

The panoramic dental radiograph for emergency physicians

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ABSTRACT

Dental emergencies are common reasons for presenting to hospital emergency departments. Here, we discuss the panoramic radiograph (orthopantomogram (OPG, OPT) as a diagnostic tool for the assessment of mandibular trauma and odontogenic infections. In this article, we review the radiographic principles of image acquisition, and how to conduct a systematic interpretation of represented maxillofacial anatomy. The aim is to equip the emergency physician with the skills to use the OPG radiograph when available, and to rapidly assess the image to expedite patient management. Included is a discussion of a number of cases seen in the emergency setting and some common errors in diagnosis.

INTRODUCTION

The panoramic radiograph represents one of the most common plain film radiographic investigations of the oral and facial structures. It is a low-cost, rapidly obtainable imaging modality and a powerful diagnostic tool for maxillofacial trauma and dental emergencies, due to its representation of the jaws and entire dentition.^{1,2}

Maxillofacial and dental emergencies are frequent presentations in the emergency department^{1,3} and can be severe and potentially life-threatening.⁴ As such, it is critical that emergency physicians are well versed in the diagnosis and management of such conditions, including assessment of the panoramic radiograph.^{4,5} Given the unique method of image acquisition, anatomic representation and radiographic artefacts, reporting errors are commonly seen with this form of imaging of the facial skeleton.^{6,7} This article outlines the principles of image acquisition, details the radiographic anatomy and provides a methodical approach to interpretation of the most common maxillofacial emergencies diagnosed using this imaging technique.

METHODS

We performed a comprehensive narrative review of the existing literature regarding panoramic radiography and clinical uses. Research papers were obtained using PubMed, OvidSP and Google Scholar, using the following search terms: panoramic radiograph, dental radiograph, orthopantomogram (OPG), interpretation, anatomy, odontogenic infections, mandibular trauma and CT. Full-text papers were included only if their content yielded significance to the aims of the paper. Details on the methodology are outlined in the online supplementary material.

THE OPG RADIOGRAPH

Structural components

Like all plain film radiographs, panoramic radiography units have two major components: the X-ray tube, which generates radiation; and the film cassette, which receives X-ray beams after passing through the tissues. These two components lie on either side of the patient's head, connected above by a rotating gantry. The unit has additional components used to stabilise the patients head and neck during acquisition of the radiograph, including a chin and forehead rest, notched bite block and lateral head support. Many machines also incorporate light beam markers to aid alignment of the patient's head. **Figure 1** shows a patient positioned for a panoramic radiograph. Patients who are unable to remain still due to behavioural issues or intoxication may not be suitable. Severely kyphotic patients may not be suitable for this imaging modality.

Image acquisition

The process of image acquisition requires the patient to be in a standing or sitting position. As the equipment circles the patient's head, a different part of the maxillofacial region is imaged discretely, with the final radiograph being reconstituted from these individual image sections. The final OPG, therefore, provides a distinct image of structures within a 'focal trough', with all other structures lying outside the selected layer being blurred.⁸ The focal trough is curved and forms the arc of a circle, following the shape of the jaws and extending superoinferiorly from the orbital floor to just below the lower border of the mandible. In this process, only objects within the focal trough remain in focus, while the other maxillofacial structures appear blurred, distorted or not represented in the image.⁹⁻¹¹

Radiographic representation of anatomy

Figure 2 illustrates a typical panoramic radiograph, with important structures labelled. Unlike other forms of plain film imaging, panoramic radiography does not represent a true two-dimensional view of the facial structures. A phenomenon commonly observed is the appearance of a single structure in more than one position. A primary image is formed when the object is located between the rotation centre of the beam and the film. However, some structures located in the midline are intercepted twice by the beam, leading to formation of a double image, with the two images being mirrors of each other, having comparable clarity and magnification.¹² Anatomical structures, which can cause double images, include the cervical vertebrae, hard



