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Ch. head Maxillofacial injuries

"Beauty of face is a frail ornament, a passing flower, a momentary brightness belonging to the skin." Moliere (1622-1673)

A Introduction

Facial trauma and its sequelae have been described since ancient times. The Edwin Smith papyrus (c 1550 BC) contains excellent descriptions of nasal and zygomatic fractures, the management of mandibular dislocations and wound suture techniques. The diagnostic significance of bleeding from the nostrils and ears following a severe skull injury is also discussed (the existence of the dura and cerebrospinal fluid were well known even if their functions were not).

Maxillofacial fractures occur when the facial bones are subjected to forces that exceed their impact tolerance. The facial bones of females have lower impact tolerance levels than those of males. The impact force to the face in a 30 mph collision is approximately 1200 pounds which easily exceeds the fracture limits of most of the facial bones (Figure 1).

A Aetiology

In most countries, the commonest causes of civilian maxillofacial injuries are road traffic accidents (RTA), assaults, accidental falls, sport and industrial accidents. There are marked variations in the frequency of these aetiological factors both between, and within, different countries (Table 1). Much of this variation is the result of differing socio-economic, cultural and environmental influences.

The incidence of maxillofacial injuries has increased and continues to increase during the latter half of this century. There was a 20% increase in the number of patients sustaining maxillofacial fractures in the United Kingdom (UK) between 1977 and 1987. Similar trends have been noted in other countries. In 1997, maxillofacial injuries accounted for over 4% of all attendances to UK accident and emergency departments. One third of all major trauma victims (ISS > 16) have associated maxillofacial injuries.

B Road traffic accidents

Ever since the first fatal accident involving a motor vehicle in 1834 RTA have been a major cause of maxillofacial injuries throughout the world. In the United States of America (USA) it has been estimated that the annual incidence of RTA associated maxillofacial injuries requiring hospital treatment is 139 per 100,000 population. Maxillofacial injuries are the severest injuries sustained in 80% of RTA and occur in approximately 80% of fatal RTA.

Until relatively recently, RTA was the commonest cause of maxillofacial injuries in most countries studied. This is no longer the case in several countries following improvements in road safety measures, particularly the compulsory wearing of seat belts for vehicle occupants, crash helmets for motorcyclists, stricter drink-driving legislation, and continuing technological advances in vehicle and road design. However, RTA still remains the commonest source of maxillofacial injuries in many countries, including India, Japan and Saudi Arabia, often due to drunken driving and speeding.

The introduction of compulsory seat belt legislation in Sweden in 1975 led to a 28% reduction in severe maxillofacial fractures. A 25-72% reduction in maxillofacial injuries of all types was reported in the UK following the introduction of compulsory seat belt legislation in 1983. It has been estimated that in the UK full compliance with seat belt usage would result in a 53% reduction in fatalities and a financial saving of over £5 million per year from the reduction in maxillofacial injuries alone. Conversely, in countries where seat belt compliance is poor little or no reduction in vehicle occupant injuries has been observed.

Maxillofacial injuries sustained by restrained vehicle occupants most commonly arise following facial contact with the steering wheel. Unrestrained front seat occupants are usually injured following facial contact with the windscreen, and unrestrained rear seat occupants, (predominantly children), are most frequently injured following facial contact with the rear of the front seats.

Almost 40% of bicycle-related injuries sustained by children involve the maxillofacial area and standard bicycle helmets offer little or no protection against maxillofacial injuries.

B Inter-personal violence

Assault is now the commonest cause of maxillofacial injuries in many countries. While the number of maxillofacial injuries secondary to RTA in the UK decreased by 34% in the ten years between 1977 and 1987 the number due to assaults increased by 47%. In Norway between 1970 and 1980 there was a 15% increase in assault-related maxillofacial injuries.

Numerous theories have been proposed to account for this trend. The two factors that have consistently been associated with increased levels of assault, and subsequent maxillofacial injuries, are excessive alcohol consumption and poor socio-economic status, particularly male unemployment. In the UK in 1997 nearly a quarter of all maxillofacial injuries were caused by assaults, over half of which were alcohol related. Similar results have been found in Swedish and Norwegian populations. Young men aged between 15 and 25 years are the commonest section of society to suffer assault-related maxillofacial injuries, particularly those in which alcohol is involved. The consumption of more than 7 units of alcohol in any 6-hour period by males in this age group substantially increases the risk of them being involved in inter-personal violence.

B Accidental falls

The majority of maxillofacial injuries caused by accidental falls are minor cuts, abrasions and bruises and they are a common source of facial injuries sustained by young children. In adults, over 10% of falls that result in a maxillofacial injury are associated with alcohol consumption. There is a strong clinical impression that a substantial number of maxillofacial injuries ascribed to accidental falls are actually secondary to an assault. Much of this “misreporting” seems to involve women injured in the home. Non-accidental injuries to children are also often attributed to accidental falls by their perpetrator.

A Classification

Maxillofacial injuries may involve the facial skeleton, the teeth or the overlying soft tissues. Numerous classification systems have been described, and the majority concentrate on characterising the pattern of facial fractures present. Soft tissue facial injuries may be superficial or deep, and either simple or complicated. Complicated wounds involve important underlying structures, such as named nerves, blood vessels and ducts.

For classification purposes, the facial skeleton is traditionally divided into unequal thirds: upper, middle and lower by 2 imaginary horizontal lines. The upper line passes between the two zygomatico-frontal sutures and the lower line passes along the occlusal plane and incisal edges of the maxillary teeth. Fractures of the maxilla, naso-orbito-ethmoid (NOE) complex and zygomas are thus termed middle third fractures (Figure 2a).

The classification system proposed by Kelly *et al* (1990) divides the face into upper and lower halves at the LeFort 1 level (*vide infra).* Each facial half is subdivided into 2 units. The occlusal unit consists of the teeth, palate and the alveolar processes of the mandible and maxilla. The mandibular unit consists of the remainder of the mandible. In the upper face the cranial unit is composed of the frontal and temporal bones laterally, and the frontal sinus and orbital roofs centrally. The midfacial unit is composed of the zygomas laterally, and the naso-orbito-ethmoid complex centrally (Figure 2b).

Maxillary fractures are usually delineated according to the LeFort lines of weakness first described by the French surgeon Rene LeFort in 1901 as a result of his personal observations on the fracture patterns sustained by cadavers subjected to blunt facial trauma (Figure 3). Although fractures sustained by patients are frequently comminuted or asymmetric, the simple LeFort description is helpful when conceptualising complex facial fracture patterns and planning their subsequent management. Mandibular fractures can be readily classified according to the region of the bone involved (Figure 4) and the simple numerical system devised by Henderson is a convenient method for classifying zygomatic fractures (Table 2).

For routine day-to-day clinical use, the maxillofacial fracture classification system detailed in Table 3 is adequate. It enables the surgeon to produce an accurate description of the injured region and its severity, leading onto a logical treatment plan, and provides the trainee surgeon with a useful *aide memoir*. Cooter & David (1989) have refined this type of classification by the addition of an alphanumeric coding system making it ideal for entry onto a computer database. The system devised by Haug & Greenberg (1993) based on the AO/ASIF classification of mandibular fractures proposed by Spiessl is probably the most comprehensive currently available (Table 4). Using this classification a compound intraoral bilateral mandibular fracture with normal occlusion and involving the right angle and left condyle would be coded as:

- Mn $F_1L_4O_0S_1$ / $F_1L_6O_0S_0$

Although the extended AO/ASIF classification can readily transcribe even the most complex cranio-facial fractures into "surgical shorthand" it is arguably too complex for routine clinical use but it is a powerful tool for research and audit purposes.

