TPM Vol. 32, No. S5, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

# COMPARATIVE ANALYSIS OF OPEN REDUCTION PLATE OSTEOSYNTHESIS AND CLOSED REDUCTION IMIL NAILING FOR EXTRA-ARTICULAR DISTAL TIBIA FRACTURES

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**Abstract**
Distal tibia fractures provide considerable difficulties in orthopedic trauma surgery owing to their intricate anatomy, inadequate soft tissue covering, and elevated risk of sequelae. This prospective comparative study, carried out at Saveetha Medical College and Hospital from January 2023 to January 2025, assessed 60 patients with extra-articular distal tibial fractures treated with either open reduction and internal fixation (ORIF) utilizing plate osteosynthesis (Group A, n=30) or closed reduction and internal fixation with intramedullary interlocking (IMIL) nailing (Group B, n=30). Patients were evaluated for time to union, complications, and functional results using the American Orthopaedic Foot and Ankle Society (AOFAS) and Olerud-Molander Ankle Score (OMAS). The results indicated a significantly reduced mean operative duration (72.4 vs. 92.5 minutes, $p<0.001$), expedited radiological union (18.5 vs. 20.8 weeks, $p=0.02$), superior functional scores (AOFAS: 88.6 vs. 85.2, $p=0.04$; OMAS: 85.4 vs. 81.6, $p=0.03$), and a lower incidence of wound-related complications (3.3% vs. 13.3%, $p=0.04$) in the nailing cohort. Nonetheless, plating yielded enhanced radiological alignment with a reduced incidence of malalignment (3.3% vs.10%). One patient in each group had nonunion. Both procedures demonstrated efficacy; however, IMIL nailing provided benefits in expedited healing, less wound morbidity, and superior functional results, while plating guaranteed accurate anatomical reduction. These data indicate that fixing selection should be tailored according to fracture morphology, osseous integrity, and patient-specific needs.
**Keywords:** Distal tibia fracture; Extra-articular fracture; Open reduction internal fixation (ORIF); Plate osteosynthesis; Intramedullary interlocking nailing (IMIL); Fracture union; Functional outcome; Orthopaedic trauma

## INTRODUCTION

Fractures of the distal tibia represent one of the most intricate injuries in orthopaedic trauma surgery, posing considerable obstacles for diagnosis and therapy. The tibia is the most frequently broken long bone in the human body, accounting for roughly 17–21% of all long bone fractures, with injuries to its distal third constituting around 7–10% of tibial fractures (Joveniaux et al., 2010; Thompson et al., 2025). Among them, extra-articular distal tibia fractures are notably prevalent owing to the distinctive anatomical and biomechanical characteristics of the tibia. The subcutaneous positioning of its medial surface, the restricted muscular coverage, and the relatively inadequate vascular supply in the distal segment often result in these fractures being linked to significant soft tissue damage, prolonged healing, and elevated complication rates compared to diaphyseal or proximal tibial fractures (Chauhan et al., 2025; Hoenig et al., 2010). Distal tibia fractures often result from high-energy trauma, including vehicular accidents, athletic injuries, or falls from elevation; however, low-energy mechanisms, especially in osteoporotic individuals, are also prevalent. These injuries often accompany considerable comminution, metaphyseal extension, and simultaneous fibular fractures (Bister et al., 2022). The distinctive anatomical configuration of the distal tibia marked by metaphyseal flare, reduced cortical bone thickness, and its adjacency to the ankle joint makes reduction and fixation technically challenging. Even a slight malreduction or malalignment of a few degrees in this area can severely disrupt ankle mechanics, leading to altered gait, premature arthritis, and long-term functional impairment (Pflüger et al., 2023; Robinson et al., 1995). The objectives of therapy for distal tibia fractures are well defined: to restore anatomical

