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Research Article

Closed Intramedullary Nailing Vs. Percutaneous Plating for Distal Tibia Metaphyseal Fractures

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ABSTRACT
Background: Distal tibial metaphyseal fractures are difficult orthopedic injuries due to the fact that they are relatively soft tissue-deficient and hard to fix without compromising the fracture biology.
Objective: The clinical, radiological, and functional results of closed intramedullary nailing versus percutaneous plating of distal tibial metaphyseal fracture.
Materials and Methods: The study was a prospective comparative study at the Khyber Teaching Hospital Peshawar from September 2025 to February 2026. A total of 80 patients with extra-articular distal tibial metaphyseal fractures were randomly divided into two groups: intramedullary nailing and percutaneous plating.
Results: The intramedullary nailing group had a significantly lower blood loss, shorter hospital stay, and lower operative time. There was no difference in the rate of fracture union or functional results, but plating had slightly better alignment and more superficial wound complications and implant irritation.
Conclusion: Both methods are effective, but intramedullary nailing is more efficient in the operation and has a quicker recovery.

Keywords: Distal Tibial Metaphyseal Fracture, Intramedullary Nailing, Percutaneous Plating, Minimally Invasive Plate Osteosynthesis, Fracture Union and Functional Outcome.

INTRODUCTION

Preserving the soft tissue around the fracture while obtaining anatomical alignment is the key to treatment, with risk of malunion, delayed union, nonunion, post-traumatic arthritis, and prolonged functional disability if the reduction is not adequate (1). Technological developments in the surgical techniques and implant design have contributed to better treatment of distal tibia fractures. However, there is still some controversy on the best fixation method for extra-articular distal metaphyseal fractures. Two of the operative techniques currently available, such as closed intramedullary nailing and minimally invasive percutaneous plating, have become the two most commonly used techniques since both aim to achieve stable fixation with the least amount of surgical trauma. The distal tibia has specific biomechanics and biology that affect fracture management.

The metaphyseal area is wider than the diaphysis, and has a larger medullary canal, which makes it more challenging to obtain stable fixation with conventional intramedullary nails (2). In addition, the extremely small soft tissue envelope and relatively poor vascularity make the wound a greater risk for complications if extensive surgical exposure is performed. This led to the evolution of "minimally invasive" fixation techniques that allow the maintenance of fracture biology with acceptable alignment and stability. Recent evidence has shown that modern surgical techniques place a greater emphasis on the principles of biological fixation, so that healing can take place without soft tissue complications to the detriment of the patient (3). Closed intramedullary nailing is now a technique of choice for many tibial fractures because it leaves the periosteal blood supply intact, has relatively small incisions, and allows for early

mobilization and weight bearing. Multiple distal locking screws and improved angular stability have expanded the indications to include distal metaphyseal fractures that were previously thought to be unsuitable for nailing.

However, there are some concerns with malalignment, particularly with fractures that are near the ankle joint, where distal fixation may be restricted. In a recent meta-analysis, intramedullary nailing was found to have shorter operating time, less blood loss, and earlier functional recovery, but equivalent union rates compared with plate fixation under proper surgical conditions. The success of intramedullary nailing will also rely on the surgical approach for the insertion of the nail (4). The infrapatellar approach is the traditional method used, but it may have technical difficulties in achieving accurate reduction of the distal fracture, as knee flexion is needed for insertion. The suprapatellar approach has become more common in recent years due to the relative ease of maintaining fracture alignment during insertion of the nail and the decreased deforming forces on the distal fragment. The suprapatellar technique has been demonstrated to provide better radiological alignment and a lower incidence of anterior knee pain after surgery while having no significant increase in the rate of complications, making it a potentially useful approach for distal tibial fracture nailing.

Another important development in the treatment of distal tibial fractures is percutaneous plating by minimally invasive plate osteosynthesis (MIPO). The goal of this technique is to maintain the fracture hematoma and periosteal blood supply while minimizing dissection of the soft tissues. Locking compression plates can be useful for achieving angular stability and are especially beneficial in metaphyseal bone, where screw purchase may be restricted. Both intramedullary nailing and minimally invasive plating have proven to have similar functional results in clinical studies comparing the two methods, though plating may offer better alignment control for fractures very near the ankle joint. However, known drawbacks of plate fixation include implant prominence, irritation of the wound, and sometimes the removal of the implants (5).

