59 Fracture immobilization

59.1 Principles of fracture reduction & stabilization

Non-surgical management of fractures involves obtaining an acceptable reduction of the fragments, and maintaining it for the appropriate amount of time, either with cast or traction. Splints and casts are the cornerstone in the management of many lower extremity injuries and almost all injuries of the upper extremity. In low-resource environments, casts are mostly made of Plaster of Paris (PoP), but the availability of fibreglass is slowly increasing. PoP is dried calcium sulphate powder which forms a paste when wet and becomes hard when allowed to dry. It usually comes on impregnated gauze rolls of different sizes. It is amost universally available, cheap, easy to mould but can be heavy, cumbersome and breaks down easily, particulalrly in humid environments.

Fibreglass is a compound made of a plastic matrix reinforced with fine fibres of glass. It is stronger, lighter, water-resistant and shows better on radiographs than POP but does not mould as well and, more importantly, is much more expensive.

Reducing a fresh fracture or a fresh dislocation is painful and can be quite a traumatic experience, especially for children. Proper analgesia is mandatory. It is usually pretty clear at the time of presentation whether a patient needs to go quickly to the operating theatre (open fracture), admitted, or managed as an outpatient.

You can manage many closed injuries, particularly of the upper extremity with LA haematoma blocks (direct injection of a local anesthetic *under proper sterile precautions* into the fracture/dislocation haematoma) or conscious sedation.

N.B. Always have resuscitation equipment to hand when you use anaesthetics!

Once analgesia is adequate, the general principle of reduction is to exaggerate the initial deformity, pull, and realign the limb, using the intact periosteal hinge on the concave side of the deformity to stabilize the reduction.

It is safer to immobilize limbs in splints for a few days and have the patient come back for definitive casting at that time, unless the reduction is very unstable. If you need to put a circular cast from the start, *you should always uni- or bi-valve it* before discharge, and give clear orders on what to look for in terms of complications, and how to manage life with a cast.

Get a check radiograph after reduction to make sure the position is acceptable.

You can manage some fractures of the lower extremity according to the same principles. But most fractures of the spine, pelvis, hip, femur and many tibial and ankle fractures need admission for immediate or delayed treatment, or even just observation.

In the meantime, extremity fractures need splinting in a comfortable appropriate position, with adequate analgesia.

Whether you use a splint or a cast, the general principle is that you should immobilize both joints above and below the fracture & try to get all visible on radiographs. Pad bony prominences to avoid pressure sores. Give patients clear instructions on weight-bearing, limb elevation and cast maintenance. Importantly, give instructions on how to use the muscles inside the cast, and stress that it is not dangerous even if there is some discomfort: this will make recovery much easier and quicker.

N.B. Many childhood fracture treatments differ from those in adults: see chapter 73.

EXERCISE THE MUSCLES INSIDE A CAST

59.2 Plaster and equipment

PLASTER BANDAGES, normal, slow setting, best quality, 10, 15, & 20cm wide.

Good quality plaster bandages make the strongest casts but *using poor quality is a mistake.* If you use these, you will need twice as much plaster, and the cast will be twice as heavy. It will also break sooner, often meaning you have to apply a whole new cast, so any economy is lost!

CREPE BANDAGES come in different widths to secure plaster to a limb. *Don't apply them too tightly* in order to allow for some underlying swelling to occur.

STOCKINETTE, woven tubular, orthopaedic, of various widths is useful to put direcly on the skin, under cotton layers. It prevents hairs sticking to the cast, and skin being cut by a cast saw, *but not burns from a overheated saw blade*. It is also helpful in containing slabs of PoP used to make a splint.

PADDING: orthopaedic cotton wool rolls of different widths are very useful. If you can't get these, cut slabs of cotton of desired size & roll them up.

Make STIRRUPS locally. These support a patient's leg when he wears a walking cast. The cross pieces at the top should be thin so that they bend easily to fit the shape of the leg and spread its weight through the cast.

PLASTER EQUIPMENT

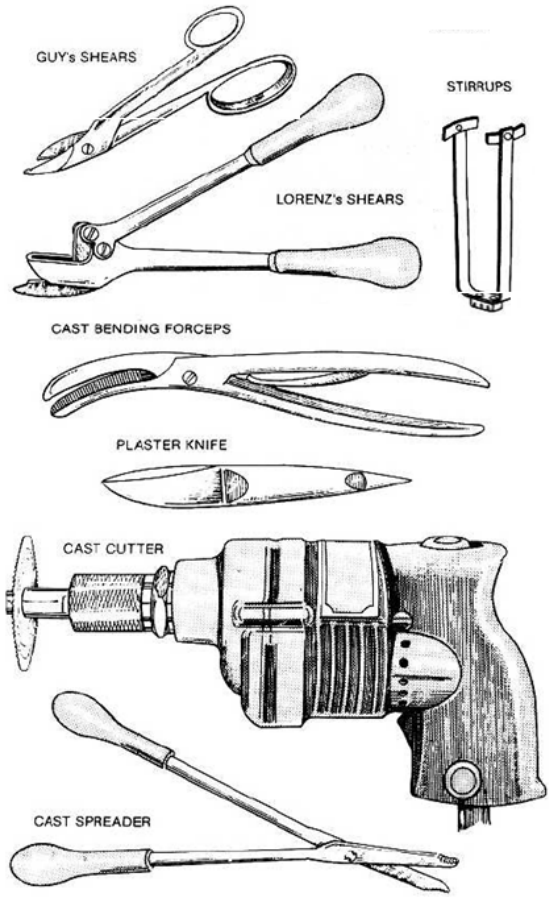

Fig. 59-1. Plaster equipment. Use this equipment to make standard casts, such as the long leg and short leg walking casts. *The indications for each of them and the details as to how you should apply them are critical.*

FOOT SUPPORTS, bars, blocks, or plates made of hard rubber are easier to use.

PLASTER CAST SAWS have an oscillating which *does not rotate* so, in theory, won't cut the underlying skin. Demonstrate this on your own forearm to a frightened patient, especially a child.

The blades become dull fairly quickly so you need to replace them at regular intervals. Dull blades overheat and do burn the skin!

SHEARS, SPREADERS AND BENDING FORCEPS are necessary if you have no electricity!

INDELIBLE PEN. When you apply a cast, write on it the date you applied it, and the date you expect to remove it, together with a sketch of the fracture inside (59-7). A permanent marking pen is ideal.

59.3 Immobilization by cast or splint

As a general rule, you can reduce & immobilize almost every fresh fracture initially in a splint or slab for a few days to allow swelling to subside. Slabs are useful for the initial treatment of a severe fracture and are safer than circular casts. But slabs don't immobilize some fractures securely enough. Slabs are weak, and easily break at the elbow or knee.

You can put a slab on one side of a limb, or on both sides, and hold it in place with a crepe bandage. The advantage of slabs is that they allow a limb to swell without obstructing its circulation (58.2). As the swelling subsides, the elasticity of the crepe bandage will hold the slabs against the limb without letting them become loose.

PADDING A LIMB

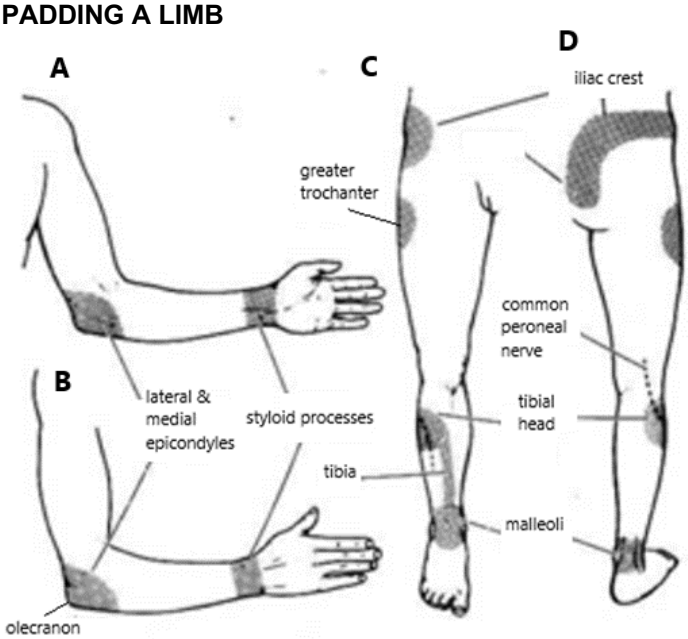

Fig. 59-2. PRESSURE SITES. A,B these need padding to make a cast comfortable and avoid pressure sores. C,D, *protection of the common peroneal nerve as it winds round the neck of the fibula is especially important.*

SPLITTING AND SPREADING A CAST

Applying a cast is always easier with an assistant to help. Every cast should be padded with cotton wool. If stockinette is available, use it; otherwise, apply cotton wool directly to the skin. Apply the stockinette or wool a few cms above and below the end of the cast, so that you can fold the stockinette or wool under the last layer or two of plaster, to make a neater finish.
Roll the cotton without tension, from distal to proximal, each roll overlapping the previous one by c.$^2/_3$. Too much padding reduces the effectiveness of PoP to immobilize the fracture. Add extra padding over bone prominences, particularly the fibular head and the malleoli (59-2). Since a cast is meant to immobilize the joints above and below the fracture, put these joints in the desired position *before* padding and casting. This is where an assistant can really make your life easier. A general rule is to put these joints in the functional position, as much as possible:

ankle: neutral flexion,
elbow: 90° flexion in half pronation-supination,
knee: 5-10° flexion,
wrist: 15-20° extension.

In this way, even if a patient is lost to follow up and stays in PoP much longer than should be, stiffening will occur in a functional position.

