Chapter 14: Fractures of the facial skeleton and facial asymmetry

Michael Gleeson

Aetiology

Fractures of the mandible and middle third of the facial skeleton are most commonly the result of road traffic accidents or physical combat (Hagan and Huelke, 1961; van Hoof, Merkx and Stekelenburg, 1977; Starkhammar and Olofsson, 1982; Brook and Wood, 1983). In recent years the introduction of compulsory seat belt legislation has decreased the incidence of these injuries in the UK (Price, 1983; Steele and Little, 1983). In children, falls, accidents while playing and sports injuries are the major causes of facial fractures (Fortunato, Fielding and Guernsey, 1982). The possibility of non-accidental injury should never be overlooked (Rowe, 1969; Hall, 1972). Fractures resulting from complicated dental extractions and pathological lesions of the jaws are seen in all age groups.

Primary care of maxillofacial injuries

Maxillofacial fractures can endanger the airway and are frequently associated with brain damage (Hoffman, 1976). Although a patient with a fracture of the middle third presents an alarmingly dramatic picture the first considerations are to:

1. ensure an adequate airway and ventilation
2. look for major abdominal or other injury if the patient is exsanguinated or in shock
3. assess the level of consciousness.

Detailed examination and definitive treatment of the facial injury must take second place to these requirements.

The establishment of a safe airway and effective ventilation is the most essential primary measure to prevent hypoxia and retention of carbon dioxide, as these are the most important factors in the development of post-traumatic cerebral oedema and damage.

The need for endotracheal intubation should be carefully considered in both the conscious and comatose patient. Posterior displacement of the tongue secondary to mandibular fractures, or posteroinferior displacement of the maxilla with middle third injuries, directly compromises the airway. It may be necessary to reduce a middle third fracture immediately by hooking the fingers of one hand around the posterior margin of the patient's hard palate and pulling the displaced jaw forward. Even those patients with a good airway initially may deteriorate to a very critical state as oropharyngeal oedema develops. Paradoxical chest movement due to a flail segment is a further indication for primary intubation. In conscious patients the loss of voice, dysphagia, surgical emphysema of the neck and pain on palpation of the thyroid cartilages suggests a fracture of the larynx. Increasing stridor with these symptoms and signs is a mandate for immediate tracheostomy.

Haemorrhage into the airway from either the nose or mouth can be torrential. It usually ceases spontaneously but must be controlled by nasal packs, balloons, catheters, sutures or arterial ligature. Super-selective arteriography and embolization is very effective.
and indicated in severe late onset bleeds (Mehrotra et al, 1984). Shock is rarely the result of haemorrhage from a facial fracture and, when present, is likely to be due to rupture of abdominal viscera, intrathoracic injury, fractures of the limbs or extensive soft tissue lacerations. The source of blood loss must be recognized, controlled and replaced appropriately and promptly, otherwise hypotension further compromises the patient’s cerebral state.

Only after such complications have been controlled should assessment of the head injury be undertaken. The level of consciousness is the most useful criterion. Regularly repeated accurate documentation of spontaneous speech, response to command and reaction to painful stimuli provides a clinically useful scale which reflects improvement or deterioration of the cerebral state (Teasdale and Jennet, 1974). Alcohol is frequently a factor in the acquisition of these injuries and it should be remembered that it may be contributing to the depression of the level of consciousness. Facial swelling may make examination of the eyes exceptionally difficult. However, pupil size and reaction to light must be recorded. Dilatation of a pupil at some interval after injury is highly suggestive of an ipsilateral expanding supratentorial lesion. Urgent reduction of pressure by either medical or surgical means is essential in such cases (Garfield, 1972). Subdural pressure monitoring is a sophisticated method of detecting changes in intracranial pressure before the traditional clinical signs develop. It is available in most neurosurgical centres and facilitates patient management.

Absence of limb movements in an acute head injury indicates primary cerebral damage. Such patients will have a diminished level of consciousness. The presence of a mono-, para- or quadriplegia in a relatively alert patient is highly suggestive of a plexus or cord lesion for which immediate immobilization should be instituted.

The cranium must be palpated very carefully to detect depressed fractures. Scalp lacerations are possible source of intracranial infection and should never be probed in case the venous sinuses are damaged. Lacerations can be satisfactorily managed by irrigation with saline and dry dressings. Cerebrospinal fluid rhinorrhoea and otorrhoea may be present and, in the acute situation, can be very difficult to detect, especially when mixed with blood. It may be distinguished at this stage by comparing the discharge with blood escaping from other sites. As the blood flow diminishes due to clotting the escape of cerebrospinal fluid becomes more obvious. If present, prophylactic antibiotics should be administered. Nasal intubation should be avoided, when possible, if the cerebrospinal fluid leak is from the nose.

Tetanus prophylaxis should be administered to any patient who has not been immunized within 3 years of the accident; 0.5 mL adsorbed tetanus toxoid intramuscularly is the recommended booster dose for those immunized between 3 and 10 years before their injury. A supplementary 250 units of human antitetanic globulin should be given at a different site in the non-immunized patient and to those who have not received toxoid for over 10 years.

Clinical examination of facial injuries

There is rarely any urgent need to reduce and fix facial fractures. Indeed the optimal time for definitive treatment is between the fifth and eighth days post-trauma. This allows
sufficient time to assess the fracture, make splints if required and improve the general medical
condition of the patient. Some complications such as orbital haematoma require urgent
treatment and even if initially absent may develop before or after reduction. The clinical
condition of the patient on admission can preclude full radiological examination and
unavoidably some emergency room films lack sufficient definition. There is therefore no
substitute for careful clinical extra- and intraoral examination. The following is an accepted
approach to the clinical examination of these injuries.

