Distal tibia fractures: when is nailing preferred?

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Background
The treatment of distal tibia fractures remains controversial. Despite the well-known advantages of nailing, its use in distal tibia fractures has been reported to be associated with technical difficulties and high malalignment rates. Many surgeons are still hesitant to use nailing for distal tibia fractures.
Objectives
The aims of this prospective study were to evaluate the results of using static-reamed intramedullary nailing in the treatment of distal tibia fractures, and to define the situations in which nailing may be preferred.
Patients and methods
Between January 2008 and December 2011, 30 patients – 21 men and nine women – were treated in King Fahad Hospital at Al-Baha, KSA. Their mean age was 28.6 years. According to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, 20 cases had type A, eight had type B, and two had type C fractures. Ten fractures were open: four type I, five type II, and one type III-A. The American Orthopedic Foot and Ankle Society ankle–hindfoot scale was used for assessment in this study.
Results
The mean follow-up time was 26.3 months. Three patients with open fractures got superficial infections. All the fractures united with acceptable alignment in a mean time of 15.74 months with two delayed unions. No difference in alignment was encountered between the immediate postoperative and final radiographs. Limb length discrepancy of 5 mm or less was encountered in one patient. Two (6.66%) patients had less than or equal to 10° reduced range of ankle motion. One (3.33%) patient lost his job, four (13.33%) patients did not return to their preinjury daily activity, and eight (26.66) patients stopped sports-related activities. Implant removal was carried out for three patients with knee pain. The mean American Orthopedic Foot and Ankle Society score was 93 at the end of follow-up.
Conclusion
Static-reamed nailing is a safe and effective biological stable fixation option in treating distal tibia fractures. Nailing may be preferred in uncontrollable patients, open fractures, osteoporotic bone, pathological fractures, obese patients, and when early weight-bearing is unavoidable. We did not recommend nailing for articular comminution, failure of closed reduction, and types III-B and III-C open fractures.

Keywords:
distal tibia fractures, intramedullary nailing, minimally invasive percutaneous plate osteosynthesis

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Introduction

Management of distal tibia fractures remains controversial. The choice of suitable implant may be affected by the unique criteria of the distal tibia, including specific anatomical shape, minimal soft-tissue envelope, precarious blood supply, and high energy nature of most of the injuries.

The goal of management of these fractures involves providing a biological stable fixation with as little surgical trauma as possible. Although open reduction and internal fixation (ORIF) provide stability, they require extensive soft-tissue dissection, further devascularization of the bone fragments with higher rates of complications, and secondary surgeries [1]. As recognition of soft tissues is important for successful management of these injuries, minimally invasive percutaneous plate osteosynthesis (MIPPO) and closed nailing are possible treatment options that preserve the extraosseous blood supply and fracture hematoma, and maintain the integrity of the soft-tissue envelope. Nailing offers load-sharing, and an improvement in nail designs extend the spectrum of fractures amenable to this type of fixation [2,3]. The previously reported problems as technical difficulties to achieve stable fixation, iatrogenic comminution of the fracture, secondary displacement, and malunion have decreased the enthusiasm to accept it as a standard treatment option for these fractures [2,4]. This motivated us to be part of this controversy.

Objectives

This study was a prospective evaluation of the results of using static-reamed intramedullary nailing (SR-IMN) with at least two distal-locking screws for the treatment of distal tibia fractures, and an attempt to determine when it is preferred.

Patients and methods

Between January 2008 and December 2011, 30 consecutive patients – 21 men and nine women – were managed by primary SR-IMN with at least two distal-locking screws. Their mean age was of 28.6 (range: 20–65) years. The inclusion criteria included skeletally mature patients having distal third tibia fracture with or without simple articular extension. The exclusion criteria included multifragmentary depression fractures (AO-43-B3), articular multifragmentary (AO-43-C3), long spiral fractures, associated neurological or vascular disease of the affected lower limb, deformity before this injury, and type III-B and III-C open fractures as per the Gustilo and Anderson classification.

