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Original Article

Minimizing the complications of intramedullary nailing for distal third tibial shaft and metaphyseal fractures

Vishwanath Yaligod, Girish H. Rudrappa*, Srinivas Nagendra, Umesh M. Shivanna

Department of Orthopaedics, Sathagiri Institute of Medical Sciences and Research Center, Bangalore 560090, India

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ABSTRACT

Background: The complications of intramedullary nailing of distal third tibial shaft and metaphyseal fractures have a direct impact on ankle and hind foot function.

Methods: We retrospectively evaluated 28 patients. Unreamed nail was negotiated across the well reduced fracture till subchondral bone and fixed with 2 to 3 distal locking screws in different planes.

Results: Fracture union rate was 85%. Three out of 28 patients had malalignment. Mean ankle, hindfoot functional score was 85.

Conclusion: Complications can be minimized by impacting the unreamed nail till the subchondral bone while maintaining the fracture well reduced and by using multiple distal locking screws in different planes.

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1. Introduction

Fractures of the distal third shaft and distal metaphysis of tibia are one of the difficult and challenging problems faced by orthopaedic surgeons.¹ The problems associated with these fractures are due to the fact that distal third shaft and distal metaphysis of tibia are relatively less vascular. Since this area is having less soft coverage, even relatively low energy injuries can result in severe soft tissue damage and comminution of the fracture. These fractures are usually associated with fractures of the lower third of fibula which need to be addressed separately to get well aligned ankle

mortis, unlike the proximal and mid third shafts fractures of tibia, where fibular fractures need not always be treated separately. Nearby ankle joint (being a hinged type), poses unique problem. Any malunion disturbs the normal biomechanics of the ankle and foot, thereby leading to arthritis of the ankle and foot joints.

The aim of the treatment of the distal tibial fractures is to achieve union of the fracture in normal alignment and regaining the stable, mobile and painless ankle joint while avoiding the infection and other complications.²

These fractures can be treated with cast and braces in undisplaced, isolated injuries but the prolonged immobilization, fracture displacement within the cast and ankle stiffness

* Corresponding author. Tel.: 91 9845516613 (mobile).

E-mail address: orthoambition@gmail.com (G.H. Rudrappa).

are the drawbacks.³ In the literature there is no well defined criterion about the best surgical method for these fractures. The fracture comminution, distance between the distal most fracture line to the ankle joint, soft tissue injury, associated fibular fracture etc. influence the surgical method to be used in each patient. Intramedullary interlocking (IMIL) nailing of the diaphyseal fractures is a well accepted method.⁴ Their role in the treatment of distal third shaft and metaphysis is controversial due to difficulties in fractures reduction, distal iatrogenic propagation of the fracture, hardware failure and inadequate distal fixation leading to malalignment.⁵ The distal widening of the medullary canal prevents the tight endosteal fit of the nail and compromises the reduction leading to rotational, translatory and angulatory deformity.

The present study was conducted to evaluate the results of distal third tibial shaft fractures treated with IMIL nailing in terms of fracture union rate, malunion, anterior knee pain, functional results like ankle & hindfoot movements, gait, walking distance etc. and methods to minimize the known complications.

2. Materials and methods

This is a retrospective study. Between August 2010 to December 2012, about 106 tibial fractures were treated in our institution. The inclusion criteria for the present study were the skeletally mature patients with displaced fractures of tibia in or extending into distal third shaft and metaphysis. Type I and type II open fractures were included in the study. The fractures extending into distal tibial articular surface, open type III fractures were excluded. About 28 patients meeting these criteria were included in the study.

In our study, 21 patients were male and 7 were female and the mean age was 42 years and the range being 20 to 75 years. Most of our patients sustained injury due to road traffic accidents (21 patients), few cases due to fall from height (6 patients) and assault (1 patient). According to Gustilo and Anderson's classification⁶ of compound fractures, 4 patients had type I open fracture and 2 patients had type II open fracture. Open fractures were treated with wound lavage, wound debridement before the surgical stabilization of fractures. All the open fractures were operated within 6 to 12 hours from the time of injury. We analyzed the fracture pattern radiologically in all patients and classified them according to Arbeitsgemeinschaft fur osteosynthesefragen (AO) classification. Eighteen patients had A1 fracture (no comminution), 8 patients had A2 fracture (with butterfly fragment) and 2 patients had A3 fracture (with severe comminution). Three of our patients had associated injuries like ipsilateral metatarsal fracture (1 patient), heel pad avulsion (1 patient), olecranon fracture (1 patient). All the patients in our study were operated within 24 hours after the injury. None of our patients had compartment syndrome.