AVOIDABLE DISASTERS

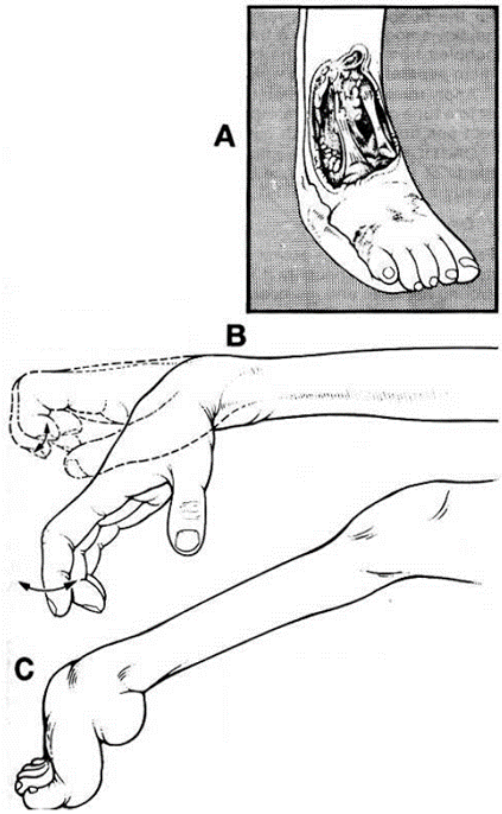

Fig. 59-3. AVOIDABLE DISASTERS. A, a pressure sore. B, ischaemic contracture of the hand. C, ischaemic contracture of the leg.

If you decide to apply a circular cast, you *must split it immediately* so that it can stretch open a little as the tissues under it swell. Otherwise a compartment syndrome (49.6) may result.

DANGERS OF CASTS

Damage can occur even if ischaemia lasts <1h, and is a particular danger with fractures of the forearm and lower leg. An unsplit circular cast is especially dangerous if a patient already has signs of circulatory impairment.

Ischaemia results as the muscle swells, reducing the blood supply within fascial compartments. The skin remains intact till much later. The classic Volkmann's ischaemic contracture is a fixed flexion contracture of the wrist & fingers, or ankle in extreme equinus, with midtarsal flexion & dorsiflexion of the toes (59-3). *This is almost untreatable & a veritable disaster!*

In its less extreme forms, ischaemia is more common than most people think. It may only show itself later as a stiff hand or foot, that gradually begins to develop a severe contracture during months following an injury.

The forearm muscles are most commonly involved in supracondylar or forearm fractures in children (73.7,8) or thumb dislocation (65.15), and occasionally the lower leg muscles in tibial fractures (70.7) or knee dislocation (68.8), but almost never the muscles of the upper arm, or thigh, which are less firmly enclosed in fascia.

Other causes of ischaemia may be:
(1) A tight bandage (including an Esmarch bandage),
(2) A tourniquet,
(3) Gallows (73-23) or extension traction (73-24),
(4) A serious soft tissue injury (even when there is no fracture)

Splitting a cast with a scalpel will not destroy its capacity to hold the bony fragments, and is easy if you do it while a cast is still soft.

ALWAYS SPLIT THE FIRST CAST ON FOREARM AND LOWER LEG FRACTURES

Correct management will usually prevent ischaemia, but always watch out for the early signs (58.2); these are pain, disproportionate to the injury, or pain on passive streching of the intra-compartmental muscles, a pathognomonic sign.

Paraesthesiae, pallor, pulselessness and paralysis are late signs. The involved compartment will most often be more tense than the opposite side, but not necessarily.

N.B. The presence of a peripheral pulse does not exclude the compartment syndrome.

A well applied circular cast should reduce the pain of a fracture. *If a patient, especially a child, complains of pain,* take such complaints seriously: it is probably due to pressure on a bony point which may only subside as the skin erodes away, or ischaemic pain which will get worse until you remove the cast.

Pain is not an indication for analgesia; it is an indication to find out why there is pain, and to split, open or renew the cast. *So, never apply a circular cast to a patient who is unconscious*, and is unable to complain of pain. He may develop the compartment syndrome only too easily.

SHANTI (8 years) had an undisplaced fracture of the distal end of her radius. There was almost no swelling. A circular cast was applied. She returned the next day crying in pain. She was given aspirin and sent home. Three days later she returned with a gangrenous hand and sloughing forearm muscles. Her forearm was amputated.
LESSONS (1) An undisplaced forearm fracture does not require a circular cast; all she needed was a slab and a crepe bandage. (2) *Never treat a painful cast with analgesics only.* (3 If you apply a circular cast, *always split it.* (4) *Pain and pain on passive stretching are early signs of impending compartment syndrome.*

ABDULLAH (8 years) had a supracondylar fracture. It was successfully reduced within an hour and a skin tight cast was applied. He returned the following day saying that his fingers hurt, but was sent home without removal of the cast. Five days later he returned. This time all his fingers and thumb were black and gangrenous, and had to be amputated.
LESSONS (1) A cast is not the treatment for this fracture. (2) *Don't apply a skin tight cast immediately after an injury*, before the limb has had time to swell: wait at least 12h. (3) *Take any complaint of pain seriously* and split or remove the cast immediately.

Identify patients at particular risk and examine them frequently. Record your findings carefully, and note at what time you made them. *Watch for pain, pain on passive stretching, paraesthesiae, pallor, and finally paralysis,* and teach your staff to do the same.

Check for 2-point discrimination, with a pin. In injuries of the forearm, test for pain on passive extension of the fingers. Test the strength of all involved muscles. Feel the compartment for tenderness and tenseness.

If you suspect a compartment syndrome clinically, surgical decompression is necessary. *don't wait for more signs to appear!* Better an unecessary fascitomy than missing case of gangrene!

Make sure to record your pre-, intra- and post-operative findings clearly. In many places, a missed compartment syndrome has serious medico-legal consequences.

TAKE THE COMPLAINT OF PAIN UNDER A CAST SERIOUSLY

A poorly applied malleolar cast, for example, can make it impossible to reduce an ankle fracture.

BASIC PLASTERCRAFT

Some casts are really critical. Here we describe some points of technique which apply. Learning skillful plastercraft is worth learning. It is a dying art, lost even to the younger orthopedic surgeons.

For all slabs and casts, get everything ready before you wet the plaster bandages. Put stockinette on the limb, or cut and roll a layer of cotton wool directly on to the skin. Fold and trim the slab, and have your assistant ready.

WETTING A PoP BANDAGE

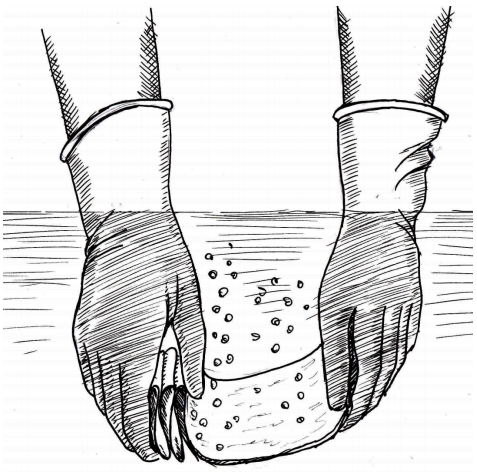

Fig. 59-4: WETTING A PLASTER BANDAGE.

Hold the bandage in your right hand. Unwind it a ½ turn, hold it with your left hand, and put both hands in warm water. Leave the bandage under the water for c.5secs until the bubbles have stopped. Hold it gently, so that water enters all its layers. Then, holding one end of the bandage in each hand, take it out of the water, and twist it gently. This will remove excess water, and yet keep the powdered plaster in the bandage.

N.B. Don't wring it out, or squeeze it, because this will leave it too dry to make a good cast.
It is a good idea to put on gloves beforehand!

PLASTER SLABS (TUBULAR/FLAT CASTS)
Take a dry bandage of suitable width, and use its loose end to measure the required length of the slab. Lay this length of bandage on a table and then double more bandages backwards and forwards over it until you have enough layers to make a slab of the right thickness. Usually, 4 layers are enough. If necessary, fold the bandage double.
Hold the dry slab in both hands, and dip it in water. Wait for c. 5secs for the bubbles to stop, hold it gently so that water enters all its layers. Then take it out of the water with both hands and twist it gently. *Don't squeeze it or wring it out* or it will become too dry to make an effective cast. Quickly smooth it out on a flat surface. This will remove the bubbles between the layers of bandage, and prevent them separating later to weaken the cast.

Apply the wet plaster slab over the stockinette or wool on the limb. Hold it in the correct position and smooth out the slab.

CAUTION! Don't let a plaster slab cover $>^2/_3$ *the circumference of the limb*, as even this may not allow space for enough swelling.

PLASTER ROLLS (CIRCULAR CASTS)
If you prefer to roll on the PoP, protect the bony points with particular care as in all casts (59-2), especially in a thin patient. Be sure to pad well around the knee and heel. Then pad the rest of the limb.

If necessary, cut a hole for the thumb. Roll this cotton evenly with no folds or lumps, and without obscuring the shape of the limb. *Don't pull it tight* or it will tear.

An upper extremity cast usually requires 2-3 layers, but a weight-bearing or long leg cast at least 3-4 layers (1cm width). Put extra padding over bony prominences. Apply it from well above to well below where the cast will end.

CAUTION! (1) *Don't apply too much padding* so that the limb is freely mobile inside the cast, as inside a boot. (2) If there is a wound on the limb, cover it with a dressing, over-pad it loosely with cotton creating a protuberance where you will apply the plaster. This will allow you to know where to make the window that will allow access to the wound. Unless you make the window immediately, mark its site & borders with a marking pen.

Roll on the wet plaster bandage without lifting it off the limb, pressing each fold firmly with the base of your thumb, so that most of the tension is transmitted to the middle of the bandage, and not to its edges, where it might cause a sharp ridge. The tension you need will vary with the thickness and elasticity of the padding.

CAUTION! (1) *The correct tension is important* or the cast will be loose.
(2) The inside of the finished cast must be smooth, because ridges may cause sores.
(3) *Never pull a plaster bandage tight.*

Apply each turn slowly, settle it carefully in position, and join it to the turn below by smoothing it with your hands to remove bubbles. Let it follow the way it wants to go. Cover about $^2/_3$ of the previous layer. Apply it as a spiral without reverses, and when you have to change direction, make a quick tuck, and smooth it out. *Don't twist the whole bandage, or attempt a figure-of-8 bandage, or apply 2 turns in exactly the same place,* except at the ends.

