Although not based on any firm data, traditional guidelines for treatment of tibial shaft fractures dictate that alignment should be maintained such that there is 1 cm of shortening, 5° of angulation, and 10° rotational deformity. Some have indicated that more angulation in the sagittal plane (10°) as well as external rotation (10°) may be acceptable. However, as the fracture site approaches the distal third of the tibia, even small amounts of malalignment can affect the forces traversing the ankle joint.

Numerous factors related to the patient and injury other than residual angular deformities can affect the outcome of a patient with a tibial shaft fracture. These factors include other associated injuries, extent of soft-tissue injury and time to union, patient education, substance abuse, ability to return to work and activities, and complications during fracture treatment. Numerous authors have reported the outcomes of tibia fractures treated by various methods; many studies have compared nonoperative to operative treatment methods. Despite this, a lack of consensus exists on the ideal management of tibial shaft fractures, especially those involving the distal third.

Although intramedullary nailing techniques have advanced over the past 10 years, obtaining an acceptable closed reduction using an intramedullary nail can be difficult, especially in distal third fractures. This retrospective review compares and evaluates the time to union, alignment, return to function, and complications of intramedullary nailing of distal third tibia fractures in a level II trauma center before and after the implementation of orthopedic trauma surgeons.

Abstract

We hypothesized that less malalignment and complications occur with intramedullary nailing of distal third tibia fractures (42A, B, C) after the implementation of orthopedic trauma surgeons to this level II community hospital. We also hypothesized that patients with 5° of malalignment have poorer function as measured by the MODEMS functional outcome scale. Two cohorts of distal third tibia fractures were identified by discharge diagnosis or by the Orthopaedic Trauma Association database. Group I (n=39) patients were stabilized with an intramedullary nail by community orthopedic surgeons. Group II (n=18) patients were treated by orthopedic trauma surgeons. In Group I (community), 9 (23%) patients treated by the community surgeons exhibited >5° of angulation in at least one direction. Five (13%) of these patients displayed angulation in more than one direction, and 3 of these patients exhibited >10° of angulation. In Group II (trauma) 1 (5%) patient had >5° angulation in any plane (P<.05). No differences were noted in time to union, nonunion, delayed union, hardware failure or infections between the two groups. Functional outcomes were assessed using the MODEMS lower limb module. In comparison of the patients with and without significant angulation, the P value for bodily pain was 0.042. Patients treated by the community orthopedic surgeons had a higher incidence of malalignment, as compared to those treated by orthopedic trauma specialists.

Materials and Methods

The charts and radiographs of all patients with tibial shaft fractures treated with an intramedullary nail at a level II trauma center from 1992-2000 were compared and evaluated. Two cohorts of distal third tibia fractures were identified by discharge diagnosis or by the Orthopaedic Trauma Association database. Group I (n=39) patients were stabilized with an intramedullary nail by community orthopedic surgeons. Group II (n=18) patients were treated by orthopedic trauma surgeons. In Group I (community), 9 (23%) patients treated by the community surgeons exhibited >5° of angulation in at least one direction. Five (13%) of these patients displayed angulation in more than one direction, and 3 of these patients exhibited >10° of angulation. In Group II (trauma) 1 (5%) patient had >5° angulation in any plane (P<.05). No differences were noted in time to union, nonunion, delayed union, hardware failure or infections between the two groups. Functional outcomes were assessed using the MODEMS lower limb module. In comparison of the patients with and without significant angulation, the P value for bodily pain was 0.042. Patients treated by the community orthopedic surgeons had a higher incidence of malalignment, as compared to those treated by orthopedic trauma specialists.

From the 1Department of Orthopedics and Rehabilitation, Division of Orthopedic Trauma, Vanderbilt University Medical Center, Nashville, Tenn; and the 2University of North Carolina, Chapel Hill, NC.

Reprint requests: William T. Obremskey, MD, MPH, Dept of Orthopedics & Rehabilitation, Division of Orthopedic Trauma, Vanderbilt University Medical Center, 2100 Pierce Ave, 131 Medical Center S, Nashville, TN 37232-3450.
reviewed. Inclusion in the study required the fractures to be isolated, closed, and in an adult (closed physes). In 1996, orthopedic trauma surgeons were introduced to this level II community hospital and from 1996 to 2000; patients were either treated by a community surgeon or a trauma surgeon. After discharge from the hospital, patients were followed until radiographic union or established nonunion was noted.

Radiographs were taken monthly and were blindly evaluated by the senior author (W.T.O.) for time to union (bridging callus noted on 3 cortices on two views) and amount of angulation at union. Angulation was determined on anteroposterior and lateral radiographs taken immediately postoperatively and at latest follow-up. Rotational alignment was not examined. Demographic data and postoperative course were obtained from chart review. Patients were contacted to determine ability to return to work and activities (sports and recreational). Postoperative complications and elective implant removal were recorded. Functional outcomes were assessed using the MODEMS lower limb module.

RESULTS

Fifty-seven fractures of the distal third of the tibia (OTA 42A/B, 43A) treated with intramedullary nail fixation met the entry criteria. Patients were divided into two groups based on their treating physician, community orthopedic surgeon (n=39) or orthopedic trauma surgeon (n=18).

