Chapter 7
Maxillofacial Fractures
Tertius Venter

The restoration of normal facial features and function after facial injury can be very challenging. If certain basic principles are meticulously applied though, good functional and aesthetic results can be achieved. Attention to detail and early surgical management of the damage caused by trauma will often circumvent even more difficult and sometimes nearly impossible secondary reconstruction.

Prompt and definitive repair of the aesthetic defect (restoration of the pre-injury appearance) and restoration of function to minimize disability (including normal dental occlusion, mastication, speech, respiratory airway, and vision) are the goals of management of facial injuries.

Timing of Intervention for Facial Fractures

Facial trauma victims often sustain injuries to other organ systems. Definitive care of maxillofacial injuries should be rendered only after a thorough multisystem evaluation is done with emphasis on the respiratory, the cardiovascular and the central nervous systems (head and cervical spine). Securing a safe airway is paramount. The oral cavity must be cleared of fractured teeth, fractured dentures, foreign bodies, and clots that may cause obstruction. The nasal passages should be evaluated for patency. If the patient cannot maintain a safe and totally unobstructed airway pre- or post-operatively, a temporary oropharyngeal airway should be considered for placement. Endotracheal intubation or tracheostomy may be necessary until the fractures have been treated and the edema resolves. With any facial fractures, the cervical spine must be evaluated early, most often with plain x-rays after a clinic examination.

Once life-threatening injuries have been managed and the patient is stable, the maxillofacial injuries should be treated as soon as possible.

Principles in the Management of Facial Fractures

The management of facial fractures depends on the initial clinical evaluation and radiologic examinations. Ideally, radiologic evaluation would include Panorex of the mandible (orthopantomogram) and a CT scan of the facial bones. In situations where neither Panorex nor CT scans are available, the x-ray views described later in this chapter (see “Plain Facial Films”) can give helpful information for fracture management.

When dealing with maxillofacial injuries it is important to keep the maxillofacial bony complexes in mind:

♦ Mandible
♦ Maxilla
♦ Malar bones
Nose

The last three constitute the middle third of face. Fig 1

![Fig 1]

The maxillofacial bony complexes: maxilla, nose, mandible and malar bones.
The stippled segment indicates the middle third of face.
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These complexes each have its own distinctive injury patterns, either as a single pattern or combination of several patterns of fractures. Maxillofacial fractures may involve a solitary bony complex or multiple ones. In jaw fractures, it is not uncommon for isolated fractures around the teeth to occur within the upper dental arch, lower dental arch or both. This type of fracture is known as a **dento-alveolar fracture**. This is a localized fracture of the alveolar plate of the maxilla or mandible with a varying number of teeth attached to the fractured segment.

Fractures of the facial skeleton can also be categorized as:

♦ Fractures that involve dental occlusion: mandibular and/or maxillary fractures (Fig 2).
♦ Fractures that do not involve dental occlusion such as malar and nasal fractures.

![Fig 2]

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In a fractured mandible, if the teeth are not occluding correctly, the fracture is displaced. Due to poor dentition, many patients may have had malocclusion prior to their jaw fracture. If so, then proper occlusion will not be achievable even with perfect fracture reduction. It is
important to ask the patient if their bite feels like it comes together differently than before the injury—this would indicate a displaced fracture. The first figure demonstrates an unreduced, displaced fracture, with the teeth not occluding. The second figure shows a non-displaced or reduced fracture with teeth occluding correctly.

It must be emphasized that to achieve and maintain proper dental occlusion is the core of all treatment of fractures which involve the teeth. The surgeon who has to deal with such a fracture in the absence of dental support will do very well to prevent a permanent and largely irreparable deformity by making accurate and precise occlusion the main aim in the treatment, either by closed reduction and interdental wiring, by open reduction and plating, or if necessary a combination of wiring and plating after open reduction of fracture fragments.

With suspected fractures involving the orbit, a good eye exam should be done including checking for diplopia. Diplopia is a symptom, not a sign, and, thus, can only be elicited in a conscious patient. The patient should be asked about any double vision while performing an extra-ocular muscle examination—during lateral and upward/downward gaze. If present, it may suggest an orbital fracture which, if appropriately treated in a timely manner, may resolve the diplopia. If persistent, it is a very debilitating disability.

Clinical Examination of the Face

Overlying soft tissue signs like edema, contusions, abrasions, ecchymosis and distortion of the facial proportions must raise the suspicion of underlying bony injuries. Subconjunctival haemorrhage with ecchymosis and edema in the region of the orbit or a palpebral hematoma may suggest a fracture of the zygoma or orbit. Bilateral periorbital hematomas suggest a Le Fort, nasoethmoid, or anterior cranial fossa fracture. Contused intraoral tissue, loose teeth, and malocclusion suggest possible maxilla or mandible fractures.

An orderly examination of all facial structures from either superior to inferior or inferior to superior in a systematic fashion as well as meticulous examination in search for dysfunction of the orbital, masticatory, and neurosensory systems of the face will often reveal the anatomy of the underlying fracture pattern to the facial skeleton.

Systematic palpation of all bony surfaces must be carefully performed:

- the superior, inferior and lateral orbital rim
- the nose
- the zygomatic arches
- the malar eminence
- outline of the maxilla
- the inferior border of the mandible

Specific symptoms and signs produced by facial injuries include:

- pain or localized tenderness overlying a fracture site
- crepitation from areas of underlying bone fracture
- hypaesthesia or anaesthesia in the distribution of a specific sensory nerve e.g. infra orbital or mental nerves,
- malocclusion
- visual acuity disturbance, double vision (diplopia) as a result of severe swelling, muscle paralysis or dystopia
facial asymmetry, facial deformity
♦ obstructed respiration
♦ lacerations, bleeding, and contusions

**Particular Attention to:**

1. **Periorbital Region**

Signs/symptoms of an orbital fracture are:

♦ tenderness, crepitus
♦ contour defects
♦ unequal globe levels (dystopia of the globe)
♦ enophthalmos or proptosis
♦ double vision (diplopia)

Any of these structures may be injured: orbital rim, orbital floor/roof, medial/lateral orbital walls along with the zygoma and/or maxilla.

Visual acuity as well as extra-ocular muscle and pupillary function should be assessed before any surgical treatment is undertaken. Intraocular pressures should be measured if possible.

In uncooperative patients, the response to light stimuli, such as photophobia, pupillary constriction, aversion of the head, or lid closure, indicates probable light perception.

An assessment of pupillary reactivity is of critical importance because the direct pupillary response to light is the most reliable sign of the extent of optic nerve injury. The absence of pupillary reactivity is an indication of serious visual compromise.

Pupillary size and symmetry, speed of pupillary reaction, globe turgor, globe excursion, eyelid excursion, double vision, and visual acuity and visual loss are noted.

Extra-ocular movements (cranial nerves III, IV, and VI) and the muscles of facial expression (cranial nerve VII) are examined in the conscious, cooperative patient.

Signs of injury to the globe and/or any confirmed orbital fracture should initiate ophthalmology consultation if available. Examples of globe injury may include the presence of hyphema, corneal abrasion, visual disturbance (field defect), double vision, decreased vision, or absent vision.

