Craniomaxillofacial Trauma

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The facial skeleton is often damaged as a result of sports injuries, interpersonal violence and road traffic accidents, and craniomaxillofacial injuries present in increasing numbers to accident and emergency departments. With the introduction of seat-belt legislation in the UK, the pattern of injury has changed. Although, more recently, airbags have been fitted to cars, their effect has not yet been fully assessed. Many patients who are victims of interpersonal violence present with isolated facial injuries, but those who have suffered major craniofacial trauma in road traffic accidents also tend to have multisystem injuries. Primary repair of the craniofacial injuries affords the best opportunity of obtaining a satisfactory outcome and it is imperative, therefore, that members of the multidisciplinary trauma team are aware of the scope of treatment that may be available from their maxillofacial colleagues.

Primary survey

Early assessment and resuscitation must be according to Advanced Trauma Life Support (ATLS) principles. During the primary survey, the airway may be compromised by fractures of the dentition or jaws, indicating severe supraclavicular trauma and hence the possibility of a cervical injury. Breathing may also be inhibited if a fractured or displaced tooth is inhaled. Assessment of the circulation, including treatment of haemorrhage, should follow. Haemorrhage from the scalp or face may be visible, and should not be underestimated. Initial control of the bleeding can be obtained by the application of pressure packs and/or sutures. Should the mid-facial skeleton be involved, however, significant haemorrhage may occur which is not so easily identified or controlled. Although external carotid artery ligation may resolve this type of haemorrhage, it is inappropriate in the resuscitation room. The application of epistats and appropriate mouth props (Figure 1) may afford sufficient haemostasis to allow the patient to be transferred to theatre. It is necessary to insert the mouth props before the application of the epistats (or other nasal balloons), because inflation of the balloons may further distract the fractures and increase haemorrhage. To provide support to the maxilla via the mouth props, it is necessary for the mandible to be intact or, if it is fractured, to be supported by a hard cervical collar. This should already be in position if ATLS principles are being followed. Further treatment depends on the general status of the patient. If the only injuries are to the craniomaxillofacial area and if the patient is stable, treatment should follow standard lines of a full history, examination, special tests and treatment. If the patient has multiple severe injuries, and has to go immediately to theatre, it may be appropriate to stabilize major fragments of the facial skeleton and perform a definitive tracheostomy.

Secondary survey

Maxillofacial examination

A thorough systematic examination of the cranium, face and cervical spine is the first part of a secondary survey to be carried out and must be strictly adhered to. A careful inspection and palpation must be carried out over the skull vault, taking special note of any lacerations, crepitus or areas of large haematoma. The orbital rims should be palpated, as should the bridge of the nose and the zygomatic prominences. The cranial nerves should be formally assessed. Any deformity, asymmetry and movement of the facial skeleton should be reported and, if the patient is conscious, note should be made of pain and tenderness. The intercanthal distance and the interpupillary distance (usually 30-34 mm and 55 mm respectively) should be recorded. The eyes must be fully assessed with respect to pupillary size and reactivity, ocular movements, visual acuity and fundoscopy, and, if appropriate, ophthalmological assistance should be sought immediately. Subconjunctival haemorrhage should be looked for, though it is not an absolute indicator of an underlying fracture of the zygomatic complex.

The signs of retrobulbar haemorrhage must be looked for; these include proptosis, ophthalmoplegia, decreasing or loss of visual acuity, dilating pupil and loss of direct pupillary reflex. Permanent blindness may result if these are overlooked.

The maxilla should be palpated for movement and crepitus, and sensation must be assessed in the maxillary branch of the trigeminal nerve. The ramus and lower border of the mandible should then be palpated for step deformity and sensation checked in the mandibular branch of the trigeminal nerve. Mandibular movement in lateral and protrusive directions can be assessed, but vertical movement will be restricted by a cervical collar.

Intra-oral examination

Intra-oral examination is also essential, noting teeth present in upper and lower arches and, more importantly, a note of lost or fractured teeth with an assessment of the occlusion. The floor of the mouth, the tongue, the palate and the oropharynx should be fully visualized. Lacerations should be noted, as should sublingual and palatal haematomas - these are often related to mandibular and maxillary fractures. The intra-oral examination affords a further opportunity to test the stability of the maxilla and mandible.

Radiological investigations

Radiography is a benchmark in the diagnosis of facial fractures. With an uncooperative patient, however, the usefulness of radiographs taken in the accident and emergency department is doubtful. If surgery is not indicated immediately, radiography is probably best left until the patient is more cooperative.

