Imaging in trauma of the facial skeleton and soft tissues of the neck

Abstract

Trauma to the face and neck is a frequent reason for emergency department attendance. Imaging is invaluable in the characterisation of such injuries, enabling delineation of fracture patterns as well as identification of vascular and other soft tissue injuries. It may also be used to prevent long-term mortality and morbidity and provide a roadmap for surgical intervention so that form and function may be restored. This article gives a pictorial review of the imaging of craniofacial trauma, stratified according to the thirds of the face, followed by a review of blunt and penetrating trauma of the neck. It discusses appropriate imaging modalities for each trauma category, describes major patterns of craniofacial trauma on cross-sectional imaging and identifies clinically relevant imaging features that should trigger subspecialist review or be of relevance to pre-surgical planning. It starts with the upper third comprising frontal sinus fractures before describing the component fractures of the middle third (including nasal, zygomaticomaxillary and orbital fractures) and then focusing on the lower third (specifically mandibular and dentoalveolar fractures). The article concludes with a review of soft tissue injuries of the neck, particularly penetrating, blunt and laryngeal trauma.

Key words: Blunt; Face; Head and neck; Laryngeal; Penetrating; Trauma

Submitted: 7 January 2020; accepted after double-blind peer review: 27 January 2020

George Bitar[1]

Philip Touska[2]

Author details can be found at the end of this article

Correspondence to:
George Bitar; g.bitar@uclmail.net

Introduction

Penetrating trauma of the face and neck accounts for a significant number of emergency department attendances in the UK (Offiah and Hall, 2012). Blunt trauma to the neck, excluding cervical spine injuries, is less common and represents 5% of all neck trauma (Verdonck et al, 2016). While isolated injuries are common, they may occur in the context of major trauma. In such instances, a systematic and thorough clinical examination is essential to guide further investigation and management. The Advanced Trauma Life Support protocol (Kortbeek et al, 2008) should be followed, and an otolaryngologist and/or anaesthetist consulted where there are particular concerns relating to airway compromise. It is beyond the scope of this article to describe the essential components of the clinical examination as applied to head and neck trauma, but the *Resident Manual of Trauma to the Face, Head, and Neck* is a useful resource (Brennan et al, 2012).

In the absence of clinical features of instability that require immediate operative management, the majority of patients will benefit from imaging to establish the extent of trauma and identify clinically occult injuries. While several modalities (including plain film radiography, ultrasound and magnetic resonance imaging) can be used in select cases, multidetector computed tomography remains the mainstay of trauma imaging owing to its rapidity and capacity to produce high resolution three-dimensional datasets. The role of multidetector computed tomography in imaging these patients is therefore the focus of this article.

Since imaging forms such an integral part of the assessment of patients with cervicofacial trauma, close multidisciplinary working with radiology colleagues is beneficial. In particular, discussion of the mechanism of injury and areas of clinical concern with the duty radiologist can facilitate the production of a tailored report that can be used to guide appropriate management.

This article provides a pictorial overview of the imaging of craniofacial fracture patterns and soft tissue injuries of the neck.

How to cite this article:
Bitar G, Touska P. Imaging in trauma of the facial skeleton and soft tissues of the neck. Br J Hosp Med. 2020. https://doi.org/10.12968/hmed.2020.0008

Craniofacial fractures

Imaging modality and protocol

Plain film radiographs remain helpful in the evaluation of facial trauma, particularly where injuries are isolated and the risk of complex fracture patterns is low. In particular, facial series, comprising occipitomental (OM)15° or 30° views, can be used to evaluate the orbital margins and zygomata, and dedicated mandibular or panoramic radiographs can be used to evaluate the mandible and dentition. McGhee and Guse (2000) established that the sensitivity and specificity for the detection of a midfacial fracture was 89.4% and 82.1% respectively with an OM15° alone and 90.9% and 84.8% with OM15° and OM30° views, the difference not being significant.

However, for more severe injuries, where complex patterns are likely, or in the setting of major trauma, non-contrast computed tomography with high resolution (<1 mm voxel size) with both soft tissue and bone reconstruction algorithms is recommended.

Approach to computed tomography evaluation

A practical approach is to divide the face into upper, middle and lower thirds (Winegar et al, 2013) as in Figure 1. The various fracture patterns that may be encountered within each third are outlined in Table 1.

The facial skeleton can be conceptualised as five transverse and four paired vertical buttresses that support both the form and function of the face (Figure 2, Table 2). The buttresses represent areas of relatively increased bone thickness that support the functional units of the face in an optimal relation and define the form of the face by projecting the overlying soft tissue envelope (Winegar et al, 2013). Preoperative planning is guided by significant buttress displacement.

Frontal sinus fractures

Frontal sinus fractures account for only 5–15% of maxillofacial injuries (Bradley Strong, 2009) and these are often the result of high velocity injuries such as road traffic accidents. Given the resistance of the thick cortical bone surrounding the frontal sinus, a frontal sinus fracture suggests high impact trauma, hence up to 66% of patients will have associated facial fractures (Bradley Strong, 2009).

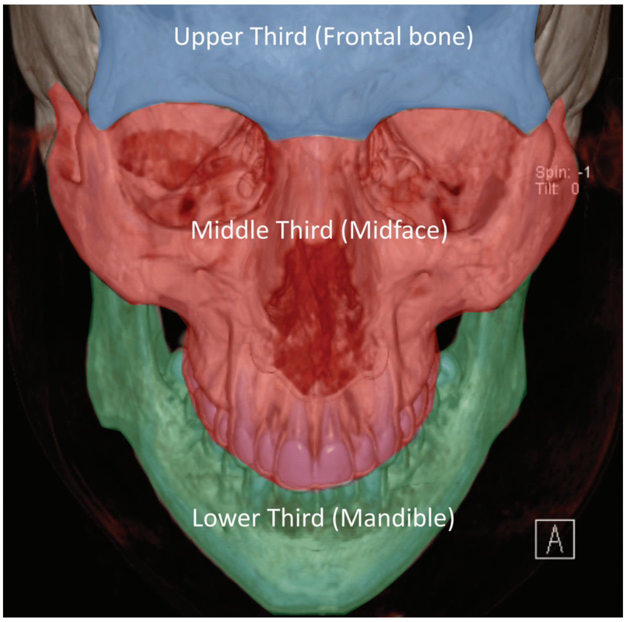

Figure 1. The 'thirds' of the face can help localise a fracture pattern (Winegar et al, 2013). The upper third of the face consists of the frontal bone (including the frontal sinuses) and is delineated from the middle third by the superior orbital rims and wall. The middle third extends from the superior orbital rims to the maxilla and includes the orbits, ethmoid, maxillary and sphenoid sinuses. The lower third comprises the mandible.

