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Research Article

CLINICAL AND RADIOLOGICAL OUTCOMES OF INTRAMEDULLARY INTERLOCKING NAILING VERSUS MINIMALLY INVASIVE PERCUTANEOUS PLATE OSTEOSYNTHESIS IN DISTAL TIBIA FRACTURES: A PROSPECTIVE STUDY

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Abstract: ***Introduction:*** Fractures of the distal third of the tibia present a significant surgical challenge due to limited soft tissue coverage and the wide medullary canal of the distal metaphysis. This study compares the clinical, radiological, and functional outcomes of Intramedullary Interlocking (IMIL) Nailing versus Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO).**Materials and Methods:** A prospective comparative study was conducted involving 42 patients with extra-articular distal tibia fractures. Patients were divided into two groups: Group I (IMILN, n=21) and Group II (MIPPO, n=21). Parameters assessed included surgical time, time to union, weight-bearing progression, alignment, and complications. Functional outcomes were evaluated at 24 weeks using the Modified Klemm and Borner scoring system.**Results:** Demographics were comparable between both groups ($p > 0.05$). The IMILN group had significantly shorter operative times (58.5±10.2 min vs. 74.2±12.8 min; $p < 0.01$) and earlier weight-bearing. However, the MIPPO group demonstrated a significantly faster mean time to union (16.5±1.9 weeks vs. 18.8±2.4 weeks; $p = 0.01$) and superior anatomical alignment, with a lower incidence of malalignment (4.8% vs. 19.0%; $p = 0.04$). Anterior knee pain was significantly more common in the IMILN group (28.6% vs. 0%; $p < 0.01$). Final functional assessment revealed that 71.4% of the MIPPO group achieved "Excellent" results compared to 47.6% in the IMILN group, a difference that was statistically significant ($\chi 2= 8.64$, $p = 0.034$).**Conclusion:** While IMIL nailing allows for shorter surgical duration and earlier mobilization, the MIPPO technique is superior in achieving anatomical alignment and significantly better functional outcomes. By avoiding knee-entry morbidity and better stability in the metaphyseal flare make MIPPO a more effective modality for managing extra-articular distal tibia fractures.

Keywords: Distal Tibia Fracture, IMIL Nailing, MIPPO, Klemm and Borner Score, Malalignment.

INTRODUCTION

Distal metaphyseal fractures of the tibia—typically defined as injuries occurring within the 4–12 cm zone proximal to the plafond—present significant therapeutic hurdles (1). The region's limited vascularity, coupled with minimal anterior soft-tissue coverage and its subcutaneous position, elevates the risk of post-surgical complications, including delayed osseous union, infection, and wound dehiscence (2). Consequently, achieving a balance between rigid fixation and soft-tissue integrity remains a subject of ongoing debate(3).

Traditional open reduction and internal fixation (ORIF) allows for precise anatomical alignment but is often sidelined due to the high morbidity associated with extensive periosteal stripping and surgical trauma. Conversely, Intramedullary Interlocking (IMIL) nailing offers a biological advantage by preserving the fracture hematoma and providing relative stability; however, its utility is frequently hampered by concerns regarding malalignment and chronic post-operative knee pain (4,5) Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) has gained traction as a middle-ground strategy. By utilizing percutaneous tunnels, MIPPO maintains the local biological environment while

ensuring a stable biomechanical construct (6,7). Despite these benefits, challenges such as hardware prominence and localized skin complications persist

Despite advancements in various fixation techniques—including the use of poller screws, locking plates, and adjunct fibular fixation—the "gold standard" for extra-articular distal tibia fractures remains a subject of clinical controversy. Furthermore, patient comorbidities such as diabetes, peripheral vascular disease, and smoking history significantly influence the risk-benefit ratio of each approach.

The present study aims to evaluate and compare the functional outcomes (using the modified Klemm and Borner scoring system), union rates, and complication profiles of the MIPPO technique versus IMIL nailing in the treatment of distal tibia fractures.

