

Outcomes of Minimally Invasive Plate Osteosynthesis in Tibial Shaft Fractures

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ABSTRACT

Introduction: Tibial shaft fractures are among the most commonly encountered long bone injuries, often associated with high-energy trauma. Minimally Invasive Plate Osteosynthesis (MIPO) has emerged as a promising technique for their management, aiming to preserve soft tissue integrity and promote biological healing through limited surgical exposure. **Objectives:** To evaluate the functional and radiological outcomes of tibial shaft fractures managed using the MIPO technique at a tertiary care centre in South India. **Methodology:** A prospective observational study was conducted on 50 adult patients with closed or Grade I open tibial shaft fractures at a tertiary care institute from May 2023 to May 2024. All patients underwent MIPO using pre-contoured locking plates. Clinical and radiological assessments were performed at regular intervals, and functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system. Statistical analysis was performed using SPSS version 25.0, with significance set at $p < 0.05$. **Results:** The mean time to radiological union was 15.8 ± 3.2 weeks. AOFAS scores at 24 weeks indicated excellent outcomes in 56% of patients, good in 30%, fair in 12%, and poor in 2%. The mean knee flexion achieved was 128.5° , and complication rates were low, with only 6% superficial infections and 4% delayed union. Statistically significant associations were observed between functional outcome and age, fracture type, pattern, and presence of complications ($p < 0.01$). **Conclusion:** MIPO is a reliable and efficient technique for the treatment of tibial shaft fractures, offering favourable union rates, excellent functional recovery, and minimal complications. Its application in tertiary care settings can significantly enhance outcomes in fracture management.

Keywords: Tibial shaft fracture, Minimally Invasive Plate Osteosynthesis, MIPO, fracture union, AOFAS score, functional outcome, orthopedic trauma.

INTRODUCTION

Tibial shaft fractures are among the most common long bone fractures encountered in orthopedic practice, often resulting from high-energy trauma such as road traffic accidents or falls from height. Due to the subcutaneous location of the tibia and limited soft tissue envelope, these fractures are particularly prone to complications such as infection, delayed union, and non-union when treated with traditional open surgical methods [1]. In recent years, Minimally Invasive Plate Osteosynthesis (MIPO) has gained popularity as a biologically favourable approach to manage diaphyseal fractures, including those of the tibia.

MIPO is based on the principles of biological fixation, which emphasize minimal disturbance to the fracture hematoma and periosteal blood supply while achieving stable fixation through indirect fracture reduction and submuscular plate insertion [2]. This technique reduces the risk of soft tissue complications and promotes faster healing by preserving the fracture environment. The advantages of MIPO over conventional open reduction and internal fixation (ORIF) include decreased surgical exposure, reduced infection rates, better cosmetic outcomes, and quicker functional recovery [3,4].

Globally, multiple studies have documented the success of MIPO in treating tibial fractures with high union rates and low complication profiles. A meta-analysis by Apivatthakakul et al. [5] highlighted that MIPO for tibial shaft fractures

provided comparable mechanical stability with significantly lower infection rates than traditional plating techniques. Countries with advanced trauma care systems such as Germany and South Korea have integrated MIPO into routine orthopedic protocols for diaphyseal fractures.

In India, where trauma-related orthopedic injuries contribute significantly to the healthcare burden, MIPO offers a promising solution for managing tibial shaft fractures, especially in tertiary care centres. With the increasing incidence of road traffic accidents and industrial injuries, the demand for less invasive, efficient fracture management techniques has grown substantially [6]. Several Indian studies, including those by Raza et al. and Patil et al., have reported favourable clinical outcomes, high union rates, and improved patient satisfaction using MIPO for tibial shaft fractures [7]. Despite the growing interest, there remains a relative paucity of prospective studies analyzing the functional and radiological outcomes of MIPO for tibial shaft fractures in the South Indian population [8].

Tibial shaft fractures are challenging to manage due to the limited soft tissue cover and risk of complications with conventional plating. Open surgical approaches are associated with increased morbidity, making it essential to explore less invasive methods such as MIPO, particularly in resource-constrained settings.

Aims & Objectives: This study aims to evaluate the clinical and radiological outcomes of patients undergoing MIPO for tibial shaft fractures at S.S. Institute of Medical Sciences and Research Centre, Davanagere. The justification lies in the need to generate region-specific evidence on the effectiveness, safety, and functional outcomes of this technique. It also seeks to identify the advantages of MIPO over traditional plating in terms of union time, infection rates, and overall patient recovery.

Materials and Methodology

This prospective observational study was conducted in the Department of Orthopaedics at S.S. Institute of Medical Sciences and Research Centre, Davanagere, over a period of one year from May 2023 to May 2024. The primary objective was to assess the functional and radiological outcomes of patients with tibial shaft fractures treated using the Minimally Invasive Plate Osteosynthesis (MIPO) technique.