alignment, maintain fracture biology, provide enough stability for bone healing, and facilitate early functional rehabilitation. The ideal fixation mechanism continues to be a topic of active discussion. Conservative therapy of extra-articular fractures historically led to extended immobilisation, joint stiffness, malunion, and suboptimal functional results. Advancements in surgical procedures and implant design have made operative treatment the preferred strategy, with open reduction and internal fixation (ORIF) using plate osteosynthesis and closed reduction with intramedullary interlocking (IMIL) nailing as the two primary alternatives. Open Reduction and Internal Fixation (ORIF) with plate fixation provides the benefit of direct fracture viewing, facilitating accurate anatomical reduction, particularly in comminuted and displaced fractures (Box et al., 2024; Burnei et al., 2011). The use of contemporary pre-contoured locking compression plates (LCP) offers angular stability and aids in sustaining a decrease in osteoporotic and metaphyseal bone. The conventional open plating method requires extensive soft tissue dissection, periosteal stripping, and disruption of the fracture hematoma, which might jeopardise local vascularity and increase the risk of problems such as infection, wound necrosis, delayed union, or nonunion (Ring et al., 2004; Sommer et al., 2004). The minimally invasive plate osteosynthesis (MIPO) approach has been increasingly recommended to address these difficulties. MIPO safeguards the periosteal vascular supply, sustains fracture biology, and mitigates wound-associated problems. Nonetheless, despite MIPO, hazards persist, including hardware prominence, protracted healing owing to extreme stiffness of the build, and elevated implant expenses (Andalib et al., 2017; Shakya et al., 2025). Intramedullary nailing has emerged as the gold standard for diaphyseal tibial fractures and is being used for distal tibial fractures as well. The method is minimally invasive, maintains soft tissue integrity, and offers a load-sharing structure that facilitates secondary bone repair via callus development. IMIL nailing facilitates early mobility and weight-bearing, which is especially beneficial for young, energetic patients and in circumstances where extended immobilisation is unwelcome (Andalib et al., 2017; Shakya et al., 2025). Notwithstanding these benefits, the fixing of distal tibia fractures with nails is technically challenging. The metaphyseal flare of the distal tibia offers little cortical contact, and the abbreviated distal fragment complicates the achievement of sufficient distal locking. Malalignment, especially valgus, recurvatum, or rotational abnormalities, is a well-described problem. Nail insertion may result in anterior knee discomfort and, in some instances, complications in managing comminuted pieces adjacent to the ankle joint (Iqbal & Pidikiti, 2013; Sağlam et al., 2021). Numerous studies have attempted to evaluate plate osteosynthesis with intramedullary interlocking nailing for distal tibia fractures; yet, the findings remain incongruous. Certain studies advocate for plate fixation due to its enhanced capacity to attain anatomical alignment and superior early functional outcomes; however, others indicate that intramedullary interlocking nailing reduces operation duration, blood loss, length of hospital stay, and wound-related problems (Kc et al., 2022). A meta-analysis indicated similar union rates for both techniques, although it highlighted increased malalignment associated with nailing and elevated infection risks linked to plating. More rapid time to union with intramedullary interlocking nailing; however, superior radiological alignment with plating. The absence of agreement in the literature highlights the need for more comparative investigations (Liu et al., 2023). The diversity in research designs, patient demographics, fracture classifications, and surgical methodologies fuels the persistent debate. Since both techniques are extensively used globally, it is crucial to create clearer standards about their relative effectiveness, complication profiles, and functional results to enhance patient care. Given the intricate architecture of the distal tibia, the elevated risk of complications, and the absence of a generally endorsed fixation approach, it is essential to provide substantial clinical data comparing the two prevalent surgical techniques plate osteosynthesis (ORIF) and intramedullary interlocking nailing (IMIL) (Motififard et al., 2024). This study aims to offer valuable insights into the optimal management strategy for extra-articular distal tibia fractures by systematically analysing parameters such as time to union, incidence of malalignment, infection rates, soft tissue complications, necessity for secondary procedures, and functional outcomes. This comparative research will aid in settling the continuing controversy and assist orthopaedic surgeons in making evidence-based treatment choices, thereby enhancing patient outcomes and diminishing morbidity related to these complex injuries. A Midsummer Night's Dream by William Shakespeare is playfully written about the exploration of love, marriage, and the unrealistic expectations that can inexorably come along with them. This essay will explore how marriage is portrayed as limiting and difficult but ultimately worthwhile. Commensurate with its origins in a court marriage, this drama speaks throughout for a sophisticated Renaissance philosophy of the nature of love in both its rational and irrational forms. This is shown by depicting that there then existed a significant disparity in the expectations placed on men and women. Hermia embodies this struggle as she defies her father Egeus's wishes to marry Demetrius, showcasing her desire for autonomy and true love rather than just fulfilling only her duty to her society. Conversely, men are generally afforded a broader range of achievements and aspirations. They are encouraged to pursue careers, adventures, and personal accomplishments that can lead to social recognition. Demetrius, for instance, initially pursues Hermia out of a sense of entitlement, thinking he can claim her because that is what society expects of her. Another example is the marriage of Theseus and Hippolyta. Their relationship is rooted in conquest

