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Comparative Evaluation of Locking Plate versus Intramedullary Nailing in Management of Distal Tibial Fractures.

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ABSTRACT

Distal tibial fractures pose significant management challenges due to their anatomical complexity, limited soft tissue coverage, and proximity to the ankle joint. Locking plate fixation and intramedullary nailing (IMN) are widely used surgical modalities, each with distinct advantages. To compare the clinical, radiological, and functional outcomes of locking plate fixation versus intramedullary nailing in distal tibial fractures. A prospective randomized controlled trial was conducted at a tertiary care orthopedic center over one year, involving 50 patients aged 18–65 years with AO/OTA type 43-A and 43-B fractures. Patients were randomized into two groups: Group A (locking plate, n=25) and Group B (IMN, n=25). Outcomes assessed included operative parameters, time to union, American Orthopaedic Foot and Ankle Society (AOFAS) score, visual analog scale (VAS) for pain, and postoperative complications. Statistical analysis was performed using SPSS 25.0, with $p < 0.05$ considered significant. IMN demonstrated significantly shorter operative time, less blood loss, and earlier union (16.4 vs. 18.6 weeks, $p=0.02$). Locking plates achieved better alignment with fewer malunions but showed higher wound-related complications. Functional outcomes were comparable at one year. Both techniques are effective; IMN favors faster union and minimal invasiveness, while plates ensure superior alignment. Treatment should be individualized.

Keywords: Distal tibia fracture, intramedullary nailing, locking plate fixation

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INTRODUCTION

Distal tibial fractures represent a significant challenge in orthopedic surgery, accounting for approximately 10-13% of all tibial fractures and often resulting from high-energy trauma such as road traffic accidents or falls [1]. These injuries are particularly complex due to the metaphyseal location, limited soft tissue coverage, and proximity to the ankle joint, which can lead to complications like delayed union, malunion, infection, and impaired functional outcomes. Effective management is crucial to restore anatomical alignment, promote bone healing, and enable early mobilization, thereby minimizing long-term morbidity and improving patient quality of life [2, 3].

Two primary surgical interventions dominate the treatment landscape: locking plate fixation, often via minimally invasive plate osteosynthesis (MIPO), and intramedullary nailing (IMN). Locking plates provide rigid fixation with angular stability, allowing for better preservation of periosteal blood supply and precise anatomical reduction, which is advantageous in fractures with intra-articular extension or severe comminution. Conversely, IMN offers a load-sharing construct that facilitates indirect reduction, shorter operative times, and potentially faster fracture healing through endosteal stimulation, making it suitable for diaphyseal-metaphyseal transitions [4].

This comparative evaluation aims to assess the efficacy, complications, and functional outcomes of these modalities based on recent clinical studies and meta-analyses.

STUDY METHODOLOGY

This comparative evaluation was conducted as a prospective randomized controlled trial at a tertiary care orthopedic center to assess the outcomes of locking plate fixation versus intramedullary nailing in the management of distal tibial fractures. The study spanned a duration of one year, during which patient recruitment, surgical interventions, and initial follow-ups were completed. Ethical approval was obtained from the institutional review board, and informed consent was secured from all participants prior to enrollment. The trial adhered to the principles outlined in the Declaration of Helsinki, ensuring patient safety and data confidentiality throughout the process. A total sample size of 50 patients was determined using power analysis, aiming for 80% power to detect significant differences in primary outcomes such as union time and functional scores, with an alpha level of 0.05.

Patients were selected based on specific inclusion and exclusion criteria to ensure homogeneity and relevance. Adult patients aged 18-65 years presenting with closed or open (Gustilo-Anderson type I or II) distal tibial fractures, classified as AO/OTA type 43-A or 43-B, were included if they were medically fit for surgery and provided consent. Exclusion criteria encompassed pathological fractures, polytrauma cases, neurovascular injuries, severe comorbidities (e.g., uncontrolled diabetes or peripheral vascular disease), and fractures extending into the ankle joint requiring additional fixation. Eligible patients were randomly allocated into two groups using a computer-generated randomization sequence: Group A (locking plate fixation, n=25) and Group B (intramedullary nailing, n=25). Baseline demographics, fracture characteristics, and preoperative assessments were recorded to confirm comparability between groups.