A Diagnosis

Full and accurate diagnosis of any maxillofacial injury requires a thorough clinical examination in order to elicit all the signs and symptoms present. Whenever possible it is important to obtain a clear history of the cause of the injury from the victim or eyewitnesses, particularly regarding the number and magnitude of the forces involved. A high velocity impact from a RTA will produce a different and more severe pattern of injuries than those resulting from a single punch to the jaw. Where the clinical examination suggests the likelihood of a facial fracture, imaging studies will also be required to confirm the diagnosis and to fully assess its location and extent.

B Examination

As a minimum precaution, protective surgical gloves must always be worn when examining or treating any patient with a suspected maxillofacial injury. The clinical examination is divided into 2 parts: the extraoral and intraoral examinations. It is helpful to adopt a system of examination, which is performed in an identical way on every patient, in order to minimise the risk of missing an occult injury. As always, thorough visual inspection should precede palpation. It is important to meticulously examine the entire head and neck if injuries such as occipital skull fractures and scalp lacerations are not to be overlooked.

The principle signs and symptoms of facial fractures are listed in Table 5. Not all of these will necessarily be present in every case. Soft tissue lacerations may transect important underlying structures such as nerves and arteries resulting in paraesthesia, paralysis or profuse haemorrhage.

C The extraoral examination

This calls for careful and systematic inspection and palpation of the cranial bones, zygomas, orbits, maxillae, nasal bones and mandible through the overlying soft tissues starting peripherally and working centrally. Any swelling, bruising, tenderness, deformity and crepitus should be identified and noted. Surgical emphysema is occasionally detected following zygomatic and orbital floor fractures if the patient has blown their nose. Patients with midface fractures should be advised not to blow their nose to prevent this complication arising. Temporomandibular joint function is best assessed by simultaneously palpating both condylar heads and assessing for pain and symmetrical vertical and translatory movements.

Ocular abnormalities including subconjunctival haemorrhage, foreign bodies, reduced light and accommodation reflexes, reduced visual acuity, diplopia, opthalmoplegia, enopthalmos, proptosis and telecanthus must be actively sought in every case. Telecanthus is a feature of many, but not all NOE fractures and results from disruption of the medial canthal ligament attachment. It can be extremely helpful to refer to a pre-injury photograph of the patient with a suspected NOE fracture in order to exclude an existing deformity and to help assess their normal intercanthal distance.

The zygomatic complex is best assessed from above and behind the patient. By placing the tips of the index fingers on the zygomatic buttresses and observing their relative positions, any facial asymmetry is readily identified. Enopthalmos or proptosis is similarly recognised by noting any asymmetry in globe/upper eyelid projection.

Cutaneous sensation over the distribution of the opthalmic, maxillary and mandibular divisions of the trigeminal nerve is assessed by the patients’ response to a wisp of cotton wool lightly applied to the skin of the forehead, cheek and lower lip respectively. Facial nerve function is determined by asking the patient to furrow their brow, close their eyes tightly, purse their lips and smile.

Cerebrospinal fluid rhinorrhea is indicative of a fracture in the region of the cribriform plate of the ethmoid, sphenoid or frontal bones together with a tear in the overlying dura and usually occurs within 24 to 48 hours of injury. The diagnosis is usually obvious from the clinical history and the typical appearance of a thin, glairy, sero-sanguinous nasal discharge that tends to form "tram lines" on the facial skin as it evaporates and dries. If there is any doubt in the diagnosis fluid should be sent for quantitative glucose analysis. Glucose levels greater than 30 mg/100ml are indicative of CSF not nasal secretions. Glucose oxidise reagent strips should not be relied on as they not infrequently produce false negative results. Nasogastric tubes must not be inserted into patients with CSF rhinorrhea, as cannulation of the anterior cranial fossa *via* a disrupted cribriform plate is not unknown!

C The intraoral examination

This involves inspection of the teeth and their occlusal relationship together with the soft tissues of the oral cavity. A thorough knowledge of normal dental anatomy and the ability to recognise the abnormal is required for this aspect of the examination.

Fractures and luxation of the teeth are common following facial trauma, particularly in children and can be extremely painful and distressing. All missing teeth must be accounted for. Where this is not possible a chest X-ray must be obtained to ensure that the missing tooth has not been inhaled.

Mandibular and maxillary fractures in dentate patients are usually associated with a malocclusion - the patient being unable to bite their teeth together normally. Edentulous patients with full dentures will similarly be unable to bring them together normally. Malocclusion must be specifically looked for in all patients who have sustained facial trauma.

With severely displaced fractures the malocclusion will be obvious and may be associated with a palpable or visible step deformity. In less severe displacements the malocclusion may be minimal and easily overlooked but the patient will recognise its presence if specifically asked.

It should be appreciated that not all “abnormal” occlusions signify an underlying fracture. Severe soft tissue injury may produce sufficient muscle spasm to prevent normal mandibular closure and a temporomandibular joint effusion can produce a lateral open bite with deviation on opening. A “malocclusion” may also be the patients’ normal occlusion as it is subject to substantial variation within the population. Approximately 80% of patients have a class 1 occlusion, 20% have a class 2 malocclusion and only about 1% has a class 3 malocclusion. (Figure 5). It is important to appreciate this fact not only for diagnostic purposes but also to ensure correct treatment.

The maxilla should be gently manipulated to elicit any abnormal mobility. The premaxilla is held between the index finger and thumb of one hand and the nasal bridge and forehead palpated with the palm of the other. The premaxilla is then gently pulled forwards. Movement of the maxilla detectable intraorally suggests a LeFort 1 fracture while movement at the nasal bridge or forehead is indicative of a LeFort 2 or LeFort 3 fracture.

B Significant associated injuries

The possibility of concomitant life-threatening injuries should always be considered during the examination of patients with maxillofacial injuries. Patients who have sustained fractures to facial bones with high tolerance levels such as the anterior mandible and supraorbital ridges are more likely to have associated major injuries than patients whose fractures are restricted to facial bones with low tolerances such as the NOE complex.

C Head injuries

Many patients with maxillofacial injuries will have sustained a concomitant head injury. Overall, closed head injury (CHI) defined as a documented evidence of loss of consciousness and/or posttraumatic amnesia in the absence of a penetrating injury affects approximately 20% of patients with facial fractures. Approximately 10% of patients with maxillofacial injuries will have a severe intracranial injury.

C Laryngeal injuries

Fractures of the larynx may result from a high velocity anterior impact to the laryngeal-hypopharyngeal region. This typically occurs in a RTA if the victims' throat strikes the dashboard or steering wheel. Laryngeal fractures can be single or comminuted and are nearly always occult, only declaring themselves when airway patency becomes compromised. It is important to have a high index of suspicion in any patient with superficial abrasions or lacerations to the anterior neck. Signs and symptoms include loss of the normal thyroid cartilage prominence, subcutaneous emphysema, hoarseness, a week or absent voice and stridor. Once the diagnosis has been confirmed by appropriate imaging studies a secure airway must be established without delay. This is most safely and reliably accomplished by tracheostomy under local anaesthesia. Orotracheal and nasotracheal intubation is contraindicated as both may produce further laryngeal bleeding and oedema rapidly leading to acute and life-threatening airway obstruction.

