58 Limb injury

58.1 Examination of an injured limb

The principles of dealing with bone and soft tissue injury apply everywhere, but the features of each limb are different. Inappropriate treatment provides many opportunities for disaster, and these are common & serious:
(1) *Primary closure of an open fracture or a contaminated wound* (46.3).
(2) Applying, over a recent injury, *a cast without splitting it, especially in minor fractures with little initial swelling* (59.3).
(3) *Leaving a joint in a position where normal function is virtually impossible*.

N.B. Hearing the sound of a crack rarely indicates a bone has broken.

Soft tissue injuries may be just as severe, even more so, than bony injuries. *Consider an open fracture as a soft tissue wound that happens to have a broken bone in it.* Torn ligaments may make a joint unusable even when bone is not broken. Some dislocations are obvious, but others not so; good history taking will often alert you to joint injuries.

Limbs may be broken in more than one place. Several injuries may occur simultaneously. A patient may not complain of one injury if he has a more painful injury elsewhere. *You may completely fail to notice a limb injury if a victim is unconscious or paralysed.*

THINK OF A FRACTURE AS A SOFT TISSUE INJURY AFFECTING THE BONE

HISTORY
Always take a careful history. Most fractures are the result of some characteristic injury, so enquire carefully about the force which caused an injured limb.

A fall onto the heels from a height may result in a fracture of the calcaneus, and also perhaps the spinal vertebrae or pelvis.
A twist and fall playing football, may result in a spiral femoral fracture (67.1) or a ligament injury (58.4).
A fall on the outstretched hand, may result in any type of wrist fracture (64.1).
Being hit on the arm by a cricket ball, may result in a transverse fracture (63.6).
If very small force was able to break the bone, it may be weakened by some other disease (a pathological fracture).

N.B. If the patient can still move the limb normally, a fracture or serious injury is unlikely, unless distracted by other injuries.

EXAMINATION OF AN INJURED LIMB

LOOK
Remove all the victim's clothes and look for abnormal position, contour, shortening, bruising or ecchymosis. Deformity may be obvious, but need not be.
Compare one side carefully with the other. A joint may look larger than the other, either because it is swollen, or because of muscle wasting.
Measure & note shortening or thickening with a tape measure (67-3).

THE NEUTRAL POSITIONS

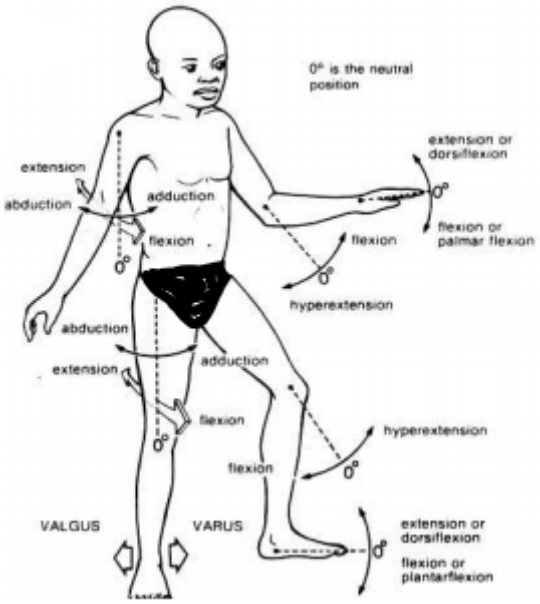

Fig. 58-1: THE NEUTRAL POSITIONS from which you can measure flexion & extension, adduction & abduction. The positions of rest, and function (for ankylosis) are both quite different (7-16), as is the position of safety for the hand (65-8). *N.B. In a valgus deformity, the distal part of the limb deviates away from the midline and in varus, it deviates towards it.* *Kindly contributed by John Stewart.*

FEEL
Ask the patient to point *exactly* to where the pain is. Important signs of a fracture are:
(1) pain: tenderness on *light* pressure at a specific site,
(2) swelling: abnormal contour (bony points not in their normal place)
(3) deformity: abnormal mobility at the fracture site,
(4) immobility: inability to move the bone actively or apply pressure on it.

Always check for distal pulses & sensation.
Note the movement possible from the neutral position for each joint (58-1). Record all your findings.
N.B. Don't forget the soft tissue injuries!

10 GOLDEN RULES FOR LIMB FRACTURES

(1) *Always follow the ABC of resuscitation* (41.1).
(2) Splint a fracture before moving a patient; *make sure the splint includes the joints above and below the suspected fracture*.
(3) Always examine for distal nerve (48.1) & vessel (49.1) injury and record your findings.
(4) Handle the injured part as little as you can.
(5) Check carefully if there is a skin perforation.
(6) Even if the fracture is obvious, examine for other injuries (*even if the victim has no other complaints*).
(7) Wash open fractures copiously with clean water, and remove any foreign material.
(8) Take note of soft tissue injury, and *don't be slow to perform a fasciotomy* (49.6) *if indicated,* especially if there is continuous severe pain.
(9) Obtain radiographs in 2 planes and include include the 2 joints above and below.
(10) Reduce any displacement; *don't wait for the swelling to go down, nor for radiographs if these are long in coming.* Place the included joints in their position of function.

If you have very limited supply of Xray film available, concentrate on getting radiographs for:
(1) hip injuries,
(2) penetrating injuries,
(3) elbow & ankle injuries,
(4) long bone injuries & proximal dislocations,
(5) severe foot injuries

Describe fractures as follows (58-2):_
(1) Open or closed?
(2) Which bone & where?
(3) Involving the joint surface
(4) Transverse (A) oblique (B) or spiral (C)?
(5) 'Butterfly' fragment, segmented (D) or comminuted (E)?
(6) Displaced by shift (F), with tilt (medial, lateral, anterior or posterior angulation, G), twist (rotation, H), overlap (I), distraction (J), or impaction (K)?

58.2 Radiographs

Always examine a patient before you order the radiographs! For most fractures take an AP (anteroposterior) and a lateral view. Look at all the films yourself, and if you are in doubt, compare them with views of the other side. *This is especially important in young children.*
In all long bone fractures, include the joints above & below the fracture.

