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Clinical Outcomes of Locking Plate Fixation for Distal Tibial Fractures: A Case Series from Afghanistan

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ABSTRACT

Background: We aimed to evaluate the clinical and radiological outcomes of closed distal tibial fractures treated with locking compression plates using the minimally invasive percutaneous plate osteosynthesis technique.

Methods: A retrospective case series was conducted at the Department of Orthopedic Surgery and Traumatology, Kabul Atlas Hospital and Wazir Mohammad Akbar Khan Hospital, Kabul, Afghanistan. The medical records of 30 patients with closed distal tibial fractures treated using locking compression plates with the minimally invasive percutaneous plate osteosynthesis technique between March 21, 2025, and March 20, 2026, were retrospectively reviewed. Patients were evaluated at 6 weeks, 3 months, 6 months, and 12 months after surgery. Clinical outcomes included surgical site infection, skin necrosis, plate exposure, wound dehiscence, and ankle stiffness. Radiological union was assessed using standard radiographs.

Results: All 30 patients achieved radiological fracture union, with a mean healing time of 14.1 ± 2.6 weeks. One patient (3.3%) developed a deep surgical site infection, resulted in plate exposure and required implant removal. One patient (3.3%) experienced ankle stiffness during follow-up. No cases of skin necrosis or wound dehiscence were observed. All patients completed the scheduled 12-month follow-up.

Conclusion: Locking compression plate fixation using minimally invasive percutaneous plate osteosynthesis technique was associated with radiological union in all patients and few documented postoperative complications. However, the retrospective design, small sample size, and absence of a comparison group preclude conclusions regarding comparative efficacy.

Keywords: Distal tibia fracture; Minimally invasive percutaneous plate osteosynthesis; Locking plate; Fracture fixation

Introduction

Distal tibia fractures are relatively common and comprise nearly 37.8% of all tibia fractures. As the principal weight-bearing bone of the lower extremity, the tibia plays a critical role in maintaining limb alignment and function [1]. Distal tibial fractures are commonly caused by high-

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energy trauma, falls, sports-related injuries, and other accidental mechanisms [2]. The overall incidence of tibial fractures is estimated at 51.7 per 100,000 individuals annually and tends to increase with age, particularly in women [3]. According to the AO foundation/Orthopaedic Trauma Association (AO/OTA) classification system, distal tibial fractures are classified into three major categories as follows: extra-articular (43A), partial articular (43B), and complete articular (43C) fractures. Extra-articular fractures are sub-classified into simple, wedge, and multifragmentary patterns (A1-A3), whereas partial articular fractures comprise split, split-depression, and depression variants (B1-B3). Complete articular fractures are further categorized as C1-C3 according to the increasing complexity of articular disruption and metaphyseal involvement [4].

Management of these fractures remains challenging due to the subcutaneous location of the distal tibia, limited soft tissue coverage, and relatively poor vascularity, which predispose patients to complications such as delayed union, infection, malalignment, and implant failure [5,6]. Reported complication rates vary between 20% and 50% [7]. Therefore, local outcome data are useful.

Several surgical treatment options, including intramedullary nailing (IMN), external fixation, and Dynamic compression plate (DCP), are available for distal tibial fractures, but no clear consensus exists regarding the optimal approach [5,8]. The two most commonly used surgical techniques are intramedullary nailing (IMN) and minimally invasive percutaneous plate osteosynthesis (MIPPO) [9]. IMN offers the advantages of a minimally invasive technique with reduced soft tissue disruption and low infection risk; however, it may be associated with malalignment, especially in fractures with short distal fragments, anterior knee pain, and technical challenges during distal locking [10,11].

Closed reduction followed by MIPPO using a locking compression plate (LCP) has emerged as an alternative treatment strategy [11]. MIPPO addresses many limitations of conventional fixation by preserving fracture fragment vascularity and minimizing soft tissue disruption. It maintains bone perfusion and the osteogenic fracture hematoma, essential for healing. Additionally, the LCP provides stable fixation without direct plate-to-bone contact, thereby preserving periosteal microcirculation and reducing the risk of nonunion [12]. However comparative evidence does not establish consistent superiority of either technique, with differences reported in union time, alignment, and soft-tissue complications. MIPPO for distal tibial fractures achieves a union rate of approximately 90%, with a mean radiological union time ranging from 11 to 16 weeks and a low incidence of nonunion [13].

However, published evidence on MIPPO for distal tibial fractures is derived predominantly from settings outside Afghanistan, and locally generated clinical outcome data remain limited. Differences in healthcare infrastructure, implant availability, patient characteristics, injury patterns, and postoperative care may influence treatment outcomes and limit the direct applicability of findings from other healthcare systems. Afghanistan faces constraints in healthcare access, specialized services, and medical resources. In this context, documenting treatment outcomes within Afghan tertiary-care hospitals can provide locally relevant evidence and establish baseline data for future prospective and comparative studies.

