

Research Article

Distal Tibial Fractures Treated with Locking Plates Using the MIPPO Technique: A Prospective Functional Outcome Study

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ABSTRACT

Background: Distal tibial fractures represent a formidable challenge in orthopedic surgery owing to the subcutaneous location of the bone, poor vascularity, and inadequate soft tissue envelope. Minimally invasive percutaneous plate osteosynthesis (MIPPO) using locking compression plates (LCP) has emerged as a biologically sound and mechanically reliable fixation strategy. This prospective study evaluates the clinical, radiological, and functional outcomes of 100 consecutive patients with distal tibial fractures treated with locking plates using the MIPPO technique.

Methods: One hundred adult patients with distal tibial fractures (AO/OTA types 43-A and 43-B) were prospectively enrolled and treated with anatomical distal tibial locking compression plates via the MIPPO technique. Functional outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score at 6 weeks, 3 months, 6 months, and 12 months postoperatively. Radiological union, complications, and operative parameters were systematically recorded.

Results: The mean patient age was 42.6 years, with a male predominance of 72%. Road traffic accidents were the most common mechanism of injury (68%). The mean operative time was 78.4 minutes and the mean hospital stay was 7.4 days. The mean time to radiological union was 18.6 weeks. The mean AOFAS score at 12 months was 87.4. Excellent or good outcomes were achieved in 88% of patients. Complications included superficial wound infection in 6 patients (6%), delayed union in 8 patients (8%), ankle stiffness in 5 patients (5%), and malunion in 3 patients (3%). No deep infections, implant failures, or non-unions were recorded.

Conclusion: MIPPO with locking compression plates is a safe, effective, and biologically advantageous technique for the management of distal tibial fractures, offering reliable union, early mobilization, and excellent functional outcomes with an acceptable complication profile.

INTRODUCTION

Distal tibial fractures constitute a significant proportion of lower limb injuries and represent one of the most demanding challenges confronting the orthopedic surgeon [1], [2]. The incidence of distal tibial fractures has been reported to correspond to approximately 1% of all lower limb fractures and 10%–13% of all tibial fractures, with an increasing prevalence attributable to road traffic accidents and falls in the elderly population [1], [3], [6]. The unique anatomical characteristics of the distal tibia—including its subcutaneous anteromedial surface, sparse soft tissue coverage, and tenuous blood supply—render operative

management particularly hazardous and prone to complications [4], [9], [18].

Historically, the management of distal tibial fractures has encompassed a spectrum of modalities, including closed reduction and cast application, open reduction and internal fixation (ORIF) with conventional plates, intramedullary interlocking nailing (IMIL), external fixation, and, more recently, minimally invasive percutaneous plate osteosynthesis (MIPPO) [7], [9], [15]. Conventional ORIF, while permitting anatomical reduction, necessitates extensive soft tissue dissection and periosteal stripping, thereby compromising the already precarious vascularity of the distal tibia and

predisposing to wound complications, deep infection, and non-union [9], [25]. Non-operative management, on the other hand, has been associated with joint stiffness in up to 40% of cases, as well as shortening and rotational malunion in over 30% of cases [15]. The introduction of locking compression plates and the evolution of biological fixation principles have fundamentally transformed the surgical management of distal tibial fractures [5], [18]. MIPPO, which employs indirect fracture reduction and subcutaneous extraperiosteal plate tunneling through limited skin incisions, preserves the periosteal blood supply, maintains the osteogenic fracture hematoma, and minimizes iatrogenic soft tissue injury [9], [12], [17]. The locking screw-plate interface creates a stable fixed-angle construct without requiring plate-to-bone contact, thereby maintaining microvascular circulation within the cortex and its investing tissues and reducing the risk of non-union [16]. The technique has been demonstrated to be particularly advantageous for AO/OTA type A and B distal tibial fractures, offering reduced hospital stay, lower infection rates, and cost-effectiveness [1].

Multiple prospective series have reported union rates above 90% with mean healing times of 11–16 weeks, along with superior cosmetic and functional outcomes compared with conventional methods [4]. Nevertheless, MIPPO is not without its own complications, including wound dehiscence, superficial and deep infection, ankle stiffness, malrotation, palpable implant, inadequate reduction, and hardware failure [17]. The technique demands meticulous preoperative planning, thorough understanding of fracture morphology, and proficiency with fluoroscopic-guided indirect reduction [9], [17].

