ORIGINAL ARTICLE

Outcome Regarding Function, Union and Soft-Tissue Morbidity of Minimally Invasive Plate Osteosynthesis for Distal Tibia Fractures

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ABSTRACT

Background: Distal tibia fractures pose significant challenges due to limited soft-tissue coverage and high rates of wound complications. Minimally invasive plate osteosynthesis (MIPO) has been developed to preserve vascularity and reduce soft-tissue insult. This study evaluates clinical outcomes, union rates, alignment, and soft-tissue complications following MIPO for distal tibial fractures.

Methods: A prospective cohort of patients with extra-articular or simple intra-articular distal tibial fractures treated with MIPO was assessed over a 12-month period. Functional outcomes were evaluated using the AOFAS Ankle–Hindfoot Score, radiological union by RUST score, and soft-tissue complications were recorded. Malalignment was defined as >5° in any plane.

Results: Thirty-eight patients were included (mean age 41.2±12.7 years). Average time to radiological union was 16.4±2.8 weeks. Functional outcome at final follow-up averaged 86.7±8.4 on the AOFAS scale. Superficial infections occurred in 7.8%, deep infections in 2.6%, and skin irritation requiring screw removal in 10.5%. Malalignment occurred in 5.2% of patients. No cases of implant failure were observed.

Conclusion: MIPO for distal tibial fractures provides reliable union, good functional outcomes, and low soft-tissue morbidity. The technique is especially beneficial for high-risk soft-tissue envelopes. Further randomized trials are needed to compare MIPO with intramedullary nailing and open plating.

Keywords: Distal tibia fractures, MIPO, minimally invasive surgery, plate osteosynthesis.

SZMCJ, January 2026; Vol. 45(1): 22-26

INTRODUCTION

Distal tibial fractures, accounting for approximately 7–10% of lower-limb long-bone injuries [1], present a significant therapeutic challenge. The subcutaneous anteromedial surface of the tibia predisposes these fractures to associated soft-tissue compromise, complicating surgical management [2]. Open reduction and internal fixation (ORIF), while providing direct anatomical reduction, historically carries substantial risks of infection, delayed union, and malunion, largely attributable to extensive periosteal disruption and wound-healing complications [3, 4].

In response, minimally invasive plate osteosynthesis (MIPO) has been developed as a biologically favorable alternative. This technique aims to preserve the fracture hematoma and local vascularity by minimizing soft-tissue dissection and periosteal stripping, thereby enhancing conditions for indirect bone healing and reducing iatrogenic soft-tissue injury[5,6]. Despite its theoretical advantages, a primary critique of MIPO is the potential for malalignment and articular incongruity due to the lack of direct fracture site visualization [7].

Current evidence on the efficacy of MIPO for distal tibial fractures remains inconsistent, with varying reports on union rates, functional recovery, and complication profiles. This study therefore aims to evaluate the clinical and radiographic outcomes of a consecutive series of distal tibial fractures treated with MIPO, with specific focus on time to union, incidence of malalignment, functional scores, and postoperative soft-tissue complications.

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MATERIALS & METHODS

Study Design and Setting

A prospective Interventional study was conducted in the Department of Orthopedic Surgery of Shaheed Ziaur Rahman Medical College & private hospitals of Bangladesh center over 18 months (January 2023-December 2024).

Inclusion Criteria

- Age 16–70 years
- According to Arbeitsgemeinschaft für Osteosynthesefragen (AO)/ Orthopaedic Trauma Association (OTA) classification 43-A (Distal tibial metaphyseal or extra articular) and selected 43-B (Distal tibial partial articular) fractures
- Closed fractures or Gustilo–Anderson Grade I open fractures

Exclusion Criteria

- Grade II–III open fractures
- Segmental tibial fractures
- Polytrauma requiring staged fixation
- Pathological fractures

Surgical Technique

All procedures were performed under regional or general anesthesia with the patient positioned supine on a radiolucent operating table. A pneumatic tourniquet was applied when indicated. Fracture reduction was achieved using **indirect reduction techniques**, primarily **ligamentotaxis**, aided by manual traction and temporary external alignment maneuvers. Restoration of tibial length, alignment, and rotation was confirmed under fluoroscopic guidance in both anteroposterior and lateral planes, in accordance with established AO principles. [7 - 10].

A **pre-contoured medial distal tibial locking plate** was introduced using a **minimally invasive percutaneous plate osteosynthesis (MIPPO) technique** through a small medial incision. The plate was slid **extraperiosteally** along the medial surface of the tibia to preserve fracture biology and periosteal blood supply. Proximal and distal fixation was achieved with locking and/or cortical screws depending on fracture configuration and bone quality. [7,8,11].