Therefore, we aimed to describe the clinical and radiological outcomes of closed distal tibial fractures treated with MIPPO using pre-contoured LCPs in two tertiary-care hospitals, in Kabul, Afghanistan. By providing locally generated clinical data, we sought to contribute to the limited evidence on the management of distal tibial fractures in Afghanistan.

Materials and Methods

Study Design and Participants

This retrospective case series was conducted at the Department of Orthopedic Surgery and Traumatology, Kabul Atlas Hospital and Wazir Mohammad Akbar Khan Hospital, Kabul, Afghanistan. Medical records of all consecutive eligible patients who underwent MIPPO for closed distal tibial fractures between March 21, 2025, and March 20, 2026, were retrospectively reviewed. The inclusion criteria were patients aged 18-55 years, of either sex, with closed distal tibial fractures and complete follow-up for at least 12 months. Patients aged >55 years, those with pathological fractures, open fractures, a history of previous surgery on the affected limb, or incomplete follow-up were excluded from the study. All patients who met the predefined eligibility criteria during the study period were included in the analysis. No eligible patients were selectively excluded based on treatment outcome or postoperative complications.

Surgical Technique

All Fractures were managed using a 3.5 mm LCP with the MIPPO technique under fluoroscopic guidance. Standardized plain radiographs, including anteroposterior, lateral, and long-leg alignment views, were obtained preoperatively. The fixation strategy involved plate placement along the anteromedial surface of the distal tibia.

Fracture fragments were aligned and reduced percutaneously, with additional stab incisions as required to achieve satisfactory reduction. Larger fragments were stabilized using independent lag screws. A precontoured plate was then applied to bridge the fracture site, functioning as a compression plate in stable extra-articular fractures and as a bridge plate in AO/OTA 43B fracture patterns. The plate was positioned to allow insertion of at least three bicortical screws both proximally and distally to the fracture. Once satisfactory reduction had been achieved, a small transverse incision was made distal to the medial malleolus, and a submascular tunnel was created for plate insertion. The plate was advanced through the submascular tunnel, and its alignment and position were adjusted using unicortical Kirschner wires to guide the plate trajectory.

In AO/OTA 43B fracture patterns, often associated with distal one-third fibular fractures, fibular fixation was performed first to facilitate accurate reduction and alignment. The plate was then temporarily secured using Kirschner wires inserted through the distal and proximal plate holes. Limb alignment and rotational profile were carefully assessed and compared with the contralateral limb to confirm appropriate positioning. Definitive fixation was accomplished through percutaneous screw insertion, with at least three bicortical screws placed on each side of the fracture. Finally, the stab incisions were closed in a standard manner, sterile dressings were applied, and the limb was immobilized in a split plaster-of-Paris cast.

Postoperative Management and Outcome Assessment

Postoperatively, the limb was elevated for 48 hours. After wound assessment, the initial splint was replaced with a short-leg synthetic cast, which was maintained for six weeks. Following cast removal, outpatient physiotherapy focusing on ankle and foot range-of-motion exercises was initiated. Postoperative weight-bearing was guided by fracture pattern and fixation stability. In patients with AO/OTA 43A fractures and stable fixation, partial weight-bearing was permitted at six weeks and progressed to full weight-bearing by three months. In patients with AO/OTA 43B fractures, weight-bearing was restricted during the first three months, after which gradual partial weight-bearing was introduced according to clinical and radiographic progression.

Patients were followed at 6 weeks, 3 months, 6 months, and 12 months after fracture fixation. Postoperative outcomes were assessed for surgical site infection, skin necrosis, plate exposure, wound dehiscence, and ankle stiffness. Radiological union was evaluated using standard radiographs and was defined as the presence of mature callus formation in at least three of four cortices together with the absence of pain during full weight-bearing. All postoperative radiographs were assessed by a single orthopedic surgeon during routine follow-up.

Ethical statement

Written Informed consent was obtained from all the participants, and data were anonymized to ensure confidentiality. The study was conducted in accordance with the Declaration of Helsinki, and Ethical approval was obtained from the institutional review board of Wazir Mohammad Akbar Khan Hospital (protocol code 02, date 05/03/2025).

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation (SD), and ranges with 95% confidence intervals where appropriate. Exact binomial 95% confidence intervals were calculated for the fracture union rate. Categorical variables were presented as frequencies and percentages. Given the descriptive case-series design and absence of a comparison group, no hypothesis-driven comparative analysis of formal between-group sample size calculation was performed.

