70 Tibial shaft injury

70.1 Introduction

The tibia is the most commonly fractured long bone, because of its exposed location. The worst civilian injuries occur in motorcyclists and pedestrians struck by motor vehicles. Tibial fractures occur also in the osteoporotic elderly. Because ⅓ of the tibial surface is subcutaneous throughout most of its length, open fractures are more common in this bone than in any other major long bone. However, tibial fractures vary greatly in severity, so we provide guidance which should cover most situations. These fractures will, however, challenge your judgment and skills. If you don't treat these them carefully, they can cause severe disability (70.8).

DIAGNOSIS
You can usually identify an acute tibial shaft fracture from the localized pain after injury and the typical physical findings of deformity, tenderness, instability, swelling, and possible open wounds. The mechanism of injury, if known, and so the amount of energy transmitted in causing the injury is the major determinant of its severity. Did the patient trip on a curb, or get struck by a car, or get run over and crushed by its wheels?

As many as 30% of victims with a tibial shaft fracture will have additional injuries, especially after road traffic accidents. Rule out any other life-threatening injuries and perform immediate life sustaining interventions according the ABC algorithm (41.1). Similarly, identify and treat any limb-threatening injuries, such as major arterial injury (49.1), compartment syndrome (49.6), and open fractures (58.12), which are potentially life-threatening as well. Note the time, place, and events surrounding the injury as precisely as possible. Note the time elapsed especially for vascular injuries, compartment syndromes, and open wounds.

The soft-tissue envelope is the most important component in the evaluation and subsequent care of tibial fractures. A complete circumferential inspection of the limb is essential to prevent overlooking even the smallest wound.

As the tibia lies directly beneath the skin, tibial fractures are usually associated with an injury to this most delicate skin cover, especially in high-energy trauma.

Compartment syndrome (49.6) occurs more often with tibial fractures than with other long bone fractures, from swelling, bleeding, ischemia, or rebound oedema following restoration of blood supply (ischemia reperfusion injury).

The anterior compartment is most commonly involved. The usual signs of severe pain, pain with passive stretch, and localized loss of sensation demand a prompt operative fasciotomy, combined with appropriate fracture stabilization. A compartment syndrome generally develops some hrs after injury, although of course may be present at initial evaluation if this is late after the event. Thus you may need emergency treatment early in the care of a tibial fracture.

Occasionally, undisplaced or incomplete acute injuries or more chronic stress & pathologic fractures may be difficult to identify.

IMAGING
You need an AP and lateral radiographs with both knee and ankle joints included. Ultrasound can readily show up a fracture of the subcutaneous parts.

TREAT MOST CLOSED TIBIAL SHAFT FRACTURES CONSERVATIVELY!

PRINCIPLES OF TREATMENT
Considering the tibial shaft fracture itself, evaluate the injury, anticipate any problems that might develop, and choose from among several alternatives an appropriate plan of management that will be simultaneously safe and effective. The main goals of treatment are to obtain a healed, well-aligned fracture with pain-free weight bearing and a functional range of motion of the knee and ankle joints, without an unduly long period of disability.

Open fractures usually need surgery, by debriding the contaminated wound, by applying traction or an external fixator for stabilization of the fracture, by repairing a major arterial injury and if necessary by closing the wound with secondary skin grafts or even rotational flaps (70.7).

Don't be tempted to fix closed tibial fractures. External fixation is an option in certain situations, especially open fractures (59.4). A simple type of external fixation is the use of 2 Steinmann pins in a cast (70.2).

Closed treatment with casting or functional bracing is effective in treating many tibial shaft fractures. For such treatment to succeed, the cast or brace must maintain acceptable fracture alignment and the fracture pattern must allow early weight bearing to prevent delayed union or non-union.

Axial or rotational malalignment and shortening cause cosmetic deformities and alter the loading characteristics in adjacent joints, and so may hasten post-traumatic arthritis. *Avoid an excessive amount of malalignment and shortening*.

Acceptable amounts are not exactly known, but this gives some guidance:
(1) 4-10° *varus-valgus* malalignment,
(2) 5-20° anteroposterior malalignment,
(3) 5-20° rotatory malalignment, &
(4) 1-2cm shortening.
However, union of a comminuted tibial shaft fracture, with some shortening or malalignment is a reasonable price to pay. *Non-union is very likely to lead to persistent disability.*

Unless there is acute arterial insufficiency, compartmental ischemia, or the presence of an open wound, *there is little urgency for definitive reduction and stabilization of a closed tibial shaft fracture*.
What is important, however, is restoring the overall alignment with the application of a well-padded splint or cast and elevation and rest for the injured limb.

Repeated manipulations, cast changes or wedging and the use of prolonged anesthesia, striving for a perfect reduction must not be a part of the early care for a tibial fracture, because this:
(1) may add to the soft tissue injury,
(2) is painful,
(3) interferes with discovery of developing ischemia,
(4) is often followed by the need to loosen or remove a laboriously adjusted cast, and
(5) is often performed in a rush with insufficient assistance.
Thus, a much better policy is prompt and gentle realignment of the injured limb, followed by the application of a well-padded cast.

Elevating an injured lower leg in a distal limb injury:
(1) eases the pain,
(2) reduces the swelling,
(3) minimizes the stiffness that follows the organization of any oedema fluid,
(4) enables application of a cast to a limb from which most of the swelling has subsided.
This will make the cast less likely to become loose subsequently. *So splint and elevate all leg fractures before you manipulate them, operate on them, or put them in a cast.*
N.B. Continue to elevate an injured leg during an operation, and afterwards.

Elevate the leg from the moment you see the patient, until swelling is no longer a problem. *Resting the leg on a chair or on pillows is not enough*. The injured leg must be above the level of the heart. Raise the end of the bed on a stool or chair, or on 30cm blocks for several days if necessary. Encourage movements of the foot and ankle actively, so as to improve the circulation in the calf muscles. Explain how important this is to all your ward staff.

N.B. **If you suspect a developing compartment syndrome**, place the affected limb at the level of the heart. Elevation is contraindicated because it narrows the arterio-venous pressure gradient.

ELEVATING AN INJURED LEG

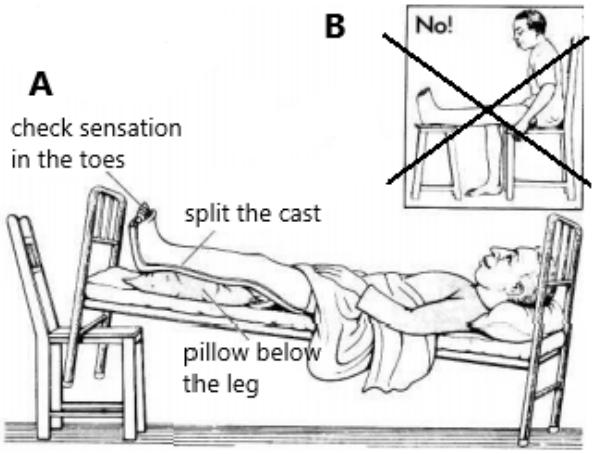


Fig. 70-1 ELEVATING AN INJURED LEG A, (1) eases the pain. (2) reduces the swelling. (3) minimizes the stiffness that follows the organization of oedema fluid. (4) enables easy application of a cast after most of the swelling has gone. B, *putting the leg on a chair does not lift it high enough!* *Kindly contributed by Peter Bewes.*

70.2 Tibial shaft immobilization

EARLY EMERGENCY IMMOBILIZATION
Reduce the fracture as soon as you can, *e.g.* under ketamine, and apply a well-padded cast or splint. Realign the leg with manual traction and support. How good the reduction after a single good attempt is a guide to subsequent therapy. Generally, use a splint for stable injuries and an emergency circumferential well-padded split cast for unstable fractures (58.2). *Never keep a cast closed*!

The cast should extend from mid-thigh to the metatarsal heads. Padding is essential to avoid skin breakdown and to accommodate some swelling, but too much padding, or a splint that is too flexible or excessively padded, will not immobilize well enough.

If the fracture is open, clean the wound by irrigation with copious amounts of water, and apply a sterile dressing before putting on the cast with a window exposing the wound (70.7). Administer prophylactic antibiotics.

The fragments of the broken tibia are much more likely to unite satisfactorily if:
(1) you get the fragments into an acceptable position to begin with, and
(2) you allow walking on the fracture inside a snug well-fitting cast early, and continuously.

Start as soon as the swelling has subsided, preferably during the first few days after injury. Early weight-bearing will *not* make infection worse, but it may shorten the leg by 1-2cm, particularly in oblique fractures, where one fragment can easily slip over another.

Although not ideal, this is not so important, because compensation of ≤4cm shortening by tilting the pelvis, or wearing a shoe-raise.

Prevent excessive shortening by a short period of traction at the start. A little shortening (66.1) is a small price to pay for the much greater certainty of union. *There is no compensation, however, for non-union which all too often complicates attempts to prevent shortening*. Although traction for >6wks is very useful for treating fractures of the femur, *never apply it for >2wks for an uninfected fracture of the tibia,* because traction for longer than this encourages non-union.

