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Original Article

Outcome of Minimally Invasive Percutaneous Plate Osteosynthesis Using Locking Compression Plate for Distal Tibial Fractures

Sagar Rampure, Harsh Choraria, Krishna Hanchate, Sujay K. Mahadik, Shrikant Deshpande

Department of Orthopedics, Bharati Vidyapeeth (Deemed to be University) Medical College & Hospital, Sangli Maharashtra, India

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Correspondence:
Sujay K. Mahadik,
Department of Orthopedics, Bharati Vidyapeeth (Deemed to be University) Medical College & Hospital, Sangli Maharashtra, India
Email: dr.mahadiksujay@gmail.com

Abstract

Objectives: To assess the functional and radiological outcomes of the distal tibia fractures managed surgically with a locking compression plate by MIPPO technique.

Methods: This prospective observational study included 34 patients with distal tibial fractures treated at Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli, India. After ethics committee approval and informed consent, eligible adults with complex or unfavorable simple, closed fractures were enrolled. Exclusions were patients under 18 with pathological fractures or comorbidities affecting functional outcomes. Standard preoperative protocols and imaging were conducted. All patients were surgically managed with a locking compression plate by MIPPO technique. Postoperatively, exercises and staged weight-bearing were implemented. Follow-up assessments at 45, 90, 135, and 180 days evaluated pain, movement, and radiological union using Olerud and Molander score. Statistical analysis utilized paired t-test and Chi-Square test.

Results: Out of 34 patients with distal tibial fractures, 24 (70.6%) were males and 10 (29.4%) were females with a mean age of 41.88 years. Most fractures were 42A1 (35.3%) and 43A2 (32.4%). Post-operative superficial wound infection occurred in 3 (8.8%) and deep infection in 2 (5.9%). Mean union time was 16.62 weeks. Functional outcomes were excellent in 3 (8.8%), good in 22 (64.7%), and fair in 9 (26.5%). At six months, complications included ankle stiffness (29.4%), non-union (20.6%), and malunion (8.8%). No cases had plate or screw breakage.

Conclusion: MIPPO technique allows for good functional outcomes while reducing complications, especially in fractures with poor soft tissue conditions.

Keywords: Distal tibial fractures, functional outcome, locking compression plate, percutaneous plate osteosynthesis

Introduction

Distal tibia fractures are typically caused by high-energy mechanisms such as falls from heights or motor vehicle accidents. They can also result from low-energy trauma, as seen in rotational injuries around the ankle.[1] Since the distal tibia has very little soft tissue cushioning, these fractures are very difficult to manage. The management of distal tibial fractures remains a significant challenge due to limited soft tissue coverage and the high complication rates associated with conventional open reduction and internal fixation techniques. This situation prompts the need for alternative approaches that minimize surgical trauma and improve outcomes. Historically, wound complications have been documented to be above 30% after open reduction and internal fixation (ORIF) of distal tibia and Pilon fractures, with infections

reported to be as high as 30% to 55%.[2] The factors c Contributing factors to complications in the management of distal tibia fractures include a high incidence of open and infected fractures.[3]

One of the more commonly used methods for the fixation of distal tibia fractures is antegrade intramedullary nailing (IMN). Studies have shown that it is a reliable fixation method, though it is associated with significant complications.[3] IMN for distal tibia fractures has been linked to knee morbidity, which has been reported to be as high as 71%. Chronic anterior knee pain is among the most common issues, with prevalence reported as high as 73.2%.[4] Additionally, IMN for distal tibia fractures has been shown to have a significantly increased rate of malalignment compared to plate fixation. Open reduction and internal fixation (ORIF) is another frequently used treatment method for distal tibia fractures. However, the extensive dissection involved with ORIF, particularly with the anterolateral approach, has resulted in increased rates of wound complications, including dehiscence, full-thickness necrosis, and ultimately, infection. These complications are serious, as they may necessitate the use of long-term intravenous antibiotics, multiple visits to the operating room for debridement, and may lead to eventual limb loss.[5]

Minimally Invasive Osteosynthesis (MIO) has been used to manage various types of fractures. This technique involves the use of intramedullary nails and percutaneous screws for fracture fixation. In 1996, Krettek *et al*. developed minimally invasive percutaneous plating osteosynthesis for distal femur fractures using a dynamic condylar screw. In their report, the authors demonstrated that infection rates were lower due to the biological healing of the fractures, and the need for bone grafts was reduced compared to open surgeries. This technique features a small skin incision and minimal trauma to surrounding tissues. In addition, it employs a submuscular plate. The depleting technique also emphasizes minimal invasiveness to avoid damaging the normal architecture and callous formation.[6]