The mechanisms of injury included a motor-vehicle accident (16), a fall from a height (five), an automobile–pedestrian accident (four), a motorcycle accident (three), and a sports-related injury (two). Twenty fractures were closed and 10 were open: four type I, five type II, and one type III-A. According to the AO classification, there were 20 cases of type 43-A (seven A1, five A2, and eight A3), eight of type 43-B (three B1 and five B2), and two of type 43-C (one C1 and one C2) fractures. The mean distance between the distal end of the fracture and the articular surface was 37.6 (range: 0–55) mm. The fibula was fractured in 22 patients.

Detailed preoperative planning was done. Each injury was individually evaluated carefully for the extent of soft-tissue injury, fracture pattern, bone comminution, bone loss, degree of articular extension, ipsilateral leg fractures, and associated injuries. Accordingly, inclusion in the study, implant choice, operative steps, and the need for fibula fixation, or bone grafting were determined. Detailed discussion with the patient was important, especially about the postoperative rehabilitation programme, and his or her required cooperation in it. Then, the patient was consented for the operation and participation in the study.

Our protocol was to interfere early, once the patient was fit for the surgery. While waiting for the surgery, immobilization by using above-knee back slab was carried out. All the patients were treated with SR-IMN with at least two distal-locking screws. In all patients, nailing was the primary and the final management with no temporary procedures before. In three patients, fibular fixation acted as a primary reduction aid to obtain length, alignment, and rotation of the distal tibial segment. In others, manual traction was used for reduction. If the reduction was difficult, reduction aids such as percutaneous clamp, Schanz pins, or small periosteal elevator were used to assist reduction. The 10 (33.33%) fractures with articular extension were treated with percutaneous fixation using cannulated screws before nailing (Fig. 1). In open fractures, aggressive debridement was carried out followed by redrapping before starting nailing (Fig. 2).

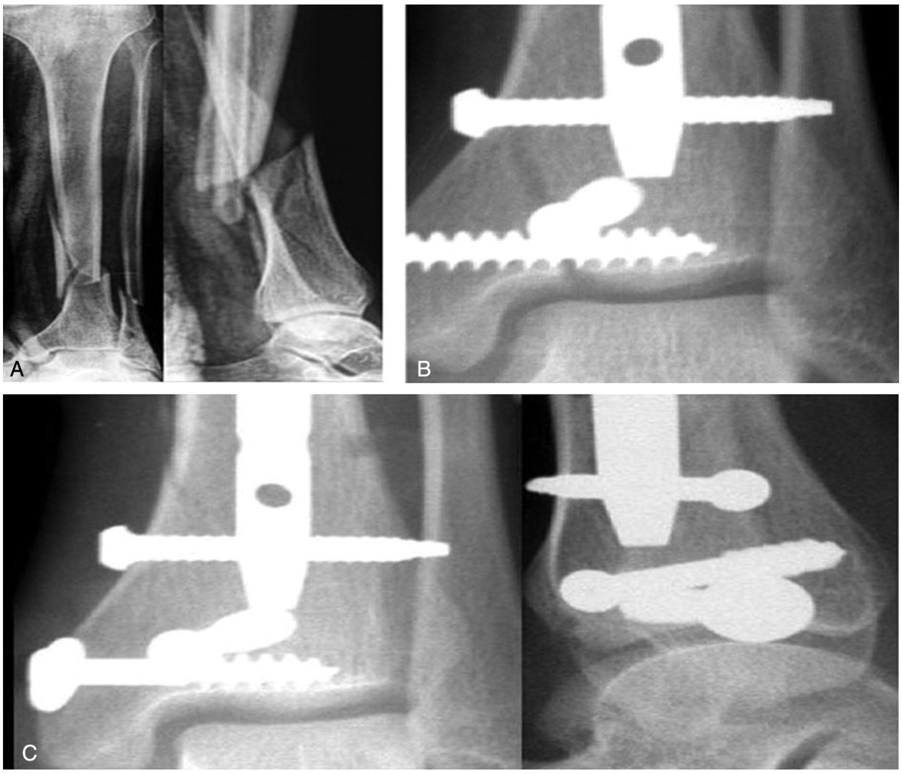
Assessment of the alignment, rotation, and length were checked and compared with the other side thrice: the first time with the reamer inside before nail insertion; the second time after nail insertion and before locking; and the final assessment after proximal and before distal locking. If satisfactory, the distal-locking screws were applied.

