

Original Research Article

A prospective randomized comparative study of interlocking intramedullary nailing and plate fixation in the surgical management of distal third tibial fractures

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ABSTRACT

Background: Extra-articular distal third tibial fractures remain challenging due to the region's anatomical characteristics and limited blood supply, with persistent controversy regarding the optimal fixation method between intramedullary nailing (IMN) and plate fixation.

Methods: This prospective randomized comparative study enrolled 60 patients (30 per group) with extra-articular distal third tibial fractures at SMS Medical College, Jaipur, from January to December 2024. Group A underwent plate fixation (ORIF/MIPO), while Group B received intramedullary interlocking nailing. Outcomes were assessed using the AOFAS ankle-hindfoot score, visual analogue scale (VAS) for pain, and radiological union at 6 weeks, 3 months, 6 months, and 9 months.

Results: Both groups were comparable in demographics and fracture characteristics. Mean operative time was significantly shorter in the nailing group (72.6 ± 4.57 vs 93.2 ± 4.94 minutes, $p < 0.001$). Partial and full weight bearing were achieved significantly earlier in the nailing group ($p = 0.008$ and $p = 0.003$, respectively). AOFAS scores at 9 months were comparable between groups (93.1 ± 2.12 vs 92.2 ± 2.13 , $p = 0.120$). Complete radiological union was achieved in all patients by 9 months, and complications were minor and comparable between groups.

Conclusions: Both intramedullary nailing and plate fixation are effective for extra-articular distal third tibial fractures, with comparable functional outcomes. Intramedullary nailing, however, offers shorter operative time, earlier weight bearing, and fewer wound complications, making it preferable when early mobilization is desired.

Keywords: Distal tibial fracture, Intramedullary nailing, Plate fixation, MIPO, AOFAS score, Fracture union

INTRODUCTION

The tibia is the most commonly fractured long bone in the human body, with an estimated annual incidence of approximately 2 per 1,000 individuals.^{1,2} Its subcutaneous position, especially along the anteromedial surface, makes it highly vulnerable to direct trauma and increases the risk of open fractures compared to other long bones. Fractures of the distal third of the tibia are particularly challenging due to their anatomical and biological characteristics, including poor blood supply and limited soft tissue

coverage.^{3,4} These factors contribute to a higher risk of delayed union, non-union, and wound complications. The distal metaphyseal region of the tibia, as defined by Müller, encompasses the area within 4 cm proximal to the tibial plafond. Extra-articular fractures in this region (AO types 43-A1, 43-A2, and 43-A3) pose specific challenges for surgical fixation due to limited vascularity and proximity to the ankle joint.^{5,6} Historically, conservative management using casting and functional bracing was employed but often led to malunion, non-union, and joint stiffness.^{7,8} The limitations of conservative methods have

led to a growing preference for surgical intervention. Modern surgical options include open reduction and internal fixation (ORIF), minimally invasive percutaneous plate osteosynthesis (MIPO), and intramedullary nailing (IMN).^{9,10} Plate fixation allows precise anatomical reduction but requires extensive soft tissue dissection, potentially compromising periosteal blood supply. The MIPO technique preserves the fracture hematoma and periosteal blood flow while providing mechanical stability.^{11,12} Intramedullary nailing offers advantages including a minimally invasive approach, load-sharing properties, and early weight bearing.^{13,14}

Despite advances in implant design and surgical technique, considerable debate persists regarding the optimal fixation method for distal tibial fractures.^{15,16} Some studies report higher malalignment rates with IMN and increased wound complications with plating.^{17,18} Recent meta-analyses have demonstrated comparable union rates but differences in operative time, weight-bearing progression, and complication profiles.^{19,20} This prospective randomized study was designed to compare the clinical, functional, and radiological outcomes of intramedullary interlocking nailing versus plate fixation in extra-articular distal third tibial fractures.

METHODS

Study design and setting

This prospective randomized comparative interventional study was conducted in the Department of Orthopaedics, SMS Medical College and Attached Hospitals, Jaipur, Rajasthan, from January 2024 to December 2024, following approval from the Institutional Ethics Committee.

