



Original Research Article

INTRAMEDULLARY INTERLOCKING NAILING VERSUS MINIMALLY INVASIVE PERCUTANEOUS PLATE OSTEOSYNTHESIS (MIPPO) IN DISTAL THIRD EXTRA-ARTICULAR TIBIAL FRACTURES

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Received : 09/09/2026
Received in revised form : 05/10/2026
Accepted : 18/10/2026

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DOI: 10.70034/ijmedph.2026.4.129

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 862-867

ABSTRACT

Background: Distal third extra-articular tibial fractures are challenging to manage because of the limited soft-tissue coverage, relatively poor vascularity, and proximity of the fracture to the ankle joint. Intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis (MIPPO) are commonly used treatment modalities, each with distinct advantages and potential limitations. **Objective:** To compare the functional and radiological outcomes of intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis (MIPPO) in patients with distal third extra-articular tibial fractures. **Study Design:** Prospective randomized controlled study. **Duration and place of Study:** This study was conducted at Ibn e Sina University Hospital Mirpurkhas from June 2025 to June 2026

Materials and Methods: This prospective randomized controlled study included 80 adult patients with closed or Gustilo-Anderson type I open distal third extra-articular tibial fractures. Patients were randomly allocated into two groups and treated with either intramedullary interlocking nailing or MIPPO. Follow-up assessments were performed at 3, 6, and 12 weeks and at 6 months. Functional outcomes were assessed using the Foot Function Index (FFI) and Olerud-Molander Ankle Score (OMAS), while radiological fracture healing was assessed using radiographic evaluation and the Radiographic Union Score for Tibial fractures (RUST). Continuous variables were compared using the Student's t-test or Mann-Whitney U test, as appropriate. A p-value of <0.05 was considered statistically significant.

Results: Among the 80 patients, 60% were male, and road traffic accidents were the most common mechanism of injury (57.5%). Patients treated with intramedullary nailing achieved weight-bearing mobilization earlier than those treated with MIPPO at the assessed time points (p=0.001). Full weight-bearing was achieved at a mean of 7 weeks in the nailing group compared with 10 weeks in the MIPPO group. The Olerud-Molander Ankle Score favored the nailing group during the early follow-up period; however, no statistically significant difference was observed between the groups at 6 months, with mean scores of 89 and 85, respectively. The Foot Function Index demonstrated improvement in both groups at the final follow-up. Radiological union assessed using the RUST score was comparable between the two groups. Delayed union was the most common complication and occurred in 12.5% of

patients in each group. Other complications were observed only in the MIPPO group; however, the difference in overall complication rates was not statistically significant ($p=0.46$).

Conclusion: Intramedullary interlocking nailing was associated with earlier weight-bearing and potentially faster functional rehabilitation compared with MIPPO in distal third extra-articular tibial fractures. However, functional and radiological outcomes at 6 months were comparable between the two treatment groups.

Keywords: Distal tibial fracture; extra-articular tibial fracture; intramedullary interlocking nail; minimally invasive percutaneous plate osteosynthesis; MIPPO; fracture fixation; RUST score.

INTRODUCTION

Distal tibial fractures commonly result from high-energy trauma, including road traffic accidents and falls, particularly when axial loading is combined with rotational forces.^[1] These fractures frequently occur within the distal metaphyseal region of the tibia, commonly referred to as the “Müller square.” The Association for the Study of Internal Fixation (ASIF) describes this region as a square area of the distal tibia adjacent to the tibial plafond, with each side measuring approximately the width of the tibial plafond.^[2] Surgical management is frequently recommended for displaced distal tibial fractures to restore and maintain the mechanical axis, achieve fracture stability, and facilitate early mobilization and functional recovery.^[3]

Extra-articular distal tibial fractures are technically challenging to manage because of the relatively poor soft-tissue coverage and vascularity of the distal third of the tibia, as well as its close proximity to the ankle joint.^[4] Several surgical techniques have been described, including minimally invasive percutaneous plate osteosynthesis (MIPPO), external fixation, and intramedullary interlocking nailing.^[5,6] Among these, intramedullary nailing and MIPPO are commonly used for extra-articular distal tibial fractures. However, the choice between these techniques remains challenging because each has potential advantages and limitations.^[7,8]