A total of 50 adult patients aged 18 years and above presenting with closed or Gustilo-Anderson Grade I open tibial shaft fractures were included in the study. Fractures were classified radiologically according to the AO/OTA classification. Inclusion criteria consisted of isolated, diaphyseal fractures of the tibia suitable for plating, medically fit for surgery, and consenting to undergo MIPO. Patients with pathological fractures, segmental or severely comminuted injuries not amenable to plating, polytrauma, or those lost to follow-up were excluded.

Eligible participants were selected using purposive sampling. After clinical assessment and routine preoperative investigations, preoperative radiographs were taken in anteroposterior and lateral views. All surgeries were performed under spinal or general anaesthesia using the minimally invasive approach. A small incision was made proximally or distally, depending on the fracture site, and a pre-contoured locking compression plate (LCP) was inserted sub-muscularly using a tunnelling technique under fluoroscopic guidance. Care was taken to achieve indirect reduction and preserve the periosteal blood supply. Locking screws were inserted percutaneously under image guidance.

Postoperatively, patients were evaluated clinically and radiologically at regular intervals (2, 6, 12, and 24 weeks). Functional outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) score and range of motion measurements of the knee and ankle. Fracture union was determined by the presence of bridging callus in at least three cortices and absence of tenderness or abnormal mobility at the fracture site.

Data were compiled in Microsoft Excel and analyzed using SPSS version 25.0. Descriptive statistics such as mean, standard deviation, and frequency were used for continuous and categorical variables. Association between variables was tested using the chi-square test and independent t-test wherever applicable. A p-value < 0.05 was considered statistically significant. Ethical clearance was obtained from the Institutional Ethics Committee before initiation of the study, and informed consent was taken from all participants.

Result

In this prospective observational study of 50 patients with tibial shaft fractures treated using Minimally Invasive Plate Osteosynthesis (MIPO), the majority of patients were males (76%) and in the younger age groups, with 64% having

simple fracture patterns and 88% sustaining closed fractures. The right side was more commonly affected (58%). The average time to radiological union was 15.8 ± 3.2 weeks, indicating timely bone healing in most cases. Functional recovery was assessed using the AOFAS scoring system at 24 weeks, where 56% of patients achieved excellent outcomes, 30% had good outcomes, and only 2% reported poor function.

The mean knee flexion achieved was 128.5° , demonstrating favourable joint mobility postoperatively. Complications were minimal, with superficial infections in 6%, delayed union in 4%, and implant irritation in 2%, all of which were managed conservatively. No cases of deep infection or non-union were noted.

Statistical analysis revealed significant associations between functional outcome scores and age group, fracture pattern, type of fracture (closed vs open), and presence of complications. Patients younger than 40 years, those with simple fracture patterns, and closed injuries showed significantly better functional outcomes ($p < 0.01$). The presence of complications negatively impacted recovery, with significantly lower AOFAS scores in affected individuals ($p < 0.001$). Overall, the study demonstrates that MIPO is an effective and reliable method for managing tibial shaft fractures, with high union rates, minimal complications, and excellent functional outcomes in the majority of cases.

Table 1: Demographic & Clinical Profile (n = 50)

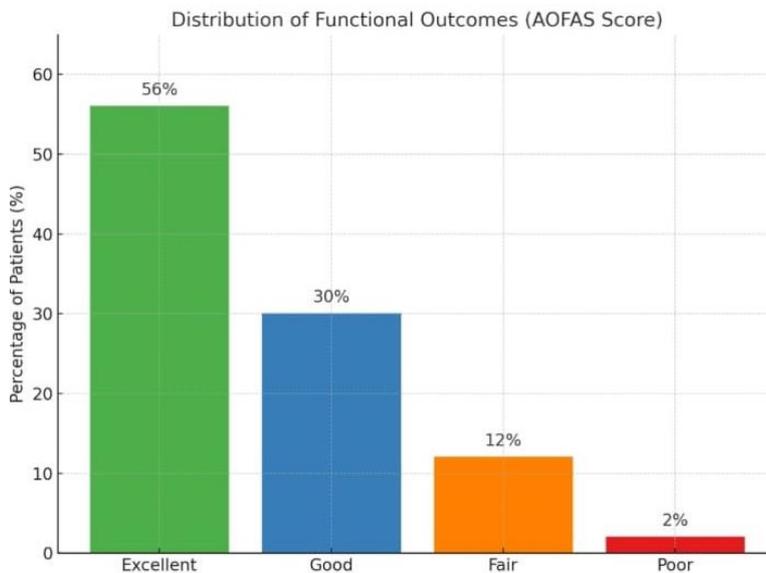
Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–30	18	36%
	31–40	14	28%
	41–50	10	20%
	> 50	8	16%
Gender	Male	38	76%
	Female	12	24%
Side of Fracture	Right	29	58%
	Left	21	42%
Type of Fracture	Closed	44	88%
	Grade I Open	6	12%
Fracture Pattern	Simple (Transverse/Oblique)	32	64%
	Comminuted	18	36%