The community group was comprised of 39 patients. Average patient age was 40±16 (range: 15-74 years). Twenty-seven (71%) patients were male and 11 (29%) were female. Thirty-two fractures (84%) occurred as a result of a low energy fall or athletic events. Thirty-three (87%) patients underwent intramedullary nailing within 48 hours of injury. Average follow-up was 17.7±9.8 months (range: 7-52 months). One patient required internal fixation of a distal fibula fracture.

Orthopedic trauma surgeons were present after 1996 and over several years the number of trauma surgeons increased. The orthopedic trauma surgeon group was comprised of 18 patients. Average patient age was 36±14.2 years. Twelve patients (67%) were male and 6 (35%) were female. Eighty-six percent of these patients' injuries occurred secondary to low energy trauma. All patients were followed to clinical and radiographic union. Average follow-up in the trauma group was 22.5±17.4 weeks. Three patients required internal fixation of a fibular fracture.

No differences in demographics were found between the community and trauma groups. All patients in both groups had reamed intramedullary nails statically locked with two distal screws.

In the community group, mean time to radiographic union was 14.7±15.3 weeks (range: 7-52 weeks). Two (5%) patients were noted to have a delayed union (>6 months from injury). One went on to union at 11 months without any additional procedures. The other underwent revision intramedullary nailing at 8 months with progression to union at 10 months. Three (8%) patients were noted to have a nonunion at the fracture site (>9 months post injury). One patient underwent revision intramedullary nailing a second time due to poor healing and then went on to union at 18 months. Two (3%) patients underwent nail removal revision (one for a delayed union and one for a nonunion).

A second patient noted to have a delayed union progressed to union after 14 months.

In the trauma group, the time to clinical union was 14.86±3.02 weeks and radiographic union was at 15.17±3.76 weeks. No delayed unions or nonunions were noted. Radiographs were taken immediately postoperatively, at monthly intervals, and at latest follow-up. No fracture in either group exhibited a change in alignment during fracture healing. Nine (23%) fractures in the community group healed with an angulation >5° in >1 planes, and 3 (8%) healed with >10° of angulation. Nine (23%) patients had >5° of angulation at union as the only deformity. One healed in 12° of varus and 14° of apex posterior angulation. A second healed in 6° of varus and 10° of apex posterior angulation. The patient with the nonunion who went on to a below-knee amputation had 15° of valgus and 15° of apex anterior angulation prior to the below-knee amputation. One patient in the trauma group had 6° of varus deformity. Using a two-tailed student’s t-test, community group patients were more likely to have malalignment >5° in any plane than the trauma group (P<.0001) (Table).

Secondary procedures and complications were also evaluated. In the community group, one patient had elective removal of the intramedullary nail after fracture healing (for persistent knee and proximal screw pain). One patient underwent nail removal for infection. Two (3.5%) underwent nail revision (one for a delayed union and one for a nonunion). The remaining two patients with nonunions underwent iliac crest bone graft to the nonunion site. In the trauma group one patient had both distal interlocking screws break and removed without sequelae; one patient had a superficial infection that cleared with debridement and a short course of antibiotics; and one patient had elective nail removal due to knee pain.

Four patients developed postoperative infections (three with osteitis in the community group and one superficial infection in the trauma group). No patients in either group had wound dehiscence at the operative site, none developed significant fracture blisters, had evidence of compartment syndrome, or developed peroneal or tibial nerve palsies. No significant differences were noted in time to union, nonunions, delayed unions, repeat operations, or infections between the two groups.

Functional outcomes were assessed using the MODEMS lower limb module for the two groups. In both groups...
Konrath et al. published a series of distal intramedullary nails with excellent results. Bonnevialle et al. also reported 38 healed with 15° of rotation malalignment. One patient in 50 patients with none healing with 19 of 20 fractures healing with 5° of angulation scored an average of 77.8 on physical function, 69.4 on physical limitations, and 86.7 in bodily pain (100 being the highest score). All patients with >5° angulation scored 63.3, 75.0, and 60.8, respectively. In comparison of the patients with and without significant angulation, the P value for bodily pain was 0.042, for physical limitations the P value was 0.24, and for physical function the P value was 0.43. In comparison between community group and trauma group in patients with <5° of angulation, the average scores in physical function, physical limitation, and bodily pain were not statistically significant.

**DISCUSSION**

Other centers have published series of distal tibia fractures stabilized with an intramedullary nail with excellent results. Konrath et al. published a series of distal tibia fractures with intraarticular involvement with 19 of 20 fractures healing with <5° of angulation in any plane. Other series presented similar distal fractures stabilized with an intramedullary nail with 0%-10% of patients with malalignment (>5°) in any plane. European trauma centers have also reported good results of intramedullary nailing with distal tibia fractures. Richter et al. followed 50 patients with none healing with >5° of angulation in any plane. One patient healed with 15° of rotation malalignment. Bonnevialle et al. also reported 38 patients with distal tibia fractures stabilized with an unreamed intramedullary nail by cutting off the distal tip of the intramedullary nail and none healed with >6° angulation in any plane. Gorzyka et al. have shown that tibial nails may be modified similarly to accommodate distal fractures without loss of biomechanical stability. These data indicate that intramedullary nailing of distal tibia fractures even with intraarticular extension is biomechanically and clinically feasible without significant rates of complications and malalignment.

