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Original Research Article

Role of tibia interlocking nail in treating distal tibial metadiaphyseal fractures: study of 46 cases

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ABSTRACT

Background: Distal tibial diaphyseal fractures are known for its various challenges that orthopaedicians face while treating. While performing surgery, many principles of fixations are needed to be properly addressed. This study was undertaken to know the efficiency of closed reduction, polar screws and tibia interlocking nail fixation at our Institute.
Methods: The data, which were collected from the medical records and Department digitalised storage system and from the HMIS patient filing system, included age, sex, date of admission, type of admission (elective versus emergency), and AO classification of distal tibial fracture admitted in Orthopaedics Department from 2007 to 2013. Analyses of 46 cases, 34 males and 12 females, were made to find out the functional, radiological outcome, associated complications in treating distal tibia with ILN. During Analysis, association of the single event with the variables was estimated using Relative Risk, with a 95% confidence interval and P value of <0.05 was considered significant.
Results: The average time to union of the closed fracture was 15.4 weeks (range: 12–28 weeks). The healing times for the primarily nailed compound Grade I averaged 17.8 weeks (range: 15-34 weeks). Complications of delayed union occurred in 3 cases, and two cases of non-union. Infection in 6 cases (5 superficial, 1 deep), screw breakage in 4 cases and 3 cases of significant malalignment. The final functional outcome of 33 patients had excellent results, 11 had good results and 2 had fair results as determined by criteria of Johner and Wruh.
Conclusions: The dynamic osteosynthesis of distal tibia by interlocking nail and judicious use of poller screws is an effective alternative for the treatment of distal metaphyseal tibial fractures.

Keywords: Metaphyseal distal tibia, Interlocking nail, Polar screws, Trauma

INTRODUCTION

Communitted metadiaphyseal fractures of distal tibia with severe soft tissue injury is the challenge faced by many Orthopaedicians to achieve early union, simultaneously avoiding joint stiffness, deformity and infections.[1] Decreased vascularity in distal leg region and limited muscle attachment have more propensity for delayed unions and nonunions following open surgery.[2] Minimally invasive techniques have been widely considered safe for dealing in distal tibial regions to avoid infection and malunions.[3] However for addressing minimal invasive plate osteosynthesis method is technically demanding and anatomic reduction of the fracture site is again difficult.[4,5] Associated fibular fracture needs separate incision on lateral side and risk for skin necrosis and implant exposure increases following surgery.[6]

Locked intramedullary (IM) nailing is the treatment of choice for closed fractures of the tibial shaft. However its use has also been extended to treat distal diaphyseo-metaphyseal junctional fracture.[7] The potential challenge is to achieve anatomical reduction using closed or

minimally invasive methods especially with intact fibula.[8,9] IM nails are currently becoming effective method for treatment of complex distal tibial metadiaphyseal fractures. The low multidirectional locked nailing may represent a superior surgical option, since it offers advantages in terms of mean operating time, hospital stay, full weight-bearing time and bony union time.[10,11]

The aim of this study is to evaluate functional and radiological outcome of these fractures treated by closed intramedullary tibial interlocking nail and supplemented Poller screws or blocking screws in extra-articular distal tibial fractures within 7.5 cm of the ankle joint. Also to study the complications associated with the procedures.

METHODS

A prospective study of 46 patients who sustained an extra-articular fracture of the distal tibia was performed between January 2007 and December 2013 at Grant Government Medical College and Sir J.J group of hospitals, Mumbai. An Ethical committee approval was taken prior to beginning of the study. A informed consent was taken from all patients who were included in the study. Orthogonal radiographs including ankle were evaluated to determine the fracture location and involvement of the distal part of the tibia. Inclusion criteria for study are acute extra-articular fractures in skeletally mature persons, involving the distal 3 to 7.5 cm of the tibia, treated with an IM nail. Cases with distal fragment of at least 3 cm in length that allowed placement of at least two interlocking screws through the nail are included. Exclusion criteria for this study were Gustilo-Anderson grade II and III and fractures with intra-articular extension into ankle joint.