Eyes

On admission look for penetrating injuries, corneal abrasions, dislocation of the lens
and lacerations involving the lacrimal apparatus. Inspect any subconjunctival haemorrhage and
determine its posterior limit, the discs for signs of retinal damage and ischaemia, light
reflexes, external eye movements and direction of maximal diplopia if present. An assessment
of ocular level should be made by comparing the position of the pupils.

Lack of patient cooperation and periorbital oedema limits the accuracy of the
ophthalmic examination. Only gross displacements of the globe will be obvious initially. As
oedema subsides such deformities become more evident. In patients with diplopia a forced
duction test may then be appropriate to determine the presence of significantly herniated
orbital contents. Avulsion of the medial canthal ligament produces an abnormal slant of the
palpebral fissure. In such injuries lateral traction of the eyelid fails to produce tension at the
medial canthus.

Nose

The examination of injuries limited to the nose has already been discussed in Chapter
13. Suffice it to mention two salient features. First, persistent cerebrospinal fluid leaks may
only be shown by tipping the patient head and face down. Second, unilateral epistaxis in the
absence of a direct nasal injury suggests a fracture involving the maxillary antrum.

Middle third of the face

The face should be inspected with particular attention to the distribution of oedema
and ecchymoses. Disproportionate lengthening secondary to posterior displacement of Le Fort
fractures, although masked by swelling in the acute phase, becomes apparent during the first
week as the oedema subsides. The bony contour of the face should be palpated to detect step
deformities and surgical emphysema. Sensory testing to determine the distribution of any
deficit and evaluation of facial nerve function must be recorded.

Mandible

The bony outline of the lower jaw should be felt for step deformity. Careful
observation of the symmetry of jaw movement on opening, while placing the little finger of
each hand in the patient's external auditory canals, ascertains temporomandibular joint
function. Any sensory deficit of the lower lip should be noted.
**Mucosa and dentition**

The state of the dentition is particularly relevant to the management of these injuries. Missing or fractured teeth should be recorded as they may have been inhaled or dislodged into the soft tissues. The health of the residual teeth is also important in planning methods of fixation. A general inspection of the dental arches for asymmetry is essential. Segments of the dental arches should be gently manipulated to elicit any abnormal mobility or crepitus. The occlusion is frequently subtly or grossly deranged, but may need expert dental assessment for its detection. Blood-stained saliva is a further indication of a fracture which is compound into the oral cavity. The mucosa should be examined for lacerations and haematoma of the buccal and lingual sulci, and of the palate. If the patient is edentulous, the dentures can be of immense assistance, even if broken. They should be obtained or retrieved and any missing fragments accounted for.

**Signs of mandibular fractures**

**Body, angle and symphysis fractures**

(1) Step deformity palpable externally or intraorally.
(2) Asymmetry of the lower dental arch and derangement of the occlusion.
(3) Pain, paradoxical movement and crepitus on distraction of the fractured segments.
(4) Haematoma in the buccal sulcus or floor of the mouth.
(5) Blood-stained saliva.
(6) Anaesthesia in the distribution of the mental nerve.

**Condyle fractures**

(1) Tenderness over the temporomandibular joint.
(2) Trismus.
(3) Deviation of the jaw towards the injured side on opening the mouth.
(4) Inability to move the mandible to the side opposite the injury.
(5) Deviation of the jaw to the fractured side at rest with anterior open bite secondary to gagging of the occlusion on the molar teeth in fracture dislocation.
(6) Symmetrical anterior open bite in bilateral fractures of the neck of the condyles.

**Signs of middle third fractures**

These injuries are classified into central and lateral types, although in clinical practice these are frequently combined.

**Central middle third fractures**

(1) Epistaxis.
(2) Circumorbital ecchymosis (panda facies).
(3) Facial oedema.
(4) Surgical emphysema.
(5) Lengthening of the face.
(6) Oral respiration.
(7) Infraorbital nerve sensory deficit.
(8) Anterior open bite (Le Fort II and III).
(9) Haematoma at the junction of the hard and soft palate.
(10) Floating palate and teeth (Le Fort I).

**Lateral middle third fractures**

Many of the features seen in fractures of the central middle third are present also in the lateral variety, for example circumorbital ecchymosis, facial oedema and surgical emphysema. In addition the following may be seen:

(1) Subconjunctival haematoma.
(2) Proptosis.
(3) Alteration of the ocular level.
(4) Increase in interpupillary distance.
(5) Limitation or absence of external eye movements.
(6) Diminished visual acuity.
(7) Step deformity of the orbital margin.
(8) Epiphora.
(9) Limitation of mandibular movement with depressed arch fractures.
(10) Flattening of the cheek.
(11) Step deformity of the zygomatic buttress on intraoral examination.
(12) Haematoma of the buccal sulcus.

**Radiological evaluation of maxillofacial fractures**

All patients must have chest, cervical spine and supine lateral skull radiographs taken. In this way significant chest and spinal fractures will be recognized at the outset. Their treatment may take precedence over further radiographical examination or contraindicate the neck extension required for other facial views. Fluid levels in the sinuses or air within the cranium indicates the presence of a cerebrospinal fluid leak which might otherwise be unrecognized.