The primary goals of surgical treatment are to restore the alignment of the distal tibia, maintain the mechanical axis, prevent varus or valgus malalignment, preserve ankle joint function, achieve adequate fracture stability, and minimize additional soft-tissue injury.^[9] MIPPO is designed to preserve the fracture-site biology and minimize disruption of the surrounding soft tissues compared with conventional open plating. This approach may reduce soft-tissue complications such as wound dehiscence and infection.^[10] In contrast, intramedullary interlocking nailing provides load-sharing fixation and may permit earlier weight-bearing and mobilization, although distal tibial nailing may be associated with challenges in maintaining alignment because of the metaphyseal location of the fracture.

Despite the widespread use of both techniques, the optimal method of fixation for distal third extra-

articular tibial fractures remains a subject of debate. Therefore, the present study was designed to compare the functional and radiological outcomes of intramedullary interlocking nailing and MIPPO in adult patients with distal third extra-articular tibial fractures.

MATERIALS AND METHODS

Study Design and Participants

A prospective randomized controlled study was conducted among adult patients aged >18 years who presented with closed or Gustilo-Anderson type I open fractures of the distal one-third extra-articular tibia. Both comminuted and non-comminuted fractures were included.

The sample size was calculated based on the expected difference in functional outcome scores between patients treated with intramedullary interlocking nailing (128.9 ± 13.1) and those treated with minimally invasive percutaneous plate osteosynthesis (MIPPO) (133 ± 4.9), with a 95% confidence level and 70% statistical power. A total of 80 patients were included in the study and randomly allocated into two groups, with 40 patients in each group.

Inclusion Criteria

Patients were eligible for inclusion if they:

- Were aged >18 years.
- Had a distal one-third extra-articular tibial fracture.
- Had either a closed fracture or a Gustilo-Anderson type I open fracture.
- Had either a comminuted or non-comminuted fracture.

Exclusion Criteria

Patients were excluded if they had.

- Intra-articular tibial fractures.
- Tibial plafond fractures.
- Pathological fractures.
- Peripheral vascular disease or significant bleeding disorders.
- Skeletal immaturity.
- Active infection or sepsis.
- Severe head injury.
- Gustilo-Anderson type I or higher open tibial fractures.

Preoperative Counseling and Consent

All patients were counseled regarding the nature of the fracture, available treatment options, potential benefits and complications of each procedure, and the expected cost. The available implant materials, including titanium and stainless steel, were also discussed with the patients.

Patients were informed about the differences in implants cost and, where applicable, the options available through government or health insurance schemes. Standard implants were used in patients receiving treatment through such schemes unless an alternative implant was specifically requested by the patient. Written informed consent was obtained from all patients before surgery.

Patient Allocation and Surgical Treatment

Patients were randomly allocated into two treatment groups. Patients in Group I underwent intramedullary interlocking nailing, whereas patients in Group II underwent minimally invasive percutaneous plate osteosynthesis (MIPPO).

All procedures were performed under spinal anesthesia according to established preoperative and postoperative protocols.

Follow-up and Functional Assessment

Patients were followed up at 3 weeks, 6 weeks, 12 weeks, and 6 months after surgery. At each follow-up visit, the wound condition, range of motion of the knee and ankle joints, and pain at the knee, ankle, and fracture site were assessed.

Functional outcomes were evaluated using the Foot Function Index (FFI) and the Olerud-Molander Ankle Score (OMAS).

Radiological Assessment

Serial radiographs were obtained during follow-up to assess fracture alignment, implant position, screw or nail-related findings, and progression of fracture healing. Radiological union was assessed using the Radiographic Union Score for Tibial fractures (RUST).

Partial weight-bearing mobilization with a walker or crutches was initiated at approximately 5–6 weeks postoperatively. Full weight-bearing was permitted once bridging callus was evident radiographically. Callus formation and fracture healing were assessed at 3 and 6 months postoperatively.

Definition of Malunion.