Table 1. Facial fracture patterns stratified according to location	
Location (thirds)	**Fracture or injury**
Upper	Frontal sinus
Middle	Naso-orbital-ethmoid
	Zygomaticomaxillary complex
	Orbital (including ocular injuries)
Lower	Mandibular
	Dentoalveolar

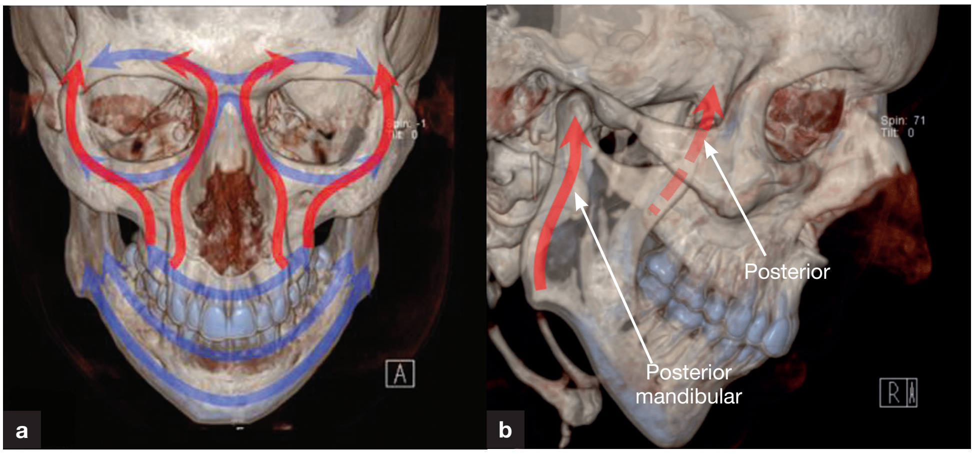

Figure 2. Facial buttresses. a. The five horizontal buttresses (blue) and two paired vertical buttresses – medial and lateral (red), and (b) the other two paired vertical buttresses – posterior and posterior mandibular .

Table 2. The horizontal and vertical facial buttresses	
Horizontal	**Vertical**
Superior transverse (frontal bar)	Medial (nasomaxillary)
Middle transverse	Lateral (zygomaticomaxillary)
Inferior transverse	Posterior (pterygomaxillary)
Upper transverse mandibular	Posterior mandibular
Lower transverse mandibular	

As these fractures are often a result of high impact injuries, many patients present in an unconscious state with other injuries, and so the frontal sinus fracture may be overlooked in the emergent setting. Clinical features include a headache, epistaxis or forehead numbness (if there has been injury to the supraorbital nerve) (Brennan et al, 2012).

Appropriate and timely management of frontal sinus fractures will help to prevent long-term complications, including chronic sinusitis and mucocoele formation; it can also mitigate intracranial complications including cerebral abscess, subdural empyema formation or meningitis (Brennan et al, 2012).

Assessment of the degree of involvement (including displacement and comminution) of the anterior and posterior tables is important owing to the risk of intracranial complications, including CSF leak (Table 3) (Bradley Strong, 2009). Additionally, patency of the frontal recess (outflow tract) is important since traumatic outflow obstruction may ultimately lead to mucocoele formation, and preventive frontal sinus obliteration may be required. An example of complex frontal sinus trauma is given in Figure 3.

Table 3. Treatment of anterior and posterior table fractures		
Type of fracture	**Degree of displacement**	**Treatment**
Anterior table	<2 mm	Observation
	>2 mm	May require surgical intervention
Posterior table	Less than the width of the posterior table and no CSF leak	Observation
	Less than the width of the posterior table and CSF leak	Consider obliteration
	More than the width of the posterior table and CSF leak or comminution	Cranialisation

From Bradley Strong (2009)

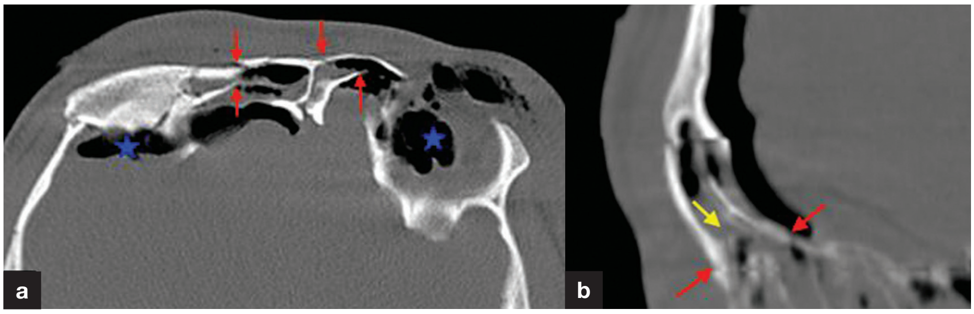

Figure 3. Frontal sinus fractures. a. Axial non-enhanced computed tomography image of the frontal sinuses demonstrating bilateral anterior and posterior table frontal sinus fractures (red arrows) and significant displacement of the posterior table fragments. Note the pneumocephalus and left intraorbital gas (blue stars), the latter secondary to a co-existent fracture of the left medial orbital wall. b. Sagittal, non-enhanced computed tomography image of the same patient demonstrates subtle fractures of the nasofrontal duct with obstruction to outflow (yellow arrow), as well as the anterior and posterior table fractures (red arrows).

Nasoseptal fractures

The nose is the most frequently fractured nasal facial subunit and is involved in more than half of facial fractures (Rhee et al, 2004; Alcalá-Galiano et al, 2008). When a nasal fracture is suspected, a clinical examination is usually sufficient. Further imaging, for example with computed tomography, is of little added diagnostic utility in the absence of naso-orbital-ethmoid region involvement (Alcalá-Galiano et al, 2008). Various classification systems exist, the more recent, introduced by Rhee et al (2004), being a computed tomography grading system based on the degree of septal deviation. Practitioners generally favour closed reduction for most injuries (Rhee et al, 2004).

Naso-orbital-ethmoid fractures

Fractures of the nasal region can involve the nasal bones only or the naso-orbital-ethmoid complex, which includes the medial orbit and the medial canthal tendon (Figures 4 and 5). Isolated naso-orbital-ethmoid fractures are uncommon; in 60% of cases they are associated with zygomaticomaxillary complex fractures, and 20% are associated with pan-facial fractures (Dreizin et al, 2018). These fractures are usually the result of high-energy blunt trauma and rarely present as isolated injuries. Accurate description of fractures will guide suitable treatment and help prevent serious complications including persistent diplopia, traumatic telecanthus (increased distance between the inner corners of the eye), sinusitis, entrapped orbital contents and ethmoid artery bleeding.

Common signs include loss of the nasal projection in profile, telecanthus and epiphora, and if such signs are present thin section computed tomography is warranted with multiplanar reformats.

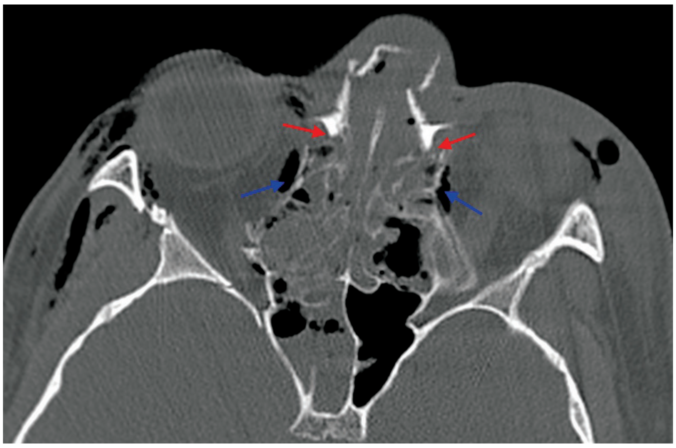

Figure 4. Naso-orbital-ethmoid fractures and involvement of the nasolacrimal ducts bilaterally (red arrows). Note intraorbital gas bilaterally (blue arrows).