Useful radiographs include:

- cervical spine views
- occipitomental views (15 and 30 degrees), for orbital and zygomatic fractures
- postero-anterior views of facial bones
- skull views
- submentovertex view, for zygomatic arch fractures
- orthopantomogram ('OPT'), for mandible and upper and lower teeth
- reverse Towne's view - a PA view inclined upwards at 30 degrees, for the condylar neck area
- occlusal films, for dento-alveolar fractures.

CT

CT scanning is now much more accessible, often with a 24-hour service in trauma centres. CT scans allow a more complete assessment of the bony fragments and, if necessary, 3-D reconstruction (Figure 2) and stereolithography can be carried out. Stereolithography is the production of a 1:1 resin model utilizing the digital data from the CT scan. Protocols should be in situ so that if scans are being performed for cranial trauma, they should include the facial skeleton if facial trauma is suspected.

Principles of treatment

The craniofacial skeleton is the foundation of facial appearance and, as such, its accurate repair is of great functional, aesthetic and psychological importance to the patient. The best opportunity for a satisfactory repair is at primary surgery. A number of studies have shown that residual defects are difficult to correct and surgical outcome in a high percentage is inadequate.

There may be a delay of 2 to 3 days in undertaking primary repair if doctors from other specialties (eg, ophthalmology) become involved in the patient's management.

The most commonly accepted treatment modality for fractures of the craniofacial skeleton is open reduction and internal fixation. Initially this was described as 'rigid internal fixation' but the term currently used is 'adequate internal fixation'. There are two basic schools of thought that most operators follow: the AO/ASIF (Association for the Study of Internal Fixation), or the Champy/SORG (Strasbourg Osteosynthesis Research Group).

The treatment methods of these two groups with regard to the mid and upper face vary only slightly in the sizing of the miniplates. Their major difference is in their treatment of mandibular fractures.

- The AO/ASIF principles are based on a large plate placed near the lower border of the mandible with a smaller tension band plate placed near the upper border.

- The Champy/SORG technique utilizes physiological forces acting on the mandible to provide the compression of the lower border, and therefore proximal mandibular fractures are treated by a single plate in the upper border (Figure 3).

Recently, there has been recognition by members of both groups of the benefits of the alternative philosophy in some situations.

Towards the anterior segment of the mandible, both groups utilize two plates to overcome the torque caused by the arched shape of the mandible. Whichever technique is used, the basic requirements are:

- anatomical reduction
- stable internal fixation
- atraumatic surgical technique
- early mobilization of the jaw.

There are also differences with regard to the treatment of the fractured neck of the mandibular condyle. The AO/ASIF group suggest the use of miniplates, whereas the CHAMPY/SORG group utilize plates or Ecklet screws (a two-part lag screw system).

Classification of fractures

There are numerous classifications of different bones of the craniofacial skeleton, and it is unfortunate that there has not been universal acceptance of one particular classification with regard to any particular bone.

Facial skeleton

The facial bones can be divided into three conventional areas:

- the upper third, formed by the frontal bones
- the middle third, which includes zygomas, nasal bones and maxilla (including alveolus and teeth)
- the lower third - the mandible and teeth.

The bones of the face vary in thickness and strength. Forces are transmitted and dissipated by the face, along lines of strength protecting the intracranial contents; this may be compared to the energy-absorbing crumple zone of a motor car.

Upper third fractures

Signs and symptoms of upper third fractures include obvious deformity, haematoma and ecchymosis, flattening of the nasal bridge with or without telecanthus, and CSF rhinorrhoea.

Management - fractures of the frontal bone, orbital roof and naso-ethmoidal area are approached easily using the coronal flap or a convenient laceration (Figure 4a-c). Should bone loss be a feature in this type of fracture, the calvarium can be accessed easily for graft material. Orbital fractures require full exploration of the orbit, including full circumferential exploration around the globe, examining all four walls. This can be achieved using an extended coronal flap, though further incisions may be required to access the floor.

Middle third fractures

Signs and symptoms include the 'balloon face' and 'dish face' deformities, bilateral periorbital haematomas ('racoon eyes'), and enophthalmos may occur if there is gross disruption of the orbital walls. Severe epistaxis and/or orbital bleeding may be present, as may CSF rhinorrhoea. If the midfacial bones have been pushed posteriorly, the teeth may be gagged posteriorly - presenting as an anterior open bite. Tapping of the teeth with a metallic instrument may give the classical 'cracked cup' sign if a fracture is present. (A dull note is heard, rather like that heard when tapping a cracked cup; cf, the resonance of an intact cup.)

Classification - fractures of the mid portion of the face were described by Le Fort.