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative study was conducted in the Department of Orthopaedics at Sree Mookambika Institute of Medical Sciences (SMIMS), Kulasekharam from January 2024 to December 2025. Following approval from the Institutional Human Ethical Committee and the Research Committee, patients presenting with extra-articular distal tibia fractures via the Outpatient Department (OPD) and Casualty were screened for enrollment.

Patient Selection and Sampling

A total of 42 patients were recruited using a non-probability sampling technique. Participants were allocated into two intervention cohorts:

- Group I (n=21): Managed with Intramedullary Interlocking (IMIL) Nailing.
- Group II (n=21): Managed with Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO).

Inclusion Criteria:

- Skeletally mature patients (>18 years).
- Extra-articular distal tibia fractures (AO/OTA Type 43A1, A2, A3).
- Closed fractures or Type 1 and 2 open fractures (Gustilo-Anderson classification).
- Acute injuries presented within 2 weeks of trauma.
- Distal fragments of at least 3 cm in length without articular incongruity.

Exclusion Criteria:

- Intra-articular extensions (AO Type B and C).
- Severe soft-tissue compromise (Gustilo-Anderson Type 3 and 4).
- Pathological fractures or pre-existing neurovascular deficits.
- Injury duration exceeding 14 days.

Pre-operative Protocol

Upon admission, patients were stabilized, and standard anteroposterior (AP) and lateral radiographs—including the knee and ankle joints—were obtained. Computed Tomography (CT) was utilized where necessary to rule out intra-articular extension. A posterior slab was applied for temporary immobilization. In cases of tenuous skin conditions, surgery was delayed until the appearance of the "wrinkle sign" to ensure soft-tissue viability. Prophylactic intravenous antibiotics were administered pre-operatively.

Surgical Techniques

IMIL Nailing Technique (Group I)

With the patient supine, a 5 cm vertical infrapatellar incision was made. Following a patellar tendon-splitting approach, the entry portal was established in the extra-articular "bare area" of the tibia, approximately 2 cm proximal to the tibial tuberosity.A ball-tip guide wire was passed across the fracture site after provisional reduction. Sequential reaming of the medullary canal was performed.A multidirectional interlocking nail of appropriate length and diameter was inserted. To counteract the "windshield wiper" effect in the wide metaphyseal flare, distal fixation involved multiple locking screws. In cases of persistent instability, Poller (blocking) screws were utilized to guide the nail and maintain coronal alignment.

MIPPO Technique (Group II)

Under tourniquet control, a 3–4 cm longitudinal incision was made over the medial malleolus, taking care to preserve the saphenous nerve and vein. An epiperiosteal, submuscular tunnel was created along the medial tibial surface using a blunt dissector or the plate itself. Indirect reduction was achieved via manual traction and percutaneous clamps under fluoroscopic guidance. An anatomically pre-contoured locking plate was slid into the tunnel. The plate was temporarily

secured with K-wires. Distal fixation was achieved with a combination of locking and non-locking screws, while proximal fixation utilized locking screws through stab incisions.

Post-operative Protocol and Rehabilitation

Postoperatively, all patients received a standardized regimen of intravenous antibiotics for three days, followed by oral antibiotics for an additional seven days. The operated extremity was initially stabilized in a posterior plaster of Paris (POP) slab and maintained in an elevated position to facilitate edema reduction. On the third postoperative day, the surgical site was inspected for wound healing, and baseline radiographs (AP and lateral views) were obtained to verify the maintenance of fracture reduction and implant positioning.