In each case a standard facial series should be taken. The entire mandible can be demonstrated by a 10° posteroanterior view, an orthopantomogram or panellipse and lower occlusal films. The facial bones are best seen with a 30° occipitomental, a 30° anteroposterior (Towne) and submentovertical views, while the orbits are more clearly projected on a 45° occipitomental radiograph. Further films and projections may be necessary after this screen, for example orbital tomograms and temporomandibular joint films.

Computerized tomography has added a further dimension to the documentation of maxillofacial injuries. Fracture lines are more clearly seen, using bone windows, than with conventional films. Furthermore, the data can be reformatted in any plane. The only drawback of this method of examination is that it must await establishment of a secure airway and requires patient cooperation.
**Principles of treatment**

The general principles of management of fractures of the long bones apply equally to the facial skeleton. The fractured segments must be accurately reduced, securely immobilized and maintained free of infection for a period of time sufficient to allow bony union.

Facial fractures differ to some extent from others in that nearly all are compound either directly into the mouth or nose, or indirectly into the mouth through the periodontal ligament. It may not be in the best interests of the patient to effect closure by extraction of those teeth involved in the fracture, as their continued presence may be required for fixation or for guidance of the jaws into a functional position. Experience has shown that this compromise between potential infection and accurate reduction is acceptable.

The viability of small fractured segments of the jaws is far better than elsewhere in the body. In general they should be retained as their preservation aids the restoration of facial contours and sequestrum formation is uncommon.

Both closed and open techniques of reduction are practised. All methods aim to fix the fractured part to the nearest superior structure in continuity with the base of the skull. Precise restoration of the occlusion registers the correct functional position of the jaws and the dentition forms an additional splint. The period of fixation is variable but ranges from 10 days for a condylar fracture to 6 weeks for angle or body fractures of the mandible and Le Fort fractures.

**Fractures of the mandible**

**Surgical anatomy**

There are several patterns and combinations of fractures recognized in the mandible. Each is determined by the magnitude of the impact, the direction of the blow, the age of the patient, state of his jaws and condition of his dentition (Hodgson, 1967; Huelke and Harger, 1969). Stability or displacement of the fragments is determined mainly by the action of the attached musculature and the plane of the fracture line.

The weakest part of the mandible is the subcondylar region and it is therefore the most common site to fracture. The angle is the next most frequent region, followed by the body, lateral chin and symphysis. Single and multiple fractures occur with equal frequency (Hagan and Huelke, 1961). The most usual combinations of mandibular fractures are bilateral subcondylar fractures, fractures of the body and opposite angle and fractures of the body with the contralateral condyle. Bilateral body, bilateral angle and comminuted fractures are comparatively rare.

The subcondylar region is protected by the zygomatic arch and is therefore usually fractured as the result of an indirect force delivered either to the chin or contralateral mandibular body. Such fractures are rarely grossly displaced. Anteromedial rotation of the condyle secondary to the pull of the attached lateral pterygoid muscle is usual. Fracture dislocations of the joint posteriorly and centrally into the middle cranial fossa are also occasionally seen (Lindahl, 1977).
Displacement of angle fractures is determined by two factors. First the masseter, medial pterygoid and temporalis muscles pull the posterior segment medially upward and forward. The second factor is the direction of the fracture line in the vertical and horizontal planes. Fractures running forward from lingual to buccal resist medial displacement of the posterior fragment and are called *vertically favourable*. Those running in the opposite direction are more easily displaced lingually and are therefore *vertically unfavourable*. Similarly fractures which run from the superior border of the mandible forward to the inferior margin resist upward displacement and are termed *horizontally favourable*. Those running in the opposite direction are more easily displaced and are called *horizontally unfavourable*. In patients with third molar teeth the fracture line invariably runs through either the socket or crypt.

Body fractures are mainly sustained in the first molar or canine regions. Like all fractures through tooth-bearing areas they are usually compound into the mouth. The tendency of the posterior fragment to upward displacement is counteracted, to some extent, by the attachment of the mylohyoid muscle. However, the action of this muscle encourages medial displacement of the posterior fragment.

Displacement of anterior fractures is governed by the extrinsic muscles of the tongue. The part of the mandible bearing the genial tubercles is pulled lingual to the other. Fractures of the ramus and coronoid process are stabilized by the splinting action of the masseter and medial pterygoid muscles and therefore minimally displaced. Conversely multiple or comminuted fractures are usually grossly displaced.

*Closed reduction techniques*

**Intermaxillary fixation**

There are several modifications of interdental wiring techniques, termed intermaxillary fixation. In a cooperative, dentate patient wiring can be undertaken under local anaesthesia. This method of fixation has much to commend it. Simplicity apart, of most significance is the fact that the conscious patient has control of his airway throughout the procedure and is less likely to vomit in the immediate postoperative period.

**Method**

Soft, 0.35 mm diameter stainless steel wire is work hardened by stretching a further 10% of its length. Small loops are made in the wire and fixed to groups of teeth in both jaws by encircling the free ends of the wires around the necks of the teeth before twisting their ends together. These anchorage points are subsequently linked and bound tightly together by elastic or wire so that the dentition comes together in centric occlusion.

In the partially dentate patient preformed arch bars or sectional, silver cap splints can be used to link the dentition into a functional unit. Intermaxillary fixation is then applied by means of wire or elastic bands. In the immediate postoperative period intermaxillary fixation is safer with elastic bands than wire as they can be cut or removed faster and more easily in the event of airway obstruction.
The addition of anchorage hooks to the dentures of an edentulous patient makes these highly suitable as splints to hold the mandible and maxilla together in the correct relationship. These Gunning-type splints are retained by peralveolar wiring through the maxilla and circumferential wires around the mandible. Placement of the wires is effected by the use of an awl.

