Reconstruction after craniofacial trauma

L. K. Lam, C. M. Ho, P. W. Yuen and William I. Wei

Abstract

Management of craniofacial trauma has became a sophisticated branch of reconstructive surgery in the last 20 years. New operative techniques and advanced technologies have evolved to allow much better treatment results to be achieved. The general principles of diagnosis and management of craniofacial trauma are discussed. The approach to individual fractures is also highlighted.

Keywords: Craniofacial; Facial; Trauma; Fractures

Introduction

The earliest descriptions of facial fractures and their treatment could be found in the ancient Egyptians' literature in the 16th century B.C. and also in Hippocrates' writings in the 4th century B.C.[1] In the following 2,000 years, slow but definite progresses were made in the management of facial fractures. The two World Wars produced a large number of casualties and spurred the development of new plastic surgery operative techniques. The introduction of antibiotics, availability of safe blood transfusion, and advances in the administration of general anaesthesia have all contributed to the improved results in the care of patient who suffered from severe and complex facial trauma.

In the last two decades or so, management of craniofacial fractures has evolved from a largely conservative approach that include delayed repair and limited exposure of fracture fragments to an early, aggressive approach of fixing the fractures via wide exposures of the fragments.

Modern management of craniofacial trauma

Early, primary and definitive treatments are the preferred strategies. The goals are anatomical reduction, fixation of the fracture fragments and restoration of the pretraumatic occlusion and facial contour. At present, the management principles include precise anatomic diagnosis, direct and adequate fracture exposure, rigid internal fixation, primary bone grafting, and periosteal and soft-tissue suspension.[2]

The techniques in craniofacial surgery were pioneered by Paul Tessier of Paris in 1960s. This undoubtedly opened up a new chapter in plastic surgery texts. Much of Tessier's work was originally on the treatment of congenital craniofacial deformities.[3] However, the principles could well be applied to traumatic injuries. Incisions are designed to expose the whole craniofacial skeleton, including the mandible, subperiosteally. The fractured fragments are reduced to anatomical position or the osteotomized segments are repositioned in the desired manner. Sporadic reports of internal fixation of fractured facial skeleton appeared in the literature as early as the 1940s.[4] This, however, has only became a popular technique starting from the mid-1970s.[5,6] Major advances have been achieved in the hardware designs and the metallurgy of different systems by different manufacturers. The plating systems can be classified as compression or non-compression. Today, most systems use titanium because of its biological inertness. Low profile plates are available. More recently, the microplating systems are gaining popularity for use in children and in regions like the infraorbital rim.

Modern radiological modalities especially computed tomography (CT) scanning of the craniofacial skeleton is mandatory in the exact fracture diagnoses in complex and extensive injuries.[7] This eliminates diagnostic guessing in such difficult situations and allows better preoperative planning. Three dimensional reformatting of CT images allows visualization of the fractures and deformities resulted.[8]

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Clinical approach to craniofacial trauma patients

(A) *Initial evaluation*

In managing patients with severe facial trauma, the principles of general resuscitation apply. Control of the airway is of the first priority. In extensive midfacial and mandibular fractures, oedema of the pharynx can compromise the upper airway. Aspiration of blood, broken teeth, dentoalveolar segment or denture can cause suffocation or more distal respiratory obstruction. Intubation or tracheostomy should be considered in severe mid- or lower facial fractures, especially if there is significant bleeding due to soft tissue lacerations or fracture base of skull.

External sources of bleeding should be stopped by appropriate methods. Bandaging is usually adequate although bleeding from scalp may be devastating, and clipping or suturing immediately may be required for more effective haemostasis. Bleeding from the nasal and oral passage may be exsanguinating. In extensive midfacial and concomitant skull base fractures, bleeding is often extremely difficult to arrest even with packing. Although tracheostomy would allow a more effective nasal/oral packing, the mortality rate under these circumstances is high. Exclusion of other associated injuries is essential. In one major series of hospitalized facial fracture patients, 19 % had a life-threatening injury.[9]

(B) *Clinical fracture diagnosis*

In history taking, attention should be given to the mode of injury, particularly the magnitude and direction of the impact. Besides, any known or suspected history of previous facial fractures should be noted. In large urban centres, motor vehicle accidents and interpersonal violence are the two major causes of injuries.[10] During physical examination, the site of soft tissue swelling, bruises and local tenderness should be noted. The initial deformities may be masked by the soft tissue swelling and tenderness. Any limitation in extraocular muscle movements and/or diplopia should be noted. Telecanthus is a feature of severe nasoethmoidal fracture. Consultation to the ophthalmologist should be a routine in any fracture involving the orbit.

