3 Principles of fracture treatment

This chapter is concerned with broad principles rather than with details, but the principles can be applied, with suitable modifications, to the treatment of any fracture.

INITIAL MANAGEMENT

Before definitive treatment of a fracture is undertaken, attention must be directed to first aid treatment (Advanced Trauma Life Support (ATLS) principles), to the clinical assessment of the patient with special reference to the possibility of associated injuries or complications, and to resuscitation.

First aid

The doctor who chances to be at the scene of an accident should seldom attempt more than to ensure that the airway is clear, to control any external haemorrhage, to cover any wound with a clean dressing, to provide some form of immobilisation for a fractured limb, and to make the patient comfortable while awaiting the arrival of the ambulance.

When it is necessary to move a patient with a long-bone fracture, it will be found that pain is lessened if traction is applied to the limb while it is being moved. If it is suspected that there may be a fracture of the spinal column, special care is necessary in transport, lest injury to the spinal cord or cauda equina be caused or aggravated. It is most important to avoid flexing the spine, because flexion may cause or increase vertebral displacement, jeopardising the spinal cord. In certain types of fracture, extension is also potentially dangerous to the cord. Accordingly the patient should be lifted bodily on to a firm surface, with care to avoid both flexion and extension. If a cervical collar is available, it should be applied as a protection for the neck before moving the patient, without allowing either flexion or extension of the neck during its application.

Temporary immobilisation for the long bones of the lower limb is conveniently arranged by bandaging the two limbs together so that the sound limb forms a splint for the injured one. In the upper limb, support may be provided by bandaging the arm to the chest or, in the case of the forearm, by improvising a sling.

Haemorrhage hardly ever demands a tourniquet for its control. All ordinary bleeding can be controlled adequately by firm bandaging over a pad. Only if profuse pulsatile (arterial) bleeding persists despite firm pressure over the wound, with the patient recumbent, does the need for a tourniquet arise. Pending its application, firm manual pressure over the main artery at the root of the limb may be applied to control the bleeding. If a tourniquet is applied, those attending the patient should be made aware of the fact and of the time of its application. If necessary, a note to this effect should be sent with the patient to ensure that the tourniquet is not inadvertently left in place for too long.

If morphine or a similar drug is given at the scene of the accident a note to that effect should be sent with the patient on admission to hospital.

Clinical assessment

It must be emphasised again that an immediate assessment of the whole patient is required to exclude injuries to other systems before examination of the skeletal injury. Examination of the limb should determine:

1. whether there is a wound communicating with the fracture
2. whether there is evidence of a vascular injury
3. whether there is evidence of a nerve injury
4. whether there is evidence of visceral injury.

Resuscitation

Many patients with severe or multiple fractures, or fractures associated with other visceral injuries, are shocked on arrival at hospital. Time must be spent on resuscitation and dealing with any other life-threatening injuries before definitive treatment for the fracture is begun. Haemorrhagic shock can develop rapidly when there has been a rapid loss of a large volume of blood. The mainstay of treatment is the immediate replenishment of the circulating blood volume, either with transfused blood when time permits cross-matching, or alternatively by the use of plasma expanders and blood substitutes. Electrolytes, such as isotonic saline or Rimmer's lactate solution, can be used to establish intravenous infusion but are of little value in replacing lost blood. Colloid solutions which remain within the circulation are of more value and include dextran, a high-molecular-weight polysaccharide, gelatin solution derived from animal protein, or a plasma protein fraction solution of human albumin with a small proportion of globulin. Transfusion with colloids or whole blood is usually only required in patients with blood loss greater than 1 litre.

TREATMENT OF UNCOMPLICATED CLOSED FRACTURES

The three fundamental principles of fracture treatment—reduction, immobilisation and preservation of function—are well known, and there is still no better way of discussing the treatment of a fracture than under these three headings.

REDUCTION

This first principle must be qualified by the words 'if necessary'. In many fractures reduction is unnecessary, either because there is no displacement or because the displacement is immaterial to the final result (Fig. 3.1). A considerable experience of fractures is needed before one can say with confidence whether or not reduction is advisable in a given case. If it is judged that perfect function can be restored without undue loss of time, despite some uncorrected displacement of the fragments, there is clearly no object in striving for perfect anatomical reduction. Indeed, meddlesome intervention may sometimes be detrimental, especially if it entails open operation.

To take a simple example, there is no object in striving to replace perfectly the broken fragments of a child's clavicle, because normal function and appearance will be restored without any intervention; the same applies to most

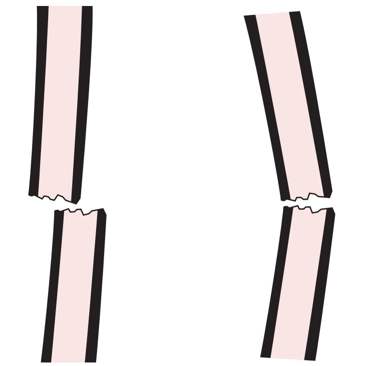


Fig. 3.1 Imperfect apposition (left) may often be accepted, whereas malalignment of more than a few degrees must usually be corrected.

fractures of the clavicle in adults. Likewise there is nothing to be gained in striving for perfect reduction of a fracture of the neck of the humerus in an elderly person—an ideal that may demand open operation for its attainment—when good or better results may be expected from conservative treatment despite imperfect reduction.

In general, it may be said that imperfect apposition of the fragments can be accepted much more readily than imperfect alignment (Fig. 3.1). For example, in the shaft of the femur a loss of contact of half a diameter might be acceptable whereas an angular deformity of 20º would usually demand an attempt at improvement. When a joint surface is involved in a fracture, the articular fragments must always be restored as nearly as possible to normal, to lessen the risk of subsequent osteoarthritis.

METHODS OF REDUCTION

When reduction is decided upon it may be carried out in three ways:

1. by closed manipulation
2. by mechanical traction with or without manipulation
3. by open operation.

Manipulative reduction

Closed manipulation is the standard initial method of reducing most common fractures. It is usually carried out under general anaesthesia, but local or regional anaesthesia is sometimes appropriate. The technique is simply to grasp the fragments through the soft tissues, to disimpact them if necessary, and then to adjust them as nearly as possible to their correct position.