The above methods of fixation are only applicable to fractures of the tooth-bearing parts of the mandible. They will not provide adequate immobilization for fractures of the condyle, ramus or for some unfavourable fractures of the angle or posterior body. In these instances other methods of fixation should be employed.

**External pin fixation**

External pin fixation still finds favour in particular situations. It can be employed to advantage in cases with combined fractures of both the mandible and maxilla, those with gross comminution or bone loss, for example pathological fractures, gun shot wounds and in cases with atrophic edentulous jaws or osteomyelitis.

**Method**

Pairs of pins linked by cross struts are screwed into the main fragments of the mandible. These are then connected and secured by a universal joint and bar assembly so that the fragments are maintained in the correct relationship.

The biphase appliance is a modification of external pin fixation. Specially designed screws, with threads at both ends, are inserted into the bone fragments and connected by a temporary metal bar. A permanent plastic connector is fashioned from cold cure acrylic resin, adapted over the free ends of the pins and secured by nuts. This system is tolerated extremely well by the tissues for prolonged periods. It is therefore particularly useful for patients in whom bone grafting is required particularly for avulsive trauma and resection of malignant tissue.

**Open reduction techniques**

**Transosseous wiring**

Direct transosseous wiring is a satisfactory and simple method of fixation. It has particular advantages in controlling the edentulous posterior fragment, comminuted fractures which are compound externally and in multiple fractures for stabilizing the lower border of the mandible.

**Method**

Holes are drilled with a No 6 rose-head burr either side of the fracture line, taking great care not to damage either the marginal branch of the facial nerve in gaining access to the mandible or the inferior dental nerve when drilling the holes. Stainless steel wire 0.5 mm in diameter is passed through these holes and tightened to approximate the fractured segments.
The reduction can be further secured by a second wire inserted through the same drill holes but tied in a figure-of-eight across the lower border.

In the past every method of plating and pinning familiar to orthopaedic surgeons has been employed to stabilize fractures of the jaws, for example Kirschner wires (Vero, 1968), Steinmann's pins, titanium mesh, titanium plates (Battersby, 1967; Frost, El-Attar and Moos, 1983), nylon straps and bone staples (Williams, 1985). Although available in most hospitals, and therefore convenient for use, they have all been superseded by the development of compression techniques. The degree of fixation achieved by these methods is unrivalled. Furthermore, compression reduction and fixation accelerates and materially alters the histological pattern of bone healing (Becker, 1974; Champy et al, 1978).

**Compression plates**

The plates are available in several lengths ranging from 3 cm to 7 cm. In one end are placed circular fixation holes by which one side of the fracture is secured with screws. At the other end is an oblong hole and an eccentrically countersunk compression hole. The insertion and tightening of a screw in the compression hole forces the fragments together along the plane determined by the screw in the oblong hole. No other form of fixation is normally required, but it has been found beneficial by some to place the jaws in intermaxillary fixation until the soft tissues have healed.

Oblique fractures are not always suitable for compression plating. In such cases compression can be achieved with lag screws which engage the lingual plate through a bucally prepared hole. Tightening the screws draws the fragments together. Neither compression plates nor lag screws need to be removed unless they become infected.

Compression plates are particularly useful when prolonged immobilization of the jaws would be better avoided in such patients as epileptics, the aged and in body fractures associated with fractures around the temporomandibular joint. Plating is only contraindicated in cases with gross contamination or wounds that will not close.

**Management of condylar fractures**

Fortunately, the degree of displacement is not significant in the majority. The ultimate aim is to produce a functional result either by creation of a pseudoarthrosis or bony reunion of the condyle. Much controversy exists over the correct method of treatment. The fragments can be plated or wired directly but this is not a simple procedure and places the main trunk of the facial nerve at considerable risk of surgical trauma. However, intermaxillary fixation for 10 days is usually sufficient to establish a functional jaw relationship. This makes the patient more comfortable while local muscle spasm and pain subside and is followed by graduated mobilization of the joint.
Fractures of the middle third

Central middle third

Surgical anatomy

These injuries are usually the result of a blow to the front of the face. It is traditional to divide them into alveolar and Le Fort I, II, and III, as most follow these lines of weakness (Le Fort, 1901). This division is of considerable practical significance as it establishes the precise level from which the fractured segment can be suspended and to which structures it may be secured.

Alveolar

This is a fracture through the alveolar process only. It may or may not contain teeth.

Le Fort I (Guerin)

This type of fracture runs above the floor of the nasal cavity, through the nasal septum, maxillary sinuses and inferior parts of the medial and lateral pterygoid plates.

Le Fort II

This is a fracture which runs from the floor of the maxillary sinuses superiorly to the infraorbital margin, through the zygomaticomaxillary suture. In the orbit it passes across the lacrimal bone to the nasion. The infraorbital nerve is often damaged by involvement in this fracture.

Le Fort III

This represents a disconnection of the facial skeleton from the cranial base. The fracture traverses the medial wall of the orbit to the superior orbital fissure and exits across the greater wing of the sphenoid and zygomatic bone to the zygomaticofrontal suture. Posteriorly it runs inferior to the optic foramen, across the lesser wing of the sphenoid to the pterygomaxillary fissure and sphenopalatine foramen. The arch of the zygoma is also broken.

