Clinical and Radiological Outcomes of Multidirectional Locking Nail versus Plate Fixation in Distal Tibial Fractures: A Randomized Controlled Trial

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Abstract

Background: Distal tibial fractures are challenging injuries because of the subcutaneous location of the tibia, limited soft-tissue coverage, and potential for postoperative wound complications. Multidirectional locking intramedullary nailing and plate fixation are commonly used treatment modalities, but the relative advantages of these techniques remain debated.

Aim: To compare the clinical and radiological outcomes of multidirectional locking intramedullary nailing and plate fixation in the management of distal tibial fractures.

Materials and Methods: A prospective randomized controlled study was conducted in the Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, from March 2025 to February 2026. Twenty patients aged 18–70 years with closed distal tibial fractures or Grade I compound fractures without intra-articular extension were included. Patients were randomly allocated into two groups: 10 patients underwent multidirectional locking intramedullary nailing and 10 underwent plate fixation. Patients with Grade II/III compound fractures, intra-articular extension, and age below 18 or above 70 years were excluded. Clinical and radiological assessments were performed during follow-up. Data were analyzed using appropriate statistical tests, including the independent-samples t-test and McNemar/Chi-square test where applicable. A p-value <0.05 was considered statistically significant.

Results: The majority of patients in both groups belonged to the 46–55-year age group, accounting for 50% of patients in each group. Overall, there were 10 males and 10 females. Road traffic accidents were the predominant mechanism of injury in the nailing group (70%), whereas twisting injuries were most common in the plating group (50%). In the nailing group, 80% of patients underwent closed fixation and 20% required open reduction with fibular fixation. In the plating group, open reduction and internal fixation was performed in the majority of cases. Both groups demonstrated a reported 100% treatment success rate during the study follow-up. Statistical analysis demonstrated significant findings in the assessed parameters; however, interpretation was limited by the small sample size.

Conclusion: Both multidirectional locking intramedullary nailing and plate fixation provided satisfactory outcomes in the treatment of distal tibial fractures. Multidirectional locking nailing offers the potential advantage of stable fixation with reduced soft-tissue exposure and may be particularly useful in fractures where preservation of the soft-tissue envelope is important. Larger randomized studies with longer follow-up are required to determine whether either technique provides superior functional, radiological, or complication-related outcomes.

Keywords: Distal tibial fracture; Intramedullary nail; Multidirectional locking nail; Plate fixation; Locking compression plate; Fracture union; Orthopaedic trauma.

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Introduction

Distal tibial fractures are relatively uncommon but clinically challenging injuries, accounting for approximately 10% of fractures involving the lower extremity. They demonstrate a bimodal pattern of occurrence, with high-energy injuries more frequently affecting younger adults and low-energy fractures occurring predominantly in older individuals. The mechanism of injury ranges from rotational forces producing spiral fracture patterns to high-energy axial loading, compression, and torsional forces associated with road traffic accidents, falls from height, and sports-related trauma. [1,2]

The management of distal tibial fractures is particularly demanding because of the limited soft-tissue envelope and subcutaneous location of the tibia. High-energy trauma may produce substantial soft-tissue damage, compromising local vascularity and increasing the risk of wound complications, infection, delayed healing, and nonunion. Associated fibular fractures are also common, being reported in a substantial proportion of distal tibial injuries. Patient-related factors such as diabetes mellitus, peripheral vascular disease, smoking, and alcohol use can further increase the risk of postoperative complications. [3,4]

Several treatment modalities have been described, including conservative treatment, external fixation, plate osteosynthesis, and intramedullary nailing. Historically, open reduction and internal fixation (ORIF) with plate osteosynthesis became an established treatment following the principles described by Rüedi and Allgöwer. Although plating allows direct fracture reduction and restoration of articular alignment, extensive soft-tissue dissection may compromise blood supply and increase wound-related complications, particularly in high-energy fractures. Wound dehiscence, superficial and deep infection, and osteomyelitis are important complications associated with conventional open plating of distal tibial fractures. [5,6]

The development of locking compression plates (LCPs) has improved the biological and mechanical principles of plate fixation. Locking screws provide angular stability and are particularly useful in metaphyseal and osteoporotic bone where conventional screw fixation may be less reliable. Minimally invasive plate osteosynthesis (MIPO) techniques further reduce soft-tissue disruption by allowing indirect fracture reduction and preservation of the periosteal blood supply. Nevertheless, postoperative wound complications and infection remain concerns because the distal tibia has relatively poor soft-tissue coverage. [7]

