Definitive Management of Tibial Shaft Fractures
Pin-to-Bar External Fixation

In the past, pin-to-bar external fixation was used extensively for definitive management of tibial shaft fractures, particularly open fractures. This method of external fixation was the standard of care for these injuries until it was largely supplanted by the use of internal fixation. Mainstream and comparative studies of external fixation and internal fixation outcomes have become available, the disadvantages associated with the use of external fixation for definitive management of these fractures have become clear. These drawbacks include deep and superficial pin-tract infections; an increased rate of malunion; the same deep infection rate as a reamed, minimally reamed, or unreamed IM nail; and an increased incidence of infection when placing an IM nail after an external fixator has been in place for 10 days to 3 weeks.1

Patient dissatisfaction is another important factor in the decreased use of external fixation for definitive management of tibial shaft fractures. The external fixator often needs to remain in place for 3 to 4 months or longer. Currently, pin-to-bar external fixation for tibial shaft fractures is used more often for initial temporizing stabilization (that is, damage-control orthopedics) when the patient is too sick for definitive fixation or when the injury to the soft-tissue envelope is too severe to permit definitive fixation (the “too sick limb;” Figure 1). External fixation is still commonly used in the military environment. In this setting, contaminated wounds are the norm, and the ability to place an IM nail is compromised by the injury and an austere environment, with limited resources available in the battlefield.

For pin-to-bar external fixation, insertion of no less than two half pins on either side of the fracture is recommended. Placement of pins in two...
different planes improves the strength of the construct. Overall strength also may be improved by using a pin or a bar with a larger diameter, placing the bar/clamps as close to the skin as the swelling allows, and spreading the pins appropriately (near-near-far-far technique). Pin care technique, although important, is not universally agreed on. This chapter’s authors prefer to allow the patient to shower and keep the pin sites free of scabs. Application of an antibiotic dressing is not recommended unless indicated for pin-site infection.

**External Fixation With Circular Frames**

The biomechanics of circular frames are unique and differ from those of the familiar pin-to-bar frames. The circular fixators need to be built properly to be effective. To increase the stiffness of a circular frame, several factors should be considered, including the size of the rings. The smallest rings possible should be used, although room must be left to allow for soft-tissue swelling to prevent impingement of the ring on the soft tissue. The largest diameter wire possible should be used, and the wires must be maximally tensioned.

Wire placement affects frame stiffness. Shear stiffness depends on the interwire angle and loading direction. Stiffness decreases dramatically when the interwire angle is less than 60°. Placing opposed olive wires to maximize the interwire angle can increase shear stiffness, although doing so can be limited by soft-tissue, safe corridor constraints. Bending stiffness can be increased by placing a drop wire, which is a wire spaced more than 4 cm away from the other wires. This increases bending stiffness to a 90° interwire angle. In addition, frames with two levels of periarticular fixation are stiffer than frames with all the wires placed close together. If the periarticular fragment is too short to allow adequate wire spacing, then temporary joint spanning for 6 to 8 weeks may be needed.

The use of circular frames for managing tibial fractures is useful for several reasons. These frames can be used for periarticular fractures with long extensions into the tibial shaft. Circular frames allow immediate weight bearing, which is beneficial for patients with bilateral and/or multiple injuries and aids in earlier mobilization, thus diminishing the potential for complications associated with recumbancy. In patients with soft-tissue defects, these frames may be used to close the defects by deliberately malreducing the fracture or shortening it and then gradually reestablishing reduction and/or length. The frames are useful for pediatric patients as well. The presence of an open physis may dictate the type of fixation that can be used, and the condition of the soft tissues may not allow for an open and/or an acute correction of a deformity.

**Hybrid External Fixation**

A hybrid fixator is a combination of a circular wire frame and the more...
familiar half-pin frame. The joint surface is reduced through small incisions, and fixation of the smaller periarticular block is achieved with thin, tensioned wires. Fixation of the long fragment is achieved using pin-to-bar frames with half pins. This limits the soft-tissue dissection required for the fixation of tibial shaft fractures by avoiding the long portion of the open incision needed for plate placement versus joint reduction (Figure 2).

