# Functional and radiological outcome of minimally invasive percutaneous plate osteosynthesis in distal third tibia fracture

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**ABSTRACT**

**Introduction:** Distal one-third tibia fractures are frequent lower limb injuries, often from high-velocity trauma. Morbidity arises from articular involvement, soft tissue damage, and compromised vascularity. Treatment outcomes depend on fracture pattern, bone quality, and associated injuries. This study evaluated functional and radiological outcomes of minimally invasive percutaneous plate osteosynthesis (MIPPO) in distal third tibia fractures. **Methods:** This prospective observational study was conducted at Department of Orthopedic Surgery, Gandaki Medical College Teaching Hospital and Research Center, Pokhara, Nepal over 12 months, enrolling 45 patients aged 18–60 years with closed, displaced, extra-articular distal tibia fractures. Following consent, all underwent MIPPO using a distal tibia locking plate (DTLP) and were followed up six months. Functional outcomes were assessed using the American Orthopedic Foot and Ankle Society (AOFAS) score at six months, and radiological union was recorded in weeks. **Results:** The mean patient age was 37 years, with the highest proportion in the 20–30 year age group 16(35.5%). Radiological union occurred at 12 weeks in 30(66.6%) patients and at 24 weeks in 15 patients (33.4%). At six months, 26 patients (57.7%) scored 90–95 on the AOFAS scale, 10(22.2%) scored 75–85, and 9(20%) scored 50–65. Overall outcomes were excellent in 23(53.1%), good in 13(28.9%), fair in 4(8.9%), and poor in 5(11.1%). Post-operative complications were minimal, limited to superficial infections in 3(6.7%) patients. **Conclusions:** Given the biological and mechanical advantages demonstrated, MIPPO showed promising results in this fracture subset, especially in centers equipped with locking plate technology and surgeons trained in minimally invasive techniques.

**Keywords:** AOFAS score, distal third tibia fracture, MIPPO.

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## INTRODUCTION

Fractures of the distal third of the tibia present a significant therapeutic challenge in contemporary orthopaedic practice due to their complex fracture morphology, periarticular location, and minimal soft tissue coverage.[1-3] Optimal surgical management must achieve anatomical alignment and stable fixation while minimizing disruption to the soft tissue envelope.[4] Distal tibial fractures account for approximately 3–10% of all tibial fractures.[5]

Multiple surgical strategies are available, including closed intramedullary nailing, open reduction and internal fixation with conventional plating, and external fixation.[6-8] Each technique has distinct limitations. Closed IM nailing is generally indicated for AO type A extra-articular fractures located ≥5 cm proximal to the ankle joint.[9] However, the hourglass morphology of the distal tibia often limits precise anatomical reduction, increasing the risk of angular and rotational malalignment.[10] Furthermore, IM nailing is unsuitable for AO type B and C fractures involving the articular region. External

fixation is useful in cases of severe soft tissue injury or as a temporizing measure, but carries disadvantages including pin tract infection, malreduction, and joint stiffness.[11] ORIF with conventional plating enables direct visualization and correction of deformity but requires extensive soft tissue dissection and periosteal stripping, which can impair fracture biology and increase the risk of infection, non-union, and wound complications.[12] Minimally invasive percutaneous plate osteosynthesis has emerged as an effective alternative, offering indirect fracture reduction and submuscular plate insertion to preserve periosteal vascularity.[13-15] Pre-contoured anatomical locking plates placed medially provide rigid fixation, resist varus collapse, and maintain alignment.[16] Advantages of MIPPO include reduced infection rates, lower soft tissue morbidity, and faster healing times.[17,18] Distal tibia fractures typically result from axial loading combined with rotational forces, high-energy direct trauma, or twisting injuries.[19] The AO/OTA classification categorizes extra-articular fractures as type 43-A1 (simple), 43-A2 (wedge), and 43-A3 (complex).[20] Standard radiographs remain the primary diagnostic modality, while computed tomography (CT) or magnetic resonance imaging (MRI) may be necessary for comminuted fractures or suspected ligamentous injuries.[21] Radiographic signs of associated ligament injury include widening of the tibiofibular space, asymmetry of the talotibial space, widening of the medial joint space, and talar tilt.[22]

A 3.5 mm distal tibial locking plate (DTLP) is the most common fixation implant for MIPPO in this anatomical region.[23] There are limited studies of MIPPO fixation technique in Nepali population. Rationale of this study is MIPPO's ability to preserve soft tissue integrity while ensuring stable fixation, suggesting it may enhance both functional and radiological outcomes for distal third tibial fractures.[24] This study aimed to evaluate the functional and radiological outcomes of MIPPO in distal third tibial fractures. It also assessed the demographic profile of patients with distal third tibial fractures and identifies the most common fracture patterns. It aimed to demonstrate and describe patients' factors (age, gender, injury side, time to surgery, and union time) and American Orthopedic Foot and Ankle Society (AOFAS) scores.