Both surgical procedures are widely used, but there is still much discussion on their respective merits and demerits. Intramedullary nailing is usually correlated with earlier weight bearing, smaller surgical incisions, and a lower incidence of wound complications, while plate fixation is correlated with better anatomical reduction and rotational stability. The two techniques have been compared in clinical studies, which report similar fracture healing rates and functional results, indicating that it is not possible to use a single method for all fracture types but should be based on fracture morphology, patient characteristics, and surgeon expertise (6). These treatment options have also been assessed in several prospective comparative studies of adults with extra-articular distal third tibial fractures. These studies have shown that both techniques have high union rates and good function of the limbs.

However, there are some minor distinctions in the surgical time, fluoroscopy time, recovery, and complication rates. Intramedullary nailing is usually more conducive to earlier recovery, but plating can help to decrease the risk of angular malalignment in certain fracture patterns. These observations highlight the need for careful planning prior to surgery and appropriate choice of treatment (7). Innovations in recent years have also focused on the use of a hybrid approach to fixation, which utilizes the benefits of both plating and intramedullary nailing. Plate-assisted reduction with temporary plates followed by intramedullary nailing has been suggested for complex fracture patterns where it is hard to maintain reduction during nail insertion. Systematic reviews indicate that the use of plates can enhance fracture alignment without compromising the biological advantages of intramedullary nailing, especially in multifragmentary fractures where fracture alignment is crucial for fracture healing (8).

Several comparative studies have shown similar fracture union rates and functional recovery with different complication patterns. Plate fixation tends to provide superior coronal and sagittal alignment, while intramedullary nailing provides for shorter hospital stay and early mobilization. Importantly, satisfaction with the restoration seems to be more related to the restoration function than to the type of implant chosen (9). Modern fixation techniques have become more reliable with the improvements in implant technology and surgical techniques. Comparative studies in recent years have compared contemporary locking plates with advanced intramedullary nails, showing excellent clinical results with both options. However, there are still some concerns about the differences in operative efficiency, implant-related symptoms, and postoperative rehabilitation, which indicates that there is no

single technique that is superior for all patients (10).

Biological fixation has become more and more relevant in the field of orthopedic trauma surgery. The evidence for dual plating is largely from the fractures around other anatomical sites, but systematic assessments have supported the benefit of stable fixation without compromising fracture biology and surrounding soft tissues. The principles have also shaped the evolution of fixation options for distal tibial fractures, guiding towards minimally invasive options where possible (11). Intramedullary fixation continues to be improved by technological innovation. Preliminary clinical experience has shown promising radiological alignment and satisfactory healing, but more comparative studies are needed to recommend the use of the implant on a wide scale (12). The literature is becoming increasingly focused on fracture-specific, rather than implant-specific, decision-making.

Comparative studies of plate fixation versus nail fixation for complex distal tibial fractures show that fracture morphology, bone quality, bone injury, and surgeon experience are significant factors affecting clinical results. Therefore, personalized treatment planning is still crucial to ensure the patient's recovery and reduce complications (13). Retrospective studies comparing the two techniques of retrograde intramedullary nailing and minimally invasive locking plates have yielded good results in recent years. Fracture healing and functional recovery may seem the same, but there are some subtle differences in the operative characteristics and complication profile that still warrant further prospective studies, using standardized outcome assessment (14).

There are also several other comparative clinical studies from various populations that have shown good fracture union and function with both intramedullary nailing and plate fixation. Intramedullary nailing is often a quicker procedure with less soft-tissue damage, but plate fixation can offer greater stability in some configurations of the distal fractures. These findings are congruent with a patient-centered implant selection (15). Clinical results of similar periarticular fractures have also demonstrated that various fixation techniques can be equally successful if proper surgical principles are followed. These findings further support the notion that accurate reduction and stable fixation combined with preservation of soft tissue integrity and proper postoperative rehabilitation can be more important than selection of the implant (16).

Despite the many comparative studies and systematic reviews published, the optimal treatment still remains unclear, especially in resource-limited healthcare environments in which patient characteristics and surgical expertise may not be the same as those reported in international literature. Recent comparative studies in the region have shown satisfactory results with both intramedullary interlocking nailing and minimally invasive percutaneous plating techniques, but highlighted the need for individual decision-making based on fracture pattern, patient requirements, and expected functional recovery. The objective of the present study is to compare the union, functional outcome, surgical characteristics, and postoperative complications of closed intramedullary nailing and percutaneous plating for the treatment of distal tibial metaphyseal fractures and pinpoint the best treatment option for these difficult fractures (17).

Objective: To compare the clinical, radiological, and functional results of closed intramedullary nailing versus percutaneous plating for the treatment of distal tibial metaphyseal fractures in adults, focusing on fracture union, complications, operating parameters, and recovery.