and power dynamics, which reflect the expectations of a hierarchical society. Theseus, as the Duke of Athens, represents a figure signifying his authority, and his marriage to a conquered queen, Hippolyta, suggests that marriage can also be about control and possession rather than something much purer.

## MATERIALS AND METHODS

This study was a prospective comparison research carried out at the Department of Orthopaedics at Saveetha Medical College and Hospital, Chennai, during a two-year period from January 2023 to January 2025. The research included 60 patients with extra-articular distal tibial fractures, categorized into two groups of 30 individuals each. All patients had comprehensive clinical assessments, initial hematological tests, and radiographic examinations (anteroposterior and lateral X-rays of the tibia, including the knee and ankle). Fractures were categorized using the AO/OTA classification method. Patients were alternatively assigned to two groups (Group A and Group B) for further care.

**Group A (Open reduction and Internal fixation (ORIF) with Plate Osteosynthesis):** Patients were operated on using either an anteromedial or minimally invasive percutaneous osteosynthesis (MIPO) approach depending on soft-tissue status. Standard low-profile distal tibial locking compression plates (LCP) were used, and fixation of the fibula was done when indicated for restoration of alignment and stability.

**Group B (Closed reduction and Internal fixation (CRIF) with IMIL Nailing):** Patients had surgery with closed reduction with fluoroscopic assistance. Both suprapatellar and infrapatellar methods were evaluated, indicating a preference for the suprapatellar technique in cases with distal fractures. Blocking screws were used as necessary to avert malalignment. Nails having a minimum of 2–3 multiplanar distal interlocking alternatives were selected.Patients had surgery with closed reduction with fluoroscopic assistance. Both suprapatellar and infrapatellar methods were evaluated, indicating a preference for the suprapatellar technique in cases with distal fractures. Blocking screws were used as necessary to avert malalignment. Nails having a minimum of 2–3 multiplanar distal interlocking alternatives were selected.

**Inclusion Criteria**

1. Patients aged 18 to 65 years (both female and male) with recent, closed extra-articular distal tibial fractures (AO/OTA 43-A).
2. Fractures located 5–7 cm from the distal tibial articular surface, excluding involvement of the tibial plafond.
3. Patients who are medically suitable for surgery and have provided agreement to participate.

**Exclusion Criteria**

1. Open fractures (Gustilo–Anderson Classification Grade II and above).
2. Intra-articular distal tibial fractures (AO/OTA 43-B and 43-C).
3. Pathological fractures (excluding osteoporosis).
4. Polytrauma individuals exhibiting life-threatening injuries.
5. Patients with concomitant ipsilateral femoral or pedal fractures.
6. Patients with pre-existing ankle abnormalities or persistent infections in the afflicted extremity.

Postoperatively, all patients were given intravenous antibiotics for 48 hours and instructed to elevate the limb. Early mobilization of the ankle and knee was advocated as permitted. Partial weight-bearing commenced with radiographic evidence of bridge callus development across a minimum of three cortices (typically 6–8 weeks) and clinically by the lack of discomfort at the fracture site. Commence complete weight-bearing contingent upon the healing of the fracture.

Patients had follow-up assessments at 6 weeks, 3 months, 6 months, and 12 months, including both clinical and radiological evaluations. Functional results were evaluated with the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score and the Olerud-Molander Ankle Score (OMAS). Complications including malalignment, non-union, delayed union, superficial or deep infection, wound complications, and implant-related issues were documented.

