Interpretation of skull and facial radiographs

Introduction

There are few indications for the skull X-ray as it has been superseded by head computed tomography (CT) as the initial investigation in head trauma (National Collaborating Centre for Acute Care, 2003). Facial radiographs remain the first-line investigation for facial trauma. This article provides a systematic approach to interpreting skull and facial films and describes the common traumatic conditions requiring these X-rays along with radiological signs.

Interpretation of the skull radiograph

Technical factors

Radiographic projections

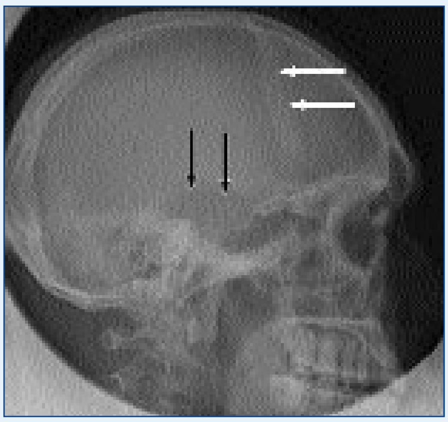
The views required will depend on the indication. In a head injury a lateral view supplemented by either an occipitofrontal (OF) or Townes view is performed.

Lateral (PA) film: The patient lies on the X-ray couch with the side of the head on the film cassette. This is the most commonly required view (*Figure 1*), and is performed by horizontal beam radiography. This means that the X-ray beam is in the same horizontal plane as the supine patient, such that an air–fluid level can be demonstrated in the sphenoid sinus.

Posteroanterior (PA) (OF) film: The patient lies prone on the X-ray couch with the forehead on the film cassette.

Townes (AP) film: The patient lies supine on the X-ray couch with the occiput on the film cassette (*Figure 2*). This is contraindicated in suspected cervical injury.

Figure 1. Normal lateral skull radiograph. Note normal vascular markings (black arrows) and coronal skull suture (white arrows).



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Systematic radiological assessment

The patient's name, date of birth and date on the film should always be checked.

Film quality: The film projection should be checked (i.e. PA, AP, lateral). The first cervical vertebra should be visible on the lateral film. The exposure, film centring and rotation should be checked for adequacy. On the lateral view the anterior clinoid processes and posterior margins of the mandibles should be superimposed. Glasses and earrings should be removed.

Linear markings: Skull vascular markings are caused by blood vessels marking an impression on the bones of the vault, resulting in branching linear lucencies. These can be difficult to distinguish from vault fractures, but are often more faint as they only involve the inner table of the skull, and also may have a sclerotic margin (*Table 1*). Normal anatomical skull sutures should also be distinguished from skull fractures. They exhibit symmetrical anatomical position and have fine sclerotic or corticated margins. Sutures are not as translucent as fractures. Fractures may occur along a suture causing diastasis. In children raised intracranial pressure may result in widening of sutures a few days after a head injury but this rarely occurs in adults. Small irregular lucencies can sometimes be seen near the vertex, caused by normal arachnoid granulations.

Figure 2. Normal Townes view of skull. Normal lambdoid skull sutures are marked (white arrows).

Skull vault thickness is non-uniform, often very thick frontally and at the occipital protruberances. It may be normally thinned in the parietal regions.

Aerated structures: The paranasal sinuses should be inspected. Aerated mastoid air cells should be present bilaterally.

Calcifications: A number of normal calcifications can be present intracranially, including the pineal gland (50% over 20 years), basal ganglia, choroid plexus, dura and vasculature.

The developing skull: At birth the cranial bones may overlap as a result of in-utero moulding, but this normally resolves within a week. Also at birth, the sinuses are not aerated, developing with the facial skeleton over the first few years of life (*Figure 3*). Small lateral fontanelles normally close by 3 months, the posterior fontanelle normally closes by 8 months, and the anterior fontanelle by 18 months. Accessory sutures are more common in children, and can be unilateral, often mistaken for fractures. The frontal bone is divided in two by the metopic suture, which usually fuses by 2 years but may persist into adulthood. The mendosal suture (accessory occipital suture) may also persist into adulthood. The major

Table 1. Distinguishing fractures from vascular markings

Vascular marking	Fracture
Sclerotic margin	Absent sclerotic margin
Grey/black density (only inner table of skull involved)	Black density (both inner and outer tables of skull bone involved)
Occur in anatomical sites	Occur in non-anatomical sites
Branches taper peripherally	Branch abruptly

sutures narrow – the width decreases from 1 cm at birth to 2 mm by 3 years old.

