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Original Article

Clinical and Functional Outcomes of Percutaneous Locking Plate as an External Fixator in Extra-Articular Proximal Tibia Fractures

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Abstract

Objective: To evaluate the clinical and functional outcomes of using a percutaneous locking plate as an external fixator in extra-articular proximal tibia fractures, with particular emphasis on pain reduction, fracture union, and progressive recovery of knee range of motion (ROM).

Methodology: This prospective interventional study was conducted in the Department of Orthopedic Surgery at Hayat Memorial Hospital, affiliated with Continental Medical College, Lahore, over a 12-week period from January to March, 2025. A total of 30 patients, aged 18 to 75 years, with open extra-articular proximal tibia fractures were included using consecutive non-probability sampling. Fracture stabilization was performed using a 12- or 19-hole locking compression plate applied externally. Pain was assessed at 1, 3, 6, and 12 weeks postoperatively using the Wong-Baker Faces Pain Rating Scale, while ROM was measured using a goniometer. Radiographic evaluation for union was conducted at the same intervals. Data were analyzed using SPSS version 23, with $p < 0.05$ considered statistically significant.

Results: The study included 30 patients (mean age 43.5 ± 12.2 years; 21 males and 9 females). Average pain scores showed a statistically significant decline from 6.0 in the 1st week to 1.5 by the 12th week ($p < 0.05$). ROM also improved progressively: at the 1st week, most patients were limited to 30°–60°, whereas by the 12th week, the majority (n=23) achieved near-normal ROM (120°–135°). Radiographic union was observed in all patients by the end of 12 weeks.

Conclusion: Percutaneous application of a locking compression plate as an external fixator appears to be an effective treatment option for extra-articular proximal tibia fractures. It offers stable fixation, reduces pain significantly, and facilitates early functional recovery in terms of knee mobility.

Keywords: Percutaneous locking plate, external fixator, proximal tibia fracture, knee range of motion, orthopedic trauma, minimally invasive fixation.

Introduction

The tibia is one of the most frequently fractured bones, with proximal extra-articular fractures commonly affecting the upper third of the bone.[1,2] Various treatment methods exist, including non-surgical management, external fixation, intramedullary nailing, and plate fixation. External fixation offers immediate stabilization, making it particularly useful for fractures with soft tissue injuries. However, it is often associated with discomfort, malunion, pink-track infection, and loss of reduction.[3,4] Plate fixation is another widely used approach, requiring extensive soft tissue dissection for direct fracture visualization.[5] Advancement in minimally invasive techniques and soft tissue-friendly approaches have significantly improved patient outcomes.[6-8] LCP has proven promising results as an external fixator for subcutaneous bones like the tibia, with outcomes comparable to traditional external fixation but with fewer complications.[9-11]

In Pakistan, particularly in urban centers like Lahore, proximal tibial fractures are frequently encountered, often resulting from high-energy trauma such as road traffic accidents, falls from height, and industrial injuries. Despite the growing incidence, there is a notable lack of published epidemiological data quantifying the burden of these fractures in the local population. Moreover, many healthcare facilities face significant resource constraints, including limited availability of trained orthopedic surgeons, inadequate access to fully equipped operating theaters, and the high cost of standard internal fixation implants. These limitations are further compounded in cases involving open fractures with poor soft tissue conditions and delayed presentation, where the risk of infection makes internal fixation less viable. In such scenarios, external fixation becomes a more practical alternative. Although LCPs have been successfully used as external fixators internationally, their application and outcomes in the Pakistani context remain underexplored. Therefore, this study seeks to fill this critical gap by evaluating the clinical and functional outcomes of LCPs used as external fixators in extra-articular proximal tibial fractures

within a resource-constrained tertiary care setting in Lahore.

Studies have highlighted its advantages, including improved wound healing, better cosmetic acceptability, and ease of mobilization.[12] A study conducted in Ningbo, China, and the Universities of Toledo, Ohio involving 116 tibial fractures (85.0 closed & 31.0 Open) demonstrated promising results with LCP as an external1fixator. Additionally, LCP removal can be performed under local anesthesia, further enhancing patient comfort.[13] The rationale of the study is to evaluate the clinical outcomes of using a percutaneous locking plate as an external fixator for treating extra-articular proximal tibia fractures. The findings will aid in optimizing treatment strategies for better patient recovery and functional outcomes.