C Cervical spine injuries

Damage to the cervical spine is usually associated with maxillofacial injuries resulting from high velocity impacts such as RTA and severe falls from height. Middle third facial trauma is more likely to be associated with injuries in the area of C5-7 whereas lower third facial trauma tends to produce C1-4 injuries. It should be appreciated that in many combined maxillofacial-cervical spine injuries the facial injury may be restricted to minor soft tissue damage with no associated fractures of the facial skeleton.

All patients with a tender cervical spine who have sustained a high impact maxillofacial injury should be assumed to have a concomitant cervical spine injury until proved otherwise. All patients at risk must have high quality cervical spine views taken in 2 planes at right angles showing the entire cervical spine including the critical C7 – T1 interface. Equivocal or sinister findings can be further imaged by computerised tomography (CT). Whatever imaging studies are obtained both they and the patient should be examined by an appropriate specialist and pronounced as normal before the cervical spine is "cleared" and definitive treatment of the facial injuries performed.

C Opthalmic injuries

Damage to the eye or its adnexae occurs in as many as 90% of patients with a middle third facial fracture with 12% of patients sustaining a severe ocular injury (Figure 6). All patients with facial injuries must be examined for an associated opthalmic injury as part of their initial maxillofacial assessment. The most important predictors of significant ocular injury in the presence of a maxillofacial injury are: decreased visual acuity, blow-out and comminuted malar fractures, diplopia and amnesia. A highly sensitive and specific scoring system based on these risk factors has been developed which is capable of identifying patients with maxillofacial injuries who require urgent referral to an opthamologist (Table 6). Visual acuity is the principle predictor of ocular damage and it must be formally assessed in all patients with midface injuries.

Rarely, a midthird facial fracture may involve the superior orbital fissure and the structures passing through it. From above downwards these are the lacrimal, frontal, trochlear, superior occulomotor, nasociliary, inferior occulomotor and abducent nerves and the inferior opthalmic vein. The signs and symptoms consequent on damage to these structures constitute the superior orbital fissure syndrome (Table 7). If the optic nerve is involved there will also be a reduction in visual acuity producing the orbital apex syndrome.

C Carotid-cavernous fistula

This rare but potentially life threatening condition occurs in approximately 0.17% of patients with craniofacial trauma as a result of a tear in the wall of the siphon portion of the internal carotid artery within the cavernous sinus. Most cases are seen in patients with middle third fractures sustained in RTA. The signs and symptoms include headache, pulsatile bruit, exopthalmos (possibly pulsatile), chemosis, opthalmoplegia and blindness. Urgent neurosurgical referral is required for the management of these cases which have a cure rate of between 72% and 80%.

B Imaging

Plain radiographs should be obtained on all patients suspected of having sustained a maxillofacial fracture (Table 8). A single 15^0 occipito-mental view is sufficient for the initial assessment of all suspected midfacial fractures. If this initial “scout” film indicates the possibility of a facial bone fracture then more specific views such as a submento-vertex for zygomatic arch fractures and a true lateral view for nasal bone fractures can be obtained. Many accident and emergency departments routinely take 3 or more “facial bone” radiographs when screening for suspected midfacial fractures. These films account for some 1% of all radiographs taken in UK accident and emergency departments. Reducing the screening radiograph to one view would result in considerable financial savings and reduce the radiation dose to patients without adversely affecting their treatment.

Two views at right angles are required to adequately demonstrate a mandibular fracture. Ideally, these should be a Towne’s view plus a panoramic tomogram. Panoramic tomography has the advantage of showing the entire mandible and facilitates the diagnosis of fractures of the body, ramus and condyles. However, all machines other than the Zonarc (Siemens Corporation, Iselin,N.J.) require the patient to be able to sit/stand upright. It is therefore not applicable to many cases of complex facial trauma and polytrauma. Where panoramic tomography is unavailable or unobtainable left and right oblique lateral views of the mandible are acceptable alternatives. Symphyseal fractures can easily be missed on extraoral views due to superimposition of the cervical spine. These fractures are often best demonstrated on an intraoral lower occlusal radiograph.

CT has significantly improved the accuracy of diagnosing the pattern and extent of facial injuries and has become the standard of care for many complex facial fractures especially those involving the orbits and NOE complex. CT readily differentiates between hard and soft tissues and can display distortion and displacement of bone, cartilage, muscle and nerves. Its ability to display the myriad of fractures often present in middle third and orbital fractures as well as the eye and its adnexae is unparalleled. It is also extremely helpful in demonstrating the soft tissue oedema consequent on laryngeal trauma that can presage acute airway obstruction. Recent advances in CT hardware and software have lead to the development of systems that can manipulate cross-sectional CT data to produce three-dimensional (3D) images that are anatomically accurate to within 0.19 mm (0.28%). 3D reconstructions demonstrate spatial relationships that are not easily appreciated by studying conventional CT images facilitating both the diagnosis and treatment planning of complex cases particularly middle third and orbital fractures. CT acquired data can be used to fabricate solid 3D models enabling preoperative model surgery and the construction of complex craniofacial implants (Figure 7). Because of the increased data acquisition time and radiation exposure 3D imaging is less indicated in patients with minor dislocations and fractures where it may actually be misleading.

If a CT scan is requested to exclude intracranial pathology in a patient with head and maxillofacial injuries, whenever possible the orbits, facial bones and mandible should also be imaged. This can save valuable time later when definitive facial reconstruction is performed and can be extremely valuable in those cases where there is early simultaneous repair of both intracranial and maxillofacial injuries.

A Treatment

The timing of treatment can be divided into 3 phases: emergency (immediate), early (0-14 days) and delayed (> 14 days) following injury.

Treatment goals include the preservation of life, sight and speech the restoration of normal function and minimising deformity. Accurate assessment of the nature and extent of the injuries followed by their early and complete repair is the best way to achieve these goals. The functional and aesthetic results following delayed reconstruction are seldom satisfactory and only acceptable when the management of associated life-threatening injuries must take priority.

B Emergency treatment

The majority of maxillofacial injuries are minor cuts and abrasions with less than 10% requiring hospital admission and operative treatment. Nonetheless, they can occasionally be life threatening as a result of airway obstruction or severe haemorrhage. Foreign bodies such as fragments of teeth, bone dentures and gastric contents may also occlude the airway. Middle third fractures can cause airway obstruction due to occlusion of the nasal airway resulting from backwards displacement of the facial skeleton or from torrential haemorrhage from torn blood vessels. Symphyseal and parasymphyseal mandibular fractures may result in loss of attachment of the extrinsic muscles of the tongue allowing it to fall backwards and occlude the oral airway (Figure 8).

There is wide variation in the reported incidence of life threatening bleeding following major maxillofacial trauma although a figure of about 10% is probably representative. Severe haemorrhage following facial trauma, defined as a loss of 3 units of blood during the first 2 hours together with a drop in the haematocrit below 29% is predominantly due to midface fractures, particularly LeFort 3 level fractures. The majority of bleeding following midface trauma originates from the external carotid system, particularly the maxillary artery although the terminal branches of the internal carotid artery may also be involved. Bleeding from the lacrimal, frontal and anterior and posterior ethmoidal arteries (all branches of the opthalmic artery) can be extremely difficult to control as they are often damaged within their bony canals.