Trismus is a feature of zygomatic arch fracture whether it is isolated or part of a 'tripod fracture'. Malocclusion occur in displaced fractures of the maxilla or mandible. Any missing teeth or dentoalveolar segment should be recorded. Chest X-ray should be taken if aspiration is suspected. Steps and/or tenderness along the mandible reveal underlying fractures. Tenderness of the palate occurs in LeFort fracture. Concomitant tenderness and crepitus of the nasal bridge implies the pyramidal or LeFort type II fracture. Numbness or paraesthesia of the infraorbital nerve distribution can occur in orbital floor or zygomatic fracture, and numbness of the lower lip can occur in mandibular body fractures.

(C) *Radiological examination*

After the initial history taking and clinical examination, radiological examinations are required to either confirm or exclude the presence of facial fractures. Some of the fractures such as those involve the ethmoids or mandibular condyle are more confidently revealed by X-rays. In addition, undisplaced stable fractures or impacted fractures could also be missed clinically. More over, X-ray documentation is important for medicolegal reasons.

The Waters view is a posteroanterior projection of the facial skeleton with the patient in the prone position and the neck extended. This allows the orbits, zygomas, and maxillary sinuses to be projected against the relatively homogeneous area of the posterior skull. Fractures of the orbital rims, lateral maxillary walls and zygomatic arches are usually demonstrated. The submentovertex view is in the patient supine positions, with the head elevated and the neck arched. The beam projects an axial representation of the skull with the zygomatic arches outlined.

The orthopantomogram (OPG) of the mandible is the single best plain film for examination of the whole mandible. It reveals the orientation of the fracture lines and their relationships with the teeth. However, it requires the patient to sit up and stay still which is not always possible in trauma patients. Towne's view of the mandible is an anteroposterior view with the x-ray beam tilted 30 degrees downwards. This projects the ascending rami and subcondylar areas.

CT scanning has important advantages over the plain films in diagnostic evaluation of the more complex facial fractures. It offers excellent delineation of the bony anatomy and pathology and provides good demonstration of soft tissues. Today, CT scanning should be considered as a standard modality of investigation of orbital, nasoethmoidal, frontal sinus and maxillary fracture as well as condylar fracture of the mandible.

Magnetic resonance imaging (MRI) is not routinely used in the investigation of facial fractures as its delineation of bony structures is poor. It may, however, have a role in the investigation of suspected disc injury of the temporomandibular joint and soft tissue entrapment in orbital fractures.

(D) *Treatment of facial fractures*

After appropriate investigations to confirm the pattern of fracture, a treatment plan can be formulated.

Fixation of the fractures, if indicated, can be performed once the soft tissue swelling has reasonably subsided, which usually takes a few days. Occasionally, fixation of the fractures is performed right away as dictated by the necessity of transcranial procedures in craniofacial fractures. And sometimes in cases like isolated zygomatic arch fracture or nasal fracture where soft tissue swelling is minimal, early surgery could be carried out.

(1) Orbital fractures

They are either the 'pure forms' where only the orbital walls (usually the floor or medial wall) are fractured, or the 'impure forms' that are in fact part of the more extensive fractures involving the orbital rim. The term 'blowout fracture' has been used for the 'pure forms' to imply the hydraulic hypothesis.[10] Signs of 'blowout fracture' include diplopia, enophthalmos, dystopia of globe, pseudoptosis, infra-orbital nerve numbness and those of injuries of the globe. The Waters view may show the 'tear drop' sign or sometimes the displaced fracture fragment. Fluid level in the maxillary sinus may also occur. Coronal CT is excellent in revealing the site and size of the fracture as well as soft tissue entrapment. Surgery is indicated in entrapment and in cases of sizable fracture with soft tissue displacement to prevent enophthalmos. The orbital floor can be assessed via the subciliary or the transconjunctival approaches.[11] After reduction of herniated soft tissues reconstruction of the orbital floor can be done with either autogenous tissues or alloplastic materials. Split calvarium or rib, cartilage, antral wall or iliac bone can be used. Silastic or Telflon sheet, Marlex or vitallium mesh, absorbable sheet like gelfilm or vicyl mesh have all been tried with variable results.[12] (Fig. 1)

