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Dr. DV Prasad
H.O.D. and Professor, Department of Orthopaedics, Rural Medical Collage, Loni, Maharashtra, India

Dr. Mahammad Akram A Saji
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Dr. Ranjan Kumar Gupta
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Dr. Pushpak Kumar
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Dr. Siddharth Shah
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Dr. Ankit Gopikishan Lohiya
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Correspondence
Dr. Mahammad Akram A Saji
PG Student, Department of Orthopedics, Rural Medical Collage Loni. Taluka - Rahata, District - Ahmednagar, Maharashtra, India

Comparative study of intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis (MIPO) in extra articular distal tibial fracture

Dr. DV Prasad, Dr. Mahammad Akram A Saji, Dr. Ranjan Kumar Gupta, Dr. Pushpak Kumar, Dr. Siddharth Shah and Dr. Ankit Gopikishan Lohiya

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Abstract
Introduction: Tibia is one of the most commonly fractured long bone of the body. Distal tibia fractures are primarily located within a square based on the width of the distal tibia. Treatment of distal tibia fracture is challenging because of its unique anatomical characteristics of subcutaneous location with precarious blood supply and proximity to the ankle joint. Minimally invasive plate osteosynthesis (MIPO) and intramedullary interlocking nail (IMLN) are two well-accepted and effective methods
Materials & Methods: Hospital based comparative study carried out to compare the effects of two different forms of treatment modalties of intramedullary nailing and minimally invasive plate osteosynthesis (MIPO). Total of 30 patients were enrolled in the study who were then randomly assigned groups for treatment modality using computer generated random numbers to receive type of treatment.
Results: The operating duration in IMLN group ranged from 45 to 70 min (mean 56.4 ± 8.30 min) whereas in case of MIPO it ranged from 60 to 80 min. The average time of union in the IMLN group was 18.26 ± 2.49 weeks (range 15–24 weeks). In the MIPO group, union occurred in an average of 21.70 ± 2.67 weeks (range 16–24 weeks). The statistical difference between the two groups comes out to be very significant ($P< 0.0001$).
Conclusion: We conclude that both minimally invasive percutaneous plate osteosynthesis (MIPPO) with a medial distal tibial locking plate and closed reduction with intramedullary nailing are viable options for management of extra-articular fractures of the distal tibia.

Keywords: Extra articular distal tibial fracture, intramedullary interlocking nailing, MIPO

Introduction
In the modern fast moving world there is a great increase in number and severity of fractures. The goal of fracture treatment is to obtain union of the fracture in the most compatible anatomical position which allows maximal and full restoration of the extremity [1].
Tibia is one of the most commonly fractured long bone of the body. Distal tibia fractures are primarily located within a square based on the width of the distal tibia [2]. The incidence of distal tibia fractures in most series is 0.6%, and it constitutes to about 10%–13% of all tibial fractures [3].
Treatment of distal tibia fracture is challenging because of its unique anatomical characteristics of subcutaneous location with precarious blood supply and proximity to the ankle joint [4].
Not only these fractures are relatively common, but they are often difficult to treat because of the propensity for severe soft tissue injury or compounding as the bone is subcutaneous in location with limited vascularity, which increases the chances of infection, wound dehiscence and non-union, and small distal fragmentation. These are difficult to control while achieving closed reduction [5, 6].
Because of its subcutaneous location, poor blood supply and decreased muscular cover anteriorly, complications such as delayed union, nonunion, wound infection, and wound dehiscence are often seen as a great challenge to the surgeon.

Various surgical modalities used for these fractures include closed intramedullary nailing, plating by open or closed methods, and various types of external fixators [7, 8].

Minimally invasive plate osteosynthesis (MIPO) and intramedullary interlocking nail (IMLN) are two well-accepted and effective methods, but each has been historically related to complications. Mal-alignment and knee pain are frequently reported after IMLN [9, 10], whereas wound complications, and implant prominence have been associated with tibial plating [11].

Due to absence of defined criteria in the literature for the surgical treatment to extra articular distal tibia fractures, this study is conducted to compare the treatment results of intramedullary nailing and locking plate technique in terms of rate of healing, functional outcome and complications.

Material & methods

It was a Hospital based comparative study carried out to compare the effects of two different forms of treatment modalties of intramedullary nailing and minimally invasive plate osteosynthesis (MIPO). The study was conducted from January 2016 to December 2016, applying consecutive sampling technique all the patients attending the OPD Of orthopaedics department with age more than 18 years, closed distal tibia fractures within 5 cm of ankle joint, AO type 43A and with valid consent to undergo the operative procedure were included in this study while those with age less than 18years, open fractures and intra articular fractures of distal tibia were excluded. Total of 30 patients were enrolled in the study who were then randomly assigned groups for treatment modality using computer generated random numbers to receive type of treatment.

Strategy

A Total of 2 groups were formed and 15 patients were enrolled in each group, all the participants received written and verbal explanations of the purpose and procedures of the study, if they agreed to participate they signed informed consent. Group 1 patients were operated with interlocking nailing and Group 2 remaining 15 with a locking plate.