Malunion was defined as a varus or valgus deformity of $>5^\circ$, anteroposterior deformity of $>10^\circ$, rotational deformity of $>10^\circ$ in either direction, or limb shortening of >10 mm.

Statistical Analysis

Continuous variables were summarized using means, medians, and standard deviations, as appropriate. Comparisons between the two treatment groups were performed using the independent Student's t-test or Mann-Whitney U test, depending on the distribution of the data. A p-value of <0.05 was considered statistically significant.

RESULTS

There were a total of 80 patients included in this study. All the 80 patients were equally divided into two groups ($n=40$ each). The majority of the participants were males. Patients were aged from 18 years and above. Table number 1 shows the baseline characteristics of our study.

Table 1

Parameters	N	%
Gender		
• Male	48	60.0
• Female	32	40.0
Mode of injury		
• Road Traffic Accidents	46	57.5
• Slip & fall	20	25.0
• Fall from height	8	10.0
• Accidental Fall	6	7.5
Fracture type		
• Closed	64	80.0
• Compound	16	20.0

Table number 2 compares the weight bearing mobilization in both the groups.

Table 2

Category	Group 1 (Nailing) n=40	Group 2 (MIPPO) n=40	p-value
Non-weight bearing mobilization with support			
Post-operative day - n (%)			0.001
• Day 2	9 (22.5%)	0	
• Day 3	12 (30.0%)	3 (7.5%)	
• Day 4	4 (10.0%)	9 (22.5%)	
• Day 5	9 (22.5%)	17 (42.5%)	
• Day 6	3 (7.5%)	6 (15.0%)	
• Day 7	3 (7.5%)	4 (10.0%)	
• Day 10	0	1 (2.5%)	
Partial weight bearing mobilization with support			

Follow-up (weeks) - n (%)			0.001
• 2	3 (7.5%)	0	
• 3	16 (40.0%)	0	
• 4	5 (12.5%)	5 (12.5%)	
• 5	5 (12.5%)	8 (20.0%)	
• 6	3 (7.5%)	10 (25.0%)	
• 7	8 (20.0%)	10 (25.0%)	
• 8	0	7 (17.5%)	
Full weight bearing with support			
Follow-up (weeks) - n (%)			0.001
• 4	3 (7.5%)	0	
• 5	12 (30.0%)	0	
• 6	10 (25.0%)	0	
• 7	5 (12.5%)	6 (15.0%)	
• 8	8 (20.0%)	8 (20.0%)	
• 9	0	10 (25.0%)	
• 10	1 (2.5%)	8 (20.0%)	
• 11	0	4 (10.0%)	
• 12	1 (2.5%)	4 (10.0%)	
Full weight bearing mobilization without support			
Follow-up (weeks) - n (%)			0.001
• 7	9 (22.5%)	0	
• 8	8 (20.0%)	0	
• 9	7 (17.5%)	0	
• 10	8 (20.0%)	5 (12.5%)	
• 11	3 (7.5%)	7 (17.5%)	
• 12	4 (10.0%)	14 (35.0%)	
• 13	0	4 (10.0%)	
• 14	0	7 (17.5%)	
• 15	0	3 (7.5%)	
• 16	1 (2.5%)	0	

Table number 3 shows the Foot Function Index scores at follow-ups.

Table 3:

Follow-up	Group 1 (Nailing) n=40	Group 2 (MIPPO) n=40
3 weeks	91	96
6 weeks	68	96
12 weeks	44	76
6 months	11	5

Table number 4 shows Olerud–Molander Ankle Score at follow-ups.

Table 4:

Follow-up	Group 1 (Nailing) n=40	Group 2 (MIPPO) n=40
3 weeks	16.5	9.6
6 weeks	44.7	32.2
12 weeks	73	52
6 months	89	85

Table number 5 shows the RUST score at follow-ups.

Table 5:

Follow-up	Group 1 (Nailing) n=40	Group 2 (MIPPO) n=40
3 weeks	3	3
6 weeks	5	5.5
12 weeks	8	8.5
6 months	16	18.5

Table number 6 compares the complications between both the groups.