Sample size and randomization

A total of 60 patients with extra-articular distal third tibial fractures were enrolled and randomly allocated to two groups: Group A (n=30) underwent plate fixation using a distal tibial locking compression plate via the ORIF or MIPO technique, and Group B (n=30) underwent closed reduction and intramedullary interlocking nailing.

Inclusion criteria

Patients aged 18–60 years, of either gender, with radiologically confirmed extra-articular distal third tibial fractures (AO type 43-A), including Gustilo-Anderson Grade I open fractures, who were medically fit for surgery and provided written informed consent.

Exclusion criteria

Intra-articular fracture extension, Grade II or III open fractures, infected or neglected fractures, pathological fractures, patients unfit for anaesthesia, and skeletally immature patients.

Surgical technique

In Group A, patients underwent plate fixation using the MIPO or ORIF technique with pre-contoured distal tibial locking compression plates. Closed reduction was achieved under fluoroscopic guidance, and the plate was inserted sub muscularly. In Group B, closed reduction was performed with nail insertion through the infrapatellar approach, with proximal and distal static locking; blocking screws were used when required for distal fragment control.

Follow-up protocol

Patients were evaluated at 3 weeks, 6 weeks, 3 months, 6 months, and 9 months postoperatively. Assessment included clinical examination (VAS for pain, weight-bearing status), functional evaluation (AOFAS Ankle-Hindfoot Score), and radiological assessment (anteroposterior and lateral radiographs). Radiological union was defined as bridging trabeculae across at least 3 of 4 cortices.

Statistical analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean±SD and compared using Student's t-test or the Mann-Whitney U test. Categorical variables were compared using the Chi-square test or Fisher's exact test. A p value <0.05 was considered statistically significant.

RESULTS

Both groups were comparable in baseline demographics and fracture characteristics, confirming successful randomization (Table 1). The majority of patients (75.00%) were aged 31–50 years, with mean ages of 40.7±8.33 years in the plating group and 39.7±7.77 years in the nailing group (p=0.644). Gender distribution was identical, with 17 males and 13 females in each group (p=1.000). Falls were the predominant mechanism of injury (65.00%), followed by road traffic accidents (28.33%).

Most fractures were closed (78.33%), and AO classification showed a comparable distribution of 43-A1 (36.67%), 43-A2 (36.67%), and 43-A3 (26.67%) fractures between groups (p=0.806) (Table 2). Mean operative time was significantly shorter in the nailing group (72.6±4.57 minutes) compared with the plating group (93.2±4.94 minutes, p<0.001) (Table 3).

Partial and full weight bearing were achieved significantly earlier in the nailing group. By week 6, 73.33% of nailing patients had initiated partial weight bearing compared with none in the plating group (p=0.008). Similarly, 73.33% of nailing patients achieved full weight bearing by week 10 compared with 10.00% in the plating group (p=0.003) (Table 4). VAS pain scores declined progressively in both

groups at every follow-up point, with no statistically significant between-group difference at any stage (Table 5). AOFAS scores improved progressively in both groups, with comparable scores at 9 months (92.2 ± 2.13 in the plating group vs 93.1 ± 2.12 in the nailing group, $p=0.120$) (Table 6). Radiological union progressed similarly in both groups, reaching 100% union in both groups by 9 months (Table 7). Postoperative complications were minor and comparable between groups. Local wound complications were more frequent in the plating group (13.33%) than in

the nailing group (6.67%); delayed union occurred in two plating patients and one nailing patient, and delayed range of motion occurred in one patient in each group (Table 8). No patient in either group required revision surgery for non-union, deep infection, or malalignment. Time to full weight bearing was also more rapid in the nailing group (Table 4). At final follow-up (9 months), 93.33% of plating patients and 96.67% of nailing patients achieved an excellent AOFAS outcome (≥ 80), with no patient in either group classified as fair or poor (Table 9).

Table 1: Baseline demographics and fracture characteristics.

Parameters	Plating (n=30)	Nailing (n=30)	P value
Mean age (in years)	40.7 $\pm$ 8.33	39.7 $\pm$ 7.77	0.644
Gender (M: F)	17:13	17:13	1.000
Side (L: R)	13:17	14:16	0.795
Closed fracture	24 (80.00%)	23 (76.67%)	0.754
Grade I open	06 (20.00%)	07 (23.33%)	

Table 2: AO/OTA classification distribution.

