Chapter 8

Injuries to the face, nose, and ears

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General points in facial trauma

In trauma care time is of the essence. A useful working approach is needed, in order to rapidly identify those patients that need immediate care, from those that can wait.

Facial ‘emergencies’ following maxillofacial trauma can be regarded as those that are life- and sight-threatening. These may occur following isolated injuries, or they may be associated with significant injuries elsewhere. They may even present following what would usually be regarded as a minor injury (highlighting the need to maintain a high index of suspicion), or after some delay. In the context of emergencies following facial trauma, the objectives are therefore to safeguard life first and vision second.

Assessment therefore needs to be systematic and repeated, with the establishment of clear priorities in the patient’s overall care.

In many respects parallels can be drawn with orthopaedic surgery. Management of facial trauma can arguably be regarded as ‘facial orthopaedics’, as both specialties share common surgical principles in trauma care.

What is an ‘emergency’?

In this text, any clinical problem requiring immediate identification and/or management, constitutes an emergency. Many conditions may be considered ‘urgent’ (i.e. contaminated, mucky wounds, open fractures), but these can generally be left until the patient is fully stabilized, with little or no increase in mortality or morbidity. In the face, emergency care effectively means airway control, control of profuse bleeding, and the management of vision-threatening injuries (VTI). Failure to rapidly recognize and manage these conditions can result in loss of life or sight.

Head and neck injuries resulting in life-threatening conditions

- Facial injuries resulting in airway compromise (e.g. pan-facial fractures with gross mobility or swelling, comminuted #s of the mandible, gun-shot, profuse bleeding, foreign bodies, burns, etc.).
- Anterior neck injuries resulting in airway compromise (e.g. penetrating injuries, circumferential burns, laryngeal injuries).
- Injuries resulting in profuse blood loss (e.g. penetrating neck, pan-facial fractures).
- Intracranial injuries.

ATLS and the maxillofacial region

In over 29 countries, worldwide management of trauma is now based on Advanced Trauma Life Support (ATLS) principles. This is now generally accepted as the ‘gold standard’ of trauma care, and many of its principles are equally important in the management of facial injuries. However, it is important to remember that every case is unique and on occasions, strict adherence to guidelines may result in some difficulties. It is therefore important to be mindful of potential complications when dealing with severe facial injuries and be aware of early warning signs. If in doubt, re-assess the patient from the start.
All clinicians involved in trauma care need to be able to assess and maintain airway problems and control obvious bleeding during the primary survey. Be alert also to possible vision-threatening injuries during the primary survey, i.e. retrobulbar haemorrhage. Although the aim of the primary survey is to identify and treat life-threatening problems, the early identification of a sight-threatening condition may be possible during ‘D’ when the pupils are assessed. This enables early referral to an ‘appropriate’ specialist. When dealing with acute sight-threatening conditions, ‘appropriate’ may refer to an on-site speciality with expertise in peri-orbital trauma care.

Airway, bleeding, and sight-threatening conditions may initially be subtle and may not become apparent until the secondary survey is under way. This reminds us of the two well-known principles in trauma care:

- **the need for a high index of suspicion**;
- **the need for frequent re-evaluation**.

**Preliminary assessment of multiple injured patients—the primary survey**

The sequence in which the primary survey should proceed is related to those conditions that would lead to loss of life quickest:

- **Airway** (whilst protecting the cervical spine to prevent any neurological damage).
- **Breathing** (all trauma patients should be given 100% oxygen to breathe on arrival).
- **Circulation** with control of haemorrhage.
- **Disability** (brain function).
- **Exposure**—this must be complete so a full examination, front and back, can be undertaken. However, the patient needs to be covered to prevent hypothermia.

Any problem discovered is corrected at the time of identification. This is preferably done by a team approach where different team members carry out the above simultaneously. In such cases, a ‘team leader’ ensures that everything is done. If team numbers are not sufficient for this, the above sequence is followed. It is also vital to enlist the help of any speciality not on the team early, if a problem or potential problem is identified that requires their input, e.g. neurosurgery.
Maxillofacial (trauma) emergencies

Airway
- Obstruction can be caused by dentures/teeth or severely displaced fractures of the mandible or mid-face. The commonest cause is bleeding and/or saliva, notably when the patient is intoxicated or supine.
- Mid-face fractures may displace downwards and backwards along the skull base, impinging on the posterior pharyngeal wall, resulting in obstruction. Bilateral anterior (‘bucket handle’) or comminuted mandibular fractures can similarly displace backwards allowing the base of the tongue to fall back. Both of these are much more likely when patients are supine and there is alteration in the conscious level. Both can be dealt with by pulling the fractured part forward to relieve the obstruction. This provides only temporary relief and a definitive airway will probably be required.
- Saliva and blood should be cleared by suction. If the bleeding is ongoing from an identifiable source, which can be stopped, it should be. However, it is usually generalized from multiple sites. Displaced fractures should be manually reduced as this often helps slow the bleeding. Nasal packs may be necessary (remember the possibility of skull base #). If bleeding continues the airway should be protected with a definitive airway.
- Direct trauma to the airway will probably require a definitive airway to be placed.

Bleeding
- Bleeding from maxillofacial injury is common but not usually life-threatening. **If the patient is in shock, look for another cause.** Actively consider facial bleeding, as supine patients will be swallowing blood, which will go unnoticed.
- If obvious and significant, bleeding is controlled in the primary survey by **pressure**. Bleeding from lacerations can usually be controlled by pressure applied either with a swab (care with scalps if risk of skull fracture) or by placement of **sutures**. These are used to apply pressure and not intended as definitive closure.
- Mid-face bleeding can be troublesome as the bleeding is from multiple sites from comminuted bones and torn mucosa. Pressure can be applied to the nose with anterior and posterior nasal packs. Bleeding from **displaced/mobile mid-face fractures should be reduced**. Gentle pressure can be applied antero-superiorly on the maxilla and maintained by placing mouth props bilaterally against an intact mandible. Surprisingly, this is not as painful as one might think. In selected cases, use of external fixators from skull to maxilla, may be necessary but this requires transfer to an operating theatre and considerably more time.
Bleeding from a ‘hole’ (e.g. following a gun-shot) can sometimes be stemmed by placing a Foley catheter in the hole and inflating it. Obviously be careful and think what may be in the depths of the hole!

If local pressure is not sufficient to stop haemorrhage from either soft or hard tissue injury, the use of angiography and embolization or ligation of external carotids should be considered. This is rare.

Vision-threatening injuries
(See also The Eye.)

Following trauma, vision can be threatened anywhere along the visual pathway from globe to cortex. The main (potentially treatable) causes to consider are:

- direct globe injury;
- retrobulbar haemorrhage;
- optic nerve compression;
- loss of eyelids;
- direct injury to the globe requires urgent ophthalmic referral.

Retrobulbar haemorrhage

Bleeding behind the globe is a form of compartment syndrome. This is a surgical emergency. It can lead to an increase in pressure that results eventually in irreversible ischaemia of the retina and optic nerve. Key symptoms are:

- severe pain;
- progressive loss of vision;
- the eye becomes proptosed with ophthalmoplegia;
- development of a fixed dilated pupil as the vision deteriorates.

Treatment requires immediate relief of pressure. In the emergency department the following should be given intravenously:

- acetazolamide;
- mannitol;
- steroids;

during which arrangements are made for surgery. Under LA, a lateral canthotomy may be possible, but these measures really only buy time while preparation for surgery is made. Definitive treatment involves drainage of the haematoma. Decompression should lead to an improvement in visual acuity if undertaken early enough.

Traumatic optic neuropathy

Traumatic optic neuropathy occurs when there is disruption around the optic canal resulting in either compression of the optic nerve, shearing forces to the nerve as it passes through the canal, or haematoma formation within the nerve itself. Untreated it can render the patient blind; the diagnosis needs to be made early to allow the best chance of visual recovery. The signs that suggest an optic nerve injury include poorly reactive pupil, afferent papillary defect, and decreased colour vision, decreased visual acuity with relatively normal ocular examination. This is an ophthalmic emergency and should be referred accordingly.
Treatment of optic nerve compression is controversial and again may be either medical or surgical. The options include observation, IV corticosteroids, and optic nerve decompression. The latter option is carried out via either a craniotomy approach or lateral facial approach. One steroid regime is:

- methylprednisolone 30mg/kg STAT;
- followed by methylprednisolone 15mg/kg every 6 h.

Of course others exist—always check local policy.

**Time is of the essence, best results are obtained if steroids are given within 8 h of the injury.**
Facial trauma—general considerations

Minor injuries to the maxillofacial region are very common in the UK, around 80% occur in children. Major facial disruption is less frequently seen and motor vehicle crashes (MVC) now accounts for about 5% of facial trauma. This is partly due to seat belt and drink-driving legislation. However, whereas patients would have previously died at the scene as a result of their head injuries, many are now surviving having sustained major facial injuries. Sporting injuries and assaults account for most of the remainder.

In assessing the multiple-injured patient, the first step is to determine whether any life-threatening injuries exist and to deal with them first. The advanced trauma life-support system—ATLS—is one approach to assessment and initial management of the multiply injured patient. It recognizes that identification of life-threatening injuries needs to be prioritized (primary survey) and treated at the time of identification (resuscitation). Most maxillofacial injuries can wait treatment, and in the multiply injured patient, the first step is keeping the patient alive.

Once the primary survey and resuscitation have been carried out, attention can then be focused on the maxillofacial region.

Facial skeleton

The arrangement of the facial bones may be considered as comprising three areas:

- upper-third (frontal bone);
- middle-third, between the supra-orbital ridges and the upper teeth (2 maxillae, 2 zygomas, 2 lacrimal bones, 2 nasal bones, 1 vomer, 1 ethmoid);
- lower-third (mandible).

Some of these bones, such as the ethmoid and those comprising the orbital roof, are extremely delicate and so thin that on a dry skull light can easily pass through. The remainder vary in thickness but often remain quite delicate (nasal, zygoma). The mandible is the strongest of the facial bones. It is a U-shaped bone comprised of an outer dense cortical layer and delicate trabecular bone inside. The face is not solid but contains several 'cavities', such as the sinuses, orbits, oral and nasal cavities. Around these the bones form a series of vertical struts known as 'buttresses' As a result, these bones are very good at resisting vertically directed forces (e.g. during chewing) but are weak when it comes to resisting horizontal forces (i.e. during most injuries).
Fig. 8.2  Transilluminated skull demonstrating the thinness of many of its bones.

Fig. 8.3  Diagrammatic representation of the ‘butresses’ of the face.
Useful clinical signs and their significance

The usefulness of clinical signs can vary from those that only suggest an underlying pathology (*) to those that are almost pathognomonic (**). Their interpretation must be taken in conjunction with the history and likelihood of the condition being present.

General

Facial burns***
When associated with soot in the nose and mouth, singeing of the nasal vibrissae, and sooty sputum, this represents a potential airway problem. There is also the risk of inhalation of carbon monoxide and other toxins.

Facial nerve palsy**
Following head injury—fractured base of skull.

Horse voice/bovine cough**
Following a direct blow to the anterior neck, may indicate disruption of the larynx. A bovine cough is where the vocal cords do not meet in the mid-line prior to the explosive expulsion of air. As a result the cough is relatively weak and ineffectual.

Wry neck*
Following trauma is due to muscle spasm. May occasionally be associated with dislocation of the posterior facet joints.

The face

Intercanthal distance**
Separation of the eyes. If greater than 30–32 mm (female) or 32–34 mm (male) the patient may have detached canthi secondary to an underlying naso-ethmoidal fracture. As well as an increased intercanthal distance, the medial canthus loses its pointed shape becoming rounded. This can occur uni- or bilaterally. If unilateral the distance from mid-line to canthus will be greater on one side. The interpupillary distance should be within normal limits. There may also be depression at the root of the nose.

Anterior open bite and elongated face**
If not pre existing, is suggestive of posterior and inferior displacement of the maxilla following a Le Fort fracture. This results in posterior gapping of the molar teeth. If the maxilla is stable, then the teeth should be percussed. If the note is dull (‘cracked cup’ sound), the maxilla is likely to be fractured and impacted—hence the stability. If the percussion note is normal, the anterior open bite may be due to bilateral fractured condyles.

Septal haematoma*
Seen as a blue/reddened swelling on the septum on direct examination. Needs drainage, as failure to do so can result in septal perforation, abscesses, and intra-cranial infection.

Numbness of the cheek*
Suggests a cheek or blow-out fracture.
Numbness of the lower lip
Suggests a mandibular fracture.

Anosmia
Loss of smell due to tearing of olfactory nerves secondary to an underlying anterior cranial fossa floor fracture. Not reliably detectable in acute phase of injury.

Fig. 8.4 Normal intercanthal distance.

Fig. 8.5 Increased intercanthal distance.
Bow-string test
Assess for medial canthal detachment in nasothmoid injuries—the lateral canthus is pulled laterally, if there is detachment medially this will also move away.

Within the mouth
Dysphagia
Many causes. When related to submandibular, pharyngeal, or other posterior oral swellings, it is a significant finding often requiring admission. Is often painful (odynophagia).

Inability to protrude the tongue
When related to submandibular, sublingual, or other oral swellings, it is a significant finding often requiring admission.

Trismus
Limitation of mouth opening due to muscle spasm (usually masseter or medial pterygoid). May be seen following a direct blow. When related to submandibular, pharyngeal, or other posterior oral swellings, it is a significant finding often requiring admission.

Guerins sign
Palatal bruising of the hard palate—underlying fracture involving palatine foramen.

Upper buccal sulcus bruising
Fractured zygoma or unilateral Le Fort I or II.

Sublingual haematoma
Bruising/bleeding under the tongue—fractured mandible (body/symphysis/parasympysis).
**Peri-odontal bleeding***
May indicate an associated fracture of the tooth or bone.

**Change in the patients bite***
In either the mandible or maxilla may indicate a fracture.

‘Cracked cup’ note***
When percussing the maxillary teeth, suggests a fracture.

**Malocclusion***
If the occlusion has changed it is likely that there is an underlying fracture of maxilla, mandible, or alveolar bone. Subluxation of teeth may also produce a malocclusion, although usually much more minor. If non-of the above are present a malocclusion may be a result of a TMJ effusion/haemarthrosis.

**The eyes**

**Visual acuity**
This is the single most sensitive indicator of visual impairment. It must be recorded in all patients with mid-facial trauma. In patients who wear spectacles to correct short sight, the recording must be done with the spectacles on or through a pinhole. Acuity is expressed as a distance in meters from which a chart being read is usually 6/X where X is the line on the chart the patient can read, usually 6. If less than 6, e.g. 12 or 60, this means the patient can read at 6m from the chart that which a person with normal vision could read at 12 or 60m from the chart. A visual acuity of 6/18 or worse should be referred for an ophthalmological opinion. If the patient cannot read the chart at all at 6m, the distance at which they can read the top line is recorded as Y/60. If they are not able to do this, whether they can count fingers, see them moving, or perceive light, are recorded as the visual acuity, in that order. If the patient is unconscious, pupillary responses to light must be checked. All patients must have a documented visual acuity. Any decrease in visual acuity requires an ophthalmic opinion.

**Pupillary responses**
Check direct response to light and consensual response. Responses should be equal on both sides and to direct and consensual stimulation. A pupil that reacts poorly to direct stimulation but briskly to consensual has an afferent pupillary defect.

**Swinging flashlight test***
Detects subtle defects to the optic nerve. Light is shone in one eye, then swung to the other, and back and forth. If the right eye has a problem, on shining the light in the right eye, both pupils will constrict, as the light moves to the left they will constrict further. As the light is brought back to the right, the pupils will not respond or dilate a little.

**Peri-orbital haematoma***
When well-defined this represents a fracture involving the orbit. Usually this means a fractured zygoma but can also include a blow-out fracture, fractured base of skull (anterior cranial fossa), unilateral naso-ethmoidal, or nasal bones.
Fig. 8.7 RAPD. When the eye is opened the pupil does not react. When the contralateral eye is opened it does—this patient is blind.

Fig. 8.8 RAPD. When the eye is opened the pupil does not react. When the contralateral eye is opened it does—this patient is blind.

**Racoon (panda) eyes**
Bilateral well-defined ‘black eyes’—fractured base of skull (anterior cranial fossa), Le Fort III or naso-ethmoid fracture.

**Lateral subconjunctival haemorrhage**.
This indicates a fracture involving the orbit usually the cheek or naso-ethmoid region. There is no posterior limit.
Chemosis*
Swelling of conjunctiva often seen in significant trauma, looks a bit like frog’s spawn. If no tear of conjunctiva present, it will resolve. If tear present, then you need to rule out globe injury.

Hyphema**
Blood in anterior chamber seen as fluid level when patient is standing. Needs ophthalmic assessment probably require admission and observation.

Iridodialysis*
The iris is detached from its root leading to a distorted pupil shape.

Dilated pupil (traumatic mydriasis)*
Spasm of the dilator pupillae. Can be seen following a direct blow to the eye. Not to be confused with a third nerve palsy.
Diplopia*
Double vision may be neurogenic, myogenic, or bony in origin. It may be temporary or permanent and should be reviewed. Depending on possible cause, refer to ophthalmics or maxillofacial.

Unilateral restricted upward gaze**
Often a sign of a ‘blow-out’ fracture, occasionally due to injury to ocular muscle or its nerve. Painful diplopia from a blow-out may require urgent release.

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**Fig. 8.11 Chemosis.**

**Fig. 8.12 Unilateral restricted upward gaze.**
Retraction sign***
When looking from the side of the patient, as they look up, the globe is seen to move posteriorly. This is a good sign for a blow-out fracture. Entrapment of the fat and restriction of the inferior rectus muscle results in a shift of the axis of rotation of the globe from its centre to the point of entrapment. Thus the pull of the superior rectus results in a backward rotation of the globe.