Reduction by mechanical traction

When the contraction of large muscles exerts a strong displacing force, some mechanical aid may be necessary to draw the fragments out to the normal length of the bone. This particularly applies to fractures of the shaft of the femur, and to certain types of fracture or displacement of the cervical spine.

Traction may be applied either by weights or by a screw device, and the aim may be to gain full reduction rapidly at one sitting with anaesthesia, or to rely upon gradual reduction by prolonged traction without anaesthesia.

Operative reduction

When an acceptable reduction cannot be obtained, or maintained, by these conservative methods, the fragments are reduced under direct vision at open operation. Open reduction may also be required for some fractures involving articular surfaces, or when the fracture is complicated by damage to a nerve or artery. When operative reduction is resorted to, the opportunity should always be taken to fix the fragments internally to ensure that the position is maintained (see p. 43).

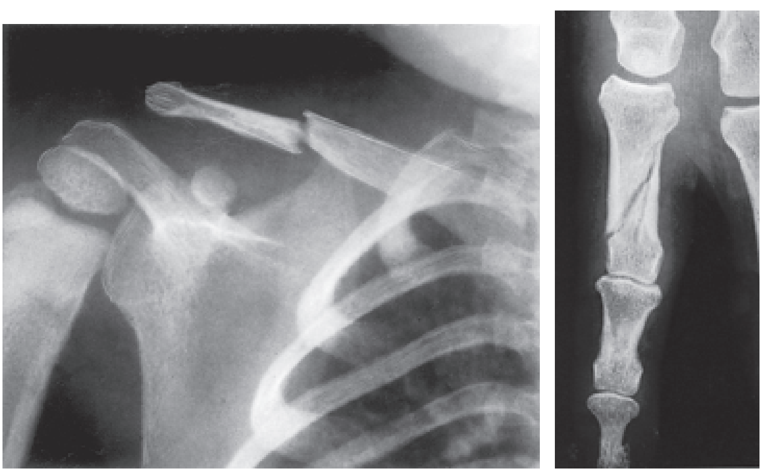
IMMOBILISATION

Like reduction, this second great principle of fracture treatment must be qualified by the words 'if necessary'. Whereas some fractures must be splinted rigidly, many do not require immobilisation to ensure union, and excessive immobilisation is actually harmful in some (Figs 3.2 & 3.3).

INDICATIONS FOR IMMOBILISATION

There are only three reasons for immobilising a fracture:

1. to prevent displacement or angulation of the fragments
2. to prevent movement that might interfere with union
3. to relieve pain.



A B

Fig. 3.2 Two examples of fractures for which immobilisations is unnecessary. A Fracture of the clavicle; B undisplaced fracture of a phalanx of a finger. The fragments are held stable by the intact periosteal sheath.

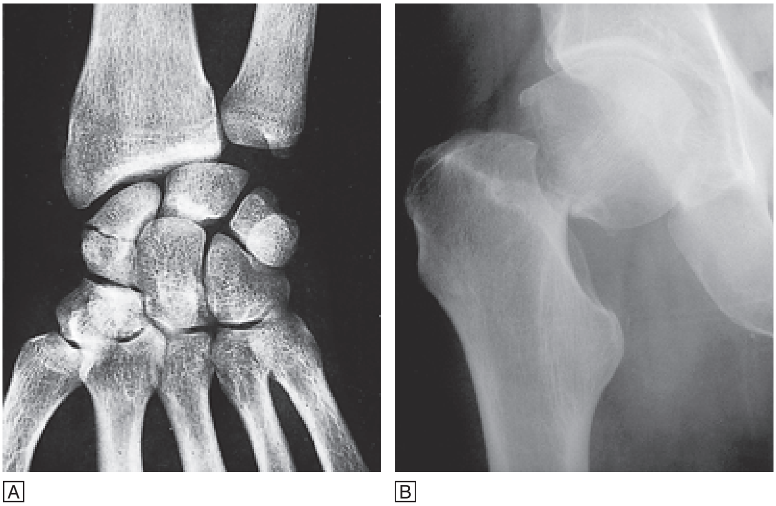


Fig. 3.3 Two examples of fractures that require immobilisation. A Fracture of the scaphoid bone; B fracture of the neck of the femur.

If in a given fracture none of these indications applies, there is no need for immobilisation. It follows from the first of these criteria that, if reduction has been necessary, immobilisation will also be required to prevent redisplacement.

Prevention of displacement or angulation

As a general rule, the broken fragments will not become displaced more severely than they were at the time of the original injury. Therefore, if the original position is acceptable, immobilisation to prevent further displacement is often unnecessary. In fractures of the shafts of the major long bones, however, immobilisation is usually necessary in order to maintain correct alignment.

Prevention of movement

As has been mentioned already, absolute immobility is not always essential to union of a fracture. It is only when movement might shear the delicate capillaries bridging the fracture that it is undesirable, and, theoretically, rotation movements are worst in this respect. There are three fractures that constantly demand immobilisation to ensure their union—namely, those of the scaphoid bone, of the shaft of the ulna, and of the neck of the femur.

Examples of fractures that heal well without immobilisation are those of the ribs, clavicle and scapula, and stable fractures of the pelvic ring. Immobilisation is also unnecessary for certain fractures of the humerus and femur, and many fractures of the metacarpals, metatarsals and phalanges. In some fractures, excessive immobilisation may do more harm than good. The injured hand, in particular, tolerates prolonged immobilisation badly. Whereas the wrist may be immobilised for many weeks or even months with impunity, to immobilise injured fingers for a long time is to court disaster in the form of permanent joint stiffness.

Relief of pain

Probably in about half of all the cases in which a fracture is immobilised the main reason for immobilisation is to relieve pain. With the limb thus made comfortable, it can be used much more effectively than would otherwise be possible.

METHODS OF IMMOBILISATION

When immobilisation is deemed necessary there are four methods by which it may be effected:

1. by a plaster of Paris cast or other external splint
2. by continuous traction
3. by external fixation
4. by internal fixation.

Immobilisation by plaster, splint or brace

For most fractures the standard method of immobilisation is by a plaster of Paris cast. Also available are various proprietary substitutes for plaster, which offer the advantages of lighter weight, radiolucency and imperviousness to water, though at much greater cost. Most such products are also more difficult to apply; nevertheless, they are being used on an increasing scale. For some fractures a splint made from metal, wood or plastic is more appropriate—for example, the Thomas's splint for fractures of the shaft of the femur, or a plastic collar for certain injuries of the cervical spine.