2. **Masticatory Dysfunction**

Careful inspection of the intraoral area should be made to detect lacerations, loose teeth, and abnormalities of the dentition or malocclusion. Palpation of the dental arches is done noting any mobility of dentoalveolar arch segments. The maxillary and mandibular dental arches are carefully visualized and palpated to detect an irregularity of the bone, loose teeth, intraoral lacerations, bruising, hematoma, swelling, movement, tenderness, or crepitus.

♦ Fractures of the facial bones may be diagnosed on the basis of **malocclusion** of
the teeth or an open bite deformity due to fracture displacement involving the upper and/or lower jaw.

♦ Pain with restricted movement of the jaw, trismus, may be caused by a fracture of the zygoma, upper jaw and/or lower jaw.

♦ The excursion and deviation of the jaws with motion, the presence of pain on opening of the jaw, the relationship of the teeth, the ability of the patient to bring the teeth into occlusion, the symmetry of the dental arches, and the intercuspal dental relationship are all important to the diagnosis of fractures involving the dentition.

♦ One finger in the ear canal and another over the condylar head can detect condylar movement, or crepitus, either by the patient's movement or when the jaw is pulled forward.

♦ A gingival laceration, a fractured or missing tooth, or a split alveolus should imply the possibility of more significant maxillary or mandibular injuries. This must be confirmed by further examinations for mobility and by appropriate facial X-rays and/or CT radiographs.

♦ Fractures of the mandible may be detected by pulling forward on the jaw or by applying "up-and-down" manual pressure on the anterior portion of the mandible, having supported the angle, or lateral pressure on the dentition. Instability, crepitus, and pain may be noted when this manoeuvre is performed. Edema and haemorrhage may mask the perception of facial asymmetry.

3. Cerebral Spinal Fluid (CSF) Leak

Bleeding from lacerations of vessels accompanying facial fractures may disguise a CSF leak.

♦ Bleeding or fluid draining from the ear canal may indicate a laceration in the ear canal, a condylar dislocation, or a middle cranial fossa fracture with a CSF leak

♦ Bleeding from the nose may indicate nasal or septal injuries, a Le Fort, naso-ethmoidal, orbital fractures or fractures of the anterior cranial fossa.

♦ Mobility of the middle third of the facial skeleton indicates a Le Fort fracture.

♦ Anterior or middle basilar skull fractures or cribriform plate fractures should be suspected when CSF rhinorrhoea or clear drainage from the ears is present.

Radiographic Examination of the Face

♦ Plain Facial Films
The Waters, Caldwell, submental vertex, Towne and lateral skull films are the most helpful. Antero-posterior and lateral oblique views of the mandible are important, as is the Panorex (orthopantomogram) examination if this is available. The middle and upper facial structures are most accurately evaluated with a detailed CT examination if available.

♦ Nasal bones, lateral views
Fractures of the nasal bones, the anterior nasal spine, and the frontal process of the maxilla are demonstrated.

♦ Temporomandibular joints
Oblique anterior-posterior and oblique lateral views are taken by the lateral, transcranial projection and demonstrate the temporomandibular joints in open and closed mouth positions.

- **Panoramic Films**
  Panoramic films (orthopantomograms) are helpful in defining location and displacement of mandibular fractures.

**Definitive Management of Facial Fractures.**

**Early care**

Before the definitive treatment is begun, the great majority of patients with maxillofacial injuries require no special care of the fracture other than adequate and repeated cleansing of the mouth. Maxillofacial fractures, apart from mandibular fractures, do not tend to be sufficiently mobile to make pain from this source a problem.

In the small group who require special care, the difficulties are either respiratory or those caused by haemorrhage.

1. **Haemorrhage**

Bleeding, particularly in maxillary fractures, may occasionally be brisk but usually stops spontaneously if a free airway is provided. It is important to prevent blood from trickling back into the pharynx where it can potentially cause respiratory difficulties with restlessness. This can increase the bleeding. Though very rare, severe and uncontrollable bleeding may call for ligation of the external carotid artery.

2. **Respiratory difficulty**

This can vary greatly in severity and is due either to swelling of the tongue from haematoma spreading from a mandibular fracture or to an inability to control the tongue in those bilateral mandibular fractures where the anterior fragment which carries most of the muscular attachments of the tongue is mobile. Also, gross soft tissue swelling after severe facial trauma may impair the airway in combination with fractures which, on their own, may not typically cause airway difficulties.

The measures to maintain a safe airway required in any particular patient depend on the severity of the respiratory embarrassment. Adequate suction should always be available. Patients breathe more easily if their head can be elevated; but, when this is not possible, it is most important not to leave them lying supine. The correct position is **prone with head turned to the side**. A suture through the tongue to hold it forward may be necessary.

It must be stressed however, that any suggestion of serious respiratory difficulty is an indication for immediate **tracheotomy** since respiratory embarrassment tends to increase rapidly.

3. **Associated Injuries**

Maxillofacial fractures do occur as isolated injuries. When there are severe vehicular
Collisions, other severe injuries are liable to be sustained simultaneously. The injuries most likely to affect the management of the maxillofacial component are soft tissue facial injuries, cranial and neck injuries, chest injuries, and eye injuries.

- **Soft tissue facial injuries** should be treated on their own merits with the minimum of delay.

- **Brain damage** following cranial injuries with or without a skull fracture is quite common in association with a maxillofacial injury. If the patient is unconscious, then with this score alone would be considered for tracheotomy. The presence of a fracture of the maxilla or mandible with additional breathing difficulties leaves little argument against early tracheotomy. *(Editor's Note: It is realized that the care of a tracheostomy is difficult in many locations without an ICU or nurses experienced to care for it. See Chapter 5 on Anaesthesia.)*

- **Cerebrospinal rhinorrhea:** leakage of cerebrospinal fluid from the nose is evidence of a fracture of the cribriform plate with a tear of the dura. It is an easy clinical diagnosis - a water-clear fluid dropping from the nose that sometimes increases in volume by dropping the head forward or straining. It usually develops within 48 hours of the injury though it may suddenly appear some days or even weeks after the injury.

Some leaks stop spontaneously when the fracture is fixed and there is no further trouble; some appear to stop but meningitis can develop after a variable and sometimes quite long period of freedom from all symptoms; some continue to leak fluid with the eventual development of meningitis even after reduction and fixation of the fracture of the maxilla.

The presence of a cerebral spinal leak and the potential for meningitis necessitates adequate antibiotic coverage. It is well recognised that movement of the fractured maxilla causes considerable movement of the cribriform plate and the fractured neighbouring bony fragments. The fracture should, therefore, be reduced and fixed at the earliest possible moment so that the dural tear may have the best chance to heal.

If the leak is small in volume and becomes less fairly rapidly, it can safely be left to stop spontaneously. The chances of late meningitis are probably remote.

If the leak is large in volume or persists, it should be surgically closed if possible in your hospital. This is rarely necessary, and most will need to refer the patient to a neurosurgeon when the patient is stable.

- **Chest injuries.** The maxillofacial injury is likely to make treatment of the chest injury more difficult by adding to the respiratory embarrassment if there is a flail segment with paradoxical respiration. In such a situation, a tracheotomy will help to solve both problems.

- **Eye Globe Injuries.** This is surprisingly rare except with orbital fractures. When it does occur the damage tends to be irreparable either with disruption of the contents of the eyeball or severe damage to the optic nerve. Patch the eye until the patient can be seen by an eye doctor or someone experienced in eye surgery. An exception to this is hyphema which is a vision threatening
problem that may be worsened with orbital fracture surgery. The operation should be delayed in the presence of a hyphema.