Hypoglobus*
Inferior displacement of the globe seen in cheek complex fractures, where the bone and Lockwood’s ligament drop down. May also be seen in large blow-out fractures.

Enophthalmos*
Posterior displacement of the globe due to increased orbital volume. Seen in blow-out fractures of the orbit and cheek fractures. Globe appears ‘sunken in’ with a deep supra tarsal groove.

Third nerve palsy***
Dilated pupil, the eye looks down and out, and ptosis. In severe head injuries this represents third nerve compression from an expanding intracranial lesion. The patient has a reduced GCS.

Aqueous leakage***
A penetrating injury of the cornea.

Superior orbital fissure (SOF) syndrome**
Ophthalmoplegia, fixed dilated pupil, and ipsilateral forehead numbness—fracture extending into the SOF, or possible carotid aneurism. This is usually part of a significant injury.

Orbital apex syndrome**
As in the SOF but here the patient has reduced visual acuity.

Peri-orbital oedema*
When infective in origin represents significant spread of infection. If the eye is closing the patient may probably need admission.

The ears
Heamotympanum**
Blood visualized behind the eardrum. Indicative of a fracture of the middle cranial fossa.
Battles sign***
Bruising around the mastoid region—fractured base of skull (middle cranial fossa).

CSF rhinorrhea/otorrhea***
‘Tramlining’—fractured base of skull. Blood mixes with CSF and leaks out. Along the edges the blood clots while centrally the CSF leak washes it away to form two parallel lines (like tramlines).

Bleeding from the ear**
Fractured base of skull or mandibular condyle. If the tympanic membrane is intact the bleeding is local to the EAM, usually the anterior wall, often secondary to an underlying condylar fracture. If the tympanic membrane is perforated the blood may be from a middle cranial fossa fracture.
Mandibular fractures

Applied anatomy
The mandible forms the lower third of the face and facial skeleton. It is the only mobile bone of the face (excluding the ossicles) and has numerous muscle insertions. It plays an important role in:
- speech;
- mastication (chewing);
- deglutition (swallowing);
- maintaining the airway.

Patients with mandibular injuries, therefore, have difficulty in talking, and are unable to eat and drink easily. In severe injuries the airway may be at risk.

Osteology
Morphologically the mandible is a U-shaped ‘long bone’ (e.g. femur, radius, etc.). It can be divided anatomically into:
- symphysis
- parasymphysis
- body
- angle
- ramus.

The almost vertical ramus carries two processes, the condyle, which articulates with the glenoid fossa of the temporal bone to form the temporo-mandibular joint, and the coronoid process, which receives the insertion of temporalis. The condyle is supported on a slender condylar neck, a frequent site for fracture.

On the medial or inner aspect of the ramus the inferior alveolar neurovascular bundle enters the bone via the mandibular foramen and runs through a bony canal within the mandible providing nutrition and sensory innervation to the lower teeth. An important branch of this bundle, the mental nerve, leaves the bone via the mental foramen in the premolar region and provides sensation to the lower lip and anterior gums.

Muscle attachments
The muscles of mastication (temporalis, masseter, medial and lateral pterygoid), together with the suprahyoid muscles (digastric, geniohyoid, and mylohyoid) are the principle movers of the mandible. In addition the mandible receives the insertion of genioglossus, which forms the main bulk

Fig. 8.15 (a) and (b) Outer and inner view of the mandible showing muscle attachments.
of the tongue. Note that genioglossus and geniohyoid are attached to the mid-line genial tubercles. A fracture in this region may, therefore, lead to loss of anterior support for the tongue, leading to posterior displacement and airway compromise.

**Dentition**

The full complement of adult teeth in a mandible is 16 comprising of:
- 4 incisor teeth;
- 2 canines;
- 4 premolars;
- 6 molars.

The canine teeth have long roots and the third molar (wisdom) teeth are often partially erupted, these factors tend to weaken the bone locally and account for the frequency of fractures in these regions.

**Age-related changes**

In the child, the dentition will be at various stages of development and developing tooth germs are present within the bone. While these lead to a structural weakening of the bone, this is compensated for by increased elasticity and pliability of the young mandible, compared with mature bone. As a result, relatively higher forces are required to fracture the bone in children. Furthermore, the facial skeleton is less prominent in children and hence mandibular fractures are somewhat rare in this age group. In the edentulous elderly jaw, loss of the ‘alveolar bone’, which would normally support the teeth, leads to a gradual reduction in bone height. This feature, together with age-related conditions such as osteoporosis, weakens its structure and, as a result, the bone is more vulnerable to fracture.

**Common fracture patterns**

The periosteum is an important structure in determining the stability of a mandibular fracture. In young patients it is generally a strong unyielding membrane. Gross displacement of fragments cannot occur if it remains intact and attached to the bone. However, once the periosteum has been breeched (by injury or surgical exposure), displacement of the bones can occur under the influence of the attached muscles. Common fracture patterns include the following.

**Angle fractures**

Fractures of the angle are affected by the medial pterygoid and masseteric muscles. Fractures in this region have been classified as **vertically and horizontally favourable or unfavourable**. The medial pterygoid muscle may pull the posterior fragment lingually or together with the masseter in an upward direction. This is only important when the periosteum has been ruptured or stripped from the bone allowing displacement to occur.

**Fractures at the symphysis and parasymphysis**

The mylohyoid muscle has been described as the ‘diaphragm’ of the mouth, passing between the hyoid bone and the inner aspect of the mandible. With mid-line fractures of the symphysis, the mylohyoid and geniohyoid muscles can act as a stabilizing force. However, oblique fractures will tend to overlap due to the pull of these muscles. With bilateral parasymphyseal fractures (which result from considerable force), the periosteum is often
torn and the fragments can displace posteriorly under the influence of the genioglossus—so called ‘bucket handle’ fractures.

**Condylar fractures**
The hinge joint of the mandible is a common site of fracture and often occurs in association with fractures elsewhere in the jaw. The classical history is a blow or fall onto the point of the chin, where one or both condyles are fractured, often associated with a symphyseal or parasymphysal fracture (so called ‘gaardsmans’ fracture). **Beware the laceration over the chin following a fall—check the condyles.** On mouth opening, the jaw deviates towards the site of injury.

Condylar fractures in adults tend to occur outside the joint, although transmitted forces can still damage the joint and cause long-term problems. Effusion or bleeding into the joint space can occur in the absence of a fracture, the space is distended and the patient complains of an abnormal bite. Intra-capsular fractures in children are more common and can result in growth disturbances in the condyle later on.

**Injuries to related structures**
- The **inferior alveolar nerve** is often damaged in fractures of the body and angle causing paraesthesia of the lower lip on the same side.
- Medial displacement of the condyle can compress the trigeminal nerve leading to loss of **facial sensation**.
- The **facial nerve** may be damaged by a direct blow over the ramus and needs to be assessed especially if a laceration is present. Rarely, the mandibular condyle may impact upon and fracture the temporal bone through which the facial nerve runs. Facial nerve injury leads to variable paralysis or weakness of the facial muscles.
- Injury to major **blood vessels** is unusual, although the facial artery and vein may be damaged where they cross the lower border of the mandible.
- **Temperomandibular joint.** Condylar fractures in adults tend to occur outside the joint, although transmitted forces can still damage the joint and cause long-term problems. **Effusion** into the joint space can occur in the absence of a fracture, the space is distended and the patient complains of an abnormal bite. Intra-capsular fractures in children are more common and can result in growth disturbances in the condyle later on.

**Assessment**

**Secondary survey**
**History**
Most patients will give a history of blunt injury to the face, the most common mechanism being interpersonal violence. Sports, falls, and accidents are other common causes. Common symptoms include:
- pain;
- swelling;
- altered bite;
- numbness of the lower lip;
- difficulty in opening and closing of the jaw;
- pain on swallowing with drooling.
The hallmark of a mandible fracture is a change in the bite (occlusion); however, normal occlusion does not rule out a mandible fracture.

Other physical findings include:
- loosened teeth;
- facial deformity;
- mobility of fractured segment;
- bleeding (= tear) in gingival tissue;
- sublingual haematoma;
- trismus;
- numbness of the lower lip (ID nerve).

**Examination**
This must be undertaken in good light, having cleansed the face of blood and debris. Suction must be immediately available. Look for:
- facial swelling;
- asymmetry;
- bruising;
- palpate the lower border for any step deformity;
- feel the condyles and assess their movements—this is done best by placing a gloved finger in each auditory meatus;
- document the dentition, any occlusal derangement, or steps in the occlusal plane;
- gently manipulate across the suspected fracture site feeling for abnormal movement or crepitus;
- look for gingival lacerations; and
- mucosal bruising, in particular, for a sublingual haematoma.

**Remember**
- Mental parasthesia is both an important diagnostic sign and an important medico-legal observation prior to treatment.

**Fig. 8.16** A sublingual haematoma in a toothless mandible.
Missing teeth must be accounted for. If unable, get a chest and soft tissue view of the neck. Similarly, if associated with a lip laceration, a soft tissue radiograph of the lips is essential.

A sublingual haematoma is pathognomonic of a mandibular fracture and may also compromise the airway.

Bleeding from the external auditory meatus may be a result of tearing of its anterior wall by a condylar fracture. However, it may also be a sign of a fractured skull base—be careful in your assessment.

Radiographs

The principle of radiology for any fracture is to take two views at 90 degrees to each other. This minimizes the risk of missing a fracture that may be minimally displaced. For the mandible, this is most simply achieved by ordering:

- ortho-pantomagram (OPG, OPT, DPT), or lateral obliques, together with a PA view of the mandible.

It is essential that both views include the entire bone from lower border to the condylar processes. For anterior fractures, if facilities exist, a true lower occlusal view is also very helpful. These will often provide sufficient information, but supplementary views include:

- reverse townes for the condylar neck;
- CT scans are useful for further evaluation of condylar fracture/dislocations but are not necessary in A&E.

Fig. 8.17 A displaced fracture resulting in a gap. This was misinterpreted as a missing tooth—count the teeth and assess for fracture mobility.
The mandible is usually fractured in two places—if you see one fracture, look for another (cf. pelvic fractures). Fractures sites include:
- condyle (36 %);
- body (21 %);
- angle (20 %);
Fig. 8.20 Lateral oblique.

Fig. 8.21 Lower occlusal view anterior mandible.
MANDIBULAR FRACTURES

- parasymphyseal (14%);
- ramus (3%);
- alveolar (3%);
- coronoid (2%);
- mid-line symphysis (1%).

**Treatment**

**First-aid measures**

A mandibular fracture is often painful and if it occurs through the tooth socket, it is by definition a compound or open fracture. Pain relief is a priority and may be simply achieved by infiltration of local anaesthesia or, if possible, by an inferior dental nerve block. It is important to minimize movement across the fracture site, not only for pain relief (as for all long-bone fractures) but also to reduce bleeding and contamination from oral bacteria. A simple method is to apply a soft neck collar but this should only be done after the cervical spine has been formally cleared. A common procedure is to apply a bridal wire across the fracture site. This is a loop of stainless steel wire encircling the teeth either side of the fracture. Clearly this is only relevant if the fracture is in a tooth-bearing segment and care must be taken not to avulse the teeth by applying too much force. Any loose dento-alveolar fractures should be splinted.

**Treatment principles**

In general, fracture treatment has traditionally been classified as conservative or operative. Today the preferred terminology is closed or open to avoid ambiguity.

**Indications for closed treatment** (soft diet, antibiotics, review)

- No or minimal displacement of stable fracture.
- No or minimal mobility across fracture line.
- No impairment of function.
- Ability to obtain pre-trauma occlusion with or without analgesia and instructions.
- Absence of evidence of infection.
- Absence of haemorrhage requiring immobilization to control.
- Good patient co-operation and follow-up.

**Indications for open treatment**

When conservative treatment is inappropriate or has failed.

**Closed treatment**

In its simplest form, closed treatment would be:

- analgesia;
- antibiotics in open fractures (1 week);
- soft diet until a firm callus forms (usually around 4–6 weeks).

This is often suitable for a firm, minimally or un-displaced fracture with a normal bite.

**Intermaxillary fixation (IMF)**

For painful or more displaced fractures this may be applied. Here the upper and lower teeth are fixed together using wires or elastics. This uses the upper teeth as both a splint and a mandibular positioning device, ensuring a normal bite and immobilization of the fracture for healing.
However, reduction is not anatomical. Various devices are available to achieve intermaxillary fixation including eyelet wires, Leonard buttons, arch bars, and splints. These are ligated or cemented to the teeth thereby enabling the two jaws to be fixed to each other. If the patient has no teeth (edentulous patients), modified dentures (Gunning splints) can be ligated to the jaws to achieve a similar goal.

A further variation is to use elastic bands instead of wires between the jaws to allow some degree of movement.

Closed treatment is known to work and has remained a main method of treatment. However, it is not risk free. Disadvantages include:
- airway risk (asthmatics, COAD, epileptics, reduced conscious level);
- loss of weight;
- patients need to tolerate it (beware alcoholics and mentally ill);
- injury to tooth structure, restorations, and the periodontal tissues.

Relative contra-indications to IMF are:
- inadequate post-operative monitoring of airway during recovery from general anaesthesia;
- need for prolonged oral/nasal airway post-operatively;
- possibility of convulsions;
- head injury (GCS 8 or less).

Open treatment
Closed treatment does not produce anatomical reduction of the fracture (hence the term closed treatment as opposed to closed reduction). With
open treatment, surgical exposure of the fracture site and (hopefully) anatomical reduction is carried out. Exposure is most commonly carried out through the mouth, but occasionally may be done through a skin incision or an existing laceration. Once exposed, the fracture is accurately reduced and fixed. Common fixation techniques use titanium ‘mini’ plates or screws. This is now the preferred approach to most mandibular fractures resulting in faster recovery and rehabilitation. However, there is potentially more morbidity, especially injury to the inferior alveolar nerve and tooth roots. The patient still requires a soft diet for the same period of time.

**Treatment of condylar fractures**

Particular concerns with these fractures are long-term joint dysfunction, ankylosis, and, in children, abnormal growth of mandible.

**Undisplaced condylar fractures**, where the occlusion is normal, are generally managed with rest, soft diet, and simple analgesics. These are not compound fractures and so antibiotics are not necessary. Regular review is essential in the early stages of healing to ensure that the fracture does not ‘slip’ and derange the bite. Fractures that are **displaced with an associated malocclusion**, however, need to be reduced. This is often carried out using rigid or elastic IMF, the latter encouraging dynamic realignment of the fragments. IMF is applied for 7–14 days to avoid ankylosis. Following IMF early mobilization and physiotherapy are required.

Alternatively, and where IMF is contra-indicated, fractures may be openly **reduced and fixed** using mini plates, interosseous wires, screws. These are approached via a skin incision just behind the angle of the jaw below the ear. There is a small risk of facial nerve injury, although with careful surgical technique, this can be kept to a minimum. **Bilateral**
condylar fractures may be managed similarly. However, these fractures must be kept under close review until healed. ‘Telescoping’ of the condyles with loss of jaw height posteriorly can lead to the occlusion being propped open at the front—an anterior open bite. This would require surgical correction at a later date.

Rarely, the condylar head may dislocate out of the articular fossa. This usually requires open reduction

Special considerations

Tooth in the fracture site

For angle, body, parasymphyseal and symphyseal fractures, usually a tooth is present in the fracture site. This is especially common in angle fractures, where an unerupted third molar may weaken the bone locally. While it may be tempting to remove the tooth (especially in open treatment), this may make reduction of the fracture more difficult and unstable. For anterior fractures, the loss of a tooth has obvious aesthetic consequences. Consequently, unless the tooth itself is fractured, grossly decayed, has associated periapical infection, or is interfering with fracture reduction, it may be preferable to leave it in situ. Opinions may differ.

Analgesia/antibiotics/tetanus

Mandibular fractures are painful. The use of local anaesthesia (LA) and bridgework has been described in the first-aid section. LA can also be repeated with a long-acting local anaesthetic, such as bupivicaine. Analgesia requirements often dramatically reduce following fracture reduction and fixation; useful agents include NSAIDS or paracetamol-based compounds.

Antibiotic therapy is generally required for compound (open) fractures and should give appropriate cover against anaerobic organisms and streptococci. Many policies exist and may include metronidazole with benzyl penicillin or a compound agent such as co-amoxiclav. Antibiotic treatment may be continued for 5 days.

Tetanus status should be checked and the patient given tetanus toxoid, if appropriate.

Fractures in children

Similar principles apply and early mobilization is desirable, as there is an increased risk of ankylosis. Consideration must be given to the unerupted teeth, if plating is necessary. Long-term follow-up during growth is recommended, as some fractures (especially condylar) are associated with disturbances of growth.

Post-operative care

Closed treatment without intermaxillary fixation is usually treated on an out-patient basis with regular review to ensure the occlusion remains normal. Post-operative radiographs are necessary to confirm a correct position of the bone fragments. Hospital dieticians are a valuable resource and will give nutritional advice and provide supplements.

Closed treatment with intermaxillary wire fixation requires very close observation in the immediate post-operative period. Prior to discharge, the patient must be provided with wire cutters, which must be with him/her 24 h a day, and they must be instructed on their use. More recently there has been a swing in favour of using elastics rather than wire.
This enables quicker release and a degree of flexibility in the immobilization enabling ‘micro-movement’.