For an open or infected tibial fracture, traction for as long as 3wks may be necessary while you treat the soft tissue injury. Apply traction from a Steinmann pin through the calcaneus (70.7) *but don't distract the fragments.*

GOOD PLASTER TECHNIQUE

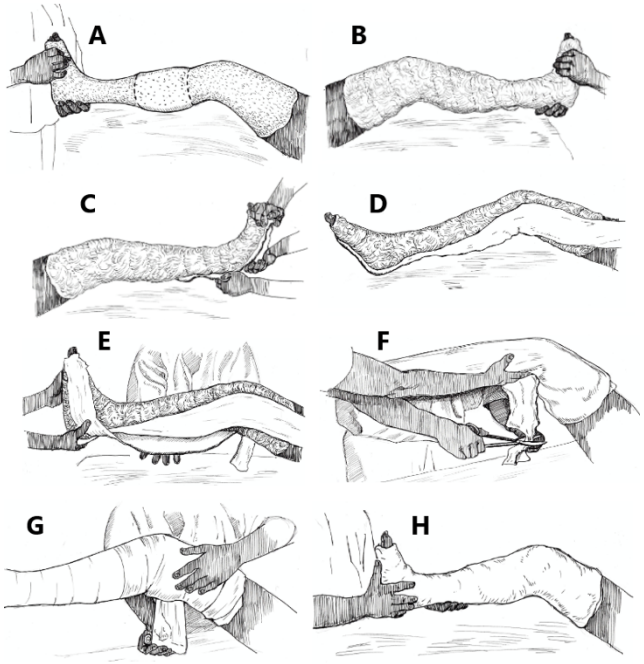


Fig. 70-2 GOOD PLASTER TECHNIQUE makes all the difference! A, apply a stockinette to the leg over any wound dressing. B, put padding over the stockinette to malleoli, the heel, the patella & fibular head (pressure points). C,D, apply the 1st wetted plaster so it encloses the 5th toe, & the lateral border of the foot, posteriorly over the heel, and moulds onto the calf, continuing behind the knee to mid-thigh. E, apply a 2nd slab starting over the hallux & medial border of the foot, crossing over the 1st slab behind the knee and finishing on the lateral thigh. *The cross-over in the popliteal fossa is critical to give the PoP its strength.* F, trim any excess plaster: *don't fold it back as it becomes lumpy & uncomfortable.* G, apply gauze or elastic bandage *firmly but not too tightly.* H, hold the backslab with the knee at 15^0 of flexion *(put a vacolitre behind the knee to make this smooth & easy),* & the ankle at 90^0 neutral position. *Check the finished edges do not dig into the skin, and rest the backslab on a pillow. Write the 'passport' details on the PoP* (59-7). *After Giannou C, Baldan M, Molde, Á. War Surgery, ICRC Geneva 2013*

GET THE FRAGMENTS INTO AN ACCEPTABLE POSITION

Uncomplicated fractures of the adult tibia take 16 weeks to heal. Healing is delayed if the tibia is comminuted, if soft tissue injury is severe, or if a fracture is open or infected; union may take a year or more.

DEFINITIVE IMMOBILIZATION

There are 4 different casts in which a patient can walk and bear weight.

In order of decreasing stability, but increasing mobility and, convenience, they are:

(a) a long leg walking cast from the groin to the base of the toes,

(b) a short leg walking cast from just below the knee to the base of the toes,

(c) a plaster gaiter from just below the knee to just above the ankle,

(d) a plaster incorporating Steinmann pins.

Apply a long leg cast first, and renew it if necessary, and follow by making shorter casts as the fracture heals.

Keep in mind that if the fracture is very recent, you must apply a *split* circular cast. *You should only apply a closed cast when there is no further risk of swelling.*

If a patient walks on the sole of the cast, it soon becomes useless. Consequently, it is important how the cast is made:

(1) The ankle should be in neutral position.

(2) The heel and foot must also be in neutral and not be everted or inverted.

(3) The sole of the cast should be strong enough to bear weight.

(4) To prevent the cast spoiling in rain, cover it with oil paint, or a disposable plastic bag.

(5) Fit the cast with a stirrup or, less satisfactorily, with a walking heel (70-4), which will raise it out of mud and puddles.

N.B. A stirrup will last longer, because it is stronger and will distribute weight more evenly. You will get the stirrup back when you change the cast, so a stock of stirrups is a useful investment.

AVOIDING ROTATION OF THE LEG

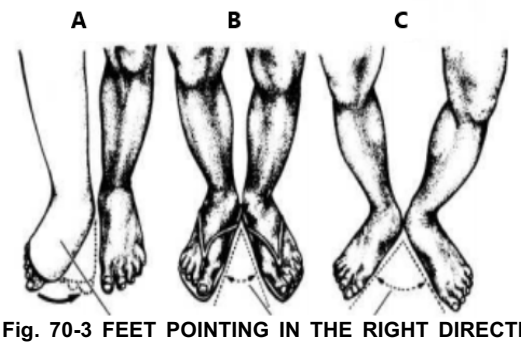


Fig. 70-3 FEET POINTING IN THE RIGHT DIRECTION. A, the cast was applied with the lower fragment in too much external rotation. This is undesirable, *but too much internal rotation would have been worse.* B, has markedly externally rotated feet, but which are equal. C, has bow legs and equally externally rotated feet since childhood. Symmetry is much more important than parallel feet. *Kindly contributed by John Stewart.*

A patient should be able to pivot on a walking heel:
(1) it must be sufficiently narrow,
(2) it must project c.2cm below the sole of the cast to allow the foot to rock, and
(3) it must be aligned with the anterior surface of the tibia.

N.B. There is no point in removing any leg cast, unless it is loose, until the patient is walking on it painlessly without a stick. If walking gives rise to pain or difficulty, replace the cast with another one in which treatment can continue.

LONG LEG WALKING CAST
(1) *Make sure that the foot points in the right direction* (70-3). So, in all tibial and malleolar casts (70.3), *make sure that the foot points in the same direction in relation to the knee on the injured side as it does on the contralateral one.*
(2) The cast must stop the distal fragment rotating on the proximal one, and so delaying union. When union is well advanced, rotation is less likely, but the fragments can easily rotate in a recent fracture. Prevent the proximal fragment from rotating by applying a long leg cast with the knee in 15° of flexion. Prevent the distal fragment from rotating by including the foot and ankle in the cast.

MAKE SURE ROTATION OF THE FEET IS SYMMETRICAL

PREVENT THE FRAGMENTS FROM ROTATING ON ONE ANOTHER

Let the leg hang over the edge of the table. The fully flexed knee relaxes the calf muscles, helps control rotation, and permits ankle dorsiflexion to neutral (90° to the leg). Pull the fracture with both hands on the heel and ankle to overcome any shortening. Cast application is far easier if you have 2 assistants. Repeatedly verify the reduction during cast application. One assistant pads the injured leg paying special attention to the malleoli, the subcutaneous surface of the tibia, and the head and neck of the fibula while you hold the reduction.
N.B.
(1) **If you neglect to pad the neck of the fibula**, the cast may compress the common peroneal nerve and cause a foot drop.
(2) ***Don't apply the cast with the leg horizontal,*** since controlling the position of the fragments will be more difficult.
(3) **If you fail to align the fragments**, union will take longer and the leg will be crooked.

You may be able to supplement an initial cast. Otherwise, make the cast in 2 parts:
(1) Use 2 15cm PoP bandages to make a thin below-knee cast which is just strong enough to control the fragments.
(2) When this cast has hardened, ask one assistant to hold the lower leg, and another to support the thigh. Cover the 1st part of the cast with a further layer of plaster from the toes to the groin, with the knee in 15° of flexion. Apply enough layers of plaster bandage for the upper part of the cast to grip the lower part. Incorporate medial and lateral slabs to strengthen the knee part of the cast. Finally, apply some more turns of bandage to make the upper part adequately strong. Always support the wet plaster with the flat hand, *don't press dimples into the plaster with the fingertips*, as this can cause pressure points inside.
N.B. **If you apply the cast in full extension**, it will be less effective in controlling rotation, and the knee will be painful.
CAUTION!
(1) While applying the cast, check the position of the ankle carefully; it should be in neutral, and neither inverted nor everted.
(2) Make sure that the foot has the same relation to the patella as on the uninjured side.
(3) A normal tibia has a slight natural inward bow, so try to restore this.
(4) Make a shelf of plaster under the toes, to protect them and prevent flexion contractures.
(5) Hold the knee position until the entire cast is firm.
(6) Take care to strengthen the knee, and the ankle parts of the cast, because here they are weakest.

