Techniques for the Surgical Treatment of Distal Tibia Fractures

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KEYWORDS

• Distal tibia fractures • Surgical treatment • Open reduction • Internal fixation

KEY POINTS

- Surgical management of extra-articular distal tibia fractures has evolved because of the high rate of complications with conventional techniques and the technically challenging aspects of the surgery.
- Open reduction and internal fixation with plating or nailing remain the gold standards of treatment, and minimally invasive techniques have reduced wound complications and increased healing.
- Adequate reduction and stabilization as well as appropriate soft tissue management are imperative to achieving good outcomes in these fractures.

ANATOMY

Distal tibial metaphyseal fractures are those that extend within approximately 4 cm of the tibial plafond.[1] The Orthopedic Trauma Association's (OTA) fracture classification, similar to Muller's definition, defines these fractures as those contained within a square with a side length equal to the widest portion of the epiphysis; extra-articular fractures are those with no or with simple extension of a nondisplaced fracture line into the plafond.[2]

In an axial cross section of the tibia, moving distally from the diaphysis to the metaphysis, the shape of the tibia transitions from that of a triangle with an anterior apex to a more circular shape.[3] Compared with that of the diaphysis, metaphyseal cortical bone is thinner and the central cortex is replaced by secondary spongiosa and cancellous bone, making screw fixation more challenging. However, the material properties of this cancellous bone vary based on the age and activity level of patients and can be quite dense in patients less than 50 years old, which allows for stronger screw purchase. The medullary canal of the tibia has an hourglass shape, with a narrow diaphyseal region and wider metaphyseal regions. This flaring out of the metaphyseal region poses a challenge for intramedullary (IM) fixation, as a tight endosteal fit with the nail is achieved only in the middle few centimeters of the diaphysis.

The fibula is situated posterolateral to the tibia and distally joins with the lateral surface of the distal tibial metaphysis at the inferior tibiofibular articulation. This articulation is composed of the lateral syndesmotic ligaments and the distal interosseous membrane and is the reason why the fibula is often injured in higher-energy fracture patterns. Conversely, the inferior tibiofibular articulation is important because an intact or repaired fibula may help maintain tibial alignment during fracture healing. The lateral malleolus and the lateral ligamentous complex are critical to maintaining stability at the ankle joint.

Blood supply to the distal tibia is derived from 2 sources. Perfusion to the outer one-tenth to one-third of the tibial cortex is extraosseous and arises from a network of periosteal vessels on the medial surface that are branches of the anterior and posterior tibial arteries. The inner two-thirds of the distal tibia are supplied by intraosseous nutrient arteries, which are branches of the posterior tibial

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artery. Segmental fractures can potentially obliterate this intraosseous supply, leaving only the extraosseous supply intact. As a result, significant periosteal stripping during fixation may destroy the remaining blood supply and cause avascular necrosis of the bone, with consequent complications in bone healing.

At the level of the distal tibia, the structures most at risk during medial fixation are the great saphenous vein and the saphenous nerve. This vein and the major branch of the saphenous nerve intersect at the posterior cortex of the tibia at an average of 10 cm from the tip of the medial malleolus and then pass the anterior cortex approximately 3 cm from the tip of the medial malleolus.

CLASSIFICATION

Multiple classification systems have been developed to describe distal tibia fractures. Soft tissue injury can be evaluated with the Gustilo-Anderson or Tscherne-Gotzen classification systems for open or closed fractures, respectively. Robinson and colleagues[4] developed a classification system after studying distal tibia metaphyseal fractures treated with IM nailing (IMN). Two distinct injuries were noted: type I fractures resulted from a direct bending force producing a transverse fracture pattern, and type II fractures resulted from a torsional force producing a spiral/helical fracture pattern of the tibia with an associated oblique fibular fracture at the same or different level. The Association for Osteosynthesis/Association for the Study of Internal Fixation (AO/ASIF) system was also developed primarily for use in research and describes all fractures in the form of an alphanumeric code. Distal tibial extra-articular metaphyseal fractures are 43-A (4 = tibia, 3 = distal metaphysis, A = extra-articular). Based on the degree of comminution of the fracture, 43-A1 are noncomminuted extra-articular fractures, 43-A2 are wedge fractures, and 43-A3 are comminuted extra-articular fractures. Simple extension of the fracture line into the tibiotalar joint without depression of the joint surface is classified as 43-B1 and can often be treated in the same manner as extra-articular (43-A) fractures.

PRESENTATION AND INITIAL MANAGEMENT

Distal tibia fractures are frequently caused by high-energy trauma and are often associated with life-threatening injuries. Management of these injuries should be initiated according to Advanced Trauma Life Support principles.

A thorough medical history should be obtained identifying patient factors associated with the risk of soft tissue complications, poor fracture healing, and fixation failure. Preexisting peripheral vascular disease, smoking, diabetes mellitus and associated neuropathy, alcoholism, malnutrition, and osteoporosis have all been associated with an increased risk of infection and nonunion and may affect the choice of fixation.

A complete physical examination should be performed, and it is critical to evaluate for neurovascular compromise of the lower extremity. In the event of vascular compromise, immediate fracture reduction should be attempted. A full evaluation for possible compartment syndrome is mandatory, especially in closed injuries; urgent 4-compartment fasciotomy should be performed if suspected.

The soft tissue envelope of the involved lower extremity should be closely examined. Early recognition of impending skin compromise and urgent fracture reduction reduces the risk of conversion to an open fracture and a compromised surgical approach. Soft tissue injury signs include edema, ecchymosis, fracture blisters, and open fracture wounds; injury is often greater with distal metaphyseal fractures than with diaphyseal fractures. Open distal tibia fractures occur with an approximate incidence of 20%; the medial surface of the tibia, covered by thin subcutaneous tissue, is the most common site of open injury. Prompt administration of antibiotics, tetanus vaccination, and urgent debridement and irrigation should be performed. The limb should always be splinted pending definitive management.

RADIOGRAPHY/IMAGING

Radiographic imaging is necessary for injury classification and determining surgical technique and approach. Imaging of the fracture should include orthogonal views of the distal tibia and ankle mortise. Full-length radiographs of the tibia and fibula and orthogonal views of the knee are routinely obtained. Computed tomography (CT) is also useful for preoperative planning as it has been shown to add information in 82% of patients and change the surgical plan in 64%.[5,6] It is especially recommended if there is concern for intra-articular extension of the fracture.

It is important to define similar standards of radiographic outcomes that can be used by all studies, but this has not always been the case. Union can be defined as healing of at least 3 of 4 cortices on anteroposterior and lateral radiographs. Nonunion can be defined as a lack of healing within 6 months. Malunion is typically defined as fracture healing of greater than 5° of angular deformity in any plane or shortening greater than 10 mm.[7–9]