Intramedullary Nailing of Proximal and Distal One-Third Tibial Shaft Fractures With Intraoperative Two-Pin External Fixation

Robert W. Wysocki, MD, James S. Kapotas, MD, and Walter W. Virkus, MD

Background: Fractures of the proximal and distal one thirds of the tibial shaft have historically higher malunion rates than those of the midshaft. This retrospective case series evaluates the postoperative radiographic outcome of intramedullary nailing of proximal and distal one-third tibial shaft fractures using intraoperative two-pin external fixation, often referred to as traveling traction.

Materials and Methods: Between 2000 and 2005, 15 consecutive patients with proximal third and 27 consecutive patients with distal third displaced extra-articular fractures of the tibia were treated with statically locked intramedullary nailing and supplementary intraoperative two-pin rectangular frame external fixation. The external fixation was removed once the proximal and distal locking screws were in place. The alignment of the fractures was determined using standard postoperative anteroposterior and lateral radiographs.

Results: Postoperatively, 14 of 15 patients with proximal fractures and 25 of 27 patients with distal fractures had less than 5 degrees of angular deformity in both the coronal and sagittal planes and less than 1 cm shortening.

Conclusions: Statically locked intramedullary nailing with simultaneous intraoperative traveling traction external fixation as treatment for proximal and distal one-third extra-articular tibial shaft fractures is successful in achieving a high rate of acceptable postoperative alignment.

Key Words: Tibial shaft fracture, External fixation, Proximal, Distal, Intramedullary nailing.

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Intramedullary nailing has become the standard of care for most displaced diaphyseal tibial fractures.[1–7] Extra-articular fractures of the proximal third of the tibial shaft are somewhat uncommon, ranging between 5% and 11% of all tibial fractures,[2,4,8–10] but these fractures can be much more difficult to treat with intramedullary nailing than other tibial shaft fractures. These fractures frequently result in malunion with apex anterior and valgus deformities.[8,10–18] Similarly, displaced extra-articular fractures of the distal tibia can be difficult to treat, with residual varus, valgus, recurvatum, or procurvatum possible. The small size of the distal fragment can make both maintaining the reduction and placing adequate distal locking fixation difficult, with the center-center placement of the nail in both the proximal and distal fragments being critical.[19–21]

Several authors have recommended changes or additions to standard intramedullary nailing technique to attempt to prevent malunion in these fractures. For proximal fractures, these have included keeping the knee in a semiextended position to decrease the pull of the quadriceps on the proximal fragment,[18] using an entry point more lateral than with standard nailing[8,10,13] to allow the nail to enter the wider lateral proximal tibia and increase the effective diameter of the nail, using a femoral distractor to neutralize the pull of the extensor mechanism while nailing in hyperflexion,[13] adding oblique proximal interlocking screws,[22] and using blocking screws to narrow the width of the proximal segment canal and keep the nail centered during insertion.[15,16,23,24] For distal fractures, previous authors have recommended the use of blocking screws,[24] unreamed nails through which three locking bolts can be placed into the distal fragment,[19] as well as removal of the distal tip off of traditional reamed nails to allow for more predictable placement of two locking screws in the distal fragment.[20,25–28]

The use of a simple two-pin external fixator in a rectangular configuration, often referred to as "traveling traction," has been applied by Moed et al.[29] as an adjunct to intramedullary nailing of tibial shaft fractures with excellent results. We attempt in this study to apply this technique specifically to proximal and distal one-third tibial shaft fractures, injuries which are notoriously difficult to treat with standard intramedullary nailing.

The goal of this study is to describe the technique of using traveling traction external fixation in conjunction with standard reamed intramedullary nails to obtain acceptable

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From the Department of Orthopaedic Surgery, John H. Stroger Hospital of Cook County and Rush University Medical Center, Chicago, Illinois.
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Address for reprints: Robert W. Wysocki, MD, Rush University Medical Center, 1725 West Harrison, Suite 1042, Chicago, IL 60612; email: robertwysocki@mac.com.

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alignment of fractures of the proximal and distal thirds of the tibia, and to provide a review of our postoperative radiographic results. Our hypothesis is that the use of this technique with intramedullary nailing improves the postoperative alignment of these difficult to treat fractures in comparison to historical controls.

MATERIALS AND METHODS

Between November 2000 and June 2005, 15 patients with proximal third and 27 patients with distal third displaced extra-articular tibial shaft fractures (all type AO 42), as measured by dividing the tibia into equal thirds from the plafond to the plateau, were treated by one of two senior orthopedic trauma fellowship-trained surgeons with simultaneous closed reamed statically locked intramedullary nailing and traveling traction external fixation. Indications for operative fixation included coronal plane deformity more than 5 degrees, sagittal plane deformity more than 10 degrees, rotational deformity more than 10 degrees, shortening more than 1 cm, and apposition less than 50%. Three of the proximal and five of the distal fractures were open injuries. There were 38 men and 4 women. All patients were skeletally mature. Fractures were excluded if the fracture had intra-articular extension or was too far proximal or distal to allow four cortices of fixation with two proximal or distal interlocking screws. Two patients were excluded because supplemental plates were used.