If you are not sure if there is a fracture or not, but suspect one clinically, splint the bone in a functional position and repeat the radiograph after 5-7days. *N.B.* A normal radiograph does not exclude a ligament injury (58.3). *So always treat a patient according to function.*
A cursory look at a radiograph is not an adequate appraisal of a limb injury.

LONG BONE FRACTURE PATTERNS

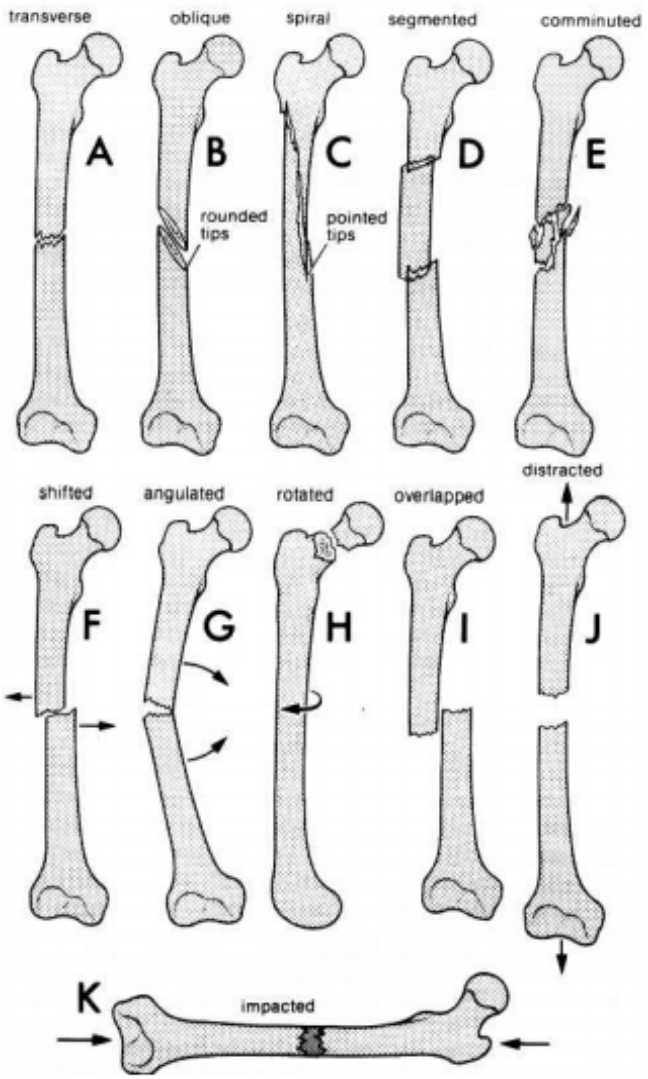

Fig. 58-2 LONG BONE FRACTURE PATTERNS. There may be several fracture types simultaneously.

58.3 Stages in bone healing

The shafts of long bones heal in 4 stages:

(a) Periosteal & endosteal disruption.
The periosteum tears away from at least one of the fragments. The endosteal circulation is also disrupted, and the ends of the fracture fragments are deprived of blood supply and die.

(b) Callus formation
During the next few weeks the periosteum & endosteum near the fracture produce soft vascular callus full of active spindle cells.
Cancellous bone only forms a significant amount of callus when the 2 bony fragments are close together; cortical bone can form callus when they are not so close. Gentle movement stimulates callus formation in a fractured long bone; complete lack of movement depresses it.

STAGES IN LONG BONE HEALING

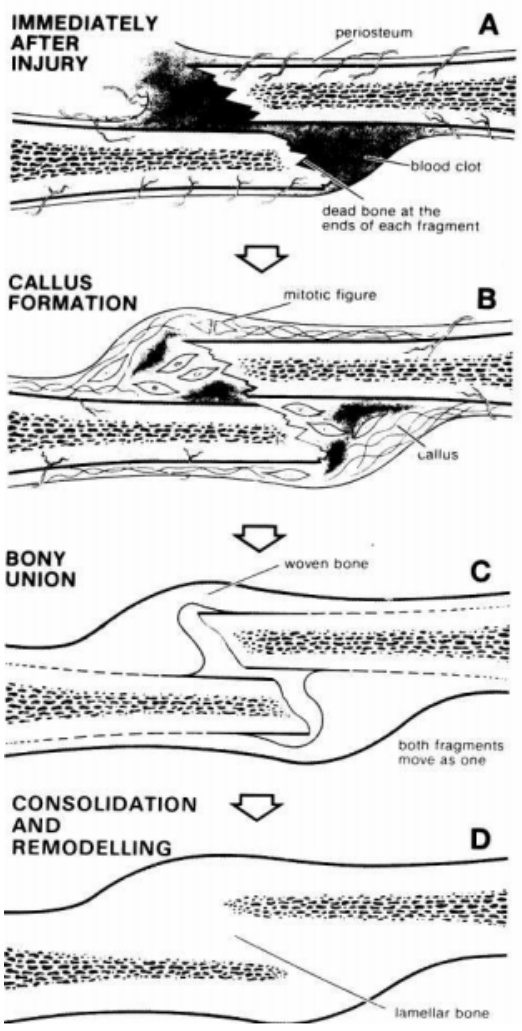

Fig. 58-3 STAGES IN LONG BONE HEALING. A, immediately after the injury. B, callus formation. C, bony union. D, consolidation and remodelling. *Kindly contributed by Peter Bewes.*

The newly formed callus forms a sheath round the broken bone, and is fixed to the fragments around the fracture, but *not to the bone at the fracture site itself*. The bone here is ischaemic and dead, and does not unite until it has been revascularized later.

After 2-3wks in adults (sooner in children), enough calcium has been deposited in the callus for it to be visible in a radiograph. This calcified callus slowly converts into loose open 'woven bone' which makes the bone ends 'sticky', and prevents them moving sideways on one another, although it still allows them to angulate.