Displacement of all these fractures is the result of the initial impact and tends to be backwards and downwards along the base of the skull. This imparts a characteristic dish face deformity to the patient. All are compound to the nose or paranasal sinuses and some breach the dura. A few are associated with a paramedian split of the palate.

External fixation techniques

External frames tend to be bulky and unsightly. They interfere with the patients visual field and sleep and cannot be used if there is a possibility that a craniotomy will be required or if the patient is likely to have an epileptic fit. External fixation has therefore diminished in popularity since the advent of plating systems which overcome these problems. It is, however, still occasionally used for fractures with gross anteroposterior instability, for
example combined Le Fort and condylar fractures. In these circumstances it usually complements other open methods of fixation.

Disimpaction and reduction of the maxilla may require some force. Either Walsham's or Rowe's forceps can be used to grip the maxillary segment, one blade being placed in the nose and the other on the palate. The maxilla is then gently rocked laterally and forward into its correct position. Occasionally it is impacted behind a fractured malar bone and is quite impossible to reposition until the latter has been reduced. The mandibular dentition is the most accurate guide to the correct, functional position of the maxilla on the cranial base, assuming that the mandible itself is or has been rendered intact. Intermaxillary fixation is therefore applied after reduction of the maxilla in these cases.

The first type of external fixation used was that of a plaster head cap and metal outrigger. It had several disadvantages, not the least of which were instability and patient discomfort. It has been superseded by designs incorporating skeletal pins, for example Box frame, Levant frame and Royal Berkshire halo (Levant, Gardner-Berry and Snow, 1969; Mackenzie and Ray, 1970; Levant, Cook and MacFarlane, 1973; Georgiade et al, 1981). All these devices provide a stable frame attached to the cranium at several points. The maxillary alveolar ridge or dentition is then firmly attached to this frame. These frames are simple to apply using Toller or Moule skeletal pins and universal joints. They are comfortable and well tolerated by the patient.

Facial transfixion is rarely used today, although it is simple and effective. It is particularly suited to Le Fort II fractures in which the zygomatic complex is intact and for those cases where external frames are contraindicated due to skull fracture. Remarkable stability can be achieved by driving a Kirschner wire through the zygomatic bone, across the facial skeleton in a plane inferior and parallel to the inferior orbital rim to exit via the opposite zygoma. The ends are protected by corks or trimmed short. No anaesthesia is required for their removal (Vero, 1968).

**Internal skeletal fixation**

The simplest method of fixation is that of internal wire suspension (Adams, 1942; Kufner, 1970). The fractured maxillary segment may be suspended from various points of the craniofacial skeleton which depend only on the level of the fracture, for example zygomatic arches, orbital rims, forehead, piriform apertures. Thus a Le Fort III may only be suspended from the frontal bone, whereas a Le Fort I can be suspended from any of the above points. This form of suspension is not ideal as it may exert a backward force on the fractured segment and thus encourage the relapse of the displacement. To avoid this, modifications using steel implants have been developed (Stoll, Schilli and Joos, 1983).

Direct wiring can be used as easily for maxillary fractures as for those of the mandible. It permits accurate alignment of the reduced fragments through simple surgical approaches. The technique is identical to that used in the mandible and similarly the wires need not be removed. Miniaturized compression plates serve exactly the same purpose and are far superior to wiring in terms of stability.
**Lateral middle third**

**Surgical anatomy**

The body and processes of the zygomatic bone constitute the lateral middle third. Blows to this part of the face are common and may cause either a depressed fracture of the entire zygomatic bone or a fracture of the arch.

Depressed fractures of the zygomatic bone are sometimes called tripod fractures because the bone breaks in three places - frontozygomatic suture, the infraorbital rim and the zygomatic buttress. These fractures are classified according to their rotation about vertical and horizontal axes. The vertical axis runs between the frontozygomatic suture and the first molar tooth, while the horizontal axis is in the plane of the zygomatic arch. Fractures may therefore be rotated medially or laterally about these planes. In severe injuries the bone is dislocated or comminuted and, in all, there is disruption of the orbital floor.

Two factors govern the degree and type of displacement. First the direction and site of the impact relative to the axes of the zygomatic bone and second, the pulls of the masseter and integrity of the fascial attachments.

The arch tends to break at its weakest point which lies just posterior to the zygomaticotemporal suture. Displacement is usually in a medial direction and can produce trismus by interfering with the coronoid process and temporalis muscle. If the temporalis and masseteric fascia is disrupted the arch tends to collapse inferiorly.

Blows to this aspect of the facial skeleton do not always break the zygomatic bone. A sudden impact with the globe may cause fracture of the orbital floor alone, producing a 'blow-out'. The external eye movements are then frequently restricted by herniation or incarceration of the orbital contents through this defect.

**Management**

Many fractures of the zygomatic complex will not require reduction (Rowe, 1985). Indeed, there is a very real risk of iatrogenic blindness following treatment which should be considered in all those with minimal deformity and impaired vision on the contralateral side (Ord, 1981).

Some patterns of fracture are likely to be stable immediately after reduction, for example medially displaced fractures of the arch, fractures rotated about the vertical axis. Others are unstable and require additional fixation, for example inferiorly displaced arch fractures and fractures rotated about the horizontal axis. Stability after reduction depends to a great extent on the integrity of the periosteum covering the bone and that of its fascial and muscular attachments.