Submuscular plating has seen rapid development due to the invention of internal fixators.[7] In this technique, blood supply is preserved by using locking head screws. Furthermore, MIPO was popularized with the development of LCP with combination holes. These plates can be used either as compression plates or in conjunction with internal fixators.[8]

Minimally Invasive Percutaneous Plate Osteosynthesis (MIPO) using a locking compression plate has emerged as a potential alternative, offering reduced soft tissue trauma and preserving periosteal blood supply. However, while MIPO has been adopted for distal femoral and tibial fractures, comprehensive data on its efficacy specifically for distal tibial fractures remain limited. This study aims to address this gap by assessing the functional and radiological outcomes of distal tibial fractures treated with the MIPO technique, thereby contributing evidence to guide clinical decision-making in the management of these challenging fractures.

Methods

This prospective observational study was conducted on 34 patients with distal tibial fractures who presented to the casualty department and were operated on in the Department of Orthopedics, Bharati Vidyapeeth Deemed to be University, Medical College and Hospital, Sangli, India, during the study period. The institutional ethics committee approved the study, and patients were enrolled after obtaining informed consent. Adult patients with complex fractures of the lower third of the tibia or simple, closed fractures that were unfavorable for interlocking nailing were included in this study. Patients below 18 years of age, those with pathological fractures, or individuals with co-morbidities likely to affect the assessment of functional outcomes (such as significant osteoarthritis of the knee, a history of meniscal injuries, or past cruciate ligament injuries) were excluded from the study, as were those with fractures associated with vascular or neurological injuries

Upon arrival at the casualty department, the patients were examined to assess the extent of their injuries. They were evaluated for the presence of vascular or neurological injuries. Analgesics, antibiotics, and intravenous fluids were administered according to the basic protocol, and tetanus prophylaxis was provided as needed. All routine investigations were performed, and imaging studies, including X-rays (lateral and AP views) and CT scans in selected cases, were conducted. All fractures were classified according to the AO-OTA classification.[9] After resuscitating the patient and stabilizing their hemodynamic status, the patients were taken for surgery.

Patients were positioned in the supine position on a radiolucent table, with the unaffected limb kept in an extended position.

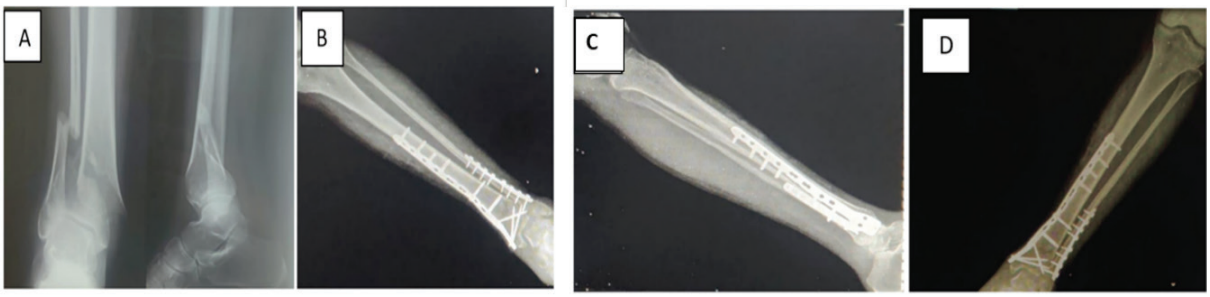

Fig. 1 Preoperative Xray (A), Immediate Postoperative X-rays Anteroposterior and Lateral (B and C) and at the Time of 6 Months Follow Up (D)

A pneumatic tourniquet was applied, and the patient was prepared, leaving the leg exposed for the surgical incision and intraoperative evaluation of the fracture. Intravenous antibiotics were administered prior to inflating the tourniquet. Fracture reduction was performed, and manipulation of the joint was attempted. This was confirmed intraoperatively with the use of a C-arm. The size of the plate was determined based on intraoperative imaging.

An incision was made starting from the medial malleolus and extending proximally over the screw holes to accommodate the plates. While preserving the saphenous vein, a submuscular tunnel was prepared for the plate's insertion using percutaneous elevators. The periosteum of the tibia was exposed by extending the incision longitudinally over the screw holes along the medial side of the tibia, reaching the fracture site. The opposite hand was used to position the plate, and to confirm its location, an allocation method was employed. A K-wire was used to fix the plate to the surface of the tibia. Imaging was then utilized to confirm the correct positioning of the plate. Using the C-arm, it was confirmed that the plate was positioned so that the shaft of the tibia remained central. Fixation screws were inserted following standard procedures. Non-locking screws were initially inserted, while locking screws were inserted after reduction had been achieved. As standard practice, four screws were used for each fragment of the fracture. After the plate fixation, the K-wire was removed, and the screws were secured in place. Wound closure was performed in layers after irrigating the surgical site with normal saline.