In this series of 39 patients in the community group, 14 different attending surgeons were involved but none cared for >3 patients. Attendings were present for all operations, and orthopedic residents assisted in the care of all patients. Surgeons at large trauma centers who have more experience with these techni-

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Malunions in Community and Trauma Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Community</td>
</tr>
<tr>
<td>Total patients</td>
<td>39</td>
</tr>
<tr>
<td>&lt;5°</td>
<td>30</td>
</tr>
<tr>
<td>&gt;5° (%)</td>
<td>9 (23)</td>
</tr>
</tbody>
</table>

>6° angulation in any plane. Gorzyka et al. have shown that tibial nails may be modified similarly to accommodate distal fractures without loss of biomechanical stability. These data indicate that intramedullary nailing of distal tibia fractures even with intraarticular extension is biomechanically and clinically feasible without significant rates of complications and malalignment.

In this series of 39 patients in the community group, 14 different attending surgeons were involved but none cared for >3 patients. Attendings were present for all operations, and orthopedic residents assisted in the care of all patients. Surgeons at large trauma centers who have more experience with these techni-

**It is critical to determine the correct central placement of the guide wire in the distal fragment early and maintain the fracture reduction while passing the reamers and intramedullary nail.**

- **Feature Article**

Some authors caution using intramedullary nailing in distal fractures because of malalignment concerns and subsequent risk for ankle arthritis. Tarr et al. found a decreased tibiotalar contact area for fractures of the distal tibia and fibula that had angulation ≥10°. Altered ankle joint biomechanics change stress placed on the articular cartilage and may result in earlier arthritis. Puno et al. attempted to correlate joint malalignment with clinical outcome in a group of patients with tibial fractures. They demonstrated that the ankle joint is increasingly deflected from the horizontal plane as the site of the fracture moves more distally. Correlation between ankle scores and varus malalignment was significant in their study (P = .001). Merchant and Dietz found no difference in the outcomes between the fractures with an intramedullary nail.
occurring at the proximal, middle, or distal third levels or with groups of patients with fractures with 5°, 5-10°, or >10° with angulation. van der Schoot et al showed statistically significant degenerative changes in the ipsilateral knee and ankle following tibial shaft fractures, but did not show significance with distal third fractures and ankle arthritis. Kyro noted decreased subjective and functional outcomes in patients with malalignment of distal third fractures treated with an intramedullary nail compared to tibia fractures without malalignment. Patients in our study with a residual malalignment did not seem to have different functional scores at the latest follow-up compared to those without a malalignment.

Open reduction and internal fixation with a plate should be considered. However, caution with the use of plating should be emphasized. Den Oeter et al reviewed conservative versus operative treatment of shaft fractures, where 83% of the operative group received plating. They advocated conservative treatment for these fractures because of increased complication risk and cost containment.

New plating techniques may encourage surgeons to consider plating as an option for distal third tibial shaft fractures. The criticism of plating is that it often requires extensive soft-tissue stripping and devitalizes a large area of bone near the fracture site. New operative techniques and implants are being refined using percutaneous approaches with locked plates. As this becomes more common, it may offer an alternative method for fixation with greater anatomical alignment with minimal soft-tissue stripping.

Currently, intramedullary nailing is an acceptable fixation method of distal third tibial shaft fractures, but careful attention to alignment is warranted. Surgeons may consider temporary stabilization with a splint or external fixation until definitive fracture treatment by another surgeon. If operative treatment is used, percutaneous plating techniques should be considered with these fractures.

The primary weakness of this study is its retrospective nature and reliance on medical records and radiographs for follow-up information. A large number of patients were available for functional follow-up.

This is the first study to compare the results of a common fracture treated by community surgeons to orthopedic trauma surgeons. Very few procedures have demonstrated any volume performance standards with superior results by surgeons more familiar with a procedure. This study indicates that orthopedic surgeons who regularly perform intramedullary nailing of long bone fractures are less likely to obtain a malalignment of a distal third tibia fracture.

What is already known on this topic
- Distal tibia fractures can be treated with intramedullary nailing with good results.
- Internal fixation of the fibula should be considered if the fracture extends to the ankle mortise.

What this article adds
- Surgeon experience with intramedullary nailing of difficult tibia fractures may aid in preventing malalignment <5° in any plane with distal third tibia fractures.
- Aids in reduction and stabilization of distal third tibia fractures are: primary internal fixation of the fibula, a medial external fixator or distractor, percutaneous large pointed reduction clamps, distal tibia Schanz screw, central placement of a guide wire, use of >12-mm intramedullary nailing, and multiple distal tibia locking screws.

REFERENCES
15. Hahn D, Bradbury N, Hartley R, Radford PJ.