**Statistical Analysis**

Data were entered into Microsoft Excel 2019 and analyzed using SPSS software version 25.0. Continuous variables such as age, time to union, and functional scores (AOFAS, OMAS) were reported as mean ± standard deviation (SD) and evaluated across the two groups using the unpaired Student's t-test. Categorical data, such as sex distribution, fracture type, and the presence of complications (malunion, infection, delayed union, implant failure), were expressed as percentages and evaluated using the chi-square test or Fisher's exact test, as appropriate. A p-value below 0.05 was considered statistically significant.

## RESULTS

This research comprised 60 patients with extra-articular distal tibial fractures, divided into two groups of 30 each (Group A – Plate Osteosynthesis, Group B – IMIL Nailing). The average age of patients in the plating group was 41.2 years (range 22–63 years), whereas in the nailing group it was 39.6 years (range 20–61 years), with no statistically significant difference seen between the two groups ($p = 0.48$). Both groups exhibited a male predominance (Plating: 20/30; Nailing: 18/30). The predominant cause of injury was road traffic accidents (70%), followed by falls from height (30%). The average operational duration was much greater in the plating cohort (92.5 ± 15.3 minutes) than in the nailing cohort (72.4 ± 12.6 minutes) ($p < 0.001$). The average time to radiological union was 20.8 ± 3.5 weeks for the plating group and 18.5 ± 2.9 weeks for the nailing group, indicating faster healing in the nailing group ($p = 0.02$), as seen in Figure 1. At the 12-month functional assessment, the mean AOFAS score was 85.2 ± 6.4 for the plating group and 88.6 ± 5.8 for the nailing group ($p = 0.04$), as seen in Figure 2. The mean OMAS score was 81.6 ± 7.2 for the plating group and 85.4 ± 6.9 for the nailing group ($p = 0.03$), indicating a preference for nailing. Regarding complications, wound-related issues, including infections (shown in Figure 3), were much more prevalent in the plating group (4 cases; 13.3%) than in the nailing group (1 case; 3.3%) ($p = 0.04$). Figure 4 indicates that malalignment (>5° angular deformity) occurred more often in the nailing group (3 cases; 10%) than in the plating group (1 case; 3.3%). Non-union occurred in two patients, one from each group. No instances of severe illness or implant malfunction were documented.

**Table 1. Demographic Profile of Patients**

| Parameter | Plating (n=30) | Nailing (n=30) | p-value |
|---|---|---|---|
| **Mean Age (years)** | 41.2 ± 10.4 | 39.6 ± 9.8 | 0.48 |
| **Male : Female** | 20 : 10 | 18 : 12 | 0.60 |
| **Mode of Injury (RTA : Fall)** | 22 : 8 | 20 : 10 | 0.58 |

**Table 2. Operative and Radiological Outcomes**

| Parameter | Plating (n=30) | Nailing (n=30) | p-value |
|---|---|---|---|
| **Mean operative time (min)** | 92.5 ± 15.3 | 72.4 ± 12.6 | <0.001* |
| **Mean time to union (weeks)** | 20.8 ± 3.5 | 18.5 ± 2.9 | 0.02* |

**Table 3. Functional Outcomes at 12 Months**

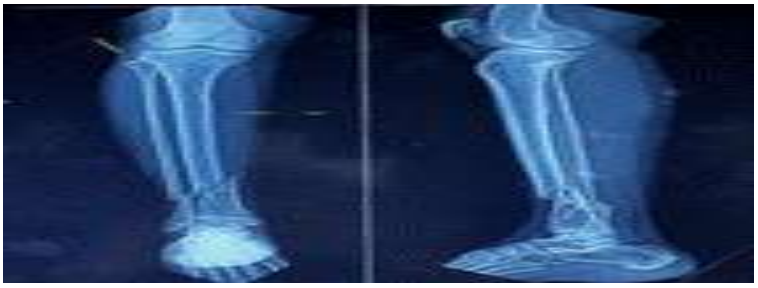
| Outcome Measure | Plating (n=30) | Nailing (n=30) | p-value |
|---|---|---|---|
| **AOFAS Score** | 85.2 ± 6.4 | 88.6 ± 5.8 | 0.04* |
| **OMAS Score** | 81.6 ± 7.2 | 85.4 ± 6.9 | 0.03* |