While you are applying one roll of plaster, ask your assistant to wet the next one. Bandage from one end to the other, and back again, making the cast slightly thicker at its ends, where it will be most likely to fray. *Don't build up its thickness over the fracture site,* where extra thickness will be useless.

Trim its edges while they are still wet, *not after they have dried. Don't immobilize the mcp & mtp joints*, except on very rare occasions. Bind the ends of the stockinette and cotton over into the cast with the last few turns of bandage. This will make it smooth and strong.

CAUTION! (1) *Don't press on a cast with your fingers or thumb while it is hardening*, or they will leave a crest inside it which will cause a pressure sore. Use the palm of your hands.
(2) For the same reason, *don't let a cast, especially a cast over the heel, rest on a hard surface while it sets.*
A large cast may not be completely dry for 72h, and will not be fully strong until then.

To make the cast stronger, start by placing a slab of 4 thicknesses of bandage each side of the limb to strengthen it. Or, incorporate such a slab between layers of bandage. This is particulalrly helpful around the elbow and knee areas, and when making a spica.

SPLITTING A CAST
The cast must be padded, or you will cut the patient as you try to split it!

INDICATIONS
(1) All casts put on under emergency conditions *(though it's always best to put on a slab or split cast).*
(2) A cast on a patient who is going on a journey.
(3) Casts over any recent injury, whether swollen or not.
(4) It is wise to split all first circular casts.

There are several ways to split a cast, but the easiest is to split it while it is still soft 3-4mins after its application.

If the cast is still fairly soft, use a disposable scalpel blade to make a single cut through the plaster down to the padding.

If the cast is already hard, use the cast saw, but this will be hard work as the inner layers are still damp. Use the scalpel blade again, protecting the skin by inserting a soft malleable plastic spatula under the cast.

MANAGING PLASTER

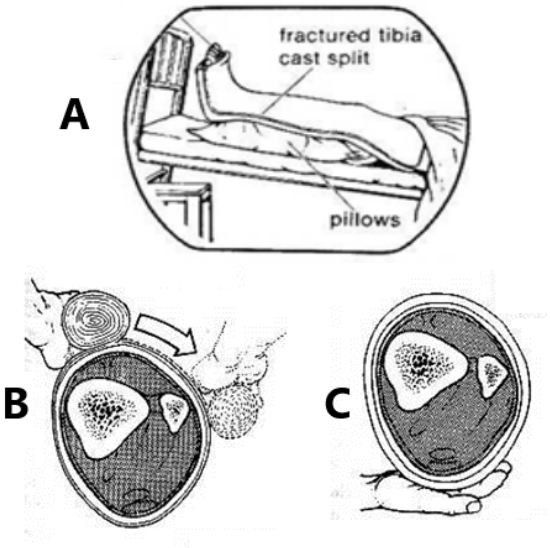

Fig. 59-5 GOOD PLASTERCRAFT A, a cast properly split. B, roll a wet plaster bandage round a cast with the base of your thumb. C, lift a wet cast with the flat of your hand.

Use the same protection technique when cutting a hard cast all the way with the saw blade. In theory, the cast saw will not cut the skin, but it may overheat and burn it. The cast saw is also quite noisy and can be frightening, particularly for children.

Demonstrate on your own forearm skin that the blade is harmless (sounds worse than it is!). In children, soften PoP casts by immersing them in warm water so that you can cut them with shears instead of the saw blade.

COMMON PLASTERING MISTAKES

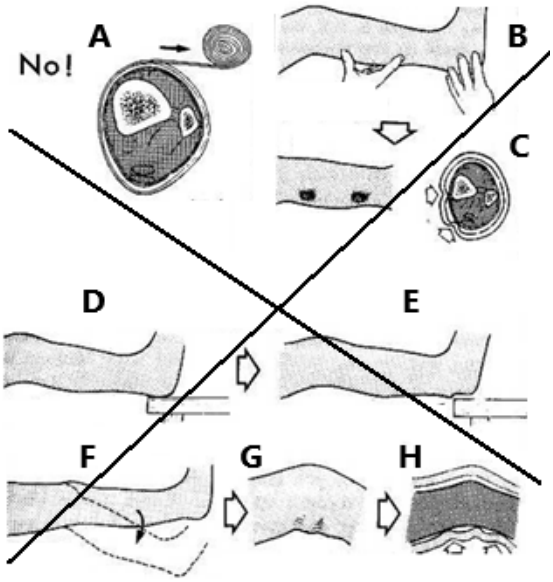

Fig. 59-6 BLUNDERS WITH PLASTERCRAFT A, *don't take the PoP roll off the limb or pull it too tight.* B, *don't use the tips of your fingers:* C, they will leave depressions in the cast, which will cause pressure points. D, *don't rest a wet cast, especially its heel, on a hard surface*: E, a depression & sore will form. F, *don't let a wet cast bend*: G, it will form folds, H, which will also produce pressure points. *After Les Agrégés du Pharo, Techniques Elémentaires pour Médecins Isolés. Diffusion Maloine, 1981.*

SITES FOR SPLITTING OR REMOVAL
Avoid the bony points, so cut an arm cast down the midline of its anterior surface. If there are anterior and posterior slabs, avoid them and slit the cast down its ulnar side. Split a leg cast down its lateral surface, cutting between the lateral malleolus and the heel.

BIVALVING A CAST
Cut the cast right down to the skin, on both sides of the limb, essentially creating two half-shells. Later on, they may be useful as splints. The patient should avoid getting the cast wet at all costs

CARING FOR A CAST
If a patient has to walk home in the rain, let the cast dry and then give it a coat of oil paint. Lice and other insects may multiply under a cast, and cause such intolerable itching that they drive a patient to remove it piece by piece. If necessary, dust some insecticide powder down the ends of the cast.

Casts often become loose in time, so oversee them regularly, and repair and replace them as necessary.

EXPLANATIONS TO PATIENTS
Explain why you are applying the cast, and when you expect to remove it.
Tell a patient not to use the limb or bear weight on the leg for 48h while the cast dries out.
Advise raising it to prevent swelling, to keep it dry, and to return immediately:
(1) if there is pain, numbness, stiffness,
(2) if the fingers or toes become cold, blue, or swollen.
(3) if the cast becomes loose.
Explain that exercising the muscles inside the cast is mandatory, as well as the joints which are not immobilized, especially the fingers and toes.
Explain these instructions, preferably in vernacular, with an instruction sheet.

CAUTION! Take any complaints about casts seriously.

DIFFFICULTIES WITH CASTS
If a cast becomes loose and plaster is scarce, cut a longitudinal strip out of it and then bind it together.

A FRACTURE PASSPORT

Fig. 59-7 A FRACTURE PASSPORT is a useful reminder to the patient, and yourself, especially if the notes are lost. Record all the dates of the fracture, the date the cast is applied, and the date it should be removed. Draw a sketch of the fracture. The best way to write on a damp cast is to use an indelible pen. *Kindly contributed by Rüdiger Finger.*

If your plaster bandages are unsatisfactory, use them with hotter water, make the cast thicker, and collect any loose powder that falls off, moisten it with a little water, make it into a paste, and rub it on to the outside of the cast. Use it on the less critical fractures, and keep your best plaster for malleolar fractures, and difficult forearm fractures.

If plaster bandages are scarce, you may be able to economize in their use by making casts lighter, and strengthening them with strips of wood, bamboo, or tin.

If you suspect even the possibility of ischaemia, immediately split the cast from end to end. If this does not relieve the symptoms, remove the cast entirely and examine the limb for signs of the compartment syndrome.

N.B. Loss of reduction is better than ischaemic contracture.

N.B. Pressure points inside a cast are painful for a few days then the pain tends to go away as the skin necroses. Often this is recognized only when the cast is removed, and can become a bigger problem than the fracture itself, particularly around the heel area.
This is why it is so important to take any complaint of pain seriously and look at the skin, either through a window or by replacing the cast.

NEVER SEND A PATIENT IN A CAST HOME WITHOUT EXPLAINING THE COMPLICATIONS

WINDOWING CASTS
In order to view a wound of an open fracture, a soft tissue injury, or of osteomyelitis, you need to make a window in the cast. This will enable you to tend these wounds, which otherwise may deteriorate and only come to light when they smell terribly!
N.B. (1) If a patient uses a leg plaster in walking, the soft tissues may swell and herniate through the window, preventing healing,
(2) windows not reinforced can weaken a cast so much that it bends at that point.

Overpad the dressing gauzes so that there is a bulge over which to roll the PoP (59-8C). You can window this immediately with a scalpel blade or mark it and when the PoP is dry, use the saw blade to cut the window open, *tangential* to the cast (59-8D), *not perpendicular to it*. This lessens significantly the so-called window oedema.

MAKING A WINDOW IN A CAST

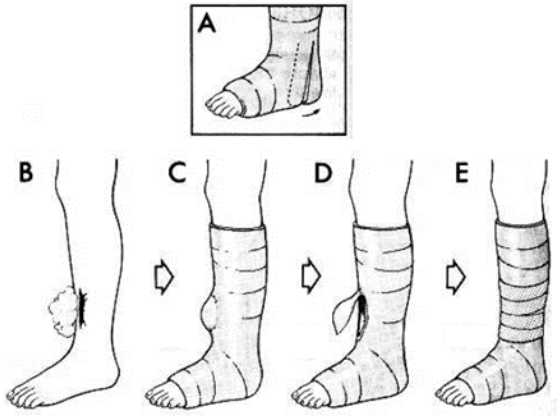

Fig. 59-8 MAKING A WINDOW IN A CAST. A, if a cast is pressing on the heel, you can open it with a saw, and then repair the cut with plaster bandages. B-E, the easiest way to make a window is to put some dressings over the lesion, make the cast, saw off the bulge, and then repair the cast. *Kindly contributed by John Stewart.*

Prevent the soft tissues herniating through the window by raising the limb and by applying firm pressure by a dressing including the window. Dress the wound and put plaster over the window to strengthen the cast, *but also to enable you to look in again through the window*.