The mechanisms of injury included fall from height (14 patients) motor vehicle accident (18 patients), sports injury (8) and trivial falls (6 elderly patient).

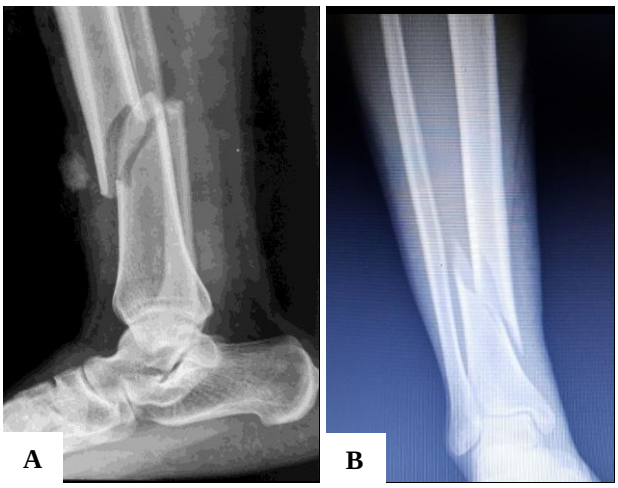

Figure 1 (A and B): Showing distal 3rd spiral oblique fracture of tibia.

The interlocking tibia nail used in this study has a modification at the distal end. The two distal interlocking holes in distal end are at right angles to each other. The most distal interlocking hole is 5 mm proximal to distal end of the nail and is in anteroposterior direction and proximal distal interlocking hole is in mediolateral direction i.e. at right angle to distal interlocking hole at 15 mm from the tip of the nail.

After admission, patients were assessed for soft tissue condition initially, given limb elevation till swelling subsided. The mean time interval from admission to surgery is 3.4 days. The routine investigations were performed and anaesthesia fitness assessed. The procedure was done under spinal anesthesia on a fracture table in supine position. After aseptic preparation, anterior 2.5-3 cm patella tendon splitting incision was taken and entry awl was used to take appropriate nail entry. Manual traction is given by the assistant. Reduction was done and checked in anteroposterior and lateral views on the image intensifier. Guidewire is inserted in the centre of ankle joint. Other minimally invasive techniques are used in 20 cases. In thirty cases, fibular length was achieved by traction. 3 cases required limited open reduction. After passing guide wire, reaming of proximal fragment is done. Nail is inserted over guide wire. In cases of translation and deformity, Poller screws are inserted to guide the nail in the centre of tibial plafond. Use of polar screws along the angle bisector line to centre of angle of rotation allows correction of varus or valgus deformities. The plating of the fibula was carried in thirteen cases where we felt that the distal tibial fragment was unstable and when fibula fracture is at same level or oblique in nature. A fibular plate was used as a primary reduction aid to obtain length, alignment, and rotation of the distal tibial segment in three patients where lateral malleolus is fractured.

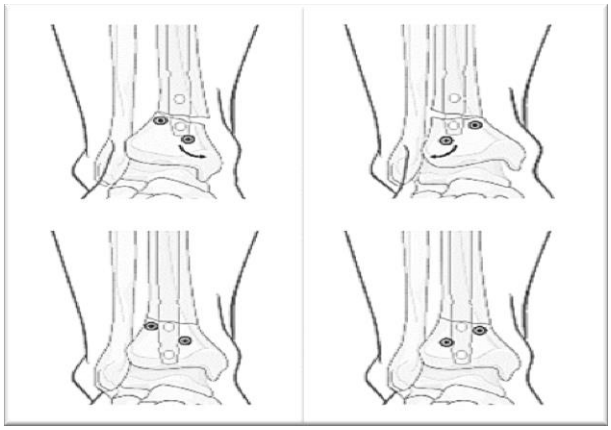

Figure 2: Showing use of Poller screw to correct malreduction.

