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Original Research Article

To Assess Time for Fracture Union Fixation by Minimally Invasive Percutaneous Plate Osteosynthesis Among Proximal Tibia Fracture

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Abstract:

Traditional open reduction and internal fixation often required extensive exposure, which, although allowing direct visualization of the fracture fragments, carried inherent risks of soft-tissue trauma, infection, loss of periosteal blood supply, and delayed healing. Over time, orthopaedic principles gradually shifted toward biological fixation concepts that emphasized the preservation of blood supply, respect for soft tissues, and maintenance of the fracture's natural biological environment. This change in philosophy paved the way for minimally invasive plate osteosynthesis, which attempted to harmonize mechanical stability with biological preservation.

Keywords: Proximal Tibia, Freacture.

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Introduction

Regardless of the mechanism, the proximal tibia plays a crucial role in weight transmission, alignment, knee stability, and coordinated mobility. Hence, even slight residual deformity or articular incongruity can translate into long-term instability, early osteoarthritis, and functional limitations that affect an individual's quality of life. The increasing incidence of these fractures in both young active individuals and the ageing population has intensified interest in surgical strategies that can provide both reliable fixation and preservation of the soft-tissue envelope to ensure better long-term outcomes.[1,2] Traditional open reduction and internal fixation often required extensive exposure, which, although allowing direct visualization of the fracture fragments, carried inherent risks of soft-tissue trauma, infection, loss of periosteal blood supply, and delayed healing. Over time, orthopaedic principles gradually shifted toward biological fixation concepts that emphasized the preservation of blood supply, respect for soft tissues, and maintenance of the fracture's natural biological environment. This change in philosophy paved the way for minimally invasive plate osteosynthesis, which attempted to harmonize mechanical stability with biological preservation.[2] Among the devices designed to support this method, the locking compression plate emerged as one of the most significant innovations. Its unique design, combining the principles of conventional plating with angular stable fixation, offered surgeons a tool capable of providing robust fixation, especially in metaphyseal bone, where screw purchase is often weak. The locking mechanism between the screw head and the plate creates a fixed-angle construct that does not rely solely on plate–bone compression, thereby minimizing periosteal stripping and preserving vasculature essential for healing. [2,3] The MIPPO technique, when paired with a locking compression plate, has therefore gained popularity as a preferred approach for fractures around the proximal tibia. By using percutaneous tunnels and limited incisions, the surgeon can slide the plate subcutaneously or submuscularly, aligning it along the bone without excessively disturbing the fracture site. The fracture is stabilized using indirect reduction methods, which rely on ligamentotaxis, traction, and gentle manipulation to restore length, alignment, and rotation. The procedure is particularly advantageous for comminuted fractures, metaphyseal collapse, and osteoporotic bone, where direct manipulation risks further damage. In theory, such an approach should reduce the incidence of soft-tissue complications, preserve biological potential for healing, and provide adequate structural support for early mobilization. Early knee

movement is critical in preventing stiffness, quadriceps wasting, and long-term functional limitations. Therefore, any technique that achieves stable fixation while protecting soft tissues lends itself naturally to better postoperative rehabilitation and functional recovery. [3,4].

Methodology

The study spanned a period of two years, from March 2024 to February 2026. This duration was chosen to ensure adequate recruitment of eligible patients and to allow for sufficient follow-up time—up to six months postoperatively—to assess functional recovery, fracture union, and complications

Inclusion Criteria:

1. Patients aged between 18 and 65 years, irrespective of gender.
2. Radiologically confirmed proximal tibia fractures classified under the AO or Schatzker (Types I–VI) classification systems.
3. Patients who provided informed written consent for surgical management.
4. Patients medically fit to undergo spinal or epidural anaesthesia and surgery.

Exclusion Criteria:

1. Open fractures (Gustilo-Anderson Types I–III).
2. Pathological fractures due to bone tumours or metabolic disorders.
3. Polytrauma patients with ipsilateral fractures above or below the knee.
4. Neglected or chronic fractures presenting beyond three weeks from injury.

Results

The age-wise distribution of patients in the present study shows that the majority belonged to the 51–60 years age group (29.09%), followed by 41–50 years (23.64%) and 31–40 years (20%). Younger individuals aged 18–30 years constituted 14.55% of cases, while patients older than 60 years accounted for 12.73%. This indicates a higher incidence of proximal tibial fractures in middle-aged and elderly populations, possibly reflecting increased exposure to trauma in active age groups along with age-related bone fragility.