Postoperatively, the limb was maintained in the elevated position with no immobilization, with only crepe bandage applied. Smooth range of motion (ROM) exercises for the ankle and non-weight-bearing ambulation were initiated on the first postoperative day. For extra-articular fractures, toe-touch weight-bearing was started 2 weeks postoperatively, and was progressed gradually to full weight according to the healing progress. Both were postponed for 2 more weeks in fractures with intra-articular extension.

Union was defined as the presence of bridging callus in three of the four cortices as seen on anteroposterior and lateral radiographs. Delayed union was defined as the ongoing process of union but not completed after 6 months. Nonunion was defined as failure of union after 9 months with no radiographic progression in the last 3 months [5]. Malunion was defined as the incongruity of the articular surface of more than 2 mm, angular malalignment greater than 5° in any plane, or more than 15° rotation difference [5]. Limb length discrepancy of more than 1 cm was considered as shortening [5]. For angle measurements, we used the method of Milner [6], which uses the radiograph of the opposite tibia as a template. Rotational alignment was assessed clinically according to Janssen *et al.* [5], wherein the position of the patient's feet is used. Patients were asked to sit on the examining table with their patellae pointing forward and to relax their feet. Then a model (a disc for marking the position of the feet) was placed under their feet to record the rotation difference.

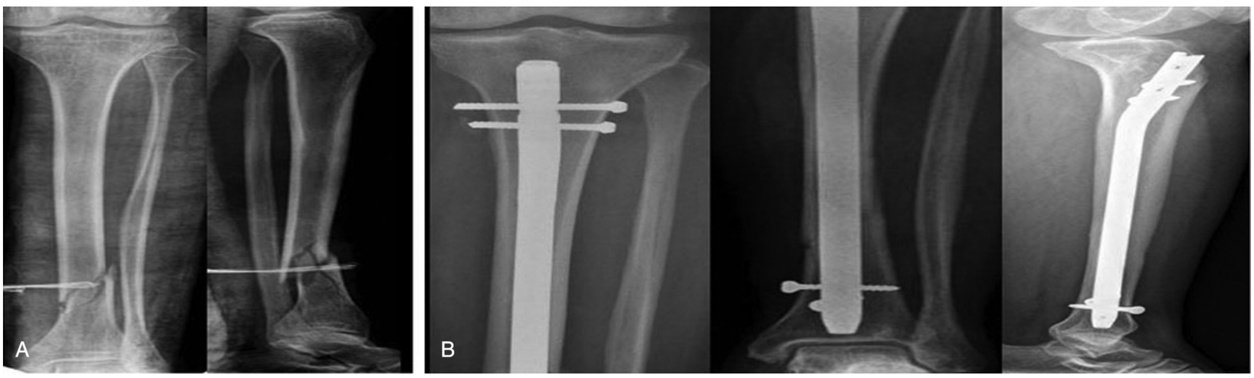
The patients were followed up after 2 weeks monthly till the fracture united, every 3 months till end of the first year, and then every 6 months till end of the follow-up. The patients were assessed clinically, functionally, and radiographically for gait analysis, deformity, ankle ROM, infection, leg-length discrepancy, union, length discrepancy, need for secondary procedures, return to previous job, return to previous daily activity and sports-related activities, complications, and American Orthopedic Foot and

Figure 1



Comminuted distal tibia fracture with intra-articular extension and oblique suprasyndesmotic fibula fracture. (a) Preoperative radiograph, (b) intraoperative radiograph showing the intra-articular fracture line, (c) postoperative radiograph showing good fixation of the intra-articular fracture and stoppage of the nail just before the screws.

Figure 2



Type II open comminuted distal tibia fracture treated with debridement, redrapping before and static-locked nailing with good healing. (a) Preoperative radiographs. (b) Final follow-up radiographs.

Ankle Society (AOFAS) ankle–hindfoot scale [7]. Comparison between the immediate postoperative and final radiographs was done for alignment measurements.

Results

The mean time between trauma and surgery was 48.6 (range: 4–100) h. The mean operative time was 54.4 (range: 40–90) min. The mean hospital stay time was 4.3 (range: 3–10) days. The mean follow-up time was 26.3 (range: 12–36) months.