(c) Bony union.
As time passes, the woven bone round the fracture becomes harder, and so firmly fixed to the fragments that they move as a single unit. This is clinical union and is a critical milestone in the healing of a broken long bone.
Assess union clinically *rather than on the appearances of the radiograph*. It usually occurs 4-8wks after the injury, but in the tibia it can take much longer. At this point, management changes.

(d) Consolidation & remodeling
Bone continues to heal during this stage, which lasts several months. The broken fragments remain firmly held by callus, while the dead bone ends of each fragment is slowly removed, and their ends joined by more callus and finally by solid bone. Minor limb movements encourage new strong bone growth.

Excess callus is slowly removed until the injured limb is as strong as it was before. As a general rule, consolidation takes at least as long as the clinical union period, so too much stress on the healing bone will disturb the process.

The time taken to consolidation varies with the age & condition of the patient. Limb ischaemia, & vitamin D deficiency make everything take much longer. (Osteoporotic bone joins in the same time, but is weaker.) Perkins's timetable suggests: 3wks for union of a spiral fracture in the arm, double to consolidate, double again for the leg, and double once more for a transverse fracture. Take special consideration of weight bearing bones in resuming function.

58.4 Ligament (joint) injury

Ligaments are specialized fibrous tissues which prevent excessive motion between articular surfaces. They can be sprained, stretched or partly torn, or completely ruptured.

Some ligaments, such as the collaterals of the knee, heal better on their own than others, such as the cruciates of the knee. Poor healing will result in some degree of joint instability.

JOINT ASPIRATION (GRADE 2.2)
Indications for joint aspiration are for diagnosis or pain relief. An acute post-traumatic swelling of a joint, particularly the knee or elbow, may be due to bleeding from soft tissue damage or from an undisplaced fracture not visible on radiography. Aspirating the joint will show if there are fat bubbles in the haemarthrosis, confirming the diagnosis of occult fracture. Decompressing the haemarthrosis also provides significant pain relief, which is unfortunately only temporary most of the time.

N.B. You must perform a joint aspiration only under the strictest aseptic conditions, as the risk of infecting a joint is considerable, and the consequences catastrophic.

Therefore, use joint aspiration for diagnostic purposes only, unless the swelling is really pronounced. Follow up patients carefully to see if the swelling increases.

In a dislocation the joint surfaces are completely displaced, but in a subluxation they are still partly touching one another. Both subluxations and dislocations are often combined with fractures.

Reduce all dislocations and fracture-dislocations immediately, because the longer you leave them, the tighter the ligaments will become, and reduction is more difficult or even impossible. Many dislocations put at risk surrounding neuro-vascular structures, so record any deficit *before & after* manipulation.

COMPARE THE ABNORMAL SIDE WITH THE NORMAL SIDE

58.5 Principles of fracture treatment

Principles of fracture treatment follow 3 stages:
(1) **Reduce** (if displaced),
(2) **Hold**,
(3) **Exercise**.
A conflict arises how to *hold a fracture and keep the limb moving*, followed by another conflict: the speed of mobilization against the risks.

To reduce a fracture, you need to distract the fragments to disimpact them (if necessary) and replace the correct alignment.

You may need to accentuate the fracture position to disimpact it, and will certainly need to pull on it to correct any overlap.
Relaxation with anaesthesia is usually necessary (and will prevent the patient's muscles resisting you).

Closed reduction is impossible when:
(1) a fragment is too small to manipulate,
(2) a fragment is trapped in a joint,
(3) soft tissues are stuck between the fragments.

The best time to reduce a fracture is either immediately after the injury, before the tissues have started to swell, or some days later, after the swelling has gone down.

If a fracture is undisplaced, no reduction is required.

Holding the reduction is the priority. There is no one method that is suitable for all fractures and all patients; each method has its advantages and disadvantages.

You must decide which holding technique is best for the specific bone fractured, the type of fracture (stability, bone defect), the presence of an open wound, and how much experience and training you have.

Remember: you, and the patient, want a good functional result, *not a good radiographic result*. You want a method of fracture holding that has the lowest risk of complications, is simple to apply, given your level of expertise, is relevant to the level of nursing and physiotherapy care of your hospital, keeps admission time to a minimum; and is not expensive.

Methods are: (1) continuous traction (59.4), (2) splinting (59.2,3), (3) fixation (59.5).

Whichever method you use, good physiotherapy will help give you the best results.

CONTINUOUS TRACTION
Continous traction is useful for bony shaft and articular (joint) fractures. It does not hold the fracture rigid, but stretches and elongates the surrounding soft tissues, which then pull the bone fragments into place and maintain limb length. The aim is to hold the reduced fracture in position till it is comfortable enough to exercise the muscles and move the joints.
Traction is possible by gravity alone for the humerus (61.12), by skin adhesion (up to 5kg only in children & for osteoporotic bones), or through skeletal pull by inserting pins through the tibia or calcaneum (69.5).

Traction should not be excessively strong and distract the fracture, because bone fragements that do not coapt will not heal.
Excessive weights on skin traction may deglove the skin! Also, insertion of traction pins needs care.

N.B. Traction must pull against something fixed (or else a patient is just pulled down the bed!)

Exert traction against a fixed point, or an opposing force (balanced traction), or in combined manner (by a Thomas's splint).
*Make sure you check traction frequently. Prevent ankle equinus (*limited dorsiflexion due to Achilles tendon or calf muscle tightness*), a common and often disastrous preventable complication. Prevent shortening & rotation in the lower limb.*

SPLINTING
The most common method is to use Plaster of Paris (PoP) which sets when it dries in the shape you wish to mould it. It is very useful to hold a fracture but will not allow a limb to swell, lets immobilized joints become stiff & unused muscles to atrophy, and may rub against bony protuberances.
To avoid the limb compartment syndrome (49.6) which may cause the complete loss of a limb, *always split a plaster cast initially,* or apply a slab at first and complete the cast only when the swelling has subsided*..*
Avoid stiffness by splinting fractures only after they have become 'sticky' in traction, and some ability to lift the bone returns.