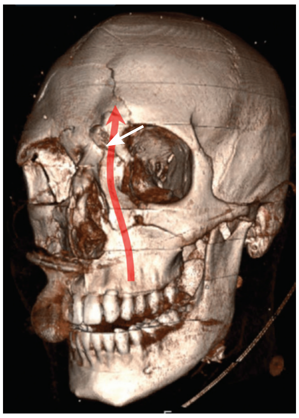

Figure 5. Comminuted naso-orbital-ethmoid fracture with involvement of the medial canthal tendon attachment (small white arrow). These fractures involve the medial vertical buttress (large red arrow) of the facial skeleton.

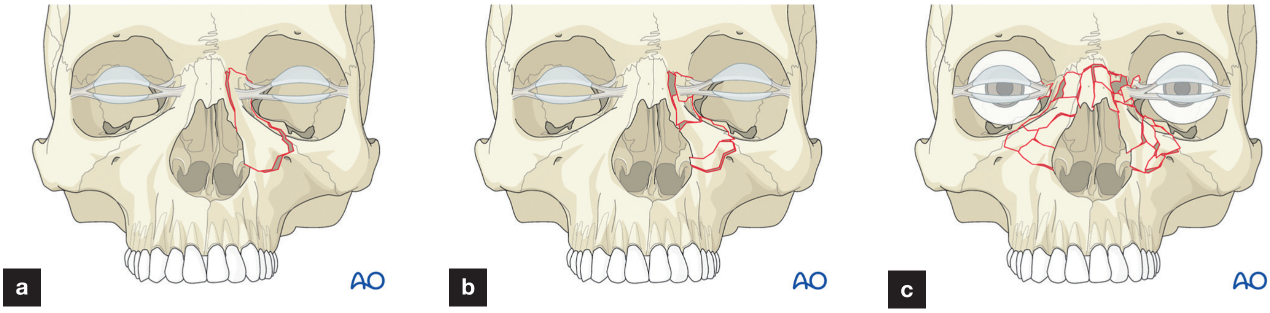

Figure 6. Markowitz and Manson naso-orbital-ethmoid classification scheme. a. Type I: single large fragment. b. Type II: some comminution, but tendon attached. c. Type III: more severe comminution and tendon detached or small fragments.

These fractures are classified into three types, based upon fracture patterns and the status of the medial canthal tendon (Figure 6). Therefore, when reviewing images of naso-orbital-ethmoid fractures, it is important to assess the degree of comminution of the medial vertical maxillary buttress, especially around the margins of the lacrimal fossa where the medial canthus inserts. However, detection of medial canthal tendon avulsion may not be possible on imaging alone and correlation with clinical examination findings is usually required. It may also be challenging to differentiate type II and type III fracture patterns (Hopper et al, 2006). Naso-orbital-ethmoid fractures frequently involve the frontonasal duct, nasolacrimal duct and frontal sinus with impairments in tear and mucociliary drainage resulting in epiphora and mucocoele formation respectively (Dreizin et al, 2018). Other associated abnormalities include fractures of the cribriform plate, which may lead to CSF leak or meningoencephalocele, and severe ocular injuries.

Zygomaticomaxillary complex fractures

Clinical and radiological features of zygomaticomaxillary complex fractures include loss of cheek projection (resulting in increased facial width and facial asymmetry), change in orbital volume (which may be accompanied by enophthalmos) and trismus. Injury to the infraorbital nerve can contribute to anaesthesia or impaired sensation of the cheek and upper lip.

Previously called tripod fractures, zygomaticomaxillary complex fractures are in fact quadripod fractures (Hopper et al, 2006). Figures 7 and 8 demonstrate the four components of a zygomaticomaxillary complex fracture. Displacement, telescoping or angulation at the zygomatico-sphenoid suture is the most sensitive computed tomography indicator of asymmetry and orbital volume changes from zygomaticomaxillary complex malalignment (Dreizin et al, 2018).

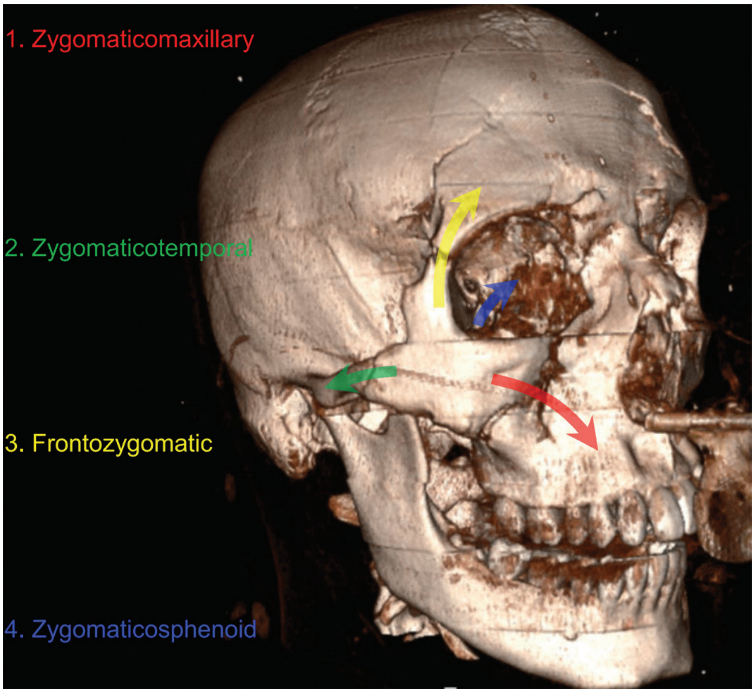

Figure 7. The components of a zygomaticomaxillary complex fracture. The following suture lines are disrupted. (1) Zygomaticomaxillary suture (2) Zygomaticotemporal suture at the zygomatic arch (3) Frontozygomatic suture and (4) Zygomaticosphenoid suture.

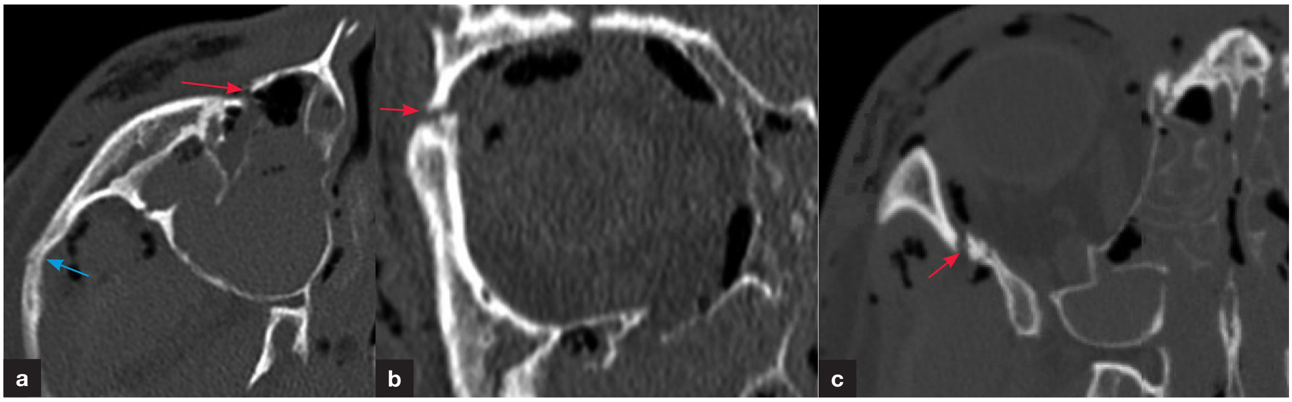

Figure 8. Zygomaticomaxillary complex fractures. a. Axial non-enhanced computed tomography images demonstrating the zygomaticotemporal (blue arrow) and zygomaticomaxillary (red arrow) component fractures. b. Coronal non-enhanced computed tomography image of the zygomaticofrontal component fracture (red arrow). c. Axial non-enhanced computed tomography image of the zygomaticosphenoid component fracture (red arrow).

