4 Tibial and malleolar fractures
4.12 I Tibial shaft fractures — Management with limited resources

1 General considerations

The primary goal of treatment for tibial shaft fractures is to restore normal anatomy («reduction» i.e. realignment of the fracture) and normal function of the leg. Treatment should be effective and avoid unnecessary risks.

1.1 Essential operative treatment
Surgical treatment is necessary for open fractures (wound debridement), compartment syndromes, and repair of arterial injuries. These issues are covered elsewhere.

1.2 Operative fracture management
Operative treatment of displaced unstable tibia shaft fractures is the treatment of choice if it can be performed in facilities with the necessary equipment and skills.

1.3 Nonoperative fracture management
Nonoperative treatment of these injuries is chosen when safe, appropriate operative treatment is unavailable. Non-operative treatment options to immobilize the fracture include splints, traction, or in most cases circular casts plaster of Paris (POP). Splints are used as a first aid emergency treatment or short term initial management. Fiberglass / resin cast material is an alternative to plaster of Paris, more expensive, but more durable and lighter. If available, a thin layer of fiberglass may be used to reinforce a plaster cast.
2 First aid for tibial fractures

The ABCs of primary care for the injured always take precedence over fracture treatment. Once the safety of the patient is established, attention is turned to the fracture.

An important step in treating a tibia shaft fracture is promptly to realign the deformed leg and to splint it in corrected alignment. Splinting can be done with two firm boards, or sticks alongside the leg, from above the knee to below the ankle.

It is essential to apply padding between a splint and the injured leg. Any soft material such as clothing, blankets, etc. can be used as emergency padding. The splints should then be kept together by bandages around both splints and the leg.

Additional stabilization can be achieved by splinting the fractured leg to the contralateral normal lower extremity.
Any padded splintage is better than none, but circumferential wraps must not be so tightly applied that they interfere with blood flow.

3 Open fractures

For open fractures, the wound should be covered with the cleanest material available, preferably a sterile dressing. This initial temporary cover should not be disturbed until the patient is in the cleanest available hospital setting.

3.1 Wound Debridement
Adequate surgical debridement is essential to decrease the risk of infection, a major concern for all open fractures. Dressing and splint should remain in place until the patient is anesthetized for debridement in the operating room. Debridement involves excising dead tissue, removing foreign material, and thorough irrigation. Typically, wound closure is delayed, and the wound is covered with a moist sterile dressing. Post-debridement immobilization is typically provided with skeletal traction, splints, or circular cast, but if available, a properly applied external fixator is often better.
4 Calcaneal pin traction

4.1 Application of calcaneal pin traction
If an external fixator is not available, open fractures, especially if they need repeated wound care, can be treated in the short term with calcaneal pin traction on a Braun frame.

4.2 Calcaneal pin insertion
If the patient is not under general or regional anaesthesia, the pin is inserted under local anesthetic (eg, 2% lidocaine, 5 ml on each side of the calcaneus) 2 cm below and 2 cm behind the medial malleolus.

It is important that the stirrup is able to rotate around the Steinman pin to prevent rotation of the pin in the bone. Rotating pins loosen quickly. Loose pins significantly increase the risk of pin track infection.

4.3 Positioning in Braun frame with 3-4kg traction
The illustration shows a tibia fracture immobilized with calcaneal traction and supported on a Braun frame. The frame supports the thigh and the proximal tibial segment. Pressure against the thigh provides counter traction. The traction force and frame with fabric supports maintain fracture alignment. The non-elastic supports on the Braun frame are arranged to leave a gap, which allows wound care without changing the leg position.

Skeletal traction on a Braun frame is also valuable for maintaining length of unstable multifragmentary closed tibial fractures (those for which stability cannot be restored with realignment alone.)
4.4 Construction of a Braun frame

Braun frames may be difficult to obtain. A satisfactory Braun frame can be made from metal bar stock (5 mm x 20 mm) according to the illustration.

5 Introduction to tibial fracture reduction and cast application

If there is no need for wound care, and the fracture is length-stable, either from its configuration and/or reduction, or after development of sufficient callus, a cast can be applied. Usually, for a tibial shaft fracture, particularly if proximal, this cast should extend above the knee – a half to two-thirds the length of the thigh.