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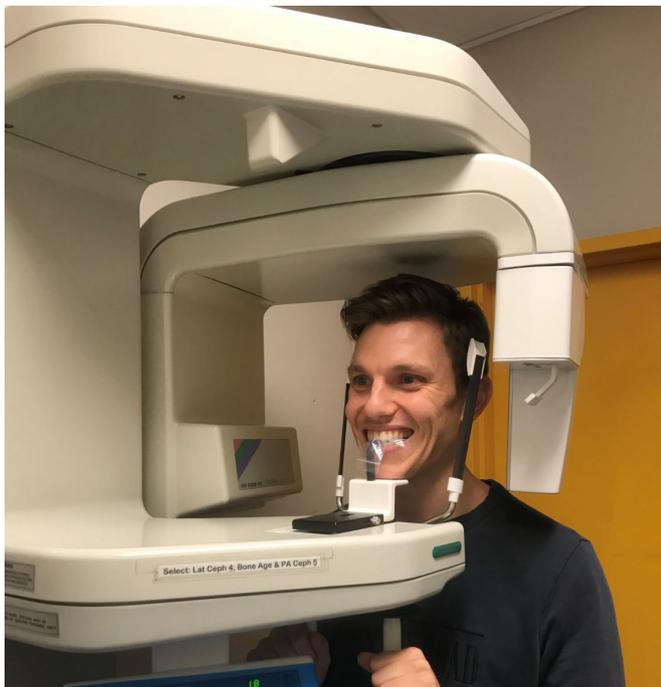


Figure 1 Image illustrates a patient positioned correctly for a panoramic radiograph. Note: the patient may be standing or sitting. Head and neck jewellery should be removed.

palate, soft palate and hyoid bone. This is illustrated in [figure 2](#). Conversely, when the structure is located between the tube head and rotation centre, there can be formation of a secondary or ghost image. This secondary image appears on the opposite side of the film in a slightly superior position, and is magnified and distorted. Anatomical structures which are susceptible to this phenomenon include the posterior and inferior border of the ramus and nasal turbinates.¹³ Head and neck jewellery, such as earrings and necklaces, may also cause ghost images ([figure 2](#)).

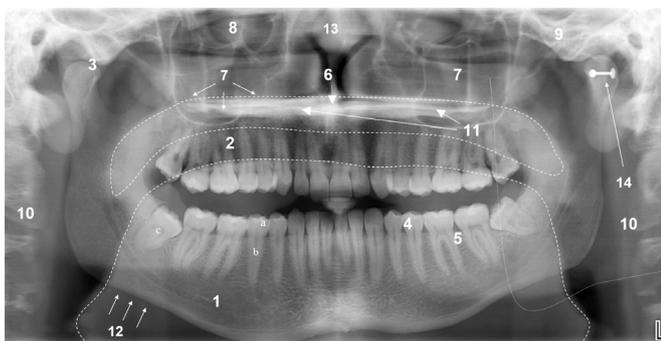


Figure 2 Panoramic image with some important features highlighted. (1) mandible (2) maxilla (3) mandibular condyle (4) dentition (teeth) (5) alveolar bone (6) anterior nasal spine (7) maxillary antrum (arrows illustrating the floor of the antrum) (8) orbit (9) zygoma (10) cervical spine (11) double image of the hard palate, seen as a radiopaque line (12) mandibular cortex, (13) nasal cavity, (in some films the bony aspect of the septum can be viewed) (14) foreign body (jewellery). The dotted lines represent areas on a panoramic radiograph where significant airway shadowing can present. (a) represents the coronal portion of the tooth, or the 'crown' (b) represents the root of the tooth, not visible clinically. (c) refers to a tooth that remains impacted, and is below the coronal aspect of the other teeth.

Radiation dose

Panoramic radiography is considered to have a significantly lower radiation dose (360 μGy) compared with conventional CT ($\sim 10\,000$ μGy) and cone-beam CT radiography (~ 1300 μGy).^{14–18} As such, there is negligible risk in situations where repeated panoramic radiographs are required due to poor quality or non-diagnostic image acquisition. The use of lead aprons or thyroid shielding is not indicated as the thyroid and torso lie outside the radiation beam.^{19 20} A thyroid shield may obscure anatomical structures, possibly leading to repeated exposure to obtain a diagnostic image.²¹