LONG LEG WALKING CAST

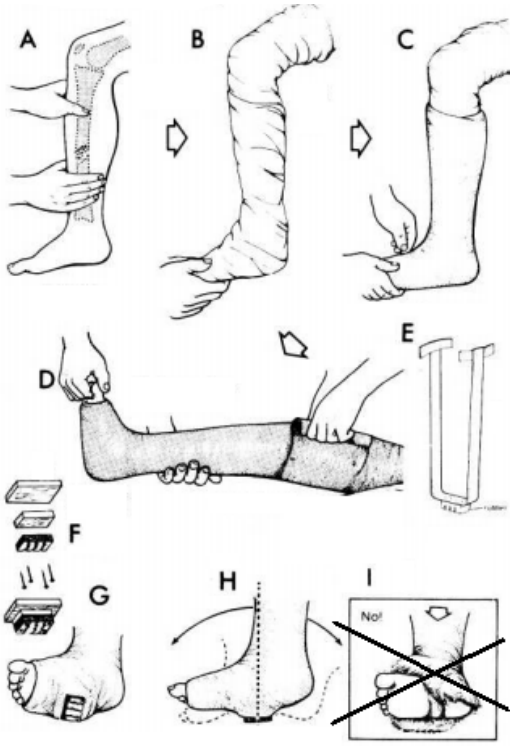


Fig. 70-4 A LONG LEG WALKING CAST. A, the leg must hang down so that you can align the fragments more easily. B, apply the padding. C, apply the distal part of the cast. D, the distal part of the cast is now firm; complete the upper part. E, a stirrup fitted to the walking heel. F, parts to make up the heel. G, a locally made walking heel. H, the walking heel correctly aligned with the tibia. I, the result of walking on a plaster without a heel. *Kindly contributed by John Stewart.*

SPLITTING A CAST

If the fracture is very recent, split the cast from top to bottom 2h after applying it (59.2). Meanwhile monitor the circulation in the feet. *Don't split it immediately*, because the junction of the top to bottom parts of the cast take 2h to become sufficiently firm to split. *Don't forget also to split the padding!*

After 2wks of calcaneal traction, any swelling will have subsided, so there is less need to split the cast. *Don't worry about a slight angulation in a recent fracture*. If necessary, correct this 2-3wks later, when the healing bone at the fracture site is still soft, but more stable. Either wedge the cast (59.2) or, preferably, replace it by another one with the leg in a better position. Replacing a cast is safer and less likely to cause pressure sores than wedging.

CAUTION!

(1) Ensure that there is no weight-bearing until the cast is dry and hard. This may take >24h in wet weather. *Walking on a soft cast will soon make it useless.*

(2) Even if you split the cast, further swelling may still produce a compartment syndrome or pressure sore. Inappropriate, increasing pain, or loss of sensation in the toes are indications to remove or change the cast. *It is best to observe a patient for 24h after applying a cast*.

(3) *Be sure to tighten or renew the cast if the leg becomes loose within it*. If you fail to do this, the fragments may displace.

CLOSING A CAST

After splitting a cast and letting the swelling disappear, close it with a few turns of plaster bandage. If it is still loose, remove a small strip of plaster from its anterior border, and close it with a few turns of plaster bandage. This is easily done with electric plaster shears.

FITTING A STIRRUP OR A WALKING HEEL

A metal stirrup or a walking heel is necessary when a patient starts to bear weight (70-4E-G)

ALTERNATIVELY:

(1) Start the cast by applying medial and lateral slabs, or a posterior slab only. This will make a smoother cast.

(2) Incorporate strips of bamboo in the cast, particularly across fracture lines and joints. This is a considerable economy in plaster.

DIFFICULTIES WITH LONG LEG CASTS

If the ankle swells when the cast is removed, treat it by elevating the leg, encouraging exercises, and compressing the swelling with a crepe bandage. Swelling is very common, but soon improves.

A stiff knee is usually the result of leaving a cast on too long.

DON'T LET A PATIENT WALK HOME IN A WET CAST

SHORT LEG WALKING CAST

For mid-shaft and more distal tibial fractures you can use a shorter cast, the patellar tendon-bearing (PTB) cast as described by Sarmiento.

Either just shorten a long leg walking cast to a short leg walking cast once the fracture is sticky (approximately after 6wks), or remove the old cast and apply a new one.

For more stable fractures, apply this cast even earlier than 6wks. For undisplaced tibial shaft fractures without significant swelling you may even use it as the initial cast. The application of such a cast requires considerable experience, especially its moulding in the infrapatellar region.

SARMIENTO TYPE SHORT LEG WALKING CAST

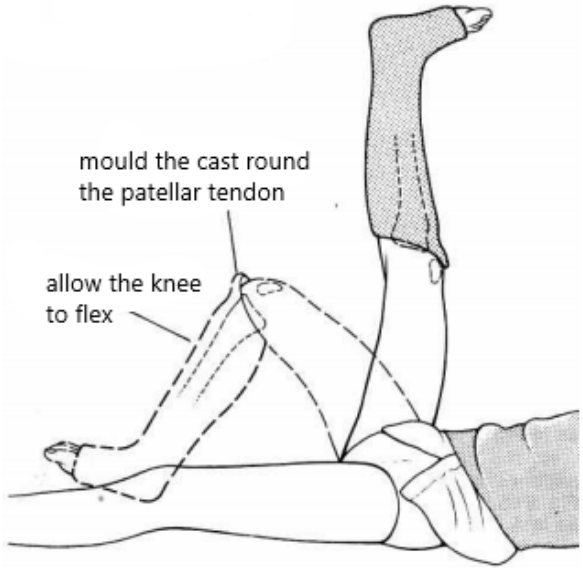


Fig. 70-5 SARMIENTO TYPE SHORT LEG WALKING CAST. Apply this with the knee flexed to 90°. It has an oblique upper edge, and is moulded by triangular compression (70-6).

An advantage of a short cast is that it allows earlier movement of the knee. If you fit a gaiter this allows earlier ankle movements. Of course, a short cast uses less plaster than a long one.

As with a long leg cast, prevent the fragments from rotating. Achieve this in one of 3 ways:

(1) Mould the cast carefully to the upper leg, using Sarmiento's total contact method of triangular compression, as described below.

(2) Pass a Steinmann pin through the proximal end of the tibia and incorporate it into the cast. This is the more certain method, and is necessary if there is also a femoral fracture in the same leg (58.13).

(3) Using an X-fix.

To apply the Sarmiento cast, have the patient sitting on the edge of a table. Steady the lower leg and apply stocking and padding above the knee. Protect all bony prominences by extra padding.

Apply the cast from just proximal to the toes to as high as possible in the popliteal fossa with the knee flexed at 90°. Bring the cast to above the knee and trim it later to above the patella in front and below the popliteal fossa at the back, so that it has an oblique upper end (70-5).

As the cast hardens, apply compression between the upper calf and the anterior surface of the leg (70-6). This will give the cast a triangular cross-section, which is flat posteriorly, and moulded to match the prominent tibial tubercle (70-6A), and help prevent rotation. This moulding forces the cast away from the fibular head and peroneal nerve, helping to avoid local pressure there.

TRIANGULAR COMPRESSION OF A SARMIENTO CAST

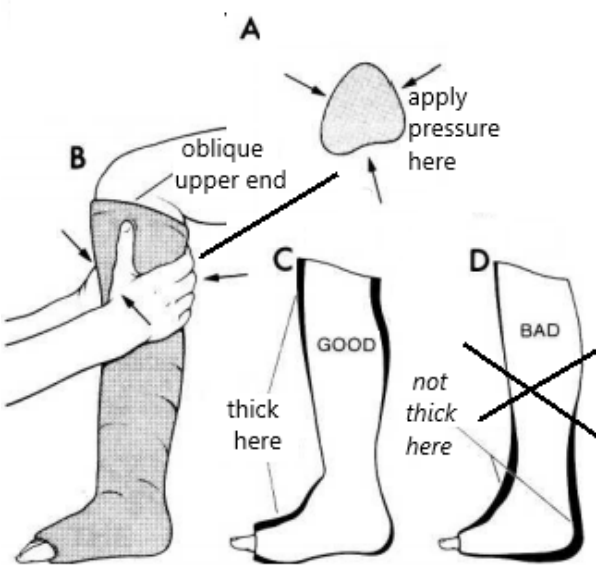


Fig. 70-6 TRIANGULAR COMPRESSION OF A SARMIENTO CAST. A, B hold the knee flexed, while the short leg cast is setting, compress its upper end to mould it to the leg. C, where the PoP should be thick. D, *where it should not!* *After Sarmiento A. Closed Functional Treatment of Fractures. Springer 1981.*

CAUTION! (1) Triangular compression is safe in a short leg cast where muscular activity can relieve excessive pressure. But, *don't apply it in a long leg cast*, as pressure necrosis may occur.
(2) *Don't try to economize by cutting off a long leg cast below the knee:* it will always be loose and render the leg unstable.

Once firm, trim the proximal margin of the cast circumferentially from the proximal pole of the patella to the proximal part of the calf. Note that the posterior trim line is thus more distal than the anterior edge of the cast, since you must position it just below the popliteal flexion crease. *Make sure that the knee is extended, and that it can flex to 90°*. Pad the cast edges by turning down the padding and stocking to provide cushioning. Secure the stocking to the outside of the cast with a little additional plaster.

A PLASTER GAITER
The success of functional bracing depends on the fact that total immobilization of the joints above and below a fracture is not necessary for fracture healing and maintaining alignment. Controlled motion allowed by the brace at the fracture site is conducive to osteogenesis.

