

Clinical outcomes of patients undergoing Minimally Invasive Plate Osteosynthesis (MIPO) for distal tibia fractures

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Abstract:

Introduction: Distal tibial fractures are challenging to manage due to poor soft tissue coverage and subcutaneous location. Conventional open reduction and internal fixation (ORIF) often lead to wound complications and delayed healing. Minimally Invasive Plate Osteosynthesis (MIPO), using locking compression plates, aims to minimize soft tissue damage and preserve fracture biology, potentially improving outcomes.

Materials and Methods: This prospective study was conducted on 40 patients with distal tibial fractures treated using MIPO at Pacific Medical College and Hospital, Udaipur, from July 2024 to July 2025. Patients aged 18–70 years with closed or Gustilo-Anderson grade I/II fractures were included. Fractures were classified by AO/OTA system. Pre-contoured distal tibial locking plates were applied submuscularly through small incisions under fluoroscopic guidance. Postoperative functional outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score at regular follow-ups up to 12 months.

Results: The mean patient age was 41.6 years; males comprised 70% of cases. Road traffic accidents were the predominant cause (65%). According to AO/OTA classification, 55% were type A, 30% type B, and 15% type C fractures. Mean radiological union time was 18.4 weeks, with 80% of patients uniting within 20 weeks. Delayed union occurred in 7.5% of cases; no non-unions were observed. Complications were recorded in 15% of patients, including superficial infection (5%), malalignment >5° (5%), and implant-related irritation (5%). At 12 months, the mean AOFAS score was 86.3, with 85% of patients achieving excellent-to-good functional outcomes.

Conclusion: MIPO provides stable fixation with biological preservation, resulting in reliable fracture healing, low complication rates, and favorable functional recovery in distal tibial fractures. Its advantages in minimizing wound-related complications and promoting early mobilization make it a preferred alternative to conventional open plating. Careful surgical planning and fluoroscopic guidance remain essential to prevent malalignment.

Keywords: Distal Tibial Fracture, Minimally Invasive Plate Osteosynthesis, Locking Compression Plate, Clinical Outcome.

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Introduction

The structural and biomechanical characteristics of distal tibial fractures make them a difficult class of injuries. Because of its subcutaneous location and sparse soft tissue covering, the distal tibia is more susceptible to consequences from wounds. These fractures account for approximately 10–15% of all tibial fractures and are most commonly brought on by high-energy trauma, such as low-energy falls in elderly osteoporotic patients or traffic accidents in young individuals [1–3]. Although open reduction and internal fixation (ORIF) with plating provides stable fixation, it is linked to wound dehiscence, infection, and delayed union because of extensive soft tissue dissection [4–6]. Conservative methods frequently result in malunion and stiffness, making management.

To lessen soft tissue issues, the focus has recently switched to biological fixing principles. Indirect fracture reduction and percutaneous plate insertion are used in Minimally Invasive Plate Osteosynthesis (MIPO), a procedure that has shown promise in reducing periosteal stripping and preserving fracture hematoma [7]. As "internal fixators," locking plates used in MIPO offer angular stability and lower the chance of fixation failure, especially in osteoporotic bone [8]. Compared to traditional plating, clinical trials have demonstrated positive results in terms of quicker union, blood supply preservation, and fewer wound sequelae; however, issues such as intraoperative fluoroscopy reliance and malalignment risk still exist [9–11].

Several authors have reported encouraging results with MIPO in distal tibial fractures. Redfern et al. demonstrated significantly reduced wound complications with satisfactory functional outcomes [12], while Hasenboehler et al. observed high union rates and minimal complications in their series [13]. Nevertheless, some studies still highlight issues such as delayed union and implant-related problems, warranting further prospective evaluation [14]. Considering the rising incidence of road traffic accidents in India and the demand for early mobilization, evaluating MIPO in the Indian setting is highly relevant. Thus, the present prospective study was undertaken at Pacific Medical College Hospital, Udaipur, to analyze the clinical outcomes of MIPO in distal tibial fractures.