C Airway

Securing and maintaining the airway is the first priority. Having donned protective gloves and using a good light, the oral cavity is thoroughly examined for foreign bodies. A finger is inserted along the side of the cheek to the back of the mouth and swept medially and forwards to dislodge any debris. The manoeuvre is performed from both sides of the mouth. A large bore sucker (plastic yankauer) is used to aspirate any blood, mucous and vomitus from the oral cavity and pharynx.

If the maxilla has been displaced posteriorly and is occluding the nasopharynx it should be disimpacted by hooking the index and middle fingers above and behind the soft palate and gently pulling forwards. If the tongue is falling backwards because it has lost its anterior attachment it should be retracted by a 0 gauge suture inserted through the dorsal surface some 2 cm posterior to the tip which is then pulled anteriorly and secured to the side of the face with surgical adhesive tape. If there is any doubt that a clear airway can be maintained orotracheal intubation should be performed and the fashioning of a temporary surgical airway considered. These measures will protect the patients' airway, facilitate optimal tissue oxygenation and minimise any secondary brain injury due to hypoxia.

C Haemorrhage

Significant bleeding from middle third fractures usually manifests itself as persistent bilateral epistaxis and bleeding that "wells up" in the oropharynx as it runs down from the back of the nasal cavity above.

After disimpacting the maxilla if required, anterior and posterior nasal packs are inserted to tamponade the haemorrhage. A 12 gauge Foley catheter is inserted through each nostril along the nasal floor and gently pushed posteriorly. Extreme caution should be exercised in cases of suspected cribriform plate fracture. When the tip of the catheter becomes visible over the soft palate it should be pulled a short distance into the mouth to ensure that the balloon has passed through the choana. The balloon is inflated and the catheter pulled back through the nose until it impacts against the choana (Figure 9). Ribbon gauze soaked in BIPP (Bismuth Iodoform Paraffin Paste) is then firmly packed into each nostril against the balloon until no more can be introduced. The 2 separate anterior nasal packs should be tied together in the midline. The Foley catheters are tied together over a gauze bolster to protect the nasal soft tissues while maintaining tension on their balloons. Alternatively, they can be secured using a Hollister umbilical cord clamp. It should be appreciated that the paraffin in BIPP can degrade the catheter balloons within 72 hours causing them to deflate.

Anterior and posterior nasal packing occasionally fails to control the bleeding due to laceration of one or both maxillary arteries. In these circumstances the haemorrhage can usually be controlled by direct ligation or packing of the maxillary artery *via* a transantral

(Caldwell-Luc) approach. Ligation of the external carotid artery in the neck as sole treatment for severe midface haemorrhage is seldom effective.

Bleeding from the facial soft tissue is best controlled by direct pressure until such time as definitive surgical exploration and vessel ligation can be performed. However, profuse bleeding from deep lacerations of the tongue, lip and soft palate etc is seldom controlled by direct pressure. While it may be possible to arrest such bleeding using artery clips or sutures in the accident and emergency department care should be taken not to damage adjacent nerves and ducts.

B Early treatment

C Treatment timing

The timing of the repair of maxillofacial injuries in patients with concomitant craniocerebral trauma is controversial. In many cases there is much to be said for performing the definitive repair of the facial fractures simultaneously with the neurosurgical repair of the intracranial injuries. This affords an ideal opportunity to use the same surgical approach (usually a coronal flap) and avoids the need for a second general anaesthetic. It has been shown that early repair of craniofacial fractures in patients with significant craniofacial trauma (ICP = 15 mm Hg or greater) has no negative impact on survival and facilitates early rehabilitation. However, the overriding priority is to prevent further brain injury and patients with a high and/or unstable ICP should be subjected to the minimum surgical and anaesthetic insults in the first few days following their injury.

Although earlier treatment is usually desirable, particularly with compound fractures, a 7 to 10 day window exists for the optimum treatment of mandibular fractures and even longer for middle and upper third fractures (14 days). Providing the maxillofacial fractures are definitively managed within these times in patients with a favourable outcome assessment the final functional and cosmetic results will not be compromised. This does not mean that the maxillofacial surgeon has no role to play during any early short neurosurgical procedures such as the placement of ICP monitoring devices or the evacuation of haematomas. This is an ideal time to fully assess the extent of the maxillofacial injuries and take impressions for study models if required. Discussion with the neurosurgeon at this time concerning placement of craniotomies and bone flaps etc can greatly facilitate future reconstruction. In particular, the maxillofacial surgeon should enjoin his neurosurgical colleague not to throw **any** bone away but to retain all fragments for future repair and reconstruction.

C Fracture fixation

Some of the various methods used to treat maxillofacial fractures are listed in Table 9. With the advent of internal fixation systems, particularly miniplates and reconstruction plates the use of external fixation systems with the exception of intermaxillary fixation has a rapidly diminishing role in the management of maxillofacial fractures. Nonetheless, external fixation continues to have a role in the management of some grossly comminuted or infected fractures.

Likewise, although internal suspension wires are seldom indicated for definitive treatment, they are extremely useful for supporting and fixing gunning splints and augmenting arch bar fixation in partially dentate jaws. It is important that surgeons who manage maxillofacial trauma are fully conversant with these more traditional fixation methods and not just the modern “high-tec” plating systems (if the only tool in your toolbox is a hammer every problem will look like a nail).

Intermaxillary fixation (IMF) involves securing the upper and lower teeth together in their normal pre-fracture occlusion. For many jaw fractures, if the teeth are placed in the correct occlusion the underlying bone of the mandible and/or maxilla will automatically assume its correct position and any contained fractures will be reduced and immobilised.

However, this assumes that there has not been any significant disruption of the jaw/tooth interface. IMF alone is often sufficient treatment but in many cases it will need to be augmented by some other method, typically open reduction and internal fixation (ORIF).

There are several methods of establishing IMF but arch bars are arguably the best. One can use any of the commercially available pre-fabricated arch bars or better still, a custom made one cast by a maxillofacial technician on a model of the patient's dentition. The arch bar is secured to the mandibular and maxillary teeth by 0.4 mm or 0.5 mm stainless steel interdental wires and then the 2 arch bars are linked together by similar wires or orthodontic elastic bands so establishing the IMF (Figure 10a). Circum-zygomatic and circum-mandibular wires can be used to augment the interdental wires where fixation is sub-optimal because of multiple missing teeth.

If arch bars are not available IMF can be established *via* interdental eyelet wires (Figure 10b). While these are quick to apply they are not as versatile as arch bars although the incorporation of stainless steel buttons onto the eyelets enables them to be used with elastic IMF which is not possible with the standard eyelet. One of the problems with both arch bars and eyelet wires is the risk of a "sharps" injury. In "high-risk" cases IMF can be established by passing elastic bands around 4 bone screws from a 2 mm miniplate system screwed into the labial cortical plate of the anterior mandible and maxilla.

Despite its almost universal application in the management of maxillofacial fractures there is a significant morbidity associated with the use of IMF. It restricts normal dietary intake resulting in significant weight and protein loss, reduces tidal volume and increases the risk of aspiration of gastric contents should the patient vomit. The wires themselves are uncomfortable and damage the periodontal tissues. Postoperative IMF should be avoided wherever possible in patients who are malnourished or at risk of malnutrition (e.g. patients with eating disorders), epileptic, have severe breathing difficulties such as COAD or asthma and where compliance is likely to be poor such as alcohol and drug abusers.

