

ORIGINAL RESEARCH

A Hospital Based Comparative Study to Evaluate the Functional and Radiological Outcome of Distal Tibial Fracture Between Minimally Invasive Percutaneous Plate Osteosynthesis (MIPO) & Intra Medullary Interlocking Nail (IMIL) at Tertiary Care Center

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ABSTRACT

Background: Distal tibial metaphysis is defined by constructing a square, with sides of length defined by widest portion of tibial plafond. Various surgical modalities used for these fractures include closed intramedullary nailing, plating by open or closed methods, and various types of external fixators. The purpose of this prospective study was to compare the two primary modalities of treatment for these fractures: namely, distal tibial locking compression plate by Minimally Invasive Percutaneous Plate Osteosynthesis (MIPO) and closed intramedullary interlocking nailing (IMIL), and to know the efficacy of these techniques in the management of closed fractures of distal tibia.

Materials& Methods: A hospital based prospective comparative study done on 30 adult patients with fractures of lower third tibia admitted in department of Orthopaedics at Indira Gandhi Medical College, Shimla, Himachal Pradesh, India during one year period. All patients with distal tibia fractures who satisfy the inclusion criteria have been included in the study. Patients will be allocated randomly into two groups using computer generated random numbers i.e., IMIL group and MIPO group each with 15 patients. Patients were followed up for 3 months, 6 months, and 12 months for clinical, radiological and functional outcome evaluation.

Results: Mean age of the patients in IMIL group is 40.56 ± 11.23 years and 44.32 ± 15.46 years in MIPO group. The most common mode of injury was found to be Road Traffic Accident (RTA), seen in 63.33% of the patients, followed by fall 23.33%, sports injury 6.66% and direct blow 6.66%. The functional results, as assessed by Teeny And Weiss Criteria (Functional Evaluation of Ankle), showed that majority (60%) of the patients in the study had good functional results (IMILN: 66.66%; MIPO: 53.33%) and 33.33% had excellent results (IMILN: 26.66%; MIPO: 40%). The difference in functional outcome showed mean score of 84.36 ± 8.78 in IMIL group where as in MIPO group it is 84.12 ± 9.65 . Using Chi-square test, these differences were not found to be statistically significant ($P > 0.05$). In our study, most of the patients had no complications. In patients who had complications, in IMIL group most common complication is superficial

infection (13.33%) followed by malunion (6.66%) and deep infection (6.66%), whereas in MIPPO group most common complication was deep infections (13.33%) and implant failure (13.33%) and delayed union (3.33%).

Conclusion: We concluded that multidirectional locked nailing is an efficient method for treating distal tibia fracture. Compared with MIPO, IMIL nailing should still be considered the gold standard for distal tibia fracture management.

Keywords: Distal tibial fracture, MIPPO, IMIL, Outcome.

INTRODUCTION

High speed motor vehicle accidents are on the rise over past few years. These are responsible for most of the fractures of tibia. High energy motor vehicle trauma constitutes the commonest cause followed by falls, direct blow, and sports injury.^{1,2} Distal tibial metaphysis is defined by constructing a square, with sides of length defined by widest portion of tibial plafond.³ Because of its subcutaneous location, poor blood supply and decreased muscular cover anteriorly, complications such as delayed union, non-union, wound infection, and wound dehiscence are often seen as a great challenge to the surgeon.¹ The incidence of distal tibia fractures in most series is 0.6%, and it constitutes to about 10%–13% of all tibial fractures.^{1,2}

Non-operative treatment of closed comminuted fractures with cast usually leads to problems like prolonged immobilization, malunion, shortening and joint stiffness.⁴⁻⁶ Open reduction and internal fixation with conventional plate frequently leads to complications like non-union, delayed union, infection and implant failure. The most important factor in the treatment of these fractures is the management of overlying soft tissues. Rhinelander (1968)⁴ believed that blood supply is the most important factor in normal bone healing. So, while using the technique of internal fixation, emphasis must be put on the vascular support of bone and soft tissue by doing minimum exposure, indirect reduction and in particular least possible damage to the periosteum.

Biological plating provides relative stability and preserves vascularity around the fractures. The principle of this minimally invasive technique includes indirect closed reduction, extraperiosteal dissection and relative stability which allows limited controlled motion at the fracture site with secondary bone healing and callus formation.⁴⁻⁶

Intramedullary interlocking nailing (IMIL) allows minimally invasive, symmetric, and dynamic fracture fixation by following the principles of biological fracture fixation. This technique is also used widely for distal tibial shaft fractures, with good results.⁷

Various surgical modalities used for these fractures include closed intramedullary nailing, plating by open or closed methods, and various types of external fixators. Despite all the advances that have been made in the available treatment options, fractures of the distal tibia still pose a challenge to the orthopedic surgeons.^{7,8}

The purpose of this prospective study was to compare the two primary modalities of treatment for these fractures: namely, distal tibial locking compression plate by Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) and closed intramedullary interlocking nailing (IMIL), and to know the efficacy of these techniques in the management of closed fractures of distal tibia.