(2) Zygomatic fractures

Often referred to as 'tripod fracture', it is more accurately described as 'quadrapod fracture' for its four limbs in plain X-rays: the frontal process, the arch, the maxillary buttress and the lateral half of the infraorbital rim. Isolated arch fracture is the result of localized impact. The body fractures can be undisplaced or depressed and rotated. Comminuted fractures occur in high energy impact and often associated with other complex midface or orbital injuries. Subconjunctival haemorrhage, steps deformity along the orbital rim, infraorbital nerve numbness and trismus may be present. The Waters view is the single most useful plain film in diagnosing the fracture. The submentovertex view reveal depressed arch fracture as well as posterior displacement of the zygomatic body. CT scan show up more accurately the displacement at different sites and the degree of orbital floor destruction. For undisplaced zygomatic fractures, conservative treatment is justified but the patient is advised to have soft diet and malar protection for four to six weeks. Intermittent examination for displacement is required.[12] Most displaced zygomatic fractures should be managed by open reduction and internal fixation preferably with the miniplating system.[13] In general the more unstable or comminuted ones require more than one point of plating and at least one plate is placed across the frontozygomatic junction.[14]

(3) Nasal and nasoethmoidal fractures

Laterally displaced fractured nasal pyramid can be repositioned by the closed method followed by nasal packing and some form of external splintage such as a plaster cast. Rigid internal fixation has been advocated in case of nasofrontal separation.[15] In a series of

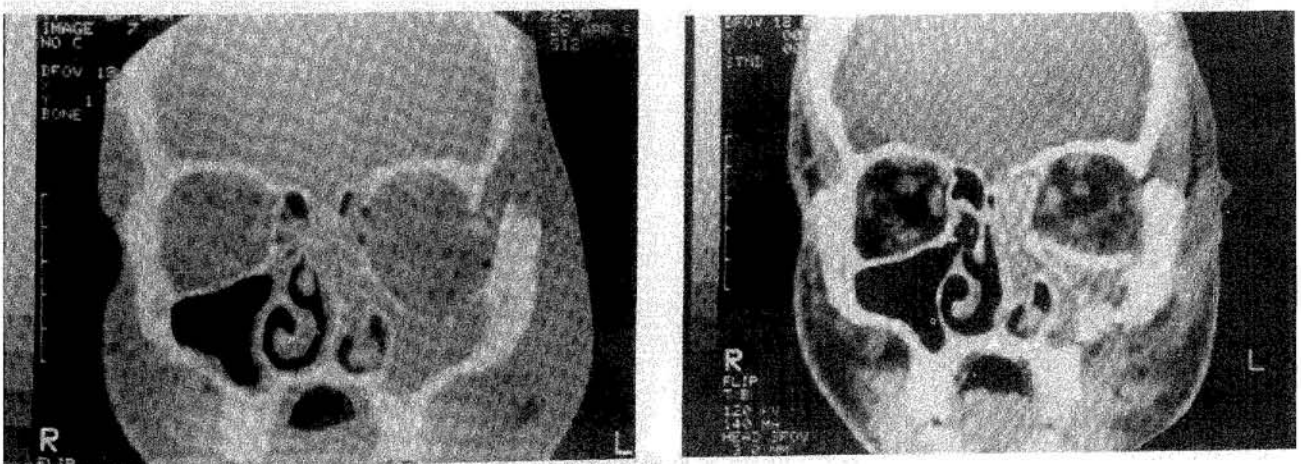


Fig. 1. (a)*(Left)* Coronal CT scan of face showing markedly displaced fractured left zygoma and disrupted orbital floor.
(b)*(Right)* Postoperative CT scan showing repositioned zygoma and repaired orbital floor with a rib graft.

107 patients treated by the closed method, 50% had some degree of nasal obstruction and 70% had obvious nasal deviation.[16] Fractures of the nasoethmoidal complex are result of direct blow to the upper nasal bridge and is the weakest part of the facial skeleton because of its fragile bony framework. The whole complex either telescoped backwards or extensively shattered. Associated orbital, maxillary or cranial fractures are common. Clinically, there is markedly swelling, flattened nasal bridge and possibly telecanthus. Anosmia and cerebrospinal fluid (CSF) rhinorrhea should also be looked for. Principles of surgical repair include correction of epicanthal folds, restoration of bony contour, and re-establishment of continuity of the lacrimal system and medial canthoplasty.[17] Reduction of the comminuted fragments and fixation with miniplates or microplates is the preferred method of treatment.