♦ **Sympathetic ophthalmia** is a granulomatous uveitis and inflammation that occurs following trauma to one eye. It may occur several days to several years after a penetrating eye injury. Though rare, if a serious non-reversible injury occurs to one eye, it could affect the other eye and lead to blindness. Therefore, it may be prudent to remove the injured eye and prevent damage to the good eye.

**Treatment of Specific Facial Fractures**

I. **Mandible**

**Patterns of injury**

The sites of fracture (Fig. 3) are condylar neck, angle, body and symphysis. Fractures at these sites may occur singly but usually in combination. Fracture patterns may exist as both condyles, both angles, body and opposite angle, body and opposite condyle, and both sides of body. **If one fracture is diagnosed, a second fracture should be excluded.**

![Fig 3](Fundamental Techniques of Plastic Surgery – and their Surgical Applications, 7th edition, Elsevier. Used by permission)

Fracture displacement may be the result of the direction of the violence but they result largely on muscle pull. The muscles that elevate the mandible - masseter, medial pterygoid, temporalis - are all inserted behind the first molar. The muscles that depress the mandible - geniohyoid, mylohyoid, digastric - are all attached in front of the first molar (Fig 4). Consequently, the most common displacement of a posterior fracture segment is upward and the anterior fracture segment is downward. The direction of the fracture line, particularly near the angle, may considerably influence the amount of displacement, either permitting or preventing it (Fig 5).
The lines of muscle pull which influence displacement of fragments in mandibular fractures.

Pull of the muscles:
- Upwards - masseter, temporalis, medial pterygoid.
- Downwards - geniohyoid, mylohyoid, digastric.

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The effect of the direction of the fracture line on the displacement of angle fractures of mandible under the influence of muscle pull.

On left, the muscle pull engages the fragments; on right it distracts the fragments.
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The condylar fracture is a special case. In a condylar neck fracture, the condylar head is hinged forward by the lateral pterygoid muscle, displacing the fracture. When both condyles are fractured, the displacement of both heads causes the mandible to rotate downward due to loss of condylar support producing an “open bite” malocclusion (Fig 6).
Clinical Picture of Mandible Fractures

The site of the fracture is usually indicated by swelling and local pain on movement or manipulation of the mandible. In fractures other than those of the condylar neck, there is often a sublingual hematoma; if the fracture is compound into the mouth, there is tearing or at least bruising of the mucosa.

Displacement in the tooth-bearing segment of the mandible may be clinically apparent with an obvious break or step in the line of occlusion. The patient may volunteer the information that “the teeth don’t close properly”.

A condylar fracture is less obvious and the only sign may be pre-auricular pain with or without swelling. There is restriction of movement and deviation of the mandible to the damaged side on opening with an open bite on the contralateral side. The great majority of patients with a fracture elsewhere in the mandible and who complain of pain in the vicinity of the temporomandibular joint are found to have a fracture of the condylar neck.

In displaced fractures between the angle of the mandible and the mental foramen there may be damage to the inferior alveolar nerve since it runs within the bone. On exam there may be anaesthesia of the lower lip.

In a suspected fracture of the mandible, bimanual palpation along the inner and outer plates of mandible intra-orally and along the lower border extra-orally will often confirm the diagnoses. Local swelling and tenderness is suggestive of a fracture while an actual step off is diagnostic.

X-Ray Diagnosis

The two most useful views are the postero-anterior projection (diagnose symphysial fractures) and the lateral oblique projection.

Treatment

(Reduction and fixation methods are described in the section immediately following)

A fracture of the tooth bearing segment is managed by eyelet wiring (MMF:
mandibulomaxillary fixation) or mini plates and screws if the latter are available. MMF is the same as IMF—intermaxillary fixation, which is an older term.

If there are no teeth present on both sides of the fracture line, internal fixation by either interosseous wiring or mini plate and screw fixation will be necessary with or without MMF, but not MMF alone. When gross displacement is present or the fracture is unstable, intermaxillary fixation with eyelet wiring and reduction will often be necessary before mini plate and screws can be applied. If plates and screws are not available, then interosseous wiring is done before the eyelet wiring can be completed. Occlusion and dentition should be treated prior to any fracture fixation.

**Fractures of the edentulous mandible** are managed with gunning splints or mini plates and screws. Interosseous wiring on its own is seldom stable enough. (Gunning splints may be made by a local dentist.) *(Editor’s Note: Most will not be able to obtain these splints and this will be a difficult fixation. Interosseous wiring should be tried. Hopefully fractures of the edentulous mandible will be rare. Some may have appropriate plates and screws.)*

**Dentoalveolar fractures** are treated by arch bar wiring.

**Unilateral condylar fractures** can usually be treated without open reduction. Open reduction may be considered when the condyle is in the middle cranial fossa, displaced lateral to the joint capsule, or the occlusion is incorrect with closed reduction. Closed reduction treats the joint as a pseudarthrosis and re-education of the muscles is relied on to establish good function. Some patients with a single, non-displaced condylar fracture will be able to chew soft foods fairly quickly with or without a period of rest depending on the degree of initial discomfort. If pain is severe, fixation with MMF with eyelet wires may be necessary for two to three weeks. In subsequent re-education of the muscles, a training flange on the splint may be required to train the mandible to close in correct occlusion.

**Bilateral condylar fractures** require open reduction of at least one of the condylar fractures to re-establish condylar support. This corrects the “open bite” deformity associated with this fracture pattern.

**Reduction and fixation methods**

The teeth can be used as an indirect method of fixing jaw fractures especially if mini plates and screws are not available. Their firm attachment to the alveolus and the fact that their occlusion is of prime importance to subsequent function makes them extremely effective for this purpose. It is usually only when teeth are absent that the alveolus is approached more directly for splinting purposes.

In reducing a fracture of the mandible or maxilla, the aim is to bring the teeth of the fractured fragments into a normal relationship with those of its non-fractured counterpart. Establishing the occlusion helps the fracture reduction by placing the fractured segments in good position. In an edentulous patient the fractured alveolus, for similar reasons, is brought into the position that it would occupy if dentures were being worn.

In fixing a fracture of the mandible or maxilla, the fractured bone, once reduced, must be anchored to an immovable structure unless mini plates and screws are used
on their own. The mandible when fractured is thus anchored to the maxilla; the maxilla when fractured is anchored to the skull (at the zygomaticofrontal suture if fractured) as well as to the mandible.

When teeth are present in sufficient numbers on both fragments, they are fixed in proper occlusion (MMF) by eyelet wiring, arch wiring or cap splinting (gunning splints).

1. **Eyelet wiring (Mandibulomaxillary fixation or MMF)** Fig 7

The wire used is a 0.4 mm diameter stainless steel wire which has been doubled on itself and twisted tightly two or three times leaving a small eyelet at the end. In some countries, the 0.4 mm wire will be a **24 gauge** wire.

The double wire is passed inwards between the necks of two adjacent teeth until the twisted segment is lying between the necks with the eyelet on the outer side. The wire is then separated into its two strands, one being turned forward and one backward, and each is passed outwards through the next interspace so that a loop is formed round the necks of the two adjoining teeth. The loops are completed by bending the wires towards one another, passing one through the eyelet and finally twisting them tightly together before cutting off the excess and turning in the end so that it will not catch on tongue or cheek.

