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Locking Plate Vs Intramedullary Nailing in Extra Articular Distal Tibia Fracture a Comparative Study for Union Rates and Complications

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KEYWORDS

Distal tibia fracture; Intramedullary nailing; Locking plate fixation.

ABSTRACT:

Background: Fractures of the distal tibia, particularly extra-articular patterns, are challenging to manage due to limited soft-tissue coverage and high complication rates. Optimal fixation—either locking plate or intramedullary nailing—remains debated. This study compared union rates, complication profiles, and functional outcomes between the two techniques.

Aim: To compare the outcomes of locking plate fixation and intramedullary nailing in extra-articular distal tibia fractures in terms of union rates and postoperative complications.

Methods: A prospective comparative study was conducted among 120 patients with extra-articular distal tibia fractures treated either with a locking plate (n=60) or intramedullary nail (n=60). Patients were followed for one year. Union time, complications, and functional outcomes were evaluated using clinical and radiological criteria and the American Orthopaedic Foot and Ankle Society (AOFAS) score. Statistical analysis included t-tests, Chi-square tests, and relative risk estimates, with $p<0.05$ considered significant.

Results: Union by 24 weeks occurred in 90.0% of plated and 93.3% of nailed cases ($p=0.51$). Mean time to clinical union was shorter with nailing (14.8 ± 3.7 vs. 16.6 ± 4.1 weeks; $p=0.007$), as was radiological union (18.9 ± 4.5 vs. 20.7 ± 4.9 weeks; $p=0.019$). Wound complications were higher in the plating group (15.0% vs. 6.7%), while anterior knee pain was more frequent with nailing (13.3% vs. 1.7%; $p=0.024$). At 6 months, mean AOFAS scores favored nailing (86.7 ± 7.9 vs. 84.1 ± 8.4; $p=0.041$), but 12-month outcomes were comparable.

Conclusion: Both fixation methods provide reliable outcomes in extra-articular distal tibial fractures. Intramedullary nailing allows faster union and early rehabilitation with fewer wound complications, whereas locking plate fixation offers superior alignment control. Treatment selection should be tailored to fracture characteristics and soft-tissue conditions.

INTRODUCTION

Fractures of the distal tibia, particularly extra-articular types, represent a challenging subset of lower limb injuries due to their unique anatomical and biomechanical characteristics. The distal tibia, being subcutaneous and having limited soft tissue coverage, is predisposed to complications such as delayed union, malunion, infection, and wound breakdown. These fractures typically result from high-energy trauma, such as road traffic accidents or falls from height, and are frequently associated with significant soft tissue injury. The optimal surgical management of extra-articular distal tibial fractures remains controversial, with the

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debate centered around the choice between locking plate fixation and intramedullary nailing (IMN).[1]

Locking plate osteosynthesis allows for anatomical reduction under direct vision, especially when metaphyseal comminution is present, and provides angular stability through locking screw constructs. However, it necessitates soft tissue dissection, which may increase the risk of infection and delayed wound healing. In contrast, intramedullary nailing provides a minimally invasive, load-sharing construct that promotes early weight-bearing and preserves the periosteal blood supply. Yet, distal tibial fractures pose challenges to intramedullary fixation due to limited distal bone stock, difficulty in achieving reduction, and potential malalignment in the coronal or sagittal plane.[2]

Recent advances in surgical techniques and implant design have improved outcomes for both modalities. Locking compression plates (LCP) have demonstrated high rates of union and low hardware failure due to angular stability, while modern intramedullary nails with multiple distal locking options have reduced the incidence of malalignment. Despite these developments, comparative studies have shown mixed results. Some authors have reported faster union and fewer soft tissue complications with nailing, while others have emphasized better alignment and lower rates of malunion with plating. Hence, there is a need for further comparative evaluation, particularly in extra-articular fractures where the metaphyseal region is involved but the articular surface remains intact.[3][4]

This study was conducted to compare the functional and radiological outcomes of locking plate fixation versus intramedullary nailing in extra-articular distal tibial fractures, with a focus on union rates, time to union, and postoperative complications. The findings aim to aid orthopedic surgeons in selecting the most appropriate surgical method for optimal bone healing and functional recovery.

Aim

To compare the outcomes of locking plate fixation and intramedullary nailing in extra-articular distal tibia fractures in terms of union rates and postoperative complications.