Le Fort fractures

These fractures are named after the 19th century French military surgeon, René Le Fort, and may be classified as Le Fort I (floating palate), II (floating maxilla) or III (craniofacial dissociation). All involve some degree of separation of all or part of the maxilla from the skull base (as a result of disruption of the posterior vertical maxillary buttress), and the pterygoid plates must be fractured. The pattern of disruption of the remainder of the vertical and transverse buttresses determines the class of fracture (Figures 9 and 10).

The posterior extent of the lower transverse maxillary buttress is the hard palate and palatal fractures may occur (Figure 11). These are significant as they widen the maxillary dental arch causing malocclusion so a dental splint or fixation may be required to restore functional occlusion (Winegar et al, 2013). Malocclusions, the assessment of which is primarily clinical, occur in 8–20% of Le Fort fractures and even 2–3 mm of malocclusion may result in impairment (Ellis, 2004).

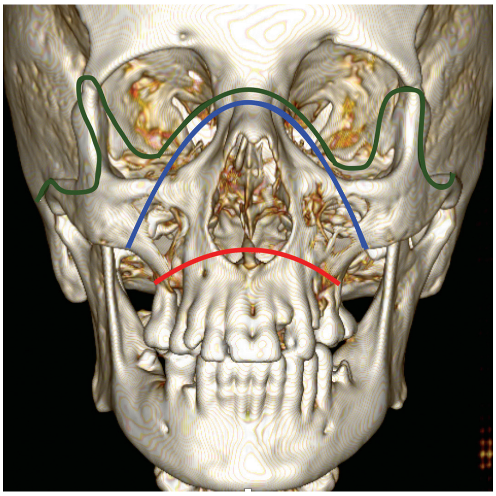

Figure 9. Le Fort fractures. A Le Fort I fracture (red line) involves the medial and lateral walls of the maxillary sinus, maxillary alveolus and septum. A Le Fort II fracture (blue line) involves the maxillary sinuses, inferior orbital rim and floor, medial orbital wall, nasal septum and frontonasal suture. Le Fort III fractures (green line) are described in Figure 10.

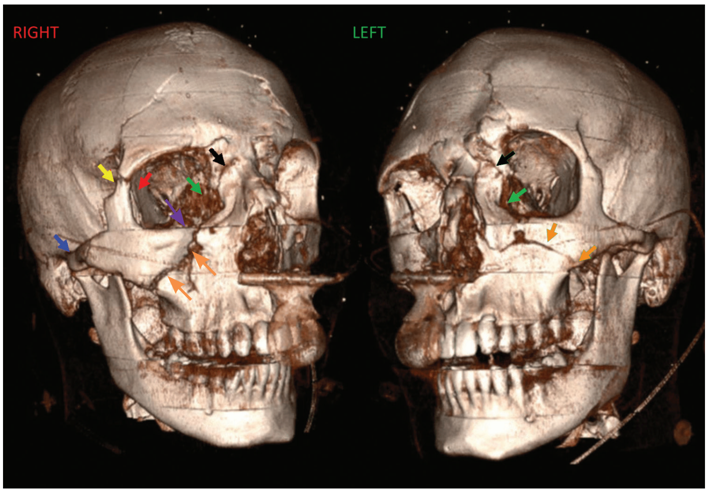

Figure 10. Le Fort III fracture complex involves fractures of the zygomatic arches (blue arrow), zygomaticofrontal (yellow arrow) and zygomaticosphenoid sutures, lateral orbital walls (red arrow) and rims, orbital floors (purple arrow), medial orbital walls (green arrows) and frontonasal sutures (black arrows). The zygomaticomaxillary suture lines are also fractured (orange arrows).

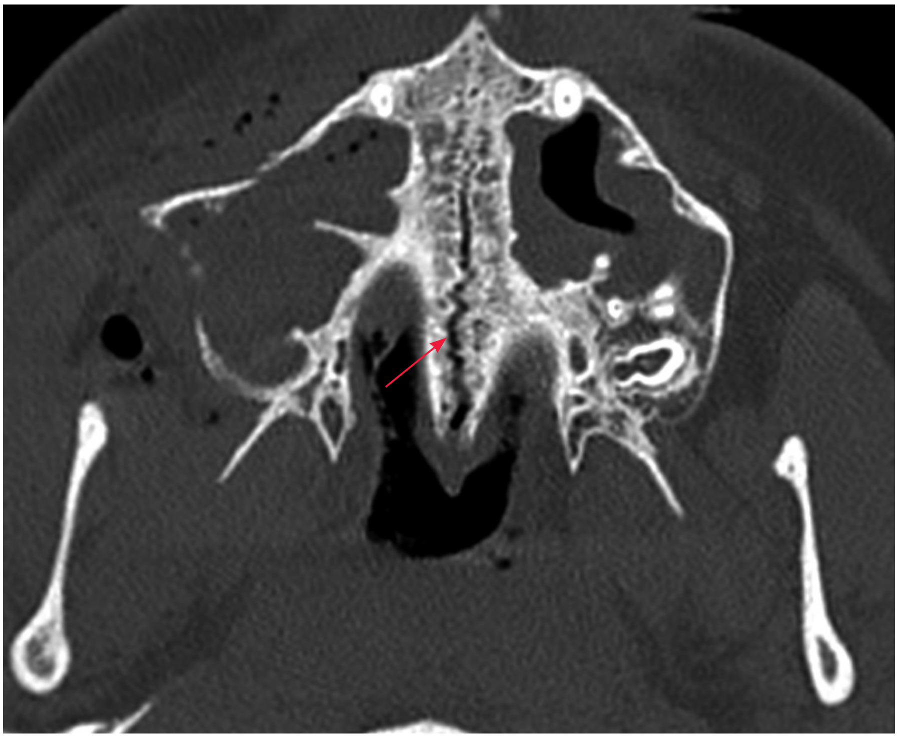

Figure 11. Palatal fracture.

Orbital fractures

Around 10–30% of facial fractures involve the orbit (Ellis, 2012). The most common symptoms are diplopia (usually related to entrapment of the extra-ocular muscles), enophthalmos and anaesthesia or other sensory disturbance around the cheek and upper lip (as a result of infraorbital nerve injury). Orbital floor fractures (Figure 12) may occur in isolation, but are not infrequently associated with zygomaticomaxillary complex and Le Fort fractures. Orbital fractures may be categorised as pure, where the fracture is limited to the internal orbit with no orbital rim involvement, or impure, where there is an orbital wall fracture (Koch et al, 2017).