Proximal locking was done in a dynamic mode through aiming device and distally locked with 4.9 mm screws in two planes within 2 cm of the articular surface of the tibia. To improve the stability of construct, more distal

screws locking is attempted. If that is not possible, blocking screw are used outside nails to add on stability in opposite direction.

Figure 3: Showing intraoperative C arm images showing role of poller screws achieving reduction.

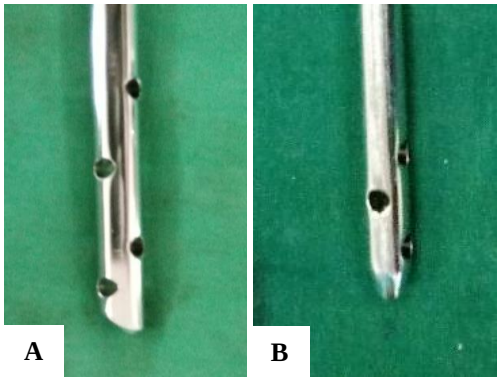

Figure 4 (A and B): Showing modifications for distal tibial metaphyseal locking.

The mean time for the surgery was 44 min (35-65 min) and the average hospitalization time in our cases was 7.5 days (5-17 days). IM nails of size 9 mm were used in 31 cases and size 10 mm in 15 cases. All patients received perioperative antibiotic prophylaxis in the form of first generation cephalosporin. Knee and ankle exercises started after pain relief. Partial weight bearing from 3rd postoperative day. Full weight bearing started from 8-12 weeks. For alignment measurement anteroposterior and lateral radiographs were made from both legs.

All radiographs were assessed digitally. The surgeon was blinded for patient information. Statistical analyses were performed in paired t test to compare differences between the two groups with regard to the time to union, time to weight-bearing, the Johner and Wruh score, the VAS scores on kneeling and squatting (to assess anterior knee pain), the time patients were unable to work, the hospital stay, and the operating time.

RESULTS

There were 46 cases (34 males; 12 females) with a mean age of 33.59 years (range: 20 to72) with spiral and oblique fractures of distal tibia were seen more frequently.

All the 46 patients with distal tibial fracture were followed for minimum 8 months or at least till clinico-radiological union. Only 6 patients did not followed after for 1 year. The follow-up period averaged 15 months (12 - 26 months). 36 Patients were allowed partial weight-bearing by 6 weeks after operation. 10 patients, type C (most unstable) fractures or where intraoperative extension of fracture line happened, partial weight-bearing was begun when the fracture was stable to axial and rotational load at 8 weeks (6-10 weeks) period. Average time to full weight-bearing was 9.2 weeks. The fracture was assessed by orthogonal and oblique x-rays for union at the follow up examinations. Range of motion of knee and ankle foot was measured and improved with physiotherapy. Absence of pain at the fracture site and radiographic evidence of callus in anteroposterior and lateral views of two or more cortices was considered as healed. Minimum 3 cortices of union are considered adequate for full load bearing. The average time to union of the closed fracture was 16.4 weeks (range, 12 -28 weeks) and for primarily nailed compound Grade I averaged 17.8 weeks (range 15–34 weeks) respectively. Non-union was seen in 2 cases and additional procedure of bone grafting was done. There were 4 cases of delayed union lead to breakage of interlocking screws and nail was penetrating into the ankle joint. Which was treated by removal of implant and patellar tendon bearing cast. The cause for these distal screw breakage probably because of the early weight-bearing, and regaining weight, doing labour work in overconfidence.

Table 1: Showing demographic data and classification of distal tibia fracture.

Types of fracture AO	Closed		Open		Fibula fractured	Intact fibula
	Males	Female	Male	Female		
43A1	12	5	8	2	20	2
43A2	7	2	2	1	12	3
43A3	3	1	2	1	7	2

Radiological assessment shows in earlier period nearly 4 patients had developed malunions. Mostly it was translation and varus, shortening by few mm. We noticed all the cases had intact fibula. On Follow up, these patients were complaining of insignificant ankle pain, managed by analgesics and physiotherapy. 8 patients significantly complained knee pain and 6 patients had ankle pain for initial 4-5 months of weight bearing which gradually subside. At one year follow up, most patients were pain free. They attained the full function of ankle and knee at 14 months of treatment.