Intramedullary nailing provides an alternative method of stabilization that can potentially minimize disruption of the surrounding soft tissues. Modern multidirectional locking intramedullary nails provide improved control of distal fragments through multiple interlocking options and may reduce problems such as malalignment and rotational instability that were encountered with earlier nail designs. Intramedullary fixation also permits a load-sharing construct and may facilitate earlier mobilization and weight bearing. However, technical difficulties including distal fragment control, malalignment, anterior knee symptoms, and difficulties in achieving satisfactory reduction can occur. [8,9]

The role of fibular fixation in distal tibial fractures remains controversial. Fixation of the fibula may facilitate restoration of length and alignment and assist reduction of the distal tibial fragment, whereas some studies suggest that routine fibular fixation may not be necessary when adequate stability and alignment can be achieved with a modern multidirectional locking intramedullary nail. [10] Therefore, implant selection should consider fracture morphology, soft-tissue status, bone quality, associated fibular injury, and patient-related risk factors.

External fixation has historically been used for severe open fractures and injuries associated with extensive soft-tissue damage. Although it provides rapid stabilization with limited initial soft-tissue disruption, prolonged external fixation can be associated with pin-tract infection, loss of reduction, ankle stiffness, malalignment, and patient discomfort. [11] These limitations have encouraged the development and increasing use of internal fixation techniques that provide stable fixation while minimizing additional soft-tissue injury.

Given the continuing debate regarding the optimal fixation method, comparative evaluation of multidirectional locking intramedullary nailing and plate fixation is clinically relevant. A prospective randomized comparison may help determine differences in functional recovery, fracture union, alignment, complications, and radiological outcomes between these techniques. Therefore, the present study was undertaken to compare the clinical and radiological outcomes of multidirectional locking intramedullary nailing versus plate fixation in patients with distal tibial fractures.

Aim

To compare the clinical and radiological outcomes of multidirectional locking intramedullary nailing versus plate fixation in the management of distal tibial fractures.

Objectives

1. To compare the functional outcomes of patients with distal tibial fractures treated with multidirectional locking intramedullary nailing and plate fixation.
2. To compare the time to fracture union between the two treatment groups.
3. To assess and compare postoperative radiological alignment, including coronal and sagittal alignment, between the two techniques.

Materials and Methods

This prospective randomized controlled study was conducted in the Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, from March 2025 to February 2026. Adult patients presenting with distal tibial fractures and fulfilling the predefined eligibility criteria were enrolled and randomly allocated to undergo either multidirectional locking intramedullary nailing or plate fixation. Patients aged 18–70 years with closed distal tibial fractures or Grade I compound fractures without intra-articular extension were included. Patients younger than 18 years or older than 70 years, those with Grade II or III compound distal tibial fractures, and fractures with intra-articular extension were excluded. Patients were evaluated clinically and radiologically before treatment, and written informed consent was obtained after explaining the nature of the injury, available treatment options, surgical procedures, potential complications, risks, and expected benefits.

Following initial stabilization of the patient, a detailed history was obtained, including the mechanism of injury, time since injury, mode of trauma, associated injuries, and relevant comorbidities. The mechanism of injury was assessed to estimate the severity and energy involved in the trauma. Particular attention was given to comorbid conditions such as diabetes mellitus, hypertension, smoking, peripheral vascular disease, and other factors that could influence fracture healing and postoperative recovery. Clinical examination included assessment of pain, swelling, deformity, abnormal mobility, tenderness, crepitus, and limb alignment. The condition of the overlying skin and soft tissues was carefully documented, including the presence of wounds, abrasions, bruising, fracture blisters, edema, and local temperature changes. A complete neurovascular examination was performed by assessing distal pulses, capillary refill, motor function, and sensory status. The injured limb was immobilized appropriately, and the soft-tissue condition was monitored before definitive fixation.

Radiological evaluation was performed using anteroposterior and lateral radiographs of the affected leg and ankle, including the knee and ankle joints where appropriate. Fracture morphology, level of fracture, displacement, angulation, shortening, comminution, and associated fibular fractures were documented. Patients underwent definitive fixation after appropriate preoperative assessment and optimization. In the multidirectional locking intramedullary nailing group, the fracture was reduced by closed or minimally invasive techniques as appropriate, followed by insertion of a multidirectional locking intramedullary nail and distal and proximal locking to achieve adequate axial, rotational, and angular stability. In the plate fixation group, appropriate reduction was achieved and maintained using a locking compression plate through an appropriate surgical approach, with care taken to preserve the surrounding soft-tissue envelope and fracture biology. Fibular fixation was performed when clinically indicated based on fracture pattern, stability, and alignment.