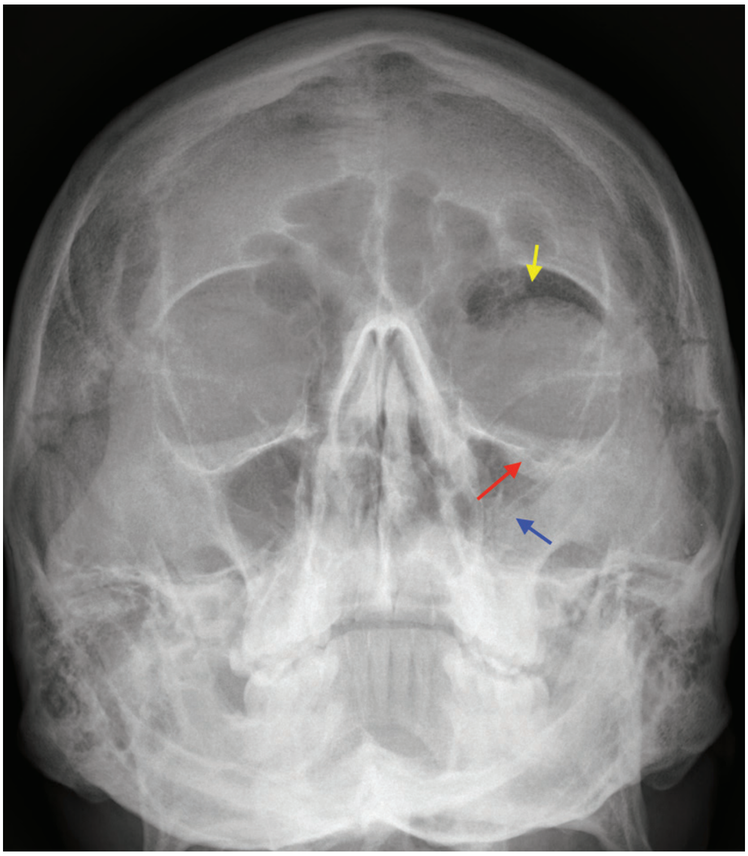

Figure 12. Orbital blowout fracture. Occipitomental 15° radiograph demonstrating a 'trapdoor sign' in the superior left maxillary antrum (red arrow) that represents an orbital floor fracture and herniated orbital content into the maxillary antrum. In addition, the rest of the left maxillary antrum is opacified (blue arrow) and lucency in the orbit is in keeping with orbital emphysema, otherwise termed an 'eyebrow' sign (yellow arrow). This constellation of findings is consistent with an orbital blowout fracture.

Entrapment is a serious complication of orbital floor fractures as this may lead to long-term extra-ocular muscle motility problems. In children, entrapment can be difficult to identify since the flexible bone fragment of the orbital floor swings back into place like a trapdoor and the computed tomography may look normal except for entrapped inferior rectus muscle beneath the bony fragment. Urgent surgical treatment is required to prevent the devastating consequences of this complication (Alcalá-Galiano et al, 2008). In adults, motility restriction is more often caused by fibrofatty tissue entrapment, which has indirect effects on the extra-ocular muscles.

Other fracture patterns that may occur include medial orbital wall fractures (Figure 13) (which may result in entrapment of the medial rectus muscles) and, very rarely, orbital apex fractures which may require urgent surgical exploration if there is any clinical or radiological evidence of optic nerve impingement such as visual defects, retrobulbar haematoma or bony fragments impinging on the optic nerve.

Injuries of the globe

Eye injuries result in blindness in about 1.6 million people and unilateral blindness or decreased vision in about 19 million people per year (Koo et al, 2005). There is an increased risk of eye injuries in patients with traumatic facial fractures. Clearly, when an eye injury is suspected, urgent ophthalmological assessment is warranted to help prevent devastating consequences. However, clinical assessment of the eye may be difficult in the context of acute trauma where the patient may be unable to cooperate or there may be significant peri-orbital swelling. In these circumstances, computed tomography imaging may be indicated to assess the extent of injuries.

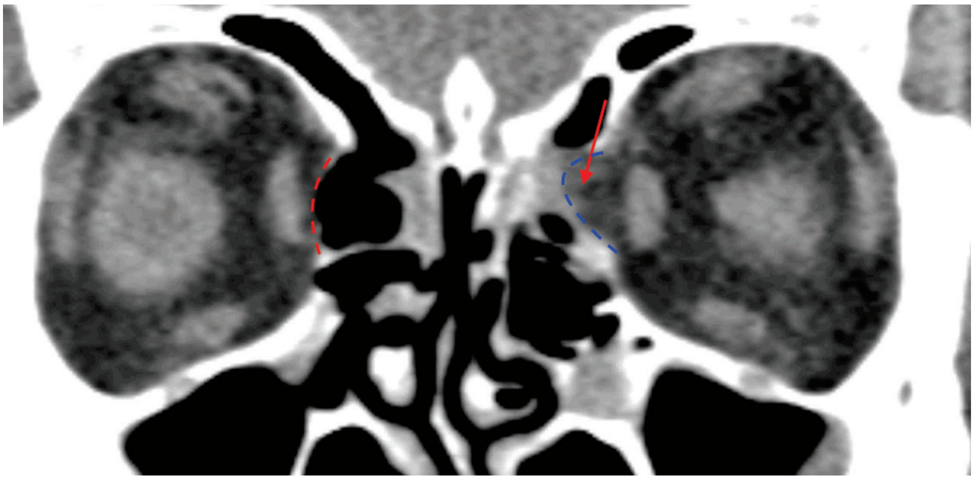

Figure 13. Left medial orbital blowout fracture. Coronal non-enhanced computed tomography image of the orbits demonstrates a normal appearance of the right medial orbital wall (red dotted line). On the left side, there is discontinuity of the medial orbital wall (blue dotted line) and herniation of orbital fat through the defect (red arrow).

A range of ocular injuries may occur and can be categorised according to location in the globe. A hyphema is a collection of blood in the anterior chamber of the eye and this appears as hyperdense attenuation on computed tomography. In the posterior segment, a collection of blood is termed a 'vitreous haemorrhage'.

The lens is surrounded by a capsule and suspended by radially oriented zonular fibres that are connected to the ciliary body. A tear involving only one side of the zonular fibres leads to a partial dislocation of the lens whereas a tear involving both sides results in complete dislocation. The lens usually dislocates posteriorly (Sung et al, 2014).

Posterior segment injuries include retinal and choroidal detachment. Retinal detachments (Figure 14) have a characteristic 'V' shape with the apex at the optic disc as this is where the retina is firmly attached. In contrast, choroidal detachments have a lentiform or biconvex shape and spare the posterior portion of the globe (Sung et al, 2014).

Other severe injuries include open globe injuries (globe rupture) and computed tomography or magnetic resonance imaging may be used to diagnose this condition if it is clinically suspected. On cross-sectional imaging, there is loss of the normal contour or volume of the globe or scleral discontinuity.

Mandibular and dentoalveolar fractures

The mandible, the anatomy of which is depicted in Figure 15, is the only mobile bone in the face and its relative lack of support means it is commonly fractured. A mandibular

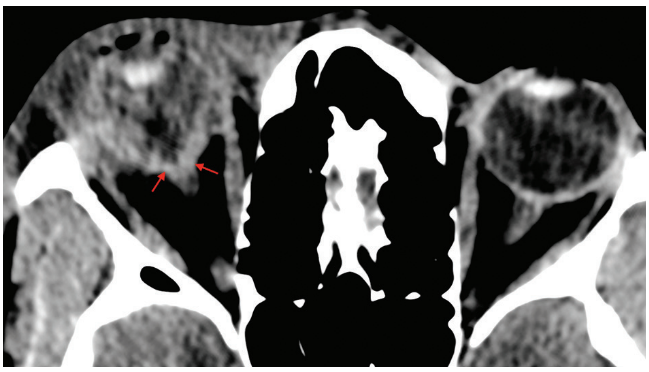

Figure 14. Retinal detachment. Axial non-enhanced computed tomography image demonstrates the classic appearance of a retinal detachment which has a characteristic 'V' shape with the apex at the optic disc (red arrows).

