

To Determine the Association Between Clinical Outcomes and Complications of Proximal Tibia Fracture Treated with Locking Compression Plate by Minimally Invasive Plateosteosynthesis Technique (Infection, Wound Healing, Intraoperative Blood Loss, Deformity)

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Received: 11-03-2026 / Revised: 14-04-2026 / Accepted: 10-05-2026

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Conflict of interest: Nil

Abstract:

Proximal tibial fractures are complex injuries that significantly affect knee function, stability, and overall mobility. With the advent of biological fixation techniques, the use of locking compression plates (LCP) combined with Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) has gained popularity due to its ability to preserve soft tissue integrity and vascularity. However, functional outcomes and their association with postoperative complications remain areas of clinical concern.

Objective: To evaluate the functional outcomes of proximal tibia fractures treated with locking compression plates using the MIPPO technique and to determine their association with postoperative complications.

Methods: This observational analytical cross-sectional study was conducted in the Department of Orthopaedics at Gadag Institute of Medical Sciences, Karnataka, over a period of two years (March 2024–February 2026). Patients with proximal tibial fractures treated with LCP using the MIPPO technique were included. Data were collected prospectively, including demographic details, fracture characteristics, intraoperative parameters, and postoperative outcomes. Functional outcomes were assessed using standard scoring systems, and complications such as infection, delayed union, non-union, malalignment, and wound healing issues were recorded. Statistical analysis was performed to determine the association between complications and functional outcomes.

Results: The study demonstrated that the majority of patients achieved satisfactory to good functional outcomes following LCP fixation using the MIPPO technique. Early mobilization and preservation of soft tissues contributed to improved recovery. The average time to fracture union was within acceptable limits. However, complications such as infection, delayed union, and malalignment were observed in a subset of patients and were significantly associated with poorer functional outcomes.

Conclusion: The MIPPO technique with locking compression plates is an effective and biologically favorable method for the management of proximal tibial fractures, providing good functional outcomes and satisfactory union rates. Nevertheless, the occurrence of complications adversely affects recovery, emphasizing the need for meticulous surgical technique, proper patient selection, and structured postoperative rehabilitation to optimize outcomes.

Keywords: Proximal tibia fracture, Locking compression plate, MIPPO technique, Functional outcome, Fracture union, Complications, Minimally invasive surgery, Orthopaedic trauma.

DOI: 10.25258/ijpqa.17.5.66

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Introduction

Functional outcome in proximal tibial fractures is influenced by multiple factors: the restoration of articular congruity, the alignment of the tibial axis, the stability of fixation, and the condition of the surrounding soft tissues. Although the locking compression plate with MIPPO technique addresses many of these aspects, the actual outcome varies

depending on injury severity, the precision of reduction, associated ligament injuries, timing of surgery, and the patient's compliance with rehabilitation. The concept of functional recovery in these fractures encompasses pain relief, range of motion, return of knee stability, muscle strength, ability to bear weight, and overall return to daily activities. Various

scoring systems such as the Lysholm knee score, Rasmussen functional score, or the Knee Society score are frequently used to evaluate these parameters, but beyond numerical assessments lies the patient's subjective sense of recovery, which is significantly influenced by postoperative complications. [1,2] Complications remain an inseparable part of proximal tibia fracture management, regardless of the technique used. Even with MIPPO, where the intention is to minimize soft-tissue insult, issues such as superficial and deep infection, delayed wound healing, irritation from hardware, malalignment, and delayed or non-union can still arise. The subcutaneous location of the anterior tibia makes it vulnerable to soft-tissue compromise, and swelling, blistering, or contusion at the time of injury can predispose to infection once implants are inserted. Although locking plates reduce dependence on bone-plate contact, they may create stress shielding, which, in some cases, contributes to delayed healing if fracture biology is already compromised. Malalignment—particularly varus collapse—is another significant concern, especially when indirect reduction techniques are used without precise fluoroscopic control. Residual articular depression can persist in complex plateau fractures, eventually affecting long-term functional outcome by contributing to pain and early degenerative changes. [2,3]