RADIOGRAPHIC INTERPRETATION

The interpretation of the panoramic radiograph should be carried out in a systematic manner. Depending on the quality of the image and the positioning of the patient, there will be a number of maxillofacial structures discernable on the radiograph, including artefactual double images and airspace shadowing. A radiology report may guide the emergency physician on the most salient pathological features of the image, however, it cannot be relied on for a comprehensive diagnosis.²²

Any approach must ensure that the clinician analyses all structures, including teeth and associated periodontal and apical tissues, all features of the mandible including body, condylar heads and ramus, the entire maxilla (including antrum), nasal cavity and zygomas.²³

The first stage in the assessment of the panoramic image is to account for the normal structures acquired on a panoramic film ([figure 2](#)). The mandible should be assessed systematically from the left side of the image to the right side. Features to examine are the correct position of the condyle, the coronoid process, then following the mandibular ramus to the body, parasymphysis and mental region of the mandible. Attention should be directed to the presence or absence of an intact mandibular cortex, as well as the quality and appearance of the bone.

The next step is to interpret the midface and maxilla, making particular note of the cortex and medullary bone of the maxilla, the antrum, zygomatic bones, as well as the nasal cavity and conchae. These features vary in clarity based on patient size, positioning and exposure settings.

Soft-tissue anatomy should be viewed, with particular attention to soft-tissue appearances that may mimic pathology, as well as the mucosal lining of the maxillary antrum which may appear thickened in cases of chronic sinusitis. The position of the patients lips and tongue can create airway shadows in the midline of the radiograph, these and any ghost images or artefact present on the image should be accounted for and noted.

Finally, the entire dentition which refers to all of the teeth present, as well as the supporting structures, is examined. The teeth should be examined for number, quality, relative position, as well as the presence or absence of dental caries, periodontal disease, periapical radiolucencies or previous restorative dental treatment. The relative position of teeth should be noted, in particular, third molars which are often impacted. [Figure 3](#) also shows the mental foramen; this radiolucency is a normal anatomic feature but may mimic the appearance of a periapical infection and represent a source of misdiagnosis. This can easily be identified by following the pathway of the inferior alveolar canal towards this foramen, as well as noting the absence of tooth decay in the premolar region.

While a number of nomenclature systems are available, the Federation Dentaire Internationale system is widely used in the UK for labelling the dentition ([figure 4](#)). This system divides



Figure 3 The arrow most anterior illustrates the location of the mental foramen. On this panoramic radiograph the tooth 48 has extensive dental caries with evidence of radiolucency at the root apices, which was the cause of significant facial swelling. The pathway of infection arises from the extensive dental caries.

the mouth into four quadrants, the upper right (quadrant 1), the upper left (quadrant 2), the lower left (quadrant 3) and the lower right (quadrant 4). Starting at the midline and moving distal (posteriorly), the teeth are numbered from 1 to 8. For example, the upper left wisdom tooth would be called tooth 28 ('two-eight'). Understanding the terminology will aid the emergency physician with interpretation of the radiologist report and communication with specialist surgical services.

PANORAMIC IMAGING IN THE EMERGENCY SETTING

Common indications for a panoramic image in the emergency department include dental pain, facial swellings, isolated mandibular trauma, temporomandibular joint pain and non-specific facial pain. Most commonly the panoramic image is used to assess mandibular trauma and odontogenic causes of head and neck infections.

MANDIBULAR TRAUMA

The panoramic radiograph plays an essential role in the workup of mandibular trauma. However, this should not be relied on as the sole image for diagnosis. As fractures can be displaced in three dimensions, a single two-dimensional image is insufficient for accurate diagnosis, and an additional image posteroanterior (PA mandible) is required.^{2,3,24-26} While a fracture may be evident on a single view, the degree of displacement in three dimensions requires a second view. The two views: OPG and PA mandible are required for surgical management.³ In cases where there is evidence of significant comminution, pathological fracture, or the presence of upper or midfacial fractures, CT is indicated.²⁷