For fixation of all these fractures, standard operative protocol was used. In all the cases we used the fracture table with either the calcaneal pin or the table boot. The fracture table holds the fracture in good reduction and maintains it till the procedure is over (Fig. 1). Good rotational alignment can be achieved with fracture table, as the foot can be held in desired

Fig. 1 – Fracture is held well reduced using fracture table even before starting surgery.

position required before the final fixing. Even the valgus, varus malalignment at fracture can also be reduced by appropriately maintaining the table boot or calcaneal pin. In this way most of the desired reduction was achieved even before starting the surgical procedure. If the fibular fractures in the lower third found well reduced, it was not fixed. If not reduced, they were reduced and fixed with plate & screws before nailing tibia. Centering the guide wire in the distal fragment in both Anteroposterior (AP) and Lateral (Lat) views and getting the nail tip till the subarticular part of the lower tibia was found important as these measures reduce the angulation and translation at the fracture site (Fig. 2).

The fracture should be held well reduced while passing the nail into the distal fragment, which is considered as an important step. The advantages of not reaming the distal fragment and also getting the nail till the subarticular bone is that the nail is impacted well into the cancellous bone of the lower metaphysis of the tibia which gives added angulatory and translator stability when augmented with two to three distal locking screws. If two distal locking screws were used, we preferred to use them at right angle to each other i.e. one mediolateral and the other anteroposterior to increase the stability of the construct (Fig. 3). We used the

Fig. 2 – (a) Pre operative radiograph. (b & c) Fracture held well reduced by fracture table, guide wire being passed till the subchondral bone, centered in both AP & Lat views. (d) Unreamed nail passed over the guide wire, which is impacted into the cancellous bone of metaphysis.

316L stainless steel Indian made tip locking nails in all the cases (Fig. 4). The distal most hole is 1.5 cm from the tip in the frontal plane and the second hole is 3 cm from the tip in sagittal plane and third hole is 4.5 cm from the tip in frontal plane. Locking screws of adequate diameter and length are used to prevent screw breakage and loss of reduction since high stress is expected on them. Proximally one or two locking screws were used based on comminution of the fracture. We did not use any other methods to obtain and maintain the reduction while nailing like the use of femoral distractor or temporary fixation with percutaneous clamp or percutaneous manipulation with pins, etc. as our method had given us the satisfactory maintainable reduction till completion of the fixation. We did not use the adjunctive blocking screws to obtain and maintain the reduction and alignment.

Post operatively the closed fractures were treated with intravenous (I.V) Ceftriaxone for 3 days and oral cefixime for 5 days. Open fractures were treated with I.V. Ceftriaxone & Sulbactam for 3 to 5 days and oral cefixime for 5 to 7 days. Non weight bearing ambulation was started on the next post operative day. In case of open fractures the ambulation was delayed till the wound settled i.e. up to 5 to 6 days. Partial weight bearing started at 8 to 10 weeks and full weight bearing with elbow crutches started after 12 to 16 weeks depending on the amount of callus and severity of pain. Ankle range of motion exercises were started the next post operative day and particular emphasis was given to forced dorsiflexion of the ankle using the sling around the foot to be pulled by the patient. The patients were reviewed monthly and the radiograph was done during each visit till the fracture union, and then reviewed every 4 months.

Fig. 3 – Pre and immediate post operative radiographs.

Fig. 4 – Stainless steel 316L tip locking nails.

Fig. 5 – Valgus angulation of less than 7 degrees at the fracture site.

Fig. 6 – Pre operative radiograph and radiographs after fracture union.

The union was defined in our study as the radiographic evidence of bridging callus on at least three of four cortices with the clinical assessment of the patient's ability to bear full weight on the extremity. Delayed union was defined when there was no adequate callus even after 20 to 24 weeks and patient's inability or difficulty in partial or full weight bearing or associated with X-ray changes of any post operative fracture alignment. Radiographically the fracture reduction was analysed for any angulation in both AP & Lat views (Fig. 5). Any angulation of more than or equal to 7 degrees in any plane and clinical shortening of ≥ 1 cm was considered malunion. Rotational alignment was measured clinically by asking the patient to sit on the examination stool with knee in 100 degree flexion and ankle in neutral and foot flat on the ground and using pendulum at the tibial tuberosity. More than or equal to 7 degree of internal rotation and more than or equal to 10 degree external rotation deformities were considered malalignment. These criteria for malalignment were checked in each visit to assess the change in alignment in all the patients till the fracture union. Anterior knee pain was assessed using visual analogue scale (VAS). Ankle, foot and the functional assessment were done using Kitaoka et al. ankle & hind foot score.⁷ The statistical analysis was done using SPSS 16.0 software. Statistical methods used were Analysis of variance and Student t-test.