## METHODS

This was a hospital-based observational quantitative study conducted at Department of Orthopedic Surgery, Gandaki Medical College Teaching Hospital and Research Center, Pokhara over one year (October 15, 2024 to October 14, 2025 in a total of 45 patients. Patients admitted with closed, displaced, extra-articular fractures of the distal third tibia who met the inclusion criteria: age 18-60 years, closed distal tibial extra-articular fractures (AO/OTA 43-A). Open fractures, Intra-articular fractures, pathological fractures, polytrauma, segmental fractures and severe medical comorbidities were excluded from the study.

Non-probability convenience sampling method was used. Sample size calculated using Cochran's formula: $n=Z^2 \cdot p(1-p)/e^2$, where: p=0.03 (estimated prevalence), e=0.05 (margin of error), Z=1.96 (95% CI). The ethical approval was obtained from the Institutional Review Committee. (Ref. No. 11/081/082-F) Written informed consent was obtained in English/Nepali. A detailed history, general and local assessment of the distal leg and ankle were done. Range of motion (ROM) was obtained using a stainless-steel goniometer. Functional outcome was assessed via AOFAS score (Pain = 50, Function = 40, Alignment = 10; Excellent = 95–100, Good = 75–94, Fair = 51–74, Poor ≤50). Radiological union of a fracture was considered when the callus is continuous across 3 cortices.

**The total AOFAS score is 100 and is categorized as below:**

**Pain — 40 points**

- None → 40
- Mild, occasional → 30
- Moderate, daily → 20
- Severe, almost always → 0

**Function — 50 points total**

**A. Activity limitations & need for support — 10**

- No limitation, no support → 10
- No limitation, support used → 7
- Limited daily or recreational activities → 4
- Severe limitation → 0

**B. Walking distance (maximal) — 5**

- 6 blocks → 5
- 4–6 blocks → 4
- 1–3 blocks → 2
- < 1 block → 0

**C. Walking surfaces — 5**

- Any surface → 5
- Uneven surfaces cause difficulty → 3
- Marked difficulty → 0

**D. Gait abnormality — 8**

- None, or slight → 8
- Obvious abnormality → 4

- Marked abnormality → 0

**E. Sagittal motion (dorsi + plantarflexion) — 8**
- Normal / >30° → 8
- 15–29° → 4
- <15° → 0

**F. Hindfoot motion (inv + eversion) — 6**
- Normal / 75–100% of opposite side → 6
- 25–74% → 3
- <25% → 0

**G. Ankle–hindfoot stability — 8**
- Stable → 8
- Definitely unstable → 0

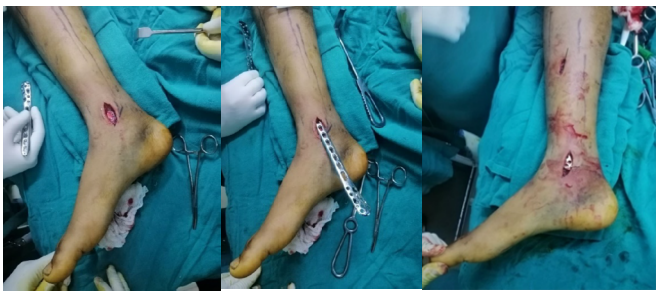
**Alignment — 10 points**
- Good, plantigrade foot, no symptoms → 10
- Fair, plantigrade but symptomatic → 5
- Poor, non-plantigrade → 0

Total 100 points.

Data was entered in Excel 2019. Descriptive statistics (frequency, percentage) were used. Data analysis was done using Statistical Package for Social Sciences (SPSS) 26.0.

Patients admitted, immobilized in a below-knee posterior slab, limb elevation, and ice compression until swelling subsided as part of pre-operative care. All the patients who met the inclusion criteria underwent surgery to manage the fracture.