![Diagram of eyelet wiring](image)

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Fig. 7

The steps in eyelet wiring and a patient showing the upper and lower teeth wired together.
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Several sets of these wires are applied at intervals around the alveolar arch and also
at corresponding points on the opposite jaw. When the fracture has been manually reduced and the mandible closed on to the maxilla, it is held in this position by looping further wires through the eyelets which oppose one another twisting them tightly together.

2. Arch Bar Wiring  Fig. 8

This technique is an alternative to eyelet wiring and uses arch bars (Erich) with hooks at intervals along its length (Fig 8). The bar is accurately moulded round the alveolar arch on its outer aspect at the level of the necks of the teeth to which it is then wired. With an arch bar similarly applied to the maxilla, the two can be fixed together with wires. This technique is most useful to fix dentoalveolar fractures (also known as an alveolar ridge fracture) and needs only one arch bar placed across the fractured segment fixing it to at least two stable teeth on either side of the fracture.

3. Gunning splints  Fig 9 (This will rarely be available at district hospitals with or without a dentist available)

When teeth are not present and the patient has dentures, the fracture can be reduced on the dentures with upper and lower teeth occluding correctly. If the dentures are broken or the patient has no dentures, impressions can be taken and ‘dentures without teeth,’ the so-called gunning splints, made (Fig 5). If the patient’s dentures are intact, however, they can be used as gunning splints. These splints are circumferentially wired on to the upper and lower jaws and subsequently to each other to obtain fixation.
4. Internal fixation (Fig 10)

♦ Interosseous Wiring

When displacement of a fracture is considerable and it cannot be readily reduced manually in preparation for fixation by one of the methods described, it may be necessary to fix the bones in a reduced position by interosseous wiring.

Exposure of the mandible can be by an internal (transmucosal) or an external (transcutaneous) approach. External approaches are dictated by where the fracture is located and may include a submandibular, submental or retromandibular incision. The submandibular and retromandibular approaches carry the danger of injury to the mandibular branch of the facial nerve to the lower lip, apart from the visible scar. The intra-oral approach has none of these drawbacks though the technique of wiring has to be modified somewhat. It is more difficult for the occasional surgeon with this approach.

The internal approach, most often utilizes upper border wiring in the non-tooth bearing segments. The fracture site is exposed, holes are drilled near the upper border of the mandible immediately adjoining the fracture site and a simple loop is inserted. When the fracture is reduced, the wire is twisted tight to maintain reduction (Fig 10 upper and lower left figures). Alternate patterns of wiring can be used to maintain more effective fixation depending on the direction of the fracture. An upper border wire is really a tension band and it should be combined with lower border wiring or MMF. Ideally this is placed through the same incision but if not, through an external approach.
Lower border wiring usually makes use of a figure of eight wire and really requires an external approach. It is only really ideal when there is an appropriate soft tissue laceration.

♦ **Mini plates and screws** *(It is realized that most district hospitals may not have these)*

The use of mini plates and screws are the preferred method of fixation of maxillofacial fractures and offer the advantage of immediate mandibular mobility and a very limited time of a liquid only diet. It is sometimes used in combination with interdental wiring (MMF). MMF is recommended in difficult reductions to get the teeth in good occlusion and to keep them in position whilst also applying the plates. The wiring can then be removed within 7-10 days.

The plates and screws can be applied through an intra-oral approach on the buccal side of the mandible. If maxillofacial plating set is not available, then a hand surgery mini-plating set is a good alternative to use. Anterior to the mental foramen (Fig 11), two plates need to be applied to counteract the rotation forces in this area. Posterior to the mental foramen a single plate is sufficient with MMF. The screws in the upper plate along the alveolar ridge need to be uni-cortical through the buccal cortex to
protect the root of the teeth. The level where the plates are applied should be no closer than one third of the height of the mandible from the dental margin of the jaw to avoid damage to the roots of the teeth. In order to obtain secure fixation, an inferior plate should be used with bicortical screws.

**Infection** around plates/screws or wires that are well covered by the soft tissues is very uncommon and the plates and screws are usually left permanently. However, infection of a mandibular fracture can occur occasionally and particularly if the fracture is through a tooth socket in the line of the fracture. The remarkable thing about infection is its rarity. If infection does occur, the wire or plate must be removed but it should, if possible, be retained until the fracture is 'sticky' so that displacement will not recur. The upper border wire is exceptional; it is so close to the underlying mucosa that it usually becomes exposed in the mouth eventually, but removal under local anaesthesia is straightforward.

Fractures are usually united by six weeks. This can be confirmed clinically and by X-ray examination but it should be recognized that X-ray evidence of union may not be present for many months. In fractures where only MMF was used, the wires between the mandible and maxilla are removed by 6 weeks. If there is clinical union, the rest of the wires (loops around the teeth) can be removed, but if the fracture is still mobile and springy, the mandible and maxilla should be wired together again until union is clinically apparent. Fractures of the symphysis and those that have become infected tend to be slow to unite.

**II. Malar Fractures**

There are three main types of fracture. Fig 12

- **Simple fracture.** (Fig 12 – first 3 diagrams) The fractured bone, consisting of the malar complex, remains in a single piece which is displaced medially and backwards, often tilted either medially or laterally, and usually impacted. The line of fracture runs from the infra-orbital foramen downwards and laterally over the anterior wall of the antrum compressing the infra-orbital nerve and tearing the branches of the superior dental nerve which cross the fracture line.

- **Comminuted fracture.** The fracture pattern is generally similar to that of the simple fracture but the bone is comminuted with depression of the orbital floor. A comminuted fracture of the floor of the orbit with depression of the floor and escape of some of the orbital contents into the antrum may occur as an isolated injury - the blow-out fracture. Classically it results from direct force by a blunt object, e.g. a fist, on the eyeball. The loss of the orbital fat is responsible for the main clinical feature, namely enophthalmos often with diplopia.

- **Arch fracture.** This consists of a localized depression of the zygomatic arch. In its medially displaced position, it tends to impinge on the coronoid process of the mandible. A clearly palpable dent is felt in the contour of the arch.
Clinical Picture

- Swelling and bruising of the overlying soft tissues. It might be absent, but sometimes it progresses rapidly until it is severe enough to virtually close the eye and mask any underlying bony deformity.
- Subconjunctival hemorrhage is often present.
- Flattening of the cheek prominence. Comparing the inferior orbital margin with the normal on the opposite side, a step-off in the vicinity of the infra-orbital foramen can usually be felt.
- Areas of anaesthesia: the superior dental nerves may be divided by the fracture making the teeth of the affected segment anaesthetic to percussion. Damage to the infra-orbital nerve is variable but the two areas most noticeably are the upper lip and the alar region of the nose.
- Diplopia may occur as a transient phenomenon in the simple fracture and temporal reduction cures it. When it persists postoperatively, it is usually found that the lateral part of the orbital floor has been severely comminuted and depressed.
- Trismus is very variable and tends to be more severe if there is significant depression of the zygomatic arch. Indeed, apart from the clinically obvious local depression, trismus with marked restriction of lateral movement of the mandible may be the patient’s sole complaint in the localized arch fracture.