Radiographic evaluation was done as Antero Posterior (AP) view and lateral view of the affected leg. Patients were operated under anesthesia as per the fitness of patient**.** All patients were given supine position following anesthesia, on a radiolucent table top to facilitate the use of image intensifier. Pneumatic tourniquet /Esmarch rubber tourniquet was used in all patients.

Surgical technique for Intramedullary nailing: A vertical patellar tendon splitting incision over skin extending from centre of the inferior pole of patella to the tibial tuberosity was made about 3cms long. The patellar tendon was split vertically in its middle and retracted to reach the proximal part of tibial tuberosity. Next step was to determine the point of insertion. Essential for the success of the procedure is the correct choice of the insertion point. As a general rule, the insertion point should be slightly distal to the tibial plateau, just medial to lateral tibial spine on a true AP view and exactly in line with the medullary canal on lateral view. Reduction of the fracture fragments under image intensifier by maintaining longitudinal traction in line of the tibia was done. Accurate closed reduction of the fracture was verified under image intensifier before insertion of the guide wire in the distal tibial metaphysis. After reduction, the tip of the guide wire was passed till it enters the subchondral bone of distal tibia. Distal locking was always done first. It was done under image intensifier control by free hand technique. Cases in which the distal fragment was large enough to accommodate two mediolateral screws, two mediolateral screws were passed, and cases in which distal fragment was too small one mediolateral and one anteroposterior screw were passed.

Surgical technique for locking plate fixation: The key concept of this approach was to preserve the soft-tissues and blood supply in the metaphyseal fracture area by not exposing them surgically. A straight or slightly curved skin incision was performed on the medial aspect of the distal tibia. The length of the incision varied from 3-5cms, depending on the type of the planned plate. Tibial length and rotation was restored indirectly with manual traction. Angulation was approximated in the same way, but was definitively corrected by plate application. The plate was inserted after proximal tunneling with the plate itself. Depending on the fracture situation, the plate was positioned on the anteromedial aspect of the tibia.

Post-operatively radiographs were taken. Passive knee and ankle range of motion was started in the 1st post operative week depending on the type of fracture and stability of fixation. Active movements were started in the second week once the pain had subsided. The weight bearing was planned as per the type of fracture, fixation and general condition of the patient. Initially partial weight bearing was advised between 4 to 8 weeks and then full weight bearing was advised when there was radiological evidence of callus formation and process of union of the fracture.

Clinical follow-up examination was performed at 4 weeks, 6 weeks, 10 weeks, 3months, 6 months and 1 year. All the patients were assessed clinically and radio graphically with following terms such as tenderness at fracture site, abnormal mobility, infection, pain on movement of knee and ankle joints and anteroposterior and lateral radiographs of the leg for union of the fracture. Student's paired t test and Chi Square test was applied to the results of both the groups for comparison.

Ethical clearance was obtained from the ethics review committee of the institute. Data was analysed using SPSS 21.0 (SPSS Inc., Chicago, IL, USA), paired t test was used compare within the groups and unpaired t test was applied to compare between the 2 groups.

Results

We included a total of 30 patients in the study, 25 males (83.3%) and 5 females (16.7%) with an average age of 37 years. The most common mode of injury in both the groups was road traffic accidents (80%), with falls being the second most common cause. Right side was the most commonly involved side in both interlocking group and plating group. There were 8 AO type 43A.1, 5 43A.2 and 2 43A.3 type fractures in interlocking group as compared to 9 AO type 43A.1, 4 43A.2 and 2 43A.3 type fractures in plating group which was not significant.(Table 1)

The operating duration in IMLN group ranged from 45 to 70 min (mean 56.4 ± 8.30 min) whereas in case of MIPO it ranged from 60 to 80 min (mean 65.67 ± 5.55 min). $P<0.0001$ showed it to be statistically significant.

The mean time for starting partial weight bearing in IMLN group was 4.6 ± 1.07 weeks as compared to 6.70 ± 1.33 weeks in MIPO group which was statistically significant ($P< 0.0001$)

The average time for full weight bearing was 10.09 ± 1.41 weeks in IMLN and 13.38 ± 1.24 weeks in MIPO group which was statistically significant ($P< 0.0001$).

The average time of union in the IMLN group was 18.26 ± 2.49 weeks (range 15–24 weeks). In the MIPO group, union occurred in an average of 21.70 ± 2.67 weeks (range 16–24 weeks). The statistical difference between the two groups comes out to be very significant (P< 0.0001). (Table2)

Complications were comparable among the two groups in regards with superficial infection, deep infection, malalignment, knee, and ankle stiffness. However, statistically significant higher incidence of anterior knee pain was found in 23.80% patients IMLN group (P = 0.0478). Similarly, MIPO group was associated with higher rate of implant irritation which was found in 23.80% of patients (P = 0.0478) and also a higher rate of infection which was found in 19.04% of patients. (Figure 3)

Discussion

Distal tibia fractures are a common consequence of road traffic accidents and injuries due to fall. Its management still continues to be a problem. Locked intramedullary nailing has the advantage of a shorter operating time, less rate of infection and early weight bearing and easier removal of the implant. Open reduction and internal plate fixation results in extensive soft tissue dissection and may be associated with wound complications and infection.