External fixation systems such as halo, box and Levant frames utilise the principle of craniomaxillary or craniomandibular fixation in order to immobilise facial fractures. Fractures of the midfacial, occlusal or mandibular units are suspended from an intact and rigid cranial unit. In the case of isolated midface fractures they are sandwiched between the intact cranial unit above and mandibular unit below.

Box frames consist of 4 threaded bone pins screwed transcutaneously into the lateral supraorbital rims above and the body of the mandible below. The pins are then linked by 2 vertical and 2 horizontal bars *via* universal clamps. Other external systems are essentially variations of this scheme. Combinations of pins and bars can be used to build custom external fixation devices to support and control virtually any facial bone fracture.

The principle disadvantage with most, if not all external fixation systems is that they involve closed fracture reduction usually guided by clinical observation of the occlusion and facial form. Because individual fractures are not visualised and anatomically reduced there is a significant margin for error, particularly in re-establishing the correct facial projection following midface fractures. External frames are also cumbersome, unaesthetic, poorly tolerated and prone to accidental dislodgement.

Miniplates have revolutionised the modern management of facial fractures by enabling precise anatomical reduction and fixation under direct vision (Figure 11). True rigid fixation, which is only achievable with compression plate or lag screw systems, is associated with rapid bone healing by primary intention. Non-compression miniplates using monocortical screws are unable to produce true rigid fixation and are actually semi-rigid systems. However, the term rigid fixation in common use usually refers to all types of small plate osteosynthesis systems both compressive and non-compressive and is so used in this chapter.

By rigidly fixing the fractured segments together in their correct position, together with immediate bone grafting where significant skeletal defects exist, the 3 primary dimensions of facial bone reconstruction namely facial width, facial height and facial projection can be restored. The requirement for external fixation is significantly reduced, as is the need for protracted postoperative IMF. The correct application of miniplates is a precise and exacting procedure unforgiving of errors in fracture reduction and immobilisation, miniplate adaptation and poor operative technique.

In all cases involving a fracture of a dentate jaw it is mandatory for the correct pre-fracture occlusion to be securely maintained in IMF while the miniplates are applied to the fracture sites. In many situations it is also necessary to initially reduce and control the fractures using stainless steel transosseous wires prior to achieving the final fixation with miniplates. A combination of transosseous wires, miniplates and bone screws may be required to achieve the optimal reduction and fixation of complex fractures.

C Nasal fractures

Nasal fractures are the commonest facial fracture reported in many published series. A history of blunt trauma to the nose, lateral deviation of the nasal bones or septum, visible or palpable deformity, epistaxis, ecchymosis, oedema and small lacerations over the nasal bridge suggest the diagnosis.

It is important to fully examine the nasal cavities which requires adequate suction, illumination and a nasal speculum. Lacerations of the nasal septum especially if sufficient to expose cartilage or bone should be sutured with 5-0 or 6-0 plain catgut. Septal haematomas must be evacuated lest they result in abscess formation or aseptic necrosis. Closed nasal fractures are best treated electively 5 or 6 days post injury to allow any associated swelling to resolve. Simple fractures of the nasal bones can often be treated by digital manipulation under local anaesthesia using intranasal lignocaine spray and external nasal lignocaine infiltration with or without intravenous sedation.

Intranasal manipulation with Asch forceps is usually adequate treatment for a deviated or fractured nasal septum. The forceps blades are slid either side of the septum and pulled upwards and forwards to guide it into its midline position. If one or both nasal bones are displaced medially it may be necessary to use Walsham forceps to manipulate it/them laterally back into position. One blade is slid into the nose while the other (which should be covered with a piece of soft rubber tubing to protect the skin) is applied to the external surface. Using a gentle twisting and lifting movement the displaced nasal bone is repositioned. The nose is then gently packed with BIPP or vaseline gauze for 24 - 48 hours and a closely adapted external nasal thermoplastic or plaster splint is applied and held securely with surgical adhesive tape for 7-10 days. Even with correct diagnosis and treatment the results of closed reduction are often disappointing with approximately one third of patients having a persistent deformity.

C Naso-orbito-ethmoid fractures

These fractures involve the central midface, the nasal bones, the frontal processes of the maxilla and the ethmoid bones and are arguably the most difficult of all facial injuries to treat successfully. Telecanthus is the principal deformity seen in NOE fractures. An intercanthal distance greater than 35 mm is suggestive of a displaced NOE fracture and a distance greater than 40 mm is diagnostic. Telecanthus is invariably due to lateral and inferior displacement of the naso-maxillary buttress or fracture of a plate of bone in the region of the anterior lacrimal crest containing the insertion of the medial canthal ligament. It is unusual for the ligament itself to be divided or avulsed from the bone.

The aesthetic results of closed reduction and external fixation of NOE fractures are frequently disappointing. Optimal treatment of these fractures requires visualisation of all fractures followed by open reduction and internal fixation. In the majority of cases a bicoronal flap together with the judicious use of local incisions and any conveniently situated lacerations provides the best access to the fracture sites. The bone fragment containing the medial canthal ligament insertion should be carefully identified, reduced in its correct position and secured with miniplates or wires. If the tendon has been avulsed or is accidentally stripped off the bone a transnasal canthopexy will be required to reattach it. Fine artery forceps are used to identify the tendon through a 4 mm vertical incision sited 3 mm medial to the medial canthus. The tendon is transfixed with a braided 3-0 wire or suture and passed transnasally on an awl posterior to the lacrimal fossa. The transnasal canthopexy rarely produces a perfectly natural appearance to the medial canthus and so accidental stripping of the medial canthal ligament off the bone should be avoided at all costs.

All other fractures are reduced and fixed and any defect greater than 0.5 cm in the orbital floor or walls is bone grafted. Split cranial bone is ideal for this purpose. Wherever possible the bone grafts should rest on sound bone peripherally and be fixed with miniplates or transosseous wires. A dorsal nasal bone graft, which can be cantilevered off the frontal bone, will frequently be required to prevent a postoperative saddle deformity.

Fractures of the frontal sinus frequently coexist with NOE injuries and must be properly managed to reduce the risk of late complications such as CSF leak, meningitis, mucopyocele and brain abscess. Displaced fractures of the anterior wall should be reduced and fixed with miniplates and immediate bone grafting as necessary. If the posterior sinus wall is intact and there is no evidence of a CSF leak it can be managed expectantly. If there is a significant posterior sinus fracture, especially with a concomitant CSF leak the sinus should be cranialised and the dura neurosurgically repaired. Cranialisation involves removing all fragments of posterior frontal sinus wall, stripping out all the remaining frontal sinus mucosa, and plugging the nasofrontal ducts with autogenous bone grafts. The insertion of a pericranial or similar flap may be indicated to separate the nasal and cranial cavities.

C Zygomatic fractures

Significant inferior displacement of the zygomatico-frontal suture produces an antimongoloid slant due to a drop in the level of the lateral canthal ligament. Diplopia is often due to oedema in the extraocular muscles and usually settles within the first few days of injury. Diplopia that fails to resolve suggests an internal orbital fracture and requires further investigation. All patients with zygomatic fractures are at high risk of associated ocular injuries and must have a thorough opthalmic assessment.