All patients had postoperative anteroposterior and lateral radiographs obtained on the day of surgery, which were assessed by an independent observer (Robert Wysocki) for length and for fracture alignment using goniometric measurements as described by Freedman and Johnson.[8] Malalignment was defined as more than 5 degrees of angulation in any plane or more than 1 cm shortening. Institutional review board approval for this study was obtained.

All patients were treated with either the Hoffman II external fixation system (Stryker Orthopaedics, Mahwah, NJ) or the large external fixator set (Synthes USA, Paoli, PA). Thirteen patients were treated with the Trigen Knee Nail (Smith and Nephew Richards, Inc., Memphis, TN), and the remaining 29 patients were treated with the T2 Standard Tibial Nail (Stryker Orthopaedics, Mahwah, NJ). All nails were inserted in a reamed fashion and statically locked with a minimum of two screws proximally and distally. The choice of nail type was based on both surgeon familiarity and hospital stock availability, but was not based on any one nail being perceived as a better choice for a particular fracture type.

Surgical Technique

Patients were positioned supine on a radiolucent fracture table. Open fractures were thoroughly debrided and irrigated. Under fluoroscopic guidance, a 5.0-mm centrally threaded transfixion pin was then placed from lateral to medial through the metaphysis of the proximal tibia, using an entry point just anterior to the head of the fibula so as to stay posterior within the intramedullary canal to allow room for nail passage. Then under fluoroscopic guidance, a second 5.0-mm centrally threaded transfixion pin was placed from medial to lateral in the distal tibial metaphysis at the level of the physeal scar, or in the calcaneus if the distal fracture was too distal to allow pin placement at the level of the physeal scar. The two pins were then connected by clamps to two either 8 mm (Hoffman II) or 11 mm (large external fixator) carbon fiber rods in a rectangular configuration (Fig. 1). A preliminary reduction was then obtained, whereby coronal plane alignment could be altered with fine adjustments of the clamp position, and sagittal plane alignment could be altered by a combination of ligamentotaxis from traction and manual manipulation or strategic bump placement.

Fig. 1. *Clinical photograph demonstrating rectangular configuration external fixation using two tibial transfixion pins.*

All starting points were identified with the assistance of fluoroscopy. The nail was inserted medial to the patella tendon in most cases; however, for some proximal fractures insertion was through the patellar tendon. For proximal fractures, the starting point was identified to be in line with the lateral tibial spine, thus slightly more lateral than for standard nailing. In the sagittal plane, the starting point was as far proximal in the tibia as possible while remaining extra-articular and the guide wire was inserted taking care to avoid

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posterior angulation, thus running along the anterior cortex as best as possible while staying intramedullary. This served to prevent flexion deformity. For distal fractures, a standard starting point just medial to the lateral tibial spine and just anterior to the anterior margin of the articular surface[30] was used. As the guide wire was passed distally as well as during reaming and nail passage, care was taken to ensure that the reduction of the distal fragment was maintained and that the distal fragment was bisected on both anteroposterior and lateral fluoroscopic views.

A tibial nail of the appropriate diameter and length was then passed over the guide wire, making sure during passage that the fracture alignment was maintained fluoroscopically. The nail was statically locked in the standard fashion with the outrigger proximally and freehand distally, with at least two screws in the smaller fracture fragment in all cases and a third screw if space allowed or if the fracture was perceived as still unstable to manual stressing by the surgeon. Once all the locking screws were in place, the external fixator was removed and appropriate alignment verified one final time. No concomitant fibular fractures were fixed.

Postoperatively, patients were kept touchdown weight-bearing and followed up clinically and radiographically every 4 weeks to 6 weeks until radiographic evidence of bridging callous was present.

RESULTS

Postoperative radiographs in the proximal fracture group revealed 14 of the 15 patients to have acceptable alignment with 5 degrees or less angulation in all planes and less than 1 cm shortening (Fig. 2). The one patient with unacceptable alignment was the first case performed using this technique, and this patient was in 12 degrees of varus (Fig. 3).

Postoperative radiographs in the distal fracture group revealed 25 of the 27 patients to have acceptable alignment with 5 degrees or less angulation in all planes and less than 1 cm shortening (Fig. 4). Of the two patients with malalignment, one was in 6 degrees of extension and the other was in 6 degrees of valgus. No patients had greater than 6 degrees of malalignment. The patient with 6 degrees of valgus had the external fixator loosened before distal locking because the fixator clamps were blocking insertion of the locking screws, which allowed the tibia to collapse into valgus. There were no cases of intraoperative fracture propagation into either the knee or ankle joints.