MATERIALS AND METHODS

Study Design: Prospective comparative study.

Study Setting: Khyber Teaching Hospital Peshawar.

Duration of the Study: From September 2025 to February 2026.

Inclusion Criteria: Patients aged 18-65 years with closed extra-articular distal tibial metaphyseal fractures (AO/OTA type 43-A) less than 2 weeks after injury were included. Patients medically suitable for surgery and receiving either closed intramedullary nailing or minimally invasive percutaneous plating as their initial surgical intervention were included. Patients who were willing to give informed consent and attend follow-up evaluations were included in the study.

Exclusion Criteria: Patients with open fractures, intra-articular fractures of the distal tibia, pathological fractures, damage-control orthopedics (DCO) surgery due to polytrauma, previous fractures or deformities of the affected tibia, associated neurovascular injuries, active local infection, and severe medical comorbidities that would preclude surgery were

excluded. Patients who were not followed up on or had incomplete clinical information were also excluded from the final analysis.

Methods: Following Institutional Ethical Review Committee approval and written informed consent from all patients, patients were consecutively included and randomly divided into two treatment groups depending on the preferred technique of fixation of the operating surgeon. Operations were conducted under spinal or general anesthesia with the conventional operating techniques. All patients were treated with the same antibiotic, postoperative analgesia, and rehabilitation protocol per institutional guidelines. Clinical and radiological follow-up was performed at 2 weeks, 6 weeks, 3 months, and 6 months. The data were analyzed with SPSS version 26.0, and a p-value < 0.05 was considered statistically significant.

RESULTS

Eighty patients with distal tibia metaphyseal fractures met the inclusion criteria and were followed up for six months. The patients were split equally between the Closed Intramedullary Nailing (IMN) group (n=40) and the Percutaneous Plating (MIPO) group (n=40). The mean age of the subjects in the IMN group was 41.8 ± 12.3 years, while in the plating group it was 43.1 ± 11.7 years. There were more males than females in both groups.

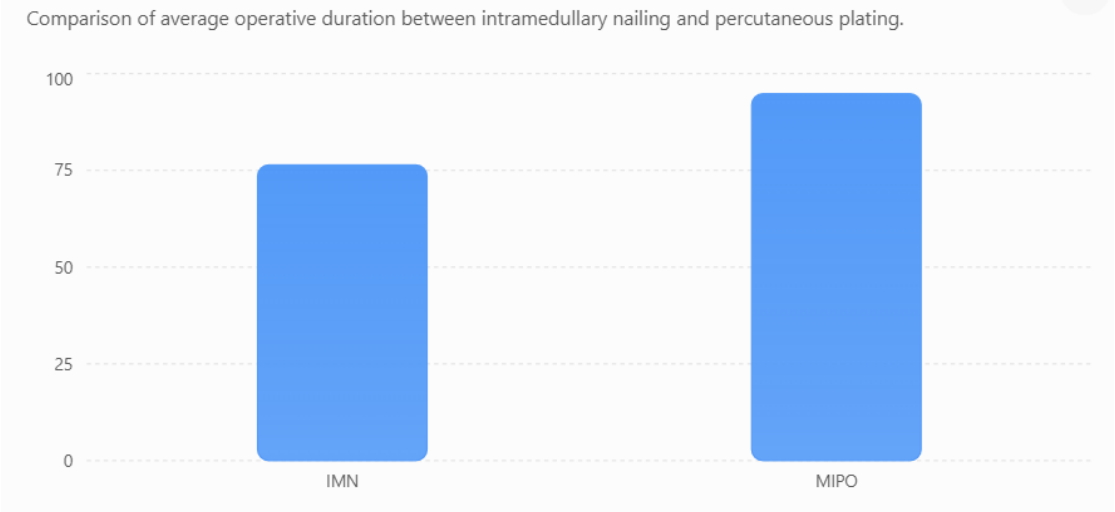
Table 1. Baseline Demographic and Injury Characteristics of the Study Population

Variable	IMN (N=40)	MIPO (N=40)	P-Value
Mean Age (Years)	41.8 ± 12.3	43.1 ± 11.7	0.64
Male, N (%)	28 (70.0)	27 (67.5)	0.81
Female, N (%)	12 (30.0)	13 (32.5)	
Right-Sided Fracture, N (%)	23 (57.5)	21 (52.5)	0.65
Road Traffic Accident, N (%)	25 (62.5)	24 (60.0)	0.82
Fall From Height, N (%)	15 (37.5)	16 (40.0)	

There were significant differences between the treatment groups with respect to operative and post-operative parameters. The mean operative time was significantly less for the intramedullary nailing group **(76.4 ± 11.2 minutes)** compared to the plating group **(94.8 ± 13.6 minutes, p<0.001).** Likewise, IMN patients had significantly reduced blood loss during surgery. Hospital stay was also shorter following intramedullary nailing.