The zygoma tends to fracture at or near its 3 main articulation points namely the zygomatico-maxillary suture, the zygomatico-frontal suture and the zygomatico-temporal suture producing what is commonly referred to as a tripod fracture. In reality they are quadrapod fractures because the zygomatico-maxillary buttress will also be involved. Attaining an anatomical reduction at this latter site is fundamental to the management of unstable zygomatic fractures. Inadequate reduction and fixation at the zygomatico-maxillary buttress is responsible for much of the late deformity often associated with fractures managed by closed reduction or single point fixation at the zygomatico-frontal suture.

The indications for treating zygomatic fractures include correction of abnormalities in ocular position and motility, restoration of eye protection, relief of infraorbital nerve paraesthesia, improvement in mandibular opening and the restoration of facial aesthetics. These indications are all relative and their importance varies with factors such as the patient's age and health. Hence many fractures are treated in young fit and healthy patients in order to restore their facial appearance, but this factor has a lower priority in the elderly or infirm.

Isolated zygomatic fractures associated with significant periorbital oedema and ecchymosis are best treated after a delay of 7-10 days. This not only allows time for the soft tissue swelling to settle and the degree of facial asymmetry to be accurately assessed, but it also provides an opportunity to obtain CT scans in cases of suspected internal orbital wall/floor fracture.

Closed reduction using a Gillies' temporal approach is adequate treatment for most minimally displaced zygomatic fractures. After making a 2-3cm skin incision at 45^0 over the temple just anterior and superior to the pinna the outer layer of temporalis fascia is divided. An instrument such as a Rowe or Bristow elevator can then be inserted below the fascia and under the zygomatic buttress. The depressed zygoma is elevated by firmly lifting the elevator in the opposite direction to the force that displaced it (Figure 12).

If the zygoma is unstable following closed reduction or if there has been any significant displacement the fracture(s) should be treated by ORIF using miniplates or transosseous wires (Figure 13). Following elevation using a Gillies approach, all fracture lines and displaced sutures are visualised *via* appropriately placed cutaneous and mucosal incisions. A mucosal incision in the upper buccal sulcus gives excellent access to the zygomatic buttress facilitating accurate anatomical reduction and miniplate fixation. A "buttress plate" applied in this fashion is the most satisfactory way of preventing late zygoma sag and flat face deformity.

The zygomatico-frontal suture can be approached through a skin incision in the lateral eyebrow (which should not be shaved) or more cosmetically *via* an upper blepharoplasty incision. Following anatomical reduction a miniplate is placed across the suture. Miniplate fixation at the zygomatico-frontal suture alone is often inadequate to resist displacing forces and consideration should be given to the application of an additional buttress plate.

Numerous approaches have been described to gain access to fractures of the infraorbital margin and internal orbit but they are all variations of the subciliary, infraorbital or transconjunctival incisions. The subciliary incision affords excellent access to the lower half of the internal orbit and orbital margins. The incision is placed approximately 1 mm below the lower eyelashes and extended 1cm laterally and inferiorly at the outer canthus. A thin skin flap is raised above the orbicularis occuli to the level of the inferior orbital rim. An incision is then made directly onto the bone of the anterior maxilla just below the rim so as to avoid opening the periorbita and avoiding the infraorbital nerve. Orbital rim fractures are best stabilised using low-profile or microplates.

Fractures of the orbital floor or walls often occur together with zygomatic fractures and are called impure blow-out fractures. Isolated fractures of internal orbit are called pure blow-out fractures. Pure blow-out fractures can be caused by a direct blow to the globe by an object that is slightly smaller in diameter than the external orbital opening causing a rapid rise in intraorbital pressure. An impact force of 2.08 J (equivalent to a 303 g weight dropped from 70 cm) is sufficient to cause a blow-out fracture by this mechanism. Alternatively, a blow to the orbital rim can cause a shock wave that propagates along the floor of the orbit causing it to buckle and fracture without necessarily fracturing the rim itself. Orbital floor fractures may produce opthalmoplegia and diplopia as a result of incarceration of the inferior rectus, inferior oblique and periorbita (Figure 14). Enopthalmos results from increased intraorbital volume, periorbita incarceration and fat atrophy.

Simple, narrow internal orbital fractures can be treated by overlaying a thin sheet of Silastic after retrieval of any prolapsed periorbita. The Silastic must rest on sound bone all round and must not sag over the fracture. It should be cut to shape so that it lies passively just inside the orbital rim to which it can be secured by a few drops of cyanoacrylate tissue adhesive. Larger defects require bone grafting harvested from the skull, anterior maxilla or iliac crest depending on the volume required.

Retrobulbar haemorrhage is a rare but well recognised complication of midface, zygomatic and orbital floor fractures and occurs following approximately 0.3% of zygomatic and orbital floor repairs. Its incidence is unrelated to the degree of surgical trauma. The usual cause is bleeding from a small branch of the infraorbital artery. The signs and symptoms include decreasing visual acuity, proptosis, diplopia and pain. Failure to recognise and treat retrobulbar haemorrhage early is likely to result in permanent blindness. It is vital that all patients are assessed for this complication on presentation and at frequent and regular intervals postoperatively until discharge. Once the diagnosis is made, medical management should be instituted immediately and urgent arrangements made to return the patient to the operating theatre for orbital decompression. The orbit is explored and all bleeding is arrested and any haematoma evacuated. If a graft was placed in the orbital floor it is removed otherwise a defect is created in the floor to decompress the orbit.

The aim of medical management is to reduce intraocular pressure and so relieve pressure on the short posterior ciliary arteries which otherwise results in ischaemia of the optic nerve head.The medical management of retrobulbar haemorrhage consists of:

- 100-200 ml 20% intravenous mannitol
- 250-500 mg intravenous acetazolamide
- 1-3 mg/Kg intravenous hydrocortisone

(Doses for standard 70Kg Adult without medical contra-indications).

C Mandibular fractures

Mandibular fractures are traditionally described as being either vertically or horizontally favourable or unfavourable depending on the propensity of the muscular forces acting upon the fractured segments to displace them from their normal anatomical position. Although the principle on which the description is based is useful the nomenclature is confusing because the terms horizontal and vertical refer to the direction from which the fracture is observed and not the direction of the fracture itself. The surgeon needs to assess whether the direction of the fractures and the direction of the muscular pull either side of them will result in adjacent segments being impacted or distracted (Figure 15). All other things being equal a simple, non-displaced “favourable” fracture is likely to require less aggressive treatment than an “unfavourable” one.

For patients with undisplaced favourable fractures who can easily bite into their normal pre-injury occlusion, and who are willing and able to comply with weekly clinical review, it may be permissible to adopt a conservative approach and prescribe a soft diet and analgesics. Minimally displaced fractures can frequently be managed by 4-6 weeks of IMF applied *via* arch bars or eyelet wires. ORIF is indicated for the majority of displaced fractures and minimally displaced fractures where IMF is contraindicated.

The most favourable site for internally fixing a fractured bone is where the tensile forces acting upon it are at their greatest. Champy *et al* (1978) applied this "tension band" concept to the internal fixation of mandibular fractures with miniplates. Tensional forces across a fracture at the mandibular angle are best resisted by a superior border miniplate, while the additional torsional forces acting across a fracture anterior to the mental foramen require the application of 2 miniplates approximately 5 mm apart (Figure 16).