6 Preparation for cast application

It is essential to prepare the patient and all necessary material and equipment before beginning the processes of fracture reduction and cast application.

6.2 Required material

- Examination couch or table
- 2-4 rolls 150 mm padding
- 8-9 plaster of Paris (POP) rolls, 150 mm wide
- Bucket with cool water
- Pillows to support casted leg
- Aprons to protect team members and patient
- Paper to cover the floor

Everything must be be assembled and ready before beginning the procedure.

6.1 Anaesthesia

Both fracture manipulation and motion relation to cast application are painful. Fracture reduction is therefore best done with a regional or general anaesthetic. Occasionally a fresh closed fracture can be anaesthetized with sterile injection of local anaesthetic into the fracture hematoma.

Tibia fractures rarely shorten more than the amount present on the initial x-ray (presuming this is obtained without traction). If shortening is greater than 1.5-2 cm, and if a length-stable reduction (transverse; end-on-end, and supported effectively by the cast) cannot be achieved, traction, or surgical fixation (external or internal fixation) will be necessary to prevent shortening. Lesser degrees of shortening are usually well tolerated.
6.3 Required equipment
Scissors and knife can be used to cut POP cast when still wet, just before it sets.
The other tools are required for dry POP.

7 Fracture reduction

7.1 Reduction principles
Reducing a fracture means restoring acceptable alignment. Proper reduction of a tibial shaft fracture requires correction of

- length
- axial alignment
- rotation
- apposition (bone contact)

If no x-rays are available during the procedure, the reduction is orientated with reference to the uninjured leg.

7.2 Reduction
During fracture reduction, the patient needs pain relief and muscle relaxation. Depending on the resources, this might be analgesia plus sedation, but preferably regional or general anesthesia.
Once the pain relief takes effect, the splint can be removed and the knee gently bent so that the lower leg is in a hanging position.
Fracture reduction is easiest with the leg hanging beside the table, with enough space between the leg and the table edge to apply the cast. The fully flexed knee relaxes the calf muscles, helps control rotation, and permits ankle dorsiflexion to neutral (90° to the leg). The person treating the fracture pulls with both hands on the heel and ankle to overcome any shortening.

The illustration demonstrates reduction of a transverse fracture. Reducing the distal fracture fragment anatomically restores length. The length is stable as long as the distal fragment is “hooked onto” the proximal one. A cast can maintain this length-stable reduction fairly easily. Fractures which are not transverse (spiral, oblique, or multifragmentary) cannot be “hooked on” and thus lack length stability. Shortening of 1 cm or even 2 cm is acceptable, but axial alignment, rotation and apposition are still important to restore.

Rotation and apposition can be judged and corrected by aligning the anterior tibial crest of the distal fragment with the proximal one. This part of the reduction is aided and confirmed by local palpation. Rotational alignment is indicated by the angle between the foot axis and that of the thigh. This angle should match that of the opposite lower extremity.
End-on-end apposition of a transverse fracture can be difficult to achieve with traction and transverse pressure. In this case, as illustrated, increasing angulation may allow the fracture ends to be hooked, followed by deangulation to correct the tibial axis.

8 Cast application

Cast application is far easier with the aid of an assistant. One person holds the reduction while the other (operator) applies the cast. If both are skilled in cast application, typically the one in charge takes responsibility for holding the reduction. If he or she must personally apply the cast, the assistant holds the leg. Reduction should be repeatedly verified during cast application.

8.1 Holding the reduced position

The leg-holder stands on the medial side of the injured leg and controls the knee and thigh position while holding the ankle dorsiflexed to neutral. Rotational alignment is approximated by holding the big toe in line with the patella, as seen from superiorly or anteriorly. This maintains the normal slight external rotation of the tibia. This technique usually holds the reduction that has been achieved, and allows the operator to apply the padding and the plaster cast.

Tip: Avoid strong dorsiflexion of the foot as this can cause recurvatum (apex-posterior angulation) of the lower leg.
8.2 Assessment of rotational reduction
The best way to assess the rotational alignment of the tibia is by means of the angle between the long axes of the thigh and of the foot. If the rotational reduction is correct, the long axis of the foot is slightly externally rotated relative to the axis of the thigh. This foot-thigh angle should be the same as for the opposite lower extremity.