The rehabilitation protocol was tailored to the biomechanical nature of the internal fixation:

- Group I (IMIL Nailing): Due to the load-sharing nature of the intramedullary construct, patients were encouraged to begin active quadriceps and calf-strengthening exercises on the first postoperative day. Passive and active-assisted range of motion (ROM) of the knee and ankle commenced within the first week as tolerated by pain. Early partial weight-bearing was initiated as soon as the patient's pain subsided, typically within the first two weeks.
- Group II (MIPPO): Given the load-bearing nature of the plate construct, mobilization was more gradual. While early ankle and knee ROM were initiated within the first week, patients remained strictly non-weight-bearing for a period of 6 to 8 weeks. Progressive partial weight-bearing was introduced only after clinical and radiological evidence of early bridging callus formation was observed.

For both cohorts, full weight-bearing and resisted strengthening exercises were transitioned after the 12th week, once stable osseous union was confirmed.

Follow-up and Outcome Evaluation

Patients were monitored in the Outpatient Department (OPD) at 4, 8, 12, and 24 weeks. During these intervals, the following parameters were rigorously evaluated:

- Radiological Assessment: Serial radiographs were utilized to determine the time to bone union and to screen for any loss of reduction, malalignment (varus/valgus >5°), or hardware failure. Union was defined as the presence of bridging callus in three out of four cortices.
- Clinical and Functional Assessment: Functional outcomes were quantified at the six-month mark using the Modified Klemm and Borner Scoring System. This assessed the restoration of limb length, gait patterns, and the recovery of ankle range of motion.
- Pain and Weight-Bearing: Pain during mobilization was documented, and the time taken to achieve independent, pain-free full weight-bearing was recorded for both groups.
- Complications: The incidence of superficial or deep surgical site infections (SSI), hardware prominence (particularly in the MIPPO group), chronic knee pain (in the IMILN group), and occurrences of delayed or non-union were recorded throughout the follow-up period.

Statistical Analysis

The collected data were entered into MS Excel and analyzed using SPSS version 20.0. Quantitative variables (e.g., age, time to union) were expressed as mean ± standard deviation. Qualitative data between the two groups were assessed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Grade	Pain Status	Gait/Walking Ability	Range of Motion (ROM)	Muscle Atrophy
Excellent	No pain	Normal gait; no limp	Full ROM in knee and ankle	No muscle wasting
Good	Occasional mild pain	Nearly normal gait	Slight restriction (<25%)	Minor atrophy
Fair	Persistent pain with activity	Noticeable limp	Moderate restriction (25%–50%)	Visible atrophy
Poor	Constant pain	Cannot walk without support	Severe restriction (>50%)	Significant atrophy

Table 1: Klemm and Borner Scoring System

Parameters	Group I: IMILN (n=21)	Group II: MIPPO (n=21)	p-value
Age (Mean±SD)	38.4 ± 8.2	39.1±7.1	0.77
Gender (Male/Female)	13 / 8	12 / 9	0.75
Injured Side (Right/Left)	11 / 10	10 / 11	0.76

Mode of Injury (RTA/Fall)	16 / 5	15 / 6	0.73
AO Type (43A1/A2/A3)	9 / 7 / 5	8 / 7 / 6	0.85

Table 2: Baseline Demographic and Clinical Characteristics

Outcome Parameter	Group I: IMILN (n=21)	Group II: MIPPO (n=21)	p-value
Surgical Time (Minutes)	58.5±10.2	74.2±12.8	< 0.01*
Mean Time to Union (Weeks)	18.8±2.4	16.5±1.9	0.01*
Malalignment (> 5°)	4 (19.0%)	1 (4.8%)	0.04*
Full Weight-Bearing (Weeks)	12.4±1.5	15.1±1.8	< 0.01*
Ankle ROM (Total Arc)	42°±6°	48°±4°	0.02*

Table 3: Clinical and Radiological Outcomes

Grade	Group I: IMILN (n=21)	Group II: MIPPO (n=21)
Excellent	10 (47.6%)	15 (71.4%)
Good	7 (33.3%)	5 (23.8%)
Fair	3 (14.3%)	1 (4.8%)
Poor	1 (4.8%)	0 (0.0%)
Statistical Analysis: χ^2= 8.64; p = 0.034 (Statistically Significant)		