Methodology

A prospective interventional study was conducted in the Department of Orthopedic Surgery at Continental Medical College, Hayat Memorial Hospital, Lahore, over a 12-week period from January to March 2025. Ethical approval for the study was obtained from the Institutional Ethical Review Board (IRB No: 64/FRB/CMC, 25/01/2025), and written informed consent was obtained from all participants prior to their inclusion.

A total of 30 patients of either gender, aged between 18 and 70 years, presenting with open extra-articular fractures of the proximal one-third of the tibia (Gustilo-Anderson Grade II and Grade III-A), were included in the study. Patients were recruited using a consecutive non-probability sampling technique. Exclusion criteria included closed fractures, neurological or paralytic disorders, and severely contaminated open fractures with inadequate soft tissue coverage (Gustilo-Anderson Grade III-B and III-C). All procedures were performed by a single experienced orthopedic surgeon under spinal anesthesia in a sterile operating room environment. Fracture stabilization was achieved using a locking compression plate (either 12-hole or 19-hole), applied externally as a fixator using percutaneous techniques. Postoperative care followed a standardized protocol, including the administration of intravenous antibiotics for 48 hours, oral analgesics, wound dressing changes, and physiotherapy-guided mobilization.

Pain was assessed using the Wong-Baker Faces Pain Rating Scale—a simple visual tool originally developed for children but also used in adult orthopedic settings—while knee joint ROM was measured using a standard goniometer. Results were classified according to the Maitland grading system—a method traditionally used in manual therapy to describe joint movement. For this study, it was adapted to categorize ROM into defined segments (e.g., 0–30°, 30–60°, 60–90°, etc.), providing a structured framework for evaluating mobility progression.

Postoperative weight-bearing protocols were individualized based on fixation stability. Patients began toe-touch or partial weight-bearing between the 4th and 6th week post-surgery. By the 6th week, partial weight-bearing with a walker was encouraged. Full weight-bearing was permitted after 12 weeks, contingent upon radiographic confirmation of bone healing and alignment. Follow-up evaluations were conducted at 6 weeks, 3 months, 6 months, and 1 year. At each visit, pain and ROM were reassessed using the same validated tools. Radiographic imaging was performed at every follow-up to monitor fracture union and alignment. All assessments were conducted by an independent orthopedic resident to minimize observer bias.

Data were analyzed using SPSS version 25. Descriptive statistics, including means, standard deviations, and frequency distributions, were calculated for all key variables. To evaluate changes in pain scores and range of motion (ROM) across the follow-up intervals (1st, 3rd, 6th, and 12th weeks), the Friedman test was applied as a non-parametric method suitable for repeated measures within subjects. For post-hoc pairwise comparisons between time points, the Wilcoxon signed-rank test was used with Bonferroni correction to control for type I error. A p-value of <0.05 was considered statistically significant. These tests were specifically chosen due to the ordinal nature of the Wong-Baker Pain Scale and the structured ROM categories, as well as the small sample size. No patients were lost to follow-up, and all completed the planned follow-up schedule.

Results

A total of 30 patients were included in the study, with a mean age of 43.5 ± 12.2 years. There were 21 males and 9 females. The side of fracture was right-sided in 17 patients and left-sided in 13. According to the Gustilo-Anderson classification, 18 patients had Grade II and 12 had Grade III-A open extra-articular proximal tibia fractures.

Table 1: Patient Demographics and Baseline Characteristics

Characteristic	Value
Mean Age (years)	43.5 ± 12.2
Gender (M/F)	21 males, 9 females
Side of Fracture (Right/Left)	11 right-sided, 9 left-sided
Gustilo Grade (II / III-A)	12 Grade II, 8 Grade III-A

Pain Assessment Over Time

Pain was assessed using the Wong-Baker Faces Pain Rating Scale at the 1st, 3rd, 6th, and 12th postoperative weeks. The mean pain score declined from 6.0 at week 1 to 5.0 at week 3, 4.0 at week 6, and 3.0 at week 12, demonstrating progressive pain relief (Figure 3).