X-Ray Diagnosis

Irregularities or definite fracture lines near the infra-orbital foramen, the zygomatic arch, and the lateral wall of the antrum, and the line of the orbital floor should be compared with the normal side. Blood in the antrum may make it appear opaque.
Treatment

The finding of a malar fracture on an X-ray plate does not always mean that surgical treatment of the fracture is necessary. The need or not for surgery is decided rather on the clinical examination.

**Indication for surgery are**
- infraorbital nerve anaesthesia – lip and nose. Anaesthesia of the teeth by itself is not an indication as the elevation of the malar will make no difference with this symptom
- trismus
- diplopia
- obvious flattening of the cheek prominence

Surgical treatment consists of elevation of the malar complex or zygomatic arch through a temporal approach The temporal approach is suitable for most of the simple fractures. The deciding factor is really whether or not the malar is more or less in a single piece and capable of being reduced by exerting leverage on the anterior part of the zygomatic arch. The arch fracture falls into this group. To lever the arch in comminuted fracture would only reduce part of the bone and has to be reconstituted and supported by an antral pack. Following reduction, most fractures maintain their reduced position. If the fracture appears to be unstable and displacement tends to recur, then direct interosseous wiring or fixation by mini plate and screws at the zygomatico-frontal suture is often necessary – see below.

1. **Temporal reduction** Fig 13

This method depends on the anatomical fact that while the temporal fascia (superficial and deep layers) are attached along the inner and outer border of zygomatic arch the temporalis muscle runs under it to the coronoid process of the mandible and a lever inserted between fascia and muscle can slide down deep to the arch to exert its leverage.

An oblique 2 to 2.5 cm incision is made in the temporal area in the hairline and just anterior to the superficial temporal artery. The artery is usually clearly palpable. The incision is carried as far down as the temporal fascia. As a pathfinder for the lever McIndoe’s scissor are inserted under the fascia and slid along the surface of the temporalis muscle deep to the zygomatic arch.

Various levers have been devised and used to elevate the bone but the most commonly available and an eminently satisfactory one is an orthopaedic (Bristow) periosteal elevator. It is slid along the path found by the scissors and once under the arch it should be brought as far forward as the arch allows so that leverage can be exerted anteriorly if necessary as well as laterally. If added leverage is required, a swab may be placed between elevator and scalp. The degree of force needed depends on the degree of impaction and the delay in treatment but considerable force can safely be used. In closing the incision it is only necessary to suture the skin.
2. Antral Reduction in Comminuted Fractures  Fig 14

(Editor’s Note: The following is an old technique. If one can elevate the orbital floor using the procedure given under orbital floor fractures below, then this will not be necessary.)

An incision is made in the upper buccal sulcus in the canine region and the soft tissues are stripped off the outer wall of the antrum. If, as very rarely happens, the particular part of the antral wall is intact, an opening must be chiselled into the antrum and enlarged with rongeurs for access.

The finger in the antrum carefully pushes out the walls to a correct position and the most important wall is the orbital floor. The cavity is then packed with 1-inch (2.5 cm) ribbon gauze soaked in Whiteheads Varnish (Pig. iodoform Co. B.P.C.) and tightly wrung is the way it is found as clean, dry, and non-smelling on removal as when inserted. Enough packing is inserted to maintain the orbital floor at its correct level and buttress out the cheek prominence. The end of the gauze is left protruding into the mouth to give an easy start for its removal in 10 to 14 days. It is usual, though not essential, to partly suture the mucosal incision. It is important not to pack too vigorously towards the orbit in case some of the pack gets pushed into the orbit itself giving rise to severe proptosis.
Fixation with Interosseous Wiring or Plating Fig 15

Once a non-comminuted malar fracture is reduced many of them will be unstable and will need fixation. The fractures are exposed with small incisions directly overlying, one in the subtarsal area of the lower eyelid—see below and one over the zygomatic-frontal fracture line. With the bone exposed, holes are drilled on each side of the fracture site and wiring is carried out with a simple loop or figure of eight as dictated by the situation. The wires are left buried permanently. If a plating set is available a 4 hole plate (1.1, 1.3 or 1.5 mm.) can be fixed over the fracture sites. One may also approach these fractures through a buccal sulcus incision.
III. Orbital Floor Fractures (‘Blowout Fracture’)

These are caused by the patient being struck in the orbital region with a ball, a fist or some other round object causing a sudden increase in pressure in the orbit. The floor of the orbit is concave, dipping downward behind the rim of the orbit and is the thinnest section of the orbit, prone to be ‘blown out’ with ‘escape’ of the orbital contents through the fractured floor potentially causing enophthalmos.

The most important, but not most common, signs are peri-orbital bruising, enophthalmos and restricted eye movement. Examination of the eye might also reveal any of the following: edema, corneal abrasion, laceration, contusion, or hematoma. Enophthalmos might not always be present or might not be apparent immediately. A subconjunctival and peri-orbital hematoma confined to the distribution of the orbital septum is evidence of a facial fracture involving the orbit until it is proved otherwise.

If the extraocular movements are affected, it is noted by double vision or restricted globe movement. Limitation of forced rotation of the eyeball, the **forced duction test** or the eyeball traction test, provides a means of differentiating entrapment of the ligaments of the inferior rectus muscle in the fractured floor from weakness, paralysis, and sometimes contusion. The test can be done under local anesthetic or while the patient is under general anesthetic; the sclera is gently grabbed with a non-toothed forceps and the eyeball moved in the different directions.

**Visual acuity should be assessed prior to anesthesia,** also, the **globe pressure** by tonometry if available and should be less than 15 mm Hg. And a **funduscopic examination** is important.

**Treatment**

The two main indications for surgery are the presence of enophthalmos or restricted eye movements caused by entrapped musculature.

An incision is made in the lower eyelid in the subtarsal area, 7-10 mm. below the eyelid margin. Incisions just below the eyelid lashes were once advocated but when these heal there is often eyelid retraction even with the best of surgeons. The dissection is carried directly through the orbicularis muscle aiming for the infraorbital rim. The periosteum is cut on the orbital rim and the periosteum
elevated from the floor. The inferior rectus muscle, the orbital fat, and any orbital soft tissue structures should be carefully dissected free from the areas of the blowout fracture using a Freer type elevator. Any pieces of orbital floor that had been dislocated into the maxillary sinus should be removed. Intact orbital floor must be located around all the edges of the displaced blowout fracture. The floor must be explored sufficiently far back into the orbit that the posterior edge of the intact orbital floor beyond the defect can be identified. The ocular globe and its surrounding structures are freed from the fracture site. Proper rotation of the ocular globe after freeing of this orbital soft tissue may be confirmed by an intraoperative forced duction test.

Restoration of the continuity of the orbital floor is required in all orbital floor fractures, except in small fractures where there is no tendency of soft tissue to herniate into the fracture defect. Large bony fragments can sometimes be used to help reconstitute the floor. If available a Medpor implant, thin silastic sheet or thin titanium mesh may be used to cover the orbital floor defects. A thinned outer layer calvarial bone graft from the parietal calvarium can also be used. A last resort would be the conchal cartilage of the ear that works fine when the other possibilities above are not available. Once the ear is injected with Xylocaine with adrenalin, an incision can be made around the edge of the concha and a segment of concha removed for the graft.

III. Maxillary Fractures Fig 16

The fracture patterns depend on two factors - the site and direction of the violence and the anatomical lines of weakness of the maxilla.

