

A Comparative Study of Management of Distal One Third Tibia Fracture by Intramedullary Interlocking Nail Versus Minimally Invasive Plate Osteosynthesis (MIPO)

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Abstract

Background: Distal one-third tibia fractures present significant therapeutic challenges due to subcutaneous location, precarious vascular supply, and a sparse soft-tissue envelope. Both intramedullary interlocking (IMIL) nailing and minimally invasive plate osteosynthesis (MIPO) are biological fixation strategies designed to preserve fracture biology, but controversy persists regarding their relative efficacy. This study compares the surgical, radiological, and functional outcomes of IMIL nailing versus MIPO in closed, extra-articular distal tibia fractures. **Material and Methods:** A prospective longitudinal study was conducted on 30 patients aged 18–60 years presenting with extra-articular distal one-third tibia fractures between December 2022 and May 2024. Patients were allocated equally into two treatment arms: Group A (IMIL nailing, n = 15) and Group B (MIPO, n = 15). Operative duration, time to union, time to full weight-bearing, complications, and final functional outcomes using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score were evaluated. **Results:** The mean operating time was comparable between the IMIL nailing group (94.73 $\pm$ 5.84 minutes) and the MIPO group (95.60 $\pm$ 4.64 minutes; p = 0.6561). Mean time to radiological union was 18.27 $\pm$ 2.37 weeks in the IMIL group compared to 21.87 $\pm$ 8.37 weeks in the MIPO group (p = 0.1201). Time to weight-bearing was slightly shorter in the IMIL group (9.47 $\pm$ 1.13 weeks vs. 10.33 $\pm$ 1.23 weeks; p = 0.0542). At final follow-up, excellent/good AOFAS scores were achieved in 86.7% (13/15) of nailing patients and 80.0% (12/15) of MIPO patients, with no statistically significant difference in functional distribution (p = 0.3871). Complication rates (superficial infection, malalignment, and delayed union) did not differ significantly between the two groups. **Conclusion:** Both IMIL nailing and MIPO are safe and effective modalities for managing extra-articular distal one-third tibia fractures, offering comparable union rates and functional outcomes. IMIL nailing facilitates earlier secondary bone healing and weight-bearing due to its load-sharing properties, whereas MIPO provides superior anatomical alignment control in selected fracture geometries.

Keywords: Distal tibia fracture, Intramedullary interlocking nail (IMIL), Minimally invasive plate osteosynthesis (MIPO), AOFAS score, Biological fixation.

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INTRODUCTION

Fractures involving the distal one-third of the tibia constitute approximately 7–10% of all tibial fractures and represent a significant therapeutic challenge for orthopaedic surgeons. These injuries commonly result from high-energy mechanisms such as road traffic accidents or falls from height, although low-energy injuries may also occur in osteoporotic individuals. The management of distal tibial fractures is complicated by the unique anatomical and biological characteristics of the region, including its subcutaneous location, limited soft tissue envelope, and relatively poor vascularity, which predispose to complications such as delayed union and infection.^[1-5]

Historically, conventional open reduction and internal fixation (ORIF) with plating was associated with high rates of soft tissue complications, including wound breakdown and infection. This has led to the evolution of biological fixation techniques aimed at preserving fracture biology and

minimizing soft tissue disruption. In recent years, both intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO) have emerged as the most commonly employed surgical modalities for distal tibial fractures, although the optimal choice remains controversial.^[2,4]

Intramedullary interlocking (IMIL) nailing is a minimally invasive technique that preserves periosteal blood supply and acts as a load-sharing device, facilitating secondary bone healing

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through callus formation.^[2] However, its use in distal fractures may be technically challenging due to metaphyseal widening, increasing the risk of malalignment and anterior knee pain.^[3]

Minimally invasive plate osteosynthesis (MIPO), in contrast, utilizes indirect reduction techniques and submuscular plate insertion to preserve the biological environment at the fracture site.

It provides superior control of alignment, particularly in metaphyseal fractures, and has been associated with lower rates of malunion in several studies.^[3,4]

Nevertheless, concerns remain regarding implant prominence, soft tissue irritation, and relatively longer operative time.

Despite advances in surgical techniques, there remains ongoing debate in the literature regarding the superiority of IMN versus MIPO. Recent systematic reviews and comparative studies have reported comparable functional outcomes, union rates, and complication profiles between the two methods, with each technique offering distinct advantages depending on fracture morphology and soft tissue condition.^[2,3,4]

The present study was therefore undertaken to perform a prospective comparative analysis of IMIL nailing and MIPO in the management of distal one-third tibia fractures.^[6,7]

MATERIALS AND METHODS

Study Design and Setting: This was a prospective longitudinal study conducted in the Department of Orthopaedics at IPGMER and SSKM Hospital, Kolkata, between December 2022 and May 2024 on patients coming to the orthopaedic OPD and emergency with distal shaft of tibia fractures.