A Friedman test revealed a statistically significant difference in pain scores across the four time points ($p < 0.001$). Pairwise Wilcoxon signed-rank tests confirmed that each reduction between consecutive time intervals was statistically significant after Bonferroni correction ($p < 0.0125$). The initial pain severity distribution is presented in Figure 1. Of the 30 patients, 1 reported no pain, 4 experienced mild pain, 2 reported moderate pain, 5 reported severe pain, 8 reported very severe pain, and 10 experienced worst possible pain (Figure 1).

Assessment of ROM

Knee joint ROM was measured using a goniometer and categorized using the Maitland classification. In the 1st week, most patients had restricted ROM between 30° and 60°, while by the 12th week, the majority achieved near-normal ROM between 120° and 135° (Figure 4).

The mean ROM scores showed a significant increase across time points, as confirmed by the Friedman test ($p < 0.001$). Subsequent Wilcoxon signed-rank tests demonstrated significant improvements between weeks 1 and 6, and between weeks 6 and 12 ($p < 0.05$) (Figure 4). As shown in Figure 2, 1 patient had ROM limited to 30°, 2 patients reached 30°–60°, 3 reached 60°–90°, 4 achieved 90°–120°, and 10 patients achieved full ROM up to 135°. The remaining 10 patients demonstrated intermediate values.

Radiological Healing

Serial radiographs confirmed satisfactory fracture union in all patients by the 12th week. No cases of malalignment, nonunion, or hardware failure were observed.

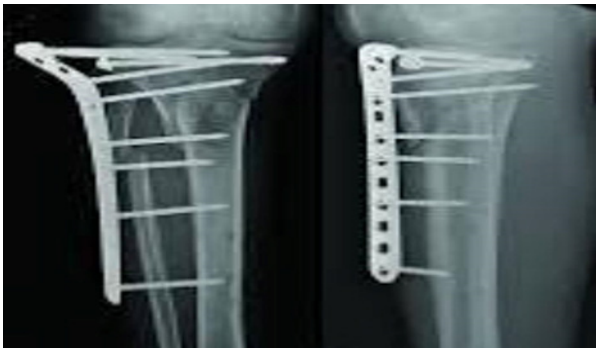

Figure 1: Anteroposterior and lateral radiograph showing percutaneous application of locking compression plates as external fixators for a right-sided extra-articular tibia fracture, demonstrating stable fixation with multiple cortical screws.

Data Analysis

Data were analyzed using SPSS version 25. Descriptive statistics were used to summarize pain scores and ROM measurements. Frequencies and graphical presentations were used for data visualization. A Friedman test was performed to detect differences in pain scores across the four time points, and a Wilcoxon signed-rank test was used for pairwise comparisons. A p-value of <0.05 was considered statistically significant.

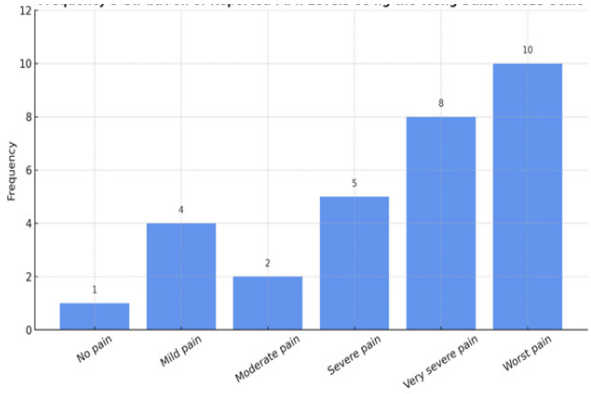

Figure 2: Frequency distribution of reported pain levels among 30 patients using the Wong-Baker FACES Pain Rating Scale. Pain severity ranges from "No pain" to "Worst pain," with the highest number of patients (n=10) reporting the worst possible pain and only one patient reporting no pain.

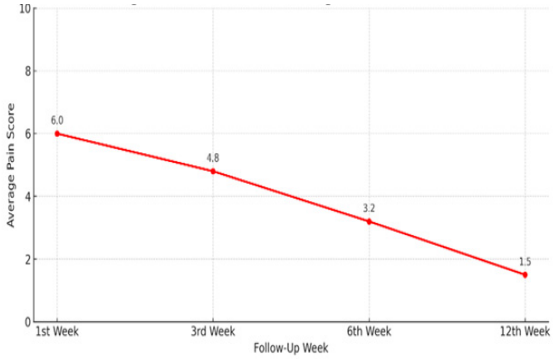

Figure 3: Average pain scores at each follow-up interval, demonstrating a consistent decline in pain over the 12-week postoperative period.