8.3 Application of POP
One of the treating team applies the padding from below the ankle to just above the knee. Next, while maintaining the fracture reduction, apply around the lower leg 2-3 rolls of POP (dipped in cold water to give more time until hardening).

The POP cuff is molded firmly to the lower leg whilst keeping traction on the heel. Relax the molding pressure only when the POP cuff is firm (4-5 minutes).

Tip: With the tibial axis properly aligned («straight»), the form of the lower leg appears slightly bowed, convex laterally, concave medially, like the opposite tibia. The external appearance of a cast should be similar. If the cast looks absolutely straight, then the tibia is likely to be aligned in valgus.
Once the plaster cuff around the lower leg has dried and stabilizes the fracture, the padding and the plaster are extended down around the ankle and the foot as far as the metatarsophalangeal (MTP) joints. Take care not to extend the plaster over the dorsum of the MTP joints, as this blocks dorsiflexion.
Do not let padding lie between layers of plaster.

Once the below knee plaster cast is firm, the knee is extended and the lower leg lifted onto a cushioned leg support. One caregiver holds the foot and lower leg to maintain flexion of the knee at about 30° and the other extends the padding and the plaster as high as the upper thigh, remembering not to place padding between layers of plaster.
Always support the wet plaster with the flat hand, do not press dimples into the plaster with the fingertips, as this can cause pressure points inside.

It is important to hold the knee position until the entire cast is firm.
The weak point of the plaster is the junction between the already well-dried below knee POP and the extension to the above knee cast.
This region should be reinforced with an extra roll of plaster.
Elevate the lower leg on 2-3 pillows for three to five days, until it is both firm and fully dry.
X-ray control after reduction should be delayed until the POP is quite dry (24-48 hours). The x-ray will confirm whether the position is acceptable or not.
9 Drying of the cast

The patient should be warned that the leg in the plaster will feel warm initially and then become cool and moist. The heat is due to the chemical reaction of the plaster’s setting; it then cools because of the evaporation of water from the plaster. Once the cast is dry, the moist, cold feeling will disappear. During the evaporation period, the casted limb should remain exposed and not fully covered by blankets.

10 Splitting of a plaster

When significant swelling is expected, it may be advisable to split and loosen the plaster. This can be made easier by placing a protective leather or plastic strip over the leg under the plaster before the cast is applied. If the plaster is still damp, it can be cut with a very sharp knife, onto that protective strip which is then removed. Instead of a single split in the cast, a 1-2 cm strip of plaster can removed. This makes it easier to release the underlying padding. Alternatively, the plaster can be split using a plaster cutter. An oscillating saw is the easiest way to cut dry plaster, however is not effective if the plaster is still wet. Either way, splitting alone does not loosen the cast. It must be spread to increase its volume. Cast padding must also be cut completely to the skin. Do this carefully using guarded scissors. Even a small strand of hardened padding can act as a circumferential band and cut into a swollen leg.
11 Compartment syndrome

Any plaster, especially one without adequate padding, or applied tightly to an injured leg that is likely to swell (fresh fracture or after significant manipulation), carries a risk of obstructing circulation and causing compartment syndrome.

In case of inappropriate and/or increasing pain, made worse by passive dorsiflexion or plantarflexion of the toes, the plaster and padding should be split immediately down to skin, over its whole length, and spread open enough to ensure that no constriction remains. Then, the leg should be watched carefully. In the absence of rapid recovery, a compartment syndrome may be present. This would require emergency fasciotomy. Loosening the cast, even if it leads to loss of reduction, is better than risking muscle necrosis.

12 Pins in plaster

12.1 Steinmann pins as reduction aids and prevention of displacement

Caution: this technique is far inferior to external fixation: pin track infection is common and the method is only to be used if an adequate external fixator is not available.

In unstable, oblique, and multifragmentary fracture types (42-B2/3 and 42-C), in which a stable apposition at the fracture site is not possible, displacement, especially shortening, can be prevented by first passing Steinmann pins through the tibia proximally and distally.

12.2 Insertion of proximal pin

At the entry point, a stab incision is made through the skin with a pointed scalpel.

A Steinmann, or preferably a Denham pin (a Denham pin has a short threaded section in the centre to prevent side-to-side motion of the pin in the bone), mounted in the T-handle, is inserted manually at a point about 2 cm dorsal to the tibial tuberosity.

