

Outcomes of Tibial Plateau Fractures Managed by Ilizarov External Fixation

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ARTICLE INFO

Received: 12 May 2026
Accepted: 26 May 2026
Published Online: 8 June 2026

DOI: 10.5281/zenodo.20586225

Volume: 9, Number: 4, Page: 3-8

e-ISSN: 2789-5912
ISSN: 2617-0817

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ABSTRACT

Background: Complex tibial plateau fractures are severe intra-articular injuries characterized by articular comminution, metaphyseal instability and soft tissue compromise, making surgical management challenging. Ilizarov technique offers stable fixation while preserving fracture biology and minimizing soft tissue trauma. This study aimed to evaluate the radiological and functional outcomes of Schatzker type V and VI tibial plateau fractures managed with Ilizarov external fixation. **Methods & Materials:** This prospective observational study was conducted at the National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR) and in a private hospital in Dhaka, Bangladesh, from January 2018 to December 2024. Thirty adult patients with Schatzker type V or VI tibial plateau fractures treated with Ilizarov external fixation were enrolled. Data on demographics, operative parameters, time to union, radiological alignment, functional outcomes and complications were collected prospectively. Functional evaluation was performed using the knee range of motion and the Knee Society Score at 12 months postoperatively. **Results:** Thirty patients with complex tibial plateau fractures were included in this study. The majority of patients were aged 30–49 years (56.6%) and males predominated (73.3%). Motor bike accident was the most common mechanism of injury (83.3%). All patients underwent Ilizarov external fixation, with 33.3% requiring additional minimal internal fixation. The mean time to fracture union was 16.8 ± 3.5 weeks. Joint stiffness occurred in 10% of patients. Satisfactory radiological alignment was achieved in 90% of patients. The mean knee range of motion was $115.3 \pm 14.7^\circ$ and the mean Knee Society Score was 84.7 ± 10.2 . Superficial pin tract infection occurred in 20% of cases, deep infection in 3.3% and loss of reduction in 3.3%. **Conclusion:** Ilizarov external fixation is an effective and safe option for complex tibial plateau fractures, providing reliable union, good functional outcomes and minimal serious complications.

Keywords: Tibial plateau fracture, Ilizarov fixator, Schatzker V–VI, External fixation.

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INTRODUCTION

Tibial plateau fractures are complex intra-articular injuries that pose substantial challenges to knee stability, alignment and long-term functional outcomes, particularly when sustained through high-energy trauma. These fractures represent approximately 1% of all fractures and frequently result from motor bike accidents or falls from height, often accompanied by extensive metaphyseal comminution and soft-tissue compromise [1]. Among these injuries, Schatzker type V and VI fractures are especially demanding due to bicondylar involvement, axial instability and metaphyseal–diaphyseal dissociation, all of which complicate surgical reconstruction and postoperative rehabilitation [2]. The fundamental objectives in managing complex tibial plateau fractures include accurately restoring articular congruity,

preserving limb alignment, achieving stable fixation and facilitating early knee mobilization. Open reduction and internal fixation (ORIF) have traditionally been regarded as the standard method for achieving anatomical reduction. However, several studies have reported high rates of wound complications, deep infection and soft-tissue breakdown following ORIF, particularly in high-energy bicondylar fractures with compromised soft tissues [3,4]. In this study, both open and closed fractures were included, though open fractures were managed with initial debridement prior to Ilizarov application. Gaucher et al. highlighted that elderly and high-risk patient undergoing ORIF experienced a notable incidence of wound-related complications, adversely affecting functional recovery [5].

Given these concerns, alternative fixation strategies have been explored to reduce soft-tissue morbidity while maintaining fracture stability. Ilizarov circular external fixation has gained increasing attention as a biologically favorable option, particularly for complex proximal tibial fractures. The tensioned wire construct allows for stable fixation through ligamentotaxis, enabling indirect reduction of articular fragments while minimizing additional surgical trauma to already compromised soft tissues [6]. Moreover, the modular nature of the Ilizarov frame permits gradual postoperative adjustment and early controlled weight-bearing. Clinical evidence supporting the use of Ilizarov fixation in complex tibial plateau fractures has been encouraging. Hassan reported satisfactory functional outcomes and acceptable complication rates using the

Ilizarov technique in proximal tibial fractures, emphasizing the importance of early mobilization and joint preservation [7]. Similarly, Ghimire et al. demonstrated reliable fracture union and maintenance of alignment in patients treated with Ilizarov ring external fixation for complex tibial plateau fractures [1].