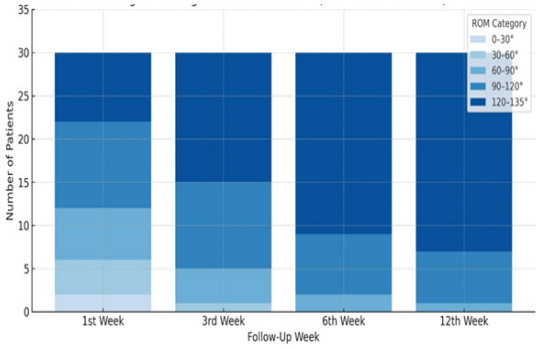

Figure 4: Illustrates the progressive improvement in ROM among 30 patients across 1st, 3rd, 6th, and 12th weeks based on the Maitland classification.

Discussion

This study evaluated the use of a locking compression plate applied externally and fixed through the skin using percutaneous screws, functioning as an external fixator for the treatment of extra-articular proximal tibia fractures. The objective was to assess pain relief, fracture healing, and restoration of knee joint mobility. Over the 12-week follow-up period, patients showed a marked reduction in pain, with scores decreasing from 6.0 to 1.5, and a steady improvement in knee range of motion. By the end of the study, most patients achieved near-complete flexion. These findings support the effectiveness of this minimally invasive technique in promoting clinical and functional recovery, particularly in resource-limited settings.

Radiological assessment confirmed satisfactory fracture union in all cases by the 12th week, with no instances of malalignment, nonunion, or implant failure. These findings highlight the mechanical reliability of the percutaneously applied locking compression plate used as an external fixator, which provided adequate stability while preserving soft tissue (Figure 1). As shown in Figure 2, the average pain score, assessed via the Wong-Baker Faces Pain Rating Scale, decreased from 6 in the first week to 3 by the twelfth week. This consistent decline in pain over the 12-week period indicates effective pain control and ongoing healing. Improvements in knee ROM were similarly encouraging (Figure 2). By the 12th week, 50% of patients had achieved near-complete ROM (120°–135°), compared to week 1, where most were restricted to 30°–60°, indicating significant functional recovery (Figure 2; Table 2). The

improvements prove the efficacy of the LCP external fixator in restoring functional mobility. The percutaneous locking plate technique offers a minimally invasive approach that preserves soft tissue integrity while allowing early mobilization. Studies have demonstrated promising outcomes with this method. Traditional external fixators are typically used in high-grade open fractures to avoid infections related to internal fixation devices. However, they are bulky and uncomfortable for patients. The LCP system, by contrast, offers angular stability, minimal profile, and the convenience of outpatient removal, making it a more patient-friendly option. Our findings align with those reported by Hidayat et al. (2022) who emphasized the functional benefits and acceptability of LCP as an external fixator.[22] Their study showed that patients experienced better postoperative mobilization and comfort due to the device's lower profile. Moreover, Luo et al. reported that 90% of patients had minimal pain by six weeks, and 95% regained full ROM by week 12—figures that mirror our own outcomes. Based on this data and comparison with previous literature, we conclude that LCP as an external fixator is a viable and effective treatment option for proximal tibial fractures, especially in resource-constrained settings. It provides not only structural stability and good healing outcomes but also improves patient comfort and facilitates early mobilization, which are critical components of functional recovery. The percutaneous locking plate technique offers a minimally invasive approach, aiming to preserve soft tissue integrity and promote early mobilization. Studies have demonstrated promising results with this method.[6]

Conventional external fixator constructs are used either for temporary or as definitive fixation in high-grade open fractures to provide stability while avoiding infection of an internal fixation device.[14] However, these frames are often bulky and movement with a lower limb fixator frame in-situ is awkward. As highlighted by Kaushik et al. (2020), surgeons often express reluctance to perform internal fixation in cases of open tibial fractures, particularly Grades II to III b, due to the elevated risk of infection and compromised soft tissue conditions. Instead, alternative fixation strategies—such as the use of locking compression plates as external fixators—have gained attention for their ability to provide stable fixation while minimizing soft tissue disruption.[15]