As the pin is felt to penetrate the far cortex, check that the exit will coincide with the area of local anaesthetic infiltration. If not, inject additional local anaesthetic. Once the point of the pin clearly declares its exit site, make a small stab incision in the overlying skin.

If the slightest suspicion of compartment syndrome remains, ensure that the plaster is completely loose and consider urgent dermatofasciotomy.
12.3 Insertion of distal tibial pin

When inserting pins in the distal zone take into account the position of the anterior tibial artery and vein. Percutaneous insertion of pins in this area is dangerous. A minimal incision will allow preparation and safe insertion.

The pin should be inserted from lateral to medial through the middle of the tibia anterior to the fibula, in the frontal plane, so it emerges medially through the subcutaneous surface of the tibia.

12.4 Plastering

Make sure that the skin is not under tension from the pin. Incise the skin if necessary to release it. With a small incision no sutures are necessary. Some antibacterial ointment and a sterile dressing are applied over the pin site. The cast is applied, by rolling plaster smoothly up to and incorporating the pin on each side with a thick cuff of plaster (2 cm) 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.

Excessive pin length can be removed with a pin cutter, but at least 2 cm or so of pin should be incorporated in the plaster, both medially and laterally.

**Note:** The transfixion pins can be used as reduction aids. Traction, rotation, and angulation of the pins can be used to correct deformities. This is done before plaster application. Then, with the fracture held reduced, POP is applied, incorporating the pins as described. Once hard, the cast functions as the frame of an external fixator, using the transfixion pins to maintain fracture alignment.

This procedure is usually done under general or regional anesthesia.

Initially the cast should be extended above the knee for better stability and comfort. It can later (3-4 weeks) be shortened to a below knee plaster, still maintaining the pins incorporated in the plaster.

Once the fracture is likely to be sticky (approximately 6 weeks), remove the cast and pins and apply a new cast. At this point it may be appropriate to begin progressive weight bearing.
13 Cast wedging

Small angular malalignments can be corrected by wedging without changing the plaster. Wedging needs to be delayed till the plaster cast is completely hardened (day 3 or 4), or later. Wedging is safer if sufficient padding is applied during the original cast application.

Central wedging (preferred technique)
Make a half-circumferential cut in the cast on the concave side of the angulation. An appropriate half-wedge is then removed from the convex side, not quite meeting the first cut, but leaving a 1 cm bridge, as shown. The angulation is then gently corrected, the first cut being held open with a piece of cork (avoid skin pressure), while the open wedge is closed. Note that the anterior and posterior plaster bridges lie on the axis of rotation, perpendicular to the plane of angulation. The wedging site is then repaired with fresh POP bandaging. Smoothly work the plaster into the open wedge without skin pressure, and wrap it circumferentially around the cast, 4 or 5 cm proximally and distally, to restore its strength.

The first half-circumferential cut (opening wedge) must be placed on the concave surface, opposite the apex of deformity. The axis of deformity correction (ends of the first cut) is thus properly oriented.

13.1 Pitfall: closing wedge
A simple closing wedge of the cast can pinch the skin and subcutaneous tissues, causing pain and, if not corrected, skin necrosis.
It also effectively shortens the cast, as well as the tibia.

13.2 Pitfall: opening wedge
Open wedging alone can distract the fracture fragments: in a transverse fracture, this can contribute to impairment of union.
13.3 To be avoided
- Manipulation without traction
- Failure to assess inappropriate pain
- Failure to loosen cast with increasing pain, or suspected compartment syndrome
- No elevation after POP application
- Covering POP before it dries
- Creating indentations with fingertips (as illustrated)
- Failure to pad over bony prominences
- Pressure on common peroneal nerve (lateral fibular neck) or fibular head.
- Application of a thinly padded cast before swelling has ceased

14 Aftercare

14.1 General guidelines
Analgesics should be prescribed for 4 to 6 weeks. If a plaster cast becomes loose, it should be removed and replaced with a new one, preferably waiting until the fracture has become sticky enough (+/- 4 weeks) to avoid losing the reduction during the replacement procedure.

Non weight bearing should be maintained for 2-4 weeks depending on the fracture type.
Then graduated partial weight bearing should be started and increased to full weight bearing by about 6 weeks. Weight bearing requires protection of the cast bottom with a cast shoe, oversized sneaker, or equivalent.
Tibial shaft fractures usually take between 3 and 5 months for complete healing. If the foot is in a functional position, graduated partial weight bearing can begin as soon as possible comfort and presumed fracture stability permit.