**Table 4. Complications**

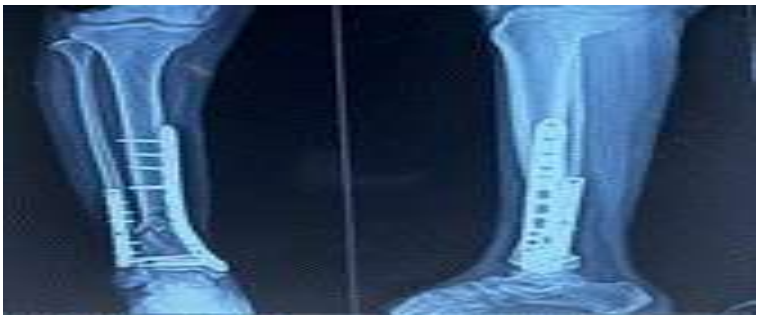
| Complication | Plating (n=30) | Nailing (n=30) | p-value |
|---|---|---|---|
| **Wound infection** | 4 (13.3%) | 1 (3.3%) | 0.04* |
| **Malalignment (>5°)** | 1 (3.3%) | 3 (10%) | 0.28 |
| **Non-union** | 1 (3.3%) | 1 (3.3%) | 1.00 |

| | | | |
|---|---|---|---|
| **Delayed union** | 2 (6.6%) | 2 (6.6%) | 1.00 |

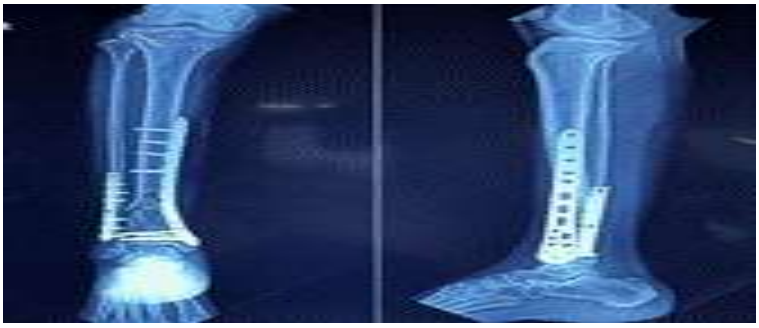
**Case 1 treated with ORIF WITH PO**



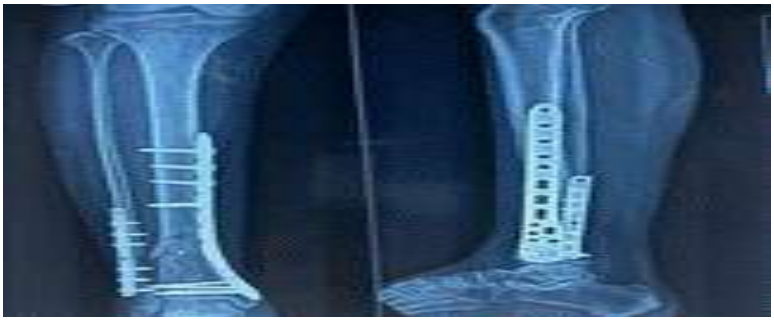
**PRE OP X RAY**



**IMMEDIATE POST OP**



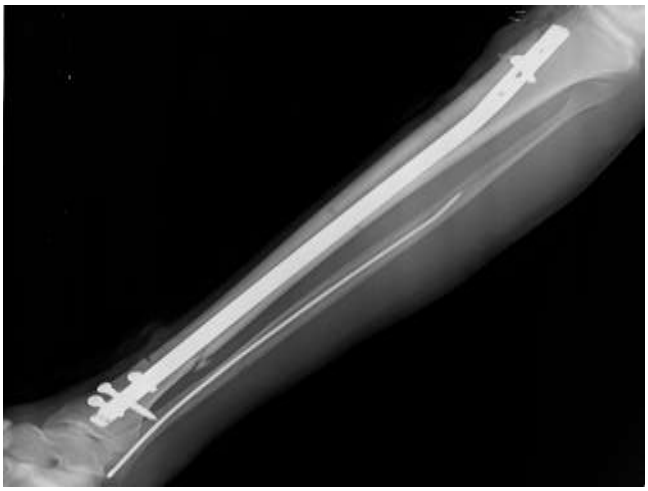
**1st month post op**



**3rd month post op x ray**

**Case 2 treated with CRIF with expert IMIL nailing**


**Immediate post op X-ray**



**1st month follow up x ray**


**3rd month follow up x ray**

**Group A (Plating) and Group B (IMIL nailing)**
**Figure 1: Comparison of Fracture Union Time between**

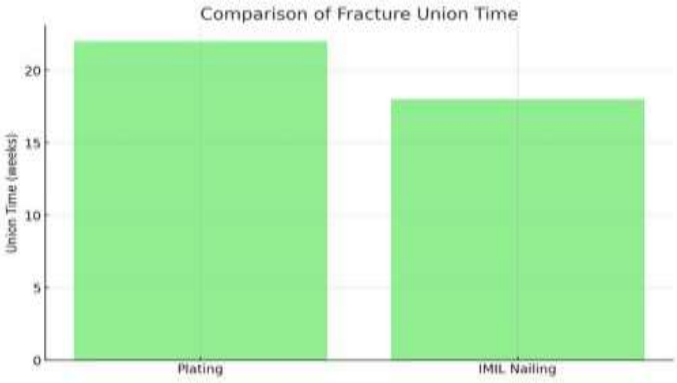



**Figure 2: Functional Outcomes comparison between Group A (Plating) and Group B (IMIL nailing)**

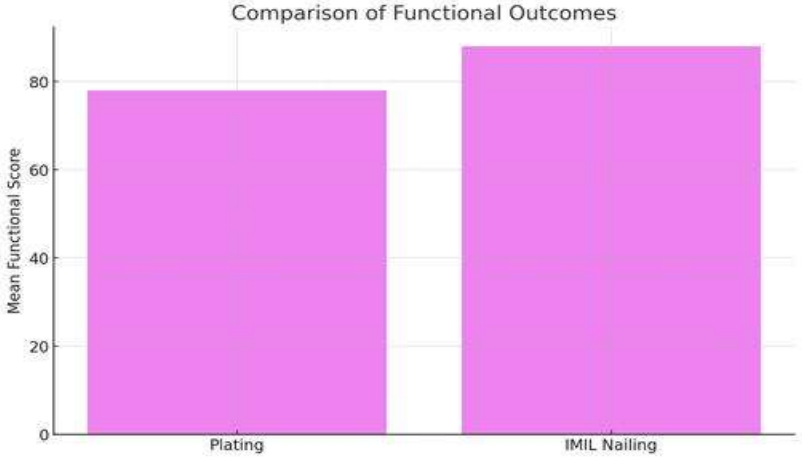


**Figure 3: Infection Rates Comparison between Group A (Plating) and Group B (IMIL nailing)**

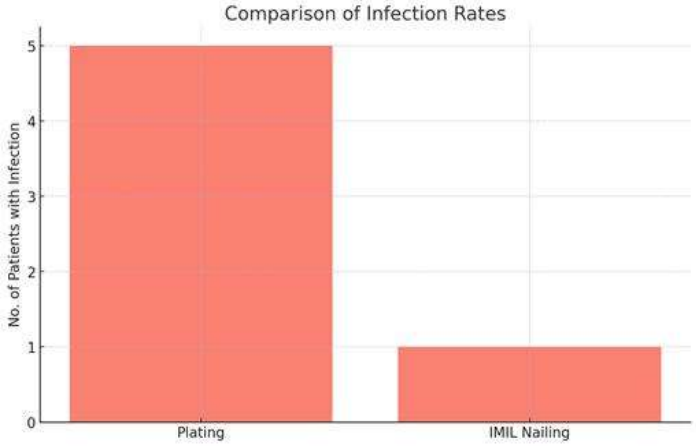