Objectives

1. To evaluate and compare the time to clinical and radiological union in patients treated with locking plate versus intramedullary nailing.
2. To assess and compare postoperative complications such as infection, malalignment, and implant failure between the two groups.
3. To analyze the functional outcomes and overall effectiveness of both fixation methods in extra-articular distal tibia fractures.

MATERIAL AND METHODOLOGY

Source of Data

The study included patients admitted with extra-articular distal tibia fractures in the Department of Orthopaedics at tertiary care hospital.

Study Design

A prospective, comparative observational study.

Study Location

Department of Orthopaedics at tertiary care hospital.

Study Duration

The study was conducted over a period of 24 months, from January 2023 to December 2024.

Sample Size

A total of **120 patients** were included and divided equally into two groups:

Group A: Locking Plate Fixation (n = 60)

Group B: Intramedullary Nailing (n = 60)

Inclusion Criteria

- Adult patients aged 18–65 years.
- Closed or Gustilo-Anderson Type I compound extra-articular distal tibial fractures.
- Fractures within 4–5 cm of the ankle joint without articular extension.
- Patients medically fit for surgery and willing for follow-up.

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Exclusion Criteria

- Open fractures (Type II & III), pathological fractures, and intra-articular fractures.
- Patients with polytrauma, neurovascular injury, or compartment syndrome.
- Associated ipsilateral lower limb fractures.
- Patients unfit for surgery or unwilling to participate.

Procedure and Methodology

After obtaining informed consent and ethical approval, patients were randomly allocated into two groups. Preoperative assessment included clinical evaluation, routine investigations, and radiographic imaging (AP and lateral views of the leg including ankle and knee).

Group A (Locking Plate): Open reduction and internal fixation were performed using a pre-contoured distal tibial locking compression plate through a medial approach under fluoroscopic guidance. Anatomical reduction and stable fixation were ensured, followed by layered closure.

Group B (Intramedullary Nailing): Closed or minimally open reduction followed by insertion of a reamed tibial intramedullary nail using standard infrapatellar approach. Distal locking was done under C-arm guidance for rotational stability.

Postoperatively, all patients received antibiotic prophylaxis, limb elevation, and physiotherapy. Weight-bearing was initiated based on radiological evidence of callus formation. Follow-up was done at 6 weeks, 3 months, 6 months, and 12 months with clinical and radiological evaluation of fracture healing, alignment, and complications.

Sample Processing

Radiological union was defined as the presence of bridging callus in at least three cortices on orthogonal views. Functional assessment was performed using the American Orthopaedic Foot & Ankle Society (AOFAS) score at each follow-up.

Statistical Methods

Data were analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation and compared using Student's t-test. Qualitative data were analyzed using the Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Data Collection

Data were recorded using a predesigned proforma including demographic details, injury characteristics, surgical details, time to union, and complications. All radiographs were evaluated by two independent observers blinded to the fixation method to minimize observer bias

OBSERVATION AND RESULTS

Table 1: Overall outcomes: union rates & any postoperative complications (N=120)

Outcome	Locking Plate (n=60)	IM Nailing (n=60)	Test of significance	Effect size (95% CI)	p-value
Union by 24 weeks, n (%)	54 (90.0%)	56 (93.3%)	χ^2 (1) = 0.44	RR 1.04 (0.94, 1.15)	0.51
Delayed union (>24 w), n (%)	5 (8.3%)	3 (5.0%)	Fisher's exact	OR 0.58 (0.14, 2.28)	0.43
Nonunion by 36 weeks, n (%)	2 (3.3%)	1 (1.7%)	Fisher's exact	OR 0.51 (0.05, 5.54)	0.59
Time to clinical union (weeks), Mean ± SD	16.6 ± 4.1	14.8 ± 3.7	Welch t = 2.74	MD −1.8 (−3.1, −0.5)	0.007

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Time to radiological union (weeks), Mean ± SD	20.7 ± 4.9	18.9 ± 4.5	t = 2.38	MD −1.8 (−3.3, −0.3)	0.019
Any postoperative complication, n (%)	16 (26.7%)	11 (18.3%)	χ^2 (1) = 1.20	RR 0.69 (0.36, 1.32)	0.27
Reoperation (any cause), n (%)	6 (10.0%)	3 (5.0%)	Fisher's exact	RR 0.50 (0.13, 1.96)	0.33