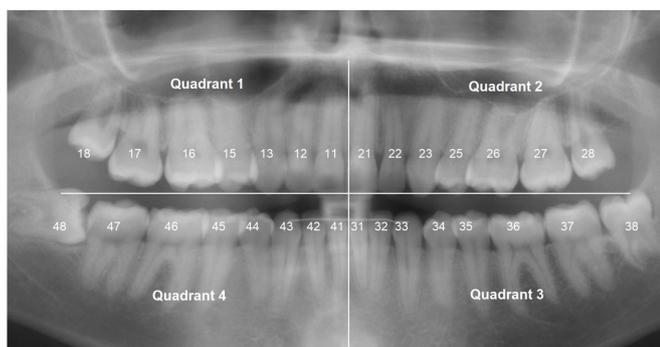


Figure 4 This panoramic radiograph illustrates the FDI nomenclature system. FDI, Federation Dentaire Internationale.

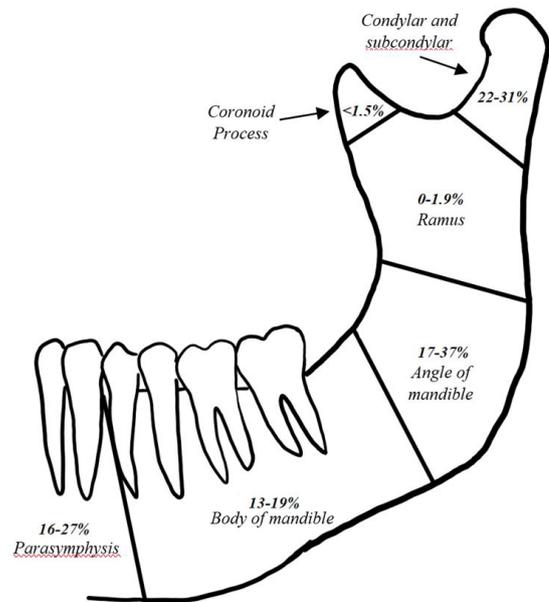


Figure 5 Regions where mandibular fractures are most likely to occur.

Mandibular fractures often occur in predictable patterns, with the subcondylar region, the angle of the mandible, and the parasymphysis commonly involved. **Figure 5** outlines regions where mandibular fractures are most likely to occur.²⁸ When a mandibular fracture is present, the clinician should have a high degree of suspicion for a second or third fracture of the mandible.¹ Fractures are usually evident as a radiolucent line. The musculature attaching to the mandible, in particular, that of the pterygomasseteric sling, may act to reduce or displace fractures.

Clinical and radiographic correlation is an essential component of making a diagnosis of maxillomandibular trauma from panoramic radiography. The two-dimensional limitation of this form of imaging can lead to missed diagnosis of mandible fractures, particularly in the condyle and subcondyle regions (**figures 6 and 7**). CT imaging or a PA radiograph gives better representation of the condyle and subcondyle areas and should be ordered in conjunction with the panoramic radiograph if there is any suspicion of bony trauma in these regions.

Similarly, the overlapping tissues represented in each area of the image can produce false-positive diagnoses. A common example is the misdiagnosis of epiglottic airway shadowing



Figure 6 Showing a right mandibular angle fracture, indicated by the arrow posterior to tooth 48. There are bilateral subcondylar fractures, which are difficult to discern on this view. The two arrows in the subcondylar region indicate where these fractures are located.

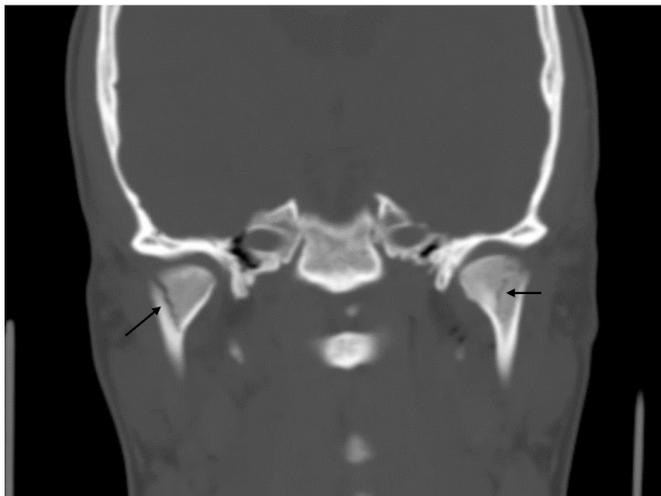


Figure 7 A CT coronal view of OPG from figure 6. The presence of bilateral condyle fractures is indicated by the arrows OPG, orthopantomogram

