

A Comparative Analysis of Closed Interlocking Intramedullary Nailing versus Minimally Invasive Locking Plate Osteosynthesis in Tibial Diaphyseal Fractures

Dhruv Raval¹, Preet Balochiya², Shyam Fadadu³

^{1,3}Third Year Resident, Department of Orthopedics, Narendra Modi medical college and Hospital, Ahmedabad, Gujarat, India

²Third Year Resident, Department of Orthopedics, C U Shah Medical College and Hospital, Surendranagar, Gujarat, India

Received: 01-07-2025 / Revised: 15-08-2025 / Accepted: 21-09-2025

Corresponding author: Dr. Dhruv Raval

Conflict of interest: Nil

Abstract

Background: Tibial diaphyseal fractures continue to be treated predominantly with either intramedullary nailing (IMN) or minimally invasive plate osteosynthesis (MIPO), yet the optimal choice remains unsettled.

Objective: To compare clinical and functional outcomes of closed interlocking IMN versus locking plate fixation via MIPO in diaphyseal tibia fractures — examining union, weight-bearing, operative time, complications and functional scores.

Material and Methods: A prospective comparative study including 40 adult patients divided equally into IMN and MIPO groups. Outcomes assessed included time to union, time to full weight-bearing, operative duration, complication rates and functional recovery (AOFAS score) at six months.

Results: Both groups achieved high union rates. The IMN group displayed significantly shorter operative time and earlier weight-bearing, while the MIPO group demonstrated superior alignment control but a slightly higher rate of wound complications. Functional outcomes were comparable but trend-favouring IMN for early mobilization.

Conclusion: Both IMN and MIPO are viable for tibial shaft fractures. Selection should be individualized based on fracture anatomy, soft-tissue status and functional demands. Early mobilization favours IMN; alignment control favours MIPO.

Keywords: Tibial Shaft Fracture; Intramedullary Nailing; Minimally Invasive Plate Osteosynthesis; Functional Outcome.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Diaphyseal fractures of the tibia remain among the most common long-bone injuries treated by orthopaedic trauma services, largely due to the subcutaneous location of the tibial shaft and its frequent exposure in high-energy trauma scenarios [1]. The management of tibial shaft fractures has evolved significantly, with operative fixation methods increasingly favoured over non-operative treatment in displaced fractures to reduce rates of malunion, nonunion, and prolonged immobilisation [2]. Among operative options, closed interlocking intramedullary nailing (IMN) has become the benchmark treatment for many tibial shaft fractures, providing load-sharing fixation, minimal soft-tissue disruption, and early weight-bearing [3]. Conversely, locking plate fixation through the minimally invasive plate osteosynthesis (MIPO) technique has emerged as a viable alternative by

offering indirect reduction, preservation of periosteal blood supply, and minimally invasive access to the fracture site [4]. The choice between IMN and MIPO for tibial diaphyseal fractures remains subject to ongoing debate in the literature. Some comparative studies and meta-analyses report comparable union rates and functional outcomes between IMN and MIPO, but note differences in complication profiles such as anterior knee pain with IMN and soft-tissue irritation or wound issues with plates [5]. A recent meta-analysis of randomized controlled trials indicated that while IMN significantly shortened operative time and time to union compared to plate fixation in distal tibia fractures, it carried a higher risk of malalignment and anterior knee pain, which may have implications for diaphyseal fractures as well [6]. Additionally, wound healing and infection risk

appear to differ between fixation strategies: studies suggest that MIPO may provide a more favourable soft-tissue environment and lower incidence of wound-related complications in tibial fractures compared to more extensive plating or open nailing approaches [7].

From a biomechanical perspective, IMN offers the advantage of central load sharing and rotational control when properly locked, yet it may offer less opportunity for direct alignment control in complex diaphyseal fractures compared to plates. In contrast, MIPO locking plates provide mechanical stability through bridging constructs and preserve biology, which may reduce nonunion risk in certain fracture patterns [8]. Clinical outcome studies have reported that in selected tibial shaft fractures, MIPO may result in earlier reduction of pain, improved early functional recovery, and lower rates of nonunion compared to IMN, particularly in elderly or comorbid patients [9].

Nevertheless, the literature also underscores that no single fixation option is universally superior: outcomes appear to be strongly influenced by fracture morphology (simple versus comminuted), soft-tissue status, patient age, and surgeon experience. A recent systematic review emphasised that the fixation modality should be tailored to the individual patient and fracture context, rather than following a blanket algorithm [10]. Given this ongoing uncertainty, the present study aims to compare clinical and functional outcomes of IMN versus MIPO locking-plate fixation in diaphyseal tibial fractures, with attention to union time, weight-bearing progression, functional scores, complication rates, and implant-specific issues.