Comparative studies and systematic reviews further support the role of circular external fixation. Zhao et al., in a meta-analysis comparing external fixation with ORIF, reported lower deep infection rates and comparable functional outcomes in patients managed with external fixation for complex tibial plateau fractures [8]. Li et al. echoed these findings, noting that circular external fixation offered equivalent radiological outcomes with reduced soft-tissue complications when compared to internal fixation techniques [9]. Subramanyam et al. also highlighted that Ilizarov fixation, with or without minimal internal fixation, achieved satisfactory alignment and functional results in Schatzker type V and VI fractures [10].

Despite these favorable reports, variations remain in union times, rehabilitation protocols and complication profiles across different populations. Data from South Asian trauma centers remain relatively sparse, particularly from high-volume referral institutions where delayed presentation and severe injury patterns are common. Debnath et al. emphasized the need for regional outcome data after demonstrating reliable union and early weight-bearing in high-energy Schatzker type VI fractures treated with ring fixators [11]. Tahir et al. further underscored the importance of contextual evidence when comparing Ilizarov fixation with ORIF in similar fracture patterns [12].

Therefore, the present study aimed to evaluate the radiological and functional outcomes of Schatzker type V and VI tibial plateau fractures managed with Ilizarov external fixation at a tertiary referral center

in Bangladesh, thereby contributing region-specific evidence to guide clinical decision-making in complex proximal tibial injuries.

METHODS & MATERIALS

This prospective observational study was conducted at the Department of Reconstructive & Deformity Correction Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh and a private hospital in Dhaka, Bangladesh. The study was conducted over a period of seven years from January 2018 to December 2024. The study population included consecutive adult patients presenting with complex tibial plateau fractures who were managed using Ilizarov external fixation and who met the predefined eligibility criteria. A total of 30 patients were enrolled and followed up prospectively.

Selection Criteria

Inclusion Criteria:

- Age ≥18 years
- Closed or open tibial plateau fractures classified as Schatzker type V or VI
- Planned management with Ilizarov circular external fixation.
- Willingness to participate and availability for regular follow-up for a minimum of 12 months

Exclusion Criteria:

- Presentation for surgery more than two weeks after trauma were excluded from the study.
- Pathological fractures
- Polytrauma patients requiring alternative fixation strategies

Data Collection Procedure

Data were prospectively collected using a structured case report form. Upon admission, baseline demographic and

injury-related information including age, sex, mechanism of injury, fracture classification (Schatzker type) and time from injury to surgery were recorded. Operative details such as surgery duration, use of adjunct internal fixation and hospital stay were documented perioperatively. Postoperative follow-up assessments were conducted at scheduled intervals (6 weeks, 12 weeks, 6 months and 12 months) to record frame duration, radiological union, alignment, knee range of motion measured with a goniometer, functional outcomes using the Knee Society Score (KSS) and complications including pin tract infection, joint stiffness, deep infection and loss of reduction. Radiological union was defined as bridging callus across at least three cortices on anteroposterior and lateral views.

Statistical Analysis

Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Descriptive statistical methods were applied to summarize demographic, operative, radiological and functional outcome data. Inter-observer agreement for radiographic assessment was evaluated using Cohen’s kappa coefficient.

RESULTS

Table I presents the baseline characteristics of the study population. Patients were predominantly middle-aged, with the largest proportion aged 40–49 years (33.3%), followed by those aged ≥50 years (30.0%). Male patients constituted 73.3% of the cohort. Motor bike accidents were the most common mechanism of injury (83.3%), while Schatzker type VI fractures accounted for 60.0% of cases. The mean interval from injury to surgery was 5.6 ± 2.3 days.

Table I
Baseline Characteristics of Patients (n=30).

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	20–29	4	13.3
	30–39	7	23.3
	40–49	10	33.3
	≥50	9	30.0
Gender	Male	22	73.3
	Female	8	26.7
Mode of Injury	Motor Bike Accident	25	83.3
	Fall from Height	3	10.0
	Sports/Work-related	2	6.7
Fracture Type (Schatzker)	Type V	12	40.0
	Type VI	18	60.0
Mean Time to Surgery (days)		5.6 ± 2.3	

Table II describes operative and postoperative parameters. The mean duration of surgery was 105 ± 25 minutes

and the average hospital stay was 8.2 ± 3.1 days. The Ilizarov frame was retained for a mean duration of 18.5 ± 4.2 weeks.

Additional minimal internal fixation was required in 33.3% of patients.

Table II
Operative and Postoperative Parameters.

Parameter	Values, Mean ± SD or n (%)
Duration of Surgery (min)	105 ± 25
Hospital Stay (days)	8.2 ± 3.1
Mean External Fixator Duration (weeks)	18.5 ± 4.2
Additional Minimal Internal Fixation	10 (33.3%)

Table III summarizes radiological and functional outcomes at 12 months. The mean time to fracture union was 16.8 ± 3.5 weeks. Radiological alignment was satisfactory in 90.0% of patients, with only mild malalignment (<5°). The mean knee range of motion was 115.3 ± 14.7 degrees and the average Knee Society Score was 84.7 ± 10.2.