Plaster technique. Plaster of Paris is hemihydrated calcium sulphate. It reacts with water to form hydrated calcium sulphate. The reaction is exothermic, a fact that is evidenced by noticeable warming of the plaster during setting.

Plaster bandages may be prepared by impregnating rolls of book muslin with the dry powdered plaster, but except in a few developing countries, most hospitals now use ready-made proprietary bandages. These are best used with cold water because setting is too rapid with warm water.

Most surgeons use a thin lining of stockinet or cellulose bandage to prevent the plaster from sticking to the hairs and skin (Fig. 3.4). The use of a lining is certainly recommended because it adds greatly to the comfort of the plaster. If marked swelling is expected, as after an operation upon the limb, a more bulky padding of surgical cotton wool should be used.

The plaster bandages are applied in two forms: round-and-round bandages and longitudinal strips or 'slabs' to reinforce a particular area. Round-and-round bandages must be applied smoothly without tension, the material being drawn out to its full width at each turn. Slabs are prepared by unrolling a bandage to and fro upon a table: an average slab consists of about 12 thicknesses. The slabs are placed at points of weakness or stress and are held in place by further turns of plaster bandage.

A plaster is best dried simply by exposure to the air: artificial heating is unnecessary. A plaster will not dry satisfactorily if it is kept covered by clothing or bed-linen.

Synthetic (plastic) splinting materials are applied in much the same way as plaster bandages, usually with warm water. Since they are stronger weight for weight than plaster, fewer layers are required. Moulding to the body contours is more difficult than with plaster bandages.

Fig. 3.4 A layer of stockinet forms a comfortable lining which prevents the plaster from sticking to the hairs. An alternative is to use a single thickness of cellulose bandage. The hand is shown in a position of function, with slight dorsiflexion at the wrist and the thumb opposed.

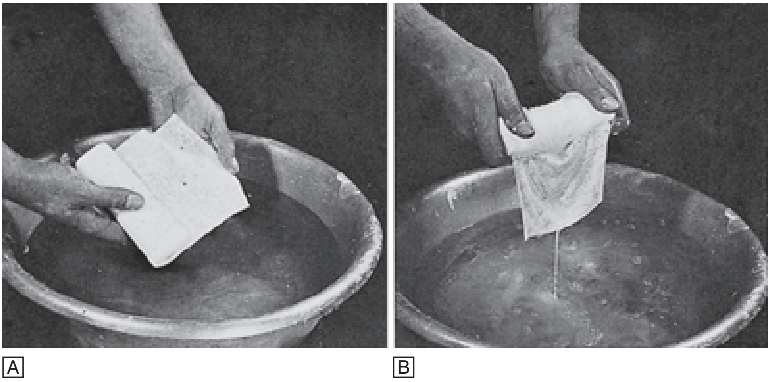


Fig. 3.5 Technique of soaking a plaster bandage. A The end is unwound for a few centimetres so that it will be found easily when the bandage is wet. B The wet bandage is squeezed lightly from the ends but is not wrung out.

Removing a plaster. Despite the development of electrically powered oscillating plaster saws, the traditional plaster-cutting shears must still be relied upon for most plaster-cutting jobs, and it is important that correct use of the shears be fully understood. The shears act on the principle of a punch, not of scissors. There are three essential points to remember in the operation of plaster shears:

1. The line of cut should be over soft tissues and concavities and should avoid the bony prominences (Fig. 3.6).
2. The point of the shears should be slid along in the plane immediately deep to the plaster—in the case of a cotton-lined plaster, between the plaster and the lining.
3. Only one handle of the shears should be oscillated—namely the handle that is farther away from the plaster. If this rule is observed it will be found that

Fig. 3.6 Correct lines of cut for removal of plasters with the hand shears. In the forearm plaster A the cut should be made in the midline of the anterior surface, crossing the wrist in the hollow between the tuberosity of the scaphoid bone and the pisiform bone. Only one cut is required, because the plaster is thin enough to be opened out without difficulty when it has been cut through. In the leg plaster B two cuts should be made. The first cut should be made along the lateral surface and should pass behind the lateral malleolus, in the hollow between the malleolus and the heel. Hence it should extend along the lateral border of the sole of the foot. The second cut should be made along a corresponding line at the medial side of the plaster, passing behind the medial malleolus.

the point of the blade will be directed constantly away from the skin towards the inside of the plaster, and will remain automatically in the correct plane (Fig. 3.7).

The powered oscillating plaster saw is useful for removing a very thick plaster or synthetic cast and for cutting a window through a plaster. Oscillation rather than rotation of the blade guards against its damaging the skin, but care is needed particularly in areas where the skin is adherent to the underlying bone and not freely mobile. It is best to cut down through the plaster in multiple sections each equal to the diameter of the blade, rather than to slide the oscillating blade along the plaster (Fig. 3.8).

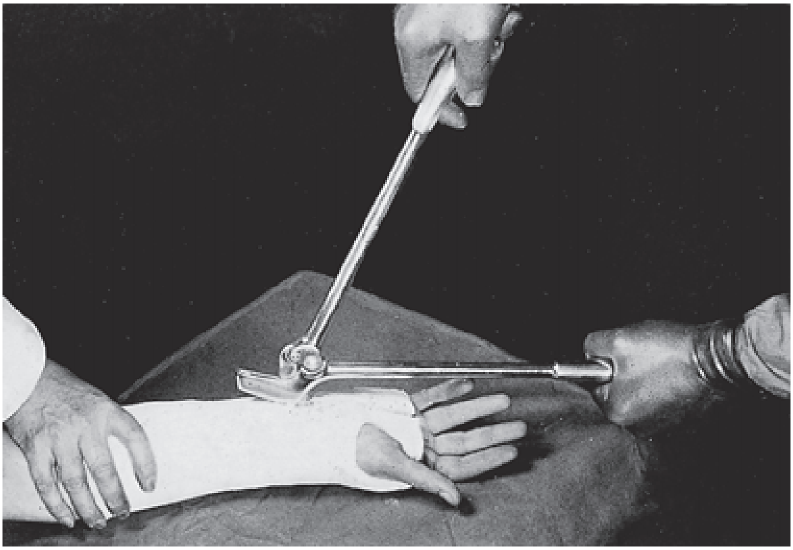


Fig. 3.7 The technique of operating the plaster shears. Only the handle away from the plaster (in this case the one in the surgeon's right hand) is oscillated: the other handle is held steady, parallel to the surface of the plaster. In this way the point of the blade is always directed outwards against the inside of the plaster, away from the patient's skin.