Table 4: Functional Outcome (Modified Klemm and Borner Score)

Complication	Group I (IMILN)	Group II (MIPPO)	p-value (χ2)
Anterior Knee Pain	6 (28.6%)	0 (0.0%)	< 0.01*
Infection (Superficial)	1 (4.8%)	2 (9.5%)	0.55
Hardware Prominence	0 (0.0%)	3 (14.3%)	0.07
Non-Union / Delayed Union	2 (9.5%)	0 (0.0%)	0.14

Table 5: Analysis of Postoperative Complications

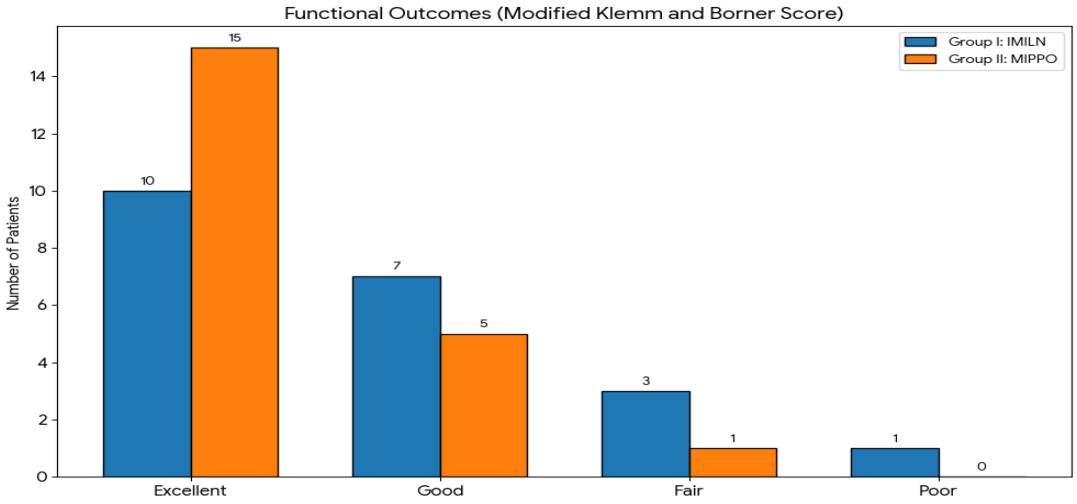


Figure 1: Functional outcome using Modified Klemm and Borner score

The graph clearly illustrates the superior functional performance of the MIPPO group, where 15 patients (71.4%) achieved an "Excellent" grade compared to only 10 patients (47.6%) in the IMILN group. Conversely, the IMILN group showed a higher distribution of "Fair" and "Poor" outcomes, primarily due to the limitations in achieving anatomical alignment and the presence of donor-site morbidity (anterior knee pain).