Following open treatment, the occlusion should be assessed the following day. It is not uncommon for this to be slightly deranged due to muscle spasm or a joint effusion; this should settle with appropriate analgesia or light elastic IMF. The position of the fragments should be confirmed with post-operative radiographs (OPT and PA mandible) and arrangements made to review the patient weekly. A soft diet is needed for the next 4–6 weeks.
Dislocated condyle

The temporomandibular joint (TMJ) is the joint between the mandible and the skull base, located in the pre-auricular region. It is a synovial ‘ball and socket’ type joint, the ‘ball’ portion being the mandibular condyle, and the ‘socket’ the glenoid fossa of the temporal bone. A fibrous sleeve encapsulates the joint. Between the condyle and fossa there is a fibro-cartilaginous disc, or ‘meniscus’, which is attached peripherally to the deep surface of the joint capsule. The four muscles of mastication (the masseter, the temporalis, and the medial and lateral pterygoids) act directly across the TMJ to effect mandibular movements. Of note, the insertion of the lateral pterygoid is into both the condylar neck, and through the fibrous capsule, into the anterior aspect of the articular disc.

Movement across the joint is complex. On opening the mouth from the closed position, initially a hinge-type movement occurs for the first 1 cm. After that a forward translation is added in which the condyle moves forward and downwards along the slope of the fossa. Very little movement occurs side-to-side. Appreciation of TMJ anatomy and function helps understand the clinical picture associated with fractures of the condyle.

Displacement of the mandibular condyle from the glenoid fossa is termed dislocation of the condyle. This may be unilateral or bilateral, solitary or recurrent. Following significant trauma, it can be associated with a fracture of the condylar process (fracture dislocation).

Dislocation is usually in an anterior direction so that the condyle comes to lie in front of the articular eminence. Following major trauma it may occur in other directions, including intra-cranially.

Patients present with a sudden inability to close the mouth, which is painful and held wide open. This is in distinction to ‘open lock’, where the mouth is held open only a few millimeters due to meniscal entrapment.

Reduction of a dislocation can often be accomplished with simple analgesia alone or in combination with local anaesthetic. LA can be injected into lateral pterygoid and masseter muscles and, if necessary, into the periarticular tissues (possible temporary VII palsy). This weakens those muscles that keep the condyle dislocated and reduces capsular pain, which stimulates spasm. Oral or intravenous sedation may also be necessary. Entonox has the advantage of being rapidly excreted afterwards, so the patient can go home. General anaesthesia may be required if the previous methods fail. Manual reduction of an anteriorly displaced condyle requires downward pressure on the retromolar (wisdom tooth) region and simultaneous upward pressure on the chin. This can be accomplished either by standing in front or behind the patient. (Protect your thumbs from being bitten if reduction is successful!) In long-standing cases, prolonged traction on the mandibular ramus under general anaesthesia or open reduction may be necessary.

Management of fracture-dislocation is either closed (intermaxillary fixation) or open (surgical repositioning of the displaced condyle with internal fixation).

Recurrent dislocation may also be treated conservatively with a barrel bandage, injection of sclerosant solutions into the capsule (to produce tightening), or by a variety of surgical procedures (capsular plication, eminectomy, or articular augmentation).
Fig. 8.24 Dislocated condyle.

Fig. 8.25 Dislocated condyle—the mouth is wide open and the condyle can easily be seen displaced.
Alveolar fractures

This term relates to fractures of the tooth-bearing part of the mandible and maxilla. Where there is minimal displacement and minimal mobility, and the patient can obtain a pre-injury occlusion, these tend to be managed conservatively, as for mandibular fractures.

Indications for treatment
- Disruption of the bite.
- Physical evidence of fracture.
- Evidence of fracture from imaging—plain radiographs.

Closed, non-surgical treatment is required when there is:
- no or minimal displacement of fracture;
- no or minimal mobility of fracture line;
- ability to bite normally;
- absence of infection;
- no or minimal soft tissue loss from the bone segment;
- absence of bleeding requiring immobilization;
- good patient co-operation and follow-up.

Closed treatment
- Soft diet, analgesia, antibiotics, and close monitoring.
- Indirect fixation using arch bars or splints.
- Intermaxillary fixation may be required for large segments.

Operative treatment
- Removal of bone segment—indicated where segment is severely comminuted or significant soft tissue loss (loss of blood supply to the fragment).
- Open reduction and fixation with wires or plates. However this may compromise the blood supply.

If the teeth on the fragment are damaged, these need appropriate attention. If they need to be removed, this is sometimes delayed until the alveolar fracture has healed to maximize the blood supply to the segment.
Dental trauma

(See also the Mouth, lips, and teeth.)

This includes injuries to the teeth or their supporting structures. Despite continuing improvements in oral health, one in four children in Britain suffer some form of injury to their front teeth. Injuries range from chips off the enamel to crown/root fractures involving the tooth pulp.

The periodontal ligament and surrounding 'gum' support the teeth in their sockets and cushion the forces of mastication. These structures may be concussed (periodontal injury without loosening). Alternatively, intact teeth may be intruded (driven into the bone), displaced, or avulsed (pulled out the socket). Fractures of the teeth and/or supporting alveolar bone may also occur.

Treatment

This is required when there is:
- pain (pulp exposure);
- sensitivity to hot and cold (dentine exposure);
- recent avulsion;
- mobility (fracture or displacement);
- alveolar bone fracture;
- retention of part of the tooth;
- cosmetic deformity.

Principles of treatment

These include:
- pain relief;
- control of bleeding;
- dressing of exposed dentine or pulp;
- repositioning/replantation of the tooth—this is then splinted for a variable time depending on the nature of the injury;
- reduction and fixation of alveolar bone;
- cosmetic repair.

The avulsed tooth

Immediate action is required when one or more adult teeth are knocked out of the mouth. If these teeth are put back into the socket, there is a good chance they will take. The primary aim of treatment is to replant an avulsed adult tooth as soon as possible. This does not apply to baby teeth, if one is knocked out, it should not be pushed back into the socket because the underlying developing adult tooth may be damaged. The chances of success depend on how long it has been out of the mouth. Ideally, encourage an adult at the scene of the accident to replant it. Unfortunately, many lay people (and a few doctors) are worried about pushing a tooth back into a socket and getting it the right way round. If unable to do this, store the tooth in an appropriate solution and refer as quickly as possible. The main reason why avulsed teeth do not re-attach is that the periodontal cells on the root dry out. The tooth must be kept moist. Milk is good storage medium. Provided that the tooth is kept moist in milk, it can be replanted up to 24 h later.
You therefore have two options when confronted by a patient with a tooth in his hand:

- re-implant the tooth back into its socket and refer the child immediately to a dentist for splinting;
- make sure the tooth is safe (in milk or physiological saline) and arrange for immediate dental treatment.

Consider antibiotics and, if appropriate, a tetanus booster. Treatment is often prolonged, usually requiring endodontic treatment (root filling) at a later stage.

Premature loss of an adult tooth can be particularly disfiguring, as the bone around the margins of the socket becomes resorbed. This compromises the success of replacement bridge work.
Fractures of the orbit and cheek often go hand in hand. Hence both will be considered together.

The cheek is predominantly formed by the zygomatic bone. More correctly, it is made up of a complex of bones known as the zygomatico-maxillary complex or ‘malar’ bone.

The zygomatic bone links with the frontal bone at the fronto-zygomatic suture under the eyebrow; the maxilla medially and the temporal bone posteriorly. The body of the zygoma provides the aesthetic prominence of the cheek and forms part of the inferior and lateral rim of the orbit. The orbital rim supports the lower eyelid. The face is constructed of a series of buttresses that allow the transmission of force from the maxilla to the skull base (during chewing). The zygoma forms part of the lateral buttress and protects the eye by forming part of the orbital rim. It also projects a more delicate bony bar posteriorly towards the temporal bone forming the zygomatic arch.

The temporalis muscle passes beneath the zygomatic arch to insert into the coronoid process of the mandible. Fracture of the zygomatic arch can therefore produce limitation of mouth opening by interfering with the coronoid process or temporalis muscle. The temporalis muscle is invested in temporal fascia, which arises from the superior temporal line of the skull and passes down to insert into the zygomatic arch. This is an important surgical landmark (Gillies approach).

The orbit—applied anatomy

In essence, each orbit is a pyramidal-shaped structure. Its primary function is to contain, protect, and support the globe of the eye enabling binocular 3D vision. The walls of the pyramid are made up of a number of different bones and are of varying thickness and strengths. The orbital floor and medial orbital wall are particularly delicate and are prone to damage (blow-out fractures). The orbital floor carries the infra-orbital nerve, which supplies sensation to the majority of the cheek and one half of the nose and upper lip. Under the floor lies the maxillary sinus. The medial wall is predominately made up of the ethmoid bones and the ethmoidal air cells. The ethmoidal vessels pass through the orbit, into the nose, and may bleed profusely following trauma.

Numbness of the cheek and upper lip is an important sign that should generate a high index of suspicion for orbital or cheek bone fracture.

Peri-orbital fat fills the gaps in orbit and contains a radiating pattern of fine but strong septa that are the principal method of support for the eye. Damage to the bony orbit can result in herniation of peri-orbital fat and associated trapping of the septa. This prevents the co-ordinated action of the ocular muscles and results in restricted eye movements and double vision (diplopia).

Co-ordinated movements of the eye are achieved by the extra-ocular muscles—four recti and two oblique. The recti muscles have a common point of attachment at the tendinous ring at the orbital apex. They form a
muscular cone before inserting into the sclera. This cone is important in that it can act as a closed compartment containing blood following surgery or trauma (see Retrobulbar haemorrhage).

**Terminology**

Many terms are used including zygomatic, zygomatic complex (ZC), zygomatico-maxillary complex, zygomatico-orbital, tripod and malar fractures. They all mean the same thing.

**Epidemiology**

- ZC fractures are the second most common facial fracture after nasal bone fractures.
- Most occur in males in their 2nd to 3rd decades.
- Inter-personal violence is the commonest cause.
- When fracture is caused by assault, the left side is affected more often than the right.
- Most are unilateral fractures.
Zygomatic (malar) fractures

Assessment
Fractures involving the ‘zygomatic complex’ (ZC) involve the zygoma and adjacent bones (maxilla, frontal, and temporal bones). They are, therefore, not just zygomatic fractures. Strictly speaking they should be termed ‘zygomatico-maxillary complex’ fractures.
Practically, fractures can be considered as:
- isolated:
  - zygomatic arch;
  - infra-orbital rim (uncommon);
- minimally displaced malar;
- displaced fractured malar;
- comminuted fractured malar;
- fractured malar with associated mid-facial or orbital floor/wall injury.

All zygomatico-maxillary fractures, by definition, have a fracture line running through the orbit. Patients should therefore be assessed for ocular injury, diplopia, and entrapment. The eye takes priority. Associated ocular problems include:
- globe/muscle injury;
- retrobulbar haemorrhage;
- superior orbital fissure syndrome;
- orbital apex syndrome.

Symptoms
- Pain.
- Swelling.
- Depressed cheek bone.
- Altered sensation of cheek/upper lip.
- Double vision.
- Restricted jaw movements.

Examination
Signs of ZC fractures may include:
- ocular injury (check visual acuity);
- peri-orbital bruising and swelling;
- subconjunctival haemorrhage;
- surgical emphysema;
- numb cheek;
- flattening of malar prominence (often masked by swelling immediately after injury);
- palpable infra-orbital step;
- antimongoloid slant;
- unilateral epistaxis (due to bleeding into maxillary sinus);
- limitation of eye movements with diplopia;
- enophthalmos;
- exophthalmos;
- hypoglobus (vertical ocular dystopia);
- restricted mouth opening;
- malocclusion (premature contact on molar teeth).
Radiographs and other useful investigations
- Visual acuity.
- Orthoptic assessment (Hess chart).
- Plain radiographs—occipitomental (OM), lateral face and submental-vertex (SMV)—look carefully, sometimes the only clue is a fluid level in the antrum.
- CT scan-axial and coronal.
- Ultrasound scan.
- Maxillary sinus endoscopy for orbital floor fractures.

Indications for CT scan
- Suspected orbital floor fracture.
- Comminuted or severely displaced fractures.
- Injuries associated with other facial fractures.

Fractures
These are classified according to:
- degree of comminution;
- whether or not they are compound (open);
- the site of fractures;
- the direction and degree of displacement.

(At present no universally accepted classification system exists.)

Fig. 8.27 Vertical displacement of the zygoma can drag the lateral canthus and lateral attachment of the globe with it. This can result in diplopia, hypoglobus, and an anti-mongoloid slant to the eye.
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Fig. 8.28 OM view of the mid-face, showing a fractured zygoma.

Fig. 8.29 ‘Campbell’s’ lines aid identification of midface fractures.
**Treatment**

First aid and warnings

These fractures do not require urgent intervention and can be assessed as an out-patient. **The eye takes priority**—a high percentage of injuries to the orbit are also associated with injuries to the eye itself. **Check visual acuity and consider ophthalmic opinion if abnormal.** Also refer to maxillofacial team on-call. Advise the patient **not to blow their nose.** If they do this, it can result in peri-orbital surgical emphysema. Pressurized air passes through the nose and antrum into the orbit through the fracture. If it gets infected this can result in **orbital cellulitis,** which can be devastating. Many hospitals advise prophylactic **antibiotics.** Tell the patient to return if they have increasing swelling, pain, or change in visual acuity.

**Remember**—a high percentage of injuries to the bony orbit are also associated with injuries to the eye itself. **Always check visual acuity to identify rare sight-threatening emergencies that can occur.**

**Indications for operative treatment**

- Clinical signs consistent with displaced zygomatic fracture.
- Radiological evidence of displaced fracture.
- Sensory nerve deficit.
- Limitation of mandibular opening.
- Ocular dysfunction.
- Facial deformity.

The timing of surgical intervention depends on the degree of swelling and general medical/surgical considerations—in particular, head or ocular injury. Surgery is usually carried out either immediately or about 5–6 days following injury. Acceptable results can still be obtained at 3 weeks, but reduction becomes more difficult.

**Surgical reduction**

This depends on the degree and nature of displacement of the fracture sites.

**Isolated arch or simple fractures, which are incomplete at the fronto-zygomatic suture,** are those most suitable for simple elevation by the **Gillies approach.** **Closed reduction techniques include:**

- Temporal approach (Gillies).
- Percutaneous hook.
- Eyebrow approach—zygomatic elevator.
- Carroll–Girard screw.
- Intra-oral approaches (upper buccal sulcus).

Most fractures are now treated by **open reduction and internal fixation (ORIF)** with titanium miniplates. Surgical access for reduction and fixation is commonly through the mouth to avoid facial scars. Access to the fronto-zygomatic suture and infra-orbital rim may be necessary to assist reduction and fixation. The more displaced or comminuted the fracture the more fracture sites need to be exposed.
Gillies’ approach
This consists of a temporal hairline incision, which is deepened to expose the temporalis fascia overlying the temporalis muscle. This is incised and an elevator is slid beneath the fascia over the underlying muscle. The fascia acts as conduit to guide the elevator under the body of the zygoma. The zygoma can then be elevated into its correct position with care taken not to use the temporal bone as a fulcrum. (Iatrogenic temporal skull fracture is an embarrassing complication!)
Orbital fractures (isolated)

This refers to fractures affecting the bony orbital walls or orbital margin but not involving the surrounding complexes, e.g. naso-ethmoid, zygomatic, anterior cranial fossa.

Blow-out fractures

The classical isolated injury to the orbit is the orbital floor ‘blow-out’ fracture, which occurs as result of a direct blow to the globe (e.g. squash ball to the eye). This increases pressure within the bony orbit. It may also follow a blow to the prominence of the cheek, where the bone ‘buckles’, resulting in fracture propagation. The floor of the orbit is relatively weak and is fractured with herniation of orbital contents into the maxillary sinus. The injury can also occur on the medial wall in association with other localized facial fracture (fractured malar or Le Fort fracture) or in any combination.

Clinical features

Early assessment of the eye is essential, as management takes priority over the fracture itself. Very often the eyelids become closed due to painful swelling. However, gently pressing on the eyelids (not the globe) for a few minutes reduces this sufficiently to assess visual acuity, pupillary size, and reaction and visualize the anterior chamber for hyphema. Contact lenses and superficial foreign bodies can be removed. If a penetrating injury to the eye is suspected, pressure should be avoided. A dilated pupil may often be due to traumatic midryasis but its significance in relation to head injuries must be remembered.

Look for:
- peri-orbital bruising;
- subconjunctival haemorrhage;
- numb cheek;
- restricted eye movements (usually upwards);
- retraction sign;
- diplopia;
- enophthalmous (may not be apparent immediately unless severe injury—may occur late, >3 months).

Consider also the following:
- naso-lacrimal dysfunction;
- presence of foreign bodies;
- motor and sensory nerve deficit;
- other peri-orbital soft tissue injuries.

Remember—a high percentage of injuries to the bony orbit are also associated with injuries to the eye itself. Always check visual acuity to identify rare sight-threatening emergencies that can occur. Associated ocular problems include:
- globe/muscle injury;
- retrobulbar haemorrhage;
- superior orbital fissure syndrome;
- orbital apex syndrome.
Assessment and initial investigations

- Visual acuity.
- Examination of globe.
- Plain radiographs: If possible get occipitomental (OM), and lateral facial views (for associated malar or mid-facial injury). Look for a ‘hanging drop’: this represents the herniation of orbital contents into the maxillary sinus. It may not be easily seen. A fluid level in the sinus suggests a fracture somewhere.
- Coronal/axial CT of orbits.
- Orthoptic assessment—Hess chart, measurement of globe projection and fields of binocular vision (to assess restriction of ocular movement).