- **Le Fort I Fracture.** The palatal segment of the complex shears off the remainder through a horizontal line corresponding in level to the floor of the nose and the lower part of each antrum. The palate as a whole can be displaced backwards.
- **Hemi le Fort I Fracture.** On occasion, when the violence has been predominantly unilateral, one half of the maxilla is fractured in this way, an added fracture line running back along the midline of the hard palate.
- **Le Fort II Fracture.** The maxillary complex is fractured as a whole. The fracture lines run upwards and medially across the anterior wall of the antrum towards the infra-orbital foramen on each side and across the nasal bones to meet in the midline at the glabellar region. Displacement is usually backwards and the inclined plane of the fracture line has the effect of forcing the maxilla also downwards. This gives rise to an open bite as the mandible is pushed down into an open position. The degree of impaction varies greatly from the massively displaced and impacted fracture to the so-called 'floating' fracture where impaction is minimal.
- **Le Fort III Fracture.** The fracture line runs transversely through the zygomatico frontal suture, through the nasal suture in the midline and across the floor of the orbits to effectively separate all mid-facial structures from the cranium. The zygomatic arch may or may not be fractured. These fractures are usually minimally displaced and present only with "black eyes" and with subtle occlusal problems.

Any combination of the above fracture patterns is possible.

When the maxilla is displaced as described above, the nasal complex is clearly
involved and would be displaced with the fracture and might in itself be fractured independently.

![Fig 16](image)

**Clinical Picture**

It is often possible to make a diagnosis on inspection alone. The face as a whole, but predominantly the middle third, is diffusely swollen with edema of cheeks and eyelids and looks ‘like a football’.

In the severely displaced fracture, there is an obvious ‘dish-face’ deformity despite the masking effect of the edema. There is failure of the teeth to occlude properly when the patient closes his mouth. The upper incisors may occlude behind the lower incisors due to posterior displacement of the maxilla or they fail to occlude at all because of the presence of an open bite.

Mobility of the maxillary complex is tested by grasping the maxilla just above the incisors between finger and thumb of one hand while the other finger and thumb feel across the bridge of the nose and hold the head steady. The maxilla is rocked backwards and forwards while independent movement of maxilla is felt for. Movement of the maxilla with detectable movement at the nasal bridge suggests that
the entire maxillary complex is fractured while movement of the maxilla without detectable movement at the nasal bridge suggests a fracture of the palatal segment alone. Each half of the palatal segment is then tested against the other for independent mobility and loose teeth are tested for to exclude alveolar fractures.

**X-Ray Diagnosis**

The diagnosis should be made on clinical examination and nearly every case can be diagnosed and treated without the need for an X-ray. The interpretation of the X-ray is often more difficult than that of the clinical examination.

**Treatment**

These fractures should be treated with the minimum of delay because they tend to fix rapidly in their displaced and often impacted position.

The first step then is to reduce and fix the maxilla. If the maxilla is floating or only slightly impacted, it may be possible to reduce it by finger manipulation. If this fails, it is necessary to disimpact it with disimpaction forceps. The malar is then reduced and, depending on the specific fracture pattern, fixed with interosseous wiring or plating at the zygomatico-frontal suture, the infra-orbital rim and or palatal segment to the rest of the maxilla as with a Le Fort I fracture. The maxilla is then reduced on to the mandible and wired (IMF) to the mandible.

Where there has been a longitudinal fracture of the palate, this should be reduced and fixed with a wire across the palate from the first or second molar to the opposite corresponding molar with wire fixation through a cut metal tube (like a liver biopsy trocar cut at the appropriate length which will prevent overcorrection). Direct plating of the palate may also be done.

The wires from maxilla to mandible providing accessory fixation can safely be removed in four weeks.

**IV. Frontal Bone Fractures and Sinus Injuries**

Treatment consists of broad exposure of the frontal bone, orbital rims, all fracture sites, and frontal lobes through a coronal incision. Localized incisions or lacerations do not provide the access or flexibility that open treatment often requires. The fractured area is exposed with subperiosteal dissection, and the fracture fragments are repositioned or removed for evaluation of the dura. A precise débridement is performed, and any dural lacerations are closed after evacuation of epidural hematoma. Injuries to the frontal lobe are appropriately managed by removal of devitalized tissue. Frontal sinus fractures demonstrating significant displacement involving the anterior or posterior walls are treated by thorough removal of mucous membrane, light abrasion of the surface of the bony frontal sinus cavity and replacement of the anterior frontal sinus wall bone fragments. The cavity may be obliterated by a cancellous bone graft. The bone fragments are cleared of any remnants of missing or unstable frontal sinus mucosa by thorough removal and light burring of the walls. The bone fragments are replaced and stabilized with small wires or rigid fixation with small plates. Replacement of frontal bone fragments avoids late cranioplasty. Primary reconstruction of the frontal skull is usually safe. Elimination or obliteration of the sinus is not necessary in patients with an isolated fracture. One must always be aware of inferior and medial sinus fractures as these may
involve the nasofrontal duct. The mucous membrane may be locally débrided or removed as necessary; full sinus ablation may not be required unless the function of the duct is compromised. One can always instill sterile methylene blue or fluorescein dye and observe for the dye when gauze is inserted in the nostril. (Editor’s Note: Many craniofacial surgeons just obliterate nasofrontal duct with bone graft, muscle, fat or pericranial or galeal flaps and then leave the actual sinus empty after removal of all mucous membrane. Rigid fixation may be just wiring or suturing the fragments together or even the use of SuperGlue if small plates and screws are not available.).

**Posterior wall frontal sinus fractures** are treated as depressed skull fractures with repair of the dura and appropriate assessment of the frontal lobe, especially if the displacement exceeds the thickness of the bone of the posterior wall. Undisplaced posterior wall fractures may be carefully observed, but meningitis, intracranial abscess, and sinus obstruction are possibilities in any posterior wall injury. If the posterior wall is comminuted with a CSF leak, then cranialization of the sinus should be considered with removal of the entire posterior wall of the sinus and removal of all the mucosal lining. The duct must be obliterated with bone, muscle, pericranium or galea. Cranialization allows the brain to expand into the sinus area. The anterior table of the sinus must be carefully repaired.

**V. Nose**

**Patterns of Injury**

The nose consists of the nasal bones and the nasal septum and both may be damaged. Fractures follow two patterns due to lateral violence and head-on violence Fig 17.

**Lateral violence.** The nasal bone on the side of the injury is fractured and displaced towards the septum, the septum is deviated or fractured, and the nasal bone, on the side away from the injury, is fractured and displaced away from the septum so that the upper part of the nose as a whole is deviated.

**Head-on violence** causes saddling of the nose and broadening of its upper half as a result of the depression and splaying of the fractured nasal bones. Such a displacement naturally cannot take place without severely damaging the septum, and this takes the form of gross buckling of the septum or actual septal fracture.
Clinical Picture

The clinical appearance of the nose and septum is the index of diagnosis. Some swelling is inevitable in patients in whom the diagnosis is being considered, but a change of bridge contour or a new asymmetry are diagnostic, and frequently the best judge of this is the patient himself. In any case, a fractured nose, apart from its septal element, is treated on the grounds of appearance alone, and an X-ray showing a fracture is of no significance unless there is associated nasal deformity.

Even when the nose is not appreciably deviated or depressed the septum should be examined for haematoma. This show with gross bulging of the septal mucosa and it may either be unilateral or bilateral.