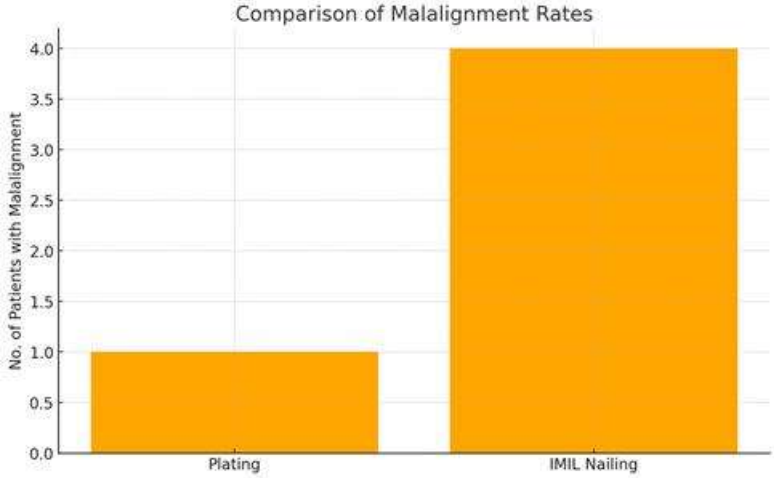



**Figure 4: Comparison of Malalignment Rates between Group A (Plating) and Group B (IMIL nailing)**




## DISCUSSION

The treatment of extra-articular distal tibial fractures continues to be a contentious issue in orthopedic trauma care. The distinctive anatomical and biomechanical features of the distal tibia, together with insufficient soft tissue covering and inadequate vascularity, render these fractures susceptible to problems including infection, delayed union, non-union, and malalignment (Casstevens et al., 2012). This prospective study compared two prevalent surgical techniques, open reduction and internal fixation with plate osteosynthesis versus closed reduction with intramedullary interlocking (IMIL) nailing in 60 patients, aiming to assess outcomes related to union rates, functional recovery, and complications. Our findings indicated that both procedures yielded good results; however, IMIL nailing exhibited reduced operational time, expedited union, elevated functional scores, and fewer wound-related problems, while plate osteosynthesis offered enhanced radiological alignment (Kc et al., 2022). The mean operating duration in our research was much greater in the plating cohort (92.5 ± 15.3 minutes) than in the nailing cohort (72.4 ± 12.6 minutes). This discovery corresponds with the observations of Im and Tae (2005), who indicated that plating often requires significant dissection and precise reduction, resulting in prolonged operating times . In contrast, IMIL nailing is minimally invasive, often requiring less manipulation of soft tissue and less surgical exposure, leading to shorter operation durations. Minimizing surgical duration is especially significant in polytrauma patients, since it reduces anesthetic and operating stress, which are crucial factors. The IMIL nailing group attained radiological union sooner (18.5 ± 2.9 weeks) than the plating cohort (20.8 ± 3.5 weeks). This conclusion aligns with the findings of Vallier et al. (2008), who indicated that IMIL nailing facilitates secondary bone healing via callus development due to its load-sharing mechanics. Conversely, plate fixation offers stiff stability, perhaps inhibiting callus development and prolonging