(4) Frontal sinus fractures

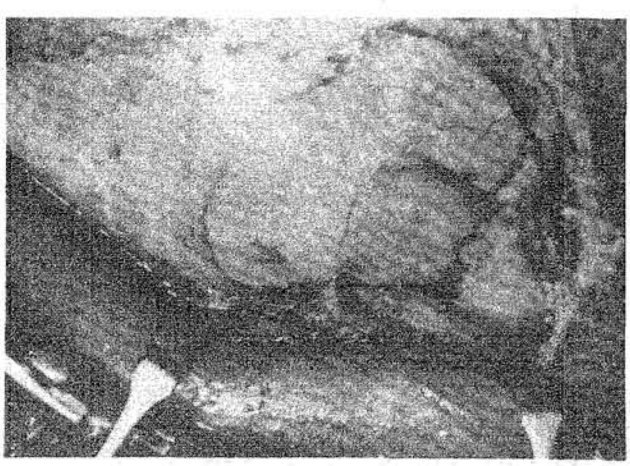
They can be missed by palpation because of the overlying soft tissue swelling. Other signs include tenderness and depression, supraorbital nerve numbness, CSF rhinorrhoea and subconjunctival ecchymosis. The Waters view and lateral skull film may reveal the fracture and fluid level in the sinus. CT is particularly useful in showing the posterior table fractures as well as excluding intracranial complications. Only undisplaced linear fractures of the anterior table are managed conservatively. Surgery is indicated in depressed comminuted fractures of the anterior table, nasofrontal duct injury and comminuted posterior table fractures.[18] Combined efforts of the neurosurgeon and plastic surgeon are often required. The anterior wall fracture fragments are carefully reduced and stabilized with miniplates or preferably microplates. In cases with evidence of nasofrontal duct involvement, sinus obliteration is indicated. (Fig. 2)

(5) Maxillary fractures

Based on experimental works on cadavers, Le Fort grouped the maxillary fracture lines into three types: I (transverse), II (pyramidal) and III (craniofacial disjunction).[19] With the more common high-velocity injuries nowadays, combinations of more than one type of fracture are usually seen. Clinically, the midface is swollen, flattened or elongated. Malocclusion is a rule. CSF leakage should be checked for in Le Fort II or III types of fractures. Mobility of the maxilla is demonstrated by grasping and gently moving the upper dental arch while the skull is stabilized. Concomitant skull base fractures should be noted and globe injuries be excluded. The Waters view is diagnostic but CT scan is much more informative in terms of delineating the exact fracture lines and soft tissue injuries. The principles of operative treatment include wide exposure of the fractures, reduction of the fracture fragments, and establishment of the pretraumatic occlusion which may require the use of prefabricated splints and rigid fixation at the structural struts.[20] Mandibular fractures, if present concomitantly, should be reduced and rigidly fixed before the manipulation of the maxillary fragments.

(6) Mandibular fractures

Mandibular fractures are classified as closed or open, displaced or non-displaced, complete or incomplete, linear or comminuted. Fractures in the body (tooth-bearing region) are often open or compound because of tearing of the gingiva or the periodontal ligaments. Anatomically, the fracture can be classified as dento-alveolar, condylar, subcondylar, coronoid, ramus,



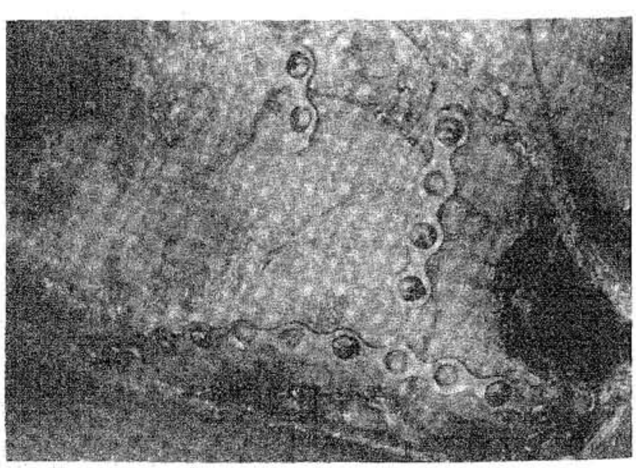


Fig. 2. (a)*(Left)* Operative photo showing depressed comminuted fracture of the anterior wall of frontal sinus.
(b)*(Right)* After fixation with titanium miniplates and screws.

angle, body, parasymphyseal or symphyseal. Another useful categorization is to divide them into unilateral, bilateral, multiple or comminuted types.