KEEP ALL OTHER JOINTS MOVING

FIXATION
Some fractures are liable to non-union or malunion:
(1) femoral neck fractures,
(2) unstable ankle fracture-subluxations,
(3) mid-shaft forearm fractures,
(4) transverse olecranon & patella fractures,
(5) pathological fractures,
(6) multiple fractures in the same limb.

The options are then (a) external fixation (59.4), (b) open reduction with or without internal fixation, or (c) internal fixation without open reduction, *e.g.* using a K-wire.
Don't forget the soft tissues: treat oedema by elevation & exercise. *Never dangle the limb nor force excessive activity.*
Debride open fractures!!
If you intend to refer a fracture for internal fixation, the sooner the patient reaches the referral hospital the better. This should be in at least 2wks, with the fracture splinted in the position of function.

58.6 Adequate function with minimum risk

Since the 1st edition of this book almost 40yrs ago, the trend in high-resource environments has been to manage the vast majority of orthopaedic injuries surgically, most commonly with internal fixation. The obvious aim of good treatment is return to good function with minimum risk.

The big advantages of internal fixation are perfect reduction and early mobilization, but the big disadvantage is the risk of infection. Because of the former, many ignore the latter.

Infection in bone is a disaster, and the presence of foreign metallic material makes it almost impossible to clean up an infection.

Avoiding complications is more important than early patient mobilization. Simple methods of fracture immobilization are best.

Alas, much experience in treating fractures conservatively has been lost and no longer appears in many textbooks. It is important to point out that: (1) *perfect radiological reduction does not always mean perfect function*, and (2) function may be perfect, even though reduction is not.

When a fracture is fixed rigidly by metal, there is no callus but primary osteoclast activity and osteoblast deposition. Thus, the bone integrity depends on the metal implant, which diverts stress from the bone, so allowing it to become osteoporotic. In contrast, the small amount of bone movement that occurs in a splinted fracture stimulates callus formation, and it is the callus that ensures mechanical strength whilst the bone heals. With increasing stress, the callus grows stronger.

INCORRECT INTERNAL FIXATION

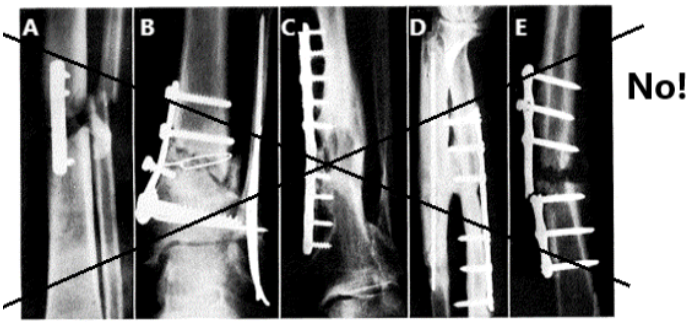

Fig. 58-4 ***HOW NOT TO DO IT.*** **A, inadequate fixation. B, excessive use of material. C, screws too short + bone infection. D, unorthodox fixation & cross-union. E, plate fracture (bone not yet united).** *After Apley AG, Solomon L. Apley's System of Orthopaedics and Fractures. Butterworth, 6th ed. 1982.*

Preconditions to successful internal fixation are:
(1) surgeons skilled in the correct procedure, replacing gloves, instruments & drapes after debridement *before* starting internal fixation,
(2) nurses skilled in assisting,
(3) a proper aseptic operation theatre,
(4) complex sets of equipment,
(5) plates, nails & screws of different types & sizes,
(6) a supply system to replace used plates, nails & screws,
(7) a mobile Xray machine with C-arm,
(8) safe sterilisation systems,
(9) good postoperative care,
(10) appropriate antibiotic prophylaxis.

If you attempt internal fixation without *all* the necessary conditions, too many of your patients will end up severely disabled by painful, malunited or chronically infected bones.

The famous AO osteosynthesis group gave a warning in its 1st instruction manual, "we cannot advise too strongly against internal fixation if it is carried out by an inexperienced surgeon and in the absence of full equipment and sterile operating room conditions".

Many of therequirements of internal fixation can be met by **external fixation** which carries much lesser risks, and is often more appropriate anyway (59.4).

Because internal fixation is such a disaster when it is badly done and infection a clinical catastrophe, even if you have equipment for internal fixation, *don't use it unless you can meet all the strict criteria*.

If you do have the necessary training and experience and your hospital has the necessary equipment, logistic supply chain for the provision of materiel, degree of cleanliness, and nursing care, then you may elect to perform internal fixation whenever optimal for the patient; it is inappropriate for this book to go into any further operative detail.
One possibility is the SIGN nail system, produced especially for use in low-resource hospitals without the need for expensive radiography machines or even electricity. SIGN is an entire programme run by a humanitarian organisation, which includes education and training, not just material for internal fixation. More information can be obtained at https://www.signfracturecare.org/. If your working conditions don't meet the above criteria, then conservative techniques, as described in this book, are for you.

DISASTER WITH INTERNAL FIXATION

Fig. 58-5 DISASTROUS RESULTS OF INTERNAL FIXATION. There were no indications for plating the humerus; the plate is now loose, and the screws have fallen out. There is a pseudarthrosis and a radial nerve palsy, so a plaster wrist cock-up splint was applied. Using active movements and a sling would almost certainly have resulted in union, and may have avoided the radial nerve palsy, besides being simpler and cheaper. *After Charnley J, Closed Treatment of Common Fractures E&S livingstone, Edinburgh & London 3rd ed.1961*

On the other hand, K-wires and nails, in contrast to plates & screws or intra-medullary nails, are usually temporary, and you can remove them after some wks. They are small and less prone to produce chronic osteomyelitis.

K-wires are useful for some hand or foot injuries (the excellent blood supply decreases the possibility of infection), and for fixation of displaced intra-articular fragments; K-nails are good for the radius or ulna.

