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Intramedullary Interlocking Nailing versus Minimally Invasive Percutaneous Plate Osteosynthesis (MIPO) in Extra-Articular Distal Tibial Fracture: A Comparative Study

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Abstract

Introduction: Distal tibial fractures are one of the perplexing injuries encountered due to their poor blood supply and limited soft tissue cover. We aim to study and compare clinical and radiological outcomes in extra-articular fractures of the distal tibia treated with intramedullary interlocking nail (IMILN) and Minimally Invasive Plate Osteosynthesis (MIPO) locking compression plates.

Methods: The study included 7 women and 17 men. 12 patients underwent MIPO, and 12 patients underwent CRIF with an IMIL nail. Postoperative outcomes were evaluated using the Johner & Wruhs criteria for up to 12 months, focusing on fracture union, malunion, infection, range of motion, pain, and gait abnormalities.

Results: The age of the patients ranged from 18 to 70 years. Road traffic accident was the major cause in both groups. Mean surgical time was 59.6 (± 8.9 SD) minutes in the MIPO group and 57.1 (±7.5 SD) minutes in the IMILN group. The mean full weight-bearing period was 20.6 (±1.5 SD) weeks in the MIPO group and 18.2 (±2.2 SD) weeks in the IMILN group, while the mean union time in MIPO was 21.0 ± 1.9 weeks and 17.92±2.31 weeks. 3 cases in MIPO had ankle stiffness, and 4 cases in IMILN developed knee pain.

Conclusion: The study concluded that both MIPO with a medial distal tibial locking plate and closed IMILN are viable options for managing extra-articular fractures of the distal tibia. The choice depends on patient and fracture characteristics.

Keywords: Distal Tibia Fracture; Interlocking Nailing; MIPO Locking Plate

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Introduction

One of the long bones in the body that fractures most frequently is the tibia. Based on the breadth of the distal tibia, distal tibia fractures are typically seen within a square.[1] Distal tibial fractures represent less than 10-12%[1,2] of all tibial fractures, and they contribute to less than 10%[3,4] of all lower extremity fractures. When it comes to injuries, they can range from low energy to high energy and are more common in males between the ages of 30 and 50.[5] Limited soft-tissue coverage and poor vascular supply make these fractures challenging to treat, with increased risks of delayed healing, non-union, and infection. Therefore, treatment aims to provide stability while preserving soft tissues and promoting biological healing.

Intramedullary nailing provides three-point fixation and minimizes surgical trauma, although achieving stable fixation can be difficult because of the distal tibial canal morphology.[1] Minimally invasive plate osteosynthesis (MIPO) provides stable fixation while minimizing soft-tissue disruption, but complications including angular deformity, implant failure, and nonunion have been reported.[13] Fibular fractures occur in approximately 85% of distal tibial fractures, and the need for fibular fixation remains debatable.[6,18]

This study aimed to compare the outcomes of distal tibia fractures treated with interlocking intramedullary nails and locking plates via MIPO, evaluating the rate of union, duration of surgery, functional outcomes (e.g., ankle joint range of motion), and complications, while guiding the management of extra- articular distal tibial fracture.

Methods

Study Design

This was a prospective comparative non-randomized study conducted among patients with distal tibial fractures treated with either minimally invasive plate osteosynthesis (MIPO) or intramedullary interlocking nail (IMILN). Eligible patients presenting during the study period were enrolled consecutively after application of the predefined inclusion and exclusion criteria. Participants were allocated alternately to the MIPO and IMILN groups in a 1:1 sequence. The study was conducted at the National Trauma Centre, National Academy of Medical Sciences, Kathmandu, Nepal, from May 2021 to June 2022. Ethical approval was obtained from the Institutional Review Board of the National Academy of Medical Sciences (Reference No. 1436). Written informed consent was obtained from all participants before enrolment.

Participants

Patients aged ≥18 years with closed extra-articular distal tibial fractures who were considered clinically suitable for treatment with either MIPO or IMILN were included. Patients with open fractures, intra-articular distal tibial fractures, pathological fractures, and those younger than 18 years were excluded.

Sample Size and Sampling

The sample size of cases enrolled was calculated using the formula,

$$N = \frac{2\,(Z\alpha + Z\beta)^2\,\sigma^2}{d^2}$$

$Z\alpha$ = 1.96 (at 5% level of significance)

$Z\beta$ = 1.28 (for 90 % power)

σ^2 = Standard deviation = 2.56 (Prasad et al.)[1]

d = difference in means between two groups = 3.77 (Prasad et al.)[1]

N: minimum sample size

Minimum sample size: 12 in each group, accounting for 10% loss to follow-up

Consecutive sampling was used to allocate the enrolled participants alternately to the IMILN and MIPO groups.

Statistical Analysis

Data were entered and analysed using IBM SPSS Statistics version 22.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Between-group comparisons of continuous variables were performed using the independent-samples Student's t test for normally distributed data and the Mann–Whitney U test for non-normally distributed data. Between-group comparisons of categorical variables were performed using the chi-square test when the assumptions for the test were satisfied; Fisher's exact test was used when expected cell frequencies were small. A p-value <0.05 was considered statistically significant.