WEDGING CASTS

If a fracture is angulated inside a cast, you may be able to straighten it inside the cast provided the fragments have not yet fully united.

This is not as easy as it looks, because you may make a wrinkle inside the cast which will cause a pressure sore, and not even budge the fracture! So wedging needs care and skill!

N.B. Alternatively, you can wait until the fracture is healed enough not to displace, but is still soft enough bend. This is 3-6wks after an injury in an adult, but sooner in a child. Remove the old cast, straighten the limb under ketamine, and apply a new cast. This is a useful method If you don't have X-ray machines. Changing a cast is safer than wedging it.

DON'T LET WEDGES CAUSE PRESSURE SORES

Opening a wedge lengthens a cast slightly, and if the fragments are overlapped, it helps to distract them. *Don't use this method for the forearm* because of risk of ischaemia!

Study the radiographs and plan the geometry of what you intend to do carefully. Draw a line round the cast where you want to cut.

Open the wedge on the concave side of the deformity, extending >50% of the cast circumference.

Start at two places 5-6cms apart (a line representing the base oft he wedge triangle, 59-9C). This will prevent the plaster from cracking when you open the wedge. Measure the width of the wedge by adding 1mm/^{o} correction needed. Prepare pre-cut pieces of cork or wood of different heigths, and use them as wedges after your manipulation. They should keep the wedge open but *not touch the skin whatsoever*. Get a radiograph to assess the need for further correction. Once you are satisfied with the alignment, simply close the cast with more PoP, again making sure that the wedge does not put any pressure on the skin.

N.B. Don't use >1 wedge in different planes: change the cast!

MAKING A WEDGE

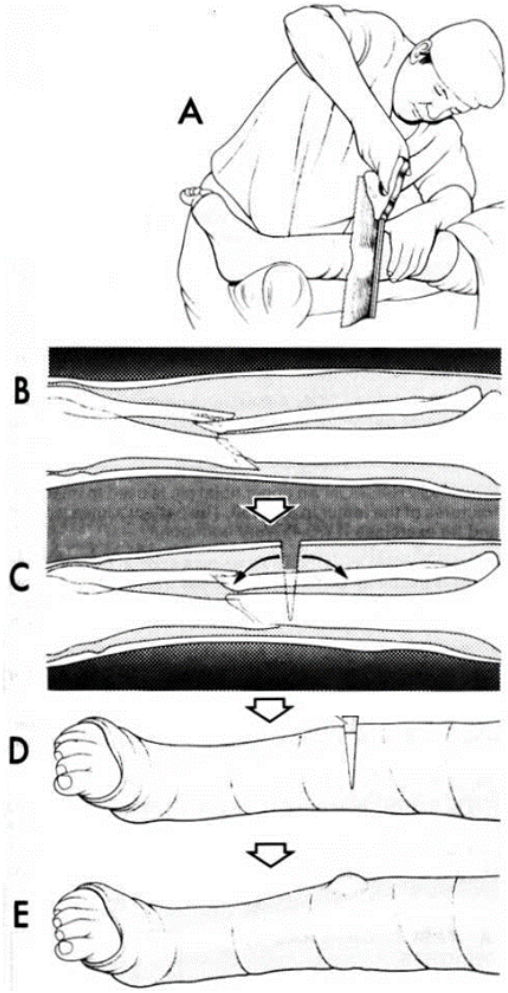

Fig. 59-9 MAKING A WEDGE. Obtain some small blocks of wood to hold the wedge open. A, cut through the whole circumference of the cast except for 2-3 cm on its convex side, B, leave a hinge on which it can bend. C, make the cut c.2 cm proximal to the fracture, so that if there is a wrinkle inside the cast, it will not be directly over the fracture, where it may erode the skin. Using a saw or plaster knife, cut down to the padding, *but not into the limb!* D, carefully bend the cast, if necessary holding it open with a block of wood, *making sure the block is clear of the skin*. E, repair the cast with a few turns of plaster bandage. *Kindly contributed by Peter Bewes.*

THE GEOMETRY OF WEDGING

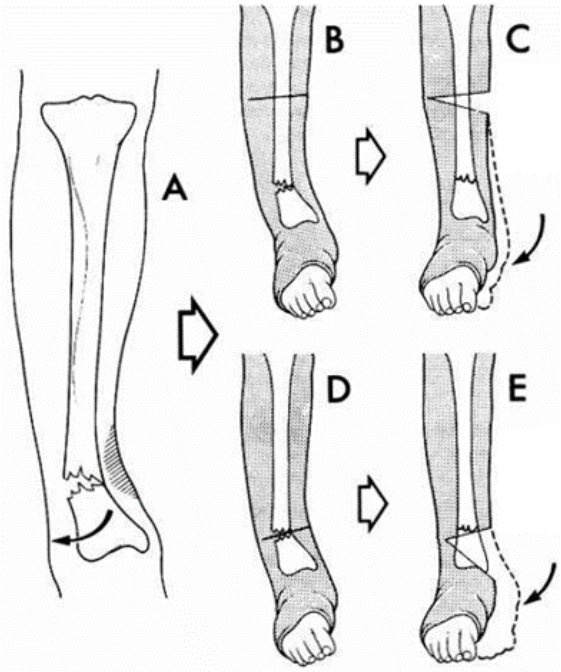

Fig. 59-10 THE GEOMETRY OF WEDGING. A, an angulation that requires correction. B,C if the wedge is far from the fracture a small movement will correct the displacement. D,E if the wedge is near or over the fracture, a larger movement is necessary. *Kindly contributed by Peter Bewes.*

N.B. Don't close a wedge by cutting a piece out of a cast and then closing up the gap. This tends to cause wrinkles & pressure sores.

WOODEN SPLINTS

You can use splints made of strips of wood padded with paper and cloth for fractures of the humerus, radius, and ulna, and for extension fractures of the wrist. There is no evidence that they are better that plaster casts, but you may find them useful for the 1st 24-48h. Wooden splints are light, tenaceous, elastic, radiotranslucent, permeable to the natural moisture of the skin, and can be moulded to the shape of the limb, but *not so effective when joints above & below the fracture need immobilizing.*

WOODEN SPLINTS

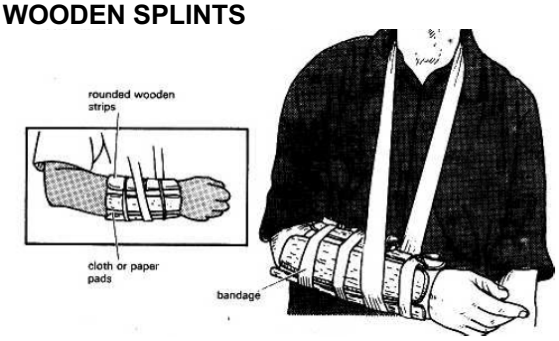

Fig. 59-11 WOODEN SPLINTS. Use separate splints padded with paper & cloth, and tied together strapping or bandage for forearm & extension wrist fractures.

59.4 Traction

To exert traction is to pull. You can use traction:
(1) to pull fractured bones into place
(2) to keep them moderately immobile until they have united,
(3) to do both, one followed by the other.
To apply traction successfully, find some way to grasp the patient's limb safely, for several weeks if necessary. You can do this by:
(1) Adhesive strapping to the skin
(2) Pass a Steinmann, or Denham pin, or K-wire through the bone.
Then attach a cord to the strapping, pin, or wire, passed over a pulley, and pull it with a weight.

SKIN TRACTION

The great advantage of skin traction is that there is no need to pass any instrument through the tissues.

As a general rule, skin traction can often be the definitive treatment in children, but should be used only temporarily in adults (≤2-3 days). *Don't use it if the circulation is impaired!*

Disadvantages are:
(1) You cannot apply >2.5-3kg to the lower leg, and even then not for long, so *it is not suitable for Perkins traction.*
(2) Joints across the strapping cannot flex and exercise.
(3) The skin may become sensitive to the strapping.
(4) In old patients, it easily causes skin blisters.
(5) It often slips off completely, if not applied properly.
(6) It is very uncomfortable in hot climates.
(7) It can occasionally cause ischaemia.

Nevertheless, skin traction is particularly useful for treating elbow and femoral fractures in children (73.4).

Orthopaedic traction strapping is very readily available. After applyingbenzoin tincture to the skin, apply it to both sides of the limb up to, but not above, the fracture line. Then, wind a crêpe bandage spirally over it. *Never wind circular turns of ahesive strapping round a limb*, because the strapping can become too tight.

Either fix a piece of wood in a loop of strapping (59-11), making it slightly wider than the ankle so that the strapping does not compress the malleoli. Or, fold each end of the strapping, and tie a cord to it.

CAUTION! (1) *Don't let the strapping extend above the fracture line onto the proximal fragment,* or it will be useless.
(2) *Don't let it press on the common peroneal nerve.*
(3) Don't let it interfere with the circulation.

N.B. GALLOWS TRACTION is useful in a small child <20kg. EXTENSION TRACTION is useful in an older child or teenager (73.4).

CHINESE FINGER TRAPS
A special kind of traction uses the ingenious bamboo traps to hold the fingers and the weight of the elbow provides the counter-traction (63-12).

These are especially useful for wrist fracture reduction (64.2), but you should not leave the traps on for more than 2h.

SKELETAL TRACTION
Make sure the joint within the traction system itself is not damaged: make sure there is no deformity, no effusion, no instability & no pain. This is not always easy, particularly with distal femoral fractures. In this case, get a radiograph of the knee showing the proximal tibia and distal femur, and look for avulsion of the tibial spines. Do the same where knee pain ensues after you have set up traction.