We have collected together here a system of non-operative methods for most of the common fractures and for many of the rarer types. Fractures of the olecranon and patella, which absolutely need internal fixation, are included. The femoral neck fracture needs more skill and equipment, and will need referral.

You will find that conservative methods will give you a much lower rate of infection and non-union. The thinking behind conservative treatment is to follow the natural healing processes of the body, to use closed methods wherever possible, to encourage the patient to start using the limb as soon as he can, and to interfere surgically only if absolutely necessary, and then only in the simplest way possible.

N.B. If it is not essential to restore the exact anatomy after a fracture, the non-operative method should not try to do so.

The perfect immobilization which operative methods try so hard to achieve is seldom even desirable, as in many fractures a little movement is a good thing encouraging callus formation and union, and preventing the absorption of bone.

Despite cogent explanation of methods of conservative treatmernt by Böhler, Perkins, Charnley & Sarmiento, few systematic descriptions of non-operative methods now exist.

THE POSSESSION OF EQUIPMENT FOR INTERNAL FIXATION SHOULD NOT BE A FREE LICENCE TO USE IT

With more difficult fractures, particularly fractures into joints, your results, *and those of most surgeons*, are unlikely to be perfect. With difficult fractures your aim is to obtain fracture union in the position of function, so that the limb will still be useful even if not perfectly aligned. The measure of adequate function in a limb is its usefulness in relation to the patient's life and work, *not your own assessment*.

You may need to warn a patient that function is unlikely to be perfect. You should discuss possible problems to allow preparations to be made for the future. But you will only get good results if you follow all the details carefully.

How you apply a cast, when you should remove it, and exactly which exercises the patient should follow are just as important as the mechanical niceties of internal fixation.

Here are some important general principles:
(1) Maintenance of alignment
(2) Avoidance of rotation of fragments.
(3) Avoidance of distraction.
(4) Encouragment movement of nearby joints.
(5) Careful application of casts and traction.

In addition, each fracture has its own rules. Remember that the size of a fracture has little relation to its seriousness. For example, you can easily treat a Colles fracture in a young person, but a chip off the head of the radius may have to be removed at an open operation.

Aim always to restore function. If the arm is injured, range of motion and the use of the hand are the most important: a little bit of shortening, rotation or angulation are acceptable. If the leg is injured, try to restore painless stable weight bearing; prevent misalignment; maintaining length is desirable, but a little shortening <2cms is usually well tolerated and can be compensated by a special shoe.

Finally, remember to treat the patient as a whole person; *don't only consider the injured limb*.

THE DETAILS ARE CRITICAL

58.7 Clinical examination for union

Don't rely on radiographs to tell if union is adequate. A proper clinical examination is safer and more reliable.

*(*1) Feel the fracture site for tenderness, looking at the patient's face as you do so. If the site is no longer tender, the fracture has probably united.
(2) Feel the fracture site for warmth. If it is warm, it has probably *not united*.
(3) Put one hand over the callus and grasp it firmly. Ask the patient to keep the limb muscles loose. With your other hand, move the lower end of the broken bone from side to side. If the fracture has united, the upper end of the bone should move in the opposite direction. *Don't be too gentle, but don't move the bone too vigorously* that you cause pain, or refracture it.
Repeated examination is useful, especially in the early days, as it may also promote callus formation.
Pain, particularly at night, indicates that a fracture has *not united*.
If manipulation is painless and there is no movement, the fracture has united.

Despite clinical union, you must protect a fracture from stress, and especially from stresses that are likely to break it. For example, a patient must protect a fracture of the shaft of the humerus from the angulation stresses that dangling it out of a sling will cause while the elbow is still stiff (71.17).

Allow the bone ends to move a little, and encourage the patient to keep exercising the muscles, even if they are inside a cast. Active movements involving own muscles, are better than passive movements.

A recent fracture is painful. This pain helps to limit excessive movement of the fragments.

For the 1st 3days after an injury, pain prevents almost all movement. The limited range of movement increases the formation of callus and promotes union.

So, encourage the use of the joints on either side of a fracture within the range of painless movement. However, if this movement is excessive the bone may refracture!
Pain is subjective, so you will have to restrain some patients and encourage others.
Cautious weight bearing speeds healing, so encourage a patient to walk cautiously on the broken leg! This is only possible if you can prevent the fragments from angulating.

A plaster cast can prevent this in the tibia, but is much less satisfactory in the femur.

'Active movements' and 'weight bearing' are not the same. It is never too soon to start active movements, whereas bearing weight, if applied too soon, may be disastrous.

GENTLE MOVEMENT INCREASES CALLUS
EXERCISE IS NECESSARY,
EVEN INSIDE A CAST

58.8 Fractures involving joints

In an articular fracture, where the cracked bone disrupts the joint surface, you will be unable to reduce the fragments precisely.
The alternative, as soon as pain will allow, is active movement. This smooths the opposing joint surfaces, and lets them mould to one another as union proceeds.
Although arthrosis often follows where the broken joint surfaces remain irregular, especially in the ankle, it is less true in these situations:
(1) comminuted supracondylar humeral fractures,
(2) comminuted extension wrist fractures in the elderly,
(3) comminuted fractures of the calcaneus & the subtalar joint.

ARTICULAR INJURIES

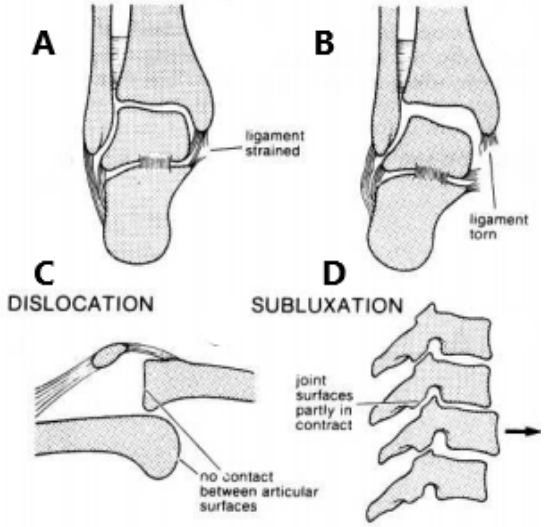

Fig. 58-6 SOME JOINT INJURIES. A,B,C, in a dislocation the joint surfaces are widely displaced. D, in a subluxation they are still partly touching one another. *Kindly contributed by Peter Bewes.*

Surprisingly good functional results often follow from accepting a poor position of fragments, and allowing early active movements to smooth out the irregular joint surfaces as union proceeds. These good results will be much better than you (and many 'experts') will be able to achieve with internal fixation.