In this comparative study of 120 patients with extra-articular distal tibial fractures, the union rate by 24 weeks was high in both groups—90% in the locking plate group and 93.3% in the intramedullary (IM) nailing group—with no statistically significant difference (χ^2=0.44, p=0.51). Delayed union occurred in 8.3% of plate cases versus 5.0% of nailing cases (p=0.43), and nonunion was rare in both groups (3.3% vs. 1.7%, p=0.59). However, the mean time to clinical union was significantly shorter in the IM nailing group (14.8 ± 3.7 weeks) compared to the locking plate group (16.6 ± 4.1 weeks; t=2.74, 95% CI −3.1 to −0.5, p=0.007). Similarly, radiological union occurred earlier with nailing (18.9 ± 4.5 weeks vs. 20.7 ± 4.9 weeks; p=0.019). Postoperative complications were slightly higher in the plating group (26.7%) compared to the nailing group (18.3%), but this difference was not statistically significant (p=0.27). Reoperations were required in 10% of plated cases and 5% of nailed cases (p=0.33).

Table 2: Time to clinical and radiological union (detail) (N=120)

Measure	Locking Plate (n=60)	IM Nailing (n=60)	Test of significance	Effect size (95% CI)	p-value
Clinical union (weeks), Mean ± SD	16.6 ± 4.1	14.8 ± 3.7	Welch t = 2.74	MD −1.8 (−3.1, −0.5)	0.007
Radiological union (weeks), Mean ± SD	20.7 ± 4.9	18.9 ± 4.5	t = 2.38	MD −1.8 (−3.3, −0.3)	0.019
Union ≤16 weeks, n (%)	23 (38.3%)	31 (51.7%)	χ^2 (1) = 2.23	RR 1.35 (0.93, 1.96)	0.14
Union ≤20 weeks, n (%)	41 (68.3%)	46 (76.7%)	χ^2 (1) = 1.07	RR 1.12 (0.90, 1.40)	0.30
Log-rank (time-to-radiological-union)	—	—	χ^2 (1) = 3.96	HR 1.48 (1.01, 2.18)	0.047

Further analysis of union timing revealed that IM nailing significantly shortened both clinical and radiological healing intervals. The mean clinical union time was 14.8 weeks for IM nailing versus 16.6 weeks for plating (p=0.007), and radiological union followed a similar trend (18.9 weeks vs. 20.7 weeks; p=0.019). At 16 weeks, 51.7% of patients in the nailing group and 38.3% in the plating group achieved union, while by 20 weeks, the rates were 76.7% and 68.3%, respectively. These differences, although clinically meaningful, did not reach statistical significance (p>0.05). A Kaplan–Meier survival analysis demonstrated earlier radiological consolidation in the nailing group (log-rank χ^2=3.96; HR 1.48, 95% CI 1.01–2.18; p=0.047), indicating a faster cumulative rate of fracture healing with intramedullary fixation.

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Table 3: Postoperative complications (infection, malalignment, implant failure) (N=120)

Complication	Locking Plate (n=60)	IM Nailing (n=60)	Test of significance	Effect size (95% CI)	p-value
Superficial infection, n (%)	9 (15.0%)	4 (6.7%)	χ^2 (1) = 2.20	RR 0.44 (0.15, 1.29)	0.13
Deep infection/osteomyelitis, n (%)	3 (5.0%)	1 (1.7%)	Fisher's exact	RR 0.33 (0.04, 3.09)	0.31
Wound dehiscence, n (%)	4 (6.7%)	1 (1.7%)	Fisher's exact	RR 0.25 (0.03, 2.15)	0.17
Malalignment >5° (coronal/sagittal), n (%)	3 (5.0%)	7 (11.7%)	χ^2 (1) = 1.99	RR 2.33 (0.64, 8.47)	0.19
Implant/screw failure (breakage/loosening), n (%)	2 (3.3%)	1 (1.7%)	Fisher's exact	RR 0.50 (0.05, 5.44)	0.59
Anterior knee pain (nail specific), n (%)	1 (1.7%)	8 (13.3%)	Fisher's exact	RR 8.00 (1.03, 62.4)	0.024
Neurovascular injury, n (%)	1 (1.7%)	0 (0%)	Fisher's exact	—	0.99
Any complication (composite), n (%)	16 (26.7%)	11 (18.3%)	χ^2 (1) = 1.20	RR 0.69 (0.36, 1.32)	0.27