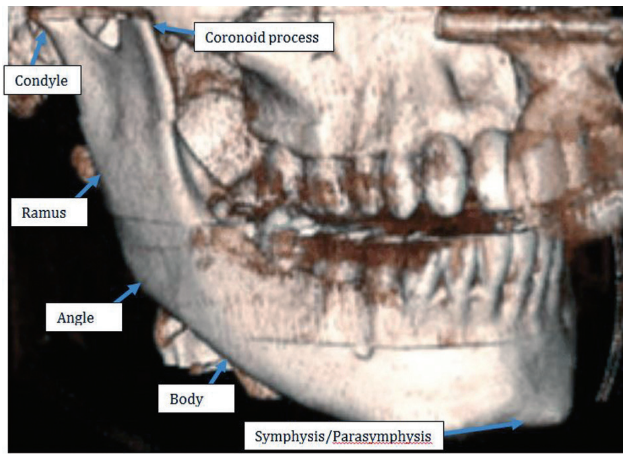

Figure 15. Anatomy of the mandible.

fracture should be suspected if the patient presents with malocclusion, trismus, broken teeth or obvious deformity. The leading causes of mandibular fractures are road traffic accidents and assault (Laub, 2016). Table 4 lists the frequency of fractures at the different subsites of the mandible.

Fractures through the mandibular canal may lead to damage to the inferior alveolar nerve, causing anaesthesia in the lower lip, chin, anterior tongue and lower teeth (Brennan et al, 2012). The mandible may be considered to form a bony ring via its articulation with the temporal bone at the temporomandibular joints. In this respect, a fracture at one site of the mandible should elicit the search for a second fracture, frequently on the opposite side of the mandible (Alimohammadi, 2018) (Figures 16 and 17).

Although plain radiographs (in the authors' institution, posteroanterior and orthopantomogram views) may be used, they are limited in establishing the level of fracture displacement and detail of the condylar region is poor. As with midface fractures, multidetector computed tomography is the imaging modality of choice and can demonstrate 100% sensitivity for the detection of fractures (Naeem et al, 2017).

Fractures of the alveolar process usually involve the facial or lingual plates or both, and are often accompanied by injuries to the teeth, hence the term 'dentoalveolar fractures.' Although intraoral and extraoral radiographs may help in detection of such fractures, cone beam computed tomography provides greater characterisation, for example, the width and displacement of the fracture and whether one or two cortical plates are involved (Alimohammadi, 2018).

Table 4. Mandibular fracture frequencies

Subsite of mandible	Fracture frequencies (%)
Condyle	30
Angle	25
Body	25
Symphyseal/parasymphyseal	15
Ramus	3
Coronoid process	2

From Koch et al (2017)

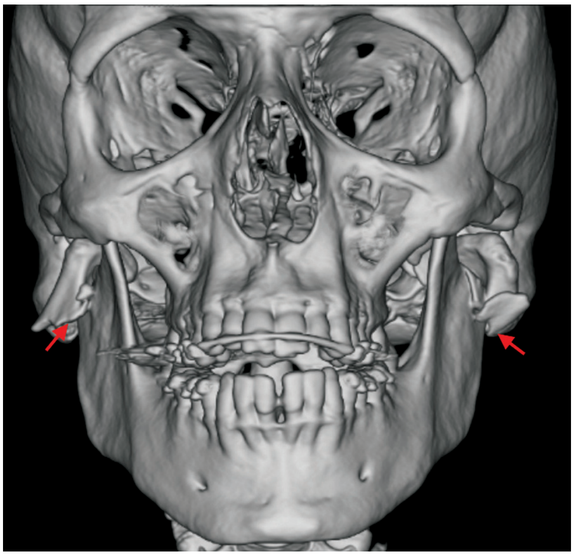

Figure 16. Three-dimensional computed tomography reconstruction demonstrating bilateral, displaced condylar fractures (red arrows).

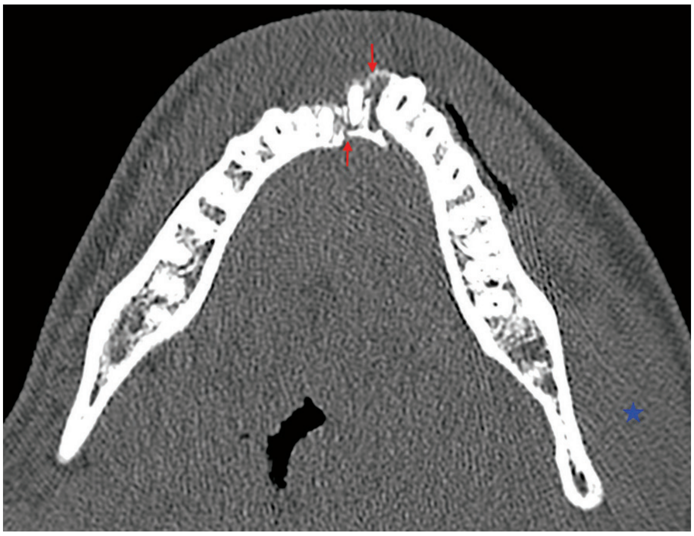

Figure 17. Symphyseal and displaced left parasymphyseal fractures (red arrows). Note the perimandibular soft tissue swelling and left masticator space haematoma (blue star). In addition, the left mandibular condyle was fractured.

Penetrating neck injuries

Zones of the neck

Penetrating neck injuries are classified by the anatomical zone of entry (Figure 18) as determined by physical examination (Steenburg et al, 2010). The importance of this classification lies in the different vascular and other structures that may be injured.

Haemodynamic instability or signs of vascular injury such as expanding or pulsating haematoma, haemorrhage, or loss of pulse warrant surgical exploration.

Computed tomography angiography

Haemodynamically stable, asymptomatic patients may be investigated initially with computed tomography angiography which is fast, reliable and safe (Miracle and Uzelac, 2016; Verdonck et al, 2016). As well as facilitating evaluation of the arterial and venous neck vasculature, the neck soft tissues, upper aerodigestive tract, spine and osseous structures may also be assessed and the presence of any radio-opaque foreign bodies determined.

Computed tomography angiography may be limited by artefacts caused by metal, specifically bullet fragments, or shoulder streak artefacts which may obscure vascular detail. In these circumstances, conventional angiography may be considered for optimal vascular assessment (Núñez et al, 2004).

Other imaging modalities: fluoroscopy and endoscopy

Cervical oesophageal injuries are uncommon, although clinically significant. They have a high mortality rate (approaching 20%), mainly because of complications including mediastinitis and sepsis, hence the need for rapid, early diagnosis (Steenburg et al, 2010). If the computed tomography findings are inconclusive or if there is a high clinical suspicion of oesophageal injury, further investigation with a contrast swallow, oesophagoscopy or endoscopy may be required, although endoscopy is more reliable than contrast swallow to identify injuries to the hypopharynx or cervical oesophagus (Miracle and Uzelac, 2016; Verdonck et al, 2016). Injuries to the trachea and larynx will be discussed in the next section.