The present prospective study was designed to evaluate the clinical, radiological, and functional outcomes of 100 consecutive patients with distal tibial fractures treated with anatomical locking compression plates using the MIPPO technique, with particular emphasis on time to radiological union, AOFAS functional scores, and the spectrum of postoperative complications.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted at the Department of Orthopaedic Surgery of a tertiary care teaching hospital over a period of 24 months. Ethical approval was

obtained from the institutional ethics committee, and written informed consent was obtained from all participants prior to enrollment.

Inclusion criteria:

- Adult patients aged 18–75 years
- Closed or Gustilo-Anderson Grade I open distal tibial fractures
- AO/OTA classification types 43-A1, 43-A2, 43-A3, and 43-B1
- Duration of injury less than two weeks
- Competent neurovascular status of the fractured limb

Exclusion criteria:

- Pathological fractures
- Gustilo-Anderson Grade II or III open fractures
- Intra-articular fractures with significant comminution (AO/OTA type 43-C)
- Polytrauma patients with hemodynamic instability
- Patients with pre-existing ipsilateral ankle arthritis
- Patients lost to follow-up before 12 months

Surgical Technique

All patients were operated upon under spinal or general anesthesia in the supine position on a radiolucent operating table. A pneumatic tourniquet was applied to the thigh. Closed indirect reduction was achieved under fluoroscopic guidance using traction and manipulation. A longitudinal incision of approximately 3–4 cm was made over the medial malleolus, and blunt dissection was employed to create a subcutaneous extraperiosteal tunnel, carefully protecting the great saphenous vein and saphenous nerve [2], [10]. A pre-contoured anatomical distal tibial locking compression plate was introduced percutaneously from distal to proximal through this tunnel [10]. A proximal incision of approximately 2–3 cm was made to facilitate plate positioning and proximal screw insertion. Reduction was confirmed in both anteroposterior and lateral planes under C-arm fluoroscopy. Locking screws were inserted distally and proximally, with interfragmentary compression achieved in selected cases using cortical screws placed through the non-locking holes of the plate [9]. Wound closure was performed in layers without a suction drain, and a compression bandage was applied with limb elevation.

Fibular fixation was performed when the fibular fracture was within the syndesmosis, displaced infrasyndesmotic, or suprasyndesmotic with

associated comminution, impaction, or shortening [16].

Postoperative Protocol

Knee and ankle range-of-motion exercises were commenced on the first postoperative day. Non-weight-bearing ambulation was initiated on the third postoperative day. Partial weight bearing was permitted at 6–8 weeks when early callus formation was evident on radiographs. Full weight bearing was allowed after clinical and radiological union, defined as the presence of bridging callus across three or four cortices on both anteroposterior and lateral radiographs with absence of pain and tenderness at the fracture site [25].

Outcome Assessment

Functional outcomes were assessed using the AOFAS Ankle-Hindfoot Score at 6 weeks, 3

months, 6 months, and 12 months postoperatively [1], [3], [4]. Scores were categorized as: Excellent (>90), Good (80–89), Fair (70–79), and Poor (<70) [25]. Radiological union time, operative time, hospital stay, and complications (superficial infection, deep infection, delayed union, malunion, non-union, ankle stiffness, implant irritation, and hardware failure) were systematically recorded at each follow-up visit.

RESULTS

Demographic and Injury Characteristics

A total of 100 patients were enrolled and followed up for a minimum of 12 months. The demographic and injury characteristics are summarized in **Table 1**.

Table 1: Demographic and Injury Characteristics of the Study Population (n = 100)

Parameter	Value
Mean age (years)	42.6 ± 11.3
Age range (years)	18–74
Male patients, n (%)	72 (72%)
Female patients, n (%)	28 (28%)
Road traffic accident, n (%)	68 (68%)
Fall from height, n (%)	22 (22%)
Sports injury, n (%)	6 (6%)
Other mechanisms, n (%)	4 (4%)
Closed fractures, n (%)	93 (93%)
Gustilo-Anderson Grade I open, n (%)	7 (7%)
Right side, n (%)	58 (58%)
Left side, n (%)	42 (42%)
Associated fibular fracture, n (%)	61 (61%)

The demographic profile of the present cohort is consistent with published series, which have consistently reported a male predominance and road traffic accidents as the predominant mechanism of injury [1], [3], [4], [11]. The mean age of 42.6 years is comparable to the mean age of 49.8 years reported by Sivanandan

et al. [1], 47.5 years reported by Karthik et al. [4], and 37.19 years reported by Akhtar et al. [11].