On the other hand, the very design of locking plates offers advantages in mitigating these complications. Their angular stability aids in maintaining reduction, especially in osteoporotic bone, thereby decreasing the rates of loss of alignment and implant failure. The MIPPO technique protects the periosteal blood supply and reduces infection rates compared to extensive open procedures. Yet, even these theoretical benefits need to be assessed critically against real-world data, since clinical outcomes often depend not

only on the principles of the technique but also on execution, postoperative care, and individual healing potential. Thus, understanding the relationship between functional outcomes and complications in patients treated with locking compression plates by the MIPPO technique becomes essential, as it sheds light on the true effectiveness of this approach in both biological and practical terms. [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

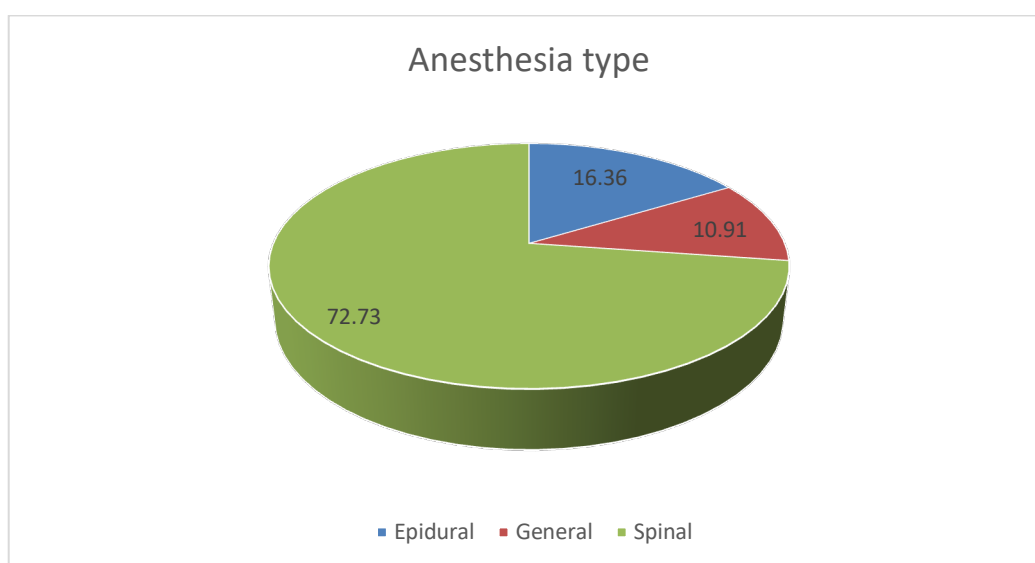
Inclusion Criteria:

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.