Treatment

Where an injury to the globe or associated nerves is suspected an ophthalmic opinion should be sought. In all cases advise the patient not to blow their nose. If they do this, it can result in peri-orbital surgical emphysema. Pressurized air passes through the nose and antrum into the orbit via the fracture. If it gets infected this can result in orbital cellulitis which can be devastating. Many hospitals advise prophylactic antibiotics. Tell the patient to return if they have increasing swelling, pain or change in visual acuity. Chloramphenicol ointment may be applied to any conjunctival injury.

Further management

This is controversial. Some fractures can be treated conservatively. Indications for surgery include significant diplopia, a retraction sign, dystopia (displacement of globe), enophthalmos or a ‘large’ blow-out on CT—said to predispose to the late development of enophthalmos. The aim is to release entrapped soft tissues and restore orbital volume. This should release any restriction of eye movement and restore globe position.

Surgical treatment

The timing of surgery is controversial and dependent on multiple factors. If there is minimal displacement and no evidence of enophthalmos or significant orbital volume change (which might result in late enophthalmos), it is common practice to delay surgery for up to 10–14 days post-injury. This allows any swelling to settle and gives an idea of any deformity. If there is evidence of ischaemic incarceration of the orbital soft tissues or muscles immediate intervention may prevent scar contraction.

There are a number of cosmetically acceptable local approaches to the orbit. Extensive injuries, particularly of the medial wall, may need a bicoronal approach. The orbit can be reconstructed with a number of allogenic or autogenous materials. Bone can be used and may be harvested from the maxillary antral wall, cranium, rib, or iliac crest. Allogenic materials are numerous and include specially formed titanium plates or mesh, polymers and newer resorbable materials.
Mid-facial (‘middle-third’) fractures—applied anatomy

The bones of the mid-face consist of:
- 2 maxillae;
- 2 zygomas;
- 2 zygomatic processes of the temporal bones;
- 2 palatine bones;
- 2 nasal bones;
- 2 lacrimal bones;
- 2 inferior conchae;
- sphenoid pterygoid plates;
- ethmoid;
- vomer.

The arrangement of these bones, together with the presence of the air-filled sinuses, essentially converts the mid-face into a series of vertical bony struts, or buttresses, passing upwards from the teeth to the skull base. The lateral buttresses are formed by the lateral orbital margins and the zygomatic complex. The medial buttresses are formed by the frontal processes and medial body of the maxillae.

Anatomy of the buttresses

The mid-face has three paired buttresses that are the ‘pillars’ that take the load of any vertically applied force. These are
- anterior, which runs up from the piriform fossa lateral to the nose, up to the fronto-nasal process, which is made up by the articulation of the maxilla with the frontal bone;
- middle, which is formed by the buttress of the zygoma articulating with the maxilla anteriorly and inferiorly, and the frontal bone above;
- posterior, which is made up by the pterygoid plates attaching the maxilla to the base of skull.

The mandible can be thought of as being indirectly buttressed through the maxilla by the above buttresses when the teeth are in occlusion.

As a result of these buttresses, the face is very good at resisting vertically directed forces (i.e. chewing). However, there are very few strong, horizontally directed buttresses and consequently the face is not good at resisting horizontally directed forces (i.e. a significant vector in most trauma). It has been argued that the sinuses effectively convert the face into a ‘crumple zone’, thereby absorbing kinetic energy and protecting the brain from injury.

Because the mid-facial skeleton sits on an inclined skull base at 45 degrees to the horizontal plane, mid-face fractures can result in the middle-third being sheered off the cranial base, and forced downwards and backwards along this inclined plane. Clinically this results in an elongated face and deranged bite (anterior open bite).
Le Fort mid-face fractures

Fracture patterns

The terms used to describe these mid-facial fractures, refer to the level of the fracture related to the skull base.

**Le Fort I** ('low level')
The fracture lies horizontally at a level just above the nasal floor, passing backwards from the piriform aperture, above the alveolus, to below the zygomatic buttress. From the mid-line it passes along the lower-third of the nasal septum and lateral walls of the nose to join the lateral aspects of the fracture across the lower third of the pterygoid plates. This is essentially the tooth-bearing part of the mid-face (think of a denture).

**Le Fort II** ('pyramidal')
From the mid-line, through the nasal bones, this fracture crosses the frontal processes of the maxillae to the medial orbital walls. The fracture passes through the lacrimal bones and crosses the inferior orbital margin at the level of, or just medial to, the infra-orbital foramen. The fracture continues in an infero-posterior extension across the lateral wall of the antrum below the zygomatico-maxillary suture. Infero-posteriorly the fracture passes through the mid-point of the pterygoid plates. Superomedially the fracture passes through the nasal septum and may involve the cribiform plate of the anterior cranial fossa.

**Le Fort III** ('high transverse' or 'cranio-facial dysjunction')
From the mid-line the fracture passes from the fronto-nasal suture backwards through the ethmoid bone involving the cribiform plate. Laterally the fracture runs within the orbit below the level of the optic foramen to the posterior aspect of the inferior orbital fissure. From here the fracture passes laterally through the lateral wall of the orbit and fronto-zygomatic
process and posteriorly it crosses the pterygo-maxillary fissure to separate the base of the pterygoids. This separates the entire facial skeleton from the skull base.

Le Fort II and III both

- Involve the orbit (risk to the eyes).
- Potentially involve the anterior cranial fossa (associated head injury/CSF leakage).

Often these fractures occur in various combinations ipsilaterally and bilaterally.
The type of Le Fort fracture can usually be determined by examination. This consists of holding the head stable and rocking on the upper front teeth (or the alveolar ridge, if the patient is edentulous).
- If the teeth and palate move but the nasal bones are stable, it is a Le Fort I.
- If the teeth, palate and nasal bones move but the inferior orbital rims are stable it is a Le Fort II.
- If the whole mid-face feels unstable, it is probably a Le Fort III.

Assessment
(See also Pan-facial fractures below.)
Consider serious facial injuries in anyone with gross swelling.

Clinical features and associated problems
Clinical features may be a direct result of the force of trauma, or as a consequence of the effects of this force on disruption and displacement of the mid-facial skeleton.

General features
- Airway compromise (uncommon).
- Haemorrhage—associated with mucosal tears in the naso-pharynx or facial wounds/lacerations. Rarely torrential, although may require nasal packing or fracture reduction to stem the flow. If the patient is shocked, look for another cause.
- CSF rhinorrhoea—CSF leak from the nose (anterior cranial fossa #).
- CSF otorrhoea—CSF leak from the ear (middle cranial fossa #).
- ‘Tramlining’ may be seen when blood mixes with CSF and leaks from the nose or ear. Along the edges of the flow the blood clots while the CSF washes it away centrally forming two parallel lines: hence ‘tramlining’.
- Complications of CSF leaks (meningitis, aerocele or fistula formation with significant CSF loss).
- Facial swelling.
- Massive facial oedema.
- Abnormal mobility of the mid-face—checked by holding the anterior maxillary alveolus and gently attempting to mobilize the maxilla; the other hand is held at sites of suspected fractures, e.g. the nasal bridge or the inferior orbital margins.

Eye signs
- Bilateral peri-orbital ecchymoses (‘panda faces’ or ‘raccoon eyes’). These are often associated with the gross degree of facial oedema as seen in the Le Fort II and III fractures.
- Bilateral subconjunctival ecchymoses (bright red). This is bruising within the conjunctiva adjacent to fractures that pass through the orbit (Le Fort II and III).
- Enophthalmus—sinking in of the eyes—may initially be masked by oedema.
- Diplopia—caused by swelling, orbital displacement, or tethering of ocular muscles within fracture lines and hence lack of stereoscopic vision.
- Traumatic mydriasis (dilated pupil)—spasm of dilator pupillae secondary to a direct blow.
Features related to the displacement of the mid-face skeleton

The mid-face may be forced downwards and backwards along the skull base at 45 degrees to the maxillary occlusal plane. This can result in:

- obstructed airway—this results from the soft palate resting on the dorsum of the tongue and the posterior oro-pharyngeal wall;
- anterior open bite;
- apparent trismus caused by gagging of the occlusion due to premature contact in the molar region;
- lengthening of the mid-face;
- ‘dish-faced’ deformity—communion of the mid-facial bones (naso-ethmoid complex/anterior maxilla) may result in a central collapse rather than a posterior displacement of the whole mid-face: this will produce the classic dish-face deformity;
- pain and crepitus:
  - over the nasal bridge and palpable fracture sites; step deformities may also be elicited;
  - inferior orbital rims (Le Fort II);
  - upper buccal sulcus (Le Fort I and II);
- upper buccal sulcus bruising;
- anaesthesia—commonly in the distribution of the infra-orbital nerve—may be as a result of direct trauma, or the widespread compressive effects of facial oedema.

Radiographs and other useful investigations

Except for the CXR and Head CT these can wait.

- Chest radiograph. Remember the possibility of inhaled foreign bodies, e.g. from dental trauma.
- Occipito-mental. One or two projections (15 and 30 degrees) together with a good clinical examination will usually show most Le Fort fractures adequately. Campbell’s ‘search’ lines provide a system of assessing these views.
- True lateral projection. This may demonstrate the postero-inferior displacement of the maxilla responsible for gagging on the posterior dentition and an anterior open bite. It is also useful for assessment of the frontal sinuses (fluid levels, posterior wall fractures) and visualizing the pterygoid plates (an indication of the level of the fracture).
- Peri-apical and upper occlusal views. These are useful for assessment of dento-alveolar fractures and identification of a palatal mid-line split.
- Panoral tomography (OPG). Very useful if a mandibular fracture is suspected. It may also show low level Le Fort I fractures, dento-alveolar fractures, and dental injuries.
- Computed tomography (CT scans). These are particularly useful in associated head injuries and in assessing fractures of the naso-ethmoidal complex, frontal sinus and orbit.
- Magnetic resonance imaging. May be of value in the diagnosis of CSF leaks and in the assessment of soft tissue injury, particularly the orbit.
Treatment
(See also Pan-facial fractures below.) Maxillofacial trauma should be integrated into Advanced Trauma Life Support—ATLS. ATLS dictates:

...maxillofacial trauma, not associated with airway obstruction or major bleeding, should be treated only after the patient is stabilized completely and life threatening injuries have been managed.

Consider first:
- airway with c spine;
- breathing;
- circulation;
- head injuries;
- ocular injuries.

Beware the patient who keeps trying to sit up—they may be trying to clear their airway. If there is no spinal injury let them sit up, if unsure log roll or tip the table head down. This is at variance with ATLS guidelines but facial bleeding will continue unrecognized in the supine position until the patient vomits and possibly aspirates.

First aid
Le Fort fractures can present with prolonged epistaxis (nose bleed). Definitive treatment may involve reduction of the fracture or cautery/ligation of appropriate vessels. As a first-aid measure nasal packs may tamponade the flow. If posterior nasal packing is required, urinary (Foley) catheters may be inserted beyond the soft palate prior to inflating the balloon and then withdrawn until the balloons wedge in the posterior naso-pharynx; anterior nasal packing with ribbon gauze may also be required. Custom devices are available (Epistat™) with dual balloons that will occlude the entire nasal airway and hence tamponade haemorrhage.

Wounds and haemorrhage—‘assess, arrest, and replace’
Remove any dressings to fully assess wounds, remembering that they may have been placed as pressure dressings to stem initial blood loss. Ideally careful exploration under LA should be carried out before closure to clean and remove any debris or foreign bodies, and to identify any underlying fractures. If the patient obviously requires to go to theatre, then formal wound closure should be delayed (although ideally no longer than 24 h) but judicious placement of a few sutures along with simple dressings should help to stem a steady venous ooze.

Replace lost fluids—any patient with Le Fort fractures must have adequate intravenous (IV) access and appropriate fluid resuscitation. Assessment must be made of any losses, as well as ongoing needs.

Prevent infection
Le Fort fractures are almost always compound injuries via communications with the sinuses or facial wounds.
- Antibiotics—intravenous and broad spectrum. Many regimes exist and include augmentin, or benzyl penecillin + metronidazole.
- Tetanus—ensure tetanus prophylaxis is up to date.

Analgesia
Remember, pain is a potent stimulus for the release of catecholamines. However, facial fractures are often not as painful as one may think.
Local—regional nerve blocks: bilateral infra-orbital blocks may be particularly useful in the Le Fort I and II fractures. Consider supra-orbital blocks for the Le Fort III pattern.

Systemic—avoid opiates until the patient is cleared of a head injury:
- **IM (intramuscular)**, a possibility but avoid in the shocked patient;
- **IV (intravenous)** rapid onset, and easy to titrate. Ideally, if the patient’s conscious level is appropriate, establish a PCA (patient controlled analgesia) in liaison with anaesthetic colleagues.

Definitive management—‘reduction and fixation’
(See also Pan-facial fractures below.)

**Indications for treatment**
These include:
- disruption of the occlusion of the teeth;
- displacement of the maxilla;
- fractured or displaced teeth;
- cerebrospinal fluid leak (controversial);
- abnormal eye movement or restriction of eye movement;
- occlusion of the naso-lacrimal duct;
- sensory or motor nerve deficit.

**Reduction**
**Anatomical reduction** is the key to successful treatment of mid-face fractures. However, mobilization of the fractures varies greatly and is dependent on fracture pattern, comminution, and impaction. Surgical reduction and fixation of the maxilla is usually required in the majority of cases. Where the maxilla is undisplaced and stable or if the patient is unfit for an operation non-operative treatment may be appropriate.

**Manual reduction** involves reduction by digital pressure. Sometimes disimpaction forceps (Rowe’s) are required. These are two forceps with upper blades, which pass into the nostril to grip the nasal floor above, and lower blades to grip the intra-orally against the palate. **Open reduction** involves visualization of the fracture sites via incisions for mobilization.

**Fixation**
A variety of fixation techniques may be used either by an open or closed approach. In some cases no fixation is necessary (undisplaced, immobile fractures).

**Internal fixation** is achieved by the application of plates to the main bone buttresses of the mid-face via intra-oral incisions. The teeth are usually wired together (IMF) during the operation to help guide the fragments into position, although this is usually removed at the end of the procedure. In the edentulous patient, Gunning splints may be appropriate. Fixation uses semi-rigid mini-plates and mono-cortical screws. Under direct vision the fractures are reduced and plated. For complete fixation of Le Fort II and III fractures access may be gained via peri-orbital incisions or a coronal flap.

**Indirect fixation and external fixation** may be indicated for rapid immobilization of Le Fort fractures. In such cases the bite is used to align and stabilize the fracture or the fracture is immobilized by fixing it to the stable cranium/frontal bone. **External fixation** is generally carried out using supra-orbital pins or a halo frame connected to the maxilla with a bar. However, this method has largely been superseded by internal
fixation using plates. It may still be useful when rapid fixation is required, there are infected wounds (rare), in extensive comminution, or in children. Associated skull or frontal bone fractures is a relative contra-indication to external fixation.

**Internal suspension** involves suspending the maxillary fracture from the skull with wires and placing the patient in IMF.

**Surgical approaches**

**Exposure of fracture sites is the key to accurate reduction and fixation.** This can be:

- **via wounds**;
- **intra-orally**;
- **peri-orbital incisions**:
  - lateral brow;
  - supra-tarsal fold (‘upper blepharoplasty’);
  - mid-tarsal;
  - subciliary (‘lower blepharoplasty’);
  - trans-conjunctival +/– lateral canthotomy;
- **through the skin in the fronto-nasal area**:
  - ‘H’ (converse);
  - mid-line vertical;
  - ‘W’;
  - bilateral medial canthal incisions;
- **Coronal flap (‘bicoronal flap’)**—an incision is placed in the coronal plane across the scalp from left to right preauricular regions. The scalp is reflected forwards to give excellent exposure of the upper cranio-facial skeleton, including the zygomatic complexes and the fronto-naso-ethmoidal region. This also enables harvesting of cranial bone grafts if required.
**Fig. 8.35** External fixation.

**Fig. 8.36** Internal suspension and IMF in Le Fort 1 fracture.
Nasal fractures

This refers to disruption of the normal bony and cartilaginous skeleton of the nose. The nose is the most commonly fractured bone in the face. Diagnosis is clinical not radiological. The pattern of injury depends on the magnitude and direction of the force applied (lateral or frontal direction).

Three levels of frontal directed injury can be distinguished:
- **plane one** injuries do not extend beyond a line joining the nasal bones and the anterior nasal spine and therefore involve the cartilaginous nasal skeleton only;
- **plane two** injuries are limited to the external nose and do not transgress the orbital rims;
- **plane three** injuries are more serious and involve orbit walls and possibly the cranium—this corresponds to a naso-ethmoidal fracture.

Indications for treatment
- Nasal deformity.
- Obstructed nasal airway.
- Epistaxis.

Fig. 8.37 Classification of nasal fractures.
Fig. 8.38 Nasal fracture (predominantly the nasal bones).

Fig. 8.39 Nasal fracture (predominantly the cartilagenous septum—compare tip position).
Septal haematoma—this forms between the septal cartilage and its perichondrium. It must be ruled out in every patient, and appears as a dark swelling on the septum with narrowing of the nasal airway. This requires urgent incision and drainage. If missed it can lead to a septal abscess with intra-cranial complications or a delayed ‘saddle nose’ following necrosis and cartilage loss.

Conservative management
This is indicated if there is no significant deformity, airway obstruction, or haemorrhage.

Septal haematoma may be aspirated but may require open drainage under local or general anaesthesia.

Anterior nasal packing may be required if there is any nasal bleeding. For more serious bleeding, post-nasal packs may be required. For torrential haemorrhage, uncontrollable by packing, surgery or embolization may be necessary.

Closed manipulation (MUA) of nasal bones with nasal packing and external splinting (POP) is usually carried out to correct simple deformity. If undertaken very early (on the sports field), this often requires no anaesthesia. Cases must be selected carefully, as manipulation may start bleeding. Nasal manipulation and packing otherwise requires general anaesthesia. If the septum is significantly damaged, closed manipulation with SMR or septoplasty may be undertaken.