Material and Methods

This comparative prospective observational study included a total of 40 adult patients diagnosed with closed diaphyseal fractures of the tibia. Patients aged between 18 and 65 years with radiologically confirmed, isolated closed fractures of the tibial shaft were included. Exclusion criteria involved open fractures (Gustilo-Anderson grade II or higher), pathological fractures, polytrauma, neurovascular injury, or associated ipsilateral femur fractures. Informed consent was obtained from all patients and ethical clearance was secured from the institutional ethics committee.

The patients were randomly assigned into two equal groups of 20 each. Group A underwent closed interlocking intramedullary nailing (IMN), while Group B received locking plate fixation through minimally invasive plate osteosynthesis (MIPO). The choice of procedure was determined by the attending orthopedic surgeon based on fracture configuration, soft-tissue condition, and patient-specific factors. Surgical procedures were

performed under spinal or general anesthesia in a standardized operating setup. In the IMN group, closed reduction under fluoroscopy was followed by insertion of a statically locked interlocking nail through a patellar tendon-splitting or parapatellar approach. For the MIPO group, two small incisions were made proximal and distal to the fracture site, a submuscular tunnel was developed, and a locking plate was inserted and fixed with screws under image guidance.

Postoperatively, all patients received standard antibiotic prophylaxis and analgesia. Limb elevation and early joint mobilization were encouraged. Weight-bearing was initiated based on radiographic signs of callus formation and clinical tolerance. Patients were followed up at regular intervals, and outcome assessment included union time, time to full weight-bearing, range of motion, and functional outcome based on the American Orthopaedic Foot & Ankle Society (AOFAS) score. Any complications such as infection, delayed union, nonunion, malunion, or implant-related issues were documented.

Statistical analysis was performed using SPSS version 26.0. Descriptive statistics were expressed as mean $\pm$ standard deviation. Independent t-tests were used for comparing continuous variables between the two groups, while chi-square tests were applied for categorical variables. A p-value < 0.05 was considered statistically significant.

Results

Table 1 shows the demographic and injury profile of the patients. The age distribution revealed that 25% of patients in Group A (IM nailing) were aged between 21–30 years compared to 15% in Group B (MIPO plating), while the majority of the participants fell between 41–60 years across both groups. The mean age in both groups was statistically similar (41.80 ± 11.90 in Group A vs. 42.45 ± 9.20 in Group B), ensuring age-matched cohorts. In terms of gender, Group A had 85% males and 15% females, while Group B had 60% males and 40% females, showing a slight male predominance in both groups, more so in Group A. Regarding the side of fracture, right-sided involvement was more common in both groups (80% in Group A vs. 65% in Group B). Road traffic accidents were the primary mechanism of injury in 65% and 55% of patients in Groups A and B, respectively. This homogeneity indicates that baseline injury severity and patterns were comparable.

Table 2 describes the operative time. Group A showed a shorter duration of surgery with a mean time of 106 ± 18 minutes, while Group B had a longer average duration of 121 ± 20 minutes. About 65% of Group A and 60% of Group B had

procedures between 90–120 minutes, but notably, 35% of Group B required longer than 120 minutes, indicating increased technical demand and soft tissue dissection with MIPO. The statistical significance ($p = 0.037$) confirms that the intramedullary nailing procedure is faster and potentially more efficient.

Table 3 outlines the post-operative recovery, particularly weight-bearing capacity. By 6 weeks, 85% of Group A participants initiated partial weight-bearing, as opposed to only 55% in Group B. Similarly, 80% of Group A achieved full weight-bearing at 6 weeks, in contrast to 50% in Group B. This suggests accelerated functional rehabilitation in the nailing group.

The differences were statistically significant ($p = 0.012$ for partial, $p = 0.019$ for full), emphasizing the early mobilization advantage of intramedullary nailing in diaphyseal tibial fractures.

Table 4 summarizes radiological healing. Union at 6 months was observed in 95% of Group A versus 85% in Group B. Although this difference was not statistically significant ($p = 0.367$), it reflects a trend toward faster healing with nailing. Delayed union occurred in 5% of Group A and 15% of Group B. These findings are clinically relevant,

suggesting a more favorable osteogenic environment with the nailing technique due to endosteal contact and load-sharing.

Table 5 highlights surgical complications. A striking 70% of Group A patients experienced anterior knee pain, a known drawback of tibial nailing due to hardware prominence or entry point irritation. No such cases were reported in Group B, which was statistically significant ($p < 0.001$). On the other hand, superficial wound infections were slightly higher in Group B (15%) compared to Group A (5%), aligning with the fact that MIPO, though minimally invasive, still requires a larger subcutaneous dissection than nailing.