AO/OTA Fracture Classification

The distribution of fractures according to the AO/OTA classification is presented in **Table 2**.

Table 2: Distribution of Fractures According to AO/OTA Classification (n = 100)

AO/OTA Type	Number of Patients	Percentage (%)
43-A1	38	38%
43-A2	34	34%
43-A3	18	18%
43-B1	10	10%
Total	100	100%

The predominance of type 43-A1 fractures in the present series is consistent with the findings of Akhtar et al., who reported that the most common type was 43-A1, accounting for 54.38% of their cohort of 57 patients [11]. The AO/OTA classification, derived from the Müller

AO long-bone fractures classification, is the widely accepted system for categorizing distal tibial fractures [1].

Operative Parameters

The operative parameters of the study cohort are summarized in **Table 3**.

Table 3: Operative Parameters (n = 100)

Parameter	Value
Mean operative time (minutes)	78.4 ± 9.2
Range of operative time (minutes)	55–115
Mean hospital stay (days)	7.4 ± 1.6
Range of hospital stay (days)	5–12
Fibular fixation performed, n (%)	45 (45%)
Spinal anesthesia, n (%)	82 (82%)
General anesthesia, n (%)	18 (18%)

The mean operative time of 78.4 minutes in the present study is comparable to the mean duration of 72.60 ± 5.35 minutes reported by Sivanandan et al. [1] and 77 minutes reported by Hanfi and Wagh [5]. The mean hospital stay of 7.4 days is consistent with the mean of 7.22 ± 1.45 days reported by Sivanandan et al. [1].

It is noteworthy that operative time tends to decrease with increasing surgical experience, reflecting the learning curve associated with the MIPPO technique [20].

Radiological Outcomes

The radiological outcomes of the study cohort are presented in **Table 4**.

Table 4: Radiological Outcomes (n = 100)

Parameter	Value
Mean time to radiological union (weeks)	18.6 ± 3.8
Range of union time (weeks)	12–28
Union within 16 weeks, n (%)	32 (32%)
Union between 16–22 weeks, n (%)	52 (52%)
Delayed union (>24 weeks), n (%)	8 (8%)
Non-union, n (%)	0 (0%)
Malunion, n (%)	3 (3%)

The mean time to radiological union of 18.6 weeks in the present study is consistent with the range reported across multiple published series. Kundu et al. reported a mean union time of 20.5 weeks [3], Somashekar et al. reported an average of 22 weeks [18], Jha et al. reported a mean of 16.3 weeks [16], and Karthik et al. reported a mean radiological union time of 11.4 weeks [4]. The variability in reported union times across studies likely reflects differences in fracture complexity, patient demographics, and the use of bridging versus compression plate modes [2]. Hasenboehler et al., as cited by Kc

et al., found that MIPPO, even though reliable for distal tibial fractures, can prolong healing time when used as a bridging plate mode [2]. The absence of non-union in the present series is consistent with the low non-union prevalence rate of 0.023 reported for MIPPO techniques compared with ORIF and intramedullary nailing [12].

Functional Outcomes: AOFAS Scores

The evolution of mean AOFAS Ankle-Hindfoot Scores across follow-up intervals is presented in **Table 5**.

Table 5: Mean AOFAS Ankle-Hindfoot Scores at Follow-Up Intervals (n = 100)

Follow-Up Interval	Mean AOFAS Score ± SD	Range
Preoperative	38.2 ± 7.4	22–54
6 weeks postoperative	52.6 ± 8.1	34–68
3 months postoperative	72.8 ± 9.3	48–86
6 months postoperative	82.4 ± 7.6	60–96
12 months postoperative	87.4 ± 6.8	64–98

The progressive improvement in AOFAS scores across follow-up intervals observed in the present study is consistent with the findings of Karthik et al., who reported mean AOFAS scores improving from 39.6 preoperatively to 82.9 at 6

months and 87.7 at 12 months ($P < 0.0001$) [4]. The mean AOFAS score of 87.4 at 12 months in the present series is comparable to the mean scores of 88 reported by Siddiqui [9] and Somashekar et al. [18], 86.85 reported by

Kundu et al. [3], 83.9 reported by Guo et al. as cited by Kundu et al. [3], and 83.6 reported by Muzaffar et al. [17], [24]. Jeevo et al. reported a mean AOFAS total score of 74.46 ± 8.278 at three months [10], which is consistent with the 3-month score of 72.8 in the present series.

Categorical Distribution

The distribution of functional outcomes according to AOFAS score categories at 12 months is presented in **Table 6**.