as a fracture of the mandibular angle, due to loss of visualisation of the lower border cortex (figure 8). As with all fractures, a well-defined discontinuity in the cortical bone, with or without displacement, is required for a radiographic diagnosis of mandibular fracture, and this should always correlate with clinical history and examination. Figure 9 provides illustration of a left mandibular angle fracture.

ODONTOGENIC INFECTIONS

Head and neck infections can be difficult to diagnose, due to the variety of presentations such as sinusitis, soft-tissue, salivary gland and tonsillar infection. The panoramic radiograph will help the emergency physician determine if there is potential for an odontogenic source, and if it is unclear then specialist advice can be sought.

The teeth should be assessed, noting the integrity of the coronal portion of the tooth. Patients may be edentulous (have no teeth), partially dentate (have several missing teeth), or fully dentate (have their entire dentition). Dental restorations which encroach on the dental pulp may induce 'pulpitis' with potential



Figure 8 This panoramic image shows how airway shadowing can mimic pathology. Over the angle of the mandible the epiglottic airway creates a shadow indicated by the two arrows, in the setting of trauma or a fall, this can be misdiagnosed as a fracture. In this setting, an additional image would have helped to overcome this issue. (a) Illustrates teeth with root canal fillings. *Highlights teeth with metallic restorations, appearing as dense radiopaque areas in the coronal portion of the teeth.



Figure 9 This panoramic shows a left mandibular angle fracture indicated by the arrow; represented as a radiolucent line. The presence of two mandibular plates from a previous surgery is indicated by two arrows in the parasymphysis region.

to cause a spreading odontogenic infection. Different dental restorative materials will appear with various degrees of radiopacity; while metallic amalgam fillings can be readily identified on plain film imaging, tooth coloured (composite) restorations are not as clearly radiopaque as metallic amalgam fillings, and can be mistaken on X-ray for natural tooth structure. Figure 8 provides an illustration of the radiopacity created by metallic dental fillings; teeth which have had prior root canal treatment can also be noted with the radiopaque line in the middle of the roots. In figure 10, the large restoration on tooth 16 resulted in facial swelling which presented to ED. The careful assessment for such restorations is essential in identifying the potential source of facial infection.

The periapical tissue should then be assessed, with particular attention to the apex of tooth roots. Loss of lamina dura (radiopaque line around the roots of teeth) is an early sign of periapical infection, a late sign of infection is bone destruction presenting as a radiolucent area, often at the apex of tooth roots.²³ Figure 11 highlights teeth with dental caries, the reader can appreciate the varying degrees of radiolucency associated with the tooth roots.

The periodontium refers to the supporting structures of the teeth, and includes the periodontal ligament, the cementum of the root surfaces of teeth and the alveolar bone. Periodontal infections are more likely in older patients, smokers and patients with poorly controlled diabetes. Unless in advanced stages, it may be difficult to appreciate periodontal disease radiographically. Eventually, infections of the periodontium result in the loss of alveolar bone height which is readily assessable on a panoramic film. Figure 11D shows the lower anterior teeth with significant periodontal bone loss.

The root apices and the periodontium of the teeth, including tissues surrounding impacted teeth, provide a pathway for bacterial invasion which can lead to abscess formation requiring surgical management. Figure 11A–C illustrates the apical lucencies associated with infections originating from the root apices.

Odontogenic infections, from dental caries, pericoronal and periodontal disease can form abscesses which may present as small fluctuant intraoral collections, buccal and canine space infections, or in severe cases; deep space infections involving trismus, dysphagia and a compromised airway. In the case of a simple dentoalveolar abscess, lacking trismus, dysphagia or airway compromise, an OPG radiograph provides sufficient diagnostic information and a facial CT scan will not alter the management.²⁹



Figure 10 This panoramic shows a large dental filling in tooth 16 which caused a facial swelling, indicated by the arrow. This was a subtle finding which was initially missed. Key features indicating a likely cause of infection are: the filling is placed on the pulp of the tooth, if you contrast the highlighted tooth to the first molar (26) on the contralateral side you can appreciate the development of a radiolucent line around the infected tooth root.