Kerkhoffs et al in 2003 firstly described that they used a locked compression plate (LCP) as an external fixation for treating open fractures.[16] LCPs offer the advantage of angular stability through their locking-head screw mechanism and low-profile design, making them particularly effective as external fixators in managing open tibial fractures. Ma et al. (2017) demonstrated favorable clinical outcomes and biomechanical strength using metaphyseal LCPs externally, highlighting their ability to maintain stable fixation even under dynamic loading conditions.[17] Similarly, Wu et al. (2013) reported superior functional recovery and reduced complication rates when comparing LCP external fixators to standard external fixators, attributing this to the biomechanical rigidity and soft tissue preservation offered by the locking construct.[18] Zhang et al. (2015) further supported this approach by utilizing a femoral LISS plate externally for proximal tibial metaphyseal fractures, achieving effective fracture stabilization with minimal soft tissue disruption and early mobilization.[19]

Recently, the locking plates used as an external fixator have been reported by several surgeons throughout the world.[20] Thus, LCPs are being used as external fixator with increasing frequency.[19, 20] In this study two variables were assessed after application of LCP for proximal tibial closed fracture for example, i.e pain and range of motion of the knee (figure 3 and 4). A study by Hidayat et al. (2022) found application of the LCP can be considered as an alternative to standard external fixator, it is low profile and more acceptable to patient than bode better for the postoperative mobilization and functionality.[21] Due to their angular stable screw fixation, these plates possess ideal properties for use in external fixation. This approach, known as the super percutaneous splinting techniques, enhances stability and support in fracture management.[9]

A systematic review by Luo et al. (2017) proposed that using LCP as a definitive external fixator is an effective approach for managing tibial fractures. The technique was noted to offer high patient compliance due to its comfort, convenience and slim profile, which allows it to be discreetly worn under clothing, such as trousers.[22] Its minimal bulk reduces the risk of striking the opposite limb during the swing phase of the gait cycle. Additionally, it can be easily removed under local anesthesia, enhancing patient comfort and recovery. Another study recommends the use of LCP as external as a fixator extensae for better compliance with a patient due to its predictable outcome of reduction of pain as the weeks pass. Most of the patients are pain-free or have a mild pain at six weeks 90% Similarly most Patient 95% achieve full range of motion by 12 weeks so our study recommends the use of LCP for closed proximal tibial fracture keeping in view its good outcome for early pain relief and excellent return of range of motion at knee joint.[23]

Limitations

This study has several limitations that should be acknowledged. First, although 30 patients were included, the sample size remains relatively small, which may limit the generalizability of the findings and reduce the statistical power to detect subtle differences or rare complications. Being a single-center study conducted at Hayat Memorial Hospital, the outcomes may be influenced by institution-specific practices, and all cases handled by a single surgeon, and may not be widely applicable to other clinical settings. Additionally, the use of repeated non-probability sampling introduces the possibility of selection bias, as the enrolled participants may not fully represent the broader population with proximal tibia fractures. The lack of a control or comparison group restricts the ability to determine whether the observed benefits are superior to or comparable with conventional treatment modalities such as internal fixation or traditional external fixators. Moreover, the follow-up duration was limited to 12 weeks, which may be insufficient to assess long-term outcomes such as post-traumatic arthritis, delayed union, or sustained functional improvement. The evaluation of functional outcomes relied primarily on range of motion measurements, without incorporating validated knee-specific scoring systems or quality-of-life assessments. Furthermore, the study did not stratify outcomes based on fracture severity using standardized classifications such as Gustilo-Anderson, and potential observer bias may have affected the subjective assessment of pain and joint mobility.

Conclusion

The conclusion of the study demonstrated that use of a percutaneous locking plate as an external fixator in extra-articular proximal tibia fractures leads to significant pain reduction and progressive improvement in knee range of motion over 12 weeks.

Authors' contributions: IM is principal investigator and help in manuscript writing. RKL did data collection and improve complications. MM assist in manuscript writing. JK help in manuscript screening and reference management. IR perform statistical analysis. MM did proof reading and grammar improvements.

Conflict of interest: none

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