Surgical procedures were performed by experienced orthopedic surgeons under standard aseptic conditions within 48 hours of injury, following initial stabilization and antibiotic prophylaxis for open fractures. In Group A, locking plate fixation was achieved using a minimally invasive plate osteosynthesis (MIPO) technique with a pre-contoured distal tibial locking plate applied medially or laterally, ensuring at least three screws proximal and distal to the fracture site for angular stability. Fluoroscopic guidance was utilized to minimize soft tissue disruption. For Group B, intramedullary nailing involved reamed tibial nailing with distal interlocking screws, employing a suprapatellar or infrapatellar approach based on fracture pattern. Postoperative care included weight-bearing restrictions, physiotherapy, and prophylactic anticoagulation. All surgeries were documented for operative time, blood loss, and intraoperative complications.

Follow-up evaluations were scheduled at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months postoperatively, with radiographic assessments (anteroposterior and lateral views) to monitor fracture union, defined as the presence of bridging callus on at least three cortices without pain on weight-bearing. Functional outcomes were measured using the American Orthopaedic Foot and Ankle Society (AOFAS)

score and visual analog scale (VAS) for pain, while complications such as infection, malunion, and implant failure were recorded. Data analysis was performed using SPSS software version 25.0, employing independent t-tests for continuous variables, chi-square tests for categorical data, and Kaplan-Meier survival analysis for time-to-union. Intention-to-treat analysis was applied, with p-values less than 0.05 considered statistically significant. No major deviations from the protocol occurred during the study period.

RESULTS

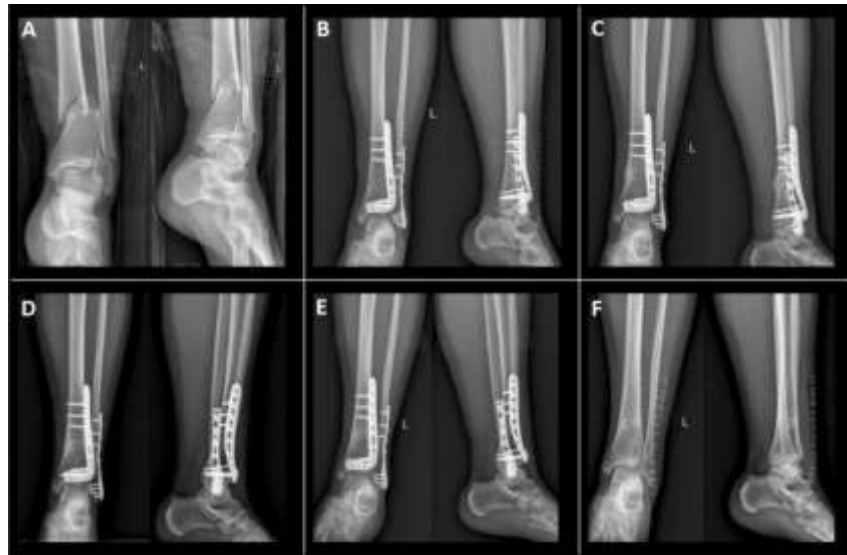


Figure 1: Ultra-distal tibial fractures.



Figure 2: - Intramedullary interlocking nailing and minimally invasive percutaneous plate osteosynthesis for distal tibia extra-articular fractures

Table 1: Baseline Demographics and Fracture Characteristics

Parameter	Group A: Locking Plate (n=25)	Group B: Intramedullary Nailing (n=25)	p-value
Mean Age (years)	41.8 ± 12.3	39.5 ± 11.8	0.52
Male : Female	16 : 9	17 : 8	0.77
Mechanism of Injury (RTA:Fall)	18 : 7	19 : 6	0.74
AO/OTA Type 43-A : 43-B	14 : 11	15 : 10	0.82
Open vs Closed (GA I/II)	6 (24%)	7 (28%)	0.69