LIMITATIONS OF THE PANORAMIC RADIOGRAPH

Although panoramic radiography does have significant advantages in the emergency setting, there are limitations that need to be considered when selecting the appropriate imaging modality. First the panoramic radiograph mainly evaluates the lower third of the face and as such is limited to pathology and trauma in this region.³⁰ For the diagnosis and assessment of upper and midfacial fractures, CT is indicated to provide sufficient diagnostic detail.^{27 30} Secondly, when compared with CT, there is a lack of cross-sectional information due to the panoramic radiograph being two dimensional.³¹ This can obscure fractures, particularly if there is minimal displacement or displacement in the

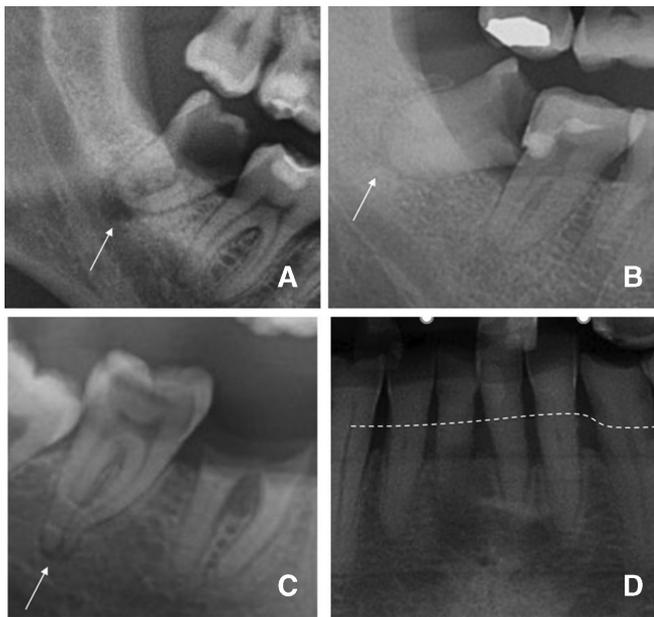


Figure 11 Examples of radiolucency indicating an infective process (A, B, C). The dental caries have extended into the pulp of the tooth, creating a path of infection into the underlying bone. The arrow in A, B and C indicate area of peri-apical radiolucency (D) Shows the loss of periodontal bone, a late sign in periodontal disease. The dotted line shows the level where the bone should be.

lateromedial direction.³² Figure 12 shows a clinical algorithm for the role of panoramic radiograph in the assessment of facial trauma.

With regard to fascial space infections from odontogenic sources, panoramic imaging can help to identify the source of infection, however, it does not provide detailed information on the soft-tissue and fascial space involvement. CT imaging with soft-tissue windows provides a more accurate representation of this, particularly if the image is contrast enhanced.³³ Figure 13 outlines indication for additional imaging for an odontogenic infection.

In panoramic radiography, images outside of the focal trough will undergo considerable distortion and thus patient positioning and their ability to stand or sit still is of utmost importance. If this is unachievable, alternative imaging may be considered, which can include a series of plain film radiographs^{24 30 32} or ultrasound.^{34 35} A mandibular series involves multiple different plain film images, including PA, oblique and lateral views. They are useful when patients are unable to remain stationary for the duration of panoramic radiograph exposure, or in cases where the patients must remain supine and have a cervical collar present.^{2 36} Furthermore, when used in conjunction with panoramic radiography, the diagnostic accuracy for mandibular trauma increases.²⁶

Ultrasound is particularly useful in patients who are pregnant, or unable to remain stationary, due to it being fast, relatively inexpensive and does not use ionising radiation.^{35 36} However, ultrasounds may not be sufficient to diagnose complex maxillofacial fractures or non-displaced fractures, and their use may be precluded in the emergency setting due to large inflammatory oedema, pain and tenderness at the injured site.³⁴