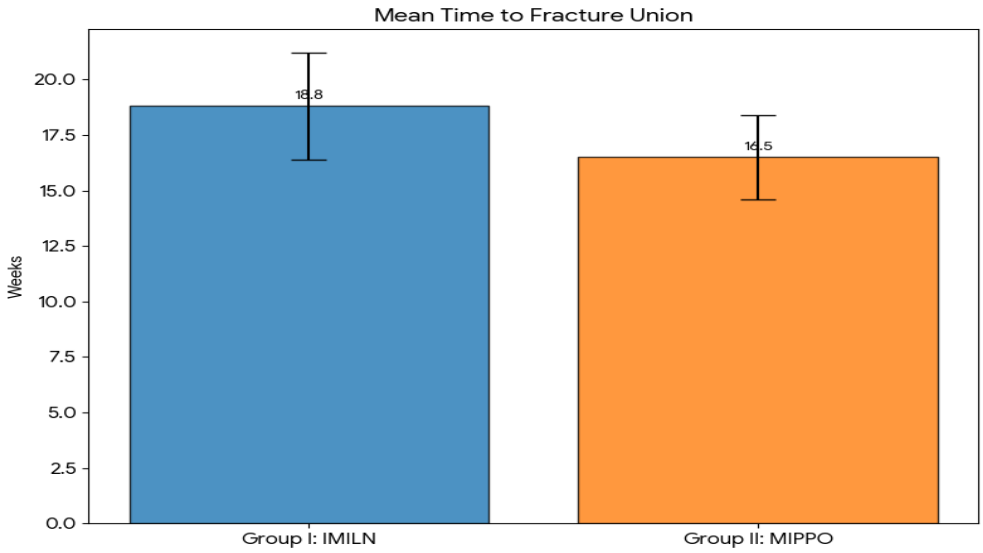
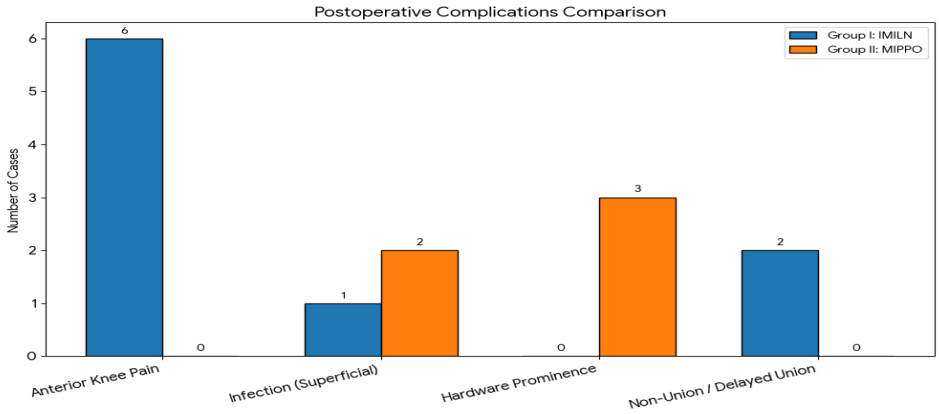


Figure 2 Mean Time to Fracture Union

The MIPPO group achieved osseous union significantly faster (16.5±1.9 weeks) than the IMILN group (18.8±2.4 weeks) with a p-value of 0.01. This indicates a statistically superior biological healing environment provided by the percutaneous plating technique.



Graph 3: Postoperative Complications Comparison

The incidence of anterior knee pain was significantly higher in the IMILN group compared to the MIPPO group ($p < 0.01$). Differences in infection rates and hardware prominence did not reach statistical significance ($p > 0.05$), representing standard trade-offs between the two modalities.