58.9 Fracture-dislocation.

Common examples are:
(1) extension wrist fractures,
(2) clavicle fractures,
(3) humeral shaft fractures,
(4) tibial fractures,
(5) femoral shaft fractures,
(6) combined radius & ulna fracture,
(7) metacarpal & metatarsal fractures.

Some fractures also occur with joint dislocation. This is particularly common in the shoulder and less common in the wrist, hip and ankle.

Reduction of the dislocation improves the position of the fracture fragments, so that conservative management in cast or splint is usually possible.

The hazard is that, if you don't know there is a fracture present, you may inadvertently make it worse when you reduce the dislocation, so check first with a radiograph.

If the fracture is displaced and needs reduction, do this first, and hold the reduced fracture (if necessary in PoP) before reducing the dislocation.

DISTRACTION IS DANGEROUS
REDUCE DISLOCATIONS EARLY

58.10 Open joint wounds

Excise the edges of all layers of the wound, clean out the joint cavity with copious amounts of sterilized water. If necessary, extend the wound (7.17), remove any foreign material, and close synovium and capsule of the joint loosely with interrupted sutures. *Don't use a drain*, unless the joint is already infected.
Leave the rest of the wound open, as for any other contaminated wound.

If the bones in a joint wound are dislocated and the wound is open, reduce it urgently. Every hour makes the loss of the joint more certain.
Splint the joint in its functional position until delayed primary closure, at which time gentle active range of motion exercises may begin.
CAUTION! Don't forget tetanus toxoid!

AIM FOR ACTIVE PAIN-FREE MOVEMENTS

58.11 Stress fracture

These are generally fractures which occur to normal bone subjected to unaccustomed, frequently repeated normal movements, as in fatigue fractures of the tibia (70.4), fibula (70.5), calcaneum (72.7), & metatarsals (72.11).

Often the only leading clinical sign is pain on weight bearing or tenderness on palpating. Radiographs often miss these fractures but you may see a periosteal breach in early presentations or periosteal reactive thickening in the healing phase. These injuries are never of sudden onset and are the result of gradual but persistent wear and tear. Often all that is needed is rest and some pain management for c.3wks and gradual resumption of activity.

58.12 Pathological fracture

These are generally fractures which occur without major trauma in diseased bone from:
(a) primary bone tumors,
(b) metastatic cancer,
(c) degenerative bone disease (*e.g.* Paget's, vitamin D deficiency),
(d) chronic infection (*e.g.* osteomyelitis, TB),
(e) atrophy (*e.g.* paralysis, severe arthritis),
(f) osteoporosis.

The last is most common, and mostly affects the elderly & post-menopausal women. Frequent sites include the spine, pelvis and hip, proximal humerus and distal radius. Osteoporotic fractures heal in the same way and in the same time as fractures in normal bones, but the bones remain weak despite union.

BONE TUMOURS PRONE TO FRACTURE

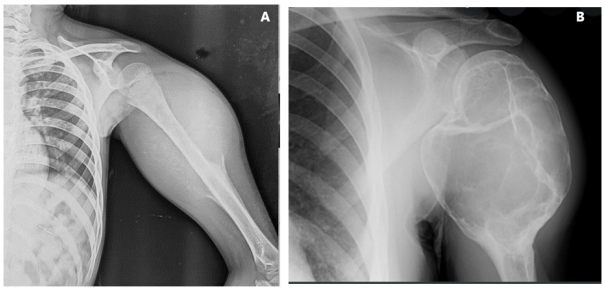

Fig. 58-7 BONE TUMOURS PRONE TO FRACTURE. When the cortex becomes thin, it can easily break without much force. A, the cortex is abnormal, so the tumour is likely to be malignant. B, the cortex, though very thin, is intact, so this cyst is benign. *Shared by Departments of Radio-diagnosis and Orthopaedics, Government NSCB Medical College Jabalpur, India*

If this is not possible, the best you can do is often to make those patients as comfortable as possible with adequate analgesia. They often present late with advanced disease and a proximal amputation or disarticulation may be the only procedure you can offer.

RADIOGRAPHS
Benign bone tumours typically have a smooth margin, and malignant ones a ragged gnawed appearance. The management of bone tumors is complicated. *Don't biopsy the lesion*, as your intervention may compromise further treatment. Try to refer such cases.

Fractures through benign lesions often heal on their own, but fractures thourgh malignant lesions rarely do.

Stress fractures rarely need more than a firm bandage and analgesia. If excessive stresses have caused the fracture in the first place, you need obviously to outline what these stresses are so that a change in life style is possible.
Fractures due to other causes need treatment of the primary condition as well as management of the fracture.