Indications

In moderate and more severe head injuries, patients should be referred directly for a head CT, as stated in National Institute for Clinical Excellence guidelines (National Collaborating Centre for Acute Care, 2003). Patients who have lost consciousness, have significant amnesia, CSF leak from ear or nose, suspected penetrating injury or foreign body, suffered an epileptic fit, repeated episodes of vomiting or any neurological deficit should be considered in this category.

In more mild injuries, in an alert and orientated patient, there is still a role for the skull radiograph, although usually only to assess for soft tissue foreign bodies. However, occasionally on such a study, a skull fracture may be revealed (*Figure 4*). A depressed skull fracture can be more difficult to diagnose, as it may appear only as a dense white line or double density as a result of overlapping bone fragments. A fluid level in the sphenoid sinus is only detected on a lateral film, and is a strong indicator that a base of skull fracture has occurred (*Figure 5*).

The presence of intracranial air is a rare but important sign, as this implies a fracture has occurred through a sinus (*Figure 5*). This is typically seen as an abnormal lucency within the lateral ventricles or at the base of the brain, and often results from penetrating trauma (*Figures 6a* and *b*). If a skull fracture is diagnosed, the head injury should be reclassified as moderate to severe. Although a fracture is an important sign of a head injury, it bears little correlation to underlying brain damage, and the patient should be referred for an urgent head CT to assess for any possible intracranial injuries.

Assessment of craniocervical junction and atlantoaxial joint (abnormal >3 mm in adult and >5 mm in children) should be performed routinely.

Figure 3. Skull radiograph in the neonate. Note the opacification of the paranasal sinuses. This is a normal appearance at birth, as the paranasal sinuses aerate over the first few years of life.

Figure 4. A frontal radiograph showing a linear skull fracture through the right parietal bone (arrow).

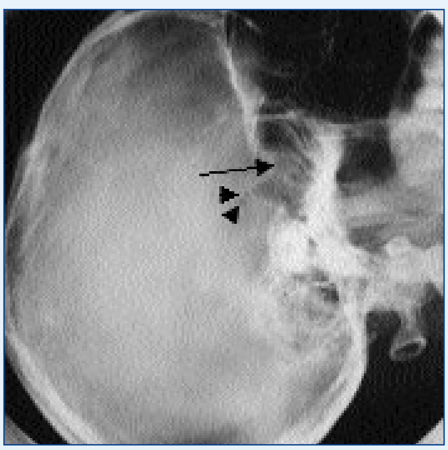
Interpretation of facial radiographs

Technical factors

Radiographic projections

For most indications three standard views are normally adequate: two tilted frontal views, with differing degrees of angulation (termed the occipitomental (OM) view and OM30 view), and a lateral view (the least useful). Occasionally, a submentovertical (SMV) view is required, in which the ethmoid and sphenoid sinuses are visualized, and also the skull base. An orthopantomogram (OPG) is a specialized view of the mandible. This uses tomography: the X-ray tube and film move in opposite directions, generating a panoramic image of the jaw, while blurring out other structures. Additional views will be discussed in the appropriate clinical contexts.

Figure 5. A lateral horizontal beam skull radiograph showing an air–fluid level in the sphenoid sinus (arrow), and intracranial air (arrowheads). In the context of head trauma, these indicate that a base of skull fracture has occurred.