Table 2: Showing means of various study variables.

Variable	Mean
Age (years)	33.5±2.59
Trauma to surgery (days)	3.4±1.2
Surgical time (min)	44±10
Hospitalization (days)	7.5±2.5
Partial weight bearing (weeks)	6.1±3.3
Full weight bearing (weeks)	9.2±2.1
Bony union (weeks)	16.4±3.4

Superficial infection occurred in five cases, three of which were on the nail entry portal whereas two were at the distal locking site. They were treated successfully with debridement of the wound and antibiotics. There was one case of deep surgical site infection and non-union, treated by implant removal, debridement and compression of non-union using olive wires and ring fixator assembly.

For alignment measurement anteroposterior and lateral radiographs were made from both legs. Shortening more than 1 cm was considered significant. Malalignment was defined as >5˚ varus/ valgus deformity, >10˚ procurvatum/ or recurvatum or >10˚ rotation.4 patient had significant malalignment. Three patients of comminuted fractures had a shortening of 1 cm. Six patients had less than 1 cm of shortening ranging from 5 - 8 mm. The proximal migration of the nail was not seen. Only single case, where dynamisation was performed reported of having knee pain after 3 weeks of dynamisation None of patient required nail removal for unresolving knee pain. The Implant removal was performed on patients request after 2 years in 19 cases. Average time for implant removal was 2.3 yrs (23-28 months).

Fibula united uneventfully at average 6.7 months (5 months – 8 months). Two patients developed infection and required early plate removal at around 5 months. After that fibula united fully. One nonunion of fibula was noticed after one year follow up but functionally there was no problem to the patients. No treatment was required as it was at higher leval.

Table 3: showing relative risk of malalignment with and without polar screw and fibula fixation.

	Malalignment	Relative risk	P value
With polar screw	1	0.165	0.042
Without polar screw	6		
With fibula fixation	2	0.38	0.035
Without fibula fixation	4		

The results show that there is 16% high chance of malalignment without use of polar screw and 38% increase malalignment without fibula fixation.

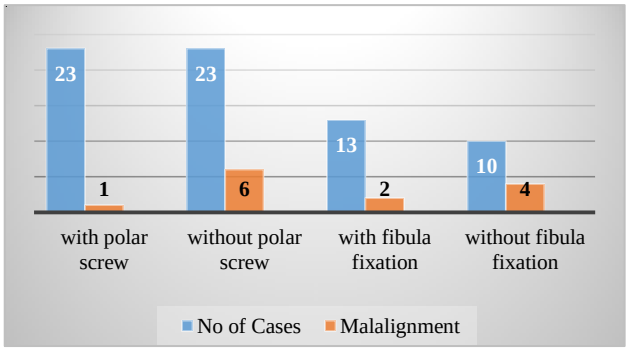

Figure 5: Outcome on tibial alignment with/without use of polar screw and fibular fixation.

After average follow up of twelve months (7 months-18 months) the results were graded according to the criteria laid down by Johner and Wruhs. Our results were excellent in 33 cases (71.44%), good in 11 cases (23.91%), and fair in 2 cases (4.34%.).