Unlike other facial fractures reduction of the zygomatic complex can only be performed by open techniques. The restitutumal force can be applied in either a direct or indirect fashion. The classical method is that described by Gillies, Kilner and Stone (1927) using the temporal fossa approach. A skin incision is made just behind the hair line.
anterosuperior to the pinna. The incision is developed through the temporal fascia so that an elevator of the Bristow type can be passed deep to it on the surface of the temporalis muscle to lie behind the body of the zygomatic bone. Controlled elevation can then be applied to the bone which usually snaps back into place. Great care should be taken to avoid undue pressure on the parietal bone in this manoeuvre. The Rowe elevator avoids this by incorporating a hinged lifting arm of the same length as the elevator. Furthermore, the precise location of the tip of the elevator can be gauged by the position of the lifting handle relative to the orbit. This is also the preferred method for the reduction of a medially displaced fracture of the arch.

Elevation of the body of the zygoma has also been described through a direct, transcutaneous approach using a hook (Poswillo, 1976) and through the buccal sulcus using a periosteal elevator (Balasubramaniam, 1967; Quinn, 1977). Temporary fixation may be applied either by packing the maxillary antrum with bismuth-iodine-paraffin paste gauze through a Caldwell-Luc approach, by a silicone wedge supporting the lateral antral wall (Gorman, 1980) or a Foley catheter inserted through an intranasal antrostomy.

Fractures found to be unstable following reduction need to be wired or plated using a direct approach. Stabilization across both the fronto-zygomatic suture and the infraorbital margin is then obtained. The zygomatic arch can be reassembled in a similar fashion, but it is also wise to darn the periosteum of the arch to the temporalis fascia in order to prevent subsequent inferior relapse.

In a few cases the floor of the orbit together with some of the orbital contents collapses into the antrum. This produces severe limitation of the movement of the globe and permanent alteration of its position. This so-called 'orbital blow-out' fracture, may be an isolated injury or the result of a direct blow to the eye ball itself. More commonly, herniation of the orbital contents into the maxillary antrum is part of a Le Fort II, III, or zygomatic complex fracture.

The decision to intervene operatively can be very difficult, as minor degrees of blow-out are not always attended by subsequent diplopia and nearly all orbital injuries cause diplopia in the acute phase (Crumley et al, 1977; Steidler, Cook and Reade, 1980). It is sensible to explore and provide support for the orbital floor during the acute phase in some circumstances, for example gross herniation of orbital contents. Certainly it adds little to the procedure of transosseous wiring of the orbital rim and similarly an antral pack can serve the dual role of providing temporary fixation for a tripod fracture while reducing the blow-out. In other cases, it is better to adopt a conservative approach by observing eye movements at regular intervals until it becomes clear that fixation or limitation of movement has developed (van Herk and Hovinga, 1973; Bartkowski and Krzystkowa, 1982). In cases where doubt exists the antrum can be opened to inspect the defect. Fibreoptic inspection using a sinuscope is a simpler way to obtain the same information (Westphal and Kreidler, 1977).

There is a wide choice of methods for repairing the orbital floor or medial wall. Transconjunctival and subciliary approaches are described and both have their advocates (Tessier, 1973; Converse et al, 1973; Wray et al, 1977). The inexperienced may find that the transconjunctival route gives them inadequate access and that a lateral canthotomy is required. The operative field is rarely a problem with the subciliary route, although postoperative
ectropion, either transient or permanent, can follow. In most, gentle freeing of the incarcerated
contents together with reduction of the malar fracture will suffice. More significant
deficiencies need to be grafted with bone or supported by Silastic. Occasionally these may
need to be supported by an antral pack.

It is essential that the retinal blood vessels, visual acuity or pupillary reflexes are
carefully monitored in the immediate postoperative period as the central retinal artery may
be compromised by retrobulbar haemorrhage. Immediate evacuation of haematoma must be
undertaken if the sight is to be preserved. The clinical signs of this painful complication are
increasing proptosis and intraocular pressure, an afferent pupillary defect, pallor of the optic
disc and diminishing visual acuity.

Postoperative care

Careful attention should be paid to oral hygiene. The nursing staff must swab the
mouth three times a day with diluted hydrogen peroxide followed by aqueous chlorhexidine
(Corsodyl mouthwash). A hygienist should visit regularly to attend to local inflammation of
the gingivae. The intermaxillary fixation needs to be regularly checked, wires or bands
replaced as necessary and the free ends carefully buried between the teeth or protected with
wax so that they do not traumatize the soft tissues. In due course damaged teeth, having
served their purpose of fixation require restoration or removal and missing teeth may need
to be replaced.

Cerebrospinal fluid rhinorrhoea

Cerebrospinal fluid rhinorrhoea is classified into aetiological categories under two
main subdivisions, traumatic and non-traumatic (Ommaya et al., 1968, Table 14.2). Most cases
are produced by accidental or iatrogenic trauma. Non-traumatic cerebrospinal fluid rhinorrhoea
is important to consider and recognize but rare.

It has been reported that between 2% and 9% of head injuries are complicated by
cerebrospinal fluid rhinorrhoea and, in those with fractures involving the paranasal sinuses,
this incidence increases to 25% (Lewing, 1954; Raaf, 1967; Charles and Snell, 1979). Most
of these involve the anterior cranial fossa and allow cerebrospinal fluid to leak through the
cribriform plate or roof of the ethmoids where the dura is attached firmly and easily torn. In
others the cerebrospinal fluid passes through a breach in the posterior wall of the frontal sinus
(Calcaterra, 1980).

Cerebrospinal fluid leaks from fracture or congenital defects of the temporal bone may
also present as rhinorrhoea if the tympanic membrane is intact. The cerebrospinal fluid then
escapes via the eustachian tube into the nasopharynx. Non-traumatic cerebrospinal fluid
rhinorrhoea is usually secondary to intracranial tumour or hydrocephalus (Ommaya, 1964).