Fig. 3.8 The technique of using an oscillating saw to cut through a plaster cast.

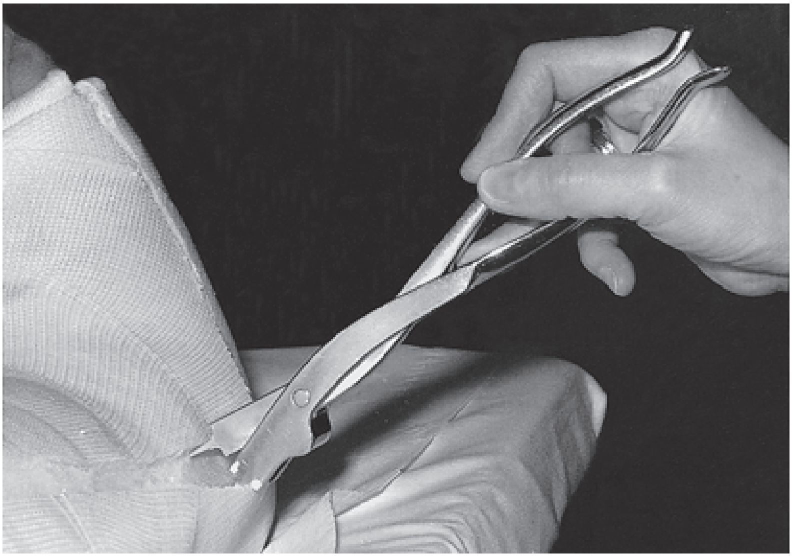


Fig. 3.9 The method of using a plaster spreader to open up the cast after it has been cut with a saw or shears.

Disadvantages of the powered saw are that it is noisy and rather frightening for the patient, and that it creates an unpleasant amount of dust.

The plaster spreader is a useful instrument with which to open up a plaster cast that has been split down one side (Fig. 3.9).

Other external splints. Apart from plaster of Paris, splints that are in general use are mostly those for the thigh and leg (Figs 3.10 & 3.11) and for the fingers. Individual splints may also be made from malleable strips of aluminium, from wire, or from heat-mouldable plastic materials such as polyethylene foam (Fig. 3.12). Rarely, a halo-thoracic splint is used for an unstable fracture of the

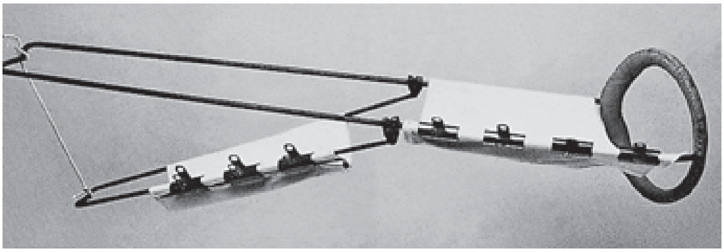


Fig. 3.10 Thomas's splint with Pearson knee flexion attachment, used mainly for fractures of the shaft of the femur. Note the canvas strips slung between the two bars to support the limb.

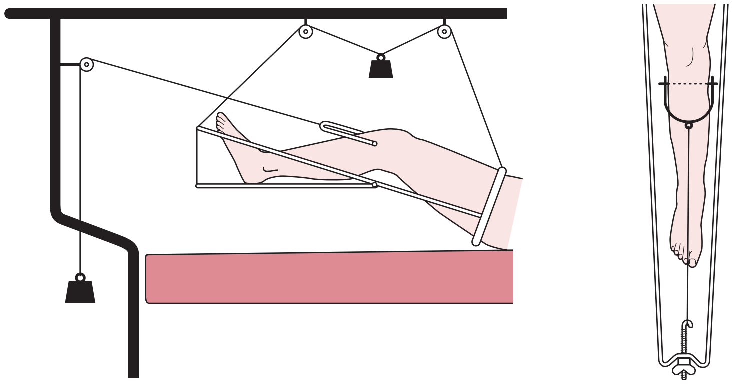


Fig. 3.11 Continuous skeletal traction through a tibial pin with balanced suspension, using a Thomas's splint and a Pearson knee flexion attachment.

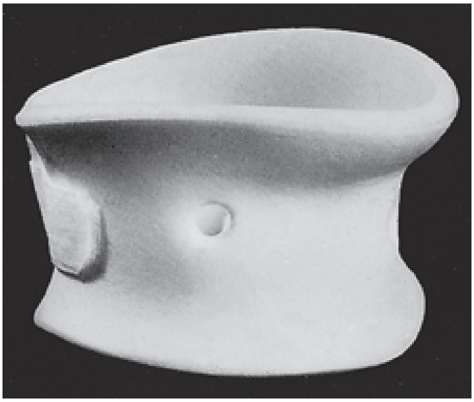


Fig. 3.12 Cervical collar constructed from polyethylene foam. For more rigid support of the neck a 'halo-thoracic' splint may be used (see text).

cervical spine. This consists of a metal 'halo' or ring that is screwed to the skull and joined by bars to a plaster or plastic splint enclosing the chest (see Fig. 8.10).

Precautions in the use of plaster and splints. When a plaster has been applied over a fresh fracture, or after operation upon a limb, careful watch must always be kept for possible impairment of the circulation. Undue swelling within a closely fitting plaster or splint may be sufficient to impede the arterial flow to the distal part of the limb. The period of greatest danger is between 12 and 36 hours after the injury or operation. Severe pain within the plaster and marked swelling of the digits are warning signs that should call for a careful reassessment of the state of the peripheral circulation. The clinical tests to be applied were described on page 21.

It should be noted that after operations upon the limbs a coagulated blood-soaked dressing may act in exactly the same way as a tight plaster and may seriously obstruct the circulation.