For definitive care, adults require skeletal traction.
N.B. Don't use skeletal traction across joints in children (73.4).

Insert the fixation pin in the metaphysis of the distal fragment. Attach the traction apparatus to a weight; this may pull the patient out of bed, so exert countertraction by raising the foot of the bed.

One of the main purposes of skeletal traction is to allow exercise of the muscles and joints, *so make sure this happens!*

Traction takes time to apply and manage, but is something easy to teach to assistants. It is most useful in the leg. In the arm it is uncomfortable, inconvenient, difficult to maintain, & frustrating for the patient, so only useful in rather exceptional circumstances.
Elaborate traction, such as that of Hamilton and Russell for the leg, require sophisticated equipment and are not described here.

PATIENTS IN TRACTION MUST EXERCISE

ARM TRACTION METHODS

FOREARM TRACTION is useful for a supracondylar fracture in children (73-8)

SKIN TRACTION FOR A HUMERAL FRACTURE is only necessary when a patient is confined to bed when a cast is impractical.

OLECRANON TRACTION
Pass a K-wire or small Steinmann pin through the olecranon for some lower humerus fractures, especially comminuted supracondylar fractures in adults (62-5).

METACARPAL TRACTION
Pass a K-wire through the 1st 2 metacarpals for some forearm fractures, especially if the circulation of the forearm is impaired (61-15)

LEG TRACTION METHODS
'90-90 TRACTION' is useful when the proximal fragment of the fractured femur is sharply flexed. Put a Steinmann pin through the supracondylar region of the femur, or the upper tibia, and flex the hip & knee both to 90º (67.7).

PERKINS TRACTION
Use an upper tibial pin to treat most adult femoral fractures. Flex the knee & exercise it (68.11).

BÖHLER–BRAUN TRACTION uses a special frame and is good for some supracondylar femoral fractures (67.3). You can also use this for tibial fractures, (69.3), although Perkins traction is usually better.

DISTAL TIBIAL TRACTION
Use a pin through the distal tibia to treat some proximal tibial fractures (70.7).

CALCANEAL TRACTION
Use a calcaneal pin to treat some tibial fractures (71.6). The purpose of the traction is to reduce overlap and bring the displaced bone ends together, not to pull them so far apart (distract them) that they cannot unite!
So: (1) Check the length of the injured limb by measuring it, or with radiographs, adjust the traction accordingly.
(2) Vary the traction to the needs of the patient; light patients need less weight than heavy ones. *Don't apply too much traction, and be prepared to adjust it.* To begin with you need to apply greater force than later, when the soft tissues have stretched. For example, for femoral fractures, the golden rule is to start with 10% of body weight and then reduce by 1kg/wk

A TABLE OF TRACTION WEIGHTS

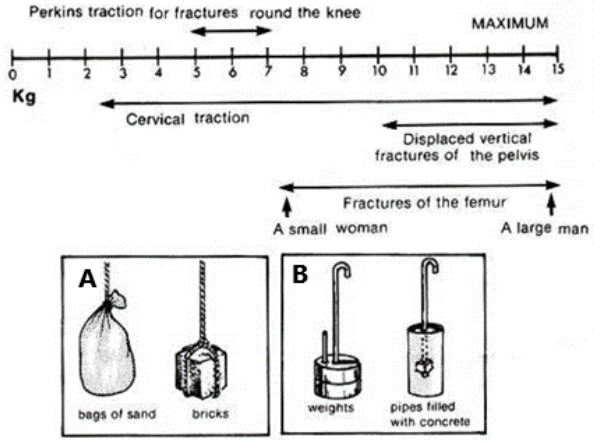

Fig. 59-12 A SCALE OF TRACTION WEIGHTS showing the range of weights needed for various fractures. Adjust them: (1) to the patient's build, and (2) during the course of treatment.

Ideally, traction should be checked with radiographs, but if you don't have portable X-ray machines, this is difficult. *There is no point of taking pictures with the traction disconnected.* The solution is to have a few beds with large castors on which you can wheel them to the X-ray department without taking down the traction.

N.B. Don't apply traction to a cast because the skin through which pressure is applied is likely to necrose. The only safe way to apply traction to a cast is to pass a pin proximal to the bone or through it, incorporating it into the cast.

EQUIPMENT FOR BONE TRACTION

•STRAPPING, traction, adhesive, 50x10mm rolls. This is elastic across its width, but not along its length.*'Elastoplast', which is elastic in both directions is useless, and dangerous!*
•PIN, Denham, (Denham is a centrally-threaded Steinmann pin), stainless steel, 4-5mm, tapered, self-tapping, with long coarse screw thread.

N.B. If you re-use re-sterilized pins, make sure they are still straight, sharp & not warped. Sharp tips create less heat than blunt.
•PIN, Steinmann, stainless steel, trocar, pointed at one end, diameter ranging 2-5mm and length 180-220mm, the smaller for the olecranon and the larger for the tibia.
•CHUCK. If you don't have a chuck, you can, if necessary, hammer in a Steinmann pin, if you follow the instructions below, but you cannot hammer in a Denham pin, because of its threads.
•HANDLE, with Jacobs chuck, 2-5 mm capacity, and key attached by chain, fully cannulated, stainless steel. This is an ordinary drill chuck on a handle. This chuck has 3 jaws, and although it is intended for K-wire and for pins & nails with triangular shanks, you can use it with square shanks. It will not grip the round section of a pin.
•STIRRUPS, Böhler, for Steinmann pins, with rotating swivel fixation pieces, of varying sizes. These can be used with Steinmann or Denham pins, the smaller for the calcaneus & olecranon and the larget for the tibia.
If you don't have these stirrups, take a wire coat hanger and bend it to shape, or tie the cords over corks (59-16E).

EQUIPMENT FOR BONE TRACTION

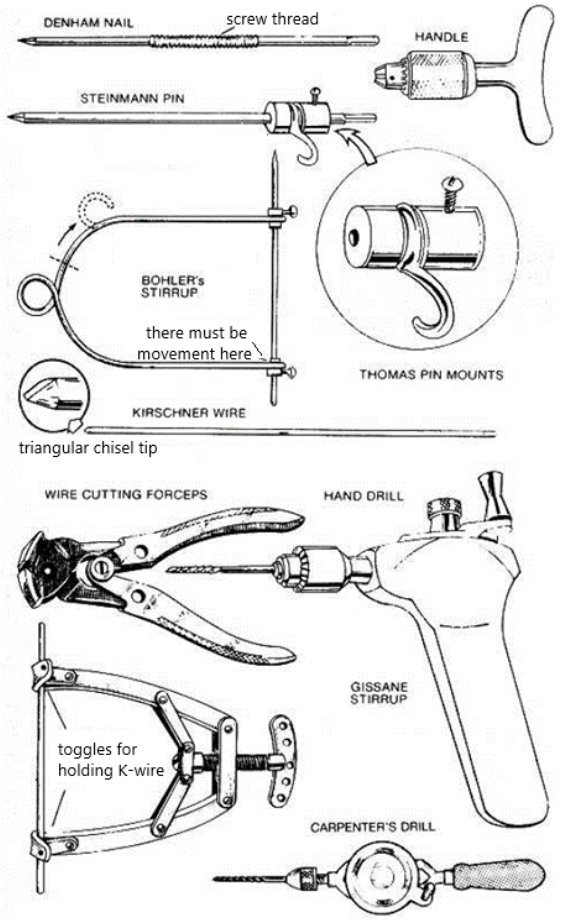

Fig. 59-13 EQUIPMENT FOR BONE TRACTION. Both the handle and the hand drill are cannulated so that a K-wire can pass right through them and be held close to the skin. If you don't have any other kind of drill, use an ordinary carpenter's drill.

•PIN MOUNTS, Thomas, stainless steel with rotating collar for Perkins traction. If you don't have them, you can make them by cutting a Böhler stirrup and bending the wire. The hooks must rotate freely round the collars.
•STIRRUPS, for wire traction, adjustable, tensioning, Gissane, with 2 cord hooks. These are for exerting tension on K-wire. They are more expensive than the standard K-wire stirrups, but there are no loose parts to get lost. Use these stirrups for exerting traction on the olecranon in fractures of the humerus, on the metacarpals in fractures of the radius, and on the metatarsals in some fractures of the foot.
•WIRE, Kirschner, plain unthreaded, stainless steel, drill pointed at one end, of diffrent diameters (usually 1, 1.6 and 2mms) and lengths. K-wires are weak and bend easily but they gain enormously in strength when tensioned by a device such as the Gissane stirrup.
Use them for traction in smaller bones or even in the tibia if Steimann pins are not available.
•WIRE CUTTERS. If you don't have these, sterilize a pair of ordinary pliers, but take care to oil them carefully afterwards.
•HAND DRILL, for K-wires and drills, up to 4 mm capacity, cannulated throughout.
Unfortunately, a carpenter's drill is not cannulated, so you can use it only with drill bits, not with K-wire. If you don't have any kind of drill, you may be able to hammer in a sharp Steinmann pin through cancellous, but not through cortical, bone to relieve osteomyelitis (7.3).

•DRILL BITS, twist, bone, 4 mm. Use these to:
(1) Drill a hole for a Steinmann pin. (2) Explore for pus in patients with osteomyelitis. Don't drill so vigourously that the bit becomes too hot, and necroses.
•CORD, braided, for traction, local purchase. If you don't have this use a length of bandage.
BED FRAME: there are many different kinds of orthopaedic bed frames, many improvised, but they all have the same purpose: facilitate mobilization and maximize the effectiveness of the traction system. It is not an absolute necessity, but makes everybody's life easier, starting with the patient himself. They are inexpensive to produce locally.
•PULLEYS, assorted, with appropriate connections for the bed frame
•BARS, for overhead traction & for a patient to pull himself up. These are needed for '90–90' traction (67.3), for some pelvic fractures (66.2), and for humeral fractures in unconscious or supine patients (61.13).
•WEIGHTS, for traction, local manufacture. Use bags of water, sand, or bricks suspended in stockinette (59-11); each brick weighs about 3kg. Or, use lengths of pipe filled with concrete into which a hook has been placed before the concrete sets. For example, 45cm of 7.5cm pipe filled with concrete weighs c.7kg.