Diagnosis is made with history, physical examination and appropriate radiology. Symptoms include pain especially during jaw moving, change in occlusion, paraesthesia in the distribution of the inferior alveolar nerve, lingual nerve and long buccal nerve. Signs include tenderness, steps along the mandible, tears in the gingiva, trismus, swelling, ecchymosis, haematoma and malocclusion. An orthopantomogram and Townes view are good for screening purposes while other options, as mentioned above, are required for certain cases. In cases where the fractures are undisplaced, without mobility across the fractured fragments, unchanged occlusion and minimal symptoms, conservative treatment with analgesics and blenderized diet for four to six weeks can be tried. The patients should be examined weekly for any unfavourable signs. Other fractures often treated conservatively are intracapsular condylar fractures and high subcondylar fractures. Resting by intermaxillary fixation for two to four weeks followed by active jaw exercise is often preferred.[21] Intermaxillary fixation is the conventional method of immobilizing the fractured mandible. Use of direct interdental wiring or with arch bars are commonly employed. In unstable or severely displaced fractures, opened reduction and fixation is required. Interosseous wiring has been used for decades. Although effective and cheap, it often does not provide adequate stability to dispense intermaxillary fixation. On the other hand, the use of metal bone plates provides much more rigid fixation to allow omission of intermaxillary fixation in most cases. Two major systems are in use — the compression plates[22] and the semirigid miniplates.[23] Both systems produce good clinical results provided correct methods of application are complied with. External fixation is seldom indicated nowadays, but is still used in selected cases of gross infection, severely comminuted fractures with major tissue loss and very atrophic mandible. Certain fractures are difficult to treat, for example, the edentulous fracture and the children's fractures. In the former, the intermaxillary fixation period may have to extend to eight weeks or even longer. In the latter, the mandibular body is packed with unerupted teeth, and the condylar fractures may result in significant growth disturbance. (Fig. 3)

(E) *Secondary surgery for craniofacial trauma*

The need for secondary surgery in the management of craniofacial trauma is greatly diminished if appropriate primary treatment is instituted. The following are some of the more commonly performed procedures:

(a) soft tissues adjustment such as scar revisions, ranging from simple excision and re-suturing to the use of complex procedures like tissue expansion or free tissue transfer;
(b) osteotomy or re-fracturing for malunited fractures such as in cases of unreduced nose or markedly depressed zygomatic fractures;
(c) correction of contour defects in cases of depressed fractures of the supraorbital region, the nose or depressed uncorrected zygomatic fractures;
(d) correction of enophthalmos in cases of inadequately treated orbital fractures. This involves the freeing of the periorbita from the orbit, repositioning of the bony orbit by osteotomies if required and reconstruction of the walls by bone grafting;
(e) correction of malocclusion or temporomandibular joint dysfunction in cases of condylar or difficult subcondylar fractures where primary treatments are often less satisfactory;

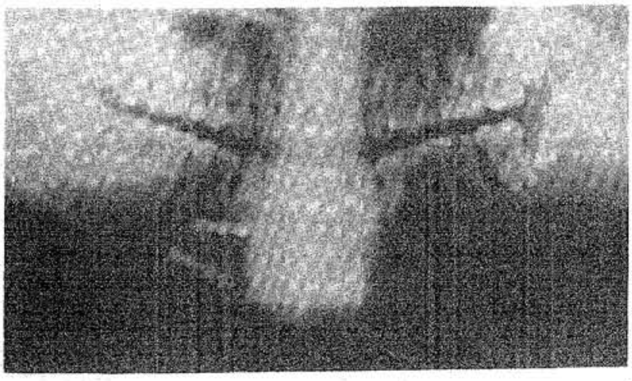



Fig. 3. (a) *(Left)* Post-operative OPG of mandible showing anatomical reduction and fixation of left angle and right parasymphyseal fractures.
(b) *(Right)* PA view of the mandible. Note that the last molar tooth was extracted to allow plating at the left angle.

(f) surgery for dental restoration with the use of osteointegrated implants.

Conclusion

Craniofacial trauma is common in daily clinical practice. It requires a coordinated team approach in management especially in complex cases. Exclusion of associated injuries is important. Early definitive treatment of the facial fractures with wide exposure of the fractures, anatomical reduction and rigid fixation are the favoured approach. Liberal use of bone grafting in primary repair lessens the chance of it being done secondarily. Secondary procedures are at the best able to produce suboptimal results.

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