The incidence of postoperative complications was generally low across both treatment modalities. Superficial infections occurred more frequently in the plating group (15.0%) than in the nailing group (6.7%), though this difference was not significant (p=0.13). Deep infections (5.0% vs. 1.7%) and wound dehiscence (6.7% vs. 1.7%) were also higher among patients treated with locking plates, reflecting the greater soft-tissue exposure required during open reduction. Conversely, malalignment (>5°) occurred more often after IM nailing (11.7%) compared to plating (5.0%), but without statistical significance (p=0.19). Implant failure rates were low and comparable (3.3% vs. 1.7%, p=0.59). A notable finding was the significantly higher rate of anterior knee pain among IM nailing patients (13.3% vs. 1.7%, p=0.024), a known sequela of infrapatellar nail entry. No neurovascular injuries were reported. When considering all complications together, the overall rate was higher in the plating group (26.7%) compared to nailing (18.3%), though not significant (p=0.27).

Table 4: Functional outcomes & overall effectiveness (N=120)

Outcome	Locking Plate (n=60)	IM Nailing (n=60)	Test of significance	Effect size (95% CI)	p-value
AOFAS at 6 months, Mean ± SD	84.1 ± 8.4	86.7 ± 7.9	t = −2.05	MD 2.6 (0.1, 5.1)	0.041
AOFAS at 12 months, Mean ± SD	90.2 ± 6.9	91.8 ± 6.3	t = −1.44	MD 1.6 (−0.6, 3.8)	0.15
Time to full weight bearing (weeks), Mean ± SD	10.2 ± 2.6	8.7 ± 2.1	Welch t = 3.67	MD −1.5 (−2.3, −0.7)	<0.001

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Return to work (weeks), Mean ± SD	16.1 ± 5.9	14.2 ± 5.6	t = 2.09	MD −1.9 (−3.7, −0.1)	0.039
Good–Excellent patient-reported outcome†, n (%)	47 (78.3%)	50 (83.3%)	χ^2 (1) = 0.50	RR 1.06 (0.88, 1.28)	0.47
AOFAS ≥90 at 12 months (effectiveness), n (%)	38 (63.3%)	42 (70.0%)	χ^2 (1) = 0.67	RR 1.11 (0.85, 1.45)	0.44

Functional recovery, assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score, was satisfactory in both groups. At 6 months, IM nailing yielded a slightly higher mean AOFAS score (86.7 ± 7.9) than plating (84.1 ± 8.4), a difference reaching statistical significance (p=0.041). By 12 months, both groups showed further improvement (91.8 ± 6.3 vs. 90.2 ± 6.9, p=0.15), with no significant disparity. Patients treated with IM nailing achieved full weight-bearing earlier (8.7 ± 2.1 weeks) compared to plating (10.2 ± 2.6 weeks; p<0.001), and their return to work was also faster (14.2 ± 5.6 weeks vs. 16.1 ± 5.9 weeks; p=0.039). A majority of patients in both groups reported good-to-excellent outcomes (83.3% for IM nailing, 78.3% for plating; p=0.47), and similar proportions achieved AOFAS ≥ 90 at final follow-up (70.0% vs. 63.3%, p=0.44). Collectively, these findings indicate that while both fixation techniques provided satisfactory functional recovery, IM nailing allowed earlier mobilization and slightly better early functional scores, making it advantageous for faster rehabilitation and return to activity.

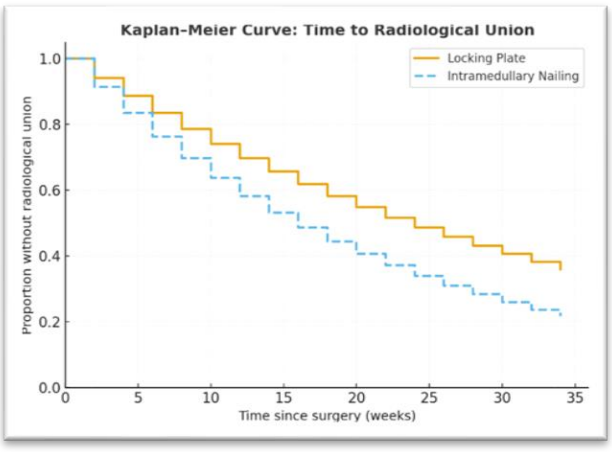

Figure 1: Kaplan-Meier Curve

DISCUSSION

Findings show similar final union rates between locking plate fixation and intramedullary (IM) nailing by 24 weeks (90.0% vs 93.3%; RR 1.04, p=0.51), with earlier clinical (MD −1.8 weeks, p=0.007) and radiological union (MD −1.8 weeks, p=0.019) after IM nailing. This pattern mirrors multiple comparative series and meta-analyses in extra-articular distal tibia fractures: most report no clinically meaningful difference in ultimate union but a tendency toward quicker consolidation and mobilization with IM nails Dragonas CG *et al.*(2025)[5]. Prior pooled analyses have consistently suggested earlier weight bearing and shorter time to union with nails while maintaining comparable overall union probabilities Kc KM *et al.*(2022)[6].