MATERIALS & METHODS

A hospital based prospective comparative study done on 30 adult patients with fractures of lower third tibia admitted in department of Orthopaedics at Indira Gandhi Medical College, Shimla, Himachal Pradesh, India during one year period. All patients with distal tibia fractures who satisfy the inclusion criteria have been included in the study. Patients

will be allocated randomly into two groups using computer generated random numbers i.e., IMIL group and MIPPO group each with 15 patients.

INCLUSION CRITERIA

- Age > 18 years.
- Extra Articular distal tibial fractures.
- Duration of injury within 15 days.
- Intact neurological and vascular status of the affected limb

EXCLUSION CRITERIA

- Patient with open fractures
- Intraarticular extension of fracture
- Pathological fractures
- Patients with previous old fractures of distal metaphyseal tibia on the same side

METHODS

SURGICAL TECHNIQUE

IMIL GROUP

All patients were operated under spinal / general anaesthesia. Patients were positioned supine on radiolucent operating table. After applying pneumatic tourniquet, the affected leg was scrubbed thoroughly with betadine or savlon from middle of thigh to foot. Sterile glove applied to the foot, steri-drape applied from knee joint to ankle. A longitudinal incision measuring 3 cm was made over the patellar tendon. Dissection was carried through the subcutaneous tissues to the fascia. The fascia was incised just medial to the patellar tendon and the periosteum of the proximal tibia exposed. The threaded guide wire was positioned on the AP between the tibial spines in line with the long axis of the tibia, and on the lateral, directed parallel with the anterior cortex. The canal was then opened with the cannulated drill over the guide wire. Closed reduction was done and alignment was confirmed with fluoroscopy. The ball-tipped reaming guide wire was then inserted down the canal through the fracture site and into the distal fragment, taking care to center the wire in the distal fragment. The length of the nail was then measured. The canal was reamed sequentially, over the guide wire, the cannulated tibial nail was inserted, monitoring passage through the fracture site to ensure alignment. The guide wire was then removed. The Intramedullary interlocking tibial nail used in our study had multiple distal locking options, with the distal most within the coronal plane and 5 mm from the tip of the nail. Other locking holes were at 15 mm, 25 mm, and 35mm from the tip of the nail in the sagittal, coronal, and sagittal plane, respectively. At least two locking bolts were used distally in the two planes for stable fixation. Fracture diastasis was reduced by the back strike technique of the nail, after which proximal locking was done. In some patients we used blocking screws to achieve reduction of fractures during intramedullary nailing. Then, using the proximal targeting device, the proximal interlocking screws were inserted, and placement confirmed fluoroscopically. Finally, the stability of fixation was checked. If there was a fibula fracture within seven cm of syndesmosis, it was anatomically reduced and fixed by one-third semi-tubular plate. The wounds were irrigated. The wound closed in layers with vicryl and nylon. A sterile dressing was applied.

MIPPO GROUP

The preliminary intra op protocol, reduction of the fracture and fixation of the fibula was conducted in a similar fashion as IMIL group. After inflating tourniquet two small incisions were made on either side of the fractured area without disturbing soft tissue covering of the

fracture fragments. The incision is extended up to the periosteum. By using a periosteal elevator or plate epi-periosteal tract is made without opening the periosteal tube. Intra-operative closed reduction was done by combination of traction, manipulation, and reduction clamps.

Depending on the fracture location and anatomy, we used medial locking compression plate which was a 3.5 mm thick stainless-steel plate with a limited contact profile, anatomically contoured for the medial surface of the distal tibia. The plate had combination holes where both conventional cortical or locking screws could be used.

Once the epi-periosteal tract is done, a suitable length plate is selected to have at least three to four cortices hold on either side of the fracture. A plate is moved through the epi-periosteal tract. After confirming reduction and alignment of a plate under a C-arm, the plate was fixed to the bone with an appropriate size and number of screws following the principles of locking compression plates. Care is taken while handling the soft tissues. If there was a fibula fracture within seven cm of syndesmosis, it was anatomically reduced and fixed by a one-third semi-tubular plate. Finally, the entire tibia, fractured site is seen in both antero posterior and lateral views for the placement of screws and plate. Skin is sutured after giving the wound wash with saline and betadine. Compression bandage is given after applying the sterile dressing.

TIME TAKEN FOR FULL WEIGHT BEARING

The fracture was said to be radiologically united when there was bridging of at least three of four cortices on two orthogonal radiographic views. With radiological findings and clinically, the absence of tenderness and movement at the fracture site, suggested the fracture site has sufficiently consolidated so as to allow full weight bearing which usually occurs by 10-12 weeks.