3. Results

Out of 28 patients included in the study, one patient was lost to follow up after 8 weeks post operatively. The male to female ratio was 3:1 and the male patients were having more

comminuted fractures and having severe soft tissue injury than the female patients. Most of our patients were in the age group of 20 to 50 years i.e. the most active period of one's life. The average follow up of the 27 patients was 19 months with range being 6 months to 30 months. Average hospital stay was 7 days, range being 5 to 15 days.

Twenty-three out of 27 patients (85%), had fracture union without the need for any further surgical intervention (Fig. 6). The average time to union in these 23 patients was 15.6 weeks with range being 14 to 20 weeks. There was no significant difference in the mean time for union based on the type of fracture ($F = 0.681$; $p > 0.05$). Three patients had delayed union and one patient had infected non-union. One patient with delayed union required exchange nailing (who had segmental fracture with one fracture line in the distal third of the tibia). Other two patients with delayed unions were having comminution at the fracture site, required bone grafting at 20 & 24 weeks post-operative period respectively. These two fractures healed well after 29 and 34 weeks post operative period. In both these patients we changed the distal two locking bolts while bone grafting as a precautionary measure to avoid screw breakage. One patient had infected non-union who was treated with IMIL nail removal and Ortho fix application and is under follow up. We had not done primary bone grafting in any of our cases. No thromboembolic episodes were noted.

Our study included 6 patients with open fracture⁶; with 4 being type I & 2 being type II. All these fractures were operated within 6 to 12 hours after injury. Three patients with type I fractures healed well without any complication and the other type I open fracture needed bone grafting at 20 weeks which healed well by 29 weeks. Out of two patients with type II open fracture, one patient had superficial infection and small area

Fig. 7 – Pre operative radiographs and radiographs after fracture union.

of skin necrosis, which healed with regular dressing, excision of the necrosed tissue and settled with secondary wound healing. The other type II open fracture with comminution did not unite even by 30 weeks and there was a discharging sinus, so was considered as infected non union and treated with IMIL nail removal, open debridement of the fracture and infected soft tissues followed by fixation with Ortho fix. This patient is still under follow up.

Of the 28 patients treated, one patient had varus, one patient had valgus deformity of more than 7 degree but less than 10 degree. One patient had 10 degree of external rotation deformity and limb shortening of 1 cm. Among all these cases of malreduction, fibula was fixed in one case and not in other 2 cases. One patient with malreduction who also had delayed union was treated with bone grafting. There was no loss of alignment during the healing phase even though we mobilized and ambulated all our patients early. One patient had complex regional pain syndrome, which subsided with physiotherapy after 6 months.

All 28 patients in our study had fibula fracture. Ten fibular fractures were in upper two third and 18 were in lower third. There was no significant difference in time for union based on the site of fibular fracture ($t = 0.997$; $p > 0.05$). Six of the lower third fibular fractures were fixed before nailing (Fig. 7) and in 12 cases of lower third fibular fractures, we felt there was no need to fix fibula as we could get good maintainable reduction of tibial and fibular fractures during nailing of tibia and we also observed that there was no significant difference in time for union based on whether fibular fracture was fixed or not ($t = 1.169$; $p > 0.05$).

Analysis of anterior knee pain was done during last follow up using the visual analogue scale (VAS). The patient who lost to follow up and the case of non union were excluded. Out of the 26 patients, 11 had mild and 9 had moderate anterior knee

pain. The remaining 6 patients did not have any anterior knee pain. In order to get the nail till the subchondral bone in the distal fragment, often there was undersizing or oversizing of the nail length, which might be the cause for more patients with anterior knee pain. Ankle, foot and the functional assessment were done using Kitaoka et al. ankle & hind foot score. The case of infected non-union who is still under treatment and the patient who lost follow-up were excluded. For the remaining 26 patients the average assessment score was 85, ranging from 68 to 98. The median score was 90. There was no significant difference in the mean ankle & hind foot score based on the type of fracture ($F = 0.376$; $p > 0.05$). The patients who had associated injuries had poorer results in terms of the functional and ankle & foot assessment. None of the 27 patients had their implants removed at the latest follow up.