Postoperatively, patients were managed according to a standardized rehabilitation protocol. Limb elevation, wound care, analgesia, thromboprophylaxis where indicated, and early controlled ankle and knee mobilization were instituted. Weight-bearing was progressed according to fracture stability, radiological evidence of healing, and the treating surgeon's assessment. Patients were followed clinically and radiologically at predetermined intervals to assess fracture union, alignment, ankle range of motion, functional recovery, and postoperative complications. Radiographs were evaluated for progressive callus formation, maintenance of alignment, and eventual bridging of the fracture site. Delayed union, nonunion, malunion, infection, wound complications, implant failure, and other adverse events were documented. Functional outcome was assessed using an appropriate validated lower-limb functional scoring system, together with assessment of ankle and knee range of motion and ability to return to routine activities.

Data collected during the study were entered into a Microsoft Excel spreadsheet and analyzed using appropriate statistical software. Continuous variables such as age, operative time, time to radiological union, and functional scores were expressed as mean ± standard deviation (SD) or median with interquartile range, depending on data distribution. Categorical variables such as sex, fracture characteristics, union status, infection, malunion, and other complications were expressed as frequencies and percentages. Comparisons between the multidirectional locking intramedullary nail and plate fixation groups were

performed using the independent-samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. Changes in functional scores and other paired measurements over follow-up were assessed using appropriate paired statistical tests. A p-value <0.05 was considered statistically significant, with a 95% confidence interval used where applicable.

Result:

In this study, the data analysis was conducted using SPSS version 16.01. The statistical procedures employed included the paired sample t-test and the McNemar Chi Square test. The results of these analyses indicated statistical significance.

Table 1: Age Distribution

Age Groups	Nailing		Plating	
	Number of Patients	%	Number of Patients	%
25 - 35	2	20.00	2	20.00
36 - 45	3	30.00	3	30.30
46 - 55	5	50.00	5	50.00
≥ 56	00	00	00	00
Total	10	100	10	100

The age range typically observed for individuals undergoing multi-directional interlocking nailing procedures is between 33 and 55 years. The average age range for plating often spans from 27 to 60 years. The predominant age range for patients in both the nail and plate groups was 46-55 years.

Table 2: Sex Distribution

Sex	Nailing		Plating	
	Number of Patients	%	Number of Patients	%
Male	3	30.00	7	70.00
Female	7	70.00	3	30.00
Total	10	100	10	100

Within a sample size of 20 individuals, an equal distribution of 10 men and 10 females was observed. The gender distribution in the practice of nailing, specifically with regards to males and females.

Table 3: Nailing and Plating

Status	Nailing		Plating	
	Number of Patients	%	Number of Patients	%
Closed	08	80.00	02	20.00
Open	02	20.00	08	80.00
Total	10	100	10	100

Out of a cohort of 20 patients, a group of 10 patients was chosen for the application of intramedullary nails, while another group of 10 patients was picked for the implementation of bone plates. In the nailing cohort, a total of 8 patients had closed technique surgery, while in 2 individuals, open reduction and fibular fixation were performed. The surgical procedure involved the utilization of open reduction and internal fixation with a low profile 3.5 mm locking compression plate for tibial fixation, as well as the use of a one third tubular plate for fibular fixation.

Table 4: Mode of Injury

Mode of Injury	Nailing		Plating	
	Number of Patients	%	Number of Patients	%
Fall From Height	3	30.00	2	20.00
Road Traffic Accident	7	70.00	3	30.00
Twisting of Ankle	0	0	5	50.00
Total	10	100	10	100

The primary factor contributing to both nailing and plating procedures is road traffic accidents. The success rate for nailing is approximately 100.00%, whereas the success rate for plating is approximately 100.0%. The incidence of falls from height in the context of nailing is 30.00%, whereas in the context of plating, it is 20.00%.

Table 5: Weight Bearing

Weight Bearing	Nailing		Plating		8	80.00	0	0
	Number of Patients	%	Number of Patients	%				
Delayed	2	20.00	10	100.00				
Immediate								
Total					10	100	10	100

The initiation of weight bearing for the nail group occurs 48 hours post-implantation, as these implants are designed to sustain loads. Immediate weight bearing is began for patients in this context.