This is the simplest and lightest leg cast; it is the easiest to walk with, but also the least stable and secure. Use it for protecting fractures of the middle tibial ⅓, *after union has taken place.*

A PLASTER GAITER

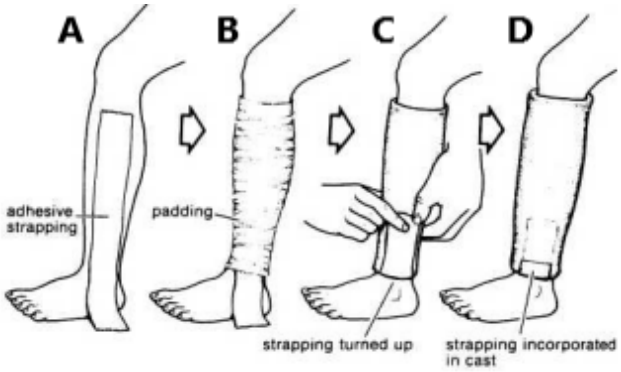


Fig. 70-7 MAKING A PLASTER GAITER. Use this for protecting fractures of the middle tibial ⅓ as it heals. *Kindly contributed by Peter Bewes.*

It does not provide enough stability for fractures of the proximal or distal ⅓. If you apply it immediately after removing a long leg cast, the foot and ankle will swell immediately. There exists a manufactured brace made of plastic and velcro fastener, which is more expensive than making one yourself from plaster.

Apply pieces of adhesive strapping to either side of the leg (70-7A), as if you were going to apply skin traction. Pad the leg and especially the Achilles tendon (70-7B). Then apply the cast. As you apply the last layer of plaster bandage, fold up the 2 pieces of strapping (70-7C) and incorporate them in the cast (70-7D). They will stop it slipping down the leg and rubbing against the top of the foot.
As the cast sets, mould it around the expanding upper and lower ends of the tibia, so that it grips them firmly. The knee, foot, and ankle should be free.

STEINMANN PINS INCORPORATED IN THE PLASTER
Fix pins passed through the proximal & distal tibia into the cast to aid reduction prevent displacement. Insert the pin from lateral to medial through the middle of the tibia anterior to the fibula in the frontal plane, so that it emerges medially through the subcutaneous surface of the tibia. Apply some antibacterial ointment, such as iodine and a sterile dressing over the pin site.
N.B. Use the transfixion pins as reduction aids. Apply traction, rotation, or angulation to the pins to correct deformities. Do this before fixing them in PoP.

Then, when you have held the fracture reduced, apply the PoP incorporating the pins.

CAUTION! This technique is hugely inferior to external fixation: pin track infection is common. *Use it only if external fixation is not available.* However, it is indicated in unstable, oblique, and comminuted fractures, where stable apposition at the fracture site is impossible, or when there is a simultaneous femoral or ankle fracture (70.7).

Apply the cast by rolling the PoP smoothly up, incorporating the pin on each side with a thick 2cm cuff of PoP around each pin. *Be careful not to pull the plaster tightly from one end of the pin to the other*, since there should be no extra pressure on the skin. Cut off excessive pin length with a pin cutter, but fix at least 2cm of pin into the plaster, both medially and laterally.
Once hardened, the cast functions as the frame of an external fixator, using the transfixion pins to maintain fracture alignment.

GET THE PATIENT WALKING EARLY WITH A CAST

DON'T REMOVE A CAST UNTIL THE PATIENT IS WALKING PAINLESSLY WITHOUT A STICK

DON'T LET A PATIENT WALK ABOUT IN A LOOSE CAST

70.3 Isolated closed tibial shaft fracture

Usually, 4 kinds of injury can break the tibia without breaking the fibula:
(1) If the leg is struck from the side, it may break transversely or obliquely, leaving the fibula intact, and thus splinting the fragments, so that they shift only very little.
(2) A combination of compression and twisting can cause a long spiral oblique fracture with almost no displacement, and very little soft tissue injury. These fractures usually heal fast.
(3) A gunshot to the tibia. The healing depends on the soft tissue and bone loss.
(4) Isolated tibial fractures in the osteoporotic elderly, usually due to simple traumatic torsion.

REDUCTION
If fragments are significantly displaced, reduce them. ***If the fibula splints the tibial fragments apart,*** remove a segment of fibula by an osteotomy.

Apply a long leg cast or medial and lateral splints, held with a crepe bandage until the acute swelling has subsided. Close the cast, fit a walking heel, get the patient up as soon as he can bear weight with crutches, making him bear weight on the leg.

If there is a long, spiral oblique fracture, discard the long leg walking cast after c.6wks, and apply a protective gaiter for another 2wks. These fractures usually heal fast. *Make sure the fragments are not kept apart.*

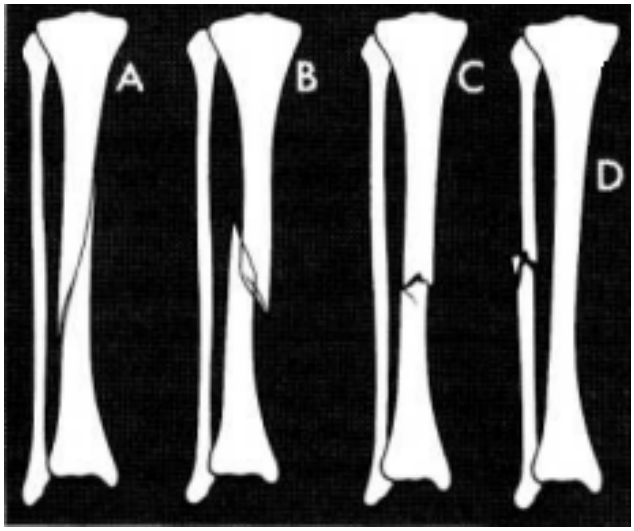
If there is a transverse fracture, it will probably take 3-4months to heal. It will heal sooner if the fragments are nicely impacted and weight bearing starts immediately. *Make sure no butterfly fragment or spike* (70-9D,E) *holds the bone fragments apart.*

If the fracture is in the middle tibial ⅓ *and union is present,* fit a Sarmiento brace.

If the fracture is elsewhere, fit a short leg walking cast. Continue protection until there is no pain on springing the tibia and fibula together. As soon as the tibia is solid and no longer springy, remove the cast or gaiter.

If the patient has a short oblique fracture, expect it to heal more slowly owing to the shearing stress. Apply a long leg cast for 2months, and test for clinical union (58.7). If then radiographic and clinical union *is not* present, apply a close fitting short leg cast (70-5) for another 6wks. But if clinical union *is* present and the fracture is in the mid-shaft, apply a Sarmiento brace.

FRACTURES OF A SINGLE LOWER LEG SHAFT



70-8 FRACTURES OF A SINGLE LOWER LEG SHAFT. A, a long spiral oblique fracture heals readily. B, a short oblique fracture takes longest to heal. C, a transverse fracture. D, a single fibular fracture.

70.4 Tibial stress fracture

If bones are repeatedly stressed without adequate training, they may break as `fatigue' or 'stress' fractures. This can happen when an athlete starts training too hard after a break, when a raw recruit starts marching extensively, or when an invalid gets out of bed.

Fatigue fractures start without any history of injury as microscopic lesions which steadily progress. The tibial diaphysis is the commonest reported location and comprises up to 75% of all stress fractures. Anterior tibial fractures are less common but more problematic than postero-medial fractures.

The first symptoms are bone pain at night after use. The callus that forms presents as a tender bony lump and the fracture may not be visible on radiographs for 5wks, or may even remain completely invisible. The only signs may be slight periosteal elevation and increased density of the cancellous bone. The danger of these fractures is that you can mistake them for tumours.
In general, management includes rest and immobilization, for example by the protection of a plaster gaiter for the tibia. If the fractures don't heal by 6-9months, compression plating or intramedullary nailing might be needed.

70.5 Closed fibular shaft fracture

A force applied to the outer side of the leg can break the fibula transversely anywhere. The tibia remains intact, so that there is either no displacement, or only a little shift sideways. The patient is usually able to stand. The muscles of the leg cover the fracture, so you need radiographs to confirm the diagnosis.

Reduction, splinting, and protection are unnecessary. Provided that the ankle joint is normal, encourage walking as soon as any soft tissue injury allows.

N.B. Rule out a Maisonneuve fracture, which can cause much disability if wrongly treated (71.6). It usually presents as a spiral fracture in the proximal fibula with a severe ankle injury.

70.6 Closed tibial & fibular fracture

These fractures are usually less stable. By twisting the leg, both bones break obliquely, commonly in the lower ⅓ of the leg. Alternatively, a high energy injury impact, *e.g.* from a motorcycle accident or a fall from a great height causes the fragments to shift laterally, overlap, or rotate.

Treatment depends on whether or not there is shortening. A week of calcaneal traction will reduce significant shortening (70.7). Admit the patient, who needs close observation, because the leg may swell severely and may develop a compartment syndrome (49.6).

WHERE THERE IS NO SIGNIFICANT SHORTENING
If there is swelling or signs of threatened ischaemia, maintain the position of the fragments by applying either medial and lateral slabs from the foot to the groin held on with crepe bandages, or a temporary long leg cast split to allow swelling.

When the swelling has subsided, apply a long leg walking cast (70.2), or close the split in the cast he already has.

