Intramedullary Nailing and Angulation Prevention in Distal Metaphyseal Tibial Fractures

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abstract

Intramedullary nailing, which is preferred in tibial diaphyseal fractures, is also frequently used in distal third tibia fractures. Various angular deformities, including varus/valgus deformity, may be observed during postintramedullary nailing. Orthopedic surgeons use several methods to prevent this problem.

In this study, at least 2 static locking screws were placed proximal and distal to the nail during intramedullary nailing of distal third tibial fractures. No additional supportive methods were used. The efficacy of this technique in the prevention of postoperative angular deformities was retrospectively investigated. Thirty-four patients with distal third tibial fractures who were treated with intramedullary nailing were included in the study. Angulations were measured in the anteroposterior and lateral planes on plain radiographs obtained preoperatively, on postoperative day 1, and after fracture union. Angulations measured on postoperative day 1 were compared with those measured after fracture union, and an increase was observed. Based on statistical analyses, the increase in the angulations was not significant.

In distal third tibial fractures, when fixation was performed by placing 2 static screws distal and proximal to the intramedullary nail following adequate reduction, the angulations that developed during the period until union were not significant in terms of causing deformity, although additional fixation methods are not used.

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Distant third tibial fractures (range, 4-11 cm) are difficult to treat. Treatment options for tibial fractures include operative and nonoperative management. Among the operative treatment options, plate fixation and intramedullary nailing are commonly used. Intramedullary nailing is frequently preferred because it preserves the soft tissue coverage around the fracture, allows early mobilization of the neighboring joints, and results in low infection rates. Although strong mechanical stability can be achieved with intramedullary nailing of tibial diaphyseal fractures, malalignment is a common problem in distant third tibial fractures because the metaphyseal diameter is larger than the diameter of the nail. Therefore, the use of intramedullary nailing in distal metaphyseal tibial fractures is controversial. Experts use several methods to overcome this difficulty and maintain reduction, including fixation with casting or plate fixation of the fibula in addition to intramedullary nailing. Another common method includes the use of Poller screws.

The current study investigated the efficacy of statically locked intramedullary nailing without supportive methods in preventing the development of angular deformities in distant third tibial metaphysis fractures, where the medullary diameter is wider than the tibial shaft.

**Materials and Methods**

The study was initiated after receiving approval from the ethics committee of the authors’ institution. Thirty-eight patients who presented for distant third tibial fractures and were treated with intramedullary nailing following reduction with no additional fixation methods were selected for the study. Four patients were excluded from the study, including 2 who developed pseudoarthrosis, 1 who died postoperatively due to additional problems, and 1 who was lost to follow-up. Of the 34 patients who were included, 10 (28.5%) were women and 24 (71.5%) were men. Mean patient age was 41 years (range, 17-81 years). Twenty-one tibial fractures were on the right side and 13 were on the left side.

Closed fractures were classified according to the AO classification, and open fractures were classified according to the Gustilo-Anderson classification. No fractures involved joints. Twenty-six patients had closed fractures, 5 had type I open fractures, and 3 had type II open fractures. Of the closed fractures, 6 were A1, 7 were A2, 8 were B1, and 5 were B2.

**Surgical Technique**

The patients underwent fluoroscopy-assisted surgery on a standard operating table in supine position following induction of general anesthesia, epidural anesthesia, or spinal anesthesia depending on their general condition. A pneumatic tourniquet was not used in any patient.

In all patients, the tibia was exposed through a 5-cm longitudinal skin incision over the tibial tuberosity. The patellar ligament was accessed through the skin and subcutaneous tissue. The tibial intercondylar region was reached on the medial side of the patellar ligament by pulling the ligament laterally.

All fractures were reduced by closed reduction. A bone reduction forceps was used percutaneously to prevent losing reduction, then all tibias were drilled. After drilling, intramedullary nails of appropriate length and width were pushed through the drilled hole and placed approximately 1 cm proximal to the ankle joint.

Under fluoroscopic control, particular care was taken not to distract the fracture line. Static locking was performed with distal screws by a freehand technique after rotation and reduction control. Proximal screws were placed on the proximal locking device from medial to lateral. All nails were locked using at least 2 locking screws distally and proximally. After completion of the locking procedure and reduction control, the end cup of the intramedullary nail was placed. The bone reduction forceps were removed, and the skin incisions were closed primarily.

Postoperatively, no external fixators or casts were applied to the extremities. Patients were allowed to bear weight in a controlled manner depending on the shape, stability, and state of union of the fracture.

Anteroposterior and lateral control plain radiographs were taken at 15-day intervals. Fracture union was considered to be present in patients with callus formation in 3 of the 4 cortices on anteroposterior and lateral views.

Varus/valgus angulations were measured on anteroposterior and lateral plain radiographs taken preoperatively, on postoperative day 1, and after fracture union (Figures 1-3).