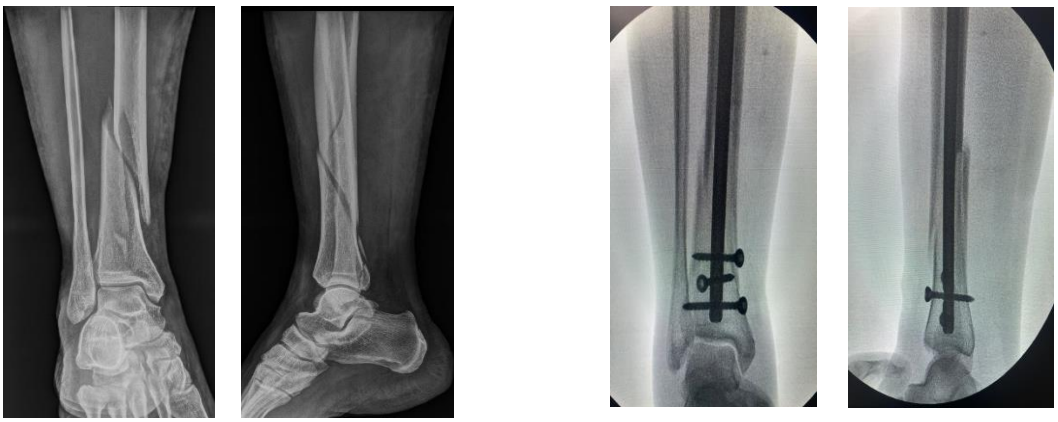


Figure 1 DISTAL TIBIA FRACUTRE WITH IMIL NAIL

Figure 2 DISTAL TIBIA FRACUTRE WITH MIPPO

RESULTS

A total of 42 patients met the inclusion criteria for extra-articular distal tibia fractures and completed the 24-week follow-up protocol. The study participants were equally distributed into two treatment cohorts: Group I (IMILN, n=21) and Group II (MIPPO, n=21). Baseline demographic data demonstrated no statistically significant differences between the groups, ensuring a comparable baseline for analysis ($p > 0.05$). The mean age was 38.4± 8.2 years for Group I and 39.1± 7.1 years for Group II. Male predominance was observed in both cohorts (57.1% and 52.4%, respectively), with road traffic accidents (RTA) identified as the primary mechanism of injury in over 70% of cases. Furthermore, no significant disparities were found regarding the injured side or the AO fracture classification distribution between the two groups.

Surgical and radiographic outcomes revealed distinct advantages for each modality. The IMILN group benefited from a significantly shorter operative duration (58.5± 10.2 minutes) compared to the MIPPO group (74.2± 12.8 minutes; $p < 0.01$). Additionally, Group I achieved full weight-bearing significantly earlier than Group II (12.4± 1.5 weeks vs. 15.1± 1.8 weeks; $p < 0.01$). However, the MIPPO group demonstrated superior radiographic and biological performance. The mean time to osseous union was significantly faster in the MIPPO cohort (16.5± 1.9 weeks) compared to the IMILN cohort (18.8± 2.4 weeks; $p = 0.01$). Anatomical alignment was also better maintained in the MIPPO group, which showed a significantly lower incidence of malalignment ($p = 0.04$) and a superior total arc of ankle range of motion ($p = 0.02$).

The analysis of postoperative complications further differentiated the two techniques. A statistically significant incidence of anterior knee pain was noted in the IMILN group, affecting 28.6% of patients, whereas no cases were reported in the MIPPO group ($p < 0.01$). Conversely, Group II (MIPPO) experienced a higher rate of hardware prominence (14.3%) compared to Group I (0.0%), though this did not reach statistical significance ($p = 0.07$). Rates of superficial infection (4.8% vs. 9.5%) and delayed union (9.5% vs. 0.0%) were comparable between the intramedullary and extramedullary modalities, showing no significant statistical variance.

Functional evaluation at the 24-week mark, conducted using the Modified Klemm and Borner Score, indicated a statistically superior functional profile for the MIPPO group. In Group II, 71.4% of patients attained an "Excellent" grade and 23.8% a "Good" grade. In contrast, Group I yielded 47.6% "Excellent" and 33.3% "Good" outcomes. Statistical analysis via the Chi-square test confirmed this difference was significant ($\chi2= 8.64$; $p = 0.034$), suggesting that the MIPPO technique provides a more favorable long-term functional recovery for extra-articular distal tibia fractures.

DISCUSSION

The management of distal third tibia fractures remains a significant challenge due to the subcutaneous nature of the bone, the precarious soft-tissue envelope, and the widening medullary canal of the distal metaphysis. In the present study, definitive surgical intervention was performed only after the "wrinkle sign" appeared, ensuring that limb edema had subsided. This standardized preoperative protocol optimized the biological environment for both **Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO)** and **Intramedullary Interlocking (IMIL) Nailing**.

The mean age of our cohort (Group I: 38.4 years; Group II: 39.1 years) aligns closely with findings by **Vallier et al. (8)** and **Collinge and Protzman (9)**, who reported mean ages of 39.1 and 43 years, respectively. The male predominance (57.1%) observed in our study mirrors trends noted by **Vallier et al. (8)** (69%) and **Collinge and Protzman (9)** (77%). High-energy road traffic accidents (RTA) were the primary mechanism of injury in over 70% of our cases, consistent with data from **Grose et al. (10)** (58%) and **Shrestha et al. (11)**. Regarding fracture morphology, our distribution of AO Type A fractures was consistent with the predominance of Type A1 injuries reported by **Shrestha et al. (11)**.