Table 1: Age Distribution of Study Population

Age Group (Years)	Frequency (n)	Percentage (%)
18–30	8	14.55
31–40	11	20.00
41–50	13	23.64
51–60	16	29.09
>60	7	12.73
Total	**55**	**100.00**

Sex Distribution of Study Population: The distribution of patients according to sex demonstrates a clear male predominance, with males constituting 87.27% of the study population, while females accounted for only 12.73%. This significant male preponderance may be attributed to higher exposure of males to high-energy trauma such as road traffic accidents and occupational hazards, which are common causes of proximal tibial fractures. The findings suggest that such injuries are more frequent among the actively mobile and working male population.

Table 2: Sex Distribution of Study Population

Sex	Frequency (n)	Percentage (%)
Female	7	12.73
Male	48	87.27
Total	**55**	**100.00**

Side of Injury Distribution: The distribution of fracture side shows that the right side was more commonly involved, accounting for 60% of cases, compared to the left side which constituted 40% of the study population. This slight predominance of right-sided injuries may be related to limb dominance and the mechanism of trauma, particularly in road traffic accidents and falls, where the dominant limb is more frequently exposed to impact.

Table 3: Side of Injury Distribution

Side	Frequency (n)	Percentage (%)
Left	22	40.00
Right	33	60.00
Total	**55**	**100.00**

Mode of Injury Distribution: The majority of proximal tibial fractures in the present study were attributed to road traffic accidents (RTA), accounting for 87.27% of cases. Falls from height contributed to 7.27%, while domestic falls constituted only 5.45% of injuries. This distribution highlights that high-energy trauma is the predominant mechanism of injury in these fractures, particularly in active populations. The relatively lower incidence of low-energy injuries suggests that severe force is commonly required to produce such complex fracture patterns.

Table 4: Mode of Injury Distribution

Mode of Injury	Frequency (n)	Percentage (%)
Domestic fall	3	5.45
Fall from height	4	7.27
RTA	48	87.27
Total	**55**	**100.00**

Schatzker Classification Distribution: The distribution of fractures according to Schatzker classification revealed that type II fractures were the most common, accounting for 30.91% of cases. This was followed by type V (18.18%) and types IV and VI (16.36% each). Type I fractures constituted 10.91%, while type III fractures were the least common at 7.27%. The predominance of type II fractures suggests a higher occurrence of split-depression patterns, commonly associated with high-energy trauma.

Table 5: Schatzker Classification Distribution

Schatzker Type	Frequency (n)	Percentage (%)
I	6	10.91
II	17	30.91
III	4	7.27
IV	9	16.36
V	10	18.18
VI	9	16.36
Total	**55**	**100.00**

AO Classification Distribution: According to AO classification, type 41-C2 fractures were the most prevalent, accounting for 45.45% of cases, indicating a high proportion of complex complete articular fractures. This was followed by type 41-C3 (18.18%) and 41-B3 (12.73%). Types 41-B1 and 41-B2 each constituted 9.09%, while 41-C1 was the least common at 5.45%. The findings reflect a predominance of severe intra-articular fracture patterns in the study population.

Discussion

The present study evaluated 55 patients with proximal tibial fractures treated using locking compression plate through the MIPPO technique, focusing on functional outcomes and associated complications. The study population predominantly comprised middle-aged individuals, with the highest proportion in the 51–60 years age group (29.09%), and a marked male predominance (87.27%). Road traffic accidents were identified as the leading cause of injury (87.27%), indicating a predominance of high-energy trauma. Fracture pattern analysis revealed that Schatzker type II fractures were most common (30.91%), while AO classification showed a predominance of complex intra-articular fractures, particularly type 41-C2 (45.45%), reflecting the severity of injuries encountered. From a surgical perspective, all patients underwent MIPPO with proximal tibial locking compression plate fixation, ensuring uniformity in intervention. The mean operative time was 107.6 ± 18.43 minutes, and intraoperative blood loss was minimal (2.51 ± 0.50 units), supporting the minimally invasive nature of the technique. Early postoperative complications were low, with 87.27% of patients showing no complications, while superficial infection occurred in 9.09% and wound dehiscence in 3.64%. Late complications were similarly minimal, with 89.09% of patients having no complications; isolated cases of implant failure (3.64%), delayed union (1.82%), knee stiffness (1.82%), and angular deformities (varus and valgus, each 1.82%) were observed. Functional recovery showed a progressive and favorable trend. The mean Rasmussen functional score improved from 17 ± 3.42 at 1 month to 23.62 ± 3.35 at 6 months, indicating steady clinical improvement. At final follow-up, the majority of patients achieved good (67.27%) or excellent (21.82%) functional outcomes, with only 10.91% having fair results. Additionally, knee range of motion at 6 months averaged 115.07 ± 10.71 degrees, reflecting satisfactory restoration of joint mobility. These findings are consistent with