healing in some instances (Tarr & Wiss, 1986). Moreover, the maintenance of fracture hematoma and periosteal circulation with IMIL nailing likely facilitates improved biological healing, a notion highlighted in the research. Functional results in our research, assessed by AOFAS and OMAS scores at 12 months, were much superior in the IMIL nailing group (AOFAS: 88.6 vs. 85.2; OMAS: 85.4 vs. 81.6). The same findings, indicating that patients treated with IMIL nails achieved quicker mobilization and a swifter resumption of daily activities than those handled with plates. The early weight-bearing facilitated by nails, owing to the intramedullary load-sharing design, presumably accounts for these enhanced functional results (Deliberato et al., 2022). Our results, however, diverge from those of who showed marginally superior functional scores with plating, highlighting the variability in outcomes among diverse populations and surgical methodologies. Complication rates are a crucial factor in determining surgical success. In our study, wound-related problems were markedly elevated in the plating group (13.3%) in contrast to the nailing group (3.3%). This aligns who highlighted the susceptibility of plating to wound dehiscence, infection, and soft tissue irritation owing to the subcutaneous placement of implants. Minimally invasive plate osteosynthesis (MIPO) seeks to mitigate these issues by maintaining vascular integrity and reducing incision dimensions; nonetheless, dangers persist, especially in high-energy injuries with impaired skin conditions. In contrast, IMIL nailing minimizes wound-related morbidity by circumventing extensive incisions in the fracture area (Apivatthakakul & Chiewcharntanakit, 2009). Malalignment occurred more often in the nailing group (10%) than in the plating group (3.3%). The shape of the distal tibial metaphysis often restricts cortical contact and complicates intramedullary fixation, especially when the distal piece is abbreviated. Research conducted also indicated elevated rates of malalignment associated with nailing, ranging from 5% to 15%, mostly manifesting as valgus or rotational abnormalities (Vallier et al., 2011). Adjunctive procedures, including blocking screws, suprapatellar nailing, and nails with numerous distal locking possibilities, have been advocated to reduce this risk, many of which were used in our research. Nevertheless, plating provides enhanced control of alignment because of the direct visibility and manipulation of fracture pieces (Yang et al., 2023). Concerning non-union, our investigation identified one occurrence in each category, aligning with literature indicating similar union percentages for plating and nailing. A meta-analysis conducted with more than 700 patients revealed no significant disparity in total non-union rates between the two fixation techniques. Nonetheless, while nailing is physiologically advantageous, excessive movement at the fracture site resulting from malalignment may lead to delayed or non-union. Conversely, whereas plating guarantees anatomical reduction, significant periosteal stripping and stiff fixing may negatively affect biological processes, resulting in a risk balance that accounts for the similar frequency seen across investigations. The overarching themes from our investigation validate the results of other comparative trials and systematic reviews. IMIL nailing resulted in reduced union time, expedited mobilization, and fewer infections, while plating yielded superior anatomical alignment but increased soft tissue morbidity. A randomised controlled experiment that indicated superior functional scores with nailing, despite a higher incidence of malalignment. These findings underscore that no fixing approach is inherently preferable; instead, the selection should be tailored according to fracture morphology, soft tissue status, patient characteristics, and surgeon proficiency (Papotto et al., 2025). The constraints of our investigation include a relatively modest sample size and a brief follow-up period of 12 months, which may inadequately reflect long-term consequences such as post-traumatic arthritis. Moreover, despite our efforts to standardize surgical methods, disparities in surgeon expertise and intraoperative decision-making may have affected the results (Dilley et al., 2023). Nonetheless, the anticipated design and methodical comparison of functional, radiological, and complication-related outcomes bolster our conclusions. In conclusion, our research indicates that both plate osteosynthesis and intramedullary interlocking nailing are effective alternatives for extra-articular distal tibia fractures. IMIL nailing has benefits such as reduced operating duration, expedited union, diminished wound problems, and enhanced functional recovery, while plating ensures improved radiological alignment with a decreased likelihood of malalignment. The results indicate that IMIL nailing may be advantageous for younger patients with robust bone quality and minimal comminution, especially when early mobilization is sought. Conversely, plating may be preferred in scenarios where precise anatomical reduction is critical or when the length of the distal fragment restricts stable intramedullary fixation. Future multicenter randomized controlled studies with bigger cohorts and extended follow-up are necessary to develop definite recommendations for managing these complicated fractures.

## CONCLUSION

This research illustrates that both plate osteosynthesis and intramedullary interlocking nailing are dependable and efficacious treatment modalities for extra-articular distal tibia fractures, each with unique advantages and drawbacks. IMIL nailing results in reduced operating duration, expedited radiographic union, decreased wound complications, and enhanced functional outcomes, making it especially appropriate for younger, active patients who need early

mobility. Conversely, plating provides superior control over fracture alignment, minimizing the likelihood of malunion, and may be advantageous in instances of intricate fracture configurations or abbreviated distal pieces. No one procedure can be generally endorsed; instead, the selection should be customized according to the patient's fracture attributes, soft tissue condition, and the surgeon's proficiency. Comprehensive multicenter randomized studies with prolonged follow-up are necessary to provide definitive treatment protocols for this complex clinical condition.

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