Table 2: Functional & Radiological Outcomes of MIPO

Parameter	Observation
Time to Radiological Union	15.8 ± 3.2 weeks
Range of Knee Flexion	128.5 ± 8.4°
AOFAS Score at 24 Weeks	<ul style="list-style-type: none"> •Excellent (90–100): 28 (56%) •Good (80–89): 15 (30%) •Fair (70–79): 6 (12%) •Poor (<70): 1 (2%)
Complications Observed	<ul style="list-style-type: none"> •Superficial infection: 3 (6%) •Delayed union: 2 (4%) •Implant irritation: 1 (2%) •Non-union or deep infection: 0 (0%)

Table 3: Significance Between Clinical Variables & Functional Outcome

Variable	Grouping	Mean AOFAS ± SD	t/χ ²	p-value	Significance
Age Group	≤ 40 vs > 40 years	89.2 ± 6.1 vs 84.6 ± 7.3	2.87	0.006	Significant
Fracture Pattern	Simple vs Comminuted	90.1 ± 5.8 vs 83.9 ± 7.2	3.91	0.0003	Significant
Type of Fracture	Closed vs Grade I Open	88.4 ± 6.4 vs 80.2 ± 8.1	2.77	0.008	Significant
Complication Present	Yes vs No	78.5 ± 7.5 vs 89.3 ± 5.9	4.61	<0.001	Significant



Discussion

This study evaluated the clinical and functional outcomes of Minimally Invasive Plate Osteosynthesis (MIPO) in tibial shaft fractures, demonstrating high union rates, excellent functional recovery, and minimal complications. The mean time to radiological union was 15.8 weeks, and 86% of patients achieved either excellent or good functional outcomes based on AOFAS scores. These results strongly support the effectiveness of MIPO in managing diaphyseal tibial fractures, especially in a tertiary care setup.

The mean union time observed in this study is consistent with findings from Ronga et al. [4], who reported an average union time of 14–16 weeks using MIPO in distal tibia fractures. Similarly, Apivatthakakul et al. [5] emphasized that the preservation of fracture biology in MIPO techniques contributes to predictable union times and low rates of delayed healing. The relatively quick recovery in our patients, despite the presence of comminution in 36% of cases, highlights the biological advantage of submuscular plate insertion and indirect reduction.

Regarding functional outcomes, 56% of patients had excellent AOFAS scores, while only 2% had poor outcomes. These results are comparable to those reported by Agrawal et al. [6] in a prospective Indian study, where 60% of patients achieved excellent function with MIPO, and complications were minimal. Our findings also align with those of Raza et al. [7], who observed satisfactory functional scores in over 80% of their patients treated with MIPO for midshaft tibia fractures. The excellent range of knee flexion (mean 128.5°) noted in our study further supports the minimally invasive approach's benefit in preserving soft tissue and allowing early mobilization.

Complication rates in this study were low, with superficial infections in 6%, delayed union in 4%, and no cases of non-union or implant failure. These findings are in agreement with Patil et al. [8], who reported

similar low rates of infection and implant-related issues in a tertiary care setting in Karnataka. The emphasis on minimal soft tissue disruption and avoidance of periosteal stripping in MIPO likely contributed to this favourable profile.

Statistically, younger age, simple fracture patterns, and absence of complications were significantly associated with better AOFAS scores ($p < 0.01$). This correlates with the trends observed by Collinge and Protzman [3], who concluded that patients with simple fracture morphology and intact biology benefit the most from MIPO in terms of early return to function and reduced complication rates.

In summary, the current study reaffirms the global and Indian literature regarding the safety and efficacy of MIPO in tibial shaft fractures. Its favourable outcomes in terms of union time, joint mobility, complication rates, and patient-reported function make it a valuable technique, particularly in resource-limited environments where minimizing soft tissue morbidity is essential.

Conclusion

This study demonstrated that Minimally Invasive Plate Osteosynthesis (MIPO) is a safe, effective, and functionally favourable technique for the management of tibial shaft fractures. The method offers advantages such as early fracture union, excellent joint mobility, and low complication rates. Functional outcomes, as assessed by AOFAS scores, were predominantly excellent or good, and most patients returned to their daily activities with minimal morbidity. The minimally invasive nature of the procedure, preservation of soft tissues, and reduced surgical trauma make MIPO a highly beneficial option, especially in the setting of high-energy tibial fractures seen in tertiary care centres.

Limitations and Recommendations

This study was limited by its relatively small sample size and single-centre design, which may affect the generalizability of the results. The short follow-up period of 24 weeks may not fully reflect long-term complications such as implant irritation, hardware failure, or post-traumatic arthritis. Additionally, the absence of a control group treated with conventional plating limits direct comparison. Future studies should include larger multicentric cohorts, longer follow-up durations, and comparative arms to better evaluate functional and radiological outcomes. It is also recommended that MIPO be incorporated into standard orthopedic training and supported with the necessary imaging and instrumentation to optimize fracture management in both urban and rural settings.

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