Fig. 3.13 A & B Functional brace (cast brace) suitable for certain fractures of the femoral shaft or tibia. Note the plastic hinges incorporated at the knee. Hinges may also be fitted at the ankle.

If a plaster has to be split for threatened circulatory arrest it is important that it be split *throughout its length*. Dressings and bandage under the plaster should also be divided right down to the skin, and the plaster should be opened up thoroughly from top to bottom. Nothing less than this can be regarded as adequate; the consequences of half-hearted measures may be catastrophic.

Cast bracing (functional bracing). A brace has come to be understood as a supportive device that allows continued function of the part. Cast bracing, or functional fracture bracing (to use a better term), is a technique in which a fractured long bone is supported externally by plaster of Paris or by a mouldable plastic material in such a way that function of the adjacent joints is preserved and use of the limb for its normal purposes can be resumed. The technique entails snug fitting of the plaster or plastic material over the appropriate limb segments and the incorporation of metal or plastic hinges at the level of the adjacent joint (Fig. 3.13).

Functional bracing is used mainly for fractures of the shaft of the femur or tibia. Since the support that a brace gives to the fractured bone is usually less than that provided by a conventional plaster, it is prudent to defer the application of a functional brace until the fracture is already becoming 'sticky'—

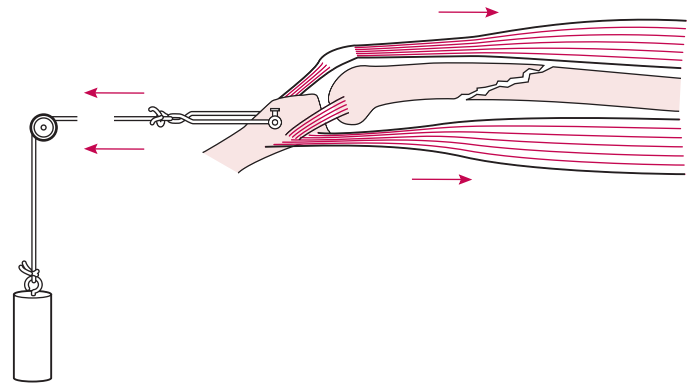


Fig. 3.14 To show how the elastic pull of muscles, which tends to cause overriding of the fragments, may be balanced by sustained weight traction.

often about 5 or 6 weeks after the injury. Earlier application of the brace may result in a recurrence of the deformity. In the meantime, treatment should be continued by sustained traction or by a conventional plaster, depending upon the nature of the fracture.

Immobilisation by sustained traction

In some fractures—notably those of the shaft of the femur and certain fractures of the shaft of the tibia or of the distal shaft of the humerus—it may be difficult or impossible to hold the fragments in proper position by a plaster or external splint alone. This is particularly so when the plane of the fracture is oblique or spiral, because the elastic pull of the muscles then tends to draw the distal fragment proximally so that it overlaps the proximal fragment. In such a case the pull of the muscles must be balanced by sustained traction upon the distal fragment, either by a weight or by some other mechanical device (Fig. 3.14). Sustained traction of this type is usually combined with some form of splintage to give support to the limb against angular deformity—usually a Thomas's splint or modified version of it in the case of a femoral shaft fracture, or a Braun's splint in the case of the tibia. The 'gallows' or Bryant method of traction for femoral shaft fractures in young children employs the principle of immobilisation by traction without any additional splintage (Fig. 15.8, p. 246). Also in this category is traction upon the skull for cervical spine injuries.

Immobilisation by external fixation

Strictly, immobilisation in plaster or in a splint might be regarded as external fixation. By convention, however, the term external fixation is used to imply anchorage of the bone fragments to an external device such as a metal bar through the medium of pins inserted into the proximal and distal fragments of a long bone fracture. In its simplest form, external fixation may be provided by transfixing each fragment with a Steinmann pin and incorporating the protruding ends of the pins in a plaster of Paris splint.

This simple method is now seldom used, and fixation is now by means of rigid bars or a frame—the fixator—to which the pins are attached by clamps with multiaxial joints. Such systems allow adjustment of the position of the fragments and, if necessary, compression of the fractured bone ends together, after the fixator has been applied. Surgeons now prefer to grip the fragments not by transfixing them through and through, but by inserting threaded pins into the bone from one side only. Two or three pins are inserted into each fragment and the protruding ends of the pins are clamped to the rigid body of the fixator, which lies just clear of the skin surface parallel with the fractured bone (Fig. 3.15A). External fixation finds its main application in the management of open or infected fractures, where the use of internal fixation devices such as plates or nails (see below) is undesirable because of the risk that it carries of promoting or exacerbating infection. The method has also gained some support as an alternative to internal fixation in the management of certain closed fractures of the long bones, particularly in the metaphyseal region.

A more specialised configuration of external fixation is the circular or Ilizarov frame (Fig. 3.15B), first pioneered in Russia but now used on a worldwide basis. It employs thinner transfixion wires, rather than pins, to secure the proximal and distal fracture fragments to the rings of the device under tension. The fixator rings are connected by more rigid threaded longitudinal rods, which can be adjusted for length and angulation. This also permits secondary procedures for the gradual correction of deformity, or even the transport of bone fragments to fill defects and restore length.

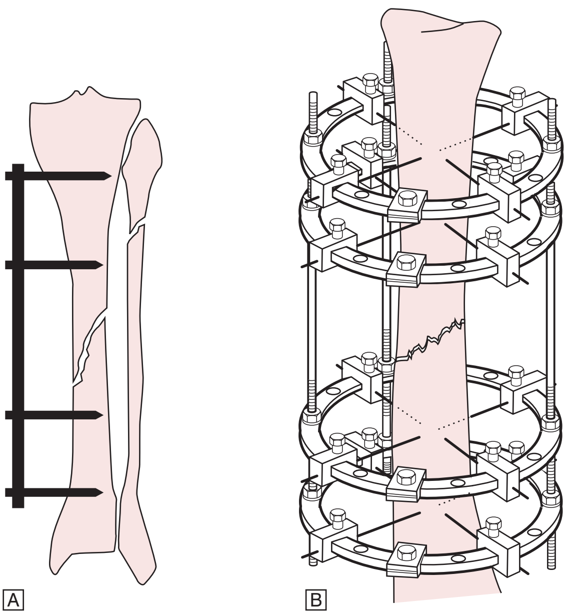


Fig. 3.15 Diagram showing the principle of two types of external fixation. A Unilateral frame using threaded half-pins anchored to the external bar by clamps. B Circular (Ilizarov) frame with thinner transfixion wires attached to rings linked by adjustable rods.