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DON'T APPLY STRAPPING PROXIMAL TO THE FRACTURE LINE

ADJUST THE TRACTION CAREFULLY

SKELETAL TRACTION
Steinmann pins are stainless steel rods 3-6mm in diameter. Some are fully threaded but most are completely smooth. Smooth pins tend to loosen sooner, and loose pins lead to pin tract infections (and vice-versa)

A Denham pin is similar, except that it has large threads in the middle it only, which you can screw into the cortex of the bone to stop it slipping from side to side. If you use a Denham pin, be sure to identify it as such with a piece of tape, and to note it in the chart.

N.B. When you remove it, you will only see the smooth parts of the pin on either side of the limb and, unless you are aware, may be tempted simply to pull out what you think is a Steinmann pin, instead of unscrewing the inside part of a Denham pin.

Denham pins are better than Steinmann pins for Perkins traction (67.3) and for calcaneal traction (70.7). Steinmann pins have other uses, so you will need both. Insert them with the chuck.

Inserting a sharp tipped pin puts at risk neurovascular strucutres on both sides of the bone. You can control where a pin goes in the bone, but not where it comes out.

For this reason, it is safer to insert the pin on the at-risk side and exit on the less risky side:
(1) from medial to lateral for the olecranon,
(2) from medial to lateral for the distal femur,
(3) from lateral to medial for the proximal tibia,
(4) from medial to lateral for the calcaneus.

SITES FOR SKELETAL TRACTION

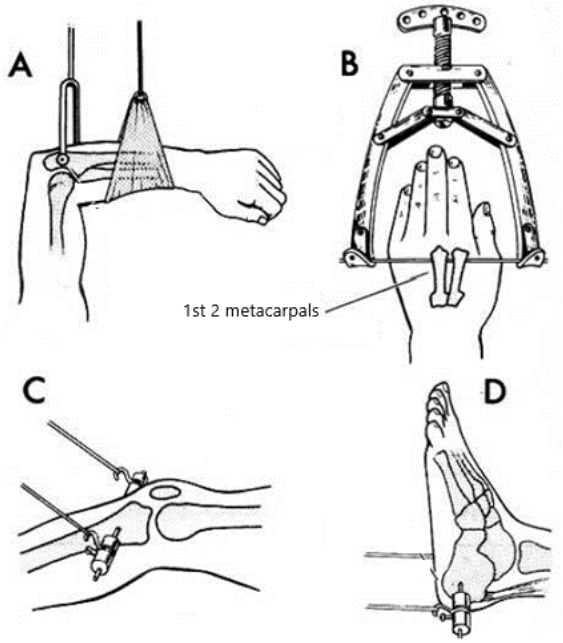

Fig. 59-14 SITES FOR SKELETAL TRACTION. A, use a K-wire or a small Steinmann pin. B, use a K-wire only for the hand. C, make sure the pin is perpendicular to the tibia. D, likewise to the calcaneus. *After de Palma AF, Management of Fractures and Dislocations, An Atlas, WB Saunders, 2nd ed 1970 with kind permission.*

These pins are stiff, so you can apply traction to them without tensioning them. You can use:
(1) A Böhler's stirrup (70-12) and a single traction cord and weight.
(2) 2 Thomas pin mounts (swivels) with 2 traction cords & 2 weights.
(3) Corks on the ends of the pin and tie the cords to them. If you tie the traction cords directly to the ends of a pin, they usually slip off and cause agony as they do so. Join the cords together and run them through a pulley attached to a single weight, so as to equalize the pull on either end of the pin (59-16B).

Pins can spread or introduce infection, so:
(1) Put them through healthy tissues some distance from a fracture, but *not through a fracture site* where the injured tissue is easily infected. You can use them to treat open infected fractures, but the further they are from the site of infection, the better.
(2) Keep pins still. The pin must stay fixed in the bone, and the stirrup rotate around it freely. This is why a Denham pin, which is firmly screwed into the bone is better than a Steinmann pin.
If your pin mounts have set screws, *don't tighten them*.
(3) *Never put a pin through a joint capsule*. The most serious complication of skeletal traction is knee joint infection, or calcaneal osteomyelitis, (7.13). If sequestrectomy does not cure this, it may be necessary to remove the whole calcaneus.

A LOOSE PIN PROMOTES INFECTION

INSERTING STEINMANN'S OR DENHAM'S PINS (GRADE 2.1)
Use a sterile sharp pin, as blunt ones promote infection. Make sure you have a strictly sterile environment (this is often best in the theatre).
You can either sterilize the chuck, or use an unsterile chuck and a no-touch technique.

If you intend to hammer a pin in, do it through cancellous bone near the end of a long bone, and not through the thick cortical bone of the shaft, *because this may split*.

TIBIAL TRACTION − RIGHT & WRONG

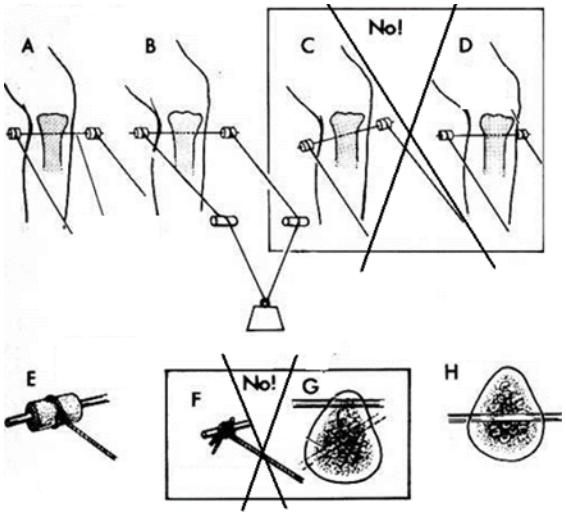

Fig. 59-15 TIBIAL TRACTION RIGHT & WRONG. A,B, at all sites the pin must be at 90^0 to the axis of the limb and in a horizontal plane. The pin must be clear of the skin, and protrude the same length of pin either side. C,D, If the pin is skew, or asymmetrical, the cord will slide along it and rub against the skin. E, if you don't have a Thomas swivel, tie the cord to a cork, F, *not to the pin directly*. G, pin too anterior, or skew. H, correct position of the pin. *Kindly contributed by John Stewart.*

Get 2 assistants, and use ketamine. Apply antiseptic to the pin-points on the skin, and introduce LA at these sites down to the periosteum of both sides, making sure it goes under the periosteum.

Make a generous longitudinal incision (5-10mm) in the skin with the point of a sharp scalpel. The main reason pin tracts become inefected is because the skin closes over the pin and prevents secretions from draining.

Insert the pin at the distal end of the incision, as the skin will glide over it when you reduce the fracture with some traction. *Check that there is no pressure on the skin.* If so, extend the incision.

Have an assistant apply counter-pressure and stabilize the limb. Advance the pin bluntly until you reach the bone. You can 'walk' the pin on the bone to identify its anterior & posterior borders, and aim for the middle.

With the toes pointing upward, the pin should be parallel to the floor and perpendicular to the long axis of the bone. Putting it in is hard work!

As the pin comes out of the bone on the other side of the limb, its point will raise the skin, so nick this with a scalpel, and push the pin through.

When the threads of a Denham pin reach the bone, screw them in about 6 turns, so that some of them enter its cortex. Ideally, the threads should bite both cortices *otherwise they will wear loose.*
Finally, secure the pin in a Böhler's stirrup or, preferably, with Thomas pin mounts. If the sharp point might injure the other leg, put a cork or a cap (*e.g.* an empty medicine vial) on it. Remember to mark your Denham pin and record it in the operative note!

PARTICULAR SITES FOR PIN FIXATION

THE LOWER FEMUR is used mostly for 90-90 traction, or if the knee or leg are also injured.
Insert the pin at the level of the flare of the condyles, opposite the upper pole of the patella, slightly anterior to the midline of the leg.

THE UPPER TIBIA is much the most important site, and is used for most femoral fractures, and many fractures around the knee. There are 2 alternative sites.

If you are using a chuck, put a 4 or 5mm pin through firm cortical bone 3cm distal to the tibial tuberosity. Push from the lateral to the medial side. Feel the fibular neck with your thumb: the common peroneal nerve will be winding round here, so insert the pin anterior to that point.

If you have no chuck and you have to hammer a pin in, do so from the lateral to the medial side 1cm distal to the tibial tuberosity through the junction of cortical & cancellous bone, that is, through the flare of the condyles. Make sure the tip is sharp. The pin will be less firmly held here but the bone is less likely to split.
N.B. On either site, don't insert the pin too far anteriorly, because there will not be enough bone to hold it. Insert it in the midline of the shaft, *taking care not to damage the peroneal nerve.*

THE LOWER TIBIA is used for some rare upper tibial fractures (69.5). Insert the pin from the lateral side 4-6cm above the medial malleolus immediately in front of the fibula. This makes sure it is well clear of the ankle joint, and avoids injuring the superficial peroneal nerve. Align it carefully so that it is at right angles to the long axis of the limb and is in the coronal plane.

THE CALCANEUS is used for some fractures of the tibia (70.7). Insert a 4-5mm pin, preferably of the Denham type, from the medial side, to avoid injury to the posterior tibialis bundle, through the posterior part of the calcaneus, (59-15,59-17). Put the pin approximately 2cm below and 2cm posterior to the tip of the medial maleolus.

N.B. If you put the pin in too far posteriorly, you will dorsiflex the foot.