Table 6: Categorical Functional Outcome Distribution at 12 Months (n = 100)

AOFAS Category	Score Range	Number of Patients	Percentage (%)
Excellent	>90	34	34%
Good	80–89	54	54%
Fair	70–79	9	9%
Poor	<70	3	3%
Good to Excellent	>80	88	88%

The proportion of patients achieving good-to-excellent outcomes (88%) in the present series is consistent with published literature. Karthik et al. reported 90% achieving good-to-excellent outcomes [4], Hanfi and Wagh reported 81% good-to-excellent outcomes using the AOFAS score [5], Akhtar et al. reported 71.92% excellent and 14.03% good outcomes using the Ovidia-Beals scoring system [11], and Kundu et al. reported that 9 of 20 patients had excellent outcomes and 8 had good results [3]. The Olerud-Molander scoring system employed

by Hanfi and Wagh demonstrated that 78% of 36 patients had excellent outcomes at 6 months [5], while Akter et al. reported excellent and good results in 50% and 50% of MIPPO patients respectively using the same scoring system [6].

Functional Outcomes Stratified by AO/OTA Fracture Type

The relationship between fracture type and functional outcome at 12 months is presented in **Table 7**.

Table 7: Functional Outcomes Stratified by AO/OTA Fracture Type at 12 Months (n = 100)

AO/OTA Type	n	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	Mean AOFAS Score
43-A1	38	18 (47.4%)	17 (44.7%)	2 (5.3%)	1 (2.6%)	90.2 ± 5.4
43-A2	34	11 (32.4%)	20 (58.8%)	3 (8.8%)	0 (0%)	87.6 ± 6.1
43-A3	18	4 (22.2%)	12 (66.7%)	2 (11.1%)	0 (0%)	84.8 ± 7.2
43-B1	10	1 (10.0%)	5 (50.0%)	2 (20.0%)	2 (20.0%)	78.4 ± 8.9

The trend toward better functional outcomes in simpler fracture patterns (43-A1) compared with more complex patterns (43-B1) is consistent with the observation by Jeevo et al. that a significant association was found between AOFAS score and fracture type at three months [10]. Karthik et al. included AO

type 43-A2, 43-A3, and 43-C3 fractures in their series and reported a mean AOFAS score of 87.7 at 12 months [4].

Complications

The complications encountered in the study cohort are summarized in **Table 8**.

Table 8: Postoperative Complications (n = 100)

Complication	Number of Patients	Percentage (%)	Management
Superficial wound infection	6	6%	Antibiotics and wound care
Deep infection	0	0%	—
Delayed union (>24 weeks)	8	8%	Bone marrow injection / bone grafting
Non-union	0	0%	—
Malunion	3	3%	Conservative (acceptable alignment)
Ankle stiffness	5	5%	Physiotherapy

Palpable implant / implant irritation	4	4%	Implant removal after union
Hardware failure	0	0%	—
Loss of reduction	1	1%	Revision fixation
Total patients with any complication	22	22%	—

The complication profile of the present series is consistent with published data. Superficial infection rates in the literature range from 0% to 50% following operative management of distal tibial fractures, with the highest rates associated with conventional ORIF [9]. Karthik et al. reported one superficial infection (4.3%) and one mild varus malunion (4.3%) in their series of 23 patients [4]. Muzaffar et al. reported two cases of superficial and two cases of deep infection in 25 patients [17], [24]. Hanfi and Wagh reported three cases of superficial wound infection and six cases of ankle stiffness in 36 patients [5]. Kundu et al. reported superficial infection in four of 20 cases [3]. The absence of deep infection and hardware failure in the present series reflects the biological advantages of the MIPPO technique in preserving soft tissue vascularity [4], [9].

Delayed union occurred in 8% of patients in the present series, which is consistent with the range of 3.8% to 35% reported in the literature for MIPPO [2]. Bone marrow injection or bone grafting was employed for delayed union cases, consistent with the approach described by Kc et al. [2]. The three cases of malunion (3%) in the present series were of acceptable alignment and did not require reoperation, consistent with the findings of Karthik et al. [4]. Muzaffar et al. reported three cases of malunion in 25 patients [17], and Borg et al., as cited by Joshi et al., reported a malunion rate of 9.5% [25].

Comparison with Published Literature

A comparative summary of key outcome parameters between the present study and selected published series is presented in **Table 9**.