Inclusion Criteria

- All patients aged >18 years & <60 years
- Closed fractures
- Fracture of distal shaft of tibia
- Fractures of variable duration (<4 weeks old)
- Extra-articular fractures

Exclusion Criteria

- Polytrauma and/or open injury patients
- Associated life-threatening injuries
- Pathological fractures
- Skin with blisters
- Fractures more than 4 weeks old
- Age below 18 years and more than 60 years
- Intra-articular fractures

Surgical Procedure: MIPPO / MIPO Technique: After applying a tourniquet, the leg was prepped circumferentially from the toes to the mid-thigh. To avoid injuring the saphenous nerve and vein, a 3–4 cm longitudinal incision was made above the distal tibia metaphysis. An epi-periosteal tunnel was created using a blunt retractor or the blunt tip of a long plate inserted through the incision and directed towards the diaphysis.

Depending on the fracture pattern, an anatomical precontoured plate was placed on the anteromedial portion of the tibia shaft following traction, manipulation, and reduction

of the fracture.

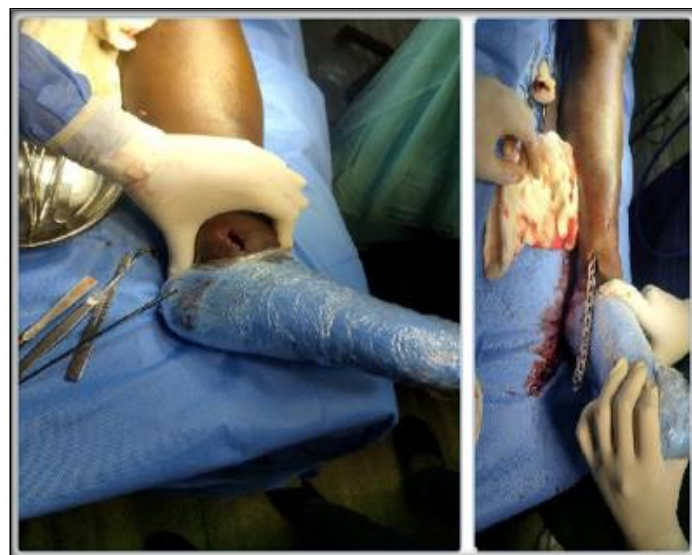


Figure 1: Intraoperative clinical images illustrating the Minimally Invasive Plate Osteosynthesis (MIPO) technique: distal incision (left) and submuscular tunnel insertion of precontoured anatomical plate (right).

Reduction parameters that were deemed acceptable included anteroposterior angulation of less than 10 degrees, valgus angulation of less than 5 degrees, and shortening of less than 10 mm. Following plate insertion and reduction, the proximal fragment was secured with a single locking screw and K-wires were used to temporarily secure the plate to the bone. A combination of cortical nonlocking and locking screws, either with or without lag screws, were used to finish distal fragment fixation. If necessary, a lag screw was placed through the plate's nonlocking hole or independently. Unless the fracture occurred near the syndesmosis region or within 7–10 cm of the tibia plafond, fibulas were not regularly mended.

IMIL Nail Technique: A vertical incision of about 5 cm was made on the anterior face of the knee, from the distal tip of the patella to the proximal aspect of the tibial tuberosity, following the administration of a tourniquet under the same conditions as before. A bare spot on the tibia extra-articularly, around 2 cm proximal to the tibial tuberosity, was used as the entry portal after the patella tendon was split. Using lateral and anteroposterior images, the central location of the entrance point in the C-arm was verified.

Following a temporary reduction of the fracture, a ball tip guide wire was inserted via the entrance portal and passed to the distal end of the tibia. In the C-arm, intramedullary confirmation of the guide wire was verified from both anteroposterior and lateral views.

Following flawless fracture reduction—which occasionally calls for the use of pointed bone-holding forceps—sequential reaming was carried out and the fracture was secured with an appropriate length IMIL nail. One or two proximal locking screws and two distal locking screws were used to secure the nail.

Occasionally, polar blocking screws and/ or anteroposterior interlocking screws were used to improve fracture stability and alignment.



Figure 2: Intraoperative image demonstrating proximal entry and jig alignment during Intramedullary Interlocking (IMIL) nailing.