X-ray diagnosis
The fracture is treated on the basis of the clinical examination, and X-rays are quite unnecessary.

Treatment
Nasal fractures requiring reduction should be treated with the minimum of delay for they tend to fix in their displaced position in a matter of days. The surgical approach depends on whether the fracture has resulted in deviation or collapse of the nasal bones.

Deviation
This type of displacement is caused by lateral violence and it can sometimes be corrected by simple thumb pressure (Fig 18) particularly if the fracture is very recent.

Manipulation from inside using Walsham’s nasal forceps is sometimes required (Fig 19 and 20). With the particular forceps for the side of the nose being manipulated, the slim blade is inserted into the nostril and the broader blade outside. The blades are closed over the nasal bone. The bone is then mobilized with a rocking movement of the forceps first laterally and then medially to disimpact it. The mobilized both bones are manipulated with the fingers to mould them into a symmetrical position.
The septum should be inspected and if necessary reduced into a central position using Walsham’s septal forceps as described below (Fig 21 and 22). In practice, reduction of the nasal bones frequently reduces the septal displacement simultaneously.

**Collapse**

This displacement is the result of head-on violence. It is essential from the point of view of treatment to recognize that the nose cannot collapse without either buckling of the septum or fracture. Straightening or reconstitution of the septum automatically corrects the nasal collapse.

Walsham’s septal forceps are most effective for this purpose (Fig 21 and 22). The blades of the tightly closed forceps are so made that they remain apart leaving a gap corresponding to the thickness of the septum. With a blade inserted into each nostril along the nasal floor the forceps are “closed” and swung up towards the nasal bridge. As they move upwards the blades straighten the septum. Any associated broadening of the nasal bones can be reduced by finger pressure if necessary after mobilization with Walsham’s nasal forceps.

**Septal hematoma**

In a nasal injury the state of the septum should be examined for hematoma which if
present must be evacuated by incising the mucosa.

**Packing and Immobilization**

The nostrils are packet with Tulle gras, Vaseline gauze, Merocel or similar non-adherent nasal packing to provide support for the septum in its reduced position. This also helps to prevent the occurrence or recurrence of hematoma. It also provides some counter pressure for the plaster of Paris immobilizing the nasal bones and prevents them from collapsing inwards. It can be removed in 24 hours. A plaster of Paris splint moulded to the nose (Fig 23) is left in place for a week.

**Skull Fractures**

The skull is divided into the cranium, which contains the brain, and the facial bones. The cranium is made up of eight bones: the two parietal and two temporal bones and one frontal, one occipital, one ethmoid, and one sphenoid bone. The superior rounded portion of the cranium is the vault. In the adult, this bone consists of firm inner and outer tables with cancellous bone, or diploe, lying between them. The base of the skull forms the floor of the cranial cavity and separates the brain from other facial structures. The five bones that make up the skull base are the ethmoid, sphenoid, occipital, paired frontal, and paired parietal bones. The skull base can be subdivided into 3 regions: the anterior, middle, and posterior cranial fossae.

Fractures of the cranium are referred to as 'skull fractures'.

**Classification of Skull Fracture**

Fractures are described by

- the pattern of the fracture (linear, stellate/radiating or comminuted)
- the term "depressed" is used to describe an inward displacement of a portion of the vault
- the name of the bone involved.
- the term 'basilar' are used for fractures traversing the base of the skull
- ‘compound fracture’ describes a scalp laceration in continuity with the fracture—an open fracture.

A fracture can therefore be a comminuted, depressed, compound fracture of the parietal bone.
Brain
Mechanisms of Injury
The most critical aspect of head trauma is what happens to the brain.

The immediate brain damage that results from head trauma is dependent upon the force applied to the head, the size of the area of its application, and whether the head is fixed or freely movable. The damage can be caused directly by the injuring object, the effects of force transmitted through the skull to the brain, or a portion of the skull lacerating the brain, and/or the effects of acceleration and deceleration (indirect forces) of the head on the brain confined by the semi-rigid dura and rigid skull. The resulting neurologic dysfunction relates to the area of the brain involved and the degree of damage caused by the direct or the indirect forces. Delayed brain damage is mainly caused by the reactions of the tissues within the skull. A force applied to the skull may have a local effect of a laceration of the scalp, a fracture of the skull, and laceration and contusion of the brain, or it may have a more generalized effect caused by the effect of energy transmitted through a semisolid substance, when the brain is driven against the inner portion of the skull and edges of the dura, the stretching and tearing effect of the resulting internal movement of tissue, and the loss of function by the compressive effect of the torque or stress applied to the upper portion of the midbrain with rotational movement of the brain. These mechanisms result in the clinical conditions of cerebral concussion, cerebral contusion, and cerebral laceration. They, along with the effect of alteration in total function of the nervous system, the alterations in cerebral circulation, the changes in respiration and vasomotor control, and the reaction of the nervous system tissue to injury, are the main reasons for the clinical syndromes seen in the head injured patient.

Treatment of Skull Fractures

- Most skull fractures require no treatment e.g. closed linear fractures without any depression, intra or extra cranial hematoma.
- **Compound fractures** must be treated. Compound fractures of the vault vary in severity, from severe crushes, with the escape of cerebral substance, to relatively insignificant compound fissured fractures. High-speed motor-cycle accidents produce the worst examples of severe frontal crushes, and many are rapidly fatal. Severe cases which survive exhibit serious disability, such as hemiplegia or mental deterioration from loss of cerebral substance. The incidence of these injuries has been reduced by the wearing of crash helmets. When the velocity of impact is low, large compound depressions can occur with less diffuse cerebral injury, particularly when produced by blows from the side - in which the midline septum of the falx will limit the associated brain displacement. **Treatment** of Compound Fractures. The replacement of large loose skull fragments in the area of a compound fracture depends upon the degree of contamination, the integrity of the dura and the area of the skull involved. If there is any doubt, it is best to remove all fragments of a compound fracture. The resultant bony defect can be closed secondarily making use of plate and screws, wires, SuperGlue or, if available, bone cement can be used and shaped into the defect and screwed or wired in position (caution must be taken to keep the brain protected from the heating reaction as the cement sets; it should be shaped in the actual bony defect and then
removed while the chemical hardening process takes place). All compound skull fractures need prophylactic antibiotics. Staphylococcus aureus should be covered e.g. Augmentin (amoxicillin and clavulanate) irrespective of whether the dura is lacerated or intact.

♦ As a general rule it is best to elevate all depressed fractures, but a decision should depend on the size of the depressed segment, the depth of depression, the area of the skull depressed, and the ability to be certain that the dura has not been torn. The following requires elevation:
  ♦ any fragment which has been depressed more than a centimeter
  ♦ a fragment overlying the speech or motor area
  ♦ most small fragments that appear sharp on x-ray usually should be elevated, since they may tear the dura and cause damage to the brain.
  ♦ special caution should be exercised when the depression overlies a venous sinus e.g. the sagittal sinus. Elevation might tear the sinus or cause a clotted tear to bleed anew.
  ♦ bleeding can be controlled by pressure for several minutes and with Surgicel, Gelfoam or Thrombin soaked Gelfoam if these are available.
  ♦ Dural tears should be repaired with 4-0 or 5-0 Neurolon or Vicryl on a small taper needle.