Systematic radiological assessment

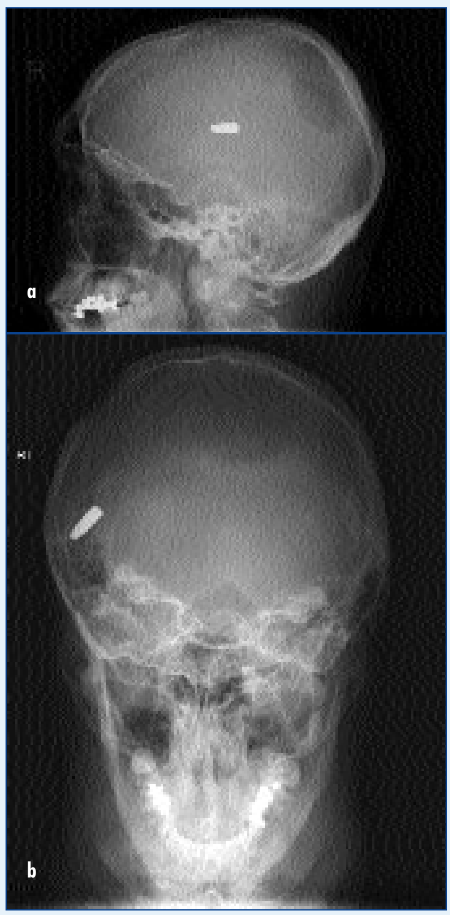
The patient's name, date of birth and date on the film should always be checked.

Film quality: The film projection should be checked (i.e. OM, OM30, lateral). The mandible should be visible on the frontal films. Glasses and earrings should be removed.

Interpretation

A useful system for inspecting the frontal facial views uses a series of lines traced over

Figures 6a and b. An AK-47 rifle bullet is seen intracranially, embedded within the right side of the brain. There is also a post-surgical rounded bony defect within the right parietal bone.

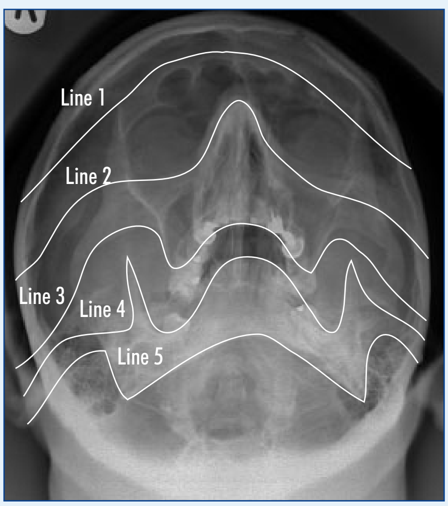


the radiograph, termed McGrigor's lines (*Figure 7*). Soft tissue swelling, sutural widening, air–fluid levels and any fractures should be observed, with particular attention paid to symmetry between the injured and uninjured sides. Line 1 passes through the frontozygomatic suture at the lateral margin of the orbit, and then runs over the superior orbital margin and across into the frontal sinus, before passing across the same structures in reverse on the contralateral side. Line 2 passes along the superior border of the zygomatic arch (likened to an elephant's trunk), crosses the zygomatic body, and onto the inferior orbital margin, before passing up to the bridge of the nose and to the contralateral side. Line 3 passes along the inferior border of the zygomatic arch (the elephant's trunk), along the lateral border of the maxilla, around the lateral and inferior margins of the maxillary antrum, and across to the contralateral side. Lines 4 and 5 relate to the superior and inferior surfaces of the mandible.

Paranasal sinuses: The maxillary sinuses and ethmoidal air cells should be fully aerated. The frontal and sphenoid sinuses may have widely varying pneumatisation, and are often asymmetrical. The maxillary sinuses appear radiographically a few weeks after birth, while the others appear over the first few years of life. A fluid level in the sphenoid sinus in the context of trauma implies a skull base fracture has occurred.

Bony anatomy: The orbits, zygomatic arches, nasal bone and mandible should all be inspected. The zygomatic sutures should not be widened. On the frontal views, in the context of trauma, the uninjured side is a useful 'normal' comparison.

Figure 7. A normal angled occiptomental view of the face, overlaid with McGrigor's lines, used to identify bony or soft tissue injuries.