MRI has clinical utility in selected cases and is advantageous due to the absence of ionising radiation coupled with excellent soft-tissue contrast. However, it does not represent cortical bone well and is subject to extensive scattering from metallic fragments, including dental fillings and implants.³⁷ Its main indication in maxillofacial imaging is for assessment of soft-tissue involvement in trauma of the orbit where there has been visual or extraocular muscle impairment, and in cases of severe facial fractures with high risk of intracranial complications.^{37 38}

CONCLUSION

Facial trauma and odontogenic infections are frequent presentations to hospital emergency departments. This paper has outlined the utility of the panoramic radiograph in the emergency setting, and provides a clinical algorithm for its use. In some settings, a panoramic radiograph will provide sufficient diagnostic information for facial swellings, and when a PA mandible is also obtained, the two images can be sufficient to diagnose and manage isolated mandible fractures. Interpretation of the panoramic image requires familiarity with the method of acquisition, and understanding of the presence of image artefacts which may mimic pathology. The low radiation dose and lack of requirement for intravenous contrast make the panoramic image a safe method of imaging when CT is not required. However, for patients who are bedridden, unable to remain still or severely kyphotic, it may not be feasible to obtain a diagnostic quality image. An understanding of the nomenclature and relevant anatomic features imaged will help facilitate a diagnosis, interpretation of the radiologists report and communication between treating teams.

Contributors AS, SND, DB and RK all contributed to the text, ideas, algorithm and case discussion in the text.