Surgical techniques and Follow-up

Anteroposterior (AP) and lateral views of the afflicted leg were used for radiographic examination, and fractures were classified according to the AO classification system. Initially, patients were managed with an above-knee back slab with elevation until definitive fixation. Routine pre-operative investigations and assessments were performed.

In IMIL, the patient was positioned supine with the injured knee flexed over the table's end, and the contralateral leg supported. A 5-cm incision was made over the anterior tibia, and the patellar tendon was split and retracted. Nail diameter was determined by measuring the breadth of the medullary canal at the isthmus, with a 1.5% subtraction for radiological magnification. The entry point for the nail was at the proximal tibia, confirmed radiographically. A ball-

tipped guide wire was passed across the fracture, followed by serial reaming to enlarge the medullary canal. The nail was inserted with the knee flexed beyond 90 degrees, and distal locking was performed first under image intensifier control. Depending on the distal fragment size, either two mediolateral screws or one mediolateral and one anteroposterior screw were placed.

In minimally invasive percutaneous plate osteosynthesis, the patient was positioned supine with the limb externally rotated. The limb was exsanguinated, sterilized, and draped, followed by tourniquet inflation. A 3-4 cm incision was made over the medial malleolus, and the epi-periosteal plane was developed. Fracture reduction was performed under C-arm guidance, using a Kirschner wire for difficult reductions. Provisional fixation was done with a cortical screw, and locking screws were applied on both sides of the fracture. The wound was closed in layers, and a compression bandage was applied after tourniquet deflation

For a valid comparison between IMIL nailing and MIPPO, surgical procedures should ideally be standardized to ensure uniformity and minimize bias. However, in clinical practice, patient welfare takes precedence over strict uniformity. Fracture morphology, bone quality, soft tissue condition, and overall patient status vary significantly, necessitating individualized surgical approaches. Using different techniques within each procedure allows optimization of outcomes while still maintaining a basis for meaningful comparison. This approach ensures that while the study remains methodologically sound, it does not compromise patient safety and recovery.

A short leg plaster was applied immediately post-surgery. Active knee and ankle exercises started after 48 hours, with non-weight-bearing walking initiated using support. Wound care included sterile dressings on the 2nd, 5th, and 10th days, with suture removal on the 14th day before discharge. Follow-ups were conducted at 2 weeks, 4 weeks, 3 months, 6 months, and 12 months and were evaluated for clinical outcomes, radiological union, and the development of complications such as pain, infection, stiffness, or non-union. Partial weight-bearing was allowed after 6–8 weeks based on pain tolerance and radiological healing, with full weight-bearing permitted after fracture consolidation. Functional outcomes were assessed using Johner and Wruhs criteria.

Radiological assessment and definitions of union

Standard anteroposterior and lateral radiographs of the affected tibia were obtained during follow-up. Radiological healing was assessed based on the presence of bridging callus and/or cortical continuity across the fracture site, according to the predefined study criteria.

Radiological union was defined as bridging callus across at least three of four cortices on orthogonal radiographs.

Delayed union was defined as failure to demonstrate expected progression of fracture healing within six months.

Non-union was defined as persistent failure of fracture healing by nine months, together with clinical and radiological evidence of failure of progression.

Radiographs were assessed by two investigators. The assessors were not blinded to treatment allocation. Progression of weight bearing was determined by the treating surgeon based on clinical examination and radiological evidence of progression of fracture healing. Therefore, weight-bearing progression should be interpreted as a partially clinician-dependent outcome.

Results

The study showed the mean age for MIPO was 44.9±18.8 and for IMIL Nail 35.25 ±14.6. Their age ranged from 18 to 77 years. In the MIPO group, there were 12 patients, equally split between 6 males (50%) and 6 females (50%). In the IMILN group, 10 patients (83.3%) were male, and 2 (16%) were female. (Table 1)

Table 1. Demographic Characteristics

Parameter	MIPO Group (n=12)	IMILN Group (n=12)	Total
Age (years)			
Mean ± SD	44.9 ± 18.8	35.25 ± 14.6	
Gender			
Male	6 (50.0%)	10 (83.3%)	16 66.7%)
Female	6 (50.0%)	2 (16.7%)	8 (33.3%)
Mode of Injury			
Road Traffic Accident (RTA)	5 (41.7%)	6 (50.0%)	11 (45.8%)
Fall from height	4 (33.3%)	5 (41.7%)	9 (37.5%)
Sports Injury	3 (25.0 %)	1 (8.3%)	4 (16.7%)

Table 2. Comparison of mean MIPO vs IMIL nail for various parameters

Parameters		Mean	SD	p value
Duration of Surgery (mins)	MIPO	59.58	8.91	>0.05
	IMIL	57.08	7.53	
Complete Weight Bearing (weeks)	MIPO	20.63	1.50	<0.05
	IMIL	18.18	2.22	
Union Time (weeks)	MIPO	21.00	1.9	<0.05
	IMIL	17.92	2.31	