Postoperative protocol and follow-UP

Postoperative Protocol: MIPO group fractures were stabilized with posterior slabs for two weeks following surgery. Immediately following surgery, standard lateral and anteroposterior views of the leg were obtained. The day following surgery, active quadriceps and calf strengthening exercises were initiated. Three days of intravenous antibiotic therapy followed surgery. On the third postoperative day, the

wound was examined for signs of soakage and infection. If the wound was dry and the skin health was adequate, patients were released from the hospital in a week.

Follow-Up: Suture and posterior slab were removed 2 weeks after surgery. Exercises to strengthen the quadriceps and increase the range of motion in the ankle and knee joints were initiated. In the outpatient section, patients were checked on every three months following the initial six-week period. A post-operative radiograph was taken during every visit to the outpatient clinic. As soon as the callus appeared on the radiograph possibly after six to eight weeks, participation in weight bearing began.

When a definitive callus was apparent in three of the four quadrants on anteroposterior and lateral views, together with clinical evidence of no discomfort and mobility at the fracture site, the condition was called fracture union. Treatment options included bone grafts or bone marrow injections if union did not advance to a satisfactory level. After a year of surgery or after the fracture had fully fused, a clinical evaluation for the functional assessment of the ankle was obtained using the American Orthopaedic Foot and Ankle Society (AOFAS) score.

Functional Assessment Metric: American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale (100 Points Total) consisting of Pain (40 points), Functional & Gait parameters (50 points), and Alignment (10 points).

RESULTS

A total of 30 patients were included, with 15 in each group. The demographic data, including age and sex distribution, were comparable between the two groups.

Table 1: Comparison of surgical and radiological parameters between IMIL Nailing and MIPO

Parameter	IMIL Nailing (Mean ± SD)	MIPO (Mean ± SD)	p-value
Operating Time (mins)	94.73 ± 5.84	95.60 ± 4.64	0.6561
Time to Union (weeks)	18.27 ± 2.37	21.87 ± 8.37	0.1201
Weight Bearing (weeks)	9.47 ± 1.13	10.33 ± 1.23	0.0542

Functional Outcome (AOFAS Score)

Functional results at final follow-up were categorized based on the AOFAS score:

- Excellent (90–100): Nailing 66.7% (10/15), MIPO 46.7% (7/15)
- Good (80–89): Nailing 20.0% (3/15), MIPO 33.3% (5/15)
- Fair (70–79): Nailing 6.7% (1/15), MIPO 0% (0/15)
- Poor (<70): Nailing 6.7% (1/15), MIPO 20.0% (3/15)

The difference in AOFAS categories between the two modalities was not statistically significant ($p = 0.3871$).

Complications

- Superficial Infection: Observed in 1 patient in the MIPO group and 0 in the nailing group ($p = 0.5428$).
- Malalignment: 1 patient in the nailing group (valgus) and 1 in the MIPO group ($p = 1.0000$).
- Delayed Union: 1 patient in the nailing group and 3 in the MIPO group ($p = 0.2827$).

DISCUSSION

The management of distal tibia fractures remains a clinical challenge. Our study found that both IMIL nailing and MIPO yield satisfactory functional and radiological results.

The slightly shorter union time in the nailing group (18.27 weeks) compared to the MIPO group (21.87 weeks) may be attributed to the load-sharing nature of the intramedullary nail, which promotes secondary bone healing through callus formation. However, nailing in the distal third is associated with a risk of malalignment due to the wide medullary canal, a finding consistent with literature suggesting that at least two distal locking bolts are necessary for stability.

MIPO, while technically demanding, allows for better anatomical reduction, especially in fractures closer to the joint. The hardware prominence of the plate on the medial side remains a concern, although no cases of skin necrosis were observed in our series.

The lack of a statistically significant difference in AOFAS scores ($p = 0.3871$) suggests that the choice between these two techniques does not drastically alter the final functional outcome for the patient.

CONCLUSION

Both Intramedullary Interlocking Nailing and Minimally Invasive Plate Osteosynthesis are excellent options for the management of distal one-third tibia fractures. IMIL nailing is

preferred for its minimally invasive nature and slightly faster union, whereas MIPO is advantageous for achieving better alignment in specific fracture configurations. Surgeons should choose the technique they are most comfortable with, considering the specific fracture personality.

Limitations of the study

In spite of every sincere effort, our study has certain lacunae:

1. The sample size was small (30 cases), which limits the statistical power of subgroup analyses.
2. The study was carried out at a single tertiary care centre, so institutional and referral bias cannot be ruled out.

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Conflicts of interest

There are no conflicts of interest.

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