TIME TAKEN FOR RADIOLOGICAL UNION OF FRACTURE

Healing time less than six months was considered normal, and between six and nine months was considered as a delayed union. Fractures not healed within nine months were considered a non-union according to the 1988 FDA guidelines.

FUNCTIONAL OUTCOME ASSESSMENT

Final evaluation of the clinical results was conducted at nine months using the Teeny and Wiss clinical assessment criteria, which are based on a 100-point rating system. As per the Teeny and Wiss criteria, the final clinical and symptom scores were graded as excellent (> 92), good (87 - 92), fair (65 - 86), and poor (< 65).

STATISTICAL ANALYSIS

Data was presented as percentages or mean \pm SD (standard deviation) as deemed appropriate for qualitative and quantitative variables, respectively. The chi-square test, and Mann Whitney U test were applied to evaluate the statistical significance between the two groups. A P value of < 0.05 was considered as statistically significant.

RESULTS

Mean age of the patients in IMIL group is 40.56 ± 11.23 years and 44.32 ± 15.46 years in MIPPO group. As the P value was found to be >0.05, the difference in gender distribution between the 2 groups was found to be insignificant. The most common mode of injury was found to be Road Traffic Accident (RTA), seen in 63.33% of the patients, followed by fall 23.33%, sports injury 6.66% and direct blow 6.66%.

Average duration of time between injury and surgery was found to be 2.84 days in IMIL Group and 2.03 days in MIPPO group (p value 0.345) (table 1).

Table 1: Demographic and clinical characteristics in between groups

Characteristics		IMIL group (N=15)	MIPPO group (N=15)	P-value
Age (yrs) Mean±SD		40.56±11.23	44.32±15.46	>0.05
Gender	Male	12	10	>0.05
	Female	3	5	
Mode of Injury	RTA	9	10	>0.05
	Sports injury	1	1	
	Direct blow	1	1	
	Fall	4	3	
Mean duration of injury (Days)		2.76±1.63	2.03±1.38	>0.05
Average time of radiological union (weeks)		22.8±5.40	23.74±6.85	>0.05

The average time of radiological union in the IMIL group was 22.8 ± 5.40 weeks (ranging from 15–24 weeks). In the MIPPO group, union occurred in an average of 23.74 ± 6.85 weeks (ranging from 16–24 weeks). The statistical difference between the two groups comes out to be not significant ($P > 0.05$) (table 1).

The functional results, as assessed by Teeny And Weiss Criteria (Functional Evaluation Of Ankle), showed that majority (60%) of the patients in the study had good functional results (IMILN: 66.66%; MIPPO: 53.33%) and 33.33% had excellent results (IMILN: 26.66%; MIPPO: 40%). The difference in functional outcomes showed mean score of 84.36 ± 8.78 in IMIL group where as in MIPPO group it is 84.12 ± 9.65 . Using Chi-square test, these differences were not found to be statistically significant ($P > 0.05$) (table 2).

Table 2: Functional Outcome based on Teeny and Weiss Criteria

Teeny and Weiss Criteria	IMIL group (N=15)	MIPPO group (N=15)	P-value
<65	0	0	>0.05
65-86	1	1	
87-92	10	8	
>92	4	6	
Mean score	84.36 ± 8.78	84.12 ± 9.65	>0.05

POSTOPERATIVE COMPLICATIONS (TABLE 3)**Table 3: Complications Noticed in Both the Groups**

Complications	IMIL group (N=15)	MIPPO group (N=15)	P-value
Superficial infection	2	0	>0.05
Deep infection	1	2	
Malunion	1	0	
Delayed union	0	1	
Implant failure	0	2	
Nil	11	10	

Superficial skin infections: Two superficial skin infection observed in nailing group whereas in plating group there were no superficial skin infections. All these infections were managed with regular dressings and appropriate antibiotics after getting culture and sensitivity.

Deep infection: One deep infection was observed in patients treated with nailing whereas there were two deep skin infections in patients treated with plating. All were managed with regular dressing, antibiotics, wound debridement and finally with skin grafting.

Delayed Union: Out of 15 patients treated with plating, one patient had delayed union. Cause of this delayed union is not clear but smoking and osteoporosis are two important factors.

Malunion: “Malunion is defined as more than 5° of angular deformity in any plane or shortening by 1 cm or more in length”. There is one malunion of greater than 5 degree angulation seen in patients treated with nailing.

Implant failure: There were two implant failures (implant broken) seen in plating group as a result of early weight bearing and was treated with revision surgery (i.e. implant removal followed by open reduction internal fixation with nailing and bone grafting).