Table III
Radiological and Functional Outcomes at 12 Months.

Outcome Measure	Values, Mean ± SD or n (%)
Union Time (weeks), Mean ± SD	16.8 ± 3.5
Radiological Alignment (mild malalignment <5°)	27 (90.0%)
Knee Range of Motion (°), Mean ± SD	115.3 ± 14.7
Knee Society Score (KSS), Mean ± SD	84.7 ± 10.2

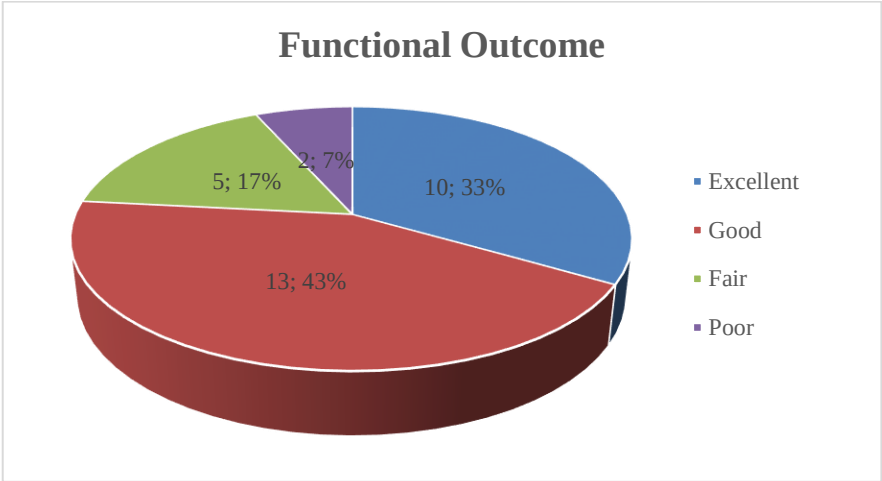


Figure 1: Functional Outcomes at 12 Months.

Figure 1 demonstrates the distribution of functional outcomes at final follow-up, based on Knee Society Scores and knee range of motion. Most patients achieved satisfactory functional recovery at 12 months after surgery. *Table IV* presents complications observed during follow-up. Superficial pin tract infection was the most frequent complication (20.0%). Joint stiffness occurred in 10.0% of patients, while deep infection and loss of reduction were each observed in 3.3% of cases.

Table IV
Complications Observed During Follow-up.

Complication Type	Frequency (n)	Percentage (%)
Pin Tract Infection (superficial)	6	20.0
Joint Stiffness	3	10.0
Deep Infection	1	3.3
Loss of Reduction	1	3.3



Figure 1 Pre-operative radiograph.



Figure 2 Postoperative radiograph following Ilizarov external fixation with adjunct minimal internal fixation.

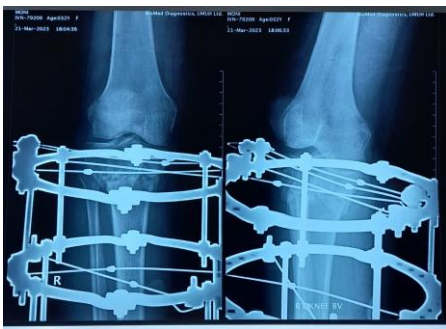


Figure 3 Follow-up radiograph at four month demonstrating solid fracture union.



Figure 4 Final clinical photograph.

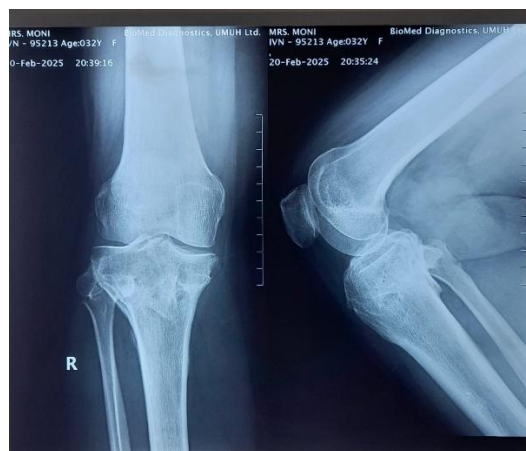


Figure 5 Final radiographs (anteroposterior and lateral views) of a complex Schatzker type VI tibial plateau fracture.

Figure 2 shows a representative pre-operative radiograph of a complex tibial plateau fracture, while Figure 3 demonstrates the postoperative radiograph following Ilizarov external fixation with adjunct minimal internal fixation. Figure 4 illustrates solid fracture union at four month follow-up. The final clinical photograph (Figure 5) and final radiographs (Figure 6) of a complex Schatzker type VI tibial plateau fracture further confirm satisfactory radiological and functional outcomes.