Materials and Methods

Over the course of a year, from [July 2024 to July 2025], this prospective study was carried out in the Department of Orthopaedics at Pacific Medical College and Hospital, Bhilo Ka Bedla, Udaipur, Rajasthan. The study comprised 40 individuals with distal tibial fractures in total. The institutional ethics committee granted ethical clearance, and before to enrollment, each subject provided written, informed permission.

Inclusion and Exclusion Criteria: The study comprised patients with closed or Gustilo-Anderson grade I and II open distal tibial fractures who were between the ages of 18 and 70 [15]. Simple intra-articular fractures as well as extra-articular fractures were deemed eligible. Patients who were unsuited for anesthesia, had pathological fractures, polytrauma with potentially fatal injuries, fractures linked to vascular injury, or had severely comminuted intra-articular fractures that needed external fixation were not included.

Preoperative Evaluation: All patients underwent thorough clinical evaluation and necessary investigations, including radiographs of the affected leg in anteroposterior and lateral views. CT scans were performed in selected intra-articular cases to delineate fracture morphology. Fractures were classified according to the AO/OTA system [16]. Preoperative planning included templating of plate length and screw positions. Temporary immobilization with a plaster slab was applied in all cases until definitive fixation. Prophylactic intravenous antibiotics were given preoperatively as per institutional protocol.

Surgical Technique: The patient was positioned supine on a radiolucent table during all procedures, which were conducted under regional or general anesthesia. Under fluoroscopic guidance, percutaneous clamps and manual traction were used to reduce fractures indirectly. A pre-contoured locking compression plate (LCP) designed for the distal tibia was inserted submuscularly through small incisions proximally and distally, without disturbing the fracture site. Fixation was achieved using a combination of cortical and locking screws, following the principles of minimally invasive plate osteosynthesis (MIPO) as described in earlier literature [7]. Intraoperative fluoroscopy was used to confirm alignment, rotation, and implant position. Wounds were closed in layers, with drains removed after 24–48 hours.

Postoperative Management and Follow-up:

Postoperatively, limb elevation and analgesics were given, and antibiotics were continued for 48 hours. Early ankle mobilization was encouraged from the second postoperative day. Non-weight bearing ambulation with crutches or walker support was started early, while partial weight bearing was allowed after 6–8 weeks based on radiological signs of callus formation. Full weight bearing was permitted only after confirmed fracture union. The American Orthopaedic Foot and Ankle Society (AOFAS) score was used to evaluate functional outcome at every follow-up [17]. At six weeks, three months, six months, and twelve months, patients were evaluated clinically and radiologically.

Results

During the study period, 40 patients with distal tibial fractures were treated using minimally invasive plate osteosynthesis (MIPO). With a mean age of 41.6 years (range 19–68 years), there were 12 girls (30%) and 28 males (70%) among them. The majority of patients sustained fractures due to road traffic accidents (65%), followed by falls (30%) and other causes (5%).

Fracture Characteristics: Twelve patients (30%) had type B (partial articular) fractures, six patients (15%) had type C (full articular) fractures, and 22 patients (55%) had type A (extra-articular) fractures, according to the AO/OTA classification. Open fractures (Gustilo–Anderson grade I and II) were seen in 6 patients (15%), while the rest were closed injuries.

Table 1: Distribution of fractures (n=40)

Parameter	Number of Patients	Percentage (%)
AO type A (extra-articular)	22	55
AO type B (partial articular)	12	30
AO type C (complete articular)	6	15
Closed fractures	34	85
Open fractures (Grade I–II)	6	15

Time to Union: The mean radiological union time was 18.4 weeks (range 14–26 weeks). Most patients (80%) achieved union within 20 weeks. Delayed

union was observed in 3 patients (7.5%), while non-union was not reported in this series.

Table 2: Fracture healing outcomes

Healing Parameter	Mean / Number	Percentage (%)
Mean union time	18.4 weeks	–
Union $\leq$ 20 weeks	32	80
Delayed union	3	7.5
Non-union	0	0

Complications: Postoperative complications occurred in 6 patients (15%). Superficial wound infection was observed in 2 patients (5%) and was managed with antibiotics and dressings. Malalignment ($>5^\circ$ angular deformity) was seen in 2

patients (5%). Implant-related irritation occurred in 2 patients (5%) and required implant removal after union. No deep infections, implant breakages, or compartment syndromes were reported.