Table 6:

Complications	Group 1 (Nailing) n=40	Group 2 (MIPPO) n=40	p-value
Delayed union	5 (12.5%)	5 (12.5%)	0.46
Infection	0	1 (2.5%)	

Wound infections	0	1 (2.5%)	
Non union	0	1 (2.5%)	
Wound dehiscence	0	1 (2.5%)	
Pressure necrosis of skin by plate ends	0	1 (2.5%)	

DISCUSSION

Distal third extra-articular fractures of the tibia continue to be among the controversial topics in trauma surgery where intramedullary interlocking nailing and MIPPO have both been well-documented as conventional modes of management with their own pros and cons from biomechanical and biological standpoints.^[11] The current study is aimed at evaluating the outcomes of these two approaches in 80 adults with distal third extra-articular fractures of the tibia.

In the current study, most of the patients were male (60%) and road traffic accidents accounted for the leading cause of injury in 57.5% of cases, observations which agree with other related literature.^[12] This scenario is due to the fact that young males are exposed to high-velocity trauma more than other people as has been mentioned in the literature regarding the mechanisms of tibial shaft fractures.^[13]

Early weight-bearing mobilization was noted to happen much earlier in the nailing group compared to the MIPPO group at all stages tested ($p=0.001$). Partial weight bearing was seen as early as 2-3 weeks in the nailing group, while in the MIPPO group, the earliest partial weight bearing was at 4 weeks. Early full weight bearing with assistance was attained at 4 weeks in the nailing group compared to 7 weeks in the MIPPO group, while full weight bearing without assistance was seen as early as 7 weeks in the nailing group compared to 10 weeks in the MIPPO group. This earlier mobilization advantage of intramedullary nailing is well known due to the fact that the load-sharing concept of the intramedullary implant gives more assurance in progressing to weight bearing compared to the load-bearing principle of a plate. Similar observations were made by Wani et al in their comparative study on distal tibial extra-articular fractures.^[14]

With regard to functional results based on Foot Function Index and Olerud-Molander Ankle Score, there is an initial improvement with nailing technique which then decreases with time. The Olerud-Molander Ankle Score was consistently better in the nailing group at 3, 6 and 12 weeks (16.5, 44.7 and 73 versus 9.6, 32.2 and 52 in the MIPPO group) and converged at 6 months (89 versus 85). The trend was also observed for the Foot Function Index, where the nailing procedure scored higher but both groups achieved favorable outcomes after 6 months. Mauffrey et al observed a similar initial improvement with the nailing group that was not sustained in their follow-up period, whereas Polat et al observed equal effectiveness between both procedures at the end of follow-up.^[15]

The most prevalent complication in the current study was the delayed union, which affected the same percentage of patients in both groups (12.5%). All the other complications occurred in the MIPPO group only but this difference was not statistically significant ($p = 0.46$). It is in agreement with previous data showing a slightly higher rate of wound and soft tissue complications for the plating procedure in comparison to intramedullary nailing, although this difference is statistically insignificant.^[16,17] On the contrary, there is some evidence of reduced risks of delayed and non-union associated with MIPPO compared to intramedullary nailing.^[18,19] Systematic review by El-kholy et al. reached the similar conclusion that both procedures can be performed safely in the cases of extra-articular distal tibial fractures with comparable rates of complications.^[20]

Our study has certain limitations. The fracture pattern and comminution of the fractures have not been taken into account while performing the analyses and they could be the confounders affecting the functional and radiographic outcomes. Moreover, blinding of the assessor has not been performed since the difference in the surgical technique and implants used was evident enough for the observer to know what procedure has been done on a patient.

CONCLUSION

Intramedullary Interlocking Nailing and MIPPO can be considered equally safe and effective methods in managing distal third extra-articular fractures of the tibia, having similar results after 6 months. Nevertheless, the intramedullary nailing method provides some additional benefits, including the possibility of faster weight-bearing and rehabilitation, as well as fewer wound complications.

Funding source

This study was conducted without receiving financial support from any external source.

Conflict in the interest

The authors had no conflict related to the interest in the execution of this study.

Permission

Prior to initiating the study, approval from the ethical committee was obtained to ensure adherence to ethical standards and guidelines.

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