If the fracture is oblique, *take care to correct rotation*.
Then continue weight bearing on crutches. Review the patient and X-ray the fracture regularly. Wedge (59.3) and replace the cast as necessary. A closed transverse fracture should unite in 3-4months. The last 2months can be in a short leg cast, especially if it is a total contact cast of the Sarmiento type (70.2).

If there is significant shortening, there is probably an oblique, spiral or comminuted fracture. Under ketamine, apply medial and lateral slabs as above. Pass a Steinmann pin through the calcaneum (59.4) and rotate the leg to correct any rotation.

Apply 5kg traction, raising the foot 25cm off the bed as counterbalance. Put a pillow longitudinally under the leg, which will hold the knee in a comfortable semi-flexed position and prevent the heel from pressing uncomfortably on the bed.

Leave the leg in traction for 1wk while treating its soft tissue. Encourage movement of the toes, the ankle, and the knee. This period of traction will allow the soft tissues to heal.

After 1wk, remove the pin, apply a long leg cast, and encourage walking. Leave the cast on for at least 8wks. Then remove it and examine the leg for signs of clinical union (58.7)

If the fracture is uniting and barely springy, apply a close fitting short leg cast for 6-8 more weeks. Encourage the patient to walk normally.

If the fracture has not united, reapply a long leg cast and continue weight bearing for another 5wks, then apply a short leg cast.

70.7 Open tibial & fibular fracture.

Familiarise yourself with the general principles of open fracture treatment & external fixation (58.12)

The tibia and fibula are the commonest sites of open fractures in men, and one of the more unfortunate results of a traffic accident, particularly a motorcycle accident. They vary from a minor cut over a broken bone to the grossest mutilation and displacement of the bony fragments. This is worst when the wheel of a car has run over the leg, squashed the muscles, and torn the skin from the underlying fascia over a wide area (46.4), or because of a gunshot injury (46.8).

The fracture may be transverse oblique, or comminuted.

Open tibial fractures are dangerous because:
(1) They are often infected and, may be fatal if necrotizing fasciitis or gas gangrene develop (58.15).
(2) They are often transverse and pieces of bone may be lost, so that great care has to be taken to make the bones unite.
(3) If treatment is prolonged, victims may become demoralized or may lose their job owing to a long absence from work.
(4) Serious complications may occur later, including a stiff ankle or foot drop.

Owing to the high risk of complications, conservative methods are most likely to get good results in most cases. Several factors are important, though:
(1) Aggressive and repeated debridement of all devitalized tissue, including fragments of bone.
(2) Stabilization with as little additional devascularization as possible. (Vascular soft tissue and bone are essential for resisting infection and providing a bed for reconstruction.)
(3) Leaving the wound open and repeated debridement as necessary until closure at 5-7days by delayed primary closure, skin grafting, or local flaps.
(4) Antibiotic & tetanus prophylaxis.

Management of the soft tissue is the most important factor in determining the outcome of open tibial fractures. An external fixator is of great help; temporary calcaneal traction or a cast with a window are alternatives. As soon as the wound is healing, apply a long leg cast and encourage walking. *The secret of success is early weight-bearing while the leg is still in a cast, even while the skin wound is still incompletely healed.*

N.B. Many severe injuries heal dramatically; even some which might at first seem to need a bone graft.

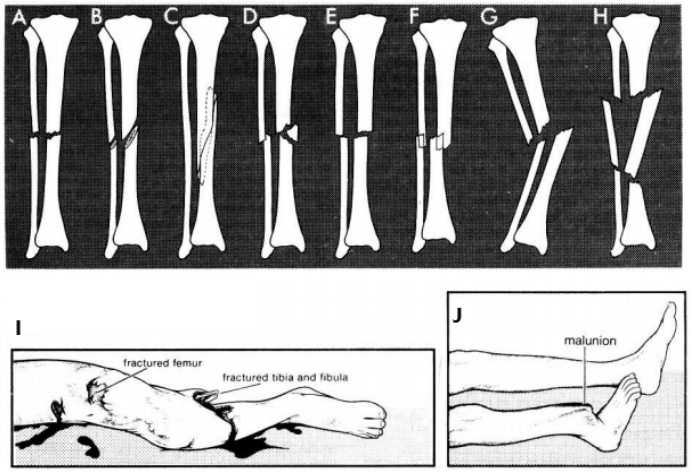
TREATMENT
Minimize the delay between injury and formal debridement under ketamine in the operation theatre, especially if you suspect a major vascular injury.

Reduce the fracture as best as you can immediately after the wound toilet is complete, and while the patient is still anaesthetized.

Bringing the fragments into contact with one another is more important than correcting angulation, because you can correct this later while the bone ends are still sticky. If the fracture is transverse, try to get as much as possible of the diameters of the fragments to touch one another. Even if they only touch over part of their circumference, this will be useful. Bringing them into contact may be difficult if there is soft tissue interposed. *Don't leave the bones overlapped* (70-9F).

A THOROUGH WOUND TOILET IS CRITICAL

TIBIAL & FIBULAR FRACTURES



70-9 TIBIA & FIBULA FRACTURES. A, transverse, B, oblique C, spiral. D, transverse fragment with a triangular butterfly fragment. E, a transverse separated & F, overlapping; *never leave fractures like this*. G, angulated fractures. H, double fractures of both bones. I, open fractures of femur, tibia & fibula in the same leg. J, malunion because a severely angulated fracture was not adequately reduced & held.

If reducing overlap is difficult, insert a periosteal elevator or some other suitable instrument between the bone ends and lever them into position.
If you cannot get enough traction on the foot to reduce the fragments, insert a Steinmann pin temporarily into the calcaneus and exert traction on this. Do this now while the patient is still in the theatre. If you cannot reduce the fracture at all, *e.g.* because the fracture is some days old, you can carefully shorten the tibia until reduction is possible.

N.B. In a transverse fracture avoid any end to end distraction, no matter how slight; it is the great enemy of union.

If the fracture is oblique or comminuted, calcaneal traction is particularly useful. You may be unable to prevent a mild overlap. Some separation of the fragments is inevitable, but they will unite slowly.

N.B. Beware of the butterfly fragment (which readily becomes ischaemic) *and will then act to keep the tibial bone fragments apart.*

If a pointed fragment of bone is protruding through the skin and you cannot readily reduce it, nibble it away.
Dress the wound, then either splint the leg with a padded backslab or medial and lateral slabs held together with crepe bandages, or apply an external fixator as temporary or definitive fracture stabilization.

LEAVE A WOUND UNSUTURED UNTIL THE DANGER OF INFECTION IS OVER, ESPECIALLY GUNSHOUT WOUNDS

CLOSURE
After 3-5days, open up the dressings and look at the wound.

If the wound looks clean and you can close it without tension, perform a delayed primary suture.

If the wound looks clean but you cannot close it without tension, apply a split skin graft if there is an adequate wound bed (50.12). You may need to repeat the dressing change on 8th and if necessary again on the 13th day. *Don't try grafting until there are good granulations*. *Don't allow weight-bearing until the graft has taken*.

If there is exposed bone in a rather small wound but you cannot close it without tension, apply a simple fascio-cutaneous flap (46.5). *Don't leave the fracture exposed too long, waiting for secondary healing*. The risk of infection is very high.

If there is exposed bone and you cannot close it with a simple fascio-cutaneous flap, use a pedicled or a muscle flap. The medial gastrocnemius flap (46.5) is very reliable, especially for wounds in the upper tibial ⅓.

N.B. Don't wait for a secondary healing as the fracture site is likely to get infected.

-

If the wound is still very dirty, toilet it again surgically in theatre.

N.B. The wound should be clean after the first debridement, and if it is not, your first debridement was probably not adequate.

DEFINITIVE TREATMENT
When the wound is for the most part closed either by skin suture or by a skin graft or flap, fit a long leg walking cast (70.2). Provided the swelling has subsided, there is no need to split the cast. Even so, monitor the circulation in the foot carefully.

Put a dressing over the wound if necessary, but preferably *don't cut a window in the cast* because it increases the risk of loosening (59.3). Inspect the wound again when the cast needs changing.

N.B. ***If the wound is still septic****, an X-Fix is best.*

Apply the cast with the ankle in 10° dorsiflexion, unless this position causes posterior angulation of the bone fragments (70-10A), as it may do in a lower third fracture when a piece of the tibia is comminuted anteriorly.

If dorsiflexion does cause posterior angulation, leave the foot in *equinus*, but fit a stirrup (70-12), or a high enough walking heel (70-4G). Make the cast strong enough to last 6-8wks. Elevate the leg for 12h after fitting the cast. Put a heel raise in the opposite shoe.

The next day allow the patient to put the cast on the floor. Provide crutches and encourage walking on the broken leg within the cast, bearing as much weight as is tolerated. Allow gradual increase in weight bearing, but *don't push this to the point of pain*. Even if there is crepitus or a sensation that the fragments are moving, encourage perseverance. Explain that such movement helps the bones to unite.