SETTING UP CALCANEAL TRACTION

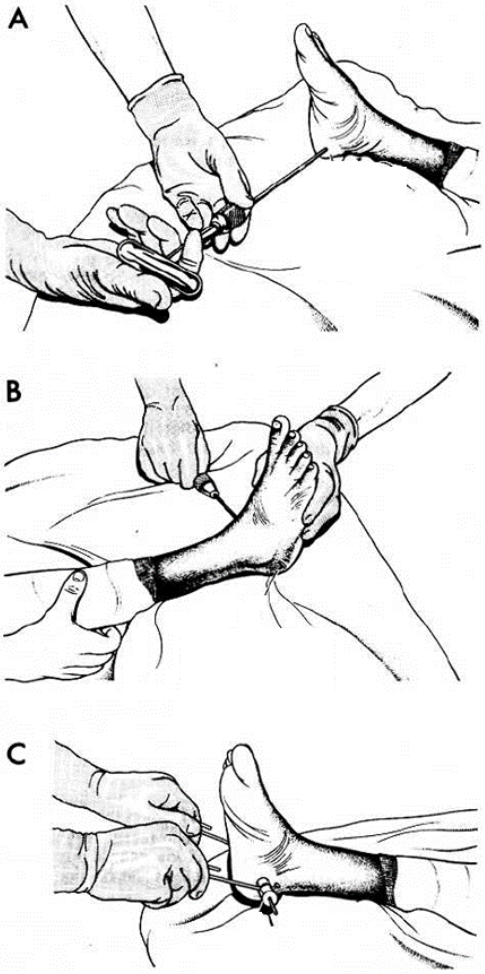

Fig. 59-16 INSERTING A STEINMANN PIN THROUGH THE CALCANEUS. A, put LA down under the periosteum before introducing the pin. B, incise the skin on the opposite side before the pin pierces the skin. C, attach the Thomas pin mounts so that they rotate freely. *N.B. If you leave it in for >15days you will increase the risk of osteomyelitis.* *Kindly contributed by Peter Bewes.*

N.B. K-wire traction is an alternative to a Steinmann pin.

THE OLECRANON is used for some distal humeral fractures. Use a thin 2-3mm Steinmann pin, or, better, a K-wire, and insert it from the medial side laterally, avoiding the ulnar nerve in the ulnar gutter below the medial epicondyle.

If there is frank purulent discharge or loosening of the pin, it needs to be removed and the tract and bone curetted to avoid the formation of a ring sequestrum. If you still need skeletal traction, put in a new pin at an alternative site.

REMOVING A PIN
Use an antiseptic to clean the projecting point of the pin to be drawn through the tissues. Pull it out with the chuck.

IF A PIN TRACK BECOMES INFECTED, REMOVE THE PIN

USING K-WIRES
K-wires are thin and flexible, and need to be tensioned to apply traction. Unlike a Steinmann or Denham pin, where movement takes place between the pin and the pin mount, movement with K-wire traction takes place between the wire and the tissues. This limits the amount of exercise that is practical.

DISTRACTION IS ONE OF THE GREAT ENEMIES OF UNION

Use traction with K-wires mostly in the calcaneus and proximal tibia, but occasionally in the olecranon and metacarpals.
K-wire fixation is also useful for internal fixation of some fractures of the hand, foot, patella and olecranon, with or without added cerclage wiring for tension banding.
To fix 2 K-wires in place, twist both ends in the *same direction* giving equal tension to both wires, but *avoid excessive twisting.*
As a general rule, *avoid circumferential cerclaging of long bones*: it kills the periosteal blood supply, and since the endosteal supply is also disrupted by the fracture, this leads to bone necrosis.

N.B. Don't leave K-wire sticking out of the skin, because this increases the chances of infection.

REMOVAL If a K-wire is causing no trouble, leave it. If the ends of the wire are painful under the skin, or if there is infection, or a sinus, remove it. Feel for the end of the wire under the skin; introduce LA, make a nick in the skin and remove it with pliers or with any convenient instrument.
If you cannot find the end of the wire, you may have to use a tourniquet under ketamine.

59.5 External Fixation

EXTERNAL FIXATION
You can efficiently stabilize open bony limb injuries with a device which holds healthy bone away from the fracture site using screws from outside, and fixes them using connecting rods. This **external fixator** (X-fix) allows stabilization of a fracture while permitting easy access to the surrounding soft tissues.

ADVANTAGES
(1) External fixation provides *rigid fixation* of bones where other methods are inappropriate, *e.g.* severe open fractures, or in damage control.
(2) It also allows compression or fixed distraction of fracture fragments as required, and this can then be varied to allow a little movement for callus to form.
(3) You can easily monitor a wound for sepsis, ischaemia, viability of skin flaps or muscle compartment tension.
(4) You can perform procedures around the fracture site, such as skin or bone grafting, without disturbing bone alignment or reduction.
(5) It is useful especially in polytrauma patients: early mobilization is possible, especially for tibial injuries, without fear of loss of fracture alignment.
N.B. Even if reduction is far from perfect, you can correct the position easily later when the patient is more stable.
(6) You can elevate a limb without pressure on the posterior soft tissues. You can suspend the pins and frames by ropes from overhead frames. This will also help oedema to resolve
(7) You can insert pins under LA, if necessary.
(8) It is ideal for temporary fixation of a fracture adjacent to a dislocation.
(9) It is ideal in treatment of infected fractures or non-union, fractures in burn patients, and to achieve arthrodesis.
(10) It is much lighter than a cast.
(11) It is useful for temporary stabilisation method in patients awaiting referral, or when awaiting necessary supplies or a helping surgeon to arrive.
(12) It is useful as temporary treatment in patients unfit for invasive surgery (*e.g.* in polytrauma, or where haematological or biochemical correction is necessary) or as definitive treatment in patients who are chronically unfit.

Its greatest benefit is in the management of the soft tissues *not the management of the bone*. However, a correctly applied external fixator is ideal for low-resource settings.

DISADVANTAGES
The equipment is expensive, although 'home-made' *(e.g.* wood, K-wires or plastic) devices will suffice, especially on the fingers. The X-fix is cumbersome, and a patient may fiddle with the apparatus, or (if confused) injure himself or another with it.

COMPLICATIONS
(1) Pin tract infection.
(2) Re-fracture after X-fix removal.
(3) Adjacent joint stiffness.
(4) Nerve, vessel or tendon damage.
(5) Non-union.
(6) Compartment syndrome (this risk is always present, although it is lessened by use of an X-fix)

Applying an X-fix may be difficult and needs experience; so, if simpler fracture fixation is adequate, and you are not very familiar with the X-fix, practice on some animal bones first : *don't experiment on humans with it!*

SPECIFIC INDICATIONS
(1) Any open fracture needing stabilization.
(2) 'Open book' pelvic fracture.
(3) Complex peri-articular injury (*e.g. elbow, wrist, knee, ankle, midfoot*.)
(4) Distal forearm fracture (definitive treatment), where the fracture is too unstable for a plaster.
(5) Unstable ankle fracture/dislocation.
(6) Finger fracture.
(7) Floating knee injury (distal femoral fracture with ipsilateral proximal tibial fracture).

TYPES OF EXTERNAL FIXATOR
There are basically 2 types of external fixators: a circular frame with K-wires, or rods connecting pins or screws. *Don't use the former unless you are familiar with it & its indications.* The latter relies on non-transfixing pins connected to rods to achieve a rigid construction. You can also incorporate transfixing pins used for skeletal traction in such frames.

There are dozens of X-fix kits available around the world. They all share the following basic components: pins, rods, pin to rod connectors and rod to rod connectors & clamps. They all come in different lengths, widths, and materials. Some sets are compatible with others, *most unfortunately are not*. The usual X-fix box available is a hodge-podge mix of all the above!

Part of your pre-operative planning is to visualize the type of frame you want to construct. Make sure *before* you start anesthesia that what you need (or an appropriate alternative) is available and in working order.

We describe here how to make your own X-fix with locally available materials.

For the 'rods', use hardwood timber of diameter 1-2cm of various lengths. A broom stick serves as a useful robust example.

For the 'pins', use sterilized autoclaved bicycle spokes: these have an ideal flexibility & strength.

EQUIPMENT FOR HOME-MADE X-FIX

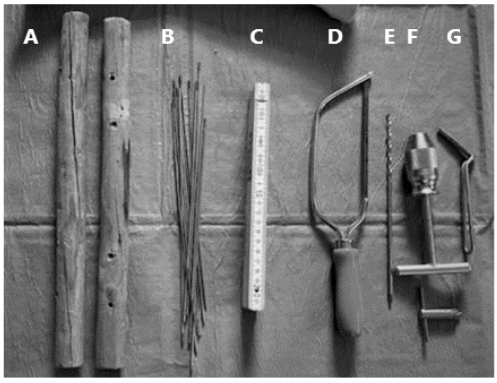

Fig. 59-17 EQUIPMENT TO MAKE YOUR OWN X-FIX. You'll need: A, wooden bars. B, bicycle spokes. C, stiff cm measure. D, handsaw. E, 4.5mm drill bit. F, hand drill with chuck. G, tissue guard. *After Bullmann T, Akim K, Domres B. The wooden external fixator.*

Basic elements of any X-fix set contain:
(1) external bars, rods, tubes of various lengths,
(2) spokes, pins or screws, either self-drilling or needing insertion through a slightly smaller hole drilled beforehand,
(3) cm measure
(4) handsaw (if you are making your own set)
(5) hand drill with chuck and bits
(6) pin inserter & soft-tissue guard,
(7) clamps
(8) pin-to-rod & rod-to-rod connectors

EQUIPMENT FOR EXTERNAL FIXATION

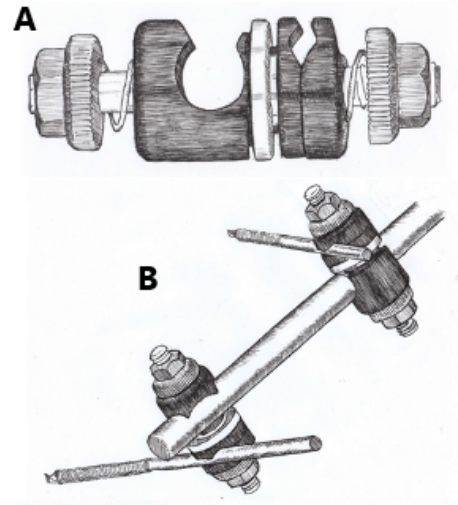

Fig.59-18 EQUIPMENT FOR EXTERNAL FIXATION A, connecting clamp. B, rod connected to 2 pins by clamps.