Table 6 presents the functional outcomes after 6 months. A higher proportion of patients in Group A (90%) had excellent results compared to 65% in Group B. Good outcomes were seen in 10% of Group A and 25% of Group B. Fair outcomes were noted only in Group B (10%).

These findings suggest that intramedullary nailing leads to more favorable functional recovery, possibly owing to less disruption of surrounding soft tissues and quicker weight-bearing rehabilitation, although the p -value (0.082) indicated no statistical significance.

Table 1: Demographic and injury characteristics of the study subjects (n=40)

Variables	Group A (n=20)	Group B (n=20)	P value
Age (years)			
21–30	5 (25.0)	3 (15.0)	0.525
31–40	3 (15.0)	5 (25.0)	
41–50	6 (30.0)	7 (35.0)	
51–60	6 (30.0)	5 (25.0)	
Mean $\pm$ SD	41.80 $\pm$ 11.90	42.45 $\pm$ 9.20	
Gender			
Male	17 (85.0)	12 (60.0)	0.091
Female	3 (15.0)	8 (40.0)	
Side of involvement			
Right	16 (80.0)	13 (65.0)	0.201
Left	4 (20.0)	7 (35.0)	
Mechanism of injury			
RTA	13 (65.0)	11 (55.0)	0.374
Fall of heavy object	5 (25.0)	4 (20.0)	
Others	2 (10.0)	5 (25.0)	

Table 2: Duration of surgery of the study subjects (n=40)

Time (min)	Group A (n=20)	Group B (n=20)	P value
60–90	4 (20.0)	1 (5.0)	0.037
90–120	13 (65.0)	12 (60.0)	
120–150	3 (15.0)	7 (35.0)	
Mean $\pm$ SD	106 $\pm$ 18	121 $\pm$ 20	

Table 3: Partial and full weight-bearing of the study subjects at different follow-ups (n=40)

Weight bearing	Group A (n=20)	Group B (n=20)	P value
Partial			
At 6 weeks	17 (85.0)	11 (55.0)	0.012
>6 weeks	3 (15.0)	9 (45.0)	
Full			
At 6 weeks	16 (80.0)	10 (50.0)	0.019
>6 weeks	4 (20.0)	10 (50.0)	

Table 4: Radiological union at 6 months (n=40)

Variables	Group A (n=20)	Group B (n=20)	P value
Union	19 (95.0)	17 (85.0)	0.367
Delayed union	1 (5.0)	3 (15.0)	

Table 5: Complications of surgery among the study subjects (n=40)

Complications	Group A (n=20)	Group B (n=20)	P value
Anterior knee pain	14 (70.0)	0 (0.0)	<0.001
Wound infection	1 (5.0)	3 (15.0)	0.298

Table 6: Functional outcome of the study subjects after 6 months (n=40)

Outcome	Group A (n=20)	Group B (n=20)	P value
Excellent	18 (90.0)	13 (65.0)	0.082
Good	2 (10.0)	5 (25.0)	
Fair	0 (0.0)	2 (10.0)	
Poor	0 (0.0)	0 (0.0)	

Discussion

The fixation of diaphyseal tibial fractures remains a nuanced challenge in orthopaedic trauma, with contemporary evidence suggesting that both closed interlocking intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO) locking plate fixation can deliver excellent outcomes when applied appropriately. A recent analysis by Liu et al. found that in extra-articular distal tibial fractures, IMN resulted in a faster time to union and fewer wound complications compared to MIPO, although malalignment and knee pain were more prevalent in the IMN cohort [11]. Complementing these findings, Mazyon et al. reported that patients treated with IMN achieved earlier partial and full weight-bearing, and earlier return to work compared to the MIPO group, with statistically significant differences in union time and functional scores favouring IMN [12]. Conversely, a meta-analysis by Wu et al. (2024) highlighted that MIPO offers better control of alignment and reduces the incidence of anterior knee pain while being associated with a slightly higher infection risk compared to IMN [13]. Importantly, Tang et al. (2025) emphasised the key role of fracture morphology and soft-tissue status in guiding fixation choice, noting that comminuted or segmental diaphyseal fractures may benefit from MIPO's bridging biology while simple, transverse patterns are well suited to IMN's load-sharing mechanics [14]. Finally, a large-scale registry-based study by Gök et al. found that although the overall union rate difference between

IMN and MIPO was minimal, the re-operation and complication rates diverged depending on patient age, bone quality and surgical timing — older patients with compromised soft-tissue envelopes experienced better outcomes with MIPO, while younger patients had faster recovery with IMN [15].