Results

A total of 30 patients, including 11 females (36.7%) and 19 males (63.3%), were enrolled, with a male-to-female ratio of 1.73:1 (Table 1).

Table 1: Baseline demographic and fracture characteristics of patients (n=30)

Variables	*Frequency (N=30)*	*Percentage (100%)*
Gender		
Male	19	63.3%
Female	11	36.7%
Age of the patients in years	Mean± SD	42.20 ± 14.51
Cause of Injury		
RTAs	20	66.7%
Fall	6	20%
Sports Injury	4	13.3%
Side of Injury		
Right	18	60.0%
Left	12	40.0%
AO Classification		
43A1	9	30.0%
43A2	4	13.3%
43A3	7	23.3%
43B1	7	23.3%
43B2	3	10.0%
Province		
Kabul	16	53.3%
Kunduz	5	16.7%
Badakhshan	5	16.7%
Herat	4	13.3%

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopedic Trauma Association classification. RTAs: Road traffic accident

All fractures achieved radiological union during follow-up (100%; 95% CI: 88.4-100%), with a mean time to union of 14.1 ± 2.6 weeks (range: 12-20 weeks) (95% CI: 13.10-15.04). Time to radiological union was recorded for each patient; delayed union was not prespecified as a separate outcome in the study protocol. Fifteen cases achieved union at 12 weeks, five cases at 14 weeks, seven cases at 16 weeks, and three cases at 20 weeks. According to the AO/OTA classification, 9 cases were classified as 43A1, 4 as 43A2, 7 as 43A3, 7 as 43B1, and 3 as 43B2. The right side was involved in 18 patients (60,0%), while the left side was involved in 12 patients (40.0%) (Table 1).

Most patients were from Kabul (16/30), followed by Kunduz (5/30), Badakhshan (5/30), and Herat (4/30).

Postoperatively, one patient (3.3%) with an AO/OTA type 43B1 fracture developed a deep-seated infection within one month. The infection was managed with broad-spectrum antibiotics for six weeks. Despite initial management, plate exposure occurred, requiring implant removal. The patient underwent multiple debridements and was followed until complete fracture union was achieved. One patient (3.3%) developed ankle stiffness, which improved following physiotherapy. Quantitative ankle range-of-motion measurements and validated functional outcome scores were not available in the retrospective records (Table 2).

Table 2: Clinical and radiological outcomes

Outcome	***Value***
Time to union (weeks), mean±SD	14.1 ± 2.6 (95% CI: 13.10-15.04)
Union rate	30/30 (100%) (95% CI: 88.4-100%)
Complications	
Infection	1 (3.3%)
Plate exposure	1 (3.3%)
Stiffness	1 (3.3%)
No other documented complication	28 (93.3%)

Note: Complication categories are not mutually exclusive. The patient with deep surgical site infection subsequently developed plate exposure and required implant removal

Discussion

In this study, we evaluated clinical outcomes of 30 patients with distal tibial fractures treated using the MIPPO technique.

Distal tibial fractures remain challenging to manage because of limited soft tissue coverage, compromised blood supply, and the potential for soft tissue injury, all of which may adversely affect fracture healing and long-term outcomes. The primary goal of surgical treatment is to restore ankle joint anatomy and biomechanics while providing sufficient stability to facilitate early mobilization and reduce complications such as infection. This can be achieved through techniques that minimize soft tissue disruption and bone devascularization, thereby reducing the risk of complications [14]. With the introduction of the MIPPO technique using LCP, which preserves extraosseous blood supply and maintains the osteogenic fracture hematoma, this approach has become an effective option for distal tibial fracture management [13].

This study demonstrated favorable clinical and radiological outcomes following MIPPO treatment, with a high union rate and a low incidence of complications. In our cohort, 63.3% of patients were male, and 36.7% were female, consistent with the findings of Illur et al. who reported a similar gender distribution of 35% females and 65% males among Indian patients [14]. Likewise, a study from Pakistan reported a male predominance, with 68.6% male and 31.4% female patients [15]. This male predominance might be associated with greater exposure to high-energy trauma mechanisms, particularly RTAs.

The mean age of patients in our study was 42.20 ± 14.51 years, which was comparable to the study by Marei et al. who reported a mean age of 40.16 ± 11.62 years in an Egyptian population [16].

In our study, RTAs were the most common mechanism of injury, accounting for 20 cases (66.7%), followed by falls from height (20%), and sport-related injuries (13.3%). These findings are consistent with previous studies [17, 18]. These results further support the association between distal tibial fractures and high-energy trauma mechanisms, often accompanied by considerable soft tissue injury and require careful surgical planning and management.