previous studies in the literature. Nikolaou et al. (n=60) reported successful fracture union in all but three cases with mean Knee Society scores of 91 and 89, demonstrating excellent functional recovery with locking plate systems [5]. Similarly, Liu et al. (n=56) observed union in 55 patients within 15–20 weeks with no major complications, supporting the biological advantage of MIPPO in preserving soft tissue and promoting healing [6]. Gupta et al. (n=30) also reported minimal complications and satisfactory outcomes, with mean union time of 17 weeks, emphasizing the role of biological fixation [7]. Wu et al. (n=20) demonstrated acceptable knee range of motion (≥120°) and low complication rates, further reinforcing the effectiveness of minimally invasive plating techniques [8]. More recent evidence from Venkatakrishnaiah et al. (n=35) showed excellent functional outcomes in 51.43% of patients, with mean union time of 14.38 weeks, aligning closely with the favorable outcomes observed in the present study [9]. The low complication rates and satisfactory functional outcomes observed in the present study can be explained by the biological principles underlying MIPPO. Preservation of periosteal blood supply, minimal soft tissue disruption, and maintenance of fracture hematoma contribute to improved healing and reduced infection rates. Additionally, the fixed-angle stability provided by locking compression plates ensures maintenance of alignment, even in complex intra-articular fractures, thereby facilitating early mobilization and better functional recovery. Overall, the present study demonstrates that MIPPO with locking compression plate is an effective and reliable technique for managing proximal tibial fractures, providing stable fixation, low complication rates, and favorable functional outcomes comparable to previously reported studies. In the present study, proximal tibial fractures were predominantly observed in middle-aged and older individuals, with the highest incidence in the 51–60 years age group (29.09%), followed by 41–50 years (23.64%) and 31–40 years (20%). Younger patients aged 18–30 years constituted 14.55%, while those above 60 years accounted for 12.73%. This distribution suggests that these fractures commonly affect the economically active population as well as individuals with age-related decline in bone quality. A marked male predominance was noted, with males comprising 87.27% of cases compared to only 12.73% females, indicating higher exposure of males to high-energy trauma such as road traffic accidents and occupational hazards. These findings are consistent with previously reported studies. Nikolaou et al. (n=60) reported a predominance of middle-aged individuals in their cohort, with a mean follow-up population largely consisting of active adults sustaining high-energy injuries [5]. Similarly, Liu et al. (n=56) observed a mean age of 41.3 years, reflecting a similar trend of fractures occurring in the productive age group [6]. Gupta et al. (n=30) also reported that the majority of patients belonged to the middle-aged population, emphasizing the role of trauma exposure and activity level in fracture occurrence [7]. Venkatakrishnaiah et al. (n=35) reported that most patients were middle-aged males, further supporting the demographic trend observed in the present study [9]. The male predominance observed in the present study (87.27%) is comparable to that reported in other studies, where males consistently formed the majority of cases. Liu et al. (n=56) reported a male predominance of 69.6% (39 males vs 17 females), while Gupta et al. (n=30) also noted a higher proportion of males in their cohort [7,9]. Similarly, Venkatakrishnaiah et al. (n=35) reported that most patients were male, which they attributed to increased exposure to outdoor activities and high-risk environments. This consistent male predominance across studies reinforces the role of behavioral and occupational factors in the epidemiology of proximal tibial fractures. From a pathophysiological perspective, the age distribution observed in the present study reflects a dual mechanism of injury. In younger and middle-aged individuals, fractures are typically the result of high-energy trauma such as road traffic accidents, leading to complex intra-articular fracture patterns. In contrast, older patients are more likely to sustain fractures due to low-energy mechanisms in the presence of osteoporotic bone, where reduced bone mineral density predisposes to metaphyseal collapse even with minor trauma. This explains the presence of a significant proportion of patients above 50 years in the present study. Overall, the demographic findings of the present study are in close agreement with existing literature, demonstrating that proximal tibial fractures are more common in middle-aged males exposed to high-energy trauma, with a smaller but significant contribution from elderly individuals with osteoporotic bone.

Conclusion

The present study concludes that minimally invasive percutaneous plate osteosynthesis using locking compression plate is a safe, effective, and reliable method for the management of proximal tibial fractures. The technique offers the dual advantage of biological preservation and mechanical stability, resulting in high rates of fracture union, low complication rates, and satisfactory functional outcomes. The majority of patients achieved good to excellent recovery, with progressive improvement in functional scores and adequate restoration of knee mobility.

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