EARLY WEIGHT BEARING IS ESSENTIAL

N.B. Early walking is critical to the success of conservative treatment.
Early on, when the patient is not actually walking around, advise elevation of the leg to minimize swelling and make it more comfortable.
When full weight-bearing on the injured leg, exchange the crutches for a stick. Most patients reach full weight bearing in a few weeks, some even within a few days. When walking well, you can allow discharge, but review in 3wks. Make sure proper walking is possible and the plaster is still in good condition. Remember that a perfectly moulded cast is essential for this method. *This is your responsibility.*

ANGULATION
If the fracture is angulated >5° in any direction, correct it by renewing the plaster or, less safely, if plaster bandages are scarce, by careful wedging (59.3). *Don't do this immediately*. The best time is usually at 3-4wks, in an adult. Be sure you do it while the patient's bone ends are still sticky, before they have united.

Use an opening wedge a little above the fracture, so that pressure does not increase over it. If the leg is angulated in two planes, you may be able to control it with 1 wedge, but you may need 2. *This may make the cast look ugly*, but it will improve the final look and function of the leg!

N.B. Don't try to wedge a cast more than once; change it, as the risk of pressure sores is too high.

DRESSINGS
Change any dressings when you change the cast. This is more effective than repeatedly changing them through a window.

N.B. Infected wounds always need a thorough debridement.

If the cast is snug and comfortable, leave it for 5-8wks. Change it earlier if it becomes loose or uncomfortable, because reduction is easily lost inside a loose cast. If plaster bandages are scarce, cut a longitudinal strip out of a loose cast and close it up. Change the cast if pus or blood soaks through excessively or if it stinks unbearably.

N.B. You need to put 3-15 casts, on average 6.

CLINICAL UNION
At 5-8wks, remove the cast and examine the fracture for signs of clinical union (58.7). If you are in doubt, get a radiograph and renew the cast.
Don't discard a full length cast until:
(1) the patient can walk without crutches,
(2) there are signs of clinical union.

Don't leave a long leg cast on too long because it will prevent the patient from bending the knee and make it stiff. Fit a short leg cast as early as possible.
Spiral or transverse fractures reach clinical union more quickly, usually at c.12wks, especially if weight bearing starts early. A short oblique fracture usually takes 12-16wks to unite, but it may occasionally take a year or more, especially in the lower third of the leg where there is a high risk for delayed union, *and particularly if you unwisely treated it in prolonged traction!*
As soon as there is good clinical union, fit a shorter cast. If the middle ⅓ tibial fracture tibia is firm, use a well-padded plaster gaiter or Sarmiento total contact cast (70.2), because these fractures need less protection. If the fracture is anywhere else in the tibia, apply a Sarmiento cast which includes the foot. Keep encouraging walking and gradually increase the range of activities.
N.B. Pain and tenderness over a fracture site are signs that clinical union is not yet complete, so continue to protect the fracture in a short leg cast.

CONTROLLING ROTATION
A long leg cast is quite heavy, and because it prevents flexion of the knee, turning in bed is difficult; this makes nursing care arduous.

In elderly patients, or where there is a simultaneous femoral or malleolar fracture, apply a short leg walking cast and prevent rotation by incorporating a Steinmann pin. Insert the pin *obliquely* 1.5-2cm distal to the tibial tuberosity (59.2). Make sure the cast allows bending of the knee. *Don't allow weight-bearing on the cast while the pin is inside*, because it may break. Remove it as soon as the fracture becomes sticky, and then allow weight-bearing.

PROVISIONAL TRACTION
Where you cannot restore alignment because of gross comminution of fragments, insert a calcaneal pin under LA into the calcaneus 2cm below and 2cm behind the medial malleolus. Apply 3-7kg traction straight on the bed raising the foot of the bed 25cm, or use a Böhler-Braun frame which provides counter-traction.

Don't use this >2wks. Encourage exercising the foot while on traction; this will reduce oedema and minimize stiffness.
When the fragments have become sticky enough to stay in place on their own and the wound is healing, remove the traction, allow the leg to shorten (if it must) to a stable position, and apply a long leg cast.

N.B. (1) *Don't apply so much weight as to produce distraction at the fracture site* or endanger the blood supply of the leg.
(2) *Don't apply traction to a cast unless there is a pin in the tibia incorporated in it*, because it is almost certain to cause sloughing on the skin on the dorsum of the foot.

BRAUN-BÖHLER FRAME

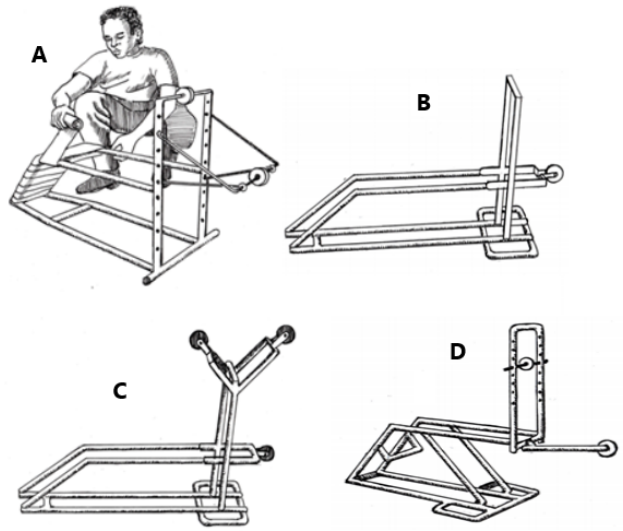


Fig. 70-10 BÖHLER-BRAUN FRAME TYPES. A, putting strapping over the bars to give limb support.

If there is a severe soft tissue injury and you don't have an X-fix system at your disposal, you can apply 2 Steinmann pins, one well above and one well below the fracture. Incorporate them in a cast, if necessary with a window. Get the patient walking soon, if the comminution is not too severe. Later, you may be able to remove the bottom pin and mould the cast around the ankle.

This will minimize shortening, but union may be slower

EXTERNAL FIXATION (GRADE 3.2)
The adaptability of external fixation makes it a veritable workhorse for the care of complex, severe tibial shaft fractures. It provides stability, easy access to the soft tissues and alignment of the fracture; it protects neurovascular structures, maintains limb length, and, in comparison to longitudinal traction, can reduce the risk of infection and non-union.

The X-fix can span the knee or the ankle for trans-articular fixation. For very distal tibial fractures, fixation should span from the proximal tibial fragment across the ankle joint to the foot. Construct a delta frame between the tibial shaft above the fracture and the foot. You need a calcaneal pin as well as one or more pins in the metatarsals to triangulate the frame and prevent the distal tibia and foot from slipping forward or backward off the plane of the proximal tibia.

Definitive treatment of the bone injury continues in a cast usually with weight bearing. If you already see some callus formation, apply a short leg walking cast. If the wound is healed but no stable callus has yet formed, it is better to apply a long leg walking cast.

MODULAR & RIGID FIXATION

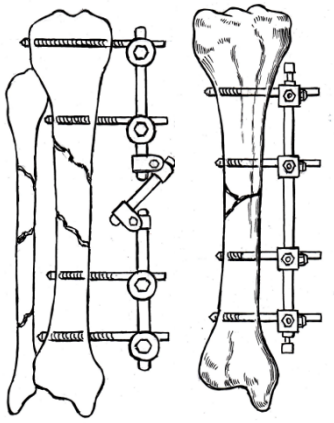


Fig. 70-11 MODULAR & RIGID FIXATION ***Remember to reduce the fracture properly before applying the fixator.*** *After Browner B, Levine A, Jupiter J, Trafton P, Krettek C. Skeletal Trauma, Elsevier 4th ed, 2019.*

In view of the importance of early motion, apply a stiffer frame to protect the fracture site during healing. Stiffer fixation, however, tends to suppress callus formation, which might prolong the need for external fixation or even lead to non-union.

When you use external fixation for definitive treatment of a fracture, it may be useful to do this with a uniplanar fixator (70-12). It requires anatomical reduction and precise application.

The advantage is that you need fewer clamps and rods than in the application of a modular external fixator and that it provides also more stability. The disadvantage, however, is that you cannot correct the reduction after two pins are placed in each fragment.
In order to adjust the position, you have to exchange the single rod for a modular X-fix with multiple rods.

DYNAMISATION OF AN EXTERNAL FIXATOR
To facilitate or accelerate callus formation during external fixation, loosen the frame construction to allow limited motion at the fracture site. You can do this easily with a single rod X-fix (70-12). Simply unlock the clamps at either site of the fracture.

Pain-adapted partial weight bearing up to full weight bearing allows axial compression across the fracture site, which improves bone healing. *But be careful in oblique or spiral fractures.* Pin loosening is a common complication.

If there is no callus formation within a few weeks or even if you have a significant initial bone loss after the wound has healed, consider bone grafting.