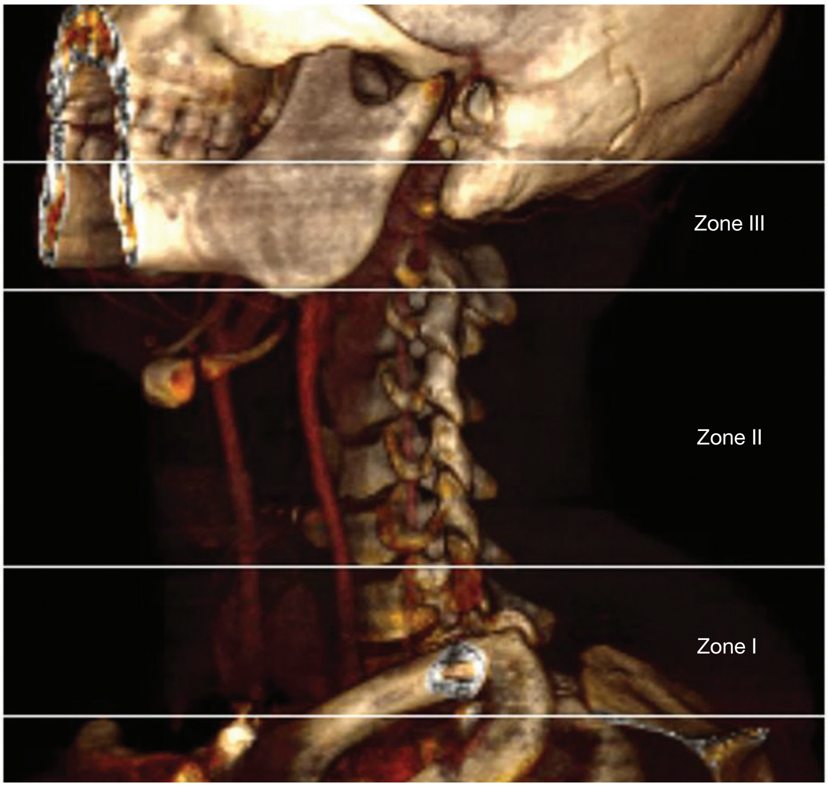

Figure 18. Zones of the neck. Zone I is bounded inferiorly by the sternal notch and superiorly by the cricoid cartilage. Zone II extends from the level of the cricoid cartilage to the angle of mandible. Zone III extends from the angle of mandible to the base of the skull.

Blunt neck injuries

Motor vehicle accidents remain the commonest cause of blunt neck trauma, resulting in hyperextension injuries (Verdonck et al, 2016). Other mechanisms include assault, strangulation and sports injuries.

The same anatomical structures described in the previous section may also be injured in blunt neck trauma, but the rate of vascular injuries (0.67%) is lower and the laryngotracheal airway and cervical spine are most clinically susceptible to injury (Núñez et al, 2004).

Following rapid, orderly assessment trauma assessment starting with the airway, which must be suitably secured, haemodynamically unstable patients or those with signs of vascular injury (expanding or pulsatile haematoma, loss of pulse, exsanguination) will require urgent surgical exploration.

Computed tomography angiography

In haemodynamically stable patients who are at risk, for example because of a severe mechanism of injury or soft tissue swelling, computed tomography angiography is indicated (Verdonck et al, 2016) (Figure 19). Computed tomography angiography will also permit evaluation of the cervical spine for any fractures or malalignment.

Other imaging modalities

Magnetic resonance imaging may have additional value if a cartilage fracture is suspected but not confirmed by computed tomography, especially in children with incompletely ossified cartilages (Miracle and Uzelac, 2016). The role of magnetic resonance imaging in the clearance of patients with obtundation remains contentious. A meta-analysis of 17 studies with 14 327 patients favoured early discontinuation of cervical spine precautions on the basis of computed tomography alone in polytrauma patients with obtundation, because few patients with positive magnetic resonance imaging findings but negative computed tomography findings required a change in management (Panczykowski et al, 2011). As with penetrating trauma, if computed tomography is inconclusive and there remains clinical suspicion of pharyngo-oesophageal perforation, further examination with fluoroscopy, computed tomography oesophagoscopy or endoscopy may be performed (Miracle and Uzelac, 2016).

Figure 19. Soft tissue trauma of the neck. a. Sagittal computed tomography angiogram image demonstrates a large prevertebral haematoma (blue star). b. The axial computed tomography image shows active contrast extravasation deep to the right sternocleidomastoid muscle (red arrow) with surrounding soft tissue and intramuscular haematoma (blue star). The left internal jugular vein (purple arrow) is normal, but no corresponding right internal jugular vein is identified indicating vascular trauma. The red star indicates the prevertebral haematoma.

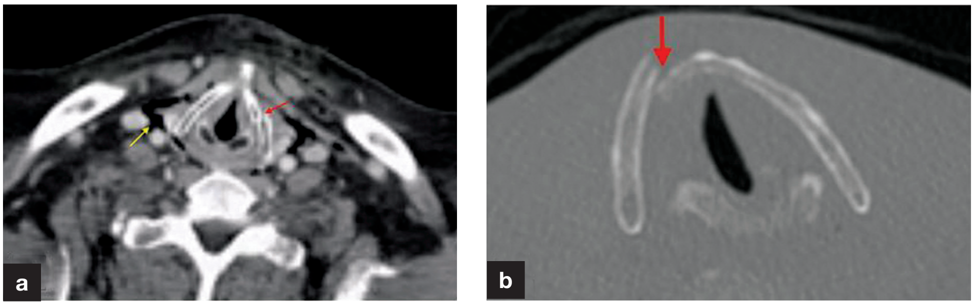

Figure 20. Thyroid cartilage fractures (red arrow). a. Axial computed tomography image (soft tissue reconstructions) of a vertical left thyroid cartilage fracture. Note the gas in the carotid spaces (yellow arrow) and also in the prevertebral space. b. Axial computed tomography image (bone reconstructions) of a displaced vertical, right thyroid cartilage fracture.

Laryngeal trauma

Laryngeal trauma may result from penetrating or blunt neck trauma or iatrogenic injury secondary to intubation. Mortality rates are estimated to be as high as 40% for blunt trauma and 20% for penetrating laryngeal trauma (Shi et al, 2019).

The severity of laryngeal trauma ranges from minor endolaryngeal haematomas through to fractures of the various components of the larynx and at the most severe end of the spectrum, complete laryngotracheal separation. However, the commonest type of laryngeal injury is a thyroid cartilage fracture (Becker et al, 2014) (Figure 20). The cricoid cartilage is less prone to fracture as it is thicker and stronger than the thyroid cartilage. Identification of fractures can be challenging, particularly when the proportion of non-ossified cartilage is high, for example in younger patients, and so evaluation with bone and soft tissue windows is required (Shi et al, 2019).

Since outward signs of injury may be lacking and acute supraglottic oedema may limit direct visualisation with a laryngoscope, the radiologist has an important role in detecting and reporting subtle findings at initial imaging. This is necessary to guide appropriate management and prevent severe complications including airway obstruction, stenosis, respiratory tract infections, aspiration and tracheo-oesophageal fistula (Prokakis et al, 2014).

It is essential that airway management is addressed before evaluation with endoscopy and imaging. In stable patients multidetector computed tomography is the examination method of choice to evaluate laryngeal trauma and associated lesions (Becker et al, 2014). While laryngeal injuries may be detected on multidetector computed tomography of the cervical spine performed for suspected cervical spine injury, ideally a dedicated multidetector computed tomography of the neck should be performed with or without contrast material and with thin-section reconstructions (Shi et al, 2019).