Our results show that the IMILN group achieved full weight-bearing significantly earlier (12.4 weeks) than the MIPPO group (15.1 weeks). This is consistent with **Daolagupu et al. (2)**, who observed that nailing facilitated earlier mobilization (10.09 weeks) compared to plating (13.38 weeks). However, despite the delayed weight-bearing in the MIPPO group—often necessary due to the load-bearing nature of the plate—the mean time to union was significantly shorter in the MIPPO cohort (16.5 ± 1.9 weeks). This clinical efficiency in healing is supported by **Fang et al. (12)** and **Cheng et al. (13)**, who argued that safeguarding the local biological environment through indirect reduction promotes faster osseous union. We observed one case of non-union in the IMILN group, a complication also noted by **Li et al. (14)**, which may result from poor bone quality or interference from fibular fixation.

Controlling the distal fragment within the metaphyseal flare remains a primary hurdle for intramedullary devices. We found a malalignment rate of 19.0% in the IMILN group compared to only 4.8% in the MIPPO group. This discrepancy is echoed by **Cheng et al. (13)**, who found higher malunion rates in nailing (13.4%) versus plating (4.3%). **Jose RS et al. (15)** noted that malunion rates in nailing can reach 58% due to the lack of "interference fit" between the nail and the wide distal canal.

While nailing is prized for preserving periosteal blood supply, **Bong et al. (16)** demonstrated that plating systems generally provide superior torsional and bending resistance in the distal region. Our findings confirm that the screw-plate interface in MIPPO acts as a more reliable internal template, reducing angular deformity. Although newer angle-stable screws and **Poller (blocking) screws** aim to mitigate these risks **(17)**, MIPPO remains more consistent in maintaining the mechanical axis.

Functional evaluation via the **Modified Klemm and Borner score** revealed a statistically significant advantage for the MIPPO group ($p = 0.034$). We achieved "Excellent" or "Good" results in 95.2% of the MIPPO group, comparable to the 90% reported by **Li et al. (14)**. Conversely, the 28.6% incidence of anterior knee pain in the IMILN group served as a major deterrent to recovery—a morbidity well-documented in nailing literature.

While **Lin et al. (3)** and **Hu et al. (1)** highlighted a higher risk of superficial infection with MIPPO, our rate (9.5%) was successfully managed with antibiotics and remained consistent with **Cheng et al. (13)**. Furthermore, unlike reports by **Hasenboehler et al. (19)** suggesting prolonged healing in bridging modes, our selective use of interfragmentary screws may explain the faster union times compared to studies requiring secondary bone grafting **(20, 21)**.

Limitations

The limitations of this study include the small sample size (n=42) and non-probability sampling. The 24-week follow-up, while sufficient for primary union, is inadequate for evaluating long-term secondary osteoarthritis. Additionally, the lack of blinding may introduce bias into the subjective functional scoring.

CONCLUSION

While IMIL nailing offers shorter surgical duration and earlier weight-bearing, the MIPPO technique is superior in maintaining anatomical alignment and achieving significantly better functional outcomes. By avoiding knee-entry morbidity and providing superior stability in the wide distal metaphysis, MIPPO is a highly effective modality for managing extra-articular distal tibia fractures.