Table 2. Comparison of Operative and Functional Outcomes

Outcome	IMN (n=40)	MIPO (n=40)	p-value
Operative time (minutes)	76.4 ± 11.2	94.8 ± 13.6	<0.001
Blood loss (mL)	118 ± 29	176 ± 41	<0.001
Hospital stay (days)	3.8 ± 1.1	5.2 ± 1.4	<0.001
Radiological union (weeks)	17.3 ± 2.8	18.1 ± 3.1	0.18
Mean AOFAS score	90.6 ± 5.4	88.2 ± 6.1	0.04



The Distribution of Mean Operative Time between Both Treatment Groups Is Illustrated Below.

However, both groups experienced postoperative complications, albeit at different rates. The plating group had an increased risk of superficial surgical site infection, while malalignment was slightly more common in the intramedullary nailing group. Delayed union and nonunion were rare in both groups. Irritation of the implant was reported, and subsequent implant removal was reported only with patients treated by percutaneous plating. The overall complication rates were low, and no cases of deep infection or implant failure were observed during the follow-up. These results suggest that both fixation methods are safe and effective, but have different complication rates and should be taken into account when planning the surgery.

Table 3. Postoperative Complications

Complication	IMN (N=40)	MIPO (N=40)	P-Value
Superficial Infection	2 (5.0%)	5 (12.5%)	0.23
Malalignment	4 (10.0%)	2 (5.0%)	0.39
Delayed Union	2 (5.0%)	3 (7.5%)	0.64
Nonunion	1 (2.5%)	1 (2.5%)	1.00
Implant Irritation	1 (2.5%)	6 (15.0%)	0.04

In general, both closed IM nailing and minimally invasive percutaneous plating had excellent rates of union and acceptable functional results. The operative time, blood loss, and length of hospital stay were shorter with intramedullary nailing, and the complications were acceptable, while the plates used for percutaneous nailing were found to be effective for achieving satisfactory fracture alignment.

DISCUSSION

The results of both treatment options were satisfactory for fracture union and good functional outcome, supporting that either treatment option may be used successfully for the treatment of extra-articular distal tibial fractures if appropriate patient selection and surgical principles are followed. However, intramedullary nailing demonstrated significant advantages in terms of shorter operative time, reduced intraoperative blood loss, and shorter hospital stay, whereas percutaneous plating provided satisfactory fracture alignment with acceptable complication rates (1). A major finding of the present study was the significantly shorter operative time in the intramedullary nailing group.

Patients undergoing IMN also had lower transfusion requirements and faster mobilization after surgery than patients treated with percutaneous plating. These findings are similar to the comparative study carried out by a study, which concluded that intramedullary nailing was associated with less surgical time, with clinical and radiological results similar to plate fixation. They found that both techniques provided an adequate healing environment for the fracture, with IMN providing more surgical efficiency and less soft tissue disruption (2). The same findings were reported in the systematic review and meta-analysis conducted by Elnewishy et al., who showed that intramedullary nailing was associated with shorter hospitalization and shorter operation times, while minimally invasive plating was associated with better alignment of the fracture in selected patients (5).

There was no significant difference in the radiological union time between the two treatment groups, and only a slight tendency toward earlier union time after intramedullary nailing in our study. They focused on the fact that both methods offer reliable mechanical fixation, which can lead to good biological healing if the appropriate surgical procedures are performed (3). Patients who underwent intramedullary nailing had slightly better functional recovery as measured by the American Orthopedic Foot and Ankle Society (AOFAS) score at the final follow-up period, but both groups demonstrated excellent functional outcomes. This may be due to early mobilization allowed by intramedullary fixation, since the preservation of the periosteal blood supply and the use of smaller surgical incisions contribute to speeding up rehabilitation. Patil et al. have reported good functional outcomes in both treatment groups, with early functional scores being marginally better in the intramedullary nailing group because of weight-bearing and less postoperative discomfort (5).

Mahapatra et al. also found that after fracture union has been attained, the functional difference between plating and the other technique becomes negligible (7). Distal tibial fracture fixation is a concern with fracture alignment, as the metaphyseal region offers little cortical support for intramedullary fixation.