The wounds healed smoothly without problems in all patients except in three with open fractures, who got superficial infections. They were treated successfully with wound care and intravenous antibiotics. No case of deep infection was encountered.

All fractures united without any secondary procedures to achieve union. The mean time to radiological union for all cases was 15.74 (range: 10–25) weeks, whereas it was longer when calculated for open fractures only: 22.36 (range: 20–25) weeks. Two (6.66%) patients had delayed union in 25 weeks.

Although acceptable alignment was obtained in all patients, seven (23.33%) patients healed with angular deformities 5° or less: three varus, two valgus, one anterior bowing, and one recurvatum deformity. The mean coronal plane deformity was 1° (range: 0–5°). The mean sagittal plane deformity was 0.8° (range: 0–5°). None of these deformities required correction or affected the final result. No patient had rotational malalignment or implant failure. Comparing the immediate postoperative radiograph with the final follow-up, no difference in alignment was encountered. Limb length discrepancy of 5 mm or less was encountered in one (3.33%) patient. Two (6.66%) patients had 10° or less reduced range of ankle motion, more in dorsiflexion. These did not affect the outcome or the functional result at the final evaluation.

All patients could keep their original job except one (3.33%), who lost his job. He had open fracture and delayed union in 25 weeks and his company refused to keep the job for him. Eight (26.66%) patients asked for implant removal because of knee pain ($n=3$) and fear to practice sports with implants or fear from refracture ($n=5$). Implant removal was carried out for the three patients with knee pain. The others were reassured.

Twenty-six (86.66%) patients were back to their preinjury daily activity at the end of the follow-up. On the other hand, only 22 (73.33%) resumed sports-related activities. Out of the eight patients who stopped sports, two had reduced ankle ROM, two had delayed union, and the remaining four reported fear from refracture.

The mean AOFAS score was 93 (range: 75–100) at the end of follow-up. Three patients had superficial infections, which were successfully treated by using local debridement and intravenous antibiotics. Table 1 presents the overall results.

Discussion

Despite the debate about the relative merits of using locked nailing in the treatment of distal tibia fractures, many surgeons are motivated to evaluate its efficiency. However, nailing is still not widely accepted [2,3], to the extent that Sharan *et al.* [8] reported that nailing of these fractures is contraindicated because of displacement of the articular surface. Being biological, atraumatic to the fracture zone, and because it spares the already violated minimal soft-tissue envelope and vascular structures, it may meet the criteria of the optimum implant to treat these fractures [9]. The European trauma centers reported good results of intramedullary (IM) nailing for distal tibia fractures even with intra-articular extension, without significant rates of complications and malalignment [10].

In comparison with MIPPO, Guo *et al.* [11] reported no significant differences between nailing and MIPPO in terms of time to union, but nailing showed lesser operation and fluoroscopy use times, and better function and alignment. Other authors [1] preferred MIPPO because of the difficulty in controlling the distal fracture fragment with nailing because of the metaphyseal flare, wound complications because of poorer soft-tissue coverage, and the proximity to the ankle joint, which may amplify the bending moment of

Table 1 Overall results according bone and functional parameters

Variables	Percentage of patients
Union	100
Angular deformities>5°	0
Leg-length discrepancy>1 cm	0
Decreased ankle ROM>20°	0
Return to preinjury daily activities	86.66
Return to preinjury sports	73.33
Deep infection	0
Implant removal	10

ROM, range of motion.

the short distal segment and may allow fracture propagation into the ankle joint.

Articular comminution due to axial loading injuries are difficult to be managed by nailing [12]. Thus, we excluded AO-43-B3, and C3, whereas simple articular involvement was included. In their study, Robinson *et al.* [3] fixed the intra-articular extension after nailing, whereas Nork *et al.* [12] fixed it before. In our study, we addressed the intra-articular extension by screws before nailing to avoid additional displacement or comminution. The manner of screw placement respected the place for nail insertion (Fig. 2). We had no loss of reduction, increased comminution, or fracture propagation following nail insertion.