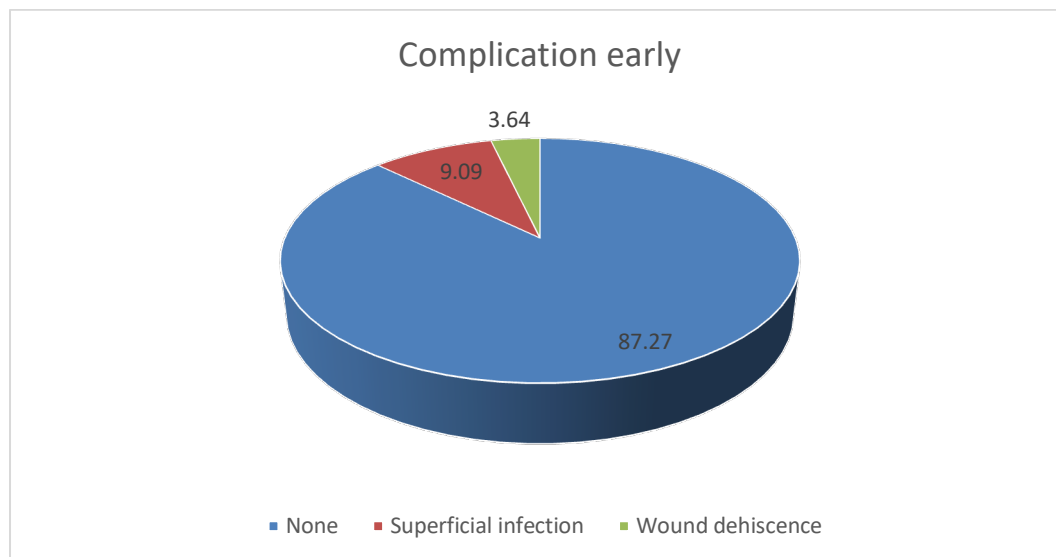
Results



Graph 1: Distribution of Anesthesia Type

Early Postoperative Complications: The majority of patients (87.27%) did not experience any early postoperative complications, indicating a favorable immediate postoperative course. Superficial infection was observed in 9.09% of cases, while wound

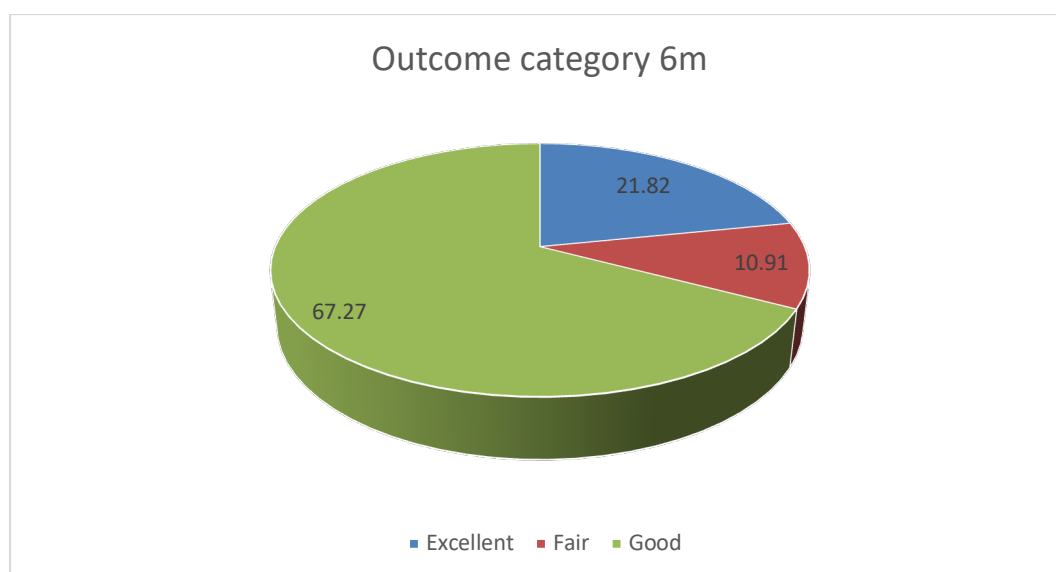
dehiscence occurred in 3.64%. These findings suggest that early complications were relatively minimal and manageable, reflecting the advantages of the MIPPO technique in preserving soft tissue integrity and reducing surgical trauma.



Graph 2: Early Postoperative Complications

Late Postoperative Complications: Late complications were observed in a small proportion of patients, with 89.09% showing no complications. Implant failure was noted in 3.64% of cases, while delayed union, knee stiffness, valgus deformity, and varus deformity each accounted for 1.82%. These findings indicate a low incidence of long-term complications, demonstrating the effectiveness and stability of the fixation method used.