Postoperatively, an above-knee splint was maintained for two days, and active and passive exercises were initiated to prevent postoperative stiffness and to strengthen the quadriceps. Sutures were removed on postoperative day 12, and non-weight-bearing walking continued for six weeks. Full weight-bearing was permitted by the 13th week.

Follow-up continued for six months, with assessments at 45, 90, 135, and 180 days, during which patients were evaluated for pain, tenderness, and range of motion at the knee and ankle. During follow-up visits, the functional outcome was assessed using the Olerud and Molander score[10] (Fig. 1).

Qualitative variables were presented as numbers and percentages, while quantitative variables were expressed as means and SD.

Results

Out of 34 studied cases, there were 24 (70.6%) males and 10 (29.4%) females, indicating a male preponderance with a male-to-female ratio of 1:0.71. The majority of patients were either 21–40 years old (47.1%) or 41–60 years old (41.7%). The mean age of the studied cases was 41.88±12.37 years. Twelve (35.3%) patients had a sedentary lifestyle, while moderate and heavy workers comprised 19 (55.9%) and 3 (8.8%) respectively. The right side was affected in 18 (52.9%) of the patients, while the left side was affected in the remaining patients (47.1%).

Table 1 Types of Fractures According to AO-OTA Classification

Fracture Type	Frequency (n=34)	Percentage
42A1	12	35.3
43A1	4	11.8
43A2	11	32.4
43A3	7	20.6

Table 2 Post-Operative Course and Union Time

Variable	Number of Cases	Minimum	Maximum	Mean	Std. Deviation
Non-weight bearing (weeks)	34	6	10	6.82	1.11
Partial weight bearing (weeks)	34	12	18	12.88	1.41
Full weight bearing (weeks)	34	16	22	18.35	1.25
Union time (weeks)	34	14	24	16.62	1.84

Table 3 Functional Outcome as Assessed by Olerud and Molander Score

Outcome by OAMS score	Frequency (n=34)	Percentage
91 to 100 (excellent)	3	8.8
61 to 90 (good)	22	64.7
31 to 60 (fair)	9	26.5
0 to 30 (poor)	0	0

Among the 34 cases studied, the most common type was 42A1 fractures, simple fractures of the distal tibia involving the metaphysis without joint extension, accounting for 35.3% of the cases. This was followed by 43A2 fractures, which are partial articular fractures involving part of the joint surface, representing 32.4%. The 43A3 fractures, complete articular fractures with the fracture line extending through the joint surface, constituted 20.6%, while the least frequent were 43A1 fractures, extra-articular fractures where the fracture line did not extend into the joint, making up 11.8% of the cases (Table 1).

In the immediate post-operative period, superficial wound infection was observed in 3 patients (8.8%), and deep wound infection was seen in 2 patients (5.9%). None of the patients had fat embolism, nerve damage, compartment syndrome, or any vascular injury. Non-weight bearing was continued from 6 weeks until 10 weeks post-operatively, with a mean of 6.82±1.11 weeks. Partial weight bearing was initiated at 12 weeks and continued until 18 weeks post-operatively, with a mean of 12.88±1.41 weeks. Full weight bearing was started at 16 weeks and lasted until 22 weeks post-operatively, with a mean of 18.35±1.25 weeks. The mean fracture union time for the patients was 16.62±1.84 weeks, ranging from 14 to 24 weeks (Table 2).

Table 4 Late Complications (6 Months)

Late Complications at 6 Months	Frequency (n=34)	Percentage
Ankle stiffness	10	29.4
Non-union	7	20.6
Mal-union	3	8.8
Infection	2	5.9
Plate exposure	2	5.9
Plate bend/break	0	0
Screw breakage	0	0

The patients were assessed for functional outcomes using the Olerud and Molander score. Among the 34 patients studied, 3 (8.8%) had excellent outcomes, 22 (64.7%) had good outcomes, and the remaining 9 (26.5%) had fair outcomes. None of the patients had a poor outcome according to the OAMS score (Table 3).

At 6 months post-operatively, 10 patients (29.4%) had ankle stiffness, 7 patients (20.6%) had non-union, 3 patients (8.8%) had malunion, and 2 patients each had infection and plate exposure (5.9% each). None of the patients had bending of the plate or screw breakage (Table 4).