In present study, the patients were in the range of 19–50 years, with mean age being 37.14 years. Of the 30 patients, 25 were males and 5 were females. IMLN group had 12 males; 3 females while MIPO group had 13 males; 2 females. Predominant male involvement was seen in this study which can be attributed to more outdoor activities and heavier labor undertaken by males as compared to females in the Indian set up. Similar results were observed by Daolagupu AK *et al*. [12] in their study conducted in Assam. Various other studies by Kumar *et al*. [13] Ram *et al*. [14] Li *et al*. [15] and Vallier *et al*. [16] have shown male preponderance.

Most common cause for this fractures was seen to be RTA followed by fall and sports injury, especially football in present study and these results are in concordance with studies by Kumar *et al*. and Ram *et al*.

The average duration of surgery in interlocking group was 56.53 min and the average duration of surgery in plating group was 65.33 min which was comparable to the studies done by J. J. Guo, *et al*. [17] and Yang Li, *et al*. [15]

The mean time of union in present study was 18.50 weeks (18.26 ± 2.49 weeks for IMIL nail and 21.75 ± 1.99 weeks for MIPO). In our study, 27 fractures (92.58%) united between 16 and 24 weeks. similar study conducted by Eknath D. Pawar *et al*. [18] average time for union was 17.43 weeks in interlocking group compared to 21.40 weeks in plating group which is almost similar to the present study. Various other studies done by Kasper W. *et al*. [19] Bahari S. *et al*. [20] had observed similar results.

Malalignment was found in 23.80% of the patients treated with IMLN whereas MIPO had 14.28% of patients with malalignment. Of the cases which had malalignment evident on immediate postoperative period healed in the same position at follow up of 1 year and no significant change was noted. These finding suggests intra-operative error could be the reason for malunion. Four cases had valgus and one case had varus malunion which were primarily fixed with IMLN, and two had varus and one cases had valgus which belonged to MIPO group. This was similar to studies by Kumar *et al*. [13] Ram *et al*. [14] and Pawar *et al*. [18]

Anterior knee pain (23.80%) and valgus angulations (19.04%) were the most common complications seen in IMLN group, whereas implant irritation (23.80%) and ankle stiffness (23.80%) were the most common complications in plating group in present study. Deep infection in one patient (4.76%), superficial infection in three patients (14.28%) was seen in plating group and one patient (4.76%) in interlocking group. other similar studies by Nork *et al*. [8] Guo *et al*. [17] Bahari *et al*. [20] and Redfern *et al*. [21] had shown similar complication pattern.

Table 1

Parameters	Group		Total
	IMLN (n-15)	MIPO (n-15)	
Male	12	13	25
	80.0%	86.7%	83.3%
Female	3	2	5
	20.0%	13.3%	16.7%
Age (Mean+/-SD)	35.67+8.12	36.57+/- 7.68	
Mechanism of injury			
1) RTA	12	11	23
	80.0%	73.3%	76.7%
2) Falls	2	2	4
	13.3%	13.3%	13.3%
3) Assaults	0	1	1
	0.0%	6.7%	3.3%
4) Sports Injury	1	0	1
	6.7%	0.0%	3.3%
Side involvement			
1) Right	12	11	23
	80.0%	73.3%	76.7%
2) Left	3	4	7
	20.0%	26.7%	23.3%
AO Classification			
1) Type 43A1	8	9	17
	53.3%	60.0%	56.7%
1) Type 43A2	5	4	9
	33.3%	26.7%	30.0%
1) Type 43A3	2	2	4
	13.3%	13.3%	13.3%

Table 2

Parameters	Group	N	Mean	SD	p- value
Duration of Surgery (mins)	IMLN	15	56.45	7.60	< 0.01
	MIPO	15	65.67	76.34	
Partial Weight Bearing (wks)	IMLN	15	4.69	1.45	< 0.01
	MIPO	15	6.78	1.78	
Complete Weight Bearing (wks)	IMLN	15	10.23	2.01	< 0.01
	MIPO	15	13.42	1.99	
Union Time (wks)	IMLN	15	18.01	2.56	< 0.01
	MIPO	15	21.78	2.38	

Table 3

Complications	IMLN	MIPO
Anterior Knee Pain	4	0
Superficial Infection	1	3
Deep Infection	0	1
Angulation > 5 deg	4	2
Knee Stiffness	2	0
Ankle Stiffness	2	5
Delayed / Non Union	2	1
Implant Irritation	0	4

Conclusion

Based on our study, we conclude that both minimally invasive percutaneous plate osteosynthesis (MIPPO) with a medial distal tibial locking plate and closed reduction with

intramedullary nailing are viable options for management of extra-articular fractures of the distal tibia, with each having its own merits and demerits although closed nailing has the advantage of shortened operating time, early weight bearing, decreased wound problems, early union of the fracture, decreased implant related problems and overall reduced morbidity.

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