Table 3: Postoperative complications

Complication	Number of Patients	Percentage (%)
Superficial infection	2	5
Malalignment ($>5^\circ$)	2	5
Implant-related irritation	2	5
Deep infection	0	0
Implant failure	0	0

Functional Outcome: The American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score was used to evaluate functional outcomes. The mean AOFAS score at the 12-month final follow-up

was 86.3 (range: 70–95). Twenty-two patients (55%), twelve patients (30%), five patients (12.5%), and one patient (2.5%) had functional outcomes rated as excellent, good, or poor.

Table 4: Functional outcomes at 12 months (n=40)

Outcome	Number of Patients	Percentage (%)
Excellent	22	55
Good	12	30
Fair	5	12.5
Poor	1	2.5

Overall, MIPO provided satisfactory fracture healing, low complication rates, and good functional outcomes in the majority of patients. The technique proved especially effective in minimizing wound complications and preserving soft tissue biology.

Discussion

The management of distal tibial fractures remains a subject of debate because of the unique anatomical and biomechanical challenges involved. The present prospective study of 40 patients treated with Minimally Invasive Plate Osteosynthesis (MIPO) demonstrated favorable results in terms of union rate, complication profile, and functional outcome. Our findings support the role of MIPO as a reliable method for managing distal tibial fractures, especially in settings where preservation of soft tissue biology is critical.

In our series, the mean union time was 18.4 weeks, with 80% of cases uniting within 20 weeks and only 3 cases showing delayed union. These results are comparable to those reported by Vallier et al., who found a mean union time of 20 weeks in their series

of distal tibial fractures managed operatively [18]. Guo et al., in a randomized trial, also observed earlier union with MIPO compared to intramedullary nailing, attributing this to preservation of fracture hematoma and reduced periosteal stripping [14]. Our union rates further align with the study by Redfern et al., who reported satisfactory healing and minimal delays when using percutaneous plating for distal tibial fractures [12].

The overall complication rate in our study was 15%, with superficial infections (5%), malalignment (5%), and implant-related irritation (5%) being the most frequent issues. Notably, no cases of deep infection or implant failure occurred. These findings are consistent with those of Lau et al., who reported wound-related complications in 8% of cases treated with MIPO [11]. Similarly, Hasenboehler et al. found a low rate of deep infections and implant failures when using locking compression plates with minimally invasive approaches [13]. However, despite these advantages, the risk of malalignment remains a concern, as highlighted in our study and

by Collinge et al., who observed malalignment in 10% of their cases [19].

Functional recovery in our series, assessed using the AOFAS score, showed excellent-to-good results in 85% of patients, with a mean score of 86.3 at one year. Comparable outcomes were reported by Oh et al., who found that most patients treated with MIPO achieved satisfactory ankle and hindfoot function [10]. In contrast, traditional open plating techniques have been associated with inferior outcomes due to higher complication rates [5]. The relatively high rate of satisfactory functional recovery in our study further highlights the advantages of MIPO in restoring mobility and minimizing long-term morbidity.

The strength of our study lies in its prospective design and uniform surgical protocol performed in a single tertiary care center, ensuring consistency in technique and follow-up. However, the study has limitations, including the relatively small sample size (40 patients) and short follow-up duration of one year. Larger, multicentric studies with longer follow-up would provide stronger evidence regarding long-term outcomes, implant-related complications, and functional recovery.

Overall, our findings reinforce the growing body of evidence that MIPO is an effective and safe technique for distal tibial fractures, combining stable fixation with biological preservation of fracture healing. The technique's advantages in terms of fewer wound complications and excellent functional outcomes make it a desirable choice in contemporary fracture repair, even if it necessitates meticulous surgical planning and fluoroscopic guidance to prevent malalignment.

Conclusion

The current prospective research of 40 patients who had minimally invasive plate osteosynthesis (MIPO) for distal tibial fractures demonstrates how well this procedure works to produce acceptable radiological and clinical results. The majority of patients in our study achieved union within an acceptable time frame, with a low rate of delayed union and minimal complications. Functional recovery, assessed using the AOFAS score, was favorable in most cases, reflecting the ability of MIPO to restore mobility and ankle function in patients with distal tibial fractures.