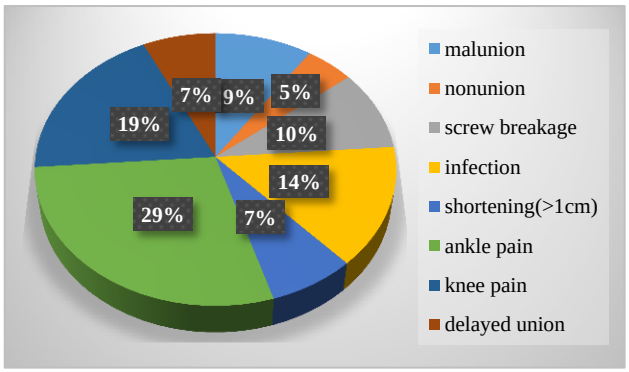

Figure 6: Showing distribution post-operative complications

DISCUSSION

The treatment of Distal Metadiaphyseal tibial fractures especially of unstable variety has always thrown challenges for correcting translation, varus- valgus or procurvatun recurvatum deformity. Second challenge remains for choice of implant whether to go extramedullary or intramedullary. The Standard tibia Interlocking Nail where distal locks are placed 1.5-2.5 cms from tip of nails cannot meet the stability in fixation and found to have more rates of non-union following unstable fixation as in most cases single locks could be used.[7] However the optimal treatment of unstable tibial fracture without articular involvement remains controversial.

Distal tibia has less vascular and soft tissue support than any other part of the tibia therefore infection, delayed union or non-union have been a more common

complications after open reduction and internal plate fixation. The distal region of tibia has muscle attachments posteriorly only. Most anterior, medial and lateral surface are surrounded by tendons. This limited blood supply warrants us to preserve the soft tissues for maintaining blood supply for healing. Periosteal stripping will further deteriorate blood supply.. Hence intramedullary implants inserted by closed techniques remains the viable choice.. Hence the requirement for distal fixation and stability needs distal holes to be move towards the tip of ILN. Fixation of distal tibial fractures with new nail system wherein there are provision of three or four holes are considered gold standard. However the potential problem of getting anatomical reduction has always remain the challenge for average orthopaedic surgeon.

Figure 7: X-rays showing effective reduction without Poller screws in distal tibia.

The basic requirement to get good alignment is restoration of anatomical and mechanical axis of tibia. To execute this intraoperatively surgeon has to place guidewire at the centre of ankle joint which falls at midpoint of talus, not the centre of tibial plafond. In the presence of intact fibula, there is varus deformity and translation which makes difficult to hold distal fragment manually and correct it due to internal splintage offered[12] If fibula is fractured then surgeon needs to put guidewire first in the centre by reducing distal fragment and then fix the fibula followed by completing interlocking procedure.

In cases of intact Fibula, where manual reduction of distal fragment is not effective in causing anatomical reduction, there is potentially desperate need of separate maneuverer that can restore mechanical or anatomical axis of tibia. Centre of rotation of axis falls nearly 3 cm proximal to the articular screws. Placing screws (Poller/blocking) at near CORA will realign tibia. Poller screws if placed properly will correct translation, varus/valgus deformity, stiffen the construct.

Intramedullary nailing can be considered the "gold standard" for the treatment of tibial midshaft fractures and recently intramedullary nailing has become widely accepted as the operative treatment of choice for tibial metadiaphyseal fractures worldwide.[13,14] The distal locking screws at tip of nail assures adequate minimum two screws distally ensures stability. Addition of blocking screws are needed to enhance stability. KH Salem and Du confirmed that biomechanical conditions in unreamed IM nailing of distal tibial fractures are unfavorable, because of a large axial to shear strain ratio between the bone fragments. Unreamed nailing of distal tibial fractures is associated with a rather high rate of bone healing complications and locking screw failure.[15,16]

Different techniques to assist in reducing the fracture have been proposed. Krettek et al used Poller screws. The principle of these additional screws is to orient the nail, preventing it from going where it should not go by reducing the metaphyseal space.[17] The judicious use of Poller screws in unstable construct effectively stabilizes the distal tibial fracture. We resorted to Poller screws in 10 cases on medial side, 10 cases on lateral side and 3 cases on posterior side of the nail to enhance the stability. The fibula plays an important role in the mechanical stability of the ankle joint. The fibular plating was recommended whenever IM nailing was used in unstable distal tibio-fractures.[18]

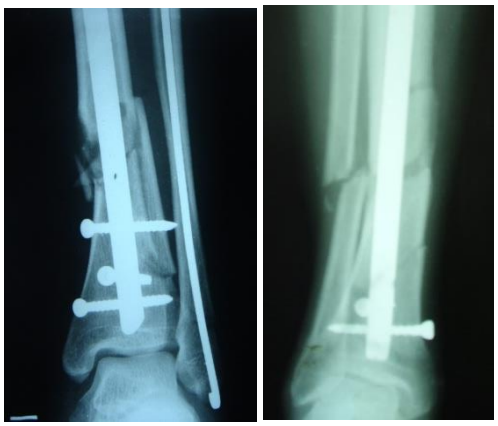

Figure 8: X-rays showing radiographs after treatment.