OPEN FRACTURE

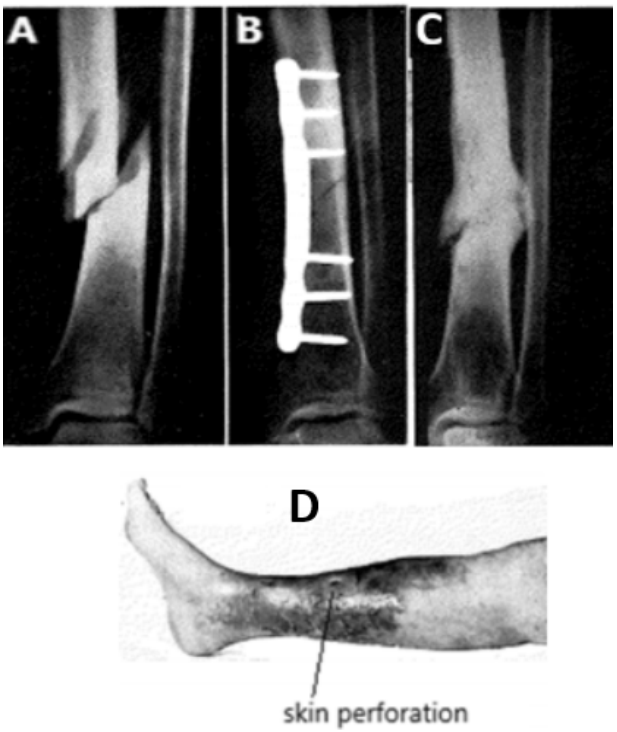

Fig. 58-8 OPEN FRACTURE WITH "MINIMAL" SKIN DAMAGE. A, a double spiral fracture of the tibial shaft. B, despite the skin perforation (D) he had an internal fixation performed. D, the skin wound healed rapidly but the bone did not; months later the skin became hot and angry. C, the plate was removed but at 1yr the fracture is still *not* consolidated. *After Apley AG, Solomon L. Apley's System of Orthopaedics and Fractures. 6th ed. Butterworth, 1982.*

58.13 Open fracture

A fracture is 'open' when skin damage allows bacteria to enter and contaminate a fracture haematoma. The skin damage may be a perforation, cut, or from tissue loss, whether from inside or out.

NEVER CLOSE AN OPEN FRACTURE BY IMMEDIATE PRIMARY SUTURE

The initial priority is ABC (41.1): the best way of controlling haemorrhage from a limb fracture is to reduce the displacement, and use a tourniquet if necessary.

Administer prophylactic antibiotics *(e.g.* a 1st generation cephalosporin) for 24h. Some very dirty or wounds >72h old may benefit from adding gentamicin and metronidazole.
N.B. Don't forget tetanus prophylaxis.

All open fractures, especially those that present late, need urgent treatment.

DEBRIDEMENT OF OPEN FRACTURES (GRADE 2.4)
The aim of debridement is to remove necrotic tissue, any loose bone fragments & all foreign material, and leave the wound open with clean well-perfused tissues.

Under anaesthesia, remove all the clothing if not yet done in theatre, while an assistant maintains traction on the limb. Wash the entire limb with soap, water and a brush and irrigate the wound initially with lots of normal saline or clean water, but *never think this is the definitive treatment*.

Remove only obviously damaged skin from the wound edges, but *don't hesitate to extend your incision to reach the depths of the wound to excise damaged muscle and to remove any foreign material.*

You must toilet all open fractures carefully: debride and excise all obviously necrotic tissue, especially muscle, and remove bone fragments completely void of soft tissue attachments and any foreign bodies. *Leaving loose pieces of bone will lead to sequestration and osteomyelitis.*

However, do leave pieces of bone that still have periosteal attachments, however tenuous, as they still have a chance to heal. Clean fractured bone surfaces, and gently re-align the bone.

If you have applied a tourniquet to control serious bleeding, this may make it difficult to decide which muscle tissue is viable and which not.
Remove it and test any doubtfully viable muscle *(which does not readily contract on pinching with tissue forceps or when touched by diathermy)* and complete your haemostasis.

Ligate large vessels meticulously with absorbable sutures. *Don't attempt to suture divided nerves & tendons initially*, unless the wound is a clean lacerated one (cut by broken glass or a knife). Mark the nerve or tendon with an unabsorbable coloured suture to facilitate finding it at a later operation.

If a joint is open, clean and irrigate this thoroughly (58.10).

Then irrigate the wound again copiously with normal saline or clean water.

Perform a distal fasciotomy if necessary (49.6).

Even if the skin wound is a small one, and occurs from within outwards, leave the wound open, making sure nerves and arteries are covered.
Don't suture the wound closed, as tension will rise in the wound leading to the compartment syndrome (49.6), which risks damaging tissues further and promoting the growth of anaerobic bacteria. Plan for delayed primary closure 2-5 days later. This is especially important if the patient presents late. If you fail to do this and the wound becomes infected, traumatic osteomyelitis will probably follow.

Failing to do an adequate toilet, and closing the wound by immediate primary suture, are very common errors.

Don't apply a tourniquet (unless to control serious bleeding) as this may make it difficult to decide which tissue is viable and which not.

HOLDING AN OPEN FRACTURE

You can immobilize many open fractures temporarily with non-circumferential PoP splinting, and perform definitive immobilization when you carry out the delayed primary closure after 5 days.

Although you can make casts to manage definitively many open fractures, with windows cut into the PoP to expose the wound, they are cumbersome and may hide part of the wound, and so be inadequate for proper wound care.

Skeletal traction using a pin through the proximal tibia can manage most isolated open femur fractures, and a pin through the calcaneum most tibial fractures.

You might be tempted to fix some open fractures internally, *but don't try it*. The wound is already contaminated, and the plates and screws will probably become infected, *and make it worse. An occasional K-wire is the maximum amount of internal fixation that is wise.*

Some wounds will be too large for simple closure and will require skin grafting or a local flap (46.5). For this wound care, external fixation (59.5) is advisable, rather than a window in a cast.

Post-operatively, raise the injured limb. Raise the foot of the bed if traction is in use.

DIFFICULTIES WITH OPEN FRACTURES
If the skin is bruised over the fracture, watch it carefuly. It may break down and a fracture initially closed becomes an open one.
If blisters develop over the fracture site, this does not mean the fracture is open. Just cover the blisters with sterile paraffin gauze.

If a large segment of bone is missing, bringing the fragments into contact with one another is more important than maintaining length, particularly in the upper limb.

58.14 Multiple fractures

Often, victims of high-energy trauma present with more than one fracture. Treat such patients following the standard ABC protocol (41.2). A secondary survey should reveal any bone injuries along with the more obvious open fractures. However, this survey may not always be reliable, particularly in unconscious or uncooperative patients.