Immobilisation by internal fixation

Operative or internal fixation may be advised in the following circumstances:

1. to provide early control of limb fractures when conservative methods would interfere with the management of other severe injuries, for instance of the head, thorax or abdomen
2. as a method of choice in certain fractures, to secure immobilisation of the fracture and to allow early mobility of the patient, e.g. in the elderly patient with trochanteric hip fracture
3. when it has been necessary to operate upon a fracture to secure adequate reduction
4. if it is impossible in a closed fracture to maintain an acceptable position by splintage alone.

Methods of internal fixation. The following methods are currently in general use (Fig. 3.16):

1. metal plate held by screws or locking plate (with screws fixed to the plate by threaded holes)
2. intramedullary nail, with or without cross-screw fixation for locking
3. dynamic compression screw-plate
4. condylar screw-plate
5. tension band wiring
6. transfixion screws.

The choice of method depends upon the site and pattern of the fracture.

Plate and screws. This method is applicable to long bones. Usually a single six-hole plate suffices, but an eight-hole plate may be preferred for larger bones.

Fixation by ordinary plates has the disadvantage that the bone fragments are not forcibly pressed into close contact; indeed, if there is any absorption of

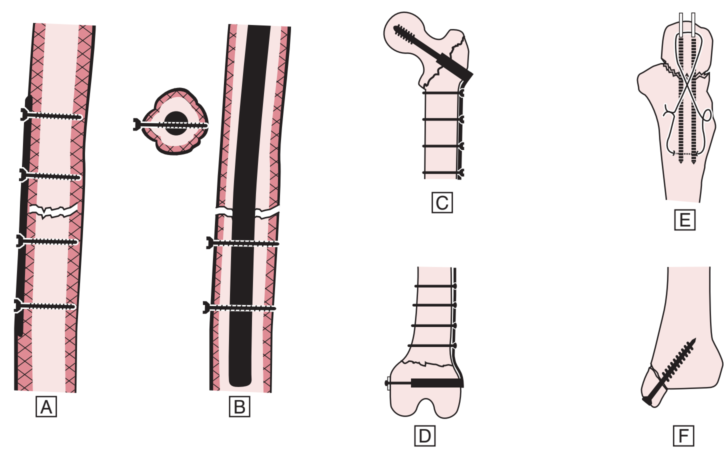


Fig. 3.16 Six methods of internal fixation for fractures. A Plate and screws. B Intramedullary nail (without and with locking screws). C Sliding screw-plate and screws. D Condylar screw-plate. E Tension band wiring. F Transfixion screws or Kirschner wires (for small fragments).

the fracture surfaces the plate tends to hold the fragments apart, and this may sometimes be a factor in the causation of delayed union. In order to counter this disadvantage of simple plates and to improve coaptation at the time of plating, special compression plates are available by which the fragments are forced together before the plate is finally screwed home (compression plating).

Locking plate. A newer concept is the 'locking plate', that uses screws with heads that are threaded and when tightened lock into matching threads in the holes of the plate. This produces a more rigid fixation in terms of length and angle, which is particularly valuable in comminuted fractures in osteoporotic bone. It can also be inserted with less stripping of soft tissue that preserves bone vascularity, particularly in the metaphyseal region.

Intramedullary nail. This technique is excellent for many fractures of the long bones, especially when the fracture is near the middle of the shaft. It is used regularly for fractures of the femur and tibia, and less commonly in the humerus. The original Kuntscher-type nail designed for the femur was hollow and of clover-leaf section and achieved fixation by its tight fit in the narrowest isthmus of the shaft. This type has been replaced by the newer more versatile locking nail with a rounder cross-section (Fig. 3.16), which offers notable advantages. These have transverse holes at both ends, allowing the insertion of transfixion ('locking') screws through bone and nail under image intensifier radiographic control. This affords greater rigidity as well as resistance to rotation forces allowing their use in comminuted fractures, particularly in the wider medullary canal near the bone ends. A new design of thinner more flexible solid nail is sometimes used for the management of shaft fractures in children.

Compression screw-plate. The compression screw-plate (dynamic hip screw) is a standard method of fixation for fractures of the neck of the femur and for trochanteric fractures (see Fig. 15.3). The screw component, which grips the femoral head, slides telescopically in the barrel to allow the bone fragments to be compressed together across the fracture. This compression effect is brought about by tightening a screw in the base of the barrel.

Transfixion screws. The use of a transfixion screw has wide application in the fixation of small detached fragments—for instance the capitulum of the humerus, the olecranon process of the ulna or the medial malleolus of the tibia.

Kirschner wire fixation. These thin flexible wires with sharpened ends are available in a number of diameters and provide a useful alternative to transfixion screws for the fixation of small bony fragments or for fractures of the small bones in the hand and foot.

Tension band wiring. This technique of fixation is most commonly used in the patella and olecranon, but can be applied to other small metaphyseal fragments such as the medial malleolus. It uses the mechanical principle of converting the tensile stresses of the muscles acting on the bone fragment, into a compressive force at the fracture site. This is achieved by means of tightening an eccentric figure-of-eight cerclage wire across the two fragments, stabilised by Kirschner wires or a screw inserted at right angles to the fracture line (Fig. 3.16).

Metals for internal fixation

Metals used for internal fixation of fractures or for internal prostheses must be resistant to corrosion in the tissues: silver, iron, ordinary steel and nickel-plated steel are all unsuitable. A special stainless steel containing chromium, nickel and molybdenum is widely used, but a non-ferrous alloy containing chromium, cobalt and molybdenum has even better resistance to corrosion in the body and is used for all types of internal appliance except wire, for which it is technically unsuitable. The metallic element titanium and its alloys have also proved resistant to corrosion in the body and are used increasingly for the manufacture of prostheses and internal fixation devices.