AO Types	Plating (n=30)	Nailing (n=30)	Total
43-A1	12 (40.00%)	10 (33.33%)	22 (36.67%)
43-A2	11 (36.67%)	11 (36.67%)	22 (36.67%)
43-A3	07 (23.33%)	09 (30.00%)	16 (26.67%)
P value	0.806		

Table 3: Operative time comparison.

Parameters	Plating	Nailing	P value
Operative time (min)	93.2 $\pm$ 4.94	72.6 $\pm$ 4.57	<0.001*

*Statistically significant

Table 4: Time to weight bearing.

Parameters	Plating	Nailing	P value
PWB by week 6 (%)	00 (00.00)	22 (73.33)	0.008*
FWB by week 10 (%)	03 (10.00)	22 (73.33)	0.003*

*Statistically significant

Table 5: VAS score progression.

Follow-ups	Plating (Mean $\pm$ SD)	Nailing (Mean $\pm$ SD)	P value
6 weeks	4.93 $\pm$ 0.74	4.57 $\pm$ 0.73	0.058
3 months	2.87 $\pm$ 0.78	2.63 $\pm$ 0.72	0.232
6 months	1.53 $\pm$ 0.51	1.40 $\pm$ 0.50	0.309
9 months	0.90 $\pm$ 0.31	0.80 $\pm$ 0.41	0.286

Table 6: AOFAS score progression.

Follow-ups	Plating (Mean $\pm$ SD)	Nailing (Mean $\pm$ SD)	P value
6 weeks	60.1 $\pm$ 3.71	60.2 $\pm$ 2.88	0.847
3 months	78.0 $\pm$ 3.15	78.5 $\pm$ 2.84	0.521
6 months	87.0 $\pm$ 2.64	87.8 $\pm$ 2.21	0.227
9 months	92.2 $\pm$ 2.13	93.1 $\pm$ 2.12	0.120

Table 7: Radiological union status.

Follow-ups	Plating (Union)	Nailing (Union)
6 weeks	12 (40.00%)	11 (36.67%)
3 months	23 (76.67%)	24 (80.00%)
6 months	28 (93.33%)	29 (96.67%)
9 months	30 (100.00%)	30 (100.00%)

Table 8: Postoperative complications.

Complications	Plating (n=30)	Nailing (n=30)
None	23 (76.67%)	26 (86.67%)
Local wound complications	04 (13.33%)	02 (06.67%)
Delayed union	02 (06.67%)	01 (03.33%)
Delayed ROM	01 (03.33%)	01 (03.33%)

Table 9: Final AOFAS outcome at 9 months.

AOFAS categories	Plating (n=30)	Nailing (n=30)
Excellent (≥ 80)	28 (93.33%)	29 (96.67%)
Good (60–79)	02 (06.67%)	01 (03.33%)
Fair/Poor (< 60)	00 (00.00%)	00 (00.00%)

DISCUSSION

The present study compared intramedullary nailing and plate fixation in 60 patients with extra-articular distal third tibial fractures. The findings demonstrate that both techniques are effective, achieving excellent functional outcomes and complete union in all patients by 9 months. However, intramedullary nailing offered significant advantages in terms of shorter operative time, earlier weight bearing, and fewer wound complications. The mean operative time was significantly shorter in the nailing group (72.6 ± 4.57 minutes) compared to the plating group (93.2 ± 4.94 minutes, $p < 0.001$). This finding is consistent with meta-analyses by Li et al and Guo et al who reported that intramedullary nailing requires 10–15 minutes less than plate fixation. Shorter operative time translates to reduced anaesthetic risk, less blood loss, and potentially lower infection rates, particularly important in this anatomically vulnerable region.^{19,21}