You may find fractures of the small bones of the hand or foot, of the scapula, spine or pelvis fortuitously in radiographs or when they reveal themselves clinically when the patient is awake.

Fractures can affect >1 bone, or >1 site in a given bone. Any and all combinations are possible. *It is absolutely mandatory that radiographs include the joints above and below the suspected fractures.*

In high-energy pelvic ring injuries, >1 fracture is frequent. It is not rare to find a femoral neck injury associated with an ipsilateral femoral shaft fracture, or a tibial plateau fracture associated with a tibial shaft.
Fractures involving >1 bone are common in the hand or foot, in the forearm (various combinations of radius/ulna fractures) or in the leg (various combinations of tibia/fibula fractures).

A fall from a height with a calcaneus fracture should raise the suspicion of an associated compression fracture of a vertebral body.
Ipsilateral fractures of the femur/tibia or humerus/forearm create an unstable "floating joint" in between, which is to challenging to manage conservatively.
The segment in between is notoriously unstable and liable to rotational displacement.

Early mobilization of these polytrauma victims is the key in preventing pulmonary complications. Multiple fractures increase the risk of fat emboli and bed rest increases the risks of pulmonary collapse, pulmonary embolus secondary to DVT, and ARDS.

In low-resource environments, bed rest is unfortunately the only option for some patients: *e.g.* those with an unstable spine or pelvic fracture, and most fractures around the hip. Fractures of the femur (hip, shaft or distal 1/3), which would normally be treated in skeletal traction, represent the main challenge.

Follow a protocol of chest physiotherapy, *both active and passive*, mobilise the uninjured extremities in bed, encourage the patient to be propped-up for most parts of the day, mobilise when possible out of bed with assistance with wheelchair or walking aids: these are all small measures that go a long way!
In polytrauma and absolutely bed-ridden patients such as those with high-velocity trauma to the vertebral column or severe head injuries, consider the use of thrombo-prophylactic drugs.

Whether treated conservatively or surgically, upper extremity fractures should not prevent early mobilization. The same is true for fractures below the knee joint. You cannot over-emphasize the importance of physiotherapy, both for limbs and chest.

58.15 Neglected fractures

Sophisticated reconstructive surgery, whether of soft tissues or bone, requires specialist expertise. In addition, open reduction and internal fixation (ORIF) or external fixation (X-fix) of fractures needs special equipment and material: plates, screws, nails, fixator bars and clamps, with, often, help with C-arm radiography and fluoroscopy.
Whilst ORIF gives the best results for the correction of many malunions and non-unions, X-fix will do just as well.
What you do will depend on what you have, what you know, and the conditions where you work. We recommend conservative methods, such as using K-wires or Steinmann pins, and casting. The most important point is proper patient selection and the indication for surgery.

Many simple fractures will heal on their own. The patient finds a way to put the injured body part to rest, until it "feels better". Other fractures, however, require some intervention to avoid pain and disability. Many, if not the majority of fractures in poor-resource environments, are not treated by a trained physician, let alone an orthopaedic surgeon, but by other more available and affordable alternatives such as bone setters, nurses, therapists or even pharmacists. We do not know their success rate because we usually only see their failures.

You may well see a number of neglected fractures or dislocations, which have healed or are healing in such a way that their functional outcome is poor.
The usual complaints are pain, stiffness, instability, leg length discrepancy, visible deformity, or any combination of these. The degree of disability will vary from mild (can work but not play football) to severe (wheelchair bound).

There are several complications you may see:
(1) Delayed union
Delayed union is not a true problem; if only delayed, the fracture will finally heal. Inadequate immobilisation, poor nutrition, or tobacco use are important factors. Put the patient in a proper PoP cast or splints. Good physiotherapy, nutrition, and tobacco cessation are important adjuncts.

(2) Non-union
For long bones, refresh the ends to bleeding bone, open the medullary canal, apply a bone graft, and immobilise.

HUMERAL SHAFT:
shortening up to 3 cm is acceptable.

RADIUS & ULNA:
If one bone is healed and the patient can flex the hand and elbow, and pronation-supination is painless, leave the fracture alone. Otherwise, refresh the bone ends, apply a bone graft, and immobilise with an X-fix using Steinmann pins or K-wires. You can shorten the forearm up to 2cm, but this shortening must be equal on both forearm bones.

SCAPHOID (64.4)
FEMORAL NECK (66.6)
FEMORAL SHAFT (67.2)
TIBIA & FIBULA (70.6)

For an open fracture, the non-union is almost always infected. The wound is the essential part: by far the most important element is a good debridement with sequestrectomy. Use appropriate antibiotics. Sugar or honey dressings, and VAC (if available, or improvised) have proven useful. Then immobilise the fracture site with the best means available. Bone grafting may be necessary, but wait until at least 6 months after infection has cleared.

(c) Malunion
Does the malunion create sufficient incapacity to require corrective surgery? If yes, refracture, re-align, and immobilise the bone. If no, leave it alone. Refer to:
(1) humerus (61.13, 61-18C)
(2) radius (63.4)
(3) femur (67.3, 67-5B)
(4) ankle (71.7)

(d) Avascular Necrosis
Where the blood supply to part of a bone is cut off by a fracture, that part will inevitably die. This is seen typically in:
(1) the femoral head (58-9A)
(2) the proximal scaphoid (58-9B)
(3) the lunate (58-9C)
(4) the posterior talus (58-9D, 72.5)
(5) epiphyseal fractures in children (73.2)

(e) Pseudarthrosis
If this does not incapacitate the patient, leave it alone. If it does, resect, bone graft, & immobilise the patient.

AVASCULAR NECROSIS

Fig. 58-9 AVASCULAR NECROSIS from fractures. A, the femoral head. B, the proximal scaphoid. C, the lunate, D, the posterior talus. *After Apley AG, Solomon L. Apley's System of Orthopaedics and Fractures. 6th ed. Butterworth, 1982*