Other imaging modalities: magnetic resonance imaging

Although infrequently used, multidetector computed tomography may miss laryngeal fractures and cartilage avulsions in young patients with non-ossified cartilage or in patients with poorly ossified cartilage. Therefore, magnetic resonance imaging may be used in this context when a cartilage fracture or epiglottic avulsion is suspected but has not been demonstrated on computed tomography (Becker et al, 2014).

Conclusions

Facial fractures are common in the trauma patient, and a wide range of soft tissue trauma may occur in the neck. Following emergent management of the patient, once the airway is secured and the patient stabilised, further investigation with plain film radiography, multidetector computed tomography and magnetic resonance imaging may be required to guide further management and pre-surgical planning.

Key points

- Facial, penetrating and blunt trauma of the neck together account for a significant number of attendances in the emergent setting.
- Stabilisation of the patient, from an airway and haemodynamic perspective, is the primary concern.
- A variety of complex fracture patterns may occur and these may be stratified according to the thirds of the face.
- Plain radiography does have a limited role, but the workhorse of imaging in the context of facial and soft tissue of the neck trauma is multidetector computed tomography which is accessible, fast, reliable and allows for multiplanar soft tissue and bone reconstructions.
- Other imaging modalities, such as magnetic resonance imaging, may be of value in specific circumstances and discussion with a radiologist as to suitability is recommended.

Author details

[1]Department of Radiology, Royal Marsden Hospital, Royal Marsden NHS Foundation Trust, London, UK

[2]Department of Radiology, Guy's Hospital, Guy's and St. Thomas' Hospitals NHS Foundation Trust, London, UK

Acknowledgement

Figure 6 is reproduced by kind permission of AO Foundation, Switzerland (www.aosurgery.org) from Cornelius et al (2009).

Conflicts of interest

The authors declare no conflicts of interest.

References

Alcalá-Galiano A, Arribas-Garcia IJ, Martin-Pérez MA et al. Pediatric facial fractures: children are not just small adults. Radiographics. 2008;28(2):441–461. https://doi.org/10.1148/rg.282075060

Alimohammadi R. Imaging of dentoalveolar and jaw trauma. Radiol Clin North Am. 2018;56(1):105–124. https://doi.org/10.1016/j.rcl.2017.08.008

Becker M, Leuchter I, Platon A et al. Imaging of laryngeal trauma. Eur J Radiol. 2014;83(1):142–154. https://doi.org/10.1016/j.ejrad.2013.10.021

Bradley Strong E. Frontal sinus fractures: current concepts. Craniomaxillofac Trauma Reconstr. 2009;2(3):161–175. https://doi.org/10.1055/s-0029-1234020

Brennan JA, Holt GR, Connor MP et al. Resident manual of trauma to the face, head, and neck. 1st edn. Alexandria (VA): American Academy of Otolaryngology – Head and Neck Surgery Foundation; 2012:1–238

Cornelius C-P, Gellrich N, Hillerup S et al. NOE, Type I. 2009. https://surgeryreference.aofoundation.org/cmf/trauma/midface/noe-type-i/definition (accessed 1 May 2020)

Dreizin D, Nam AJ, Diaconu SC et al. Multidetector CT of midfacial fractures: classification systems, principles of reduction, and common complications. Radiographics. 2018;38(1):248–274. https://doi.org/10.1148/rg.2018170074

Ellis E. Passive repositioning of maxillary fractures: an occasional impossibility without osteotomy. J Oral Maxillofac Surg. 2004;62(12):1477–1485. https://doi.org/10.1016/j.joms.2004.08.004

Ellis E. Orbital trauma. Oral Maxillofac Surg Clin North Am. 2012;24(4):629–648. https://doi.org/10.1016/j.coms.2012.07.006

Hopper RA, Salemy S, Sze RW. Diagnosis of midface fractures with CT: what the surgeon needs to know. Radiographics. 2006;26(3):783–793. https://doi.org/10.1148/rg.263045710

Koch B, Hamilton B, Hudgins P, Harnsberger R., Diagnostic imaging: head and neck. Amsterdam: Elsevier; 2017:1352

Koo L, Kapadia MK, Singh RP, Sheridan R, Hatton MP. Gender differences in etiology and outcome of open globe injuries. J Trauma. 2005;59(1):175–178. https://doi.org/10.1097/01.TA.0000173624.37438.D6

Kortbeek JB, Al Turki SA, Ali J et al. Advanced trauma life support, 8th edition, the evidence for the change. J Trauma. 2008;64(6):1638–1650. https://doi.org/10.1097/TA.0b013e3181744b03

Laub DR. Mandibular fractures. 2016. http://emedicine.medscape.com/article/1283150-overview#a4 (accessed 22 February 2020)

McGhee A, Guse J. Radiography for midfacial trauma: is a single OM 15° radiograph as sensitive as OM15° and OM30° combined? Br J Radiol. 2000;73(872):883–885. https://doi.org/10.1259/bjr.73.872.11026865

Miracle AC, Uzelac A. Imaging blunt and penetrating trauma to the neck: clinical relevance and management. Appl Radiol. 2016;45(7):14–19

Naeem A, Gemal H, Reed D. Imaging in traumatic mandibular fractures. Quant Imaging Med Surg. 2017;7(4):469–479. https://doi.org/10.21037/qims.2017.08.06

Núñez DB, Torres-León M, Múnera F. Vascular injuries of the neck and thoracic inlet: helical CT-angiographic correlation. Radiographics. 2004;24(4):1087–1100. https://doi.org/10.1148/rg.244035035

Offiah C, Hall E. Imaging assessment of penetrating injury of the neck and face. Insights Imaging. 2012;3(5):419–431. https://doi.org/10.1007/s13244-012-0191-y

Panczykowski DM, Tomycz ND, Okonkwo DO. Comparative effectiveness of using computed tomography alone to exclude cervical spine injuries in obtunded or intubated patients: meta-analysis of 14,327 patients with blunt trauma. J Neurosurg. 2011;115(3):541–549. https://doi.org/10.3171/2011.4.JNS101672

Prokakis C, Koletsis EN, Dedeilias P et al. Airway trauma: a review on epidemiology, mechanisms of injury, diagnosis and treatment. J Cardiothorac Surg. 2014;9:117. https://doi.org/10.1186/1749-8090-9-117

Rhee SC, Kim YK, Cha JH, Kang SR, Park HS. Septal fracture in simple nasal bone fracture. Plast Reconstr Surg. 2004;113(1):45–52. https://doi.org/10.1097/01.PRS.0000096705.64545.69

Shi J, Uyeda JW, Duran-Mendicuti A, Potter CA, Nunez DB. Multidetector CT of laryngeal injuries: principles of injury recognition. Radiographics. 2019;39(3):879–892. https://doi.org/10.1148/rg.2019180076

Steenburg SD, Sliker CW, Shanmuganathan K, Siegel EL. Imaging evaluation of penetrating neck injuries. Radiographics. 2010;30(4):869–886. https://doi.org/10.1148/rg.304105022

Sung EK, Nadgir RN, Fujita A et al. Injuries of the globe: what can the radiologist offer? Radiographics. 2014;34(3):764–776. https://doi.org/10.1148/rg.343135120

Verdonck P, De Schoutheete JC, Monsieurs KG et al. Penetrating and blunt trauma to the neck: clinical presentation, assessment and emergency management. B-ENT. 2016;Suppl 26(2):69–85

Winegar BA, Murillo H, Tantiwongkosi B. Spectrum of critical imaging findings in complex facial skeletal trauma. Radiographics. 2013;33(1):3–19. https://doi.org/10.1148/rg.331125080