Reduction and its maintenance has been extensively discussed in the literature. Nork *et al.* [12] reported that the difficulty to control or reduce these fractures may be related to metaphyseal flare. Thus, its larger diameter relative to the nail diameter decreases the interference fit and keeps the cortex/nail interface unable to assist in fracture reduction. To overcome this, Krettek *et al.* [13] supported the use of blocking (Poller) screws and demonstrated superior biomechanical strength of these constructs. In our opinion, obtaining and maintaining reduction before passing the guide wire, reaming, or passing the nail are the main factors for proper nail placement and preventing malalignment. Reduction can be assisted with fixation of the fibula or with reduction aids such as percutaneous clamp, manipulation with Schanz pins, or small periosteal elevator.

The optimal number and configuration of distal-locking screws represent another discussion point [2,14]. Comparing one with two distal-locking screws, Kneifel and Buckley [14] reported that one distal-locking screw failed (59.1%) significantly more than two distal-locking screws (5%), with a higher incidence of nonunion. They recommended the use of two distal-locking screws or, if that was not possible, an alternate form of fixation. Isik *et al.* [15] reported that acceptable reduction and static locking by two screws will reduce secondary angulations even if Poller screws, fibula fixation, or postoperative casting are not used. Nork *et al.* [12], also, insisted on using two distal-locking screws. In our study, we made it a prerequisite to apply at least two screws and preferably in two planes. This helped to maintain the reduction and to avoid postoperative loss of reduction, or fixation.

The recent types of nails allowed the placement of a minimum of two distal-locking screws, with the distal one very close to the plafond. Thus, the scope of distal tibia fractures amenable to fixation with nails was greatly increased. Isik *et al.* [15] reported a mean time for fracture union of 15 (range: 8–26) weeks. Obremskey and Medina [10] in their comparative study for nailing distal tibia fractures before and after traumatologists reported a mean time to radiological union of 14.70 weeks in the community group versus 15.17 weeks in the trauma group. In our study, the mean time to radiological union for all cases was 15.74 (range: 10–25) weeks, with two delayed unions in 25 weeks. Open fractures showed a longer time: 22.36 (range: 20–25) weeks. Some surgeons [12] performed prophylactic secondary procedures to obtain union as early nail dynamization and bone grafting in cases who had bone loss. Mosheiff *et al.* [2] reported the need for secondary surgical procedures to achieve union in 42% of the patients. Obremskey and Medina [10] reported six secondary surgeries in the community group: three of them for nonunion and one for delayed union. In our study, the achieved stability and primary defect filling for the cases with bone loss by bone graft or substitutes helped to achieve union without the need for secondary surgeries. We performed secondary surgeries only in three patients for implant removal because of anterior knee pain, but none of these was done for achieving union.

Malalignment was considered by many authors to be the main obstacle against the widespread use of IM nailing in distal tibia fractures [2,4]. Bucholz *et al.* [16] defined malalignment as a varus/valgus angulation more than 5°, anteroposterior angulation more than 10°, rotation difference more than 10°, and shortening more than 15 mm. In agreement with Janssen *et al.* [5], we considered shortening as a length difference of more than 1 cm and malalignment as incongruity of the articular surface of more than 2 mm, or more than 5° angulation in any plane, or more than 15° rotation difference. The slightly S-shaped tibial shaft in many normal individuals means that the mechanical axis of the tibia rarely passes down the middle of the medullary canal. This makes the conventional method of measurement of coronal and sagittal malalignment, from the knee and ankle centers to middle of the shaft, potentially unreliable [5]. This may lead to underevaluation of these deformities in many studies. Thus, we used the method proposed by Milner [6], which avoids this problem by using a radiograph of the opposite tibia as a template.

In a prospective randomized trial, Im and Tae [17] concluded that ORIF can restore alignment better than IM nailing. They found an average angulation of 0.9° after

ORIF compared with 2.8° after IM nailing. Janssen *et al.* [5] reported varus/valgus and ante/recurvatum malalignment of more than 5° in 16.7% of the patients and rotational malalignment of more than 15° in 25% after IM nailing. El Attal *et al.* [18] reported malalignment of more than 5° in 5.4% of patients. In our opinion, avoidance of increased angulations is dependent on the maintenance of reduction till securing the distal-locking screws, continuous assessment for alignment, rotation, and length, and comparison with the other side. Acceptable alignment was obtained in all our patients, although seven (23.33%) patients healed with angular deformities 5° or less. The average coronal plane deformity was 1° and the average sagittal plane deformity was 0.8°. None of these deformities required a secondary operation for correction or affected the final result.