Due to increase incidence of wound infection at the fibular fixation site [19], fibula nailing thought to enhance stability of distal tibia construct and it can be carried out mostly by close method and reduces risk of infection. The IM canal at distal tibia prevents intimate contact between the nail and endosteum, insertion of two distal locking screws becomes therefore more necessary. There is consensus in the literature on the need for double distal screw fixation so as to obtain better control of sagittal and frontal as well as horizontal movements by distributing stresses. It is also well documented that the placement of two distal screws increases the stiffness and strength of the bone-implant construct, thus leading to enhanced mechanical stability of the fixed fracture.[20] In our series distal tibial fractures were treated with a reamed intramedullary nailing system that increases distal fixation by two distal interlocking screws passing through the distal 0.5 cm to 1.5 cm from the tip of the nail. The design of the nail allows one mediolateral and one anteroposterior screw for better stabilization of the distal

fragment. Twenty two patients had a malalignment of the tibia but after union it was within acceptable range. They attained the full function of ankle and knee. The results were satisfactory even when two locking bolt were used. Only 3 cases had gross malalignment (angulation of 10˚-12˚ valgus) and restricted movements of ankle. Only in four cases there were breakages of the screws.

Incidence of delayed union and non-union rate is very low as compared to reported series as we used the single interlocking bolt in dynamic mode especially in upper part and 2 locking bolts in lower end are used to secure the distal fragment. We believe that dynamization of long bone fractures has been shown to accelerate periosteal callus formation during early stages of bone healing. In addition, a more uniform callus formation is seen as a result of this controlled reduction of the fracture gap.

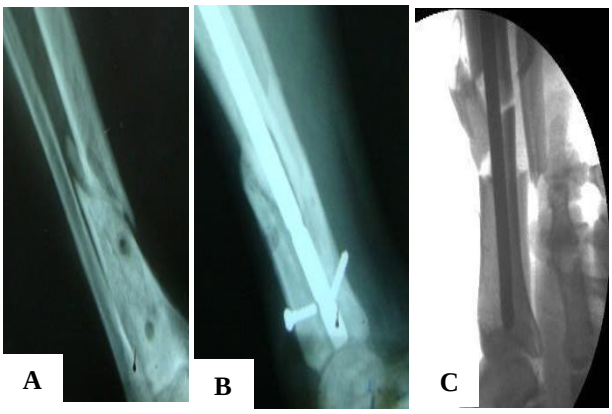

Figure 9: X-rays. A=showing complications of non-union following infection, B=screw breakage, C=intraop communition.

The interlocking nail provides sufficient stability by three-point fixation at either ends and also in the diaphysis by its bony contact. If good fit is established in the isthmus of the diaphyseal canal, then the stability and union is guaranteed as per our experience. We believe that to achieve uneventful union with minimum morbidity, minimum soft tissue dissection including dissection of periosteum, achieving anatomical reduction by closed means, using Poller screws, stable fixation by at least 2 distal screws, subchondral fixation of nail, early mobilisation-are key to success for good bony healing and functional outcome.

CONCLUSION

Based on observations in our present study, Even though the osteosynthesis of distal metadiaphyseal fracture of tibia is complex, Tibia interlocking nail with modifications in distal locking near the tipis the safest technique for treating even complex fractures in distal tibia. However achieving reductions using Poller screws has long learning curve. The procedure is technically demanding. Minimally invasive technique based on principles of limited exposure and indirect reduction methods, which avoids major soft tissue complications and shortens the length of the patient's stay in the hospital. We conclude that intramedullary nailing is a safe and effective technique for the treatment of distal metadiaphyseal tibial fractures.

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