Caution: For unstable fractures or fractures involving the knee or ankle joint, weight bearing should be delayed until healing is further advanced.
The plaster cast should not be removed until the fracture is stably healed. This is usually indicated by patient’s ability to bear full weight in the cast without pain. For tibial shaft fractures, this will rarely occur before 14 weeks after injury. Displaced fractures or fractures due to high energy forces usually take longer to heal. It is usually necessary to replace the first cast before the fracture is healed sufficiently. Check stability carefully when definitive removal is done. Sometimes alignment that initially feels stable will be lost during the first week or two after cast removal. It is wise to check the patient within a couple weeks to avoid missing such delayed deformity until it is very hard to correct.

After removal of the cast, and confirmation of a stable nontender fracture, rehabilitation should involve dedicated knee and ankle mobilization for a prolonged period. Even if fully weight bearing before cast removal, the patient may need crutches and partial weight bearing for a period after cast removal. At this stage, it may be advisable to give an anti-inflammatory for four weeks.

### 15 Alternative cast for weight bearing

#### 15.1 Hinged knee cast-brace

For proximal tibial fractures, the knee may be mobilized with the aid of a hinged cast, this is applied when the fracture is sufficiently consolidated (typically after 6 weeks). The hinged cast involves two parts as shown. A fresh cast has to be applied below the knee as well as above. The lever arms of the hinge are incorporated in the plaster cuffs above and below the knee. Great care needs to be taken to align the axis of the hinge with that of the knee joint. Remember that the knee axis is actually proximal to the joint line, roughly at the level of the femoral epicondyles, and that it is perpendicular to the knee’s arc of motion.

This cast-brace, a form of functional bracing, allows mobilization of the knee joint before the fracture is completely healed. It provides continued protection of the healing fracture, as well as progressive partial weight bearing, at the discretion of the treating surgeon. Where materials are available, such functional braces can be made of fiberglass or appropriate thermoplastics. If mobilization of the ankle is desired, a hinged foot support can be used to replace the foot portion of the cast.
16 Sarmiento’s Patellar tendon-bearing cast

In mid shaft and more distal tibial fractures, a patellar tendon-bearing (PTB) cast, as described by Sarmiento, can be applied. For more stable fractures, this cast may even be applied earlier than 6 weeks. For undisplaced tibia shaft fractures without significant swelling it might even be used as the initial cast. The application of such a cast requires considerable experience, especially the molding in the infrapatellar region.

16.1 Application of the Sarmiento cast
Where materials are available, the cast can be made of fiberglass or thermoplastic material. Additionally a hinged foot support can be used to replace the cast around the ankle and foot, permitting also mobilization of the ankle.

The patient sits on the edge of a table. The lower leg is steadied and a stocking and padding are applied to above the knee. All bony prominences are protected by extra padding.

The POP is applied to above the knee and then later trimmed to above the patella in front and below the popliteal fossa at the back.
16.2 Molding of the Sarmiento cast
Before setting, the plaster is molded to fit the contours of the proximal tibia and fibula, not only around the tibial tubercle and patellar tendon, but also the fibular head, peroneal nerve, and posterior proximal calf. The cast should be triangular in cross section, flat posteriorly, and molded to match the prominent tibial tubercle. This molding forces the cast away from the fibular head and peroneal nerve, helping to avoid local pressure.

16.3 Trimming of the Sarmiento cast
Once firm, the proximal margin of the cast is trimmed from the proximal pole of the patella, circumferentially to the proximal part of the calf. Note that the posterior trim line is thus more distal then the anterior edge of the cast, since it must be just below the popliteal flexion crease.
Check that knee extension is full, and that the knee can flex to 90 degrees. Then cast edges are padded by turning down the padding and stocking, to provide cushioning. The stocking is then secured to the outside of the cast with a little additional plaster.

16.4 Weight bearing
Once the plaster is fully hardened (24-48 hours), a cast shoe may be applied and weight bearing and knee flexion started. The cast is retained until union is sound, and the patient can comfortably bear full weight. Gait training in a PTB cast is essential to ensure full knee extension, which is necessary for optimal fracture stability in this cast.