Discussion

The present prospective randomized study compared multidirectional locking intramedullary nailing with plate fixation for distal tibial fractures in 20 patients. Each treatment group consisted of 10 patients, providing an equal allocation between the two treatment modalities. The study population was predominantly concentrated in the 46–55-year age group, which accounted for 50% of patients in both groups. Distal tibial fractures occur across a wide age range, with younger individuals more commonly sustaining high-energy trauma and older individuals more frequently experiencing low-energy injuries. The comparable age distribution between the two groups

suggests reasonable baseline comparability for evaluating the two fixation methods. [12,13]

The sex distribution showed an overall equal representation of males and females, with 10 patients of each sex. However, the distribution within the treatment groups differed, with males accounting for 70% of the plating group and females accounting for 70% of the nailing group. This difference should be interpreted cautiously because of the small sample size. Previous studies of distal tibial fractures have reported variable sex distributions depending on the mechanism of injury and demographic characteristics of the study population. [13,14]

Regarding fracture characteristics and operative management, 80% of patients in the nailing group underwent closed fixation, whereas 20% required open reduction with fibular fixation. In contrast, 80% of patients in the plating group underwent open reduction and internal fixation. The lower requirement for open exposure in the nailing group represents one of the important theoretical advantages of intramedullary fixation. Intramedullary nails can be inserted through relatively limited approaches and may preserve the periosteal blood supply and surrounding soft tissues compared with conventional open plating. [15]

The predominance of closed procedures in the nailing group is particularly relevant because the distal tibia has a relatively poor soft-tissue envelope. Extensive surgical exposure may increase the risk of wound complications and infection. A randomized study comparing intramedullary nailing with plate fixation for distal tibial fractures reported that minimally invasive fixation strategies can reduce soft-tissue morbidity while providing satisfactory fracture stabilization. [16] Similarly, Vallier et al. demonstrated comparable functional and healing outcomes between intramedullary nailing and plate fixation, while emphasizing the importance of careful attention to alignment with both techniques. [17]

The mechanism of injury differed between the two groups. Road traffic accidents were the most common mechanism in the nailing group, accounting for 70% of cases, whereas twisting injuries were predominant in the plating group, accounting for 50%. Falls from height represented 30% of injuries in the nailing group and 20% in the plating group. The higher proportion of road traffic accidents among patients treated with nails may indicate a greater proportion of high-energy injuries in this group. High-energy mechanisms are frequently associated with greater comminution and soft-tissue injury, factors that may influence the choice of fixation method. [12,18]

Both treatment groups demonstrated a reported 100% success rate in the available follow-up assessment. However, this finding should be interpreted as successful treatment within the parameters assessed rather than definitive evidence of superiority of either technique. The small sample size and absence of a larger multicenter population substantially limit the ability to detect differences in union, complications, or functional recovery.

The use of multidirectional locking nails may provide improved distal fragment control compared with earlier-generation intramedullary nails. Multiple distal locking options can help control angular and rotational deformity, which is particularly important in metaphyseal distal tibial fractures. Nevertheless, malalignment remains a recognized concern with intramedullary nailing, while plating may provide more direct control of fracture reduction. [17,19]

Overall, the present findings suggest that both multidirectional locking intramedullary nailing and plate fixation can provide satisfactory treatment of distal tibial fractures. The apparent advantage of nailing is the possibility of achieving stable fixation with less extensive soft-tissue exposure, whereas plating offers direct visualization and control of fracture alignment. Larger randomized studies with longer follow-up and standardized assessment of union time, ankle function, malalignment, infection, and implant-related complications are required to establish the relative superiority of either technique.

Conclusion

The present study demonstrates that both multidirectional locking intramedullary nailing and plate fixation are effective treatment options for distal tibial fractures, with satisfactory clinical outcomes in the studied patients. Intramedullary nailing allowed fixation through a less invasive approach in the majority of cases, with 80% of patients treated without open reduction, whereas plating more frequently required open reduction and internal fixation. Road traffic accidents were the predominant mechanism of injury in the nailing group, while twisting injuries were more common in the plating group. Both techniques achieved a reported 100% treatment success rate in this cohort. Multidirectional locking nailing may offer the additional advantage of reduced soft-tissue disruption while providing adequate fracture stability. However, due to the small sample size, larger randomized studies with longer follow-up are required to establish significant differences in fracture union, functional outcomes, alignment, and postoperative complications between the two techniques.

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