There are 3 basic types of frames: uniplanar, biplanar & modular. They are all simple but differ slightly in their fundamental principles, and whatever hardware is available to you may dictate your choice.

TYPES OF X-FIX FRAMES

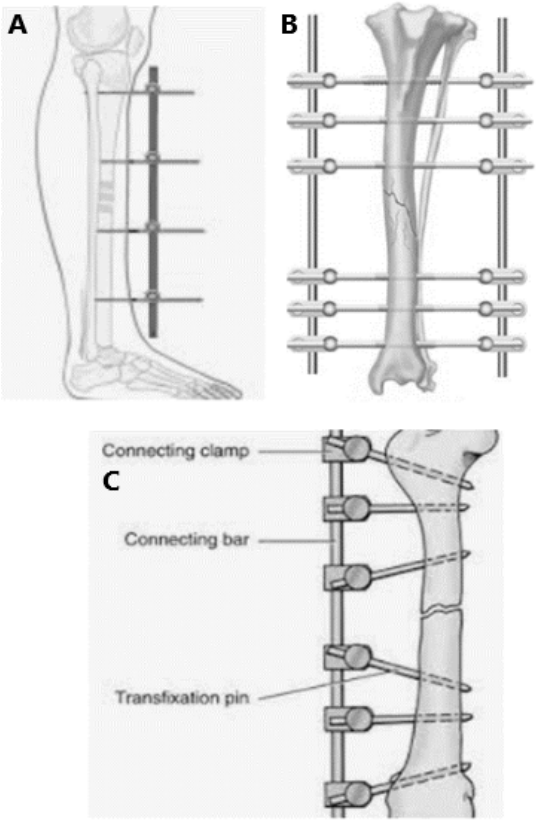

Fig. 59-19 X-FIX TYPES. A, uniplanar. B, biplanar. C, modular.

The unilateral and the segmental types, are both biomechanically inferior to the modular frame. So try to stick to the modular, if possible.

PUTTING AN X-FIX IN PLACE

Using the X-fix requires pre-operative planning, a knowledge of anatomy, understanding of basic biomechanical principles regarding pin insertion, and continuous post-operative monitoring for complications.

Remember 2 simple, but important, rules to follow when constructing an external fixator:
(1) Put the rods and the pins as close as possible to the fracture.
(2) Always use 2 rods when fixing the X-fix, in order to create a stronger frame.

Every bone and joint has designated 'safe zones' for pin insertion. Look them up before you scrub up. It is helpful to mark these safe zones with a permanent marker on the skin before surgery.

Once you have located the best areas for pin insertion, make a 1cm incision with a blade.

Dissect the soft tissues under direct vision until you reach the bone.

To protect the surrounding soft tissues when inserting the pin, either use a pin inserter and soft tissue guard or a mosquito forceps to guide your pin to the bone.

When drilling the pin with the hand drill, hold your non-dominant hand on top of the drill. With this hand, apply a constant, axial pressure on the pin. With your dominant hand, turn the drill, without applying any pressure, so that the pin stays perpendicular to the bone and so that it does not slip. You need an assistant to exert counter-pressure.

However self-drilling pins can produce thermal necrosis of both skin and bone, especially in the dense bone of the tibial diaphysis. It is therefore, advisable to pre-drill there for the external fixator pins, using a sharp drill bit that is slightly smaller than the chosen pin. A soft tissue sleeve, very limited blunt dissection to bone after incising the skin, irrigation, and a 'stop-and-cool' technique, all help to avoid tibial pin track complications.

If drilling is at all hard, remove the bit and clean off any bone chips. They should be white, not brown or black, which signify burning. If you encounter evidence of thermal necrosis, you should prepare and use another pin site, because pin site infection and associated loosening is a common complication.

In order to create the best stability, the 2nd (and sometimes 3rd) pin you wish to connect to the same clamp should be parallel to the 1st one.

Take the clamp and make the screws as loose as possible, but without detaching the 2 parts of the clamp. Put it over the 1st pin in the position you want to fix it later on. The clamp will indicate where the 2nd incision should go. Make your incision, using the same process as described above. Keep the clamp in place over both the pins when drilling the second one, to give the best indication of direction.

Attach the clamps to the pins on both sides of the fracture. Reduce the fracture in the best possible position using the clamps as joysticks. A 2nd person should now connect the rods to the posts and fix these as strongly as possible.

Elevate the limb. Get a repeat radiograph in 2 directions to check the fracture reduction. If the reduction is unsatisfactory, you can simply loosen the device and try again. ***Don't accept malalignment*****:** it defeats the object of using the X-fix!

If the reduction is acceptable and stable, add a 2nd rod for additional stability.

If you do not have rods available of the correct length, or no rods at all, connect the clamps by plaster cast bridging instead. You will need one person holding the reduction for 15mins (the time the plaster hardens), and 2nd person to take a piece of wood or cardboard to use as a rod of the correct length. Connect this provisional rod to the clamps with the plaster cast and strengthen the provisional rod itself with a few layers of plaster cast as well.

N.B. This principle is similar to the use of an anti-rotation bar or support bar in a hip spica.

Make sure that you:
(1) *avoid inserting pins through the wound*,
(2) use a hand drill, *not a power drill* as this produces excess heat & burns the bone cortex, resulting in a ring sequestrum,
(3) *don't insert pins too close to the fracture site* or in the fracture,
(4) *don't insert pins too far from the fracture site: you risk making the fixation unstable,*
N.B. 2-3cm on either side is safe.
(5) insert at least 2 pins in each part of the fracture you wish to stabilize,
(6) put pins as far apart as possible in the clamps, to use to a maximum the strength of frame,
(7) place the rod as close as possible (2cm) to the skin to use to a maximum strength of frame,
(8) always use a soft tissue protector to avoid iatrogenic soft tissue injury,
(9) *don't drill a hole a bigger size than the pin width:* it will be loose!
(10) *never attach the rods to your clamps before reducing the fracture*. This will complicate the reduction,
(11) attach the rod-to-rod or rod-to-pin connectors in the right direction, *i.e.* with the screw facing away from the fracture, so you can easily tighten it later on,
(12) tighten all screws on your construction to the fullest before leaving the operating theatre,
(13) test the stability of bone reduction on the operating table, as you may need to make some modifications,
(14) check pin position and fracture reduction with fluoroscopy or a portable x-ray machine in the operating theatre, if available.
(15) *take care if the bone is osteoporotic.*

A similarly constructed external fixator can span a joint if necessary.
Once you have assembled the frame and reduced the fracture, you should check the pin sites again. Occasionally skin tension that tents the skin may occur after reduction.
In this case, use a small pointed scalpel to incise the skin and release all tension.

GENERAL POST-OPERATIVE ADVICE
Clean the pin-skin interface twice daily, and apply antiseptic dressings.

The most important factor preventing pin tract infection is to mobilize the skin around the pin regularly to prevent the skin sides sticking to the pin, which traps the exudates inside. Pin sites need to drain, until they dry out on their own.

If a pin becomes painful with red, swollen skin, ***but is not loose,*** a course of oral antibiotics is all that is needed.

If there is purulent drainage or loosening of the pin, remove it and curette the track. Try to put in another pin elsewhere through normal skin, if it is still necessary.

N.B. You may have to reapply a completely new X-fix!

As soon as the wound is covered and stable (usually by 6wks for the leg), replace the X-fix with a cast or a brace until bony union is achieved.

N.B. Don't immediately allow mobilization until the bone can take the stress.

N.B. Don't leave an X-fix in place too long, as non-union may result.

Once you allow some fracture movement, the pins will become loose, and this may result in infection or new fracture. So, it is usually best to replace the X-fix by a cast or brace.

Details of specific X-fix insertions are mentioned in different chapters:
(1) Humerus (61-18)
(2) Elbow (62-8)
(3) Forearm (63-13)
(4) Wrist (64-9)
(4) Hip (66-9)
(5) Femur (67-10)
(6) Knee (69.5)
(7) Tibia (70-11,12)
(8) Ankle (71-13,14)

The amount of stiffness that provides the most favorable environment for fracture healing in an external fixator is unknown. More rigid frames are preferable at the start of treatment during the phase of soft-tissue healing and have usually fewer pin site problems. Fractures with more inherent instability require stiffer frames than more stable fracture patterns.

Gradually destabilizing the frame, to permit more weight bearing on the bone, stimulates fracture healing. Destabilization usually includes converting the frame from a static to a dynamic construct by loosening the pin-to-rod clamps on one side of the fracture.

Axial compression is allowed while maintaining angular and rotational alignment.

You can also make frames less rigid by increasing the distance between the rod and the bone and removing the outer rod in a double-rod frame. The fracture should be stable enough to resist excessive shortening or angulation before fracture destabilization.

REMOVING AN EXTERNAL FIXATOR
Don't hesitate to remove an external fixator when there is good callus formation & wounds are closed; do this as an out-patient under sedation. All necessary tools including a hand drill or t-handled chuck should be available.

Remove the external fixator pins, scrub the pin site with betadine solution and apply a fairly bulky sterile dressing to accommodate the usual brief bleeding. Then check for stability by manually stressing the fracture and either apply a walking cast or even allow pain-adapted partial weight up to full weight bearing without protection, if you estimate that the fracture has healed.

Most pin sites should heal after a few days and need little further care, if any at all. Occasionally, a tibial pin site may become infected, which may cause loosening, persistent purulent drainage, or a ring-sequestrum.

Don't try to clean the pin-tract with a curette, but use a hand drill with bits large enough to debride the affected bone. Do this under GA in theatre.