DISCUSSION

The present study demonstrates that Ilizarov external fixation is an effective method for managing complex Schatzker type V and VI tibial plateau fractures, yielding 100% fracture union, maintenance of alignment and acceptable functional outcomes with a low incidence of major complications. These findings align with growing evidence that circular external fixation offers biological and mechanical advantages in high-energy proximal tibial injuries.

High-energy bicondylar tibial plateau fractures are frequently associated with severe metaphyseal comminution and compromised soft-tissue envelopes, factors that significantly increase the risk of complications following internal fixation. Raza et al. reported that primary fixation using the Ilizarov external fixator provided stable fracture control while minimizing additional soft-tissue damage in complex tibial plateau fractures [13]. This biological advantage is particularly relevant in environments where delayed presentation and extensive swelling are common.

Fracture union in the current study occurred within a timeframe comparable to previously published series. Debnath et al. documented consistent union and early mobilization in Schatzker type VI fractures treated with ring fixators, emphasizing the role of controlled micromotion in promoting osteogenesis ^[11]. Similarly, Kumar et al. reported reliable union in high-energy intra-articular tibial fractures managed with Ilizarov fixation, even in the presence of severe comminution ^[14]. These findings support the notion that circular fixation preserves the fracture biology while ensuring mechanical stability. Maintenance of radiological alignment is a critical determinant of long-term knee function. Thiagarajah et al. demonstrated that malreduction of articular width in bicondylar tibial plateau fractures treated with circular external fixation was associated with the development of post-traumatic osteoarthritis ^[15]. In the present study, satisfactory alignment was achieved in the majority of patients, which may explain the favorable functional outcomes observed at one-year follow-up. Functional recovery following tibial plateau fractures is multifactorial, influenced by alignment, joint congruity and rehabilitation protocols. Larsen et al. reported that patients treated with a combination of internal fixation and Ilizarov frames achieved acceptable patient-reported and functional outcomes at long-term follow-up ^[16]. Elsoe et al. further demonstrated that although gait asymmetry may persist after bicondylar tibial plateau fractures, functional improvement continues during the first postoperative year following ring fixation ^[17]. The knee range of motion and Knee Society Scores observed in the present study are consistent with these findings. Complication profiles in the current series were dominated by superficial pin tract infections, a well-recognized and generally manageable issue associated with circular external fixation. Subramanyam et al. reported similar rates of pin tract infection, noting that most cases resolved with local care and oral antibiotics without compromising outcomes ^[10]. Importantly, the low incidence of deep infection observed in this study is consistent with comparative literature suggesting reduced deep infection rates with external fixation compared to ORIF in complex tibial plateau fractures ^[8]. Comparative and meta-analytic evidence further supports the role of circular fixation in such injuries. Naja et al. demonstrated in a meta-analysis that external fixation was associated with fewer soft-tissue complications while providing comparable functional outcomes relative to ORIF ^[18]. Bertrand et al. similarly reported that hybrid and circular external fixation

offered a safer alternative in severe Schatzker V–VI fractures, particularly in the setting of compromised soft tissues ^[3]. Socioeconomic and functional implications of complex tibial fractures must also be considered. Elsoe et al. highlighted that patients with complex tibial fractures treated with ring fixators often experience prolonged rehabilitation and social impact, underscoring the importance of achieving early stability and functional recovery ^[19]. Long-term studies by Karasev et al. further confirmed that Ilizarov fixation provides durable outcomes with acceptable joint function over extended follow-up periods ^[20].

Pain-free movement is more important than a congruent joint with a stiff, painful joint. So, confirmation of the joint is more acceptable than congruence. Overall, the findings of this study reinforce existing evidence that Ilizarov external fixation is a reliable and biologically sound treatment modality for complex tibial plateau fractures, particularly in high-velocity injuries where preservation of soft tissue integrity is paramount, as well as pain-free joint movement.

LIMITATIONS

The single center study with limited sample size restricts the generalizability of the findings. Future multicenter studies with longer follow-up are recommended to further validate functional outcomes and long-term joint preservation following Ilizarov fixation.

CONCLUSION

Ilizarov external fixation provides stable and biologically favorable management of complex Schatzker types V and VI tibial plateau fractures. This technique achieved satisfactory fracture union, maintained alignment and yielded acceptable functional outcomes with a low incidence of major complications. These results support the continued use of circular external fixation as a reliable alternative to internal fixation, particularly for high-energy injuries with compromised soft tissues.

ACKNOWLEDGMENT

I would like to express my sincere gratitude for the invaluable support and cooperation provided by the staff, participants and my co-authors/colleagues who contributed to this study.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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