Discussion

In the present study, the mean age of the patients was 41.88±12.37 years, ranging from 19 to 65 years, with the most common age groups being 21 to 40 years and 41 to 60 years (47.1% of the patients each). There was a significant male preponderance, with 70.6% of cases being male. In India, the majority of outdoor and strenuous activities are performed by males, which may explain the predominance of male patients in this study. Sreenivas KD *et al*. measured outcomes in patients with distal tibial fractures treated by the MIPO technique.[11] In their study, the average age of the patients was 44 years, and the most common age group involved

was 31 to 40 years. Males were four times as common as females. Similar age and gender distributions were also reported by authors such as Wennergren *et al*.[12]

The right side was affected in 52.9% of the patients. In the study by Gmachowska *et al*., the right side was also more frequently affected in cases of distal tibial fractures.[13] The most common fracture types in the present study were 42A1 (35.3%) and 43A2 (32.4%). Similarly, Onta *et al*. reported 43A1 as the most common fracture type (35.7%).[14] In the study by Ramesh *et al*.,[15] all fractures were classified according to the Ruedi-Allgower classification and the Gustilo-Anderson classification.The authors included all closed fractures and type I and type II compound fractures according to Gustilo-Anderson, regardless of whether they extended intra-articularly.

Distal tibial fractures are difficult to heal due to the limited soft tissue surrounding the distal tibia and relatively poor blood supply to the area. Therefore, it is important that the surgical procedure achieves biomechanical stability without disrupting callus formation. Complications are known to occur frequently in these patients, largely due to the minimal layer of skin and soft tissue around the distal tibia. It has been reported that infections occur in a significant number of patients.[16] These variations in complications are attributed to differences in the extent of soft tissue injury associated with these fractures, as well as variations in patient profiles.

In the study by Shah *et al*.,[17] out of 15 cases, two patients experienced postoperative infections—one superficial and one deep. The authors managed superficial infections with regular dressings and both topical and parenteral antibiotics. One patient, a known diabetic, developed a wound infection during the postoperative period, which was treated with antibiotics, regular dressings, and strict control of blood sugar levels.

During follow-up, non-weight bearing was maintained from 6 weeks to 10 weeks postoperatively, with a mean duration of 6.82 ± 1.11 weeks. Partial weight bearing was initiated at 12 weeks and continued until 13 weeks postoperatively, with a mean duration of 12.88±1.41 weeks. Full weight bearing commenced at 13 weeks and continued until 22 weeks postoperatively, with a mean duration of 18.35±1.25 weeks. In the study by Jabshetty *et al*., patients were encouraged to ambulate with crutches on the first postoperative day while remaining non-weight bearing. They also began exercises for the foot and ankle.[18] Two months postoperatively, partial weight bearing was initiated, which was subsequently advanced to full weight bearing based on the patient's progress.

In the present study, the mean fracture union time for patients was 16.62±1.84 weeks, ranging from 14 to 24 weeks. Rohit *et al*. conducted a comparative study to evaluate the management of distal tibial fractures treated with interlocking nails and plate osteosynthesis, assessing their functional outcomes using the American Orthopedic Foot and Ankle Society (AOFAS) score and complications. Twenty patients were treated with intramedullary nailing (IMN) and another twenty with minimally invasive plate osteosynthesis (MIPO). The mean union times were 18.45±2.45 weeks for the IMN group and 20±3.21 weeks for the MIPO group. The mean AOFAS scores were 92.6±5.41 for the IMN group and 91.2±6.81 for the MIPO group. The mean union time reported by Rohit *et al*.[19] was similar to that observed in this study.

Among the 34 patients investigated in the present study, 3 (8.8%) had excellent outcomes, 22 (64.7%) had good outcomes, and the remaining 9 (26.5%) had fair outcomes. None of the patients experienced a poor outcome according to the AOFAS score. In the study by Patel *et al*., according to the Teeny and Wiss criteria, 75% of the patients achieved excellent functional outcomes, while another 15% had good functional outcomes. The functional outcome was fair for 10% of the patients, and none had a poor functional outcome.[20]

The limitations of this study include its observational design and relatively small sample size. Additionally, the absence of a control group for comparison may affect the applicability of the findings.

In cases of distal tibial fractures, the MIPO technique significantly reduces surgical tissue trauma while preserving periosteal vascular integrity and the osteogenic fracture hematoma. The good functional results suggest that the MIPO technique should be considered for the surgical management of distal tibial fractures.

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