largely preserving its
morphology (Boeddinghaus & White, 2008).

Joint effusions, erosions, synovitis is well demonstrated with MRI. Long standing internal
disc derangement is seen with MRI and panoramic tomography but is better visualized with
CT scan. Fibrous and bony ankylosis is also diagnosed with CT (Boeddinghaus & White,
2008).

CT angiography is increasingly being used to assess vessels of the neck primarily for free flap
reconstruction following resection and neck dissection for oral carcinoma. PET, which is
regarded as a functional modality, detects lesions by imaging the uptake of the intravenously
injected radioactive glucose analog 2-[18F]-fluoro-2-deoxy-D-glucose (FDG) in metabolically
active tumors. Combined PET/CT superimposes the functional PET data on simultaneously
acquired anatomic CT data. By merging the excellent sensitivity of PET with the spatial
resolution of CT, one can potentially improve tumor localization, especially in patients who
have undergone therapy. Cross sectional imaging and the combination of CT, MRI and
various advances have revolutionized imaging in head and neck oncology (Wippold II, 2007).

Conclusions
There are numerous advances in the field of head and neck imaging that improves our ability
to diagnose and treat patients better. It is however important to keep in mind the maxim “first
do no harm” as radiation can have stochastistic tumour inducing effects.
References

Paroah MJ, editors. Oral radiology. 5th ed. Mosby: St. Louis; Pgs: 485-515