Partial and full weight bearing were achieved significantly earlier in the nailing group ($p = 0.008$ and $p = 0.003$, respectively). By week 6, 73.33% of nailing patients had initiated partial weight bearing compared to none in the plating group. Similarly, 73.33% of nailing patients achieved full weight bearing by week 10 versus only 10.00% in the plating group. Daolagupu et al reported comparable findings, with full weight bearing at 10.09 weeks for IMN versus 13.38 weeks for MIPO.²² This early mobilization advantage is attributed to the load-sharing properties of intramedullary nails, which allow axial loading without implant stress concentration. AOFAS scores showed progressive improvement in both groups with no significant difference at any time point, including the final assessment at 9 months (92.2 ± 2.13 vs 93.1 ± 2.12 ,

$p = 0.120$). This functional equivalence is consistent with findings from Vallier et al, Hu et al and Li et al who reported comparable final functional outcomes regardless of fixation method.^{9,20,21} The study confirms that when performed appropriately, both techniques achieve excellent functional recovery in extra-articular distal tibial fractures.

Radiological union progressed similarly in both groups, with near-complete union by 6 months and 100% union by 9 months. These findings align with Phadke et al who reported a mean union time of 21 weeks, and Jain et al who found union at 14.2 weeks for IMN and 18.1 weeks for plating.^{23,24} The high union rates in our study reflect appropriate patient selection, meticulous surgical technique, and standardized postoperative rehabilitation protocols.

Complications were minor in both groups. Local wound complications were more common in the plating group (13.33% vs 6.67%), consistent with literature reporting higher superficial infection rates with plating.^{19,20} Delayed union occurred in two plating and one nailing patient, all managed conservatively without reoperation. Importantly, no patient in either group developed non-union, deep infection, or malalignment requiring revision surgery. The biomechanical advantages of intramedullary nailing include its load-sharing properties, central axis positioning, and preservation of the fracture hematoma.^{25,26} The nail acts as an internal splint that allows controlled micromotion, promoting secondary bone healing. In contrast, locking plates function as internal fixators, providing angular stability but potentially delaying union due to their stiffness.²⁷ The findings support the growing consensus that intramedullary nailing

should be considered the preferred treatment for extra-articular distal tibial fractures when early mobilization is a priority.

From a cost-effectiveness perspective, shorter operative time with intramedullary nailing translates to reduced operating room utilization and anaesthesia costs. Earlier return to weight bearing may facilitate faster return to work and improved quality of life during recovery. These factors, combined with comparable implant costs, support intramedullary nailing as a more economical choice for healthcare systems managing distal tibial fractures.

Limitations

This study has several limitations, including its single-center design, relatively small sample size, and 9-month follow-up duration, which may not capture long-term complications such as implant failure or post-traumatic arthritis. The lack of blinding may introduce performance bias. Radiological assessment was limited to conventional radiographs without CT evaluation. Future multicenter randomized trials with longer follow-up are recommended to validate these findings.

Thus, percentage of operable growths in our study was less as compared to other series indicating advanced stage disease due to illiteracy, social bindings, less diagnostic tools available, lack of surveillance etc. More than half of colorectal adenocarcinomas are still diagnosed only when the disease involves regional or distant structures.¹³ Patients with Dukes A stage did not receive postoperative chemotherapy and were advised regular follow up. 38 patients received post-operative chemotherapy. 18 patients were given radiotherapy. New evidence suggests a role for anti-inflammatory drugs in the treatment and prevention of colon and rectal cancers.¹⁴ Out of 70 patients over all follow-up of 42 patients (60%) was done. 6 patients died after surgery due to metastatic disease, other were free of disease.

Current recommendations are CEA every 2 months for 2 years then every 4 months for 2 years then annually, colonoscopy within the first 2-3 months then annually, LFTs every 3 months for 2 years then every 6 months for 2 years then annually and CXR every 6 months for 3 years then annually.¹⁵

CONCLUSION

Both intramedullary interlocking nailing and distal tibial plate fixation are effective surgical options for managing extra-articular distal third tibial fractures, with comparable functional and radiological outcomes at 9 months of follow-up. However, intramedullary nailing demonstrates significant advantages, including shorter operative time, earlier initiation of partial and full weight bearing, and fewer wound complications. These findings suggest that intramedullary nailing may be the preferred fixation method when early mobilization is prioritized, while plate

fixation remains a viable alternative when anatomical considerations or surgeon preference dictate its use.

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