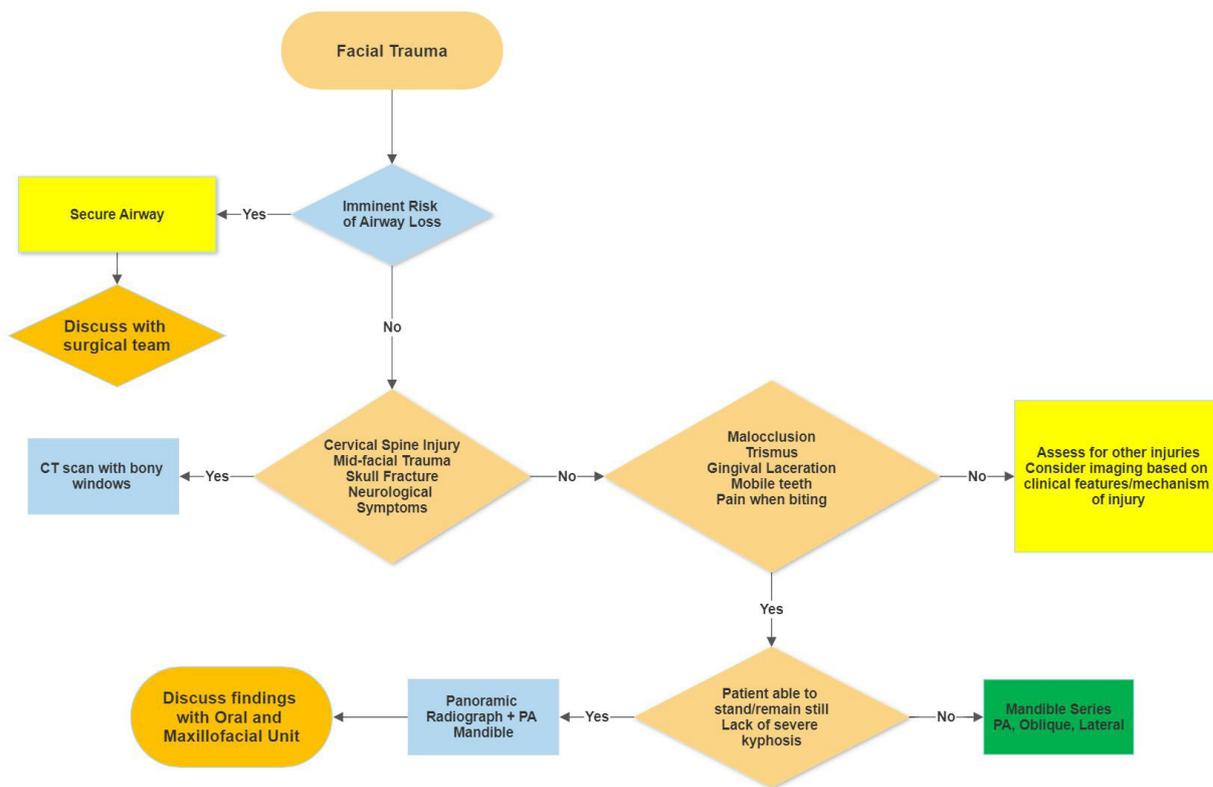


Figure 12 Clinical algorithm outlining role of the panoramic radiograph in facial trauma assessment. PA, posteroanterior.

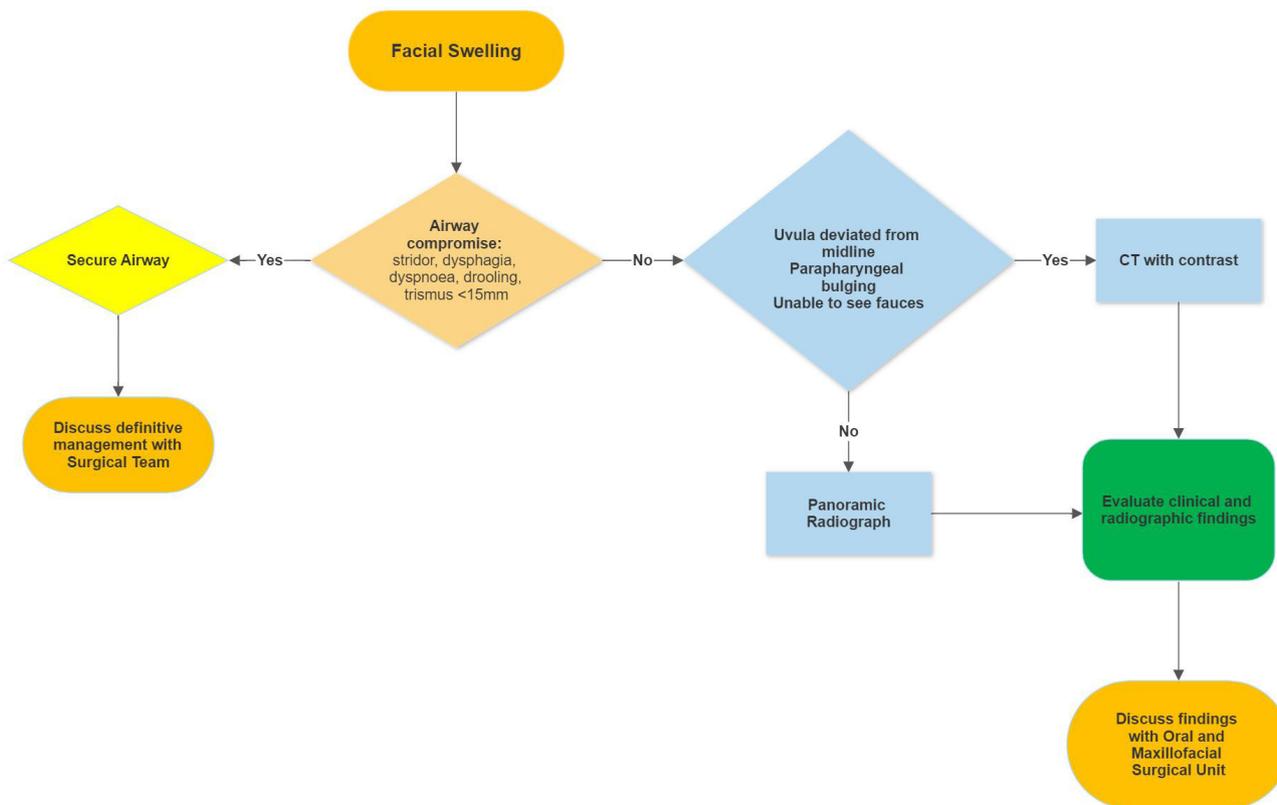


Figure 13 An algorithm for the assessment of facial swelling and the role of the panoramic radiograph.

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