TIBIAL ANATOMY

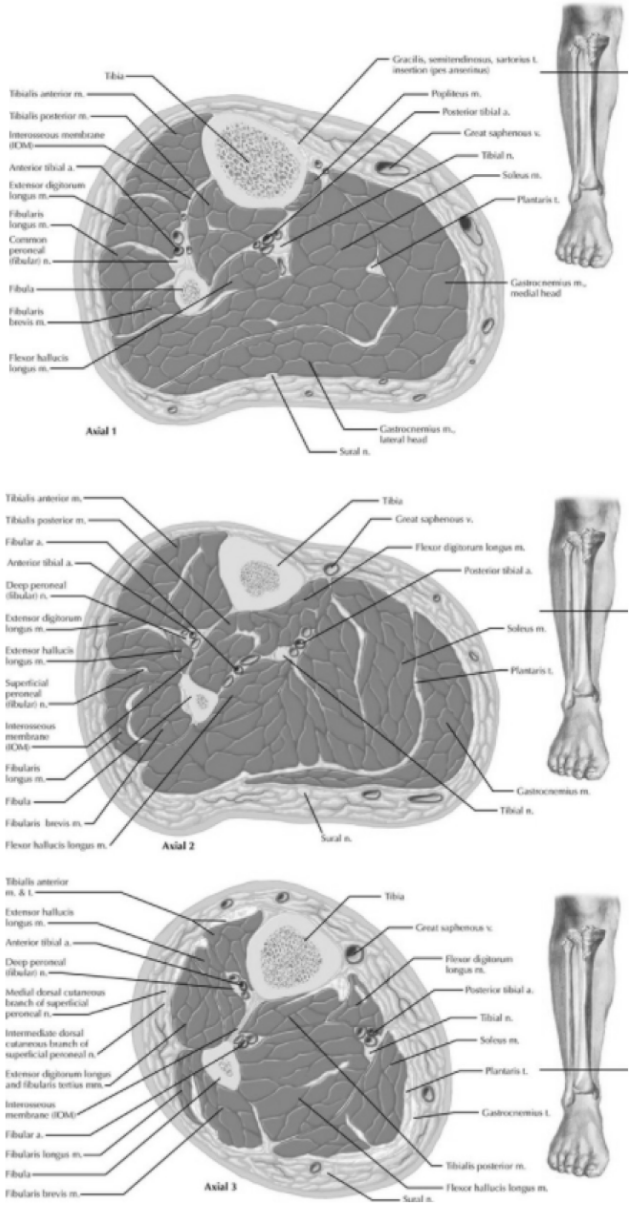


Fig. 70-12 TIBIAL ANATOMY. Cross-sections at different levels of the lower leg. The detail is to help you avoid important structures! *After Basicmedical Key ch. 42.*

If early fibular healing occurs, perform a partial fibulectomy to permit impaction of the tibial fragment. This you might achieve in a walking cast or a dynamized X-fix. Fracture healing should occur after 6-8months.

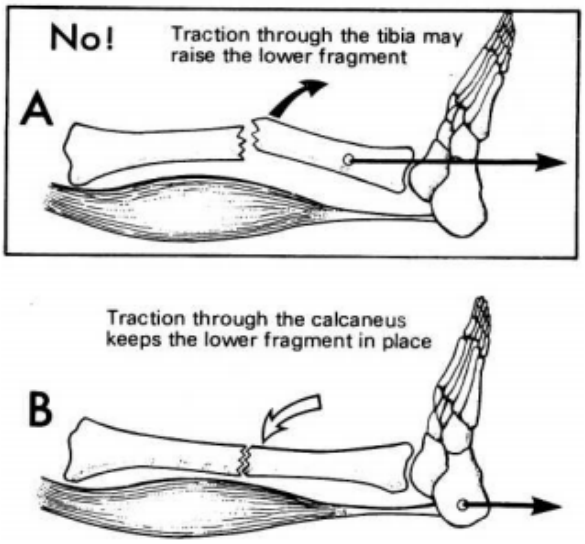
INDICATION FOR EXTERNAL FIXATION
(1) Rapid stabilization for associated vascular injury.
(2) Rapid stabilization in a multiple injured patient.
(3) Temporary support of severely injured soft tissue (*e.g.* compartment syndrome).
(4) Open fractures with the need for soft tissue reconstruction.
(5) Disaster or battlefield setting (gunshot wounds).
(6) In the management of fractures with significant bone loss by providing stabilization for autogenous bone grafting.

(7) Treatment of fracture site infection, typically after previous internal fixation or infection after an open fracture.
(8) Optionally, as definitive fracture fixation.

EXTERNAL FIXATOR REMOVAL
If you are not very experienced with X-fix and if you don't have portable X-ray machine, it's better to remove the X-fix once the soft tissue has healed, and follow on by a long or short leg walking cast. If a patient can bear significant weight across the fracture site without much local pain (though you should distinguish pin-site discomfort), this usually means the fracture is healing.

After frame removal, 30% of patients require additional casting for an average of 5months.
But if you wait with removing an X-fix until the tibial fracture is securely healed (look at the radiograph or palpate callus formation), you reduce the risk of late loss of alignment, shortening and impaired fracture healing significantly.

PROVISIONAL TRACTION FOR TIBIAL FRACTURES



70-13 TWO METHODS OF PROVISIONAL TRACTION FOR TIBIAL FRACTURES. A, traction through the lower tibia may pull the lower fragment out of the wound. B, traction through the calcaneus keeps the lower fragment in place, but if osteomyelitis occurs, it will be very troublesome. *After Charnley J, The Closed Treatment of Common Fractures. E&S Livingstone, Edinburgh 3rd ed.1961*

70.8 Difficulties with tibial fracture

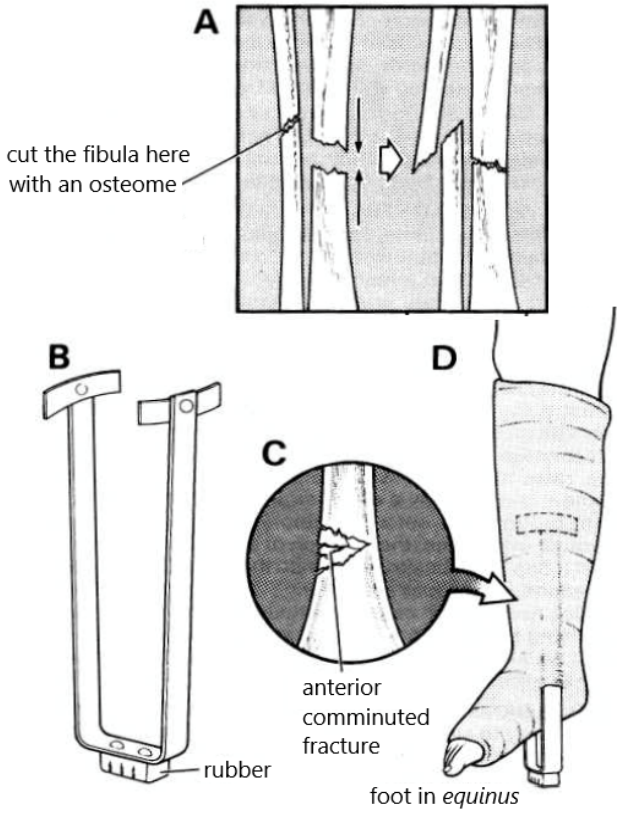
If the lower leg or foot is so severely injured that it seems completely shattered, preserve it if it still has a pulse and normal sensation. You can always amputate later, provided that you perform a thorough wound toilet and avoid the danger of gas gangrene. Stabilize and raise the leg, while resuscitating the patient. Even the severest bony injury is never by itself an indication for immediate amputation (60.2).

If a piece of the tibia is missing, treatment depends on how much is missing, and where. Try to make the broken ends of the tibia impact. *Making the bone fragments touch is more important than maintaining length.*

If a small piece of tibia is missing, it will probably heal adequately. Your goal is just to achieve a closed wound and proper stabilization.

If the tibia is intact posteriorly, but a bigger piece of tibia is missing anteriorly, the lower fragment is in danger of bending forward. Prevent forward angulation by putting the foot into plaster in *equinus*, (70-16), until the comminuted area has stabilized. Fit a metal stirrup instead of a walking heel.
This will enable walking on the injured leg, even though the ankle is in *equinus*. As soon as the fracture is stable, put the foot back in a neutral position.

A PIECE OF TIBIA MISSING



70-14 A PIECE OF TIBIA IS MISSING. A, if a piece of the tibia is missing anteriorly, the fibula will probably be broken also, so you can let the fragments of the fibula override one another and push those of the tibia together. If the fibula is intact, cut it. B, C, and D, if the tibia is comminuted anteriorly, fit him with a stirrup with the foot in the *equinus* position. If you don't have a stirrup, fit a wooden block under the heel. *Kindly contributed by John Stewart.*

BRING THE ENDS OF THE TIBIA TOGETHER

This is crucial, because with a fixed *equinus* foot, there might be even more problems with walking than with a non-union of the tibia.

If <3cm of tibia is missing, wait for the wound to heal and for the skin to become clean. If the fibula has not already been broken by the injury, make a separate lateral incision far enough above or below the tibial fracture to leave some stability at the fracture site. Cut the fibula obliquely with a sharp osteotome. Push the ends of the tibia together, so that the fragments of the fibula overlap. If absolutely necessary, you can remove a piece of fibula. Apply a long leg cast and commence walking and weight bearing as soon as possible. The tibia will unite, but it will take several months. If necessary, raise the shoe to compensate for shortening.

If >3cm of tibia is missing, apply calcaneal traction or an external fixator, but *don't try to maintain its full length*. Traction or external fixation will stabilize the leg and make wound toilet easier. If referral is impossible, you will have to treat as indicated above; here, *you cannot prevent shortening* but can handle it with raised shoes.