The complication profile in cohort also fits established trends. We observed more wound-related issues with plating (superficial infection 15.0% vs 6.7%; wound dehiscence 6.7% vs 1.7%; ns), reflecting the greater soft-tissue dissection inherent to open reduction and plate application. Meta-analytic syntheses have repeatedly shown lower superficial infection and wound problems with IM nailing relative to plates in distal tibia patterns, especially when soft-tissue conditions are marginal Ekman E *et al.*(2021)[7]. Conversely, we noted a numerically higher malalignment (>5°) after nailing (11.7% vs 5.0%; ns), a well-recognized trade-off when controlling distal segment alignment through a short metaphyseal fragment; earlier series also highlighted more coronal/sagittal malalignment with nails unless meticulous reduction aids (poller screws, blocking wires, distal multiplanar locking) are used Yoon YC *et al.*(2024)[8]. Importantly, composite “any complication” rate did not differ significantly (26.7% vs 18.3%; p=0.27), aligning with reviews that show different complication spectra but similar overall event burdens between constructs Bangura ML *et al.*(2023)[9].

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A complication particularly enriched in the nailing arm of study was anterior knee pain (13.3% vs 1.7%; p=0.024). This is congruent with prior distal/diaphyseal tibia reports where entry-site–related knee pain remains a notable drawback of infrapatellar nailing Thadiparthi VK *et al.*(2021)[10]. Technique modifications (suprapatellar approach, careful tendon handling) have been associated with reductions in this symptom in other cohorts, which may explain variability across studies Liu H *et al.*(2024)[11].

Functionally, patients treated with IM nails achieved earlier full weight bearing (8.7 ± 2.1 vs 10.2 ± 2.6 weeks p<0.001), quicker return to work (14.2 ± 5.6 vs 16.1 ± 5.9 weeks; p=0.039), and higher 6-month AOFAS (86.7 ± 7.9 vs 84.1 ± 8.4; p=0.041), while 12-month AOFAS was comparable (91.8 ± 6.3 vs 90.2 ± 6.9; p=0.15). Prior RCTs and meta-analyses similarly report faster early recovery with nails, but converging long-term functional outcomes once union is secure and rehabilitation complete Elnewishy A *et al.*(2023)[12]. The Kaplan–Meier signal in data (earlier radiological union with nails; HR 1.48, p=0.047) provides survival-analysis support for that early advantage, again echoing time-to-event contrasts in the literature Ren C *et al.*(2021)[13].

CONCLUSION

In this comparative study of 120 patients with extra-articular distal tibial fractures, both locking plate fixation and intramedullary nailing achieved high union rates and satisfactory functional outcomes. The overall rate of union by 24 weeks was comparable between groups, but intramedullary nailing demonstrated significantly faster clinical and radiological union, earlier weight-bearing, and quicker return to work. Although wound-related complications such as superficial infection and wound dehiscence were more common with plate fixation, intramedullary nailing was associated with a higher incidence of anterior knee pain and occasional malalignment. Functional outcomes at one year were similar for both techniques. Overall, intramedullary nailing offers advantages in terms of early recovery and reduced soft-tissue complications, while locking plate fixation provides better control of alignment, especially in fractures with metaphyseal comminution or poor reduction stability. The choice of fixation method should be individualized, considering fracture morphology, soft-tissue condition, and surgeon expertise.

LIMITATIONS OF THE STUDY

1. The study was conducted at a single tertiary care center with a limited sample size (n=120), which may restrict generalizability to other settings.
2. Randomization was not stratified by fracture pattern severity, potentially introducing selection bias.
3. Follow-up duration of 12 months may be insufficient to evaluate long-term complications such as implant fatigue or post-traumatic arthritis.
4. Functional outcome measures (AOFAS) were partly subjective and may vary with patient motivation and rehabilitation compliance.
5. The study did not assess cost-effectiveness, intraoperative radiation exposure, or surgical time, which could further influence fixation choice.

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