Indications

Facial skeleton: Facial fractures are common. Patients presenting with facial injuries should have an early airway assessment before radiological investigation, as this can be compromised, particularly in severe mandibular injuries. Plain radiography remains the first-line investigation, with cross-sectional imaging reserved for more specialized indications. Cortical breach is the most important sign of a fracture, although secondary signs include soft tissue swelling, sinus opacification or air–fluid level, and abnormal air. Abnormal air includes subcutaneous emphysema, intraorbital and intracranial air, all of which are highly suggestive of a fracture of an aerated sinus.

Orbital fractures: A direct blow to the front of the orbit may produce an orbital 'blow-out' fracture. The blow transmits force to the orbital rim, which in turn transmits the force to its weaker medial wall or more commonly floor, where the fracture occurs. If the floor fractures, normally only fat passes through into the maxillary sinus, although sometimes the inferior and even the medial rectus muscle may herniate through the fracture defect. Failure to recognize this may result in permanent symptomatology. Diplopia may be the only clinical sign of this, and that itself may be secondary to periorbital haemorrhage or a number of other post-traumatic disturbances.

Radiologically the only sign may be a soft tissue opacity in the upper part of the maxillary sinus (the 'teardrop' sign), as often the fractures are completely undisplaced and not visualized (*Figure 8*). Intraorbital air is a useful sign when present (*Figure 9*), although antral opacification or air–fluid level are not specific. Fracture of the medial wall is usually not particularly clinically significant.

Nasal fractures: These are extremely common and often isolated injuries. They should be assessed clinically and do not require imaging, except in medicolegal contexts, when a lateral film is usually sufficient.

Frontal fractures: These are uncommon, and usually accompany other injuries in the context of more severe trauma. There is an association with underlying brain injury, and a CT is more appropriate in this setting.

Ethmoidal fractures: An isolated naso-ethmoidal injury is uncommon, typically produced by a high energy blow to the upper nose by a small object. Associated eye and intracranial injuries are common.

Zygomatic arch fractures: The zygomatic arch can be seen on the OM, Townes, OF and SMV views. The 'tripod' fracture is a common injury in which the zygoma can detach from the remainder of the facial skeleton. The arch of the zygoma and body of the zygoma both fracture, and the fronto-zygomatic suture widens (*Figure 10*).

Figure 8. An orbital 'blow-out' fracture. Soft tissue is seen superiorly within the right maxillary antrum consistent with herniated orbital contents (black arrow). There is a fracture of the inferior right orbital margin (white arrow), with associated periorbital soft tissue swelling (arrowhead).

Figure 9. Occipitofrontal view of the skull, showing orbital emphysema (arrow).

Figure 10. A 'tripod' fracture. A large amount of soft tissue swelling overlies the bony injuries. A widened left frontozygomatic suture (white arrow), a fracture through the body of the zygoma (black arrow) and a fracture through the zygomatic arch (arrowhead) are shown.

Complex facial fractures: These have been classified according to the Le Fort system, which defines three patterns of fracture following severe blunt facial trauma (*Table 2*). In a Le Fort I fracture the lower maxilla becomes separated from the rest of the face. In a Le Fort II fracture a central pyramidal fracture occurs. Complete craniofacial separation occurs in a Le Fort III fracture (*Figure 11*). In practice many facial injuries do not fit into a pattern of Le Fort fractures but the classification is still used for descriptive purposes.

Mandibular fractures: Normally oblique views supplementing a frontal film are adequate. Other views such as an OPG may be required, e.g. to demonstrate dental injuries. The mandible should be considered as a bony ring. It will usually fracture in two places. Classically an obvious fracture will occur at the site of impact (symphysis) (*Figure 12*), and a subtle fracture where the force dissipates (condylar neck), although the ramus, body and angle also commonly fracture (*Table 3*). If a fracture involves a tooth-bearing surface, it should be considered an open fracture. Injury to the temporomandibular joint is rare, and best demonstrated on CT. Severe mandibular injuries may cause airway compromise. BJHM

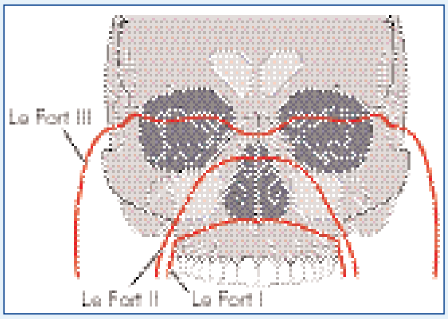


Figure 11. Fracture lines in Le Fort I, II and III fractures.