The advantages of MIPO in our series were primarily related to its biological fixation principles, which preserve periosteal blood supply and fracture hematoma, thereby facilitating natural bone healing. Additionally, the technique allowed for smaller incisions, reduced soft tissue dissection, and a lower incidence of wound-related complications compared to conventional open plating methods. Malalignment, though observed in a small proportion of cases, underscores the importance of

careful intraoperative planning and precise fluoroscopic guidance to ensure optimal outcomes.

While our findings support the role of MIPO as a safe and reliable technique for distal tibial fractures, certain limitations must be acknowledged, including the relatively small sample size and short follow-up period. Nevertheless, the consistency of results across patients in this study suggests that MIPO provides a valuable balance between stable fixation and biological preservation, making it particularly suitable for fractures in the distal tibia where soft tissue coverage is often limited.

To sum up, minimally invasive plate osteosynthesis is a successful surgical technique for treating distal tibial fractures. This approach gives promising results in terms of fracture healing, complication rates, and functional recovery when used with the right surgical expertise and patient selection. To confirm these results and further demonstrate the long-term advantages of MIPO in clinical practice, bigger patient cohorts and longer follow-up are required in future research.

References

1. Bonar SK, Marsh JL. Tibial plafond fractures: changing principles of treatment. *J Am Acad Orthop Surg.* 1994;2(5):297–305.
2. Rüedi T, Allgöwer M. The operative treatment of intra-articular fractures of the lower end of the tibia. *Clin Orthop Relat Res.* 1979;(138):105–10.
3. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury.* 2006;37(8):691–7.
4. Im GI, Tae SK. Distal metaphyseal fractures of tibia: a prospective randomized trial of closed reduction and intramedullary nail versus plate fixation. *J Trauma.* 2005;59(5):1219–23.
5. Teeny SM, Wiss DA. Open reduction and internal fixation of tibial plafond fractures. *Clin Orthop Relat Res.* 1993;(292):108–17.
6. McFerran MA, Smith SW, Boulas HJ, Schwartz HS. Complications encountered in the treatment of pilon fractures. *J Orthop Trauma.* 1992;6(2):195–200.
7. Farouk O, Krettek C, Miclau T, Schandelmaier P, Guy P, Tscherne H. Minimally invasive plate osteosynthesis: does percutaneous plating disrupt femoral blood supply less than the traditional technique? *J Orthop Trauma.* 1999;13(6):401–6.
8. Wagner M. General principles for the clinical use of the LCP. *Injury.* 2003;34 Suppl 2:B31–42.
9. Collinge C, Sanders R, DiPasquale T. Treatment of complex tibial periarticular fractures using percutaneous techniques. *Clin Orthop Relat Res.* 2000;(375):69–77.

10. Oh CW, Kyung HS, Park IH, Kim PT, Ihn JC. Distal tibia metaphyseal fractures treated by percutaneous plate osteosynthesis. *Clin Orthop Relat Res*. 2003;(408):286–91.
11. Lau TW, Leung F, Chan CF, Chow SP. Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. *Int Orthop*. 2008;32(5):697–703.
12. Redfern DJ, Syed SU, Davies SJ. Fractures of the distal tibia: minimally invasive plate osteosynthesis. *Injury*. 2004;35(6):615–20.
13. Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. *Injury*. 2007;38(3):365–70.
14. Guo JJ, Tang N, Yang HL, Tang TS. A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. *J Bone Joint Surg Br*. 2010;92(7):984–8.
15. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones. *J Bone Joint Surg Am*. 1976;58(4):453–8.
16. Müller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures of long bones. Berlin: Springer-Verlag; 1990.
17. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int*. 1994;15(7):349–53.
18. Vallier HA, Le TT, Bedi A. Radiographic and clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond): plating versus intramedullary nailing. *J Orthop Trauma*. 2008;22(5):307–11.
19. Collinge C, Protzman R. Outcomes of minimally invasive plate osteosynthesis for metaphyseal distal tibia fractures. *J Orthop Trauma*. 2010;24(1):24–9.