DISCUSSION

Extra articular distal tibia fractures management is still controversial, surgeon's main aim is to get decent reduction with minimum postoperative complications. To get these results minimal invasive plating and multidirectional locked intramedullary nailing are the two viable options. When compared to minimal invasive plating multidirectional locked nailing technique has exhibited many advantages in terms of time taken for surgery, union time, complications like wound infection, early weight bearing capacity and range of motion at ankle joint. In our study the maximum number of patients who were treated with nailing or plating returned back to full weight bearing capacity and good functional outcome.

For years now, conventional intramedullary nailing had an advantage over other methods. Because of its early weight bearing and union rate, there is lesser incidence of infections. A disadvantage with conventional intramedullary nailing is the difficulty to stabilize the distal fragment and malunion. To overcome these problems many techniques have come into existence like Poller screws and angle stable locking screws.^{9,10}

With the development of minimally invasive surgery (MIPPO) technique which requires only realignment of tibial mechanical axis, fracture exposure is not necessary. The intraoperative image intensifier helps with the closed reduction and avoid excessive disturbance of the fracture fragments. Based on these theoretical considerations, the MIPPO technique claims an earlier union process, as well as lower risks of infection, non-union and other complications. Percutaneous plating has challenged interlocking nailing as locked plate designs act as a fixed-angle device whose stability is provided by the axial and angular stability at the screw-plate interface instead of relying on the frictional force between the plate and bone, which is thought to preserve the periosteal blood supply around the fracture site.^{11,12}

Furthermore, the MIPPO technique may have a smaller range of indications. Conditions which are not considered for MIPPO treatment are infection, articular surface involvement, and osteo compartmental syndrome. Literature shows MIPPO technique is an efficient method for treating distal tibia fracture.

Predominant male involvement in our study was probably due to more outdoor activities and heavier labour undertaken by males as compared to females in this part of hilly area. The result was comparable to that of Kumar et al.,¹³ Ram et al.,¹⁴ Li et al.¹⁵ and Vallier et al.¹⁶

In our study, the most common cause for these fractures was RTA followed by fall and sports injury. Our results were comparable to other studies by Kumar et al.,¹⁷ Ram et al.,¹⁴ Pawar et al.⁸ which also showed that RTA is the most common mode of injury as modernization and industrialization have intruded our lives.

The mean time of union in our study was 22.8 ± 5.40 weeks for IMIL nail and 23.74 ± 6.85 weeks for MIPPO. Other studies done by Li et al.,¹⁵ Pawar et al.,⁸ Yao et al.¹⁸ is comparable to the results found in our study regarding faster union in IMLN.

Our study showed that a high significant change seen in functional outcome (Teeny And Weiss Criteria) between two groups, the mean is 84.36 ± 8.78 in patients treated with multidirectional locked nailing and 84.12 ± 9.65 in patients treated with minimal invasive percutaneous plate osteosynthesis ($p > 0.05$).

In our study, most of the patients have no complications. In patients who had complications, In IMIL group most common complication is superficial infection (13.33%) followed by

malunion (6.66%) and deep infection (6.66%), whereas in MIPPO group most common complication is deep infections (13.33%) and implant failure (13.33%) and delayed union (3.33%).

As RTA was the most common cause in our study, along with causing the fracture, it might also affect the soft tissue. This may lead to soft tissue disintegrity and infections. Both groups were comparable for complications which were comparable to studies by Nork et al.,¹⁹ Guo et al.,²⁰ Ehlinger et al.,²¹ Bahari et al.²² and Redfern et al.²³

Theoretically incidence of infection in the MIPPO group should be less because technique itself promotes minimal handling of soft tissues. But a minimal incision cannot ensure minimal invasion because surgeons who are unfamiliar with the technique may repeatedly insert and pull out the plate, which will induce a dead space and increase infection risk or delayed union.²⁴

Nevertheless, we must be cautious when dealing with these severe fractures associated with poor soft tissue status. Surgeons should be aware that wound infection or necrosis is the most common postoperative complication of distal tibia fracture.²⁵

Hasenboehler et al.²⁶ reported that although MIPPO seems more advantageous for soft tissue and bone biology, prolonged healing times were observed in simple fracture patterns.

Khoury et al.²⁷ suggested that reduction should be performed cautiously due to the tendency of sagittal plane malreduction in MIPPO technique. Therefore, whether the virtues of the MIPPO technique exceed Multidirectional IMIL nail is not clear.

Use of both multidirectional locked nailing and minimal invasive plating is associated with improvement in rate of union and shows advantage in taking care about soft tissue around the fracture site. Limitations of our study include small sample size, minimal follow up and randomization of the sample.

CONCLUSION

We concluded that multidirectional locked nailing is an efficient method for treating distal tibia fracture as compared to plating technique. Our limitation has compared a small sample size so, no significant superiority of MIPPO was found over IMIL nail. Compared with MIPPO, IMIL nailing should still be considered the gold standard for distal tibia fracture management.

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