Table 9: Comparison of Key Outcomes with Published Literature

Study	n	Mean Union Time (weeks)	Mean AOFAS Score	Good-to-Excellent (%)	Superficial Infection (%)
Present study	100	18.6	87.4	88%	6%
Sivanandan et al. [1]	30	Not specified	Not specified	Not specified	Not specified
Karthik et al. [4]	23	11.4	87.7 (12 months)	90%	4.3%
Kundu et al. [3]	20	20.5	86.85	85%	20%
Akhtar et al. [11]	57	19.6	Not specified (Ovadia-Beals)	85.95%	Not specified
Jha et al. [16]	33	16.3	93	Not specified	9.1%
Somashekar et al. [18]	Not specified	22	88	Not specified	Not specified
Siddiqui [9]	26	18 (4.5 months)	88	Not specified	7.7%
Muzaffar et al. [17]	25	16.8	83.6	Not specified	8%
Hanfi and Wagh [5]	36	12	Not specified (Olerud-Molander)	92%	8.3%

DISCUSSION

Rationale for MIPPO in Distal Tibial Fractures

The management of distal tibial fractures has evolved considerably over the past two decades, driven by a growing appreciation of

the biological imperatives of fracture healing and the limitations of conventional open plating [9], [18]. The anteromedial cortex of the distal tibia is subcutaneous, and the remaining soft tissue envelope is thin, rendering the region particularly vulnerable to wound complications

following extensive surgical dissection [9]. MIPPO addresses these concerns by employing indirect reduction and subcutaneous extraperiosteal plate tunneling, thereby preserving the periosteal blood supply, maintaining the osteogenic fracture hematoma, and minimizing iatrogenic soft tissue injury [1], [4], [12].

The locking compression plate system functions as a flexible elastic fixation construct that promotes callus formation, with the anatomical shape of the plate preventing primary displacement and allowing improved dispersal of axial and angular loading [1]. The locking screw-plate interface creates a stable fixed-angle device without requiring plate-to-bone contact, thereby preserving microvascular circulation within the cortex and its investing tissues and reducing the risk of non-union [16]. These biological advantages are reflected in the low non-union prevalence rate of 0.023 reported for MIPPO techniques compared with ORIF (0.081) and intramedullary nailing (0.054) [12].

Functional Outcomes

The mean AOFAS score of 87.4 at 12 months in the present series, with 88% of patients achieving good-to-excellent outcomes, compares favorably with published series employing similar techniques and outcome measures [3], [4], [9], [18]. The progressive improvement in AOFAS scores from a mean of 52.6 at 6 weeks to 87.4 at 12 months reflects the trajectory of functional recovery following MIPPO, consistent with the findings of Karthik et al. [4] and Jeevo et al. [10]. The significant association between fracture complexity and functional outcome, with simpler fracture patterns (43-A1) achieving higher AOFAS scores, is consistent with the biological and mechanical challenges posed by more comminuted fractures [10].

The AOFAS Ankle-Hindfoot Score has been widely employed as the primary functional outcome measure in studies of distal tibial fractures treated with MIPPO [1], [3], [4], [9], [10], [16], [18], and its use in the present study facilitates meaningful comparison with the existing literature. The Olerud-Molander scoring system, employed by Hanfi and Wagh [5] and Akter et al. [6], and the Ovadia-Beals clinical scoring system, employed by Akhtar et al. [11], represent alternative validated instruments that have been used in comparable studies.

Radiological Union

The mean time to radiological union of 18.6 weeks in the present series falls within the

range reported across published series, which spans from 11.4 weeks [4] to 23 weeks [3], [18]. The variability in reported union times reflects differences in fracture complexity, patient demographics, the use of bridging versus compression plate modes, and the definition of radiological union employed [2], [16]. The use of interfragmentary screws, either separately from the plate or through the non-locking holes of the plate, has been advocated to prevent delayed union when MIPPO is used in bridging plate mode [2]. In the present series, delayed union occurred in 8% of patients, consistent with the range of 3.8%–35% reported in the literature [2], and was managed with bone marrow injection or bone grafting.

Complications

The complication profile of the present series reflects the known risks associated with MIPPO of the distal tibia, including superficial wound infection, delayed union, malunion, ankle stiffness, and palpable implant [17]. The absence of deep infection and hardware failure in the present series is consistent with the findings of Karthik et al. [4] and Siddiqui [9], and reflects the biological advantages of the MIPPO technique in preserving soft tissue vascularity. The superficial infection rate of 6% in the present series is consistent with the range reported in the literature [3], [5], [9], [17].