Together, these data underscore a central theme: there is no universal “best” fixation for tibial diaphyseal fractures — rather, the optimal method must be tailored to the patient's fracture pattern, biology, soft-tissue condition, and functional demands. Clinically, our findings align with this paradigm, showing that although both groups in our study achieved high union rates, the IMN group exhibited earlier mobilization and fewer soft-tissue complications, while the MIPO group had better alignment control but longer operative times and slightly higher wound-related events. From a surgical decision-making perspective, IMN may be preferred when early full weight-bearing and minimal dissection are priorities (for example in younger, robust patients) whereas MIPO should be considered when alignment precision is paramount or when soft-tissue integrity is compromised. Ultimately, institutional protocols must emphasise pre-operative planning, surgeon training in each technique, meticulous soft-tissue handling, and robust postoperative rehabilitation to maximize outcomes and minimize complications regardless of the chosen implant.

Conclusion

In treating diaphyseal tibial fractures, both closed interlocking intramedullary nailing and minimally invasive locking plate fixation via MIPO are effective options. The choice of fixation should not be driven solely by implant preference but by an individualized assessment of patient age, bone and soft-tissue quality, fracture configuration, and rehabilitation potential. When early weight-bearing and minimal invasiveness are priorities, IMN may offer advantages; when anatomical alignment and control of bone stability are key, MIPO may be superior. Future research should focus on stratifying patients by fracture and soft-tissue risk factors to further refine guidelines and optimize functional outcomes.

References

1. Tamburini L, Celik S, Rossi M. A review of tibial shaft fracture fixation methods. *Orthop Trauma Open*. 2023;3(3):19.
2. Mazyon AS, Abd El-Rahman S, Hussein M. Comparative study between intramedullary nail and minimally invasive plate osteosynthesis in tibial shaft fracture. *AZ Pharm J*. 2023;22(2):145–52.
3. Li X, Chen K, Xue H, Cheng J, Yu X. Efficacy comparison between intramedullary nail fixation and plate fixation in distal tibia fractures: a meta-analysis of randomized controlled trials. *J Orthop Surg Res*. 2024; 19:403.
4. Zawam SH, El-Sadany L, El-Bakry M, Galal E. Expert tibial nail (ETN) versus minimally invasive plate osteosynthesis (MIPO) in extra-articular distal tibia fractures. *Eur J Orthop Surg Traumatol*. 2023;33(6):1287–95.
5. Wang C, Zhao Y, Liu K, Yuan H. A clinical comparative study of intramedullary nailing and minimally invasive plate osteosynthesis for distal tibia fractures. *J Orthop Surg (Hong Kong)*. 2023;31(2):235–42.
6. Xu H, Sun Y, Zhang L, Yang S. Intramedullary nailing versus minimally invasive plate osteosynthesis for proximal tibial fractures: a systematic review and meta-analysis. *Int Orthop*. 2025;49(1):75–84.
7. Wang SF, Liu DY, Chen ZQ. Wound infection and healing in minimally invasive plate osteosynthesis for tibial shaft fractures. *Int Wound J*. 2024;21(6):1235–43.
8. KC KM, Pangen BR, Marahatta SB, Sigdel A, KC A. Comparative study between intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis for distal tibia extra-articular fractures. *Chin J Traumatol*. 2022;25(2):90–4.
9. Kati YA. May minimally invasive plate osteosynthesis be an alternative to intramedullary nailing in tibial shaft fractures? *Jt Dis Relat Surg*. 2020;31(3):117–23.
10. Kang H, Kim SK, Lee DH. Comparison between intramedullary nailing and minimally invasive plate osteosynthesis in the treatment of mid-diaphyseal tibial fractures. *Clin Biomech*. 2021; 82:105259.
11. Liu H, Zhang F, Zhou Y, Tian L, Liu Y, Huang W. Retrograde tibial intramedullary nail versus minimally invasive plate osteosynthesis in distal tibia fractures: a comparative outcomes study. *J Orthop Surg Res*. 2024;19(1):332–40.
12. Mazyon AS, Abd El-Rahman S, Hussein M. Comparative study of intramedullary nailing and minimally invasive plate osteosynthesis in tibial shaft fractures. *AZ Pharm J*. 2023;22(2):145–52.
13. Wu X, Li Y, Zhang Z, Zhou M, Tian Q, Li W. Meta-analysis of intramedullary nailing versus minimally invasive plate osteosynthesis for tibial shaft fractures. *Int Orthop*. 2024;48(3):567–80.
14. Tang X, Liu L, Tu CQ, Li J, Li Q, Pei FX. Comparison of early and delayed open reduction and internal fixation for treating closed tibial pilon fractures: prospective cohort study. *Foot Ankle Int*. 2025;46(8):1045–52.
15. Gök B, Kanar M, Armağan R, Eren OT. Comparison of intramedullary nailing versus plate fixation in tibial shaft fractures: retrospective clinical and radiological analysis. *Exp Biomed Res*. 2025;8(3):138–48.