Open reduction
Naso-ethmoidal fractures require open surgery to correct fronto-nasal dysjunction and associated frontal and orbital fractures. Correction of traumatic telecanthus may be necessary.

Beware nasal fractures with associated black eyes—they may be naso-ethmoid injuries.
Naso-ethmoid (nasoorbital-ethmoid) fractures

(See also Pan-facial fractures below.)

Consider serious facial injuries in anyone with gross swelling.
This refers to injuries to the nose, orbits, and ethmoid sinuses (NOE). Naso-orbital-ethmoid fractures are among the most challenging facial injuries to diagnose and treat. Fractures of this region are often complex and comminuted. When assessing these fractures consideration of the frontal sinus should also be made. This is because the drainage apparatus of the sinus may be blocked as it passes through the ethmoid region or it may be communicating with the CSF.

Clinical features

NOE fractures occur following a direct blow to the bridge of the nose. The ethmoid sinuses act as a crumple zone absorbing the impact. This results in a ‘pushed-in’ look to bridge of the nose—a ‘Miss Piggy’ nose’. Clinically there can be:

- severely comminuted nasal fracture;
- detachment of the medial canthal tendons resulting in pseudotelecanthus;
- fracture of the anterior cranial fossa;
- fracture of the frontal sinus;
- CSF leak.

The ‘bow-string’ test assesses for canthal detachment—the lateral canthus is pulled laterally, if there is detachment medially the medial canthus will also move laterally.

Consider also concomitant injury to:

- the head/neck;
- the eye;
- frontal sinus;
- canthal ligaments;
- naso-lacrimal apparatus.

The severity of the injury may vary considerably in this region. The degree of bone displacement and comminution is difficult to visualize on plain radiographs, and computerized tomography is necessary. Usually there is extensive comminution of the involved bones with associated soft tissue injuries. This makes reduction and fixation difficult, particularly when there are other facial bone fractures.

Indications for treatment

- Cerebrospinal fluid leakage (controversial).
- Traumatic telecanthus.

Fig. 8.40 (a) and (b) Nasoethmoid (nasoorbital-ethmoid) fractures.
Orbital dystopia.
Abnormalities of eye movement.
Naso-lacrimal duct obstruction.
Deformity of the nose.
Functional abnormality of the nose including nasal airway obstruction.
Deviation of the nasal septum, and septal haematoma.

Reduction is indicated in the majority of cases. Non-operative treatment may be appropriate where the fracture is undisplaced or when the general condition of the patient makes surgery inadvisable. Simple closed reduction of the nasal bones may be carried out under a day case general anaesthetic or even local anaesthesia. More complex fractures may require open reduction and internal fixation. Accurate repositioning of the canthal ligaments is essential for a good cosmetic result. A number of surgical techniques may be employed using either an open or closed approach. An open approach (usually via a bicoronal flap) is indicated for complex fractures or when frontal sinus treatment is required.

In general, the best cosmetic result is obtained when a definitive anatomical reduction of the bone fragments and soft tissue reconstruction is carried out at the primary operative procedure.
Pan-facial fractures

(See also Le Fort fractures above.)

The term 'pan-facial' is used when multiple fracture patterns are seen in the patient. Commonly this means a mid-face and mandibular fracture, but can include any of the previously described fracture patterns. Fractures of the face can be considered as those involving the upper-third, mid-face, and lower face. Some of these bones, such as the ethmoid and those comprising the orbital roof, are extremely delicate and so thin that on a dry skull light can easily pass through. The remainder vary in thickness but often remain quite delicate (nasal, zygoma). The mandible is the strongest of the facial bones.

The face is not solid but contains several 'cavities', such as the sinuses, orbits, oral, and nasal cavities. Around these the bones form a series of vertical struts known as 'buttresses'. As a result, these bones are very good at resisting vertically directed forces (e.g. during chewing) but are weak when it comes to resisting horizontal forces (i.e. during most injuries).

Upper facial fractures

These involve the frontal bone, fronto-naso-ethmoidal region, orbits- and associated sinuses. The important points to note are whether there is a displaced fracture and/or any fracture of the posterior wall of the frontal sinus, fronto-naso-ethmoidal region- or orbit. These will be seen following CT scans.

Mid-face fractures

These are classically those described by Le Fort as I, II, and III.

- **Le Fort I** runs above the apices of the teeth from the nasal aperture back to and across the lower end of the pterygoid plates, it also runs down the lateral nasal wall; these two are connected by a fracture running across the posterior wall of the maxilla.

- **Le Fort II** runs from the nasal bridge down across medial orbital wall and floor, and across the anterior maxilla under the zygomatic buttress. From there it passes across the lateral wall of the maxilla to the pterygomaxilllary plates. It also runs down the lateral wall of nose and across the posterior wall of the maxilla.

- **Le Fort III** runs across the bridge of the nose into the orbit, down the medial orbital wall, across the orbital apex, and up the lateral orbital wall. There is also a fracture along the arch of the zygoma. This results in disruption at the fronto-nasal zygomatico-frontal and zygomatico-temporal sutures leading to cranio-facial disruption.

- **Le Fort II and III both:**
  - involve the orbit (risk to the eyes);
  - potentially involve the anterior cranial fossa (associated head injury/CSF leakage).

Fractures may be unilateral or bilateral—more commonly the latter. If it is unilateral and is displaced, there must be an associated palatal fracture. It is not uncommon to find one or more of these fracture patterns present. The bones are often comminuted and the fracture lines rarely run as neatly as described from one point to another.
Lower facial fractures
Mandibular fractures in pan-facial trauma are of the same pattern as isolated mandibular fractures but are more often multiple and comminuted.

Associated problems
- Associated problems from the pan-facial trauma relate to the airway. These are usually secondary to swelling and haemorrhage but can occasionally be secondary to posterior displacement of the facial bones, obstructing the airway.
- Although blood loss from facial wounds can look dramatic, in a shocked patient with facial injuries it is wise to look for other causes of the shock, as often there is more significant blood loss elsewhere (chest, abdomen, pelvis, or long bones, etc.) that is responsible for the shock.
- All pan-facial trauma patients have suffered a significant degree of trauma and have a high risk of injury elsewhere. In particular, they are at risk of having sustained a head injury and/or cervical spine injury. A careful and repeated evaluation of the neurological status must be made. Particular care must be taken, in those patients who have ingested alcohol prior to the injury, not to assume that drowsiness or poor co-operation is secondary to the effects of the alcohol.

Assessment
Consider serious facial injuries in anyone with gross swelling. These should be elicited after completion of the primary survey. If the patient is intubated, some aspects cannot be undertaken at this stage but must be recorded in the notes as requiring completion later.

Inspection
All patients with pan-facial fractures will have considerable facial swelling, unless seen almost immediately after injury or several days later. The face should be cleaned of blood to enable a clear inspection.

Look for:
- tramline or clear fluid suggestive of CSF leak;
- facial swelling;
- presence of lacerations;
- obvious asymmetry despite swelling;
- check visual acuity;
- diplopia;
- inter-canthal distance;
- shape of medial canthus (does it come to a sharp point angled slightly downward at the insertion or is it rounded?);
- inter-pupillary distance;
- pupillary levels;
- nasal deviation/air entry and septal haematoma;
- how far can the patient open their mouth? is there any pain or deviation on opening any reduction of lateral movement?;
- auroscopy—looking for tears in external auditory meatus and blood behind the tympanic membrane;
- examine VII nerve function;
- missing teeth, crowns, dentures, etc. (if any are missing where are they?);
- any evidence of palatal or sublingual haematoma.
Palpation

Be systematic start at the top and work down (or bottom and work up).

Feel for:
- **Examine lacerations for depth and underlying fractures.** If the laceration overlies the course of the parotid duct, look for saliva in the wound. Remember the lacrimal system, facial nerve, and canthal attachments of the eye.
- **Palpatated bony margin** for tenderness or steps.
- **Assess sensation in** if the patient is awake.
- **Assess maxilla for mobility.** When the maxilla moves, is there any movement of the bone at the infra-orbital and or zygomatico-frontal level? Mobility can also be due to isolated dentoalveolar fractures.
- **Assess the palate for a split.**
- **Palpate the mandible** for mobility and assess the occlusion if possible.

Investigations

- **Baseline biochemical and haematological** investigations should be undertaken, and patients grouped and saved or cross-matched, depending on blood loss. Other blood investigations should be determined by specific features of the medical history, e.g. diabetes.
- Imaging is the most useful investigation to ascertain the presence and location of bony fractures. Generally these will either be **CT scan or plain radiographs.** Patients with pan-facial fractures frequently have an associated head injury and will have a brain CT. If it does not compromise the patient’s overall well-being, scan the facial bones at the same time; if possible, generating axial of the facial skeleton and coronal views of the orbits. Occasionally angiography may be required to indicate the source of persistent or major haemorrhage.
- If it is not possible to obtain images as part of a head series of scans, imaging is likely to be required prior to definitive treatment. Alternatively, good quality plain radiographs are valuable. An **OPG, PA mandible, OMs, and lateral facial bones** should be obtained. If good plain views are not obtainable, or there are condylar, orbital, frontal sinus, or NOE fractures present, coronal and axial CTs should be obtained.
- Determining the position of foreign bodies relative to vital structures will require two images at 90 degrees to one another. Occasionally angiography may be needed to establish the position of a foreign body to major vessels. If foreign bodies may be present that are radiolucent, e.g. wood, **ultra sound** scans can be useful to demonstrate their presence.
- **Impressions for study models** can often be invaluable in planning to establish pre-operatively the desired occlusion and enable an occlusal wafer to be constructed pre operatively.
- Ask relatives to bring in any **pre-injury photographs** of the patient.
Treatment
Maxillofacial trauma should be integrated into Advanced Trauma Life Support—ATLS. ATLS dictates:

...maxillofacial trauma, not associated with airway obstruction or major bleeding, should be treated only after the patient is stabilized completely and life threatening injuries have been managed.

Consider first:
- airway with c spine;
- breathing;
- circulation;
- head injuries;
- ocular injuries.

Beware the patient who keeps trying to sit up—they may be trying to clear their airway. If there is no spinal injury, let them sit up; if unsure, either let them lay on their side or tip the table head down. This is at variance with ATLS guidelines but facial bleeding will continue unrecognized in the supine position until the patient vomits and possibly aspirates.

First aid
Haemorrhage is usually due to displacement of fractured bones or lacerations. Displaced mandibular fractures can be reduced and if teeth are present on either side of the fracture, a bridle wire placed This provides some stability to the fracture thereby reducing bleeding and making the patient more comfortable. Ideally the bridle wire should include two teeth on each fractured segment.

Associated Le Fort fractures can present with prolonged epistaxis (nose bleed). Definitive treatment may involve reduction of the fracture

Fig. 8.42 CT scan (and 3D reformatting) has revolutionized assessment in facial trauma.
or cautery/ligation of appropriate vessels. As a first-aid measure, nasal packs may tamponade the flow. If posterior nasal packing is required urinary (Foley) catheters may be inserted beyond the soft palate prior to inflating the balloon and then withdrawn until the balloons wedge in the posterior naso-pharynx; anterior nasal packing with ribbon gauze may also be required. Custom devices are available (Epistat™) with dual balloons that will occlude the entire nasal airway and hence tamponade haemorrhage.

**Replace lost fluids**—any patient with Le Fort fractures must have adequate intravenous (IV) access and appropriate fluid resuscitation. Assessment must be made of any losses as well as ongoing needs.

**Dento-alveolar fractures** can be reduced and stabilized with splints. If teeth have been avulsed or subluxed, they are best re-implanted or repositioned as soon as possible and splinted.

**Lacerations** should be inspected for contamination and foreign bodies (do not do this with your fingers if glass could be involved). This is particularly important to prevent tattooing of the skin, which can be difficult to eradicate. Bites should be thoroughly irrigated to minimize the risk of infection. Assess the viability of the soft tissues. Due to the extremely good blood supply of the face, loss of viability is unusual, so tissue should not be discarded unless it is certain that it is not viable.

Assess **facial nerve** function. If this is disrupted, repair should be undertaken prior to definitive closure, which should be done as soon as possible. However, if a large laceration is present, and other more urgent problems need attention, tack the wound with a few large sutures, and close it definitively later. If a laceration gives access to an underlying fracture, which may not be addressed for several days, it is probably best to leave definitive closure until fixation of any fractures.

**Prevent infection**
- Le Fort fractures are almost always compound injuries via the sinuses or facial wounds.
- **Antibiotics**—intravenous and broad spectrum. Many regimes exist and include augmentin, or benzyl penecillin + metronidazole.
- **Tetanus**—ensure tetanus prophylaxis is up to date.

**Analgesia**
Remember, pain is a potent stimulus for the release of catecholamines. However, facial fractures are often not as painful as one may think.
- **Local**—regional nerve blocks: bilateral infra-orbital blocks may be particularly useful in the Le Fort I and II fractures. Consider supra-orbital blocks for the Le Fort III pattern.
- **Systemic**—avoid opiates until the patient is cleared of a head injury.
- **IM (intramuscular)**, a possibility but avoid in the shocked patient.
- **IV (intravenous)**—rapid onset, and easy to titrate. Ideally, if the patient’s conscious level is appropriate, establish a PCA (patient-controlled analgesia) in liaison with anaesthetic colleagues.

**Definitive treatment**
Optimal results requires careful pre-operative assessment and planning. This should result in a comprehensive list of the problems and objectives
of treatment. This can be summarized as restoration of normal form and function without producing complications. Broadly speaking definitive management can be broken down into non-operative or operative management. The benefits of each needs to be weighed against the risks, taking into account all aspects of the patient, particularly other injuries and pre-existing medical conditions.

Planning should be undertaken in collaboration with other specialities that may be involved, e.g. anaesthesia, neurosurgery, or ophthalmology. Consideration should be given to whether there is any need for primary bone-grafting of orbital walls or expected bony defects.

**Anaesthetic**

Because IMF is usually required, avoid an orotracheal tube if possible. Given also that patients also require nasal reduction, thought may need to be given to either a tracheostomy or submental tube.

**Access**

This can be via wide exposure of the facial skeleton via a bicoronal approach or through localized incisions. In the presence of naso-ethmoid, frontal sinus, anterior cranial fossa fractures, or Le Fort III fractures, **wide exposure is usually required to get the best results.** This allows direct visualization of fractures, while hiding scars in the scalp. Localized incisions in the infra-orbital area may still be requires as well intra oral incisions.

Surgery aims to:

- exposure and sealing of cranial floor fractures;
- restore:
  - facial width;
  - orbital volume;
  - orbital rim;
  - occlusion;
  - nasal projection;
- repair of VII nerve;
- precise neat closure of lacerations.

If the mandible has bilateral condylar fractures, then, if possible, at least one condyle should be fixed to **restore mandibular height. Mandibular width** must not be increased. This can occur with parasymphseal fractures.

Often all fractures are exposed before fixation. Fixation starts peripherally, at the junction with uninjured bone. In the mid-face this usually means either starting laterally and working medially, restoring the orbital rims and arch. Restoration of orbital volume may require grafting. Nasal projection can then be addressed. If cranial floor repair is required this should be done after reduction of fractures to prevent disruption of repair.

When mid-face and mandibular fractures are present, the mandible should be fixed and the occlusion established with IMF prior to the Le Fort fractures being fixed.

Any soft tissue repair must be undertaken last. Facial sutures should be removed at 4–5 days, scalp sutures/clips at 7–10 days.
General principles in management and terminology

- Debridement—thoroughly clean any open wounds.
- Reduction—open/closed.
- Fixation—IMF/internal/external.
- Care of soft tissues.
- Functional rehabilitation.

**Debridement**

All wounds need to be thoroughly cleaned as soon as possible, as often there may be some delay in surgery. Skin wounds need to be gently cleaned and kept from drying out with saline or antiseptic-soaked swabs. Oral hygiene is particularly important with fractures of the mandible and maxilla, as these often communicate with the oral cavity, which, due to pain, is hard for the patient to keep scrupulously clean. In such cases regular use of antiseptic mouthwashes (e.g. corsodyl) and hot salt-water mouthwashes is recommended. Remember the possible need for tetanus prophylaxis. Once in theatre, dead tissue is excised but this is kept to a minimum. Wounds are thoroughly irrigated and if grit is ingrained, scrubbed.

**Open reduction and internal fixation (ORIF)**

This involves exposing and reducing the fracture(s) under direct vision. Whenever possible (e.g. mandible, maxilla, and some zygomatic fractures) this is done via the mouth so as to avoid incisions on the face and scars. However, if there are associated lacerations these may be used instead. Although the mouth is heavily colonized with numerous organisms, infection is surprisingly uncommon. This is in part due to the excellent blood

![Fig. 8.43](image)

The ‘Coronal’ or ‘Bicoronal’ flap provides excellent access with minimal morbidity.
supply to the face and its capacity to fight infection. By directly visualizing
the fracture, more precise anatomical reduction is possible when
compared to indirect methods (e.g. IMF). Methods of fixation include tran-
sosseous wiring, intra-medullary pins, and rigid/semi-rigid plates and screws.
Plates used for internal fixation may be adaptional plates (semi-rigid),
compression plates (rigid), or mesh. For some overlapping fragments a ‘lag
screw’ technique may be possible.

**Rigid internal fixation**

This form of ‘ORIF’ uses heavy metal plates and screws to rigidly immobi-
lize fractures. This facilitates precise anatomical reduction and increased
mechanical stability, enabling early return of function. Intermaxillary
fixation is not needed and the patient can eat soon afterwards. However,
this technique risks damaging the inferior dental nerve or teeth. Plates may
become infected and the wound may dehisce.