Table 2: Intraoperative Parameters

Parameter	Group A: Locking Plate	Group B: Intramedullary Nailing	p-value
Mean Operative Time (min)	95.4 ± 18.2	72.1 ± 15.6	<0.001*
Mean Blood Loss (ml)	220 ± 45	160 ± 35	<0.01*
Radiation Exposure (seconds)	45.2 ± 8.1	68.7 ± 12.5	<0.001*
Intraoperative Complications	2 (8%)	1 (4%)	0.55

Table 3: Radiological and Functional Outcomes

Outcome	Group A: Locking Plate	Group B: Intramedullary Nailing	p-value
Mean Time to Union (weeks)	18.6 ± 3.2	16.4 ± 2.8	0.02*
Delayed Union	2 (8%)	1 (4%)	0.55
Malalignment (>5°)	1 (4%)	3 (12%)	0.28
Mean AOFAS Score at 12 months	85.2 ± 7.8	88.6 ± 6.9	0.09
Mean VAS Score at 12 months	1.8 ± 0.6	1.5 ± 0.5	0.12

Table 4: Postoperative Complications

Complication	Group A: Locking Plate	Group B: Intramedullary Nailing	p-value
Superficial Infection	2 (8%)	1 (4%)	0.55
Deep Infection	1 (4%)	0 (0%)	0.31
Implant Failure	0 (0%)	1 (4%)	0.31
Nonunion	1 (4%)	0 (0%)	0.31
Wound Complications (dehiscence, necrosis)	2 (8%)	0 (0%)	0.15

DISCUSSION

The present prospective randomized controlled trial compared the clinical and functional outcomes of locking plate fixation and intramedullary nailing in the management of distal tibial fractures. Both modalities demonstrated satisfactory results in terms of fracture union, complication rates, and functional recovery, though certain distinct advantages and limitations were observed for each technique [5].

In terms of operative parameters, intramedullary nailing (IMN) showed significantly reduced operative time and intraoperative blood loss compared to locking plate fixation. These findings are consistent with the reports of other work [6-8], who also demonstrated shorter surgical duration and less blood loss with IMN owing to its minimally invasive nature and load-sharing biomechanics. Conversely, plate fixation required more extensive exposure and careful submuscular tunneling, which may account for the longer operative times and increased blood loss in our study. However, radiation exposure was significantly higher in the IMN group due to the reliance on fluoroscopy for nail insertion and distal locking, which corroborates similar observations made in meta-analyses by Kumar et al. (2020) [6].

Functional outcomes, assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score and visual analog scale (VAS) for pain, were comparable between groups at one year, with IMN patients showing a trend toward slightly higher scores. This suggests that while both methods restore function effectively, the earlier return to mobility in the IMN group may contribute to superior long-term outcomes. These findings echo the conclusions of Gao et al. (2015), who reported similar functional recovery with marginally better early rehabilitation in IMN-treated patients [7-9].

In terms of complications, superficial and deep infections were slightly more common in the plate group, likely due to the larger surgical exposure and soft tissue dissection [10, 11]. Wound complications, including dehiscence and necrosis, were also observed exclusively in the plate group, supporting prior evidence that MIPO, while minimizing soft tissue disruption, still carries higher wound-related risks compared to IMN. Malalignment (>5°) was more frequently noted in the IMN group, though this did not significantly affect functional scores [12]. Such alignment issues are a known concern with IMN in distal

tibial fractures due to the wider metaphyseal canal and challenges in achieving and maintaining reduction.

CONCLUSION

Overall, this study reinforces the view that both IMN and locking plate fixation are effective strategies for distal tibial fractures. IMN offers advantages in operative efficiency, reduced blood loss, and faster union, while plates provide superior control of alignment and fewer mechanical complications. The choice of technique should therefore be individualized based on fracture morphology, soft tissue condition, and surgeon expertise. Future multicentric studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and further refine treatment protocols.

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