4. Discussion

The tibial diaphyseal fractures are the most common type of long bone fractures encountered by most surgeons² and distal tibial fractures have the second highest incidence of all tibial fractures after the middle third.⁸ These fractures are unique in their nature due to the following fact that, the distal tibia is relatively less vascular bone. Severe soft tissue injury and bony comminution are more common in these injuries. These fractures are usually associated with distal third fibular fractures which need to be reduced to get well aligned ankle mortis, unlike the fractures of mid and proximal third tibial shaft fractures. Any mal union of these fractures can disrupt the biomechanics of the ankle & foot joints leading to the early arthritis of these joints. The fractures being very near to the ankle joint any form of fixation is vulnerable due to amplification of the bending moment of the short distal segment

leading to either implant failure or malunion or fractures propagation distally. These bending forces are better withstood by Locking compression plate (LCP) & IMIL nail with multiple locking screws in different planes.

The standardization of treatment methods for these fractures is difficult due to the fracture comminution, distance between the distal most fracture line to the ankle joint, soft tissue injury, associated fibular fracture etc. which influence the surgical method to be used in each patient. External fixators are used in patients with extensive soft tissue injury and also in patients with severe comminution of distal tibial articular surface as ligamentotaxis. External fixator application is complicated by stiff ankle, pin tract infections, septic arthritis, mal alignment, loss of reduction and delayed union.⁹ Traditional open reduction and internal fixation with plate and screws requires extensive exposure with possible devascularization of the bone, wound dehiscence and infection.^{10,11} The subcutaneous location of plates may lead to symptomatic hardware requiring removal. Recent techniques of minimally invasive osteosynthesis using locked plate and screws have addressed several of these issues with good fracture healing and minimal complications.^{12,13} The locking plates and screws are expensive and the technique is demanding.

Interlocking intramedullary nailing of the diaphyseal fractures is well accepted method.⁴ Their role in the treatment of distal third shaft and metaphysis is controversial due to difficulties in fracture reduction, distal iatrogenic propagation of the fracture, hardware failure and inadequate distal fixation leading to malalignment.⁵ The distal widening of the medullary canal prevents the tight endosteal fit of the nail and compromises the reduction leading to rotational, translatory and angulatory deformity. Intramedullary interlocking nailing is a very familiar technique to most surgeons and it spares the extra-osseous blood supply. This technique is minimally invasive in nature. In addition, the IMIL nails are load sharing in nature leading to very good callus. When associated with distal third fibular fractures, the fixation of the fibular fractures has been suggested to decrease the incidence of angulations, malrotation of tibial fractures and improves stability of the total fixation.¹⁴ The recent changes in the intramedullary nail design having the locking holes close to the tip and multiple locking holes have extended the spectrum of fractures amenable to this type of fixation. In our study we used the unreamed interlocking nailing which is known to preserve even the endosteal blood supply.

In the present study, the fracture table with either table boot or calcaneal Steinmann pin with stirrup has helped us to achieve good reduction, which can be maintained throughout the procedure. Minor angulation or translation could be corrected with manipulation while getting the guide wire and nail till the subchondral bone. In spite of the above two measures, if the satisfactory reduction could not be achieved, the associated fibular fracture fixation was undertaken prior to tibial nailing to improve the reduction. These techniques have helped us to reduce the incidence of malunion and other complications. The other techniques for obtaining and maintaining the fracture reduction which have been used in other studies include the use of a femoral distractor, temporary fixation with a percutaneous clamp, percutaneous manipulation with Schanz pins or open reduction etc. were

not used in our study.⁵ We did not use the blocking (Poller) screws, which have been described in other studies.¹⁵

Excluding the patient who was lost for follow up, out of 27 patients 23 patients (85%) had fractures united without the need for any additional surgical intervention. Out of the remaining four patients one patient ended up in infected non-union, who had open type II fracture with comminution at fracture site and was been operated within 12 hours of injury. Out of three cases of delayed union, one was treated with exchange nailing and the other two were treated with bone grafting.

Earlier studies published in the 1970s and 1980s by various authors^{16,17} reported unacceptably high infection rates (13.6% to 33%) in small series of open tibial fractures treated with reamed nailing. These reports led to the conclusion that medullary reaming is contraindicated in open tibial fractures, especially Gustilo type II and type III. The successful use of unreamed nailing in patients with open tibial fractures has led some investigators to recommend this technique for closed fractures as well. In our study all the patients were treated with unreamed tibial nailing. Potential advantages of unreamed nailing over the reamed technique include shorter operative time, less blood loss and less disruption of the endosteal blood supply in patients with severe closed soft-tissue injuries. Impaction of the unreamed nail in the cancellous bone of the distal metaphysis of the tibia gives added stability. Many recent studies have recommended unreamed nailing for closed tibial fractures.¹⁸⁻²⁰ Hardware failure most often is associated with smaller (8 mm) nails, axially unstable fractures, metaphyseal fractures, bilateral tibial fractures, and delayed union or nonunion.²¹ No patient in our study had hardware failure.