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Conflict of interest: none.

Figure 12. A fracture of the right body (black arrow) and left angle of the mandible (white arrow). The mandible should be considered as a bony ring as it will usually fracture in two places.

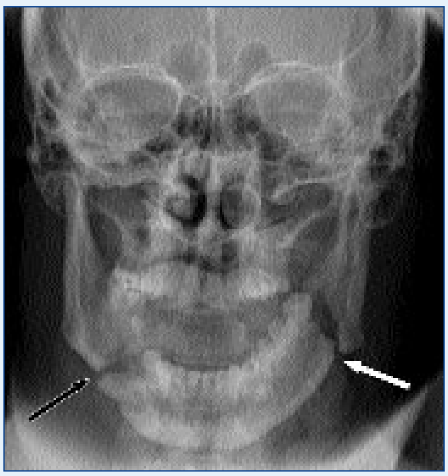

Table 2. The Le Fort fracture classification

Le Fort I	Separation of the upper jaw. The alveolar surface of the maxilla separates from the main part of the maxilla, with fractures through the medial wall and floor of each maxillary sinus, and through the lower nasal septum in the midline
Le Fort II	A central pyramid shaped fragment is separated. Fractures occur through the nasal septum, the maxillary sinuses and the inferior and medial walls of the orbits
Le Fort III	Separation of the entire facial skeleton from the skull base. Fractures occur through the nasal septum, medial and lateral walls of the orbits and through the zygomatic arches

National Collaborating Centre for Acute Care (2003) *CG4 Head injury: Triage, assessment, investigation and early management of head injury in infants, children and adults - Full guidelines.* National Institute for Clinical Excellence, London

Further reading

Druelinger L, Guenther M, Marchand EG (2000) Radiographic evaluation of the facial complex. *Emerg Med Clin North Am* **18**(3): 393–410

Hodgkinson DW, Lloyd RE, Driscoll PA, Nicholson DA (1994) ABC of emergency radiology. Maxillofacial radiographs. *BMJ* **308**(6920): 46–51

McGrigor DB, Campbell W (1950) The radiology of war injuries. Part VI. Wounds of the face and jaw. *Br J Radiol* **23:** 685–96

Morse MH (2001) Maxillofacial radiology. In: Grainger RG, Allison DJ, Adam A, Dixon AK, eds. *Grainger and Allison's Diagnostic Radiology: A Textbook of Medical Imaging.* 4th edn. Churchill Livingstone, Edinburgh

Raby N, Berman L, de Lacey G (2005) *Accident and Emergency Radiology. A Survival Guide.* 2nd edn. Bailliere Tindall, London

Table 3. Common errors

Mistaking normal vascular markings or normal skull sutures for linear fractures
Missing a depressed skull fracture, seen as a double density or as a dense white line
Missing an air fluid level in the sphenoid sinus, indicative of a base of skull fracture
Missing a 'blow out' fracture. Subtle soft tissue in the roof of the maxillary antrum
Missing a second, more subtle mandibular fracture

KEY POINTS

- Always check the name, age and date.
- Assess film quality. The mandible should be present on standard facial views.
- Familiarize oneself with normal anatomical vascular markings and normal anatomical skull sutures, in order to recognize linear fractures.
- Trace McGrigor's lines to identify bony or soft tissue injuries.
- Look for a dense white line, which may represent a depressed skull fracture.
- Look for an air–fluid level in the sphenoid sinus, indicative of a base of skull fracture.
- Look for soft tissue in the roof of the maxillary antrum. Cortical irregularity of the orbital floor is often absent in orbital 'blow out' fractures.
- Regard the mandible as a bony ring. A second, more subtle mandibular fracture usually accompanies the more obvious one.