- The Le Fort I fracture is at a low level, detaching the palate and the maxillary alveolus. The fracture passes through the maxillary sinus walls, and the lateral nasal walls and septum.

- The Le Fort II fracture, also described as a pyramidal fracture, is a little higher; it passes through the sinus wall laterally, and passes medially superior to the nasal aperture, traversing the nasal bones.

- The Le Fort III fracture (also known as craniofacial dysjunction) includes fractures through the frontozygomatic sutures, the orbits and the nasofrontal sutures, thereby detaching the facial skeleton from the base of the skull.

Management - these fractures often occur on a unilateral basis, or with fractures at different levels on either side. Treatment is by open reduction and internal fixation with osteosynthesis plates (these may be microplates, low-profile miniplates, or miniplates using an intra-oral approach for Le Fort I and II fractures), though fixation with intra-osseous wires may occasionally be appropriate if plates are unavailable or as temporary fixation before plate placement. The technique of external fixation utilizing box frames or halo frames is uncommon but should not be forgotten because it provides a relatively rapid way of stabilizing the face. (Internal suspension wires are now seldom used.)

Zygomatico-orbital fractures: isolated fractures of the zygomatic complex are common and often caused by interpersonal violence.

Signs and symptoms range from the simple 'black eye', to gross facial asymmetry, diplopia, facial numbness and trismus. Displacement of this fracture can be manifest as disruption

of the frontozygomatic suture, along the zygomatic arch or the infra-orbital rim or lateral maxillary wall.

Management - the standard methods of reducing such a fracture involve:

- a Gillies lift (using a temporal incision within the hair line, an instrument is passed deep to the temporalis fascia under the zygomatic arch to the body of the zygoma)

- a bone hook, which may be introduced percutaneously beneath the buttress of the zygoma and the fracture reduced by simple elevation.

If the zygoma remains unstable after reduction or it cannot be elevated, open reduction and internal fixation are indicated. Internal fixation can also assist in the recovery of nerve function if the infra-orbital nerve is damaged. Fixation is usually with low-profile miniplates applied via local incisions (Figure 5), though other methods may be used (eg, k-wires, external fixators) if appropriate. Packing of the maxillary antrum with a soaked gauze pack is now uncommon.

Fractures of the orbital floor are common, and may result in diplopia and enophthalmos. Classically, diplopia was said to be due to trapping of the inferior rectus muscle. It is uncommon to see entrapment of the muscle, however, and the diplopia probably results from the periorbital fat herniating into the antrum, or damage to the motor nerves of the extra-ocular muscles. Orbital floor fractures are managed by returning the orbital contents to the orbit, and reconstructing the orbital floor. Reconstruction may be carried out using bone grafts, titanium plates, resorbable materials or lyophilized pig dermis. Silastic sheets are commonly used, though there are reports that this material has a high infection rate.

Fractures of the medial wall of the orbit may result in traumatic telecanthus (distance > 35 mm between the medial canthi). There are a number of ways in which this may be corrected. It has been shown that the deformity is not usually caused by disruption of the canthal ligament *per se,* but a fracture of a small piece of bone with a canthus still attached (Figure 4c). Thus by replacing the bone in its correct position using microosteosynthesis plates, further canthal repair may be unnecessary. If the canthus has become detached from the bone, however, it may be necessary to wire it back into position by transnasal wiring or suturing.

Mandibular fractures

Signs and symptoms of mandibular fracture include deranged occlusion, often with a step deformity, sublingual haematoma and anaesthesia or paraesthesia of the lower lip.

Management - it is of paramount important that the occlusion is restored correctly because any subsequent irregularity can be a major cause of morbidity. Mandibular fractures have been treated by a number of methods, including simple wiring techniques or bonding of modified orthodontic brackets on to the teeth. These methods are most useful for undisplaced fractures.

Intermaxillary fixation has been used for many years, but it poses a potential risk of airway control. Fractures of the mandible tend to be treated by open reduction and internal fixation with osteosynthesis plates; this usually involves intermaxillary fixation, albeit only during the operation. Plates are usually applied through intra-oral incisions, through some drilling and screw placement may require a transbuccal trocar. Fractures of the condylar neck are usually approached externally (Figure 5), as are many fractures of the atrophic edentulous mandible.

Practice points

- Maxillofacial surgeons should be involved early in the treatment and reception of patients with severe trauma.

- Internal midfacial haemorrhage may be severe and need treatment by epistats and mouth props.

- Patients suffering from head and facial injuries should have CT investigations carried out in the same session to avoid multiple visits to the scanner.

- Treatment of craniofacial fractures is generally by open reduction and internal fixation with micro/miniplates and screws.