♦ Closed depressed fractures of the vault are rare. The treatment of a closed depressed fracture depends on the extent and site of the depression. Operation is not indicated if the fracture is small provided that there are no sharp spicules of bone which have penetrated the dura and the fracture does not overlie an important cerebral area. Surgical intervention is required if the fracture lies over the speech or motor areas or if x-rays suggest that spicules may have penetrated the dura. In such cases scarring may cause adhesions between the brain and membranes with the risk of subsequent epilepsy.

Operative Treatment. Trephine, burr holes adjacent to the fracture, and elevate the depressed bone should be all that is needed in most cases.

♦ The combination of a depressed and compound fracture will always require elevation to be certain that contamination has not been driven through the dura into the subarachnoid space or the brain. The scalp is relatively non-elastic and an injury sufficient to fracture and depress the bone is almost certain to lacerate the scalp. Hematomas in the scalp sometimes simulate depressed fractures. Clotted blood in the margin of a hematoma may, on palpation, resemble the edge of a fractured zone, but the edge of the clot can sometimes be indented. Often X-ray is required to distinguish the two conditions.

♦ Clinical Features. An irregular lacerated wound of the scalp is often associated with a boggy sub-galeal swelling produced by blood escaping from the fracture line, which is partly exposed in the depth of the wound. A normal suture line should never be mistaken for a fissured fracture. A suture line is irregular and free from oozing blood. All scalp wounds should be explored adequately in order to exclude and/or discover a fracture. In compound
depressed fractures, the fracture lines extend far laterally beyond the limits of the surface wound; this must be taken into consideration in planning the requisite exploration.

**Operative Treatment.** Operation should be undertaken as soon as possible to avoid infection unless the patient's condition is so precarious that delay is advisable. If delay is advisable, then antibiotics should be given in full doses. The field of operation is infiltrated with 1:100,000 adrenalin in saline or 1% Lidocaine with adrenalin (1:100,000) to diminish scalp bleeding. Small compound fissure fractures may be exposed by extending the primary scalp wound after excision of its edges. Extensive depressions are exposed by forming a large horseshoe scalp flap around the margins of the fracture site. These flaps are the basic neurosurgical flaps based on one of the major scalp arteries.

**Smaller depressions:** A burr hole is formed beside the fracture to permit unlocking of the fractured particles. Bone which has been contaminated but intact is not opened. Foreign material/foreign bodies and damaged brain tissue are removed by irrigation and careful suction, and the dura is then sutured. Clean portions of bone may now be moulded into place and then wound is sutured and antibiotic treatment commenced. Superglue will hold small pieces of bone together. As mentioned below, large bony fragments should be reduced and wired or plated together.

**Extensive depressions:** To merely trephine and elevate the depressed bone is quite inadequate in this case as a proper examination of the brain and membranes will not possible. An osteoplastic flap, that includes the fracture, is raised. The depressed bone is either molded into position or removed with suitable forceps. This osteoplastic flap is best made with a craniotome though most hospitals may not have this. Several burr holes may be made and a Gigli saw passed between holes and a flap raised. The dura is examined, penetrating spicules are removed, and the dura is then opened. Pulped brain is carefully removed by gentle suction at the site of penetration. Adhesions are separated. Hemostasis is secured and the dura is carefully sutured. A pericranial or galeal graft may be used if dura is missing. The bone flap is then replaced and secured with wires, plates or if necessary sutures.

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♦ **Head Wounds due to Missiles.** The outcome depends on the explosive impact of the missile in the cranium. This is the most common cause of fatality due to
the relation of the wound track to the great vessels and the ventricles. Through-and-through tracks, from side to side or front to back may be survivable. Patients with non-fatal injuries can be transported to a suitable hospital. Projection of the swollen brain through the dura at the site of entry or exit forms a hernia cerebri, which seals off the subarachnoid space during transport. A pressure dressing is applied. **Operative treatment**, if possible in your hospital, consists of the excision of the surface wound with suction, cleansing, and removal of foreign material from the track. The dura is closed by suture or grafting at entry and exit points. Antibiotics are always used. Mannitol and steroids may be indicated.

♦ **Penetrating wounds** produced by sticks are always to be regarded very seriously. Although scissors or pokers may enter the roof of the orbit when a child falls, they can be successfully withdrawn. A stick that goes in through the orbital roof, or backwards behind the orbit into the temporal lobe, cannot be withdrawn intact. The portions that are left behind may, from previous contact with the ground, become infected with gas gangrene or tetanus, with probable fatal infection.

♦ **Fractures of the base of the skull** are usually produced by compression of the sphere and extension of fissures radiating from the vault. The complex fracture lines thus produced are accounted for by deflection of the fissure from the buttresses of the petrous bones, the basi-sphenoid, and the sphenoid wings, which can only be crossed respectively at the weak points formed by the cavities of the middle ear, the sphenoidal air sinus, and the sphenoidal fissure. Elsewhere, the fracture lines tend to wander into the foramina for the exit of cranial nerves. The fractures become compound at the middle ear, accessory air sinuses, and the cribriform plates, but the ominous reputation of fractures of the base is derived from the severe brain injury accompanying the fracture rather than from the risk of sepsis, which has been greatly reduced by modern methods of treatment. **Treatment of a fractured base** is that of the associated brain injury. The patient is propped up to lower pressure and diminish the escape of cerebrospinal fluid. Antibiotics are administered. If the discharge persists undiminished for ten days, fascial repair of the dural gap is required. The skull is X-rayed to see if an intracranial aerocele has developed in association with cerebrospinal rhinorrhea. Air collections may be observed either in the substance of the frontal lobe or in the subarachnoid space, occasionally filling the ventricle. Sepsis does not occur at first because the upper respiratory air cells are sterile, but later, septic granulation tissue forms outside the dura. The moment the discharge of cerebrospinal fluid stops, meningitis arises from this source; thus, early repair is necessary.

♦ **Fractures of the skull that traverse one or more of the paranasal sinuses, the mastoid air cells or the middle ear** are compound skull injuries that are not as obvious as a penetrating injury. The presence of cerebrospinal fluid drainage from the nose or ear is an indication that this type of open head injury has occurred. It signifies a rupture of the protective meningeal coverings of the brain and requires observation and prophylactic antibiotics to be certain that infection of the subarachnoid space or brain does not occur. The post-traumatic cerebrospinal fluid fistula of the ear almost always heals
within a few days, but healing of rhinorrhea may be more difficult. It is important in both injuries that the patient remains under medical supervision until such drainage ceases. Usually, if either otorrhea or rhinorrhea continues for more than 10 to 14 days, surgical repair of the dural tear is necessary.

**Antibiotic therapy in Skull Fractures:**
Staphylococcus should be covered with all compound fractures. In anterior base fractures, it is important to also cover Streptococcus. In general, 24-hour cover is adequate. In severely contaminated wounds or gunshot wounds, five days of coverage is needed and guided according to wound cultures if available.

**Convulsive drugs in Skull Fractures:**
There is no standard regimen. But, it is recommended that Epanutin or Epilim (Dilantin) is given if the dura is violated (not for skull base or posterior fossa fractures). The recommendation varies from a loading dose and a week’s treatment up to one month’s treatment. This is to prevent early onset epilepsy but will not prevent late onset epilepsy. In severe brain damage, gunshot wound or severe penetrating wounds, long-term anti-convulsive therapy is recommended. If the patient has had a convolution the standard period of treatment is two years.