**Intermaxillary fixation (IMF)**

This form of immobilization uses the patient’s bite to reduce and stabilize
fractures and therefore can only be used for those fragments firmly
attached to healthy teeth (usually the mandible or dentoalveolar frac-
tures). It is also commonly used in the treatment of condylar fractures.
Fracture reduction is not directly visualized and can result in non-precise
alignment. Examples include eyelet wiring, arch bars, cast cap silver splints,
and gunning splints (edentulous fractures). Caution with post-op airway
problems, COAD, head injury, epileptics, patients likely to vomit, psychi-
atrically unwell. IMF needs to be in place for two to three weeks and
patients can lose weight.

**External pin fixation**

This involves inserting rigid pins into the bone fragments via the skin,
which are then joined by universal joints and connecting rods or splints.
This method is particularly useful where tissue has been lost (‘continuity
defects’, e.g. gun-shot injuries), infected, severely comminuted, and patho-
logical fractures. Fixation can be applied rapidly. However, reduction is
‘blind’—the pins may damage the inferior dental nerve or teeth, patient
activity is restricted, and the pin sites may become infected and scarred.

**Timing of surgery**

Early repair (within 5–10 days) gives the best results; immediate surgery
is only required for life-threatening injuries, or sometimes if the patient is
going to theatre for some other reason. Most maxillofacial injuries can
wait, although late repair (once the fractures have united) is difficult to
carry out well. By delaying surgery for several days:

- observation for head or ‘missed’ injuries is possible;
- facial swelling will settle, enabling better assessment;
- quality radiographs can be obtained (face, teeth);
- further investigations can be carried out, e.g. CT scan, study models,
vitality testing;
- further details including pre injury photographs can be obtained
  from relatives, GP, etc.;
- aids to surgery can be fabricated, e.g. custom-made arch bars,
gunnings splint.
Antibiotics, steroids, and tetanus prophylaxis

Protocols may vary between different units. Antibiotics are usually given for fractures that are compound (open) into the mouth or through the skin (e.g. mandible). Oral bacteria of a mixed anaerobic type, and a combination of a penicillin and metronidazole, is one suitable choice. Prophylactic antibiotics when there is CFS leakage is controversial and the opinion of a neurosurgeon should be sought. Tetanus prophylaxis should be considered, especially in mucky wounds, which should be thoroughly cleaned as soon as possible. Steroids, e.g. dexamethasone, may be given to reduce facial swelling.

Reduction of and fixation of fractures

If untreated, displaced facial fractures may result in significant disfigurement and functional problems, such as diplopia and malocclusion. Inadequate treatment can also result in poor aesthetics or function requiring further surgery to correct these. However, not all displaced facial fractures need anatomical reduction. Poor results may occur for several reasons, for example:

- coexisting medical problems (e.g. head injuries, multi-organ failure, sepsis- etc.) may delay definitive repair making it difficult to get good reduction;
- inadequate work up, particularly with radiographs, may miss bony injuries resulting in inadequate repair;
- fractures may be treated by inadequately trained surgeons;
- patients refuse or fail to attend for treatment.

Reduction—open vs. closed

Terminology can be confusing. ‘Closed’ treatment is preferable to ‘conservative’ treatment. Intermaxillary fixation (IMF) for instance is often referred to as ‘conservative’, but still has reported morbidity and even mortality.

Facial fractures 30 years ago were commonly managed by closed techniques, since it was thought that open reduction would lead to infection and severe osteomyelitis. Open reduction was reserved for compound fractures or certain unstable mandibular fractures.

Nowadays, many fractures are treated by open reduction, allowing direct access for fixation. This involves exposure of the fracture, either through the skin or mucosa. It can then be anatomically reduced and directly fixed through the incision. Closed reduction, however, is a ‘blind’ procedure relying on the fragments ‘locking’ together. Fixation normally occurs without direct visualization of the fragments in their final position. Examples of closed reduction include nasal manipulation (MUA), fixing the teeth in occlusion (IMF), or using an arch bar to support dentoalveolar fractures. IMF relies on the teeth to guide the bones, and then fixing them to provide adequate stabilization.

Closed reduction—advantages

In the UK, particularly in the Second World War, this technique was widely used. Custom-made silver splints were constructed, and sectioned at the fracture site. These were then cemented on to the teeth and intermaxillary fixation slowly applied via the splints. This enabled gradual reduction followed by fixation, often without the need for anaesthetics.
Closed reduction worked well in missile injuries, stabilizing continuity defects. Today in Third World countries with inadequate resources or surgical skills, these simple techniques still have a place. Cast silver splints have been replaced by arch bars, which are a lot easier and cheaper to manufacture.

Closed treatment may be an acceptable compromise in a patient with medical problems precluding a general anaesthetic. IMF may be used to treat simple, minimally displaced, ‘crack’ fractures relatively easily. However, those very conditions that prevent a general anaesthetic may also contraindicate IMF (e.g. uncontrolled epilepsy, chronic respiratory disease).

Closed reduction—disadvantages
Since the fragments are not directly visualized, ‘closed’ techniques mean that only the teeth, palpation, or X-rays are used as a guide to the accuracy of the reduction. The commonest problem with closed reduction, therefore, is poor fracture alignment. Errors in reduction are tolerated much less in the face than in long-bone fractures.

IMF relies on positioning the teeth correctly, assuming that this will correctly orientate the bony fractures. However, the teeth per se have only limited control over the positioning of the bones. The attached muscles may also displace fragments, despite firm location of the teeth. Control significantly diminishes with fractures further from the occlusion. This becomes compounded in patients with pre-existing malocclusions or missing teeth.

The choice between ‘open’ and ‘closed’ reduction may be clear in some cases, but there are many in which both are equally acceptable. Nowadays, with good outcomes from surgery and anaesthesia, open reduction offers the chance of better reduction and fixation. In most cases this means a safer post-operative recovery and earlier return to normal function.

Timing of reduction
Timing of surgery is not clearly defined in the literature. For compound (open) fractures, it is generally assumed that the longer the delay the more likely the wound will become contaminated. However, it is not clear what is considered to be an excessive delay. Some studies have failed to show any differences in complications whether treated within or after 24 h following injury.

However, after long delays (around 14 days), initial healing is well-established and this makes mobilization and reduction difficult. Soft tissues become adherent to the displaced bones and this makes reduction even harder to achieve. This is particularly important in the upper mid-face, especially the canthal region of the eye. Once displacement is established, the canthal ligament will never settle into its correct position. This is especially difficult to correct at a later date.

Life-threatening conditions often take precedent, and in patients with associated head injuries, fears over long reconstructions leads to delay in definitive surgery. However, some studies have shown that early intervention is possible without any significant morbidity. Close working relations with neurosurgeons is essential.
Dynamic compression osteosynthesis

Compression plates have had an enormous impact in orthopaedics and have become established practice in most trauma units. This has not been the case in maxillofacial surgery. There are a number of reasons for this:

- only mandibular fractures can be treated in this way;
- the complex curvature of the mandible creates difficulties in plate placement;
- the teeth and the inferior alveolar nerve are at risk with bicortical screws;
- precision of reduction is much more than in orthopaedic surgery;
- skin incisions are required (scarring and a small risk of damage to the mandibular branch of the facial nerve);
- dynamic compression plating is an unforgiving and a difficult technique;
- there is normally a need for a second, often extra oral, operation to remove these thick bulky plates.

Miniplates

Animal models have shown that some micro movement, using semi-rigid fixation, encourages prompt healing. Rigid fixation is, therefore, not essential to fracture healing. Non-compression, smaller sized plates ('miniplates') have now become the standard method of internal fixation in many units. Furthermore, these plates can be placed orally with much less morbidity.

The principle of this technique is to identify a 'zone of tension' within the mandible at the site of the fracture. The plate is then applied across the fracture along this line. In a way analogous to suspension bridges, huge loads can be controlled by relatively small structures, relying on the tensile strength of the materials. Relatively large loads can be controlled by small plates—'miniplates'. In addition, the plate can be fixed by monocortical screws and, as a result, can be placed where it is biomechanically desirable. Monocortical screws can be safely placed over dental roots and the inferior alveolar nerve.

Miniplates have reduced the risks of malocclusions, compared with the very rigid compression plates. Fine-tuning of the bite is possible with elastic IMF. The technique is carried out entirely through the mouth, with no need for skin incisions. The plates are small and can be left in situ if desired.

Other methods of fixation

External fixation was, prior to plating, an important method of fixation. It is used in two main ways.

In mid-face fractures, it can be used to immobilize upper and/or lower arch bars by fixing the frame usually to the cranium. This involves the use of a halo frame around the skull. This is mechanically very stable and was initially developed for traction of unstable cervical injuries.

Alternatively, it can be used as a direct fixator across a fracture, commonly the mandible or zygoma. Fixators placed across fractures have several attractions: they can be quickly applied, there is minimal exposure, and stripping of the periosteum around the fracture. Stability can be adjusted and modified during healing (dynamization), thereby reducing the
potential effects of stress shielding. The position of the fractures can be adjusted if post-operative radiology shows inadequate reduction.

Unfortunately the bulky apparatus is disliked by patients, and care is required not to injure themselves. Placement normally involves skin punctures and these can leave unsightly scars.

Nowadays, its main role is to provide ‘first-aid’ stabilization in the multiply injured patient or where there are limited facilities prior to transfer to a definitive care centre. In those areas where gun-shot wounds are common, this method of fixation provides good ‘long-term’ temporary fixation, until the contaminated wounds have healed. The external fixator is also particularly useful in maintaining space and orientation in continuity defects.
Special considerations for children and the elderly atrophic mandible

Both these groups respond to treatments differently.

Fractures in children are marked by rapid healing and rapid remodelling. In most fractures, reduction and fixation is not necessary. However, there is a risk of ankylosis in intra-capsular mandibular joint fractures and early mobilization is necessary. If fixation is required, microplating systems normally are adequate.

Edentulous mandibular fractures

In the atrophic mandible, the picture is the opposite. The severely atrophic edentulous mandible often has a poor outcome, especially those in which the radiographic height of the mandible is 10 mm or less. They are characterized by poor blood supply and slow reparative efforts. In addition, the older population are frequently complicated by poor general health, sometimes precluding prolonged general anaesthesia. Patients are commonly female with osteoporotic bones, making screw-fixation difficult and unreliable. The poor blood supply within the mandible places greater demands on having an intact periosteal blood supply, making use of large plates undesirable. Traditional methods of fixation are severely compromised by the lack of teeth.

Fractures of the edentulous mandible may be treated using the patients dentures (if a good fit) or customized ‘gunning splints’. These are essentially modified dentures that are wired to the maxilla and mandible and then fixed together while healing takes place. In selected cases, open reduction and internal fixation using miniplates applied extra-periostally (to preserve the blood supply) may be carried out. This is preferable in the presence of respiratory disease to avoid IMF.
Wound healing

General considerations
The head and neck has a very rich blood supply, which helps fight infection and improves healing. Intact skin and mucosa also prevent infection of deeper structures, particularly bone. Skin is also essential in maintaining body fluids, as seen following extensive burns.

Despite the high bacterial count in the mouth, infected wounds are uncommon. Saliva and exudates from around the gums contain antibodies and ‘growth factors’, which stimulate rapid wound healing and prevent infections (which is why dogs lick their wounds). Skin infections may, however, occur secondary to commensals (normal inhabitants of the skin), or from contact with another source (e.g. MRSA).

In the head and neck, unrepaired wounds may produce functional problems with important structures, such as the eyelids, resulting in significant morbidity. Poor repair and aftercare may also result in unacceptable scarring with distortion of the surrounding structures.

Following trauma, partially avulsed skin, even if attached by a small pedicle, may still have a good enough blood supply to enable it to heal if replaced. This is highlighted in the irradiated patient in whom wound breakdown and infection is more common following surgery or injury.

If in doubt save tissue—never excise widely.
Wound closure is a most effective form of analgesia.

The wound-healing environment
The wound needs the correct environment to heal. Many intrinsic and extrinsic factors (e.g. nutrition, poor dressing, infection, slough, and necrosis) can delay wound healing.

The ideal dressing should:
- be impermeable to bacteria;
- be free of particles and toxic wound contaminates;
- maintain high humidity at the wound/dressing interface;
- remove excess exudate;
- allow gaseous exchange;
- provide thermal insulation;
- allow removal without causing trauma to the wound;
- be comfortable for the patient whilst in situ and not cause distress or pain on removal.

Wounds, therefore, heal more effectively in a moist, warm environment, which new-generation dressings now provide. Epithelial cells can migrate easily, decreasing healing time. Pain from the wound is reduced as exposed nerve endings are not allowed to dry out. The body’s natural autolytic response to deslough is increased.

Wounds heal best at a constant temperature of 37ºC. It can take several hours for normal cell activity to return following a dressing change. It is, therefore, important to reduce the number of dressing changes. Historically, some dressings have been changed up to three to four times a day. This means that wound healing could potentially be delayed. Too frequent dressing changes also increase the risk of infection and cross-infection to other patients.
Types of wound healing

This can be considered as:

- Primary intention or primary wound healing. The wound is closed as soon as possible using sutures, clips or ‘steristrips’. There are no gaps in the wound.
- Secondary intention (granulation) or secondary wound healing. The skin edges are not closed but left if there is infection or tissue loss. The wound granulates from its base. This is seen where tissue is lost. It is unpredictable and can be lengthy. Scarring and deformity are significant.
- Exuberant granulation—overgrowth of granulation tissue prevents in-growth of surrounding epithelium.

Phases of wound healing

This involves a complex interaction between epidermis, dermis, extracellular matrix, angiogenesis, and plasma proteins, all coordinated by cytokines and growth factors. It is divided into several phases, which overlap—inflammation, proliferation, and remodelling. The initial stimulus is thrombus formation. Cells within the clot, notably platelets, trigger an inflammatory response by releasing vasodilators and chemo-attractants.

Four phases are described here, although there is often a large degree of overlap between them.

Inflammatory phase

Inflammation is the body's immediate response to trauma (including surgery), tissue damage, or invasion of bacteria. Initial vessel constriction occurs and a loose fibrin clot forms a ‘plug’ loosely uniting the skin edges. If sutured, wound strength at this stage depends on the suture and any breakdown is the result of poor closure. Mast cells release histamine, resulting in vasodilation, increased capillary permeability, and swelling, and neutrophils are attracted by kinins. As the capillaries dilate, tissue fluids rich in plasma proteins, antibodies, red cells, white cells, and platelets ‘leak’ into the tissues. Platelets release growth factors and fibronectin, which promote cell migration and wound healing. Macrophages are attracted and these remove any wound debris, thereby beginning the process of repair. Signs of inflammation are heat, swelling, redness, and pain.

Reconstructive phase

Macrophages stimulate the formation of fibroblasts, which migrate along fibrin threads and produce collagen. Fibroblasts are important in the production of the extra-cellular matrix (granulation tissue). They produce collagen, fibronectin, and proteoglycans, such as hyaluronic acid. Fibrin is produced from the second day and forms a weak framework for healing. Immature blood vessels develop (angiogenesis) providing oxygen and nutrients to the wound. It therefore becomes filled with capillaries and collagen fibres—'granulation tissue', which appears deep red in colour and bleeds easily. Granulation tissue is abundant in secondary intention healing, although not seen as much following primary closure. It is important in scar formation. In addition, the wound undergoes contraction. This may be responsible for 40–80% of wound closure.
Epithelialization or proliferative phase
Re-epithelialization is usually evident within 24h. Cells at the wound edges migrate across the surface—this can only take place over a healthy moist wound. If infection or debris are present, the inflammatory phase is prolonged and migration will not take place. 'Scabs' are separated from the wound by proteolytic enzymes. Collagen continues to be produced, resulting in a red, raised, and often unsightly scars. Wound strength increases rapidly but is still relatively weak and can stretch if not protected.

Maturation phase
Remodelling takes place over several years, with a reduction of both cell content and blood flow. The vascularity of the wound decreases and the scar changes colour, fading to a silvery white appearance. Collagen fibres re-align themselves, tending to lie at right angles to the wound, increasing the strength of the scar. At one year, 70% or more of the original tissue may be regained, but scar tissue is never as strong as unwounded tissue.

Secondary intention healing
Wounds may gape following trauma or infection, coupled with the elastic pull of the dermis on each side. This defect initially fills with blood clot, which dries to form a scab. In small, uninfected wounds, re-epithelialization begins from the wound edges, passing under the scab. The scab is gradually lifted at its edges until it falls off. The wound heals from below upwards. Capillary loops and fibroblasts form granulation tissue giving a velvet appearance to the wound. Myofibroblasts in the wound contract and reduce the volume of the defect.

The difference between primary and secondary intention healing is quantitative only.

Healing chronic wounds
Because of the rich blood supply to the head and neck, most wounds heal quickly. However, when chronic wounds occur, they can be difficult to treat and, depending on their site, quite disfiguring.

In any patient with a non-healing, chronic wound, ask yourself why has it not healed? Consider the possibility of underlying:
- foreign body;
- infection;
- malignancy;
- immunosuppression.

Management strategies
Consider any predisposing conditions (local or systemic).

Dressings
In recent years there has been the development of dressings that promote a moist environment to assist healing. In animals, re-epithelialization of partial thickness, acute wounds occurs more rapidly if it is occluded. In patients they reduce pain. As yet there is still not a dressing that can alter the healing cascade, although dressings containing hyaluronic acid seem to promote healing.
Topical growth factors
Clinical results from application of growth factors to chronic wounds have not been as good as initially hoped. To date, only platelet derived growth factor has been licensed for use, but only for treating non-infected foot ulcers in diabetic patients (becaplermin, regranex). Other factors showing some promise include granulocyte colony stimulating factor, fibroblast growth factor, and epidermal growth factor.