The place of operative fixation

In recent years there has been an increasing use of internal fixation for the treatment of limb fractures in most trauma centres, often as a deliberate first choice. As will be seen in a later chapter, operative fixation is already accepted as the best routine method of treating fractures of the neck and trochanteric region of the femur in the elderly. Until recently, many fractures of the shafts of the long bones have been treated conservatively—generally with excellent results, although often at the cost of rather a long time in hospital or away from work. The introduction of more sophisticated implants, inserted through small incisions under radiological screening, and offering immediate fracture fixation, has led to a dramatic change in this policy. In particular, intramedullary nailing is now used for most fractures of the shaft of the femur or tibia.

The reasons for advocating surgical intervention for fractures that were formerly managed conservatively are threefold. Firstly, there may be a substantial reduction in the time that the patient must spend in hospital and away from work. Secondly, in a favourable case function of the limb—and particularly of the joints—may be restored earlier because the need for plaster or other external splintage can often be eliminated. And thirdly, it is hoped that by providing rigid fixation of the fracture, complications such as delayed union and non-union will be reduced. In themselves, these objectives are unexceptionable, but there are arguments on the other side. The chief of these is that operative fixation, especially when combined with open reduction, entails risks that are absent or minimal with conservative treatment. Occasional fatalities—for instance from pulmonary embolism—are probably unavoidable, and major wound infection is by no means uncommon after lengthy open operations for reduction and internal fixation. Extensive stripping of soft tissues from the bone may also lead to adhesions that restrict joint movement, and may jeopardise the blood supply to the bone fragments, thereby hindering union. Thus the objects of the operation may sometimes be defeated.

It is important to strike a fair balance between these conflicting arguments, and to weigh up all the factors in every case: the age of the patient, the site and nature of the fracture, problems of employment, and economic circumstances. Advanced age should always weigh heavily in favour of an operation that will enable the patient to get out of bed sooner, whereas anything that might favour infection, such as an open wound or a pressure blister, should weigh heavily against open operation. In such cases external fixation (p. 41) as distinct from internal fixation has an important place.

The final decision on whether to use internal fixation or an alternative conservative method of fracture treatment must be made by the surgeon. They must be guided by their experience with the technique, the availability of the implants, the operating and ward environments, and the incidence of wound infection in other patients.

REHABILITATION

Improved results in the treatment of fractures owe much to rehabilitation, perhaps the most important of the three great principles of fracture treatment. Reduction is often unnecessary; immobilisation is often unnecessary; rehabilitation is always essential. In Britain, much of the credit for early enlightenment on the principles of rehabilitation must go to Watson-Jones.

Rehabilitation should begin as soon as the fracture comes under definitive treatment. Its purpose is twofold: first, to preserve function so far as possible while the fracture is uniting and second, to restore function to normal when the fracture is united. This purpose is achieved not so much by any passive treatment as by encouraging patients to help themselves.

The two essential methods of rehabilitation are active use and active exercises. Except in cases of minor injury, the patient should, ideally, be under the supervision of a physiotherapist throughout the whole duration of treatment.

Active use

This implies that the patient must continue to use the injured part as naturally as possible within the limitations imposed by necessary treatment (Fig. 3.17). The degree of function that can be retained depends upon the nature of the fracture, the risk of redisplacement of the fragments, and the extent of any necessary splintage. Although in some injuries rest may be necessary in the early days or weeks, there should be a graduated return to activity as soon as it can be allowed without risk.

Active exercises

These comprise exercises for the muscles and joints. They should be encouraged from an early stage. While a limb is immobilised in a plaster or splint, exercises must be directed mainly to the preservation of muscle function by static contractions. The ability to contract a muscle without moving a joint is soon acquired under proper supervision.

When restrictive splints are no longer required, exercises should be directed to mobilising the joints and building up the power of the muscles. Finally, when the fracture is soundly united, treatment may be intensified, movements

Fig. 3.17 Rehabilitation. Muscle and proprioceptive training and education.

being carried out against gradually increased resistance until normal power is regained.

Although every adult patient with a major fracture should attend for supervised exercises as often as possible, it should be impressed upon the patient that this organised treatment plays only a part in the rehabilitation, and that much—indeed most—depends upon continuing normal activities so far as possible when the patient is away from the department. Physiotherapy is often enormously helpful, but it should supplement, not supplant, the patient's own independent efforts (Figs 3.18 & 3.19).

Fig. 3.18 Rehabilitation. Class exercises for wrist and fingers.

Fig. 3.19 Rehabilitation. Exercises for active strengthening of leg muscles.

So far as children are concerned, supervised exercises are relatively unimportant, and in most cases children may safely be left to their own endeavours, aided when necessary by encouragement from the parents, who should always be fully informed of the programme of treatment and the likely course of events.

Continuous passive motion

In the knowledge that movement between joint surfaces favours the preservation of healthy articular cartilage, surgeons and biomechanical engineers have designed machines that provide continuous to-and-fro movement at a joint without any effort on the part of the patient. The range of movement can be varied as required, being increased gradually as the joint becomes more mobile. This technique of exercising joints passively has many applications: it is particularly valuable in situations where restriction of mobility tends to be hard to overcome, for instance in the knee after fracture of the femoral shaft or after the operation of quadricepsplasty.

Comment

Neglect of proper rehabilitation may have serious consequences. An injured limb that is kept immobile and disused for a long period tends to suffer oedema, wasting of the muscles and stiffness of the joints, with prolonged or even permanent impairment of function. Such disasters, formerly common, are now rare where the benefits of active functional treatment are fully appreciated.

TREATMENT OF OPEN FRACTURES

An open (compound) fracture always demands urgent attention in a properly equipped operation theatre. The sooner the wound can be dealt with adequately the smaller is the risk of infection arising from contaminating organisms.

Principles of treatment

The object is to clean the wound and, whenever necessary, to remove all dead and devitalised tissue and all extraneous material, leaving healthy well-vascularised tissues that are able to ward off infection from the organisms that must inevitably remain even after the most meticulous cleansing.