CONCLUSIONS

We believe we were able to demonstrate that the application of traveling traction is a very useful tool to assist in obtaining and maintaining an intraoperative reduction, without the use of an extra assistant, for extra-articular proximal and distal tibial fractures that can be quite difficult to treat using historical controls. We believe the greatest benefit of this technique to be in proximal fractures, which are notorious for high rates of malunion. We had an overall 93% rate of acceptable postoperative alignment in these fractures, and the only unacceptably aligned fracture was the first case we performed using this technique. It should also be noted that the two cases of malalignment in the distal group in this study were 6 degrees, one valgus and one extension deformity. Given that there is no clear consensus on acceptable alignment in these fractures, this degree of deformity may very well not be clinically significant and would be considered by some to be acceptable.[26] Displaced fractures of the proximal and distal thirds of the tibia are difficult to treat, and the value of intramedullary nailing as a treatment for these fractures has been debated. For proximal fractures, standard tibial nailing has been found to lead to significant angular deformity in 8% to 59% of cases.[8,10,31] The results of intramedullary nailing of distal fractures are significantly better, with angular deformity rates commonly between 8% and 20%.[25,32,33]

Fig. 2. *Postoperative anteroposterior (A) and lateral (B) radiographs demonstrating acceptable alignment in both planes for a proximal one-third fracture.*

The use of temporary intraoperative external fixation has been successfully used in many areas of fracture fixation. The classic femoral distractor has been shown to be useful in aiding both intramedullary nailing[34–36] as well as minimally invasive plating[37] of femoral fractures, and its use has been

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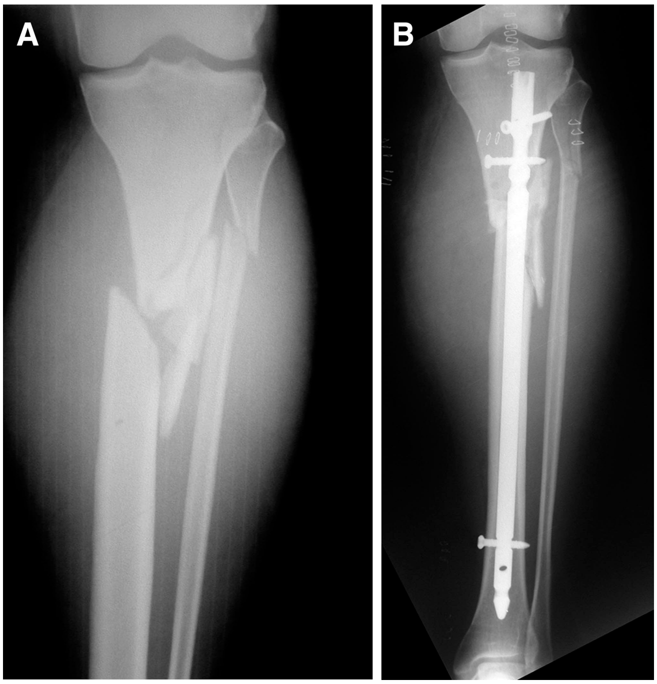

Fig. 3. *Preoperative (*A*) and postoperative (*B*) anteroposterior radiographs demonstrating varus postoperative malalignment of a proximal one-third fracture in the first case performed using this technique.*

Fig. 4. *Preoperative (*A*) and postoperative (*B*) anteroposterior radiographs demonstrating acceptable alignment for a distal one-third fracture.*

extended to the upper extremity as well.[38] The principles of using external fixation to maintain alignment and length until definitive fixation have been applied also to the tibia, as Moed and Watson[29] applied a rectangular frame similar to that used in our study to augment tibial nailing in 44 shaft fractures rather than use of a fracture table and obtained acceptable alignment in all patients. The theoretical advantage of the bilateral uniplanar rectangular frame traveling traction over the unilateral uniplanar universal femoral distractor is a better ability to control coronal plane angulation while still maintaining ideal traction without over or under distraction.

The primary limitation of this study is that the outcome measure is solely postoperative radiographic alignment, and these patients were not followed out to union. Thus, it is possible that some fractures may have either fallen into malalignment later in the recovery course or required dynamization or further procedures to achieve union. For both proximal and distal fractures treated in a similar fashion, several authors have demonstrated very low progression (<5%) from acceptable postoperative alignment to late malunion after intramedullary nailing.[19,20,39,40]

In conclusion, we believe that intraoperative two-pin rectangular frame external fixation in conjunction with intramedullary nailing in proximal and distal one-third tibial shaft fractures can greatly decrease rates of postoperative malalignment.

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