The larger diameter and progressive widening of the diameter of the distal part of tibia relative to that of IM nail is the most important reason for difficulty in the reduction of these fractures. Where as in the mid third shaft of tibia fractures, the tight endosteal fitting of the nail in the medullary canal itself gives satisfactory reduction of the fracture. The cause for the malalignment observed in 3 out of 28 cases (10.7%), may be due to the fracture geometry and comminution. Different authors have employed different criteria for the malalignment assessment and used different techniques to assess the individual component of the malalignment.^{5,22-24} The amount of residual deformity that can be accepted is still controversial.²⁵ It is difficult to correlate the post-operative radiological findings to the clinical results and use of this as a prognostic factor.²⁶

Etter and Ganz²⁷ retrospectively examined how the fracture pattern and quality of reduction correlated to post-operative arthritis in 41 patients with tibial plafond fractures treated with internal fixation. Anatomical reduction was correlated to better prognosis in terms of lower risk of post-traumatic osteoarthritis, but it did not guarantee a good clinical result. Kasper et al²³ found mal-alignment leading to complaints from the patients with regard to walking, practicing sports etc. Puno et al²⁸ evaluated 27 patients with 28 tibial fractures at an average of 8.2 years (range 6 to 23.1 years) they found a correlation between joint malalignment and clinical outcome for fractures of the tibia. Analysis showed that a greater degree of ankle malalignment produces poorer

results. They concluded that there is merit in reducing tibial fractures as close to anatomical configuration as possible to lessen the chance of early degenerative arthritis. Since average follow up of our patients was 19 months, we felt that a longer follow up is needed to find a clinically meaningful correlation between malunion and ankle & hindfoot score.

The use of fibular plating was described by Ruedi and Allgower as the first step in surgical reconstruction of pilon fractures.²⁹ The application of this concept to distal metaphyseal and shaft fractures is an extension of the original observation. The tibio-fibular ligaments are frequently spared in distal tibial fractures and hence the fibular reduction and fixation assists in tibial fracture reduction.²² Kumar et al³⁰ found that, fibular plate fixation increased the rotational stability of distal tibial fractures compared with that provided by interlocking nailing, but the difference lost significance as the applied torque was increased. The intact fibula with the tibial fractures is known to cause delayed union or nonunion.³¹ Theoretically, plating of fibular fracture and nailing tibial fracture may lead to similar problems. Buzzi et al²² concluded that fibular fixation and Interlocking nailing of distal tibial & fibular fractures is a valid technique which respects the soft tissue envelope. In our study all the patients had ipsilateral fibular fractures. In most of the studies, the rate of fibular fracture was near 80 percent.^{32,33}

Ankle, foot and the functional assessment were done using Kitaoka et al. ankle & hind foot score. The patient with infected nonunion and the patient who lost for follow up was not included in this analysis. The mean score in our series was 85, range being 68 to 98. Associated same limb injuries and severe injuries to other parts of body, delayed union, Sudeck's osteodystrophy were associated with lower scores in our study. In the previous studies various methods have been used to assess ankle foot and functional outcome. We preferred to use Kitaoka et al. ankle & hind foot score because of its simplicity, reliability, reproducibility. The functional results in our study are comparable to other similar studies.^{1,34,35} The cause of anterior knee pain is still unclear. Suggested contributing factors include younger, more active patients, nail prominence above the proximal tibial cortex, meniscal tear, unrecognized articular injury, increased contact pressure in the patellofemoral articulation, damage to the infrapatellar nerve, and surgically induced scar formation.²¹

The limitations of the study are that it is a retrospective study, relatively small number of patients, non comparative nature of the study, the bias associated with the patient selection by the surgeon and in selecting the proper implants and the fact that multiple surgeons were involved in the treatment of the patients. The bias associated with the visual analogue score for anterior knee pain, and ankle & hind foot score are also to be noted.

5. Conclusion

Distal tibial fractures are common and are challenging in nature. The intramedullary nailing is a safe, feasible & simple method of stabilization of these fractures. Using fracture table to get satisfactory reduction which can be maintained till completion of nailing and use of multiple distal locking screws

in different plane to give stable fixation for early mobilization and ambulation can minimize the complications. Impacting the unreamed nail till the subchondral bone of the distal tibia enhances the stabilization and reduces the theoretical risk of damage to endosteal blood supply. This method is definitely a better alternative to external fixator and plating techniques in the management of open distal tibial fractures.

Conflicts of interest

All authors have none to declare.

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