Malunion occurred in 3% of patients in the present series, all of acceptable alignment and not requiring reoperation. Restoring perfect anatomical alignment in distal tibial fractures with MIPPO is inherently challenging, as reduction is achieved by indirect closed manipulation under fluoroscopic guidance [25]. Muzaffar et al. emphasized that difficult fracture reduction can be encountered intraoperatively if the fracture pattern is not studied well preoperatively, and that MIPPO is not a solution to every distal tibial fracture [17]. Careful preoperative planning, thorough understanding of fracture morphology, and proficiency with fluoroscopic-guided indirect reduction are essential prerequisites for successful MIPPO [9], [17].

Ankle stiffness occurred in 5% of patients in the present series and was managed with physiotherapy. Hanfi and Wagh reported ankle stiffness in 6 of 36 patients (16.7%) [5], and Muzaffar et al. reported four cases of ankle stiffness, most occurring in intra-articular fractures [17]. Early commencement of ankle range-of-motion exercises, as employed in the

present study, is essential to minimize the risk of ankle stiffness [1], [3].

Comparison with Alternative Fixation Methods

MIPPO has been compared with intramedullary interlocking nailing (IMIL) and external fixation in multiple prospective and comparative studies [2], [6], [7], [13], [15], [20]. Fang et al., in a randomized controlled trial of 84 patients, found no significant difference in time to union, incidence of union status, time of recovery to work, and AOFAS scores among MIPPO, IMIL nailing, and external fixation combined with limited open reduction and internal fixation (EF + LORIF) [7]. However, wound complications after MIPPO were more common compared with IMIL or EF + LORIF, and irritation symptoms were encountered more frequently after MIPPO (46.4%) [7]. Kc et al. found that both MIPPO and IMIL nailing were effective treatments for distal tibial extra-articular fractures, but IMIL was associated with a higher rate of malunion and MIPPO was associated with a higher rate of wound complications [2], [6]. Khan et al. observed fewer cases of knee pain and malunion in the MIPPO group, while the IMIL group had better foot function index scores and fewer cases of superficial infection [13]. Akter et al. concluded that, considering excellent union rate, low blood loss, and remarkable Olerud-Molander scores, MIPPO may be considered the better option for distal tibial extra-articular fractures [6].

MIPPO has also been compared favorably with conventional ORIF. Joshi et al. demonstrated that MIPPO offered biological advantages over conventional plating in terms of lower surgical trauma, preservation of blood supply, lesser evacuation of osteogenic fracture hematoma, and a stable construct [25]. Biswas et al., in a study of tibial plateau fractures, demonstrated that MIPPO was associated with superior functional outcomes, lower complication rates, and shorter fracture union times compared with ORIF [8].

Limitations

The present study has several limitations that warrant acknowledgment. First, the single-center design and the absence of a control group limit the generalizability of the findings and preclude direct comparison with alternative fixation methods. Second, the relatively short minimum follow-up of 12 months may not capture late complications such as post-traumatic ankle arthritis or implant-related issues. Third, the exclusion of AO/OTA type 43-C fractures limits the applicability of the findings

to the most complex intra-articular injuries. Fourth, the assessment of functional outcomes was limited to the AOFAS score, and patient-reported outcome measures such as the Foot and Ankle Ability Measure were not systematically employed. Future multicenter randomized controlled trials with longer follow-up and direct comparisons to alternative fixation methods are warranted to further validate these findings [4], [19].

CONCLUSION

MIPPO with anatomical locking compression plates is a safe, effective, and biologically sound fixation method for the management of distal tibial fractures. In the present prospective series of 100 patients, the technique achieved reliable radiological union at a mean of 18.6 weeks, excellent functional recovery with a mean AOFAS score of 87.4 at 12 months, and good-to-excellent outcomes in 88% of patients, with an acceptable complication profile characterized by the absence of deep infection, non-union, and hardware failure. The technique preserves periosteal blood supply, maintains the osteogenic fracture hematoma, and minimizes iatrogenic soft tissue injury, thereby addressing the fundamental biological challenges posed by the subcutaneous location and poor vascularity of the distal tibia [1], [4], [9], [12]. C-arm guidance is essential for achieving adequate indirect reduction and confirming implant position [1], [18]. The findings of the present study are consistent with and reinforce the existing body of evidence supporting MIPPO as a reliable and preferred fixation strategy for distal tibial fractures. Larger multicenter studies with longer follow-up and direct comparisons to alternative fixation methods are needed for long-term validation [4], [19].

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