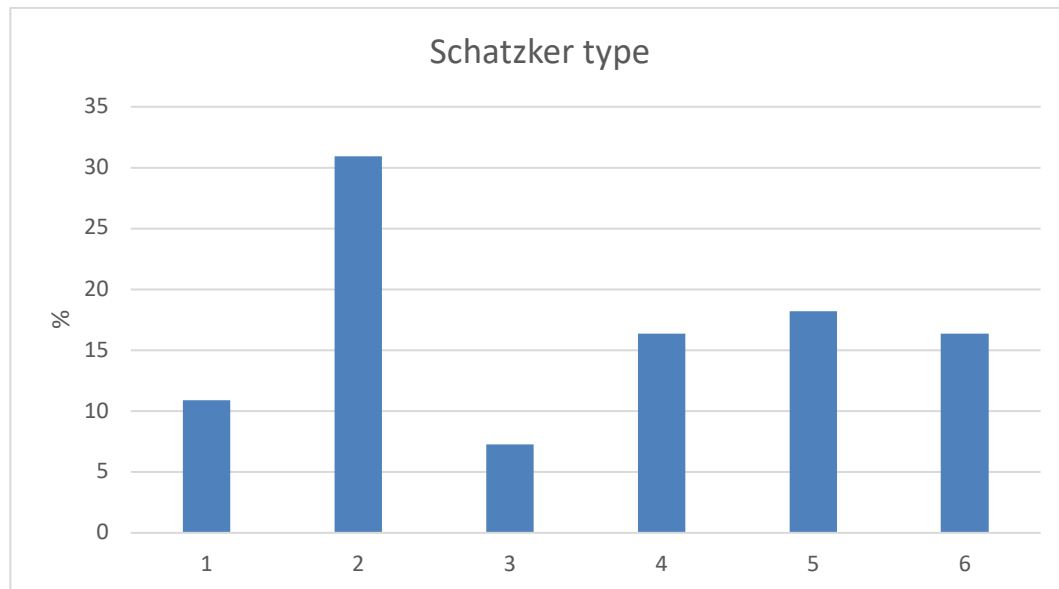
Functional Outcome at 6 Months: At 6 months follow-up, the majority of patients (67.27%) achieved a good functional outcome, while 21.82% had excellent outcomes and 10.91% had fair outcomes. This indicates that most patients experienced satisfactory functional recovery following treatment, highlighting the effectiveness of MIPPO with locking compression plate in achieving favorable clinical outcomes.



Graph 3: Functional Outcome at 6 Months

Follow-up Completion at 6 Months: All patients (100%) completed the 6-month follow-up, ensuring complete data availability for outcome assessment. This full follow-up rate strengthens the reliability and validity of the study findings, minimizing the risk of attrition bias and allowing accurate evaluation of functional outcomes and complications.

Schatzker Classification Distribution: The distribution of fractures according to Schatzker classification showed that type II fractures were the most common (30.91%), 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 (7.27%). This pattern reflects a predominance of split-depression and complex fracture types in the study population.



Graph 4: Schatzker Classification Distribution

Baseline Laboratory Parameters of Study Population: The baseline laboratory parameters showed that the mean hemoglobin level was 12.84 ± 1.52 g/dL, while the mean total leukocyte count was $9.1 \pm 2 \times 10^3/\mu\text{L}$. Platelet count averaged $303 \pm 70.98 \times 10^3/\mu\text{L}$. The mean random blood sugar was 132.51 ± 28.62 mg/dL. Renal parameters were within normal limits, with mean urea of 31.82 ± 8.72 mg/dL and creatinine of 0.88 ± 0.19 mg/dL. Overall, the findings indicate a relatively stable preoperative biochemical profile in the study population.