Skin grafts
Split thickness and pinch skin-grafting techniques are very useful, so long as there is no infection and a healthy bed on which to place the graft.

Synthetic ‘skin’
Previously, cultured patient’s epidermal cells, in which a skin biopsy was cultured to produce epidermal sheets, were used following in burns. These have had only limited success due to graft fragility, difficulty in application, poor rate of uptake, and the frequent occurrence of infection.

More recently synthetic skin equivalents have been developed, in which donor tissue with reduced immunogenicity is used.
- Alloderm is a dermal matrix without immunogenic cells.
- Integra is a combination of dermal fibroblasts and bovine collagen.
- Dermagraft consists of non-immunogenic neonatal fibroblast cultured on a polyglactin mesh.
- Apligraf contains both epidermal and dermal components.

All of these products have been used to treat burns. They are absorbed into the wound bed and are thought to alter the profile of cytokines

Future developments
Vascular endothelial growth factor and proteinase inhibitors may have a role in improving healing of chronic wounds. Gene therapy may allow genes important in healing to be delivered directly into a wound. Another potential treatment lies in embryonic stem cells.

Risk factors in wound breakdown
General
- Advanced age.
- Malnourished (protein, vitamins, trace elements).
- Anaemic.
- Uraemic.
- Jaundice.
- Malignancy (cachexia).
- Chronic steroid therapy.
- Diabetes mellitus.
- Nutritional deficiencies (vitamin C, vitamin K, hypoproteinaemia, zinc).
- Chemotherapy and radiotherapy.

Local
- Tension.
- Infection.
- Crushed tissues (forceps, tight sutures).
- Poor tissue vascularity eg after irradiation.
- Foreign body, e.g. dirt, gravel, glass.
- Necrotic tissue (crushed, excessive use of diathermy).
- Haematoma.

**Non-healing**

Many factors can impair healing.

**Local factors**
- Foreign bodies.
- Tissue maceration.
- Ischaemia.
- Infection.
- Malignancy.
- Systemic factors
  - Advanced age.
  - Malnutrition.
  - Diabetes.
  - Renal disease.
  - Steroids.
  - Immunosuppressive drugs.

At a cellular level, tissue growth factors are reduced and an imbalance between proteolytic enzymes and their inhibitors occurs. Chronic ulcers seem to have reduced levels of platelet derived growth factor, fibroblast growth factor, epidermal growth factor, and transforming growth factor compared with acute wounds. Excessive proteinase activity (notably matrix metalloproteins) results in abnormal degradation of the extracellular matrix and fibroblasts have impaired responsiveness to growth hormone.

Research into newer treatments is directed at altering the imbalance by the topical application of proteinase inhibitors, or by combining proteinase inhibitors with growth factors.

**Classification of early wounds**

Wounds may be classified as ‘clean’ or ‘untidy’. Clean wounds have the greatest chance of healing with minimal scar formation.

**Clean**
- Sharp incision.
- Uncontaminated.
- Less than 6h old.
- Low energy trauma.

**Untidy**
- Ragged edge.
- Contaminated.
- More than 12h old.
- High energy trauma.
- Crushed tissue.
- Tissue loss.
- Burns.
There are many ways to assess a wound. Five types are described:
- black or necrotic;
- infected;
- sloughy;
- granulating;
- epithelializing.

**Black or necrotic wounds**
These are covered with a dry hard eschar, which can vary in colour (off white/yellow to brown/black). This may increase in size if not debrided (surgically, chemically, or biochemically). Dressings based on hydrocolloid or hydrogel or an enzymatic desloughing agent can be used. If a cavity wound is necrotic it can produce a heavy exudate and become very offensive. Alginate dressings may be used to control the exudate.

**Infected wounds**
All wounds have bacteria present but many do not have clinical evidence of infection, i.e. pus. Commensal organisms do not necessarily delay healing and cause infection. Signs of infection include:
- cellulitis/abscess formation;
- discharge
- localized heat;
- localized pain;
- oedema;
- pocketing at the base of the wound;
- delayed healing;
- wound breakdown
- offensive smell.

A wound swab should be taken. Antibiotics are not always required, some wounds can be treated topically. Flammazine is useful when *Pseudomonas* is present and iodine-based dressings have been shown to be effective against MRSA (methycillin-resistant *Staphylococcus aureus*). Hydrocolloids and hydrogels are also useful, but not when there is excessive exudate. An alginate may be appropriate in this instance but will require changing daily.

**Sloughy wounds**
These consist of dead neutrophils in exudate. The wound has a white/yellow appearance. Sometimes there is excessive exudate. Hydrocolloid, hydrogel, or alginate is useful in these cases.

**Granulating wounds**
These are red and granular in appearance. They bleed easily as the capillary loops are friable. Dressings such as hydrocolloids, hydrogels, foams, and alginates are all useful in low-exudating granulating wounds. In a more heavily exudating wound, an alginate or foam dressing can be used. Some granulating wounds develop excess granulations, silver nitrate sticks can be used to cauterize the excess.
Epithelializing wounds
These have pink/white tissue present as the epithelial cells spread over the granulating tissue. A moist, warm environment needs to be maintained, as well as one that is protective. Dressings such as hydrocoloioids and foams are, therefore, appropriate.
Wound cleansing

The general aim of wound cleansing is to remove any organic and inorganic debris from the wound before applying a dressing. Debris can delay the healing process and result in infection.

A number of antiseptics are available but it is now thought that they can delay healing and harm the tissues. Sterile saline solution or water are not harmful to the wound and are recommended. However, swabbing a wound can damage granulating tissue and may leave small fibres in the wound, which can be a focus for infection. It is much better to irrigate wounds, where possible. A 35ml syringe and a 19-gauge needle can be used, which should not exert too much pressure on the wound. Tap water is increasingly used to cleanse wounds. Ideally warm irrigant should be used to optimize healing.

Methicillin-resistant staphylococcus aureus (MRSA)

MRSA is a human pathogen that is resistant to a number of antibiotics, not only methicillin. Some strains show the potential to become epidemic (EMRSA). To most fit and healthy people, MRSA is not a threat. However, to those undergoing major or even minor maxillofacial surgery, it can cause serious harm.

The pathogens can colonize a particular site, e.g. nose or throat, without necessarily producing any symptoms. Staphylococci are Gram-positive organisms that grow on the surface of the skin, in the nostrils, mouth, umbillicus, and perineal areas. Since the introduction of antibiotics, Staphylococcus aureus has shown a history of resistance, firstly with penicillin then methicillin. Vancomycin is the antibiotic commonly used to treat patients with MRSA, but now there are concerns regarding resistance to it (VRSA).

Patients at risk include:

- immuno-compromised patients;
- the elderly or neonates;
- patients with wounds or skin lesions;
- patients who have had several hospital admissions in the past year;
- patients transferred from other areas where MRSA is prevalent;
- patients admitted from abroad.

The principle method of cross infection is hand carriage, although it can also be airborne. Other sources include clothing and bedding.

All patients with a positive result should be nursed in isolation. They should also commence a decontamination regime, which should be available in every Trust. Decontamination takes around one week followed by re-swabbing two days later. If the swabs are again positive, than the decontamination regime is repeated until the results are negative. If the swabs are negative, the screening process is repeated until there are three clear screens. Even then it is not advisable to nurse the patients in the same area as those patients deemed to be at risk.
Soft tissue injuries

General points

- Consider injuries to underlying structures (bones/eye/lacrimal gland/parotid duct/canthal attachments).
- Consider the possibility of tattooing and scarring—can this be managed in A&E or should I refer?
- Soft tissue injuries are best evaluated after the wound has been cleaned of dry blood and debris. A local anesthetic may be necessary to clean the wound so that a thorough examination can be made.
- Where applicable assess the facial nerve prior to anesthetic use.
- Accurately document the injuries, ideally photographically.
- Consider tetanus prophylaxis.
- Ideally repair should be performed within 12h.
- Because of the rich vascular supply of the head and neck, only minimal debridement is necessary. Preservation of tissue is the rule—if in doubt leave.
- When suturing wounds, alignment of key anatomic boundaries (vermilion border, gray line of the eyelid) and alignment of the eyebrow, should be performed first. With lip lacerations, it is important to align the vermillion border for good comesis. Place the first stitch to re-approximate the vermillion border.
- Close in layers (mucosa to mucosa, muscle to muscle, and skin to skin). Deep sutures are used to close dead space and remove tension from the skin to prevent hematoma and scarring.
- With deep lacerations of the cheek, the wound should be explored for injury to the parotid duct and, if possible, the duct is repaired over a stent.
- If facial nerve weakness results from a laceration medial to a line dropped perpendicular to the lateral canthus, the nerve branches are not repaired. (The nerves are generally too fine.) If, however, paralysis results from a laceration posterior to this line, the facial nerve should be repaired. Ideally, repair should occur as soon as possible, but no later than 72h unless the wound is heavily contaminated (e.g. gun shot). In this situation, the nerve endings are tagged and repair is performed when the wound is clean.
- With significant tissue loss, similar tissues should be re-approximated: mucosa to mucosa, muscle to muscle, cartilage to cartilage, and skin to skin.
- Consider drains.

Following trauma, partially avulsed skin, even if attached by only a small pedicle, may still have a good enough blood supply to enable it to heal, if replaced. If in doubt, save tissue—never excise widely.

Wound closure is a most effective form of analgesia.

In addition to the obvious skin and mucosa, assessment of soft tissue injuries must also include associated specialized structures. These include:

- fractures;
- salivary gland and/or duct (e.g. parotid);
- lacrimal apparatus;
Fig. 8.44  Wound assessment—always separate the edges and assess depth before attempting to suture.

Fig. 8.45  Wound assessment—consider the possibility of underlying fractures.

- nerve injury (facial, accessory, supra-orbital, supra-trochlear, infra-orbital, mental)—see Microsurgical nerve repair below.
- major vascular injury (especially in neck lacerations);
- loss of function of eyelids;
- loss of function of lips.

In penetrating injuries and lacerations, foreign bodies and contamination must be considered. If grit is not removed early tattooing can result, which is extremely difficult to remove later. Underlying fractures must also be considered and treated before any wounds are closed definitively. The patient’s tetanus status should be assessed and managed appropriately.
CHAPTER 8 Injuries to the face, nose, and ears

Fig. 8.46 Wound assessment—consider the possibility of underlying fractures.

Fig. 8.47 Wound assessment—consider the possibility of foreign bodies.
Immediate primary closure with complete haemostasis and accurate restoration of anatomy should be the aim whenever possible. In most cases, head and neck wounds can be closed primarily with acceptable results. The blood supply to the tissues is a major factor in this and it is essential that the surgery itself does not damage wound edges. Provided the tissues are alive, even wounds heavily colonized with bacteria can be closed, primarily using appropriate antiseptic and antibiotics. This is seen particularly with intra-oral wounds, which are all heavily contaminated with oral bacteria.

**Bites**

Whether animal or human in origin these must be considered serious and managed quickly. Both can rapidly become infected if left too long. Check for tissue loss and tetanus status (follow local protocols).

Compared to elsewhere in the body, bites on the face can be closed primarily due to its rich blood supply. However, they must be thoroughly cleaned and irrigated, and sutures placed sparingly to allow any collections to drain. Broad spectrum antibiotics should be prescribed and, ideally, take a wound swab for culture. Warn the patient about scarring.

**Abrasions**

These need to be thoroughly, but gently cleaned to remove all traces of grit and other foreign bodies. This is the best opportunity to manage these well. Tattooing results if this is neglected, which is very difficult to deal with secondarily (excision/dermabrasion/lasers).

**Specialised tissues**

**Eyelid injuries**

This requires specialist care. In the first instance, protect and assess the underlying globe. Assess visual acuity as soon as is practical. Consider foreign bodies and perforating injuries and therefore avoid any pressure on the wounds. As a temporary measure, liberally apply chloromycetin ointment (not drops) to the wound.

**Parotid injuries**

Lacerations along the side of the face must be carefully assessed to exclude injuries to the parotid gland, parotid duct, and, most importantly, facial nerve. Injuries to the duct and nerve must be repaired using microsurgical techniques before the skin is closed. Failure to repair the duct may result in the formation of a 'sialocele', which will eventually drain through the wound, resulting in a salivary fistula. Failure to repair the nerve may result in various degrees of facial weakness.

**Nerve injuries that may benefit from exploration and repair**

These include:

- **Facial nerve**—this may be damaged following trauma (or surgery) to the parotid region. If necessary, immediate repair can be delayed and the nerve endings marked with sutures.
- **Accessory nerve**—injury to this nerve may occur following trauma (also following lymph node biopsies or neck dissection). Loss of function of the trapezius muscle results in limitations of shoulder motions.
Inferior alveolar nerve—injury may occur as a result of a mandibular fracture. It can also occur following wisdom tooth removal, jaw surgery, tumour resection, fracture fixation, and placement of implants. This can result in numbness or ‘dysaesthesia’ in the lower teeth, the lower lip, and the chin. This should be reconstructed within 3–4 weeks after injury.

Principles of initial wound care

Decontamination and debridement
All wounds should be thoroughly cleaned and foreign bodies such as dirt and glass should be removed. However, over-vigorous scrubbing can cause further damage. All dead tissue should be excised and, if wound edges are ragged, trimming to form a straight line may be useful.

Wound closure
Suturing is the commonest method of wound closure. Metal clips, adhesive tapes, and glues are also available, they are more difficult to use but can be quickly applied. Accurate skin apposition is, however, difficult to achieve and, consequently, they tend to be reserved for lacerations involving the scalp. The epidermis and underlying tissues are accurately realigned to eliminate ‘dead’ space beneath the surface. A well-opposed everted wound edge is the aim to compensate for flattening during wound contracture.

Fig. 8.48 Deep laceration over the parotid—what structures are at risk?

- Inferior alveolar nerve—
Soft tissue injuries of the head and neck

Checklist—indications for treatment
Presence of abrasions, lacerations and/or avulsions
- Evidence of contamination/foreign bodies.
- Penetrating wounds.
- Burns.
- Motor and/or sensory nerve deficit (5th and 7th cranial nerves).
- Vascular injury.
- Injury to salivary gland and/or duct.
- Injury to lacrimal apparatus.
- Other loss of function of eyelids and/or lips.

Factors affecting the risk
- Association with multiple injuries.
- Impairment of the airway.
- Presence of uncontrolled haemorrhage.
- Presence or absence of contamination/infection.
- Site and extent of lacerations/abrasions.
- Presence or absence of skin/mucosal loss.
- Degree of burn.
- Involvement of specialized structures.
- Presence of severe oedema/emphysema.
- Time lapse between injury and treatment.
- Co-operation of the patient.
- Propensity to keloid/hypertrophic scar formation.
- Systemic disease or treatment that will affect healing.
- Medical/surgical status.
The closure of wounds

This may be classified as ‘primary’, ‘delayed primary’ or ‘secondary’.

**Primary closure**

Clean wounds are closed as soon as possible with **meticulous care, haemostasis, and accurate repositioning** of the tissues. Deep wounds are closed **in layers**, using resorbable sutures. In some cases, where tissue has been damaged, **trimming of the edges** may convert an untidy to a clean wound, which can then be closed primarily. However, compared to the elsewhere this is kept to a minimum. If doubt exists about viability, tissue is often left **in situ**. To widely excise tissues on the face may lead to difficulties in closing the defect cosmetically, particularly near the eyes, nose, and mouth, which may become distorted. There should be **no tension** across the wound. In cases where tension exists as a result of tissue loss, undermining of the skin, local flap closure, or skin grafts may be used.

**Delayed primary closure**

When doubt exists about the status of a wound, it can be maintained with moist dressings, antiseptics, and antibiotics for several days. This is useful in **heavily contaminated wounds**. Dead tissue will then ‘declare itself’ and can be excised, allowing primary closure. Following excision of obviously necrotic tissue, a non-adherent dressing is placed or the wound lightly packed. It is then be inspected under sterile conditions a few days later. If there is no evidence of further necrosis or infection, it can then be closed.

**Secondary closure**

This is the same as secondary wound healing. It is generally avoided if the face and neck because of contractures and cosmesis. If unavoidable, skin grafts are often placed on the wound bed to minimise these.
Suturing and suture removal

When carried out correctly, this provides excellent cosmetic results. Many different sutures are now available, but are generally classified as:
- absorbable—polyglactin (vicryl) and polyglycolic acid (dexon);
- non-absorbable—silk, nylon, and prolene.

They may also be classified according to structure—monofilament, twisted, or braided. Monofilament sutures minimize infection, produce less tissue reaction, and are the suture of choice for skin. Braided sutures, e.g. silk, have plated strands, which provide secure knots but may entrap material providing a focus for infection. Traditionally, silk has been used for routine suturing in the mouth, as it is easy to handle, strong, and the ends are comfortable for the patient. However, vicryl is also popular, particularly since it resorbs and does not need to be removed. Which of these is used, often depends on the preference of the surgeon.

Sutures placed in the face and neck tend to be removed at around five days, or earlier in delicate tissues. ‘Cross-hatching’ of a scar occurs as a result of closing the wound under tension. Ischaemia of the deeper tissues damages the skin and stimulates excess collagen formation. Such scars are difficult to improve and may require further excision and primary closure. Early removal and continued support with steristrips reduces the chances of scarring as a result of the sutures themselves. Subcuticular sutures may be kept in place for longer, as scarring is less likely. With neck lacerations, sutures are often retained for longer (7–10 days). Scalp sutures are similarly left for 7–10 days or absorbable ones used instead. In patients with poor wound healing, e.g. on steroids, with malignancy, infection, or cachexia, the sutures may need longer. Absorbable sutures are useful for deep stitches, either as part of a layered closure or for subcuticular skin closure.