**Surgical technique (MIPPO):** Under spinal anaesthesia, supine position, pneumatic thigh tourniquet inflated to 200 mmHg above systolic pressure. A 3–5 cm medial incision extended to the medial malleolus tip; stab incisions proximally for diaphyseal screws. Saphenous vein and nerve preserved. Subcutaneous tunnel created over intact periosteum; pre-contoured DTLP inserted and fixed with 3.5 mm locking/non-locking screws. Arthrotomy is performed if the medial malleolus is involved. (Figure 1)



1.a 1.b 1.c

**Figure 1.a-c:** Landmarks for skin incision with DTLP Plate insertion

Follow-up evaluations were conducted at 2 weeks, 6 weeks, 3 months, and 6 months, including clinical, radiological, and functional assessments. Functional assessment was done using the AOFAS scores at six month. Sutures removed at 14 days; splint removed at six weeks to begin ROM exercises.

**RESULTS**

The total number of patients in the study were 45. The mean age of participants was 37 years. The majority belonged to the 20–30 years age group, comprising 16 (35.5%), followed by 31–40 years with 12(26.6%), 41–50 years with ten (22.2%), and 51–60 years with seven (15.5%). Of the 45 patients included, 27(60%) were male and 18(40%) were female. Road traffic accidents were the leading cause of injury, accounting for 22(48.9%), followed by falls from height in 20(44.4%) and sports injuries in 3(6.7%).

**Table 1:** Type of fracture pattern (n=45)

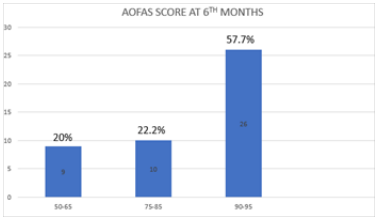
| Types of fracture | Number | Percentage |
|---|---|---|
| Spiral | 29 | 64.4% |
| Oblique | 11 | 24.4% |
| Comminuted | 5 | 11.1% |
| Total | 45 | 100 |

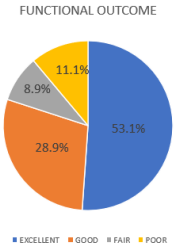
Fractures affected the right leg in 26 patients (57.8%) and the left leg in 19 patients (42.2%). Spiral fractures were the most common, occurring in 29(64.4%), while oblique fractures occurred in 11(24.4%) and comminuted fractures in 5(11.1%). Surgery was performed within one to two days in 14(31.1%) patients, within three to four days in 20(44.4%) patients, and within five to six days in 11(24.4%) patients. (Table 1)

**Table 2:** AOFAS score at sixth month

| AOFAS score | Number | Percentage |
|---|---|---|
| 90-95 | 26 | 57.7% |
| 75-85 | 10 | 22.2% |
| 50-65 | 9 | 20% |
| 100 | 45 | 100 |

Radiological union was achieved at 12 weeks in 30(66.6%) patients and at 24 weeks in 15(33.4%) patients. At the 6-month follow-up, the majority 26(57.7%) attained an AOFAS score of 90–95, while 10(22.2%) patients scored 75 to 85 and 9(20%) patients scored 50–65. Functional outcomes were rated as excellent in 23(53.1%) patients, good in 13(28.9%), fair in 4(8.9%), and poor in 5(11.1%). (Table 2)




**2.a**: AOFAS score **b**: Functional outcome

**Figure 2.a,b:** AOFAS score and functional outcome at sixth month follow-up

Postoperative complications were minimal, limited to superficial surgical site infections in 3(6.7%) patients, all of which resolved with local wound care and oral antibiotics. No deep infections, malunions, or implant failures were observed.

**3.a**: 12 weeks follow-up **3.f**: 24 weeks follow-up

**Figure 3**: Preoperative, Intraoperative, and postoperative C-arm and X-ray images of DTLP with the MIPPO technique

## DISCUSSION

The present study evaluated the functional and radiological outcomes of minimally invasive percutaneous plate osteosynthesis for extra-articular fractures of the distal third tibia in 45 patients. Our findings were compared with those from previous studies to provide context for the results.