After establishing IMF, access to the fracture is achieved *via* an incision in the labial or buccal sulcus approximately 5 mm below the mucogingival junction. A trans-buccal approach using a trochar as a conduit for drills, screwdrivers and screws facilitates plate application in areas with poor access such as the posterior mandible. The IMF can be released when satisfactory fracture fixation has been achieved.

Occasionally, the access afforded by an intraoral incision is insufficient to enable full exposure and control of the fractured segments and an extraoral approach is required. For posterior mandibular fractures the incision should be placed approximately 3cm below the lower border of the mandible so as to avoid damaging the marginal mandibular branch of the facial nerve. A submental incision is used for symphyseal and parasymphyseal fractures. In severely displaced or comminuted fractures the fragments should first be reduced and stabilised by transosseous wires prior to plate application. Lower border wires inserted *via* an elective extraoral approach are particularly helpful in controlling lingually displaced fractures.

Teeth in the line of fracture are best left *in situ* provided that they are firm, not fractured, and have no associated periapical or periodontal infection as they usually facilitate fracture localisation and reduction.

In poorly compliant patients whose lifestyle and medical or social circumstances suggest that they are at high risk of further trauma, re-fracture, or post-operative infection, a strong case can be made for utilising true rigid fixation to produce “safe fixation”.

Fractures of the edentulous mandible present a different set of problems. In simple fractures in a non-medically compromised patient it is often possible to treat the fracture with IMF *via* gunning splints secured with circum-mandibular wires. However, in many cases IMF will need to be avoided and ORIF will be required. If there is sufficient bulk of mandible then miniplate osteosynthesis is the most satisfactory method but in atrophic mandibles compression/reconstruction plates may be required.

Fractures of the mandibular condyle have traditionally been managed either conservatively or by elastic IMF. Excellent functional outcomes are usually achieved with undisplaced or minimally displaced unilateral fractures managed this way. However, there is increasing evidence that closed reduction of severely displaced, severely telescoped or dislocated fractures frequently results in an unsatisfactory outcome, particularly in bilateral cases. ORIF is indicated for this category of fracture with persistent malocclusions after 3-4 weeks of elastic IMF. Early ORIF should be considered for bilateral fractures. The potential morbidity of ORIF for condylar fractures includes facial nerve paresis, which may be permanent, and avascular necrosis of the condylar head. It is thus not a procedure to be undertaken lightly or by an inexperienced surgeon.

Dislocation of the temporomandibular joint (TMJ) occurs if the condylar head is completely displaced from the glenoid fossa. In the majority of cases the condylar head moves anterior to the articular eminence. Posterior, lateral and superior (central) dislocations are very rare. The clinical features include malocclusion (usually with an anterior open bite), TMJ pain drooling and dysarthria. Beware of misdiagnosing strokes or dementia in the elderly patient who has a dislocated TMJ. The diagnosis can be confirmed by a panoramic tomogram or lateral skull radiograph. While some dislocations reduce spontaneously (subluxations) many require manipulative or even operative reduction. In the majority of cases simple manipulation suffices. The patient should be sat down with the operator standing behind them. The operators thumbs (which should be wrapped in a gauze swab to protect them) are placed on the patients lower molar teeth and the index fingers below the patients chin. Slow, constant downward pressure is exerted on the molars while at the same time pulling upwards and backwards on the chin. The idea is to pull the condylar head onto the crest of the articular eminence and then slip it back into the glenoid fossa. Infiltrating the joint capsule with local anaesthetic before attempting to reduce the dislocation abolishes the neuromuscular reflex spasm maintaining the dislocation and significantly increases the success rate of the procedure. Occasionally, particularly with prolonged dislocations intravenous sedation or general anaesthesia will be required before the dislocation can be reduced. Condylotomy, condylectomy or mandibular osteotomy may even be required when manual reduction fails.

C Maxillary fractures

The 2 naso-maxillary and zygomatico-maxillary buttresses maintain the relationship between the maxilla and the cranial base above and the mandible below. Correct anatomical reduction of these 4 anterior buttresses following a LeFort 1 maxillary fracture will ensure that the anatomical relationship between the midfacial, cranial and mandibular facial units is correctly restored. Reconstruction of the posterior buttresses at the pterygoid plates is neither desirable nor necessary.

Following the application of IMF the anterior buttresses are exposed *via* a horseshoe incision in the maxillary buccal sulcus extending from the first molar tooth on one side to its counterpart on the other. The maxilla is then degloved up to the infraorbital margins superiorly and the maxillary tuberosities posteriorly. All fractures are exposed and anatomically repositioned. Missing buttresses and significant defects are bone grafted using split calvarium. The buttresses and all fractures and bone grafts are then stabilised with miniplates (Figure 17).

A similar approach is adopted for LeFort 2 fractures. Access to the infraorbital rims and orbital floor can be increased by using a subciliary incision. Mobility of the maxilla in the region of the nasofrontal suture will require miniplate osteosynthesis to the frontal bone. Access to this region is *via* local incisions at the medial canthus, glabella or a bicoronal flap. The management of LeFort 3 maxillary fractures is essentially the same as for panfacial fractures described in the next section.

C Panfacial fractures

While the reconstruction of a severe panfacial fracture may at first sight seem a daunting task, it simply requires the surgeon to perform many of the individual facial fracture reductions previously described and then link them all together. However, the order in which the surgery is performed is crucial if predictably good results are to be obtained and mistakes minimised.

In the era of IMF and external fixation an “inside-out” and “bottom-up” approach was favoured, in which the reconstructed mandible acted as the primary template for the remainder of the facial reconstruction which then proceeded in a caudal to cranial direction. Unfortunately, closed fracture reduction and poor fragment control invariably led to errors in reproducing the normal facial width, height and projection. With rigid fixation, correct spatial control of fractured facial bone fragments can be achieved (Figures 18a – 18c and 19a – 19b). Table 10 details a treatment sequencing system for panfacial fractures. Not all fractures will require every step to be performed but the order of treatment should be adhered to in all cases.

C Soft tissue injuries

The majority of facial abrasions and lacerations can be adequately managed in properly equipped accident and emergency departments by appropriately trained nursing or medical staff under local anaesthesia. More extensive lacerations requiring in excess of 45 minutes to close are best managed in an operating theatre, while those involving named nerves, arteries and ducts are best dealt with under general anaesthesia. Fine, high quality suturing requires fine high quality instruments and good illumination. It is unacceptable to attempt to repair facial lacerations using instruments designed for general "casualty" use.

The fundamental aim in the management of all facial lacerations is to minimise scarring and its long term cosmetic and psychological sequelae. The soft tissues can be considered as the "fourth dimension" of facial reconstruction and when associated with facial fractures they should be treated following early facial bone reconstruction as soft tissue that heals from a single insult over a correctly reconstructed facial skeleton provides the most natural facial appearance.

Most soft tissue injuries are suitable for immediate primary repair but where there are associated life-threatening injuries and the patients' condition is unstable, wounds are best covered with sterile saline dressings which are changed frequently until such time as the patients condition stabilises and definitive repair can safely be undertaken.