Hybrid fixation is still used successfully to manage tibial fractures. This technique was controversial for several reasons. One reason was the inconsistent use of open reduction and internal fixation for fractures of the articular surface. Another issue was the potential lack of attention to proper frame construction based on the biomechanics of hybrid frames. In the literature, the results of hybrid fixation are good, with a substantial reduction in the reported incidence of soft-tissue complications compared with the results of acute open reduction and internal fixation using large incisions. However, the patient is still required to wear a large, bulky external fixator on the leg for variable lengths of time.

External Fixation as an Intraoperative Reduction Tool
Plating and IM nailing techniques have evolved over the years to protect the soft-tissue envelope and the blood supply to bone. Minimally invasive percutaneous osteosynthesis (MIPO) techniques allow surgeons to place plates using smaller incisions, resulting in less soft-tissue damage. However, maintaining the reduction while passing the plate and placing screws is difficult. The use of an external fixator is helpful to maintain gross length, rotation, and alignment (Figure 3). A frame also can be helpful for placing an IM nail in the tibia, particularly for fractures of the proximal or distal third of the tibia, where the canal flares out and there is a mismatch between the diameter of the canal and that of the IM nail (Figure 4).

Several different types of temporary frames can be used. One type is a joint-spanning frame that is placed such that it crosses a joint (typically the knee or the ankle joint). A knee-spanning frame also can be helpful for placing an IM nail in the tibia, particularly for fractures of the proximal or distal third of the tibia, where the canal flares out and there is a mismatch between the diameter of the canal and that of the IM nail (Figure 4).

Temporary Management of Periarticular Tibial Fractures
Acute management of complex tibial plateau fractures with dual lateral and medial plating that is placed via a single anterior incision (referred to as the deadbone sandwich) has resulted in a high
Delivering the definitive procedure in addition to the use of MIPO techniques for placement of the diaphyseal portion of the fixation plate or plates has led to a lower incidence of soft-tissue complications and infections, with the added benefit of having permanent implants buried within the soft-tissue envelope. Both techniques can be used to manage tibial fractures. Each technique is associated with complications such as soft-tissue breakdown and the risk of nonunion.

**Rules for Temporary Pin-to-Bar Fixation Frames**

Because the frames will be used for only several weeks, the biomechanical rules used to construct temporary spanning pin-to-bar external fixation frames are not required to construct definitive half-pin/bar frames. The methods of increasing the stiffness of the pin-to-bar frame, particularly the placement of pins as far from and as close to the fracture site as possible, may lead to infection if a pin is placed within the fracture hematoma.

Temporary pin-to-bar frames can be constructed in many ways. The key is to build a frame that is simple, inexpensive, and easy to apply. Incisions should be planned and marked on the skin where the external fixator will be placed. The pins should be kept as far away from the incisions as possible. Clamps must be kept away from the fracture site because they are not radiolucent and will block visualization of the fracture in the fixator. Typically, the placement of two pins on either side of the fracture is sufficient to create traction and hold the fracture out to length. The goal is to allow for restoration of length, alignment, and rotation to facilitate final fracture fixation and management. Unless the

Thus, management of these fractures has evolved. Currently, injuries can be temporarily stabilized with pin-to-bar external fixation frames while the definitive procedure is delayed until the soft-tissue injury has been resolved.

*Figure 4* A, Intraoperative photograph of the lower extremity demonstrating placement of a nonspanning external fixation frame on the tibia to provide stability during intramedullary nailing. The frame is used for reduction during the procedure. AP fluoroscopic images of the ankle (B) and knee (C) joints demonstrating insertion of a half pin parallel to the joint to assess reduction in the AP plane. If the intramedullary nail meets the distal pin at a 90° angle, then the reduction is acceptable. A Bovie cord also can be used to assess reduction. If the cord crosses the proximal and distal pin at 90°, then the reduction is acceptable in the AP plane.

*Figure 5* A and B, Intraoperative photographs of the lower extremity demonstrating the use of a knee-spanning external fixation frame to stabilize a bicondylar tibial plateau fracture with associated lower leg compartment syndrome.
The use of external fixation for tibial fractures varies from a simple fracture-spanning frame to complex reconstructive frames, including those used to manage bone defects and nonunions. The appropriate and judicious use of external fixation is an important adjunct in the management of tibial fractures. The use of external fixation is based on a surgeon’s familiarity with the equipment and procedure.

References