In our study, the mean patient age was 37 years. This is consistent with the demographic profile of distal tibia fractures reported in other studies. Illur et al. reported a mean age of 43 years, while Manandhar et al. found a mean age of 46.4 years.[25,28] Similarly, Bingol et al. reported a mean age of 44.2 years.[7] Although our cohort had a slightly younger mean age, the distribution remains comparable with existing literature, suggesting that distal tibia fractures are most common in active, working-age adults. In our series, the average time to radiological union was 18 weeks. When compared to previous reports, this healing time is at the shorter end of the published range. Somashekar et al. reported a mean time to union of 21.4 weeks, Bahari et al. 22.4 weeks, and Manandhar et al. 21 weeks.[26-28] Other studies, including those by Somashekar et al., found mean union times of 22 weeks.[26] Mudgal Ashwani et al. reported 21.7 weeks, while Ladani et al. documented 18.5 weeks.[19,29] Overall, the average union time across studies is approximately 20 weeks, placing our results within the expected range. The relatively shorter time to union in our study may be attributed to careful patient selection (excluding compound fractures and complex intra-articular patterns) and early mobilization protocols that promote healing.

At six months, our study recorded a mean American Orthopedic Foot and Ankle Society (AOFAS) score of 95, indicating an excellent outcome. This is in close agreement with the findings of Ashwani et al., who reported a mean AOFAS score of 96.5.[19] Other studies have reported slightly lower average scores. Bahari et al. reported a mean of 90 (good), while Illur et al. reported 84.5. Manandhar et al. found average score of 93.8. In a study by Bingol et al. the average score was found to be 88.3 while Somashekar et al. found the average score of 88.[7,26] Differences in reported functional scores may be explained by variations in inclusion criteria. For example, Illur et al. included partial articular fractures, which may have affected joint function and lowered mean scores.[25] Similarly, Bingol et al. included patients with type 2 open fractures, which likely contributed to slightly poorer results.[7] The trend across the literature is clear—studies limited to extra-articular or simple intra-articular fractures report higher mean AOFAS scores and a greater proportion of excellent outcomes.

In our study, three patients (6.7%) developed superficial SSIs, which were successfully treated with local wound care and oral antibiotics. No deep infections, malunions, or

implant failures were recorded. Comparatively, Somashekar et al. reported two cases of superficial infection/delayed wound healing and one case of deep infection requiring implant removal.[26] Ladani et al. documented one case each of delayed union, superficial infection, varus angulation, and skin irritation.[29] Bingol et al. also noted one case of superficial infection, treated with antibiotics and debridement.[7] The relatively low complication rate in our study may be related to meticulous soft tissue handling inherent in the MIPPO technique, as well as careful patient selection.

The distal tibia is particularly vulnerable to complications following injury and surgery due to its subcutaneous location and relatively poor soft tissue coverage. The region's blood supply arises from two main sources: the endosteal and periosteal systems. In displaced fractures, the endosteal circulation is often disrupted, leaving fracture healing dependent on the periosteal supply.[21] Extensive soft tissue dissection in such cases risks devascularizing the bone fragments by damaging periosteal vessels, which can lead to delayed union or non-union. The MIPPO technique is designed to minimize periosteal stripping and preserve the biological environment for healing.[30] This principle likely contributes to the favorable union times and low complication rates observed in our study. Traditional ORIF allows for precise anatomical reduction but is associated with extensive soft tissue dissection, higher infection rates, and longer union times.[13] Intramedullary nailing is suitable for some extra-articular fractures but may cause malalignment in the distal segment due to the metaphyseal flare and is not appropriate when fractures are close to the joint.[11] External fixation is reserved for severe soft tissue injuries or as temporary stabilization, but it carries risks such as pin tract infection and joint stiffness.[23] Our findings align with those of previous authors who reported that MIPPO provides stable fixation with minimal soft tissue compromise, leading to high functional scores, acceptable union times, and a low complication rate.[2,14,18]

A strength of our study is the homogeneity of the patient group—all cases were extra-articular, closed fractures of the distal third tibia. This allowed for clearer evaluation of the MIPPO technique without confounding from severe open fractures or complex intra-articular injuries. Our results support the use of MIPPO for managing extra-articular distal tibia fractures, particularly in cases where preserving soft tissue integrity is essential. The technique appears to offer predictable union times, excellent functional outcomes, and low complication rates when applied in appropriately selected patients.

However, the study has limitations because of no comparison group, the sample size was relatively small and drawn from a single center, which may limit the generalizability of results. Additionally, the follow-up period was limited to 6 months for functional outcome assessment; longer follow-up is needed to assess late complications such as post-traumatic arthritis.

## CONCLUSIONS

Given the biological and mechanical advantages demonstrated, MIPPO showed promising results in this fracture subset, especially in centers equipped with locking plate technology and surgeons trained in minimally invasive techniques.

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