N.B. Remember that a shortened but stable leg is less disabling than a painful, non-united leg.

If pus gathers in the wound, it fails to heel, and the tibia fails to unite, open the wound widely so that it can drain. Remember that wounds drain by gravity or suction; if possible, open the bottom of a pus pocket. Infection may have been caused by a late presentation and treatment of an open fracture or by your initial inadequate wound toilet. Continue irrigating and toileting the infected wound as necessary.
You must stabilize the fracture temporarily by a cast, an X-fix or calcaneal traction. Stabilization is key in treating infected fractures. As soon as it is reasonably clean, apply a long leg cast and start walking.

If you suspect acute osteomyelitis, X-ray the fracture. If there are signs of periosteal elevation (7.3), under GA in theatre, remove all pieces of dead bone, irrigate the wound, and provide drainage. If the tibial fracture has already healed and is stable, you won't have to worry too much. Your main goal in such cases is to treat the wound.

If there is dead bone at the bottom of an infected wound (70-16B), take the patient to theatre, and under GA, use a bone gauge or chisel and hammer to remove any dead bone until you get to healthy, bleeding bone. *Dead bone looks white, does not become pink and is not bleeding*; make sure you remove any exposed bone. Later, when granulations have appeared, graft the wound (46.5).
However, *don't remove too much bone*, or you will weaken the tibia. Removing it to a depth of 1-2mm is usually enough.

If the wound does not heal and there is a chronic discharge from the bone, advise the patient to irrigate the wound daily with clear water followed by a thorough drying of the wound. *N.B. If there is metal inside the wound, it needs to come out!*

Patients with such a chronic osteomyelitis can live with these wounds for many decades. Sometimes they will heal spontaneously, even after some years. But advise your patient to seek immediate medical treatment if the leg becomes swollen and painful again, especially if combined with fever and general sickness. Chronic osteomyelitis can always develop into a severe acute osteomyelitis, which can threaten limb and even life (58.15).

If an acute osteomyelitis prevents the tibial fracture from uniting, it becomes more complicated. You need to remove all infected necrotic tissue, including the suspected infected bone, even if you have to shorten the tibia and fibula. If the patient is old or diabetic, consider an amputation. To achieve fracture healing, you need to remove bone until you see punctate bleeding from the bone (the 'paprika sign'). However, even if you have removed all necrotic tissue, the remaining bed of tissue may still be contaminated. Close the wound if clean, & drain it with suction drainage, stabilize it with a cast, and raise the leg on a Böhler-Braun frame. In bigger wounds, apply calcaneal traction or, better, stabilize the leg with an X-fix.

Continue regular dressing changes and irrigating the wound or surgical debridement until the wound is clean. Then close it as soon as possible without tension, if necessary with a local flap. Otherwise, get special help.

Later, if the wound is healing or already closed, reapply the cast, keep the patient walking, and change the cast only when it becomes soft or stinks excessively.

SKIN GRAFTING AN EXPOSED TIBIA

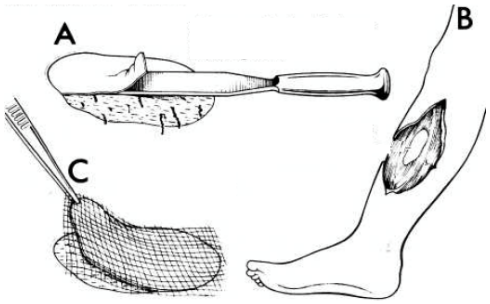


Fig. 70-15 SKIN GRAFTING AN EXPOSED TIBIA. A, chip away dead bone to get to healthy tissue. B, expose bone underlying an open fracture. C, graft healthy granulation tissue. *N.B.* If you are confident with a local fascio-cutaneous or a muscle flap, this would be the better option. *After London PS. Practical Guide to the care of the injured. E & S Livingstone 1967 with kind permission.*

If gas gangrene develops, immediate amputation may be necessary to save the patient's life (6.24). In order to prevent this disaster, make sure you: (1) explore and excise the wound properly, (2) open up all the fascial spaces where pressure could build up, & (3) lay the wound open without an encircling cast, after you have explored it, and administer the proper antibiotics.

If the tibia has not united after 4months, *don't be alarmed*. Fractures of the upper tibial ⅓ usually unite quite easily, but those of the lower ⅓, however, often don't. Some take 1 or even 2yrs. Give the fracture a further 6months to unite in a *well fitted* short leg walking cast. If there is no union in a year, bone grafting is probably necessary.

NON-UNION (58.7) may occur for different reasons. In the lower leg, specific problems are due to:
(1) Inadequate exercise of the broken leg.
(2) The fibula splinting the tibial fragments apart.
(3) Extensive injury of the tibia.
(4) Too large a gap between bony fragments.
(5) A bony spike holding fragments apart.
(6) A butterfly fragment preventing contact.
(7) Too rigid fixation, external or internal.
(8) Infection in the fracture site.
(9) Necrosis of a central segment of bone where there are 2 or more fractures.
(10) Excessive traction.
(11) Excessive wedging of the PoP.
(12) Inadequate immobilization in PoP.

If the ankle is immobilized in *equinus* without the application of a stirrup, putting the foot on the ground bends the callus around the fracture, thus causing hinging stresses which lead to healing with fibrous tissue, rather than with bone. So, either immoblize the ankle in neutral position or, if you have to immobilize it in *equinus*, fit a cast with a stirrup.

However, a non-union of the tibia does not automatically prevent walking! In case of a rigid non-union that may even be supported by a healed fibula, many patients can mobilize reasonably well. A stick to aid walking may be necessary, but as long as the non-union is rigid and mainly pain free, it is better to leave it alone. For further support to the lower leg, use an easily applicable gaiter/brace made either of leather or plastic.

If there is unbearable pain in the non-union site, it may well be infected.

MALUNION can take several forms:
(a) Shortening is usually minimal and unimportant (67.1). If the patient wears shoes, you can compensate for a loss of ≤4 cm by raising the heel of one of them while lowering the heel of the other.
(b) Angulation is serious and avoidable.

PREVENTION OF ANGULATION
(a) Align the fragments carefully to begin with.
(b) Wedge or change the cast early (70.7).
(c) Make sure that when weight bearing starts, it is in a cast which fully supports the fracture.

N.B. It is not the weight bearing that causes the malunion, it is improper casting. *Valgus* or *varus* malunion is more serious than backward or forward bowing, because there is no easy compensation.

(c) Rotation deformities in which the foot points inwards or outwards are also serious. Prevent them by making sure that the foot points in the same direction relative to the patella on the injured side as it does on the normal one (70-3). Inward rotation of the foot is more disturbing than outward rotation, because the feet can bump together when walking.

If the skin will not heal completely over the front of the tibia despite 1-2 skin grafts, leave the wound for the moment and continue walking in a cast. Remove the cast after 5-6wks and look at the wound: It will probably have healed.

If the foot swells with a cast *in situ*, admit the patient overnight. Keep the foot raised. The following day, *before you allow being out of bed,* apply a new cast which fits properly.

If the cast has been in place many weeks, the foot is sure to swell when it is removed. If necessary, compress it with an elastic bandage, elevate it at night, and advise continued exercises.

If the foot is stiff and painful after cast removal, there is unfortunately very little you can do. There is always some stiffness, especially after a fracture of the lower tibial ⅓, owing to scar tissue forming around the extensor tendons.

If there is a foot drop, the common peroneal nerve is injured, either (a) at the time of the accident, or (b) when inside a cast, especially if you did not pad it around the neck of the fibula, or (c) because of a compartment syndrome (49.6). Provide a brace to support walking and by keeping the foot in a neutral position. These are usually made out of plastic (48.1).

A MULTIFRAGMENTED INJURY HEALED

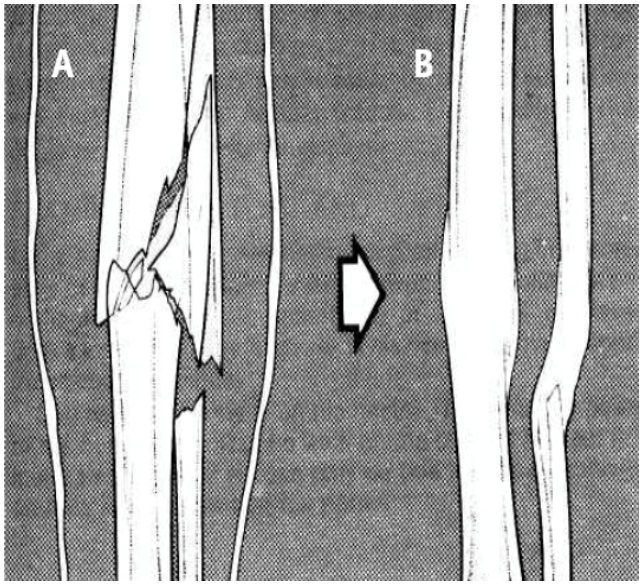


Fig. 70-16 *DON'T GIVE UP HOPE TOO EARLY*; A, this comminuted tibial fracture healed well after 28wks walking in a cast (B). *Kindly contributed by John Stewart*