The reduction obtained intraoperatively may deteriorate during the follow-up. Some authors attributed this to the difference between the screw diameter and the screw hole, which may allow micromovements that, in time, result in some degree of reduction loss [15]. To avoid this, Krettek *et al.* [13] recommended the use of blocking screws, whereas others [19] recommended using ORIF for the fibula. In our opinion, reduction deterioration usually starts intraoperatively. To avoid this, perfect primary reduction must be obtained before insertion of the guide wire for nailing, maintained until the nail is secured by proximal and distal locking with at least two screws, and continuously re-evaluated throughout the procedure. Isik *et al.* [15] reported a mean increase in angulation of 0.79° in the anteroposterior and 0.62° in the lateral plane. El Attal *et al.* [18] reported secondary malalignment after initial good reduction in 1.1% of all cases. In agreement with the findings of Obremskey and Medina [10], we had no difference in the angle measurements between the postoperative and final radiographs.

Fibular fracture fixation before IM nailing of the tibia facilitates reduction of the distal tibia fracture, improves the alignment and increases the fixation stability to resist motion, and prevents loss of reduction. But it represents a separate surgical intervention that may add additional morbidity, and may lead to delayed or nonunion of the tibial fracture [18,20]. In our study, the indications to fix the fibula were syndesmotic fractures, displaced infrasyndesmotic fractures, or suprasyndesmotic fractures associated with comminution, impaction, shortening at the tibia fracture, or failure to reduce the tibia because of the fibular fracture.

Ankle arthrosis secondary to malalignment concerns was the cause that some authors take caution in using IM nailing for the treatment of distal tibia fractures [10]. Van der Schoot *et al.* [21] 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 arthrosis. In our study, no patient showed degenerative changes during the follow-up period. In future, long-term studies are required to assess the effects of malalignments. We had only one (3.33%) patient with 5 mm or less limb length discrepancy and two (6.66%) patients with less than or equal to 10° reduced ankle ROM.

Obremskey and Medina [10] reported that patients with residual malalignment did not seem to have different functional scores as compared with those without. In our study, the mean AOFAS score was 93 (75–100) at the end of follow-up, which ranged between 18 and 36 months.

In view of the reported comparable results of MIPPO versus SR-IMN for distal tibia fractures and the reported increased stability of plating in vertical loading and of nailing in cantilever bending [22], the surgeon needs careful preoperative planning to determine which fixation option is the optimal for a specific case with a specific injury. We found that SR-IMN will be more effective for patients who cannot avoid early weight-bearing for social, economic, or medical reasons, and for uncontrollable patients such psychiatric or mentally retarded patients. In addition, for open fractures amenable for internal fixation, osteoporotic fractures, pathological fractures, and fractures in obese patients, we prefer to use nailing. The prerequisite remains the familiarity of the surgeon with tibial nailing, and the techniques to achieve and maintain accurate reduction. The main contraindications include articular comminution, failure or suspected failure of closed reduction, and type III-B and C open fractures.

Conclusion

SR-IMN is a safe and effective alternative for treating distal tibia fractures with or without simple articular extension. Being biological and atraumatic, SR-IMN spares the already damaged and violated minimal soft-tissue envelope, and vascular supply to the bone fragments. Mechanically, it showed increased stability in cantilever bending. Thus, it avoids the complications associated with ORIF and external fixators. It allows earlier ROM and weight-bearing than does MIPPO. In addition, surgeon experience and certain surgical tactics can help in overcoming concerns about malalignments.

We prefer its use for patients in whom weight-bearing is unavoidable, for uncontrollable patients, open fractures amenable for internal fixation, osteoporotic fractures, pathological fractures, and for obese patients.

We recommend a comparative prospective study between SR-IMN and MIPPO and long-term results to assess the effects of malalignments.

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Conflicts of interest

There are no conflicts of interest.

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