A slightly higher malalignment incidence was noted after IM nailing, but it was not statistically significant in the present study. Similar results were shown by KC et al., who showed that the coronal and sagittal planes were better controlled with minimally invasive plating compared to intramedullary nailing, which may have a slightly higher risk of angular deformity if the reduction was inadequate (9). This problem has been minimized with advances in nail design, such as multiple distal locking screws, but careful intraoperative reduction is still necessary.

One of the main benefits of minimally invasive techniques is soft tissue preservation. Historically, plating was associated with a higher risk of wound complications due to the large surgical exposure, but the use of minimally invasive percutaneous plate osteosynthesis has considerably reduced soft tissue damage. Superficial wound infection was more common in the plating group, while deep infection was rare in both groups. Similarly, Sharma et al. found that infection rates were acceptable with minimally invasive plating, but that it was slightly more likely to have a wound-related complication, and that the implant was located under the subcutaneous medial surface of the distal tibia (10). Similarly, Almishri et al. reported an increased incidence of superficial wound irritation in patients undergoing plate fixation, while reporting good overall clinical results (15).

The intramedullary nailing group had shorter hospital stays, which could be due to the fact that they were mobilized more quickly than the more painful group, or because of the less extensive soft tissue disruption in the smaller incisions. Peng et al. noted the advances in intramedullary fixation, including new-generation retrograde tibial nails, specifically intended for distal metaphyseal fractures. Their initial clinical outcomes showed encouraging alignment, stable fixation, and an early recovery, indicating that future use of intramedullary fixation may yield greater benefits with improvements in technology (12). Likewise, Yang et al. found that the suprapatellar approach allows for better fracture reduction and alignment with fewer technical difficulties encountered when performing conventional infrapatellar nail insertion.

Recent developments have also focused on the possibilities of combined fixation for more complex fracture patterns. Gouveia et al. reported that the use of a temporary plate to reduce complex distal tibial fractures prior to IMN may enhance alignment without affecting the biological benefits of nail fixation. Their systematic review found that in fractures with metaphyseal comminution, hybrid techniques might yield a lower rate of malalignment and satisfactory union rates (8). Such techniques were not investigated in the present study, but they offer good alternatives for selected patients with unstable fracture configurations. Overall, the postoperative complication rates seen in this study were reasonably low. Patients treated with percutaneous plating had a higher incidence of implant irritation, which led to subsequent removal of the implant, while malalignment was slightly more prevalent following intramedullary nailing. Liu et al. have reported similar results when they compared minimally invasive locking plates with retrograde tibial nails, describing similar functional results with different complication rates (17).

The present study results corroborate the notion that the principles of biological fixation should be utilized more than just the choice of an implant in modern orthopedic trauma management. Ganta et al. conducted comparative studies, which indicated that the fracture characteristics, surgeon experience, and restoration of anatomic alignment were more important than the type of implant used for the patient outcome (13). Similarly, Chapman et al. noted that different fixation methods yielded similar results in complex periarticular tibial fractures, and that stable fixation with soft tissue integrity is essential to successful fracture healing (16). These observations all point to the fact that treatment planning is essential to the best treatment of the individual patient.

The results of the present study are comparable to the latest orthopedic literature, which has shown that both closed intramedullary nailing and the minimally invasive technique of percutaneous plating are reliable treatment options for distal tibial metaphyseal fractures. Intramedullary nailing has many advantages in terms of the ability to perform an operation quickly, to minimize blood loss, to facilitate early mobilization, and to reduce the length of hospital stay, while percutaneous plating provides excellent fracture alignment with acceptable complication rates. Hence, treatment should be tailored to the fracture configuration, patient-related factors, and the operating surgeon's experience to ensure optimal clinical and functional results.

CONCLUSION

Closed intramedullary nailing and minimum invasive percutaneous plating were effective therapeutic modalities for extra-articular distal tibial metaphyseal fractures with high rates of fracture union and satisfactory functional results. The present study showed that intramedullary nailing had significant benefits, such as less operating time, less blood loss during the procedure, fewer hospital stays, and slightly better functional recovery. In contrast, the percutaneous plating group had excellent fracture alignment with an acceptable complication rate, but experienced a greater rate of superficial wound complications and implant irritation. Both fixation techniques were shown to be reliable, with comparable radiological union rates and overall clinical outcomes when appropriate surgical principles are followed, between the two treatment groups. Thus, the selection of the implant should be tailored to the characteristics of the fracture, soft tissue condition, patient-related factors, and surgeon experience.

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