Table 3. Complications in MIPO and IMILN Groups

Complication	MIPO (n=12), n (%)	IMILN (n=12), n (%)	p-value*
Anterior Knee Pain	0 (0.0%)	4 (33.3%)	0.093
Infection	4 (33.3%)	3 (25.0%)	1.000
Ankle Stiffness	3 (25.0%)	0 (0.0%)	0.217
Delayed Union	1 (8.3%)	0 (0.0%)	1.000
Varus / Valgus Malalignment	5 (41.7%)	3 (25.0%)	0.667
Knee Stiffness	0 (0.0%)	4 (33.3%)	0.093
Pain	2 (16.7%)	3 (25.0%)	1.000

**Statistically significant at p < 0.05*

Road traffic accident was the most common mode of injury in both groups: MIPO 41.7% and IMIL nail 50.0%. (Table 1)
In the MIPO group, the mean surgical time was 59.58 ± 8.91 minutes, while in the IMILN group it was 57.08 ± 7.53 minutes. Union time in the MIPO group was 21 ± 1.91 weeks, whereas in the IMILN group it was 17.92 ± 2.31 weeks. (Table 2). In addition to surgical time, union time, and functional outcomes (assessed using Johner & Wruhs criteria), a comprehensive comparison of complications was also conducted between the two groups. The complications evaluated included anterior knee pain, knee stiffness, pain, varus/valgus malalignment, infection, ankle stiffness, and delayed union; however, none of the complications were statistically significant among two groups. (Table 3)

Discussion

In our study, most fractures occurred in younger adults: 58% in the 20-30 years' age group in the IMILN group and 42% in the 20-40 years' age group in the MIPO group. Various literature also mentions that tibia fractures are common in young adults.[1,3,5] Among them, 50% were male, and 50% were female in the MIPO group, whereas 83% were male and 17% were female in the IMILN group.
The most common mode of injury in our study was road traffic accident, i.e., 41.7% in the MIPO group vs 50% in the IMILN group, followed by Fall injury as the second most common mode of injury in both groups. Regarding Pattern of fracture, this study showed comminuted fracture as the most common pattern in both groups; i.e. 58.33% had comminuted fracture in either group, followed by spiral fracture as the second most common fracture pattern in either the MIPO or IMILN group.
In our study, in the MIPO group the mean surgical time was 59.58±8.91 minutes, while in the IMILN group it was 57.08±7.53 minutes. Chandrakant et al.[17] in their study found that the mean duration of surgery was 72 minutes (range 40-100 minutes) in the interlocking intramedullary nail group and 94 minutes (range 55-150 minutes) in the MIPO group (p < 0.08). Similarly, Daolagupu AK et al.[3] reported mean durations from 45 to 70 min (mean 57.14 ± 8.30 min) for the interlocking intramedullary nail group and 60 to 80 min (mean 66.67 ± 5.55 min) for the MIPO group (p < 0.08). These findings align with other studies in the literature.
In this study, union time in the MIPO group was 21±1.91 weeks, whereas in the IMILN group it was 17.92±2.31 weeks. This finding is similar to that done by Iftikhar et al.[14] in 2017, where mean union time was 19 weeks in the MIPO group and 18.1 weeks in the IMILN group. Also, Ali et al.[16] in their study found that union time in the MIPO group was 20.5 ± 4.8 weeks and that in the IMILN group it was 18.8 ± 6.0 weeks.
In our study, as per Johner and Wruhs Parameter, in the MIPO group 33.33% had excellent, 50% had good, and 16.67 had fair functional outcome. Similarly, in the IMLN group, 41.67% had excellent, 41.67% had good, and 16.67 had fair functional outcome. In concordance with our study, Daolagupu et al.[3] found that the majority (54.76%) of the patients had excellent functional results (IMLN: 57.14%; MIPO: 52.38%) and 21.42% had good results (IMLN: 14.28%; MIPO: 28.57%), but these differences were not found to be statistically significant (P = 0.6723).

Limitation:

This study has some limitations. The small sample size may limit the statistical power and generalizability of the findings. Due to the lack of true randomization, allocation concealment was not possible, and selection bias cannot be excluded. Consecutive recruitment and a predefined allocation sequence were used to reduce discretionary selection. The study was conducted at a single center, which may limit the applicability of the results to other populations and clinical settings. Finally, the relatively short follow-up period may have limited assessment of long-term functional outcomes and late complications.

Conclusion

Both MIPO and IMILN were associated with fracture healing and functional recovery during follow-up. The study provides preliminary comparative observations but does not establish superiority of either fixation technique. Larger studies using concealed random allocation and standardized/blinded outcome assessment are required to determine whether clinically meaningful differences exist between the two techniques.

Conflict of Interest: None

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