Pituitary tumours are the most common neoplasm to produce a leak but cases
associated with nasopharyngeal carcinoma and acoustic neuromata have been reported.
Despite local disease, for example pituitary adenomata, which might be expected to predispose
to leakage from the sphenoid sinus, this entity is rare. Almost all fistulae arise in the anterior
cranial fossa (Kaufman, 1969). Escape of cerebrospinal fluid from the middle cranial fossa
directly to the nose may result from the persistence of the craniopharyngeal canals (Lowman, Robinson and McAllister, 1966; Hooper, 1971). Leakage from this area is more often a complication of trans-sphenoidal surgery, the implantation of yttrium seeds (Bateman, 1966) or secondary to tumour erosion (Norsa, 1953).

**Symptoms**

Nasal discharge is the most prominent symptom. It may be provoked or increased by physical work or change in posture. Some patients are aware of a persistent salty taste in their mouths and others may be troubled by a continuous headache secondary to low pressure.

**Diagnosis and localization**

Cerebrospinal fluid is usually clear with specific gravity of 1.004-1008. Unlike other pure nasal secretions it contains glucose. The clinical diagnosis depends on the measurement of the glucose content which must be undertaken carefully to ensure that the result is consistent with concurrently drawn lumbar cerebrospinal fluid. Glucose oxidase papers (Clinistix) are not reliable for this purpose (Gadeholt, 1964). Examination of the nose and nasopharynx with a flexible nasopharyngoscope may help localize the side from which cerebrospinal fluid is leaking (von Haacke and Croft, 1983). It is usually necessary to introduce markers or dyes, for example indigo carmine, methylene blue, fluorescein (Kirchner and Proud, 1960) or radioactive tracers into the lumbar theca and then, subsequently, to measure their relative concentrations in patties placed at the sinus ostia in the lateral wall of the nose. Aseptic meningitis has been reported following these procedures.

Plain radiographs are seldom helpful in localizing the origin of cerebrospinal fluid rhinorrhoea, although polytomography will often demonstrate the defect either directly or indirectly through changes in the adjacent paranasal sinuses or their linings (Charles and Snell, 1979). High resolution CT scanning is very useful in traumatic cases and even more so for the investigation of non-traumatic cases where an underlying tumour or hydrocephalus must be found or excluded (von Haacke and Croft, 1983). It should be remembered that cerebrospinal fluid rhinorrhoea in association with congenital malformations may be arising from multiple sites. The correction of these cases is frequently problematic.

**Treatment**

The majority of traumatic cerebrospinal fluid leaks heal without surgical intervention. Until the leak ceases the patient is at a significant risk of developing pneumococcal meningitis. All should be given adequate antibiotic prophylaxis, instructed to avoid nose blowing and kept quietly in hospital. For adults, orally administered penicillin 500 mg four times daily and sulphadimidine 500 mg four times daily provide adequate antibiotic cover. Leech and Paterson (1973) considered that repair should be undertaken if the cerebrospinal fluid rhinorrhoea persisted for longer than 7 days as the protection afforded by long-term antibiotic prophylaxis diminished after that period. Earlier repair offers no better protection against meningitis and carries with it the morbidity of a surgical procedure to close a defect that may heal spontaneously.
The first successful intradural repair, using autogenous fascia lata, was reported by Dandy in 1926. Until recently, variations of this technique were accepted as the standard approach to this problem. It is now recognized that craniotomy is attended by a significant morbidity, usually followed by anosmia and not universally successful, failure rates of up to 27% being reported (Ray and Bergland, 1967; Calcaterra, 1980).

The first extracranial approach to repair a defect of the cribriform plate was reported by Dohlman in 1948.Leaks from the frontal sinus, cribriform plate and sphenoid sinus may be tackled by an external ethmoidectomy approach using fascia or a mucosal flap from the nasal septum as described by Hirsch in 1952.

The trans-septal route employed for hypophysectomy may also be used to control cerebrospinal fluid rhinorrhoea from this region (Calcaterra and Rand, 1976). This has the advantage of avoiding any facial incision and allows the sphenoid to be packed with fascia and a free muscle graft without any open communication with the nasal cavity. In all these cases lumbar cerebrospinal fluid drainage is advisable for a few days postoperatively in order to maintain a constant low pressure on the closure.

It is thought that high pressure leaks act as a safety valve limiting the potential damage of persistent raised intracranial pressure. The repair of these should, therefore, only be undertaken after the cause of the high pressure has been dealt with or a suitable shunt inserted.

**Facial asymmetry**

No face is perfectly symmetrical. A degree of facial asymmetry adds character and sometimes enhances an individual's appearance. The rapid development of asymmetrical features is a common presentation of neoplastic, cystic and inflammatory lesions of both the facial skeleton and soft tissues. It is alarming for patients and on occasion prompts them to consult a surgeon at a relatively early stage, even before the onset of pain, anaesthesia or functional deficits. Other asymmetries, frequently subtle at the outset, continue to develop for a more prolonged period of time, sometimes spanning several decades. These conditions are usually genetic disorders or malformations. It is therefore reasonable to outline these disorders on a chronological basis according to the age at which they first manifest, detailing only those not dealt with elsewhere in the text.

**Facial asymmetry of childhood**

Dental infections, paranasal sinus sepsis and viral parotitis are the most common causes of acute facial asymmetry in this age group. The diagnosis of these conditions is rarely problematic.