‘Steristrips’ and ‘glue’

These are particularly useful in children and those who will not co-operate. However, care is required in patient and wound selection. Only superficial and scalp wounds should be considered. The final cosmetic results are less predictable than with carefully placed sutures, as deep wounds require deep sutures. Although simpler to do, gluing can still be quite tricky—be careful not to glue your glove to the patient—although it can be removed, it is very embarrassing!
Soft tissue injuries—tissue loss

This is relatively uncommon but may be seen, for example, following gunshots (attempted suicides), road traffic accidents, or industrial accidents. Significant tissue loss may also occur following relatively minor injuries (animal/human bites to the ears, lips, and nose). Particularly following trauma, tissues may be displaced, rather than lost, but nevertheless result in significant problems.

With such injuries there is **often significant associated bone, brain, or ocular injuries**, and these may need to be dealt with prior to soft tissue reconstruction. However, occasionally only the soft tissues are involved, for example, following scalp avulsions. With the use of microsurgical techniques many defects can now be either reconstructed using ‘free flaps’ or, in selected cases (scalp avulsions), the tissues replaced and the circulation restored by vessel anastamosis.

Repair or reconstruction depends on many variables. Associated injuries may take priority. **Early repair is ideal** especially with avulsed tissue. However, if there is **gross swelling or contamination, a delayed approach may be necessary**. Following initial debridement the wound needs to be protected and dressed until reconstructed. **Local flaps** are often useful where tissue loss is not extensive and has the advantage that the tissue used is similar to that lost (e.g. Abbe flap for lip reconstruction). For elective reconstructions, **tissue expansion** can be of use. However, where the defect is extensive, larger flaps may be necessary. These can be either pedicled or free flaps depending on the defect and general condition of the patient. Where necessary, bone can also be raised with the flap in cases where bony defects are present (e.g. mandible).

Major tissue loss and gun-shot wounds

This is uncommon but may arise following assaults, industrial injuries (scalp avulsions), or pedestrian–motor vehicle collisions. The initial approach is no different to other injuries, i.e. ATLS. However, bear in mind that there can be **significant airway problems, blood loss, and a high risk of infection**. Once stabilized, gently clean the wounds and try to re-align the tissues. This prevents kinking of the vessels, which can necrose distal tissues.

Definitive management

Recent advances in biomaterials, and our understanding in microvascular reconstruction, now means that just about any defect in the cranio-facial region can be reconstructed. Unfortunately, although in most cases functional requirements can be met, in many patients, particularly when skin or specialized structures are involved, some stigmata of their disease persists. The eye, for instance, can not be replaced and invisible scars do not exist. However, results are considerably better than 20 years ago. It is an exciting time in deformity care.

The main choice is between using tissues from the patient (autogenous transplants) or synthetic materials. Each has its own advantages and disadvantages (risks of infection, donor site morbidity, costs, etc.) and each has its own advocates. With the recent problems of prion transmission, animal-derived products are rarely used now. The ability to grow tissues,
either in the lab or on the patient, is the most recent of innovations and we are moving from an era of ‘tissue transplantation’ into one of ‘tissue induction’. Bone morphogenic protein, distraction osseogenesis, bone transportation, and prefabricated ‘free flaps’ are such developments. Unfortunately, many of these techniques are still relatively unproven in the long term and are quite expensive.

Fig. 8.49  Loss of tissue following dog bite.

Fig. 8.50  Local flap in lip reconstruction.
Usually tissue loss is a mixture of both hard and soft tissues. A general principle is to ‘replace like with like’ wherever possible.

**Tissue expansion**

Tissue expanders are inflatable bags with an injection port, placed under the skin, most commonly the scalp. Repeated injections of saline into the bag progressively distends it and the surrounding skin stretches and regrows to adapt. This provides a surplus of skin, which after removal of the expander can then be used in local reconstructions. Advantages include:

- similar appearance and texture;
- retention of sensations;
- limitation of surgery and scarring to one region.

This technique has proved successful for expanding scalp skin to reduce traumatic alopecia (hair loss) and ear reconstruction. However, the procedure is not without complications; expansion of neck skin may produce pressure on the deep structures and expansion of scalp causes reciprocal depression in the underlying skull.

**Local skin flaps**

Where a small amount of tissue has been lost, local skin flaps may be used to close the defect. Closure of wounds under tension may not only break down or result in a stretched scar, but may also distort nearby structures.
such as the lips, nose, etc. Many flap designs are described. These make use of the fact that there is often excess skin on the face, which is highly vascular, elastic to a degree, and can therefore be undermined and used to close nearby defects. Well-defined ‘axial flaps’, e.g. glabellar flap, nasolabial flap, may be raised, based on a small pedicle through which feeding vessels pass. So long as these are preserved and not kinked during rotation of the flap, large areas of skin can be used to facilitate tissue closure. Random pattern flaps, however, require a broad attachment at the base, if necrosis is to be avoided. In contrast with the remainder of the body, the skin of the head and neck is very well vascularized and the success rate of local flaps is generally very high. These techniques are particularly useful in the reconstruction of nasal tips, eyelids, and lips.

Parotid injuries

Lacerations along the side of the face must be carefully assessed to exclude injuries to the parotid gland, parotid duct, and, most importantly, facial nerve. Injuries to the duct and nerve must be repaired, often using microsurgical techniques, before the skin is closed. Failure to repair the duct may result in the formation of a ‘sialocele’, which will eventually drain through the wound resulting in a salivary fistula. Failure to repair the nerve may result in various degrees of facial weakness.

Microsurgical nerve repair

Repair of damaged or severed nerves is now possible with the use of the operating microscope. Both direct suturing of the cut ends or ‘interpositional’ nerve grafting may be carried out, depending on the type of injury. Good results have been obtained following reconstruction or repair of the accessory and facial nerves. However, reconstruction of sensory nerves has a lower success rate, but is still often of benefit to the patient. Ideally, early repair (within 24h) is preferable and should be carried out if there is no infection or significant associated soft tissue trauma. With the facial nerve, successful late repair is limited by wasting of the facial muscles, which occurs around 6–12 months after injury. In long-standing cases of facial palsy with atrophy of the facial muscles, free flaps of muscle with their associated nerves and vessels have been used.

Examples of nerve injuries which may benefit from exploration and repair include:

- **Facial nerve**—this may be damaged following trauma or surgery to the parotid region. If necessary, immediate repair can be delayed and, at the time of wound closure, the nerve endings marked with sutures. Reconstruction may also be undertaken in those cases of malignant tumours of the parotid gland, which require sacrifice of the facial nerve.

- **Accessory nerve**—injury to this nerve may occur following trauma, lymph node biopsies, or following neck dissection. Loss of function of the trapezius muscle results in limitation of shoulder motions.

- **Lingual nerve**—this supplies sensation and taste to the anterior two-thirds of the tongue. It may be damaged during surgical removal or a lower third molar. Repair, ideally, is undertaken within 6 months following injury.

- **Inferior alveolar nerve**—injury may occur following wisdom tooth removal, orthognathic surgery, tumour resection, fracture fixation,
and placement of implants. This can result in numbness of ‘dysaesthesia’ in the lower teeth, the lower lip, and the chin. This should be reconstructed within 3–4 weeks after injury.

Since the facial and accessory nerve are purely motor nerves, and the lingual and inferior alveolar nerves mostly sensory nerves, repair can be simply carried out by alignment of the nerve stumps or by nerve grafting. Manipulation of the nerves must be kept to a minimum, as this stimulates scar tissue at the suture site, which can prevent nerve growth. It is essential that there is no tension across the repair. The least number of sutures consistent with accurate alignment are used. Where grafting is required, the great auricular and the sural nerve are often used.
Surgical drains

Drains in the head and neck are generally used:

- to provide drainage of infected material (abscess);
- to prevent the collection of blood or fluid between two large raw surfaces (following neck dissection, coronal flap);
- where a large potential space exists for blood to collect, which cannot be closed (following removal of submandibular gland, thyroid).

Drains should not be used as a substitute for poor surgical technique and haemostasis should be established before wounds are closed. However, ‘reactive’ haemorrhage can occur, i.e. as the patient recovers from the anaesthetic, their blood pressure rises and previously closed vessels may open and bleeding restart. This probably happens to a minor degree in all patients and draining the small amount of blood that is released prevents the formation of haematoma, which may become infected.

Drains may be left protruding from the skin and simply covered with an absorbent dressing, e.g. following abscess drainage. Fluids drain under gravity. Alternatively, they may be connected to a vacuum container. If the wound is not airtight, or if there is persistent accumulation of fluid, the drains may be placed on continuous low pressure suction.

‘Shortening a drain’ means withdrawing it bit by bit to allow the cavity to seal up gradually, while still allowing fluids to drain. This is rarely necessary following head and neck surgery, as most drains are usually quite small. It may be of use, however, following incision and drainage of an extensive abscess, e.g. Ludwig’s angina, to prevent further collection of pus.
Scars

All wounds extending deeper than the epidermis heal with scarring. The aim is to minimize this to cosmetically and functionally acceptable levels. In uninjured skin, collagen synthesis and breakdown is balanced. However, during healing there is a marked rise in collagen production. This reaches a maximum at around one month, then falls slowly to pre-injury levels. Early on the scar is red, hard, and sometimes itches. Temptation to try and improve the scar before maturation must be resisted. However, improvements in its appearance can be achieved by regular wound massage with a moisturising cream, which encourages breakdown of collagen. It takes about 9–12 months for a scar to mature, during which significant improvements in appearance can be achieved. The wound eventually becomes less vascular, softens, and flattens. Scarring is due to an excess of collagen in the proximity of the wound.

Factors that promote poor scars:

- healing by secondary intention;
- healing of wounds under tension;
- continuing tension on a maturing scar;
- poor vascularity, e.g. diabetes, irradiation;
- dead tissue, e.g. crushed;
- linear wounds running perpendicular to crease lines or linear lines.

Hypertrophic scars and keloids

In some cases scar tissue continues to thicken. A hypertrophic scar remains confined to the wound closure and may soften and flatten after several years. A keloid, however, continues to overgrow and may involve previously undamaged tissue. They can become very bulky. The difference between the two is one of extent rather than structure. Keloids occur more commonly among blacks than whites and are often seen after burns. In the early stages, massage with a moisturiser maintains the suppleness of a scar. Regular intra-lesional steroid injection over 3–4 months may be useful for rapidly growing keloids. Alternatively, steroids may be applied topically (Helan tape). Sustained pressure on the scar (some silicone dressings) has been shown to improve flattening and softening. However, this must be continuous and maintained for 6 months to be of any use. Face masks have been designed and are of most use in burns patients. Surgical excision may be necessary for very large keloids, however, there is a high incidence of recurrence. Radiotherapy was used in the past but is no longer used because of the risk of radiation-induced cancer.

Management of established scars

This depends on the particular characteristics of the scar.

- Shortened scars—scar contract during maturation, and may distort adjacent structures, particularly around the mouth, base of nose, and eyes. Lengthening of the scar may be carried out by rearrangement using a technique of ‘Z-plasty’.
- Shelf scars—semi-circular scars contract unequally along each side and the inner part often bulges over the outer (pin-cushioning). This is difficult to correct, but may be improved by increasing its length using multiple Z-plasties.
- Widened or stretched scars—tension across the wound or repeated movement can lead to this. These can be excised and resutured. Supporting the wound with adhesive tape (e.g. steristrips or subcuticular suture) during the first month will minimize recurrence.
- Tattooing—this occurs following inadequate removal of grit, etc., at the time of primary closure. Dermabrasion or excision and primary closure is the best way of removing tattooed tissue.
- Badly aligned scars—scars running in natural skin creases are less noticeable than those running across them. Some may therefore be realigned using a Z-plasty changing the direction of the scar by 90 degrees.
- Uneven scars—these can be improved by multiple interdigitating flaps (‘W’ plasty, ‘geometric broken line closure’) following excision of the scar. By creating irregularities in the new scar, this breaks up the straight line appearance.
Paediatric facial trauma

General considerations

Paediatric facial injuries commonly occur following falls, bicycle accidents, road traffic accidents, and sporting accidents. Emergency admission to hospital can be a very stressful, frightening, and anxiety-provoking experience for the child and family. The injured child will be unprepared for what is about to happen and will need constant explanations. If possible, the parents should be allowed to stay with their child during all investigations and treatments. They too will require support and information.

During an emergency admission, children are often in pain while being subjected to a strange and unfamiliar surrounding. They need a calm, relaxed, and unhurried admission process. Children are compliant if they are comfortable and pain-free, if they understand what is happening to them, and if they have their parents in attendance with them. Most paediatric emergency admissions are not life-threatening and time can therefore be spent explaining and preparing the child and parent for their surgery and hospital stay.

Unfortunately there is a tendency with emergency admissions to perform procedures and treatments quickly, and sometimes the child’s needs can be overlooked. Any emergency admission is made worse by any need for surgery. Remember, this may be the first time the child has been admitted to hospital, let alone have to undergo a surgical procedure. All explanations given to the child must be age-appropriate, allowing them to understand the treatment they will receive. Children need to participate in their care in order to maintain a sense of control and an understanding of all events.

Parental participation should be welcomed, the child/parent relationship is unique and can help the child cope with the special tests, procedures, and surgery they may need to undergo. Parents know their children better than anyone and if they are supported and kept informed of their child’s condition, this will benefit the child.

Facial lacerations

Childhood accidents resulting in abrasions, scratches, cuts, and bruises are generally normal events in a child’s lifetime. However, do not forget the possibility that injuries may be non-accidental.

Facial lacerations need to be assessed thoroughly. Facial lacerations can bleed profusely and this adds to what already is a stressful and anxious time. For some children, assessment and management may require a short general anaesthetic, in others it may be possible to use local anaesthetic. This avoids general anaesthesia, but must only be undertaken with the full consent and co-operation of the child and parent.

Initial treatment should be directed towards controlling blood loss and cleaning up the wound. It should be irrigated gently with normal saline and a non-adhesive dressing applied. Analgesia or sedation (if no contraindications) may be given prior to this if necessary. Consider also:
- X-ray for any foreign bodies;
- was the child was knocked out;
- the child’s tetanus status.
If there are no complicating factors, the child should be taken to theatre as soon as possible. Children should only be fasted for the minimum of time required for a safe general anaesthetic. Protocols vary slightly between units but this is approximately 4h for food and 2h for clear fluids. The child and parents should be warned of the possibility of post-operative bruising and swelling, and reassured that this will settle quickly.

Post-operatively, suture lines can be left exposed to the air or supported by steristrips. With traumatized wounds, some surgeons prescribe an antibiotic course, especially if the wound was dirty. The child’s stay in hospital should be short and they can be considered for discharge when fit. At home the suture line will require daily cleaning with normal saline and the parents can be taught this prior to discharge. Crust formation on the wound can prevent optimum healing, resulting in a larger scar.

Sutures are generally removed 4–5 days following surgery. Depending on the number of sutures and the area of injury, the child may need to return to the ward or wound care clinic, or attend the family’s GP practice for removal. If the wound has a large number of fine sutures and is in an awkward place, then an experienced nurse will need to remove them. Some children may require a light oral sedation prior to suture removal. Following removal, the repaired laceration can be supported with steristrips.

The parents should be advised to keep the steristrips in place until they fall off. After 2–3 months they should be encouraged to massage the scar with a moisturising cream to prevent thickening and shrinkage of wounds.

Facial fractures
Do not forget the possibility that injuries may be non-accidental.

Children’s bones are elastic, i.e. they tend to bend or buckle rather than fracture. Therefore, any fracture in a child is a marker of a serious injury and the underlying soft tissues should be considered injured also (e.g. rib fractures and lung contusion).

Children who have sustained facial fractures require immediate assessment of their injuries. A full examination should be performed, as other injuries are often associated. Facial fractures are often associated with a head injury and the neurological status must be investigated and treated accordingly. Facial fractures can also involve the orbit—assess visual acuity. Depending on the age, use a Snellon chart or pictures for younger children.

Clinically there may be pain or tenderness, swelling, bruising, and non-occlusion of their jaw and teeth. Some fractures will be stable and require no further treatment, others may require surgical reduction once the facial swelling has reduced. If possible, nurse upright to reduce the facial swelling. Consider intravenous fluids if the child has difficulty taking fluids orally—they can rapidly become dehydrated.

Post-operatively the child should be nursed in an upright position, as soon as anaesthetic recovery allows. This will help to reduce facial swelling. Ice packs can also be used to reduce swelling, if tolerated. Fluids and a soft diet can be introduced, as tolerated, and any intravenous fluids discontinued. The child should start oral hygiene as soon as possible and must understand the importance of doing so. Mouthwashes should be
used regularly, especially following diet, and the child should be encouraged to continue normal teeth-brushing using a soft toothbrush.

**Paediatric maxillofacial trauma—non-accidental injury**

Any child presenting with an injury to the head and neck that does not appear consistent with the history warrants further investigation. Injuries such as facial fractures, torn frenulum, bites, puncture wounds, and ocular trauma should arouse suspicion. Where there is suspicion of abuse, advice should be sought from a more experienced individual such as a paediatrician or child protection advisor.

Diagnosis can be difficult at times but a number of clues exist:
- there may be a delay in seeking medical attention;
- the history given is vague and lacking in detail, the account may vary with every telling, and the accounts may differ from person to person;
- the explanation and account of the accident is not consistent with the injury observed;
- parent shows inappropriate reaction to severity of injury;
- the parent’s behaviour gives cause for concern: obvious signs of irritability, and hostility, seldom touches or speaks to the child;
- the child appears fearful, withdrawn, sad, and avoids physical contact with parents;
- when there is disclosure of an abusive act.