Two statistical analyses were used to increase the reliability of outcome assessments: (1) confidence intervals for the difference between the means of 2 normal populations; matched-pairs test was used to compare varus–valgus angulation between radiologic views from postoperative day 1 and after union was achieved; and (2) tests for the difference between 2 means; matched-pairs test was used to compare mean angulation values between radiologic views from postoperative day 1 and after union was achieved.

**Results**

Mean time from the day of fracture to fracture union was 15 weeks (range, 8-26 weeks), and mean follow-up was 36 months (range, 14-54 months).

In 18 patients, the angular values measured after fracture union were higher than the values measured on postoperative day 1.

Mean difference between the values measured on anteroposterior radiographs taken on postoperative day 1 and after fracture union was 0.79° (range, 0°-4°).

Mean difference between the values measured on lateral radiographs taken on postoperative day 1 and after fracture union was 0.62° (range, 0°-3°).
Data evaluated with the matched-pairs method were reevaluated using a hypothesis test (test for the difference between 2 means) to provide more reliable results. Statistical analysis revealed that the increase in angulations was significant.

**DISCUSSION**

Although many surgical treatment options exist for tibial fractures, locked intramedullary nailing is currently the most valid treatment option. Bedi et al reported that intramedullary nailing in the surgical treatment of extra-articular distal tibial fractures is an atraumatic method that does not cause soft tissue injury, spares vascular structures, and is performed without opening the fracture area. In a study of 85 patients with distal tibial metaphyseal fractures, Guo et al compared the closed intramedullary nailing technique with the minimally invasive plate osteosynthesis technique. No significant differences were found between groups in terms of time to union. However, operation time and fluoroscopy usage time were significantly longer in the locked compression plate group. Moreover, function and alignment were better in the group receiving intramedullary nailing, although the difference did not reach statistical significance. Guo et al recommended closed intramedullary nailing in the treatment of tibial metaphyseal fractures because removal of the nail is easier.

Intramedullary nailing is the preferred technique in the treatment of distal third tibial fractures because of its benefits. Unfortunately, intramedullary nailing is difficult to perform because the diameter of the tibial metaphysis is wider than the diameter of the nail. Furthermore, because the diameter of the nail is smaller than the diameter of the tibial metaphysis, angulations may occur in the sagittal and frontal planes. Debate is ongoing regarding the definition of tibial malunion. Many surgeons believe that after fracture, the original alignment of the tibia should be restored and only minor misalignments are acceptable. The most commonly accepted reduction criteria include a varus/valgus angulation less than 5°, an anteroposterior angulation less than 10°, rotation less than 10°, and shortening less than 15 mm.

In one study, the malunion rate was 7% in tibial diaphyseal fractures and 8% in distal third fractures. In another study, the reduction obtained intraoperatively deteriorated to some degree during the period until union, and the authors reported that the reason for this was that the diameter of the screw hole in the nail was larger than the diameter of the screw.

The screwing procedure is easier to perform when the screw diameter is smaller than the diameter of the hole. However, this difference causes micro-movements in time, resulting in some degree of reduction loss. Obremskey and Medina reported angulation problems in distal third tibial fractures.

Several methods have been used to overcome these problems. Velazco et al tried to prevent angulation by casting to maintain reduction after fixation. In an experimental study, Kaspar et al reported that the use of angular-stable locking of intramedullary nails increased stability. Although stability is increased by many screws directed to different directions in the distal tibia, this procedure is risky because it may cause damage to surrounding neural and vascular structures. Although good results have been reported with intramedullary nailing plus plate fixation of the fibula in distal metaphyseal tibial–fibular fractures, plating of the fibula is a separate surgical intervention and results in additional morbidity. Another commonly used method to prevent the development of angular deformity is the placement of Poller screws (blocking screws). This procedure prevents angu-
lation but requires a considerable amount of experience.

In the current study, bone reduction forceps were used percutaneously to maintain reduction and at least 2 static screws were placed proximal and distal to the nail during intramedullary nailing in distal metaphyseal tibial fractures with no additional supportive methods to investigate the efficacy of this procedure on stability. Active and passive knee and ankle exercises were initiated on postoperative day 1. The distal metaphyseal diameter was larger than the tibial shaft diameter. Weight bearing was not initiated until callus formation to prevent deformities. The angulations observed on anteroposterior and lateral plain radiographs taken preoperatively, on postoperative day 1, and after fracture union were measured. Mean increase in angulation was $0.79^\circ$ in the anteroposterior plane and $0.62^\circ$ in the lateral plane. The increase in angulations was statistically analyzed using the confidence intervals for the difference between the means of 2 normal populations, tests for the difference between 2 means and matched pairs, and matched pairs method tests. The angulation increases were negligible when evaluated based on the accepted reduction criteria.

**Conclusion**

If distal metaphyseal tibial fractures are reduced in an acceptable position and static locking is performed by placing at least 2 screws distal and proximal to the nail during intramedullary nailing, angulations in reduction that may develop during the period until union remain within the accepted reduction criteria, even if Poller screws, plate fixation of the fibula, or casting after nailing are not used.

**References**