**First and second branchial arch syndromes**

A wide spectrum of deformities is seen in patients with these syndromes. They are thought to be caused by a haemorrhage arising in the anastomosis which precedes the formation of the stapedial arterial stem (Poswillo, 1973). A number of synonyms have therefore been applied to these conditions, for example necrotic facial dysplasia,
otomandibular dysostosis, craniofacial microsomia, lateral facial dysplasia and hemifacial microsomia.

Although almost invariably unilateral in presentation some bilateral cases have been recorded. Even in these there is considerable difference in expression between the two sides. The most common abnormalities are hypoplasia of the external and middle ear, mandibular ramus and facial expression, parotid gland and occasionally the facial nerve. These defects often appear mild at birth but progress to severe asymmetrical deformities with growth. Some are amenable to surgical correction (Murray, Kaban and Mulliken, 1984).

A number of recognized syndromes exist in which branchial arch dysplasia is but one component. Most of these syndromes are symmetrical.

Goldenhaar's syndrome

This consists of hemifacial microsomia, clefts of the lips and palate, epibulbar dermoids, vertebral, cardiac and renal abnormalities. A few of these patients are mentally retarded. The degree of expression is variable and the mode of inheritance far from clear.

Hemifacial hypertrophy (Curtois' syndrome, Steiner's syndrome)

There is no recognized basis for this deformity which affects both the hard and soft tissues of the face and jaws. In some there may be total body hemihypertrophy, while in others the enlargement is limited to the face. The degree of distortion is very variable. In some it is mild while in others it is monstrous. Nearly all are evident at birth, become accentuated at puberty and stabilize when active growth stops.

Klippel-Trenaunay-Weber syndrome (angio-osteohypertrophy syndrome)

In this condition facial hemihypertrophy is seen in association with a segmentally distributed angiomatous naevus, most commonly in the second trigeminal dermatome.

Facial asymmetry secondary to osteomyelitis or trauma to the temporomandibular joint

This is a rare cause of progressive facial asymmetry which is secondary to ankylosis of the temporomandibular joint and retardation in growth of the mandible (Souyris, Moncarz and Rey, 1983). Infection may spread to the joint from localized osteomyelitis of the jaw or follow a generalized septicaemia. In the past this was most often seen after scarlet fever, typhoid, pneumonia, influenza and measles.

Facial asymmetry of adolescence

Fibrous dysplasia

In this condition areas of bone are replaced by fibrous tissue and become enlarged. These lesions may be monostotic or polyostotic. The polyostotic variety tends to be unilateral in distribution. Enlargement of the facial bones is painless, usually noticed in adolescence and
continues after somatic growth has ceased. These lesions may cause derangement of the dentition, protrusion of the eyes, obliteration of the sinuses and nasal passages. Foraminal encroachment can result in deafness and blindness. When the long bones are affected they become bowed and sometimes fracture repeatedly.

Polyostotic fibrous dysplasia when associated with cutaneous pigmentation and endocrine disorders is known as Albright's syndrome. The degree of pigmentation is proportional to the extent of bone involvement. Precocious puberty is the most frequently associated endocrine disorder but hyperthyroidism, diabetes mellitus and acromegaly have all been recorded. Skeletal growth in these children is rapid, but as the epiphyses tend to fuse early the resulting adult stature is short.

**Progressive hemifacial atrophy (Parry-Rhomberg syndrome)**

Unilateral progressive wasting of some or all of the facial tissues in this uncommon condition commences in the second decade. Atrophy of the subcutaneous fat and muscle proceeds together with underdevelopment of the facial bones. In some, intracerebral calcification has been seen and is thought to be associated with haemangiomas. Reflex asymmetry, impaired sensory function and optic atrophy may also be present.

**Neurofibromatosis (von Recklinghausen's disease)**

This disease is transmitted in an autosomal dominant fashion but rarely becomes clinically obvious before puberty. The tumours in this condition are usually multiple, smooth, and rounded, and may attain a considerable size, thereby producing craniofacial distortion. Any cutaneous, visceral or cranial nerve can be affected. Cutaneous pigmentation, café-au-lait spots, is present in these patients. Later sarcomatous change in the neurofibromata is well recognized.

**Cysts of the jaws**

Many types of cyst arise within the jaws. Some emanate from odontogenic tissue, for example primordial, dentigerous and periodontal cysts. Others develop from sequestrate fissural epithelium, for example globulomaxillary and median cysts. Although swelling limited to the jaws, displacement of adjacent teeth, infection or fracture is the most common mode of presentation, some may achieve considerable proportions so slowly and asymptomatically that facial asymmetry is the first sign.

**Facial asymmetry of adult life**

In this age group, facial asymmetries are more usually the result of sinus mucocoeles, osteomyelitis, benign salivary tumours or tumours of the jaws. In this later category ameloblastoma, Ewing's tumour, osteosarcoma and fibrosarcoma should be considered as they afflict a younger age group than other oral neoplasms.
**Facial asymmetry of old age**

Malignant salivary tumours, sinus neoplasms and carcinomata of the oral cavity are the predominant causes of facial asymmetry. These conditions produce asymmetry of the face relatively rapidly and are described elsewhere.

**Paget's disease (osteitis deformans)**

The bony enlargement seen in this disease is not always symmetrical. The facial bones are frequently affected early in the clinical course which may extend for decades. Foraminal encroachment may produce deafness and blindness. Sarcomatous change in the affected bones is a well recognized late complication of this disorder.