Discussion

In the present study, a clear relationship was observed between complications and functional outcomes. Patients without complications constituted the majority (approximately 87–89%) and demonstrated predominantly good to excellent functional outcomes. In contrast, patients who developed complications such as delayed union, implant failure, knee stiffness, or angular deformities tended to have relatively poorer functional outcomes. These findings are supported by previous studies. Phisitkul et al. highlighted that complications such as malalignment, infection, and delayed union significantly affect functional recovery and long-term outcomes. Venkatakrishnaiah et al. (n=35) also reported that

knee stiffness and infection were associated with poorer functional scores, particularly in high-energy fractures [5]. Wu et al. (n=20) noted that cases requiring additional interventions, such as bone grafting for nonunion, had relatively compromised outcomes compared to uncomplicated cases [6]. From a pathophysiological perspective, complications interfere with the normal healing process and rehabilitation. Infection can delay wound healing and necessitate additional interventions, while delayed union prolongs immobilization and delays weight bearing. Knee stiffness directly affects range of motion and functional scores, while malalignment alters joint biomechanics, leading to abnormal load distribution and reduced functional capacity. The low complication rate observed in the present study contributed significantly to the favorable functional outcomes. The MIPPO technique, by preserving soft tissue and vascularity, reduces the risk of complications, thereby indirectly improving functional recovery. Additionally, stable fixation with locking compression plates minimizes the risk of implant-related complications and maintains alignment. Clinically, early identification and management of complications are crucial to prevent deterioration of functional outcomes. Rehabilitation protocols should be tailored to address specific complications, such as

physiotherapy for stiffness or timely intervention for delayed union. Overall, the findings of the present study emphasize that minimizing complications is key to achieving optimal functional outcomes, and the use of biologically friendly techniques such as MIPPO plays a significant role in this regard. The present study demonstrates that MIPPO with locking compression plate is an effective modality for the management of proximal tibial fractures, particularly in complex intra-articular patterns. The technique combines the principles of biological fixation with mechanical stability, resulting in favorable functional outcomes and low complication rates. In the current study, satisfactory functional outcomes (good to excellent) were achieved in 89.09% of patients, with minimal early (12.73%) and late (10.91%) complication rates, supporting the reliability of this technique.

These findings are in agreement with previous studies. Nikolaou et al. (n=60) reported excellent functional outcomes with stable fixation and minimal mechanical failure using locking plate systems [55]. Liu et al. (n=56) demonstrated high union rates with minimal complications, emphasizing the biological advantages of minimally invasive techniques [7]. Gupta et al. (n=30) and Wu et al. (n=20) similarly highlighted the effectiveness of MIPPO in preserving soft tissue and promoting early mobilization, resulting in satisfactory functional recovery [6,8]. Venkatakrishnaiah et al. (n=35) also reported favorable functional and radiological outcomes with locking compression plates, particularly when combined with early rehabilitation [9]. The success of MIPPO can be attributed to its adherence to biological principles. Preservation of periosteal blood supply, minimal disruption of fracture hematoma, and reduced soft tissue trauma create an optimal environment for fracture healing. Additionally, the angular stability provided by locking compression plates ensures maintenance of alignment and prevents collapse, even in osteoporotic or comminuted bone. From a mechanical standpoint, locking plates function as internal fixators, distributing load across the construct and reducing stress at the bone-implant interface. This is particularly advantageous in proximal tibial fractures, where metaphyseal bone quality is often compromised. The ability to achieve stable fixation without extensive exposure allows early mobilization, which is critical for preventing joint stiffness and improving functional outcomes. However, the technique requires surgical expertise, accurate reduction under fluoroscopic guidance, and careful patient selection. Inadequate reduction or improper plate positioning can lead to complications such as malalignment or implant failure. Despite these challenges, the overall evidence, including the findings of the present study, supports the use of MIPPO with

locking compression plate as a preferred technique for proximal tibial fractures

Conclusion

The MIPPO technique with locking compression plates is an effective and biologically favorable method for the management of proximal tibial fractures, providing good functional outcomes and satisfactory union rates. Nevertheless, the occurrence of complications adversely affects recovery, emphasizing the need for meticulous surgical technique, proper patient selection, and structured postoperative rehabilitation to optimize outcomes.

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