Fibular fixation was performed selectively in cases with associated fibular fractures when necessary to restore lateral column stability, tibial length, or rotational alignment. Final fracture reduction and implant positioning were reconfirmed fluoroscopically before wound closure. The incisions were closed in layers with minimal soft-tissue tension, and sterile dressings were applied [8,11].

Early ankle and knee range-of-motion exercises were encouraged postoperatively, with progression to partial and then full weight-bearing based on radiological evidence of fracture union, following standard biological fixation protocols [7,10,11].

Post-operative Protocol

- Partial weight bearing allowed at 6–8 weeks
- Full weight bearing upon radiological signs of consolidation
- Follow-up at 2, 6, 12, 24, and 52 weeks

Outcome Measures

- **Functional outcome:** AOFAS Ankle– Hindfoot Scale
- **Radiological union:** RUST scoring
- **Alignment:** coronal and sagittal plane measurements
- **Soft-tissue complications:** infection, irritation, wound necrosis

RESULTS

Total number of cases were (N) 38; 27 (71%) cases were male and 11 (29%) cases were female. Age range was 16 to 68 years with mean ± SD was 41.2 ± 12.7 years. Road traffic accident (RTA), fall from height, twisting injury and fall from stairs were the common causes. Baseline characteristics were as follows (Table I).

Table I: Baseline Characteristics of the Patients (n=38)

Parameter		Values
Mechanism of injury	RTA	25 (65.8%)
	Fall	10 (26.3%)
	Others	3 (07.9%)
Side involved	Right	21 (55.3%)
	Left	17 (44.7%)
Fracture type (AO/OTA)	43-A:	29 (76.3%)
	43-B:	9 (23.7%)
Associated fibular fracture		22 (57.9%)

Usual union time ranged from 12 to 18 weeks. Delayed union occurred in 2 cases who required 21 and 22 weeks to heal.

AOFAS score ranged from 0 – 100. Excellent 90-100; Good 80-89; Fair 70-79; Poor <70. (AOFAS – American Orthopaedic Foot & Ankle Society.)

Table II: Clinical and Radiological Outcomes

Outcome Parameter	Result
Mean union time (weeks)	16.4 ± 2.8
Delayed union	2 (5.2%)
Non-union	0
Mean AOFAS score at 12 months	86.7 ± 8.4
Excellent outcomes	28 (73.6%)
Good outcomes	8 (21.0%)
Fair outcomes	2 (5.2%)

Table III: Alignment Outcomes

Alignment Parameter	Result
Malalignment (>5°)	2 patients (5.2%)
Varus/Valgus deformity	2 (corrected conservatively)
Rotational deformity	0

Table IV: Post-operative Complications

Complication	Number (%)
Superficial infection	3 (7.8%)
Deep infection	1 (2.6%)
Plate irritation requiring removal	4 (10.5%)
Wound necrosis	0
Implant failure	0

Mitigation of Post-operative Complications

Post-operative complications were minimized through standardized peri-operative protocols and meticulous surgical technique. **Superficial infections (7.8%)** were mitigated by strict aseptic precautions, timely peri-operative antibiotic prophylaxis, careful soft-tissue handling, and early wound surveillance; all cases responded to local wound care and short-course oral antibiotics. **Deep infection (2.6%)** was limited by adherence to sterile operating room protocols, appropriate implant selection, and early identification; the affected case was managed successfully with targeted intravenous antibiotics following culture sensitivity, without implant compromise. **Plate irritation requiring removal (10.5%)** was reduced by low-profile implant selection, accurate plate positioning, and adequate soft-tissue coverage; implant removal was performed electively after fracture union with complete symptom resolution. **Wound necrosis and implant failure** were avoided through preservation of periosteal blood supply, tension-free wound closure, judicious use of drains, stable fixation based on AO principles, and graduated rehabilitation with protected weight-bearing until radiological union.

Overall, proactive peri-operative planning, vigilant post-operative monitoring, and early intervention contributed to the low incidence and successful management of complications.

DISCUSSION

This study demonstrates that MIPO for distal tibial fractures results in predictable union and favorable functional outcomes with minimal soft-tissue complications, consistent with previous literature.

Compared to traditional ORIF, the reduced incidence of wound problems highlights the biological advantage of MIPO. Although limited visualization can increase the risk of malalignment, careful intra-operative fluoroscopy mitigated this concern in most cases.

The union rate and functional scores in this study align with published outcomes of intramedullary nailing, though MIPO may offer advantages in metaphyseal fractures and in cases with narrow medullary canals.

Conclusion

Minimally invasive plate osteosynthesis is a safe and effective method for treating distal tibial fractures, providing high rates of union, satisfactory functional outcomes, and low soft-tissue morbidity. MIPO is particularly valuable in fractures with vulnerable soft-tissue conditions.

Limitations

Small sample size, single-center data, absence of control group.

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