The mean time to radiological union in our study was 14.1 ± 2.6 weeks (range: 12-20 weeks). Fifteen cases achieved union at 12 weeks, five cases at 14 weeks, seven cases at 16 weeks, and three cases at 20 weeks. These findings are comparable with those reported by Shrestha et al., who observed a mean union time of 18.5 weeks (range: 14-28 weeks), with only one case of delayed union that was successfully managed with percutaneous bone marrow injection [11]. Union time following fixation with LCP using the MIPPO technique ranges from 9 to 68 weeks, which may be explained by variations in patient characteristics, fracture patterns, and follow-up protocols [17,19–21]. More recently, a systematic review and meta-analysis of 23 studies involving 1.742 patients found that intramedullary nailing was associated with a statistically shorter time to union than MIPPO [22].

Our study achieved a 100% union rate, which is consistent with previous reports showing union rates between 96% and 100% [23,24]. The favorable outcomes observed with MIPPO might be explained by its biological fixation principles, including preservation of the fracture hematoma, maintenance of periosteal blood supply, and indirect reduction techniques that facilitate secondary bone healing and callus formation.

Regarding complications, one patient developed a deep-seated infection within one month postoperatively. The infection was treated with culture-directed broad-spectrum antibiotics for six weeks; However, subsequent plate exposure required implant removal. The patient underwent repeated surgical debridement and achieved complete fracture healing during follow-up. Another patient developed ankle stiffness, which improved following physiotherapy. The observed infection rate of 3.3% was lower than that reported in several previous series. However, the present study was not designed to determine the reasons for this difference. Variations in fracture characteristics, patient selection, soft-tissue injury, surgical technique, perioperative care, and follow-up practices may contribute to differences in reported complication rates across studies. In addition, because this was a retrospective chart-based study, minor or transient complications may have been under-documented. Therefore, the low observed infection rate should be interpreted cautiously and should not be attributed solely to surgical technique or assumed to represent the true population-level complication rate in this setting. These findings are consistent with Paluvadi et al., who reported favorable outcomes following MIPPO treatment [25]. Compared with open reduction and internal fixation (ORIF), MIPPO has been associated with reduced soft tissue

disruption and favorable clinical outcomes [26]. However, MIPPO did not demonstrate a distinct superiority over ORIF in the treatment of distal tibial fractures [24]. Differences in fracture characteristics, patient selection, surgical technique, and outcomes assessment methods may contribute to the variability among studies. A recent systematic review and meta-analysis of nine studies involving 530 patients similarly found no significant difference between MIPPO and ORIF in functional outcomes, union time, or major complications. The authors also reported comparable rates of malunion, delayed union, nonunion, and wound complications between the two techniques, supporting the interpretation that the clinical advantages of MIPPO over ORIF may be limited and outcome-dependent [27].

An additional finding was the geographic distribution of the study population. Although more than half of the patients were from Kabul (53.3%), nearly half (46.7%) were referred from other provinces, including Kunduz, Badakhshan, and Herat. This referral pattern may reflect the concentration of specialized orthopedic trauma services in major urban centers and the need for referral of patients requiring specialized fracture management. However, because the present study was not designed to evaluate healthcare access or referral pathways, these observations should be interpreted descriptively rather than as evidence of regional differences in treatment availability or outcomes.

Limitations

This study has several limitations. First, the retrospective case-series design, small sample size of a control or comparison group limit the precision, generalizability, and comparative interpretation of the findings. The study was not designed or powered to determine whether MIPPO provides superior outcomes compared with alternative treatments such as intramedullary nailing or casting. Therefore, the observed union rate and complication profile should not be interpreted as evidence of treatment efficacy or superiority. Second, the relatively small sample size and absence of a control group prevented direct comparison with alternative fixation methods. Third, comprehensive functional outcome measures, including ankle function scores, pain assessments, and quality-of-life evaluations, were not routinely collected due to the retrospective nature of the study. Therefore, the findings primarily represent radiological and clinical outcomes rather than patient-reported functional recovery. Fourth, all radiographs were assessed by a single orthopedic surgeon; therefore, inter-observer reliability could not be assessed. Finally, the absence of microbiological culture and antimicrobial susceptibility data limited detailed characterization of the postoperative infection. Larger multicenter prospective studies involving diverse patient populations and standardized functional assessments are required to further validate these findings and provide a more comprehensive evaluation of outcomes associated with MIPPO in distal tibial fractures. Finally, potential selection and observational biases cannot be excluded.

Conclusion

MIPPO with locking compression plates was associated with radiological union in all patients and few documented postoperative complications. However, the retrospective design, small sample size, and absence of a comparison group preclude conclusions regarding comparative efficacy. A biological fixation strategy that incorporates locking compression plates may help achieve satisfactory fracture healing. However, these results should be interpreted cautiously because of the small sample size and lack of a control group.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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