The extent of the operation required depends upon the size and nature of the wound. It is important that the wound should not be subjected to repeated examination, but should be kept covered with a sterile dressing until it can be visualised under optimum conditions in the operating room. The simplest type of case is that in which there is merely a small puncture wound caused by a sharp spike of bone forcing its way through the skin. In such a case it is often clear, when the wound is carefully inspected, that there is no serious contamination, and it may be unnecessary to do more than to clean the area with water or a mild detergent solution. At the other extreme is the grossly contaminated wound of a gunshot injury, with severe tearing and bruising of the soft tissues over a wide area, and often with much comminution of the bone. Then the only hope of preventing serious infection lies in a most painstaking cleansing of the wound with the removal of all devitalised tissue, and in the avoidance of immediate skin closure.

Technique of operation for major wounds

The operation is begun by enlarging the skin wound, if this is necessary, to display clearly the extent of the underlying damage. The whole wound is then flushed with copious quantities of water or saline to remove as completely as possible all contaminating dirt: at the same time any pieces of foreign matter such as shreds of clothing are picked out with forceps. In general, the emphasis should be on thorough cleaning of the tissues rather than on drastic excision; nevertheless, tissue that is obviously dead should be excised (Fig. 3.20), and it is particularly important that dead or devascularised muscle be removed in order to reduce the risk of infection by gas-forming organisms (gas gangrene). Bone fragments that are small and completely detached may be removed, but large fragments, which usually retain some soft-tissue attachments, should be preserved. Damage to a major blood vessel is dealt with, according to circumstances, by ligation, suture or vein grafting. The ends of severed nerve trunks may be tacked lightly together with one or two sutures, to facilitate later definitive repair.

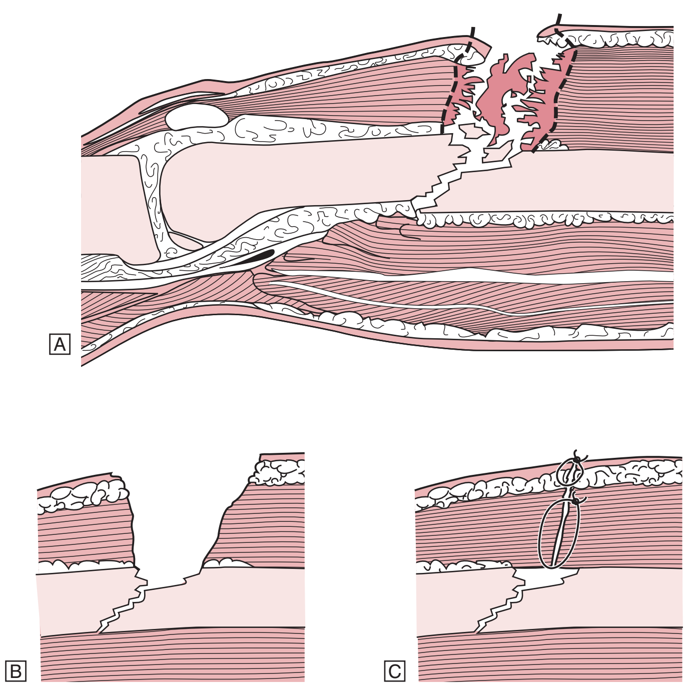


Fig. 3.20 The principles of operation for open fracture. The aim is to clean away all dirt and foreign matter and to remove dead and devitalised muscle and small loose fragments of bone, leaving the wound surfaces clean and viable. A Margin of necrotic tissue to be removed is shown. B After excision, cleansing and removal of loose bone fragments. In most cases, and invariably when there is contamination, the wound is left open until the risk of infection has subsided. It may then be closed by delayed primary suture, as in C, or by skin grafting.

The question of skin closure

Only if a wound is of a cleanly incised type, very recent, and without any sign of contamination, may immediate suture be considered. In general, the rule should be that a major wound communicating with a fracture, in which it must be assumed that pathogenic organisms have gained entry, should never be sutured primarily. To suture such a wound, especially a gunshot wound, is to risk disastrous infection. Instead, the wound after cleansing should be left open and dressed with a sterile covering. In such a case, delayed closure may be undertaken as soon as it is clear that infection has been aborted or overcome. This technique of delayed primary suture has become standard practice in the management of high-energy gunshot wounds, which are always heavily contaminated, and the temptation to suture such a wound immediately should always be resisted.

Methods of skin closure. Whether skin closure is undertaken primarily or after an interval, the ideal method is by direct suture of the skin edges; but this is not always feasible. Whether it is practicable or not depends upon the amount of skin destroyed and lost in the injury. If the skin loss is negligible and the skin edges can be brought together without tension, direct suture should be carried out. But if the skin edges will not come together easily, the wound should be closed initially by a free split-skin graft. Where there has been extensive damage or loss of the underlying soft tissue and muscle it may be necessary to cover the bone by mobilising a muscle pedicle. Exceptionally a vascularised full-thickness graft may be required, but this more complex procedure would normally require the assistance of a specialised plastic surgical unit.

Treatment of the fracture

Once the wound has been dealt with, the treatment of the fracture itself should follow the general principles already suggested for closed fractures. The only difference is that in open fractures there should be a greater reluctance to resort to operative methods of fixation, especially if there seems to be a serious risk of infection; if it is decided that metallic internal fixation must be employed the metal should be placed well away from the wound. If the fracture is unstable and unsuitable for treatment by traction or by simple splintage alone, external fixation by pins inserted into the bone fragments and fixed to a rigid external bar (Fig. 3.15, p. 42) is often the method of choice rather than internal fixation.

Supplementary treatment in cases of open fracture

Antibiotics. A course of treatment with a broad-spectrum antibiotic, such as a third-generation cephalosporin, should be begun immediately and continued until the danger of infection is past.

Prophylaxis against tetanus. A patient who has previously been immunised against tetanus by tetanus toxoid should be given a booster dose of toxoid. If the patient has not previously been immunised it is wise to begin immunisation with a standard dose of toxoid and to follow this up with a second dose 6 weeks later.

Precautions

In severe open fractures, with perhaps considerable loss of blood, there is a greater liability to shock than there is in closed fractures, and appropriate measures of resuscitation are often required.

As with any major fracture, especially when the limb is encased in a plaster splint, careful watch must always be kept on the state of the arterial circulation, so that immediate action may be taken if signs of ischaemia should develop.

Patients treated for open fractures must be watched closely for signs that may indicate infection. The temperature chart should always be noted: any large sustained rise of temperature should be taken as an indication to inspect the wound. When there has been much contusion of muscle the possible development of gas gangrene must always be borne in mind.