The margins of traumatic lacerations are often shelving, uneven and of questionable viability. If good postoperative results are to be achieved they must be meticulously managed. Under appropriate anaesthesia, wounds are first thoroughly debrided using a suitable antiseptic solution to remove all foreign bodies such as dirt and glass. A soft sterile toothbrush or surgical scrub brush is very effective if used with care. Non-vital tissue should be judiciously excised although irregular, but otherwise viable wound margins are best not converted to a straight line. The extent of any tissue loss should be accurately assessed. Minor losses are inconsequential but more significant ones particularly if full thickness, may require immediate skin grafting or even flap repair.

Wounds should be closed in layers using absorbable sutures for the subcutaneous tissues such that all dead space is eliminated and the wound edges approximated. Final closure of the epidermis using a 5-O or 6-O gauge monofilament suture should evert the wound margins without tension. For the repair of facial lacerations in young children or anyone where it is felt that co-operation with subsequent suture removal will be poor, excellent cosmetic results can be achieved using 6-O plain catgut for epidermal closure. Evenly spaced adhesive suture strips applied at right angles to its long axis provide additional support for the wound. The application of a topical antibiotic such as 1% chloramphenicol ointment prevents desiccation and reduces wound infection.

Deep facial lacerations may transect the facial artery, the facial nerve or the parotid duct (Figure 20). Lacerations around the medial canthus and naso-maxillary angle may involve the lacrimal drainage system. Facial lacerations involving any of these complications should be managed in an operating theatre under general anaesthesia. Under optimal conditions wounds should be thoroughly explored and any associated damage fully documented. The cut ends of any bleeding arteries should be fully exposed and ligated.

If a transected parotid duct is suspected the diagnosis can be confirmed by passing a fine catheter into the duct and gently infusing 3 – 4 cm^3 of sterile saline and observing for its emergence into the wound. Transected ducts should be repaired with interrupted 6-O absorbable sutures over a plastic catheter stent to allow free drainage of saliva. The stent is sutured to the buccal mucosa alongside the parotid papilla and removed after 10 – 14 days.

Failure to recognise or adequately treat a transected duct will result in a sialocoele and/or salivary fistula, which can prove extremely resistant to treatment.

A laceration that involves the parotid duct may also involve the buccal branch of the facial nerve. If transection of a peripheral facial nerve branch is diagnosed its repair should only be undertaken by a surgeon fully conversant with the local anatomy and skilled in the techniques of parotidectomy and microsurgery. If the transected branch is not readily identifiable *via* the laceration a formal superficial parotidectomy approach to the main trunk and its branches may be required before it can be located. Immediate microepineural repair using 9-O monofilament sutures offers the best hope of preserving facial animation. The functional and hence aesthetic results of late repairs of undiagnosed facial nerve injuries are poor.

The nasolacrimal sac and duct and the superior and inferior canaliculi are at risk from facial fractures and lacerations in the region of the medial canthus and naso-maxillary angle. Obstruction to the lacrimal drainage system results in epiphora and dacrocystorhinitis. Transection of the inferior canaliculus or lacrimal sac can be confirmed by applying 1 or 2 drops of fluorescein to the lower fornix and observing for the dye in the wound. Repairs to the lacrimal drainage system, especially those involving the lacrimal sac and duct can be complex and should be referred to a surgeon appropriately skilled in oculo-plastic surgery. Significant ocular trauma must always be suspected in these injuries.

A Maxillofacial injuries in children

Facial fractures in childhood are uncommon accounting for approximately 5% of all facial fractures. In children below 5 years of age the incidence is closer to 1%. Midface fractures in this age group are exceedingly uncommon accounting for less than 0.5% of all facial fractures.

The emergency management of facial injuries in children does not differ significantly from the methods previously described for adults.

B Dental injuries

Fractures of the teeth, particularly the upper central incisors are common (Figure 21). Approximately 35% of 9 year-old children have experienced some type of dental trauma.

Compared to the severe injuries described elsewhere in this book, dental injuries might appear trivial. However, if not properly treated they can have a devastating impact on the child victim. Although the definitive management of dental injuries is the preserve of the dental surgeon, patients and their parents frequently contact accident and emergency departments for advice or treatment. Early and appropriate treatment significantly influences the prognosis for many dental injuries, relieves pain and reassures anxious and concerned parents. Many of the common dental injuries and their emergency management are listed in Table 11.

If a patient, especially a child, has lost a tooth and it cannot be accounted for a chest X-ray should be obtained to exclude it having been inhaled (Figure 22). Avulsed teeth have an 85-97% chance of being successfully replanted if treatment is timely and appropriate treatment is provided.

The root surface of avulsed teeth should not be handled but gently irrigated with running water for no more than10 seconds. If a tooth is allowed to dry out for an hour or more the periodontal ligament cells covering the root will die and replantation will be unsuccessful. The viability of the periodontal ligament cells can be maintained if the tooth is placed in a suitable medium within 20 minutes of injury. Periodontal ligament cells can remain vital for 2 hours in the patient’s own saliva and for up to 6 hours in fresh milk. Water must not be used.

Once replanted the tooth must be splinted and systemic antibiotics prescribed for 5-7 days. Splints can be fabricated from numerous materials. The simplest and probably the best method is to use a length of 0.7 mm diameter surgical/orthodontic wire secured to the tooth and its immediate neighbours with acid-etch composite cement. These materials are cheap and readily available. Alternatively, if there is access to a maxillofacial laboratory a custom made vacuum formed acrylic splint can be used. All patients who have sustained dental injuries particularly fractures or luxations require regular follow-up by their dentist or specialist restorative dental surgeon.

B Facial fractures

Nasal fractures are the commonest facial bone fracture in children. The severity of injury may be underestimated because the significant soft tissue swelling that frequently accompanies these injuries often masks the deformity. Treatment is essentially similar to adult fractures but will need to be performed under general anaesthesia.

Mandibular fractures are the next most common facial bone fracture after fractures of the nasal skeleton. Many tend to be of the “greenstick” type and can be successfully managed by either a soft diet and analgesics with frequent follow-up or closed reduction. If there are sufficient teeth present IMF can be applied for 2-3 weeks, otherwise an acrylic splint can be fabricated on study models cast from dental impressions of the child’s jaws and secured to the mandibular teeth with either dental cement or circum-mandibular wires.

ORIF is reserved for unstable or significantly displaced fractures. The same ORIF principles are used as for adult fractures but miniplate placement is complicated by the presence of the tooth buds in the body of the mandible which are at risk of damage from inappropriately placed screws. Small (1.0 mm) miniplates should be used in all but the largest children and placed near the lower border of the mandible. Because of the relative weakness of 1.0 mm miniplates compared to the standard 2.0 mm ones, fixation may need to be augmented with IMF or an acrylic splint.

The mandibular condyle in children has an exceptional capacity for growth and remodelling. Fractures of the mandibular condyle in children under 12 years of age should be managed either conservatively with soft diet and analgesics or by elastic IMF if symptoms persist. Only in exceptional circumstances such as persistent pain or significantly reduced function should ORIF be contemplated. All children who sustain a condylar fracture require long term follow-up to monitor mandibular growth and function.

Zygomatic and maxillary fractures can often be managed conservatively. Minimally displaced LeFort 1 fractures in young children can be treated with IMF for 2-3 weeks. Severe zygomatic, maxillary and NOE fractures require ORIF and they should be managed along the same lines as adult fractures.

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