REFERENCES

1. Hu LC, Xiong Y, Mi BB, et al. Comparison of intramedullary nailing and plate fixation in distal tibial fractures with metaphyseal damage: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2019;14:30. https://doi.org/10.1186/s13018-018-1037-1.
2. Daolagupu AK, Mudgal A, Agarwala V. A comparative study of intramedullary interlocking nailing and minimally invasive plate osteosynthesis in extra articular distal tibial fractures. Indian J Orthop. 2017;51:292–298. https://doi.org/10.4103/0019-5413.205674.
3. Lin ZQ, Zhang HZ, Luo GG, et al. Comparison of 3 treatment methods for distal tibial fractures: a network meta-analysis. Med Sci Monit. 2019;25:7480–7487. https://doi.org/10.12659/MSM.917311.
4. Obremskey WT, Medina M. Comparison of intramedullary nailing of distal third tibial shaft fractures: before and after traumatologists. Orthopedics. 2005;27:1180–1184. https://doi.org/10.3928/0147-7447-20041101-15.
5. Newman SD, Mauffrey CP, Krikler S. Distal metadiaphyseal tibial fractures. Injury. 2011;42:975–984. https://doi.org/10.1016/j.injury.2010.02.019.
6. Ronga M, Longo UG, Maffulli N. Minimally invasive locked plating of distal tibia fractures is safe and effective. Clin Orthop Relat Res. 2010;468:975–982. https://doi.org/10.1007/s11999-009-0991-7.
7. Zou J, Zhang W, Zhang CQ. Comparison of minimally invasive percutaneous plate osteosynthesis with open reduction and internal fixation for treatment of extra-articular distal tibia fractures. Injury. 2013;44:1102–1106. https://doi.org/10.1016/j.injury.2013.02.006.
8. Vallier HA, et al. A comparative study of plate versus nail fixation of distal tibia fractures. J Orthop Trauma. 2011;25(12):736–741.

9. Collinge C, Protzman R. Outcomes of percutaneous plating of distal tibia fractures. J Orthop Trauma. 2010;24(1):24–29.
10. Grose A, et al. Open reduction and internal fixation of tibial pilon fractures using a standard protocol. J Orthop Trauma. 2007;21(3):156–162.
11. Shrestha D, et al. Comparison of methods of fixation for distal tibia fractures. Kathmandu Univ Med J. 2014;12(46):119–125.
12. Fang C, et al. A prospective study of IM nailing versus MIPPO for distal tibial fractures. Orthop Traumatol Surg Res. 2016;102(2):203–208.
13. Cheng W, et al. Comparison of MIPPO and IMILN for distal tibia fractures: A meta-analysis. J Orthop Sci. 2011;16(2):211–218.
14. Li Y, et al. MIPPO versus IMILN for distal tibia fractures: A systematic review. Int J Surg. 2014;12(9):932–937.
15. Jose RS, Vivek K, Bava NK, Moosa MS. Functional Outcome of Intramedullary Interlocking Nailing Versus Minimally Invasive Percutaneous Plate Osteosynthesis in Distal Tibia Fracture. J Orthop Dis Traumatol. 2023;6(1):66–72. doi:10.4103/jodp.jodp_56_22.
16. Bong MR, Kummer FJ, Koval KJ, et al. Intramedullary nailing of the lower extremity: biomechanics and biology. J Am Acad Orthop Surg. 2007;15:97–106.
17. Hontzsch D, Blauth M, Attal R. Angle-stable fixation of intramedullary nails using the angular stable locking system. Oper Orthop Traumatol. 2011;23:387–396. https://doi.org/10.1007/s00064-011-0048-4.
18. Guo JJ, et al. A prospective randomized study comparing operative treatment with intramedullary nailing and plate fixation. J Bone Joint Surg Br. 2010;92(10):1421–1426.
19. Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. Injury. 2007;38:365–370. https://doi.org/10.1016/j.injury.2006.10.024.
20. Collinge C, Kuper M, Larson K, et al. Minimally invasive plating of high energy metaphyseal distal tibia fractures. J Orthop Trauma. 2007;21:355–361.
21. Gupta RK, Rohilla RK, Sangwan K, et al. Locking plate fixation in distal metaphyseal tibial fractures: series of 79 patients. Int Orthop. 2010;34:1285–1290. https://doi.org/10.1007/s00264-009-0880-4.