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Comparative effectiveness of the Ilizarov method versus internal fixation for complex tibial fractures

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ABSTRACT

Background: Complex tibial fractures often occur with high-energy trauma and significant soft tissue injury. Optimal management remains controversial due to infection risks, nonunion and functional impairment. Both internal fixation and the Ilizarov method are widely used, yet comparative data in resource-limited settings remain limited. This study compared clinical, radiological and functional outcomes of the Ilizarov method versus internal fixation in complex tibial fractures.

Methods: This comparative observational study was conducted in the Department of Orthopedics at 250 Bed General Hospital, Pabna and City Health Aid Hospital, Pabna, Bangladesh, from January 2024 to January 2025. A total of 30 patients with complex tibial fractures were enrolled and allocated into two groups based on the surgical intervention received. Fifteen patients underwent Ilizarov external fixation and fifteen received internal fixation. Operative parameters, union time, complications and 12-month functional outcomes were assessed. Statistical analysis was performed using statistical package for the social sciences (SPSS) version 25.0.

Results: Operative time was longer in the Ilizarov group (p=0.004). Time to full weight bearing (p=0.006) and radiological union (p=0.049) were significantly shorter with Ilizarov fixation. Knee society scores (p=0.016) and Oxford knee scores (p=0.009) were significantly higher in the Ilizarov group at 12 months. Pin tract infection occurred in 26.7% of Ilizarov cases, while deep infection and nonunion were more frequent in the internal fixation group. Overall complication rates did not differ significantly.

Conclusions: The Ilizarov method provided earlier rehabilitation and superior functional outcomes compared to internal fixation in complex tibial fractures.

Keywords: Ilizarov method, Internal fixation, Tibial fracture, Functional outcome, Radiological union

INTRODUCTION

Complex tibial fractures, particularly high-energy tibial plateau and shaft injuries, represent a significant challenge in orthopedic trauma practice. These fractures are frequently associated with substantial soft tissue damage, comminution and articular involvement, which complicate management and may adversely affect long-term functional outcomes.[1,2] Epidemiological data indicate that tibial plateau fractures account for a considerable proportion of periarticular knee injuries, with increasing incidence due to road traffic accidents and high-velocity trauma.[3] Achieving stable fixation while preserving soft tissue integrity remains a critical therapeutic objective.

Open reduction and internal fixation (ORIF) have traditionally been considered the standard approach for managing complex tibial fractures. Internal fixation allows direct visualization of the fracture site, anatomical reduction and rigid fixation.[4] However, several studies

have reported notable complications associated with ORIF in high-energy fractures, including wound dehisence, deep infection, implant failure and compromised soft tissue healing.[5,6] The risk of infection is particularly concerning in open fractures and cases with severe soft tissue injury.[7]

The Ilizarov method, based on principles of tension-stress and circular external fixation, offers an alternative strategy that emphasizes biological fixation and minimal disruption of soft tissues.[8] By providing stable fixation with multiplanar wire constructs, the Ilizarov technique facilitates early weight bearing and promotes osteogenesis through controlled micromotion.[9] Several clinical investigations have demonstrated satisfactory functional and radiological outcomes with circular external fixation in complex tibial fractures.[1,10]

Comparative studies have attempted to evaluate the relative effectiveness of Ilizarov external fixation and internal fixation techniques. Some authors have reported lower deep infection rates and earlier weight bearing with external fixation, while others have found comparable union rates and functional scores between methods.[11-13] A meta-analysis comparing external fixation and internal fixation for tibial plateau fractures suggested that circular fixators may reduce soft tissue complications but may be associated with pin tract infections.[14] These findings highlight the trade-offs between stability, soft tissue preservation and complication profiles.

Despite growing evidence, there remains variability in reported outcomes across different populations and healthcare settings. Factors such as surgical expertise, patient selection and postoperative rehabilitation protocols may influence results.[2,15] Moreover, data from resource-constrained environments remain limited, particularly in South Asian contexts where high-energy trauma is prevalent and access to advanced implants may be restricted.

In Bangladesh, the burden of road traffic injuries continues to rise, contributing substantially to complex tibial fractures requiring operative management. However, direct comparative data evaluating the Ilizarov method versus internal fixation within this context are scarce. Understanding the relative effectiveness of these techniques in local clinical practice is essential for optimizing treatment strategies and resource allocation.

Therefore, this study aimed to compare the clinical, radiological and functional outcomes of the Ilizarov method and internal fixation in patients with complex tibial fractures treated at two tertiary-level hospitals in Pabna, Bangladesh.

By systematically evaluating operative parameters, union time, functional scores and complication rates, this research seeks to contribute context-specific evidence to guide clinical decision-making.

METHODS

This comparative observational study was conducted in the Department of Orthopedics at 250 Bed General Hospital, Pabna and City Health Aid Hospital, Pabna, Bangladesh, from January 2024 to January 2025. A total of 30 patients with complex tibial fractures were enrolled and allocated into two groups based on the surgical intervention received. Fifteen patients underwent treatment using the Ilizarov external fixation method, while fifteen patients were managed with internal fixation techniques.

Inclusion criteria

Patients aged 18–60 years, radiologically confirmed complex tibial fractures including high-energy and Gustilo type IIIA/IIIB open fractures, fractures requiring operative management, and patients with willingness to provide informed consent and comply with follow-up for 12 months were included.

Exclusion criteria

Patients with pathological fractures, associated neurovascular injury requiring repair, polytrauma requiring prolonged intensive care, previous surgery on the affected tibia, and with severe systemic illness contraindicates surgery were excluded.

Data collection procedure

Data were collected prospectively using a structured case record form. Baseline demographic data, mechanism of injury, fracture type and side involved were documented at admission. Preoperative radiographs were obtained in anteroposterior and lateral views for fracture classification and surgical planning. Operative details including duration of surgery and intraoperative findings were recorded. Postoperative protocols were standardized for both groups, including antibiotic prophylaxis, wound care and physiotherapy. Clinical assessment was performed at regular intervals to evaluate pain, wound status, time to partial and full weight bearing and evidence of complications. Radiological union was assessed using serial X-rays at 6-week intervals until bridging callus formation was observed in at least three cortices. Functional outcomes were evaluated at 12 months using the knee society score and Oxford knee score. Range of motion was measured using a goniometer by the same orthopedic team to maintain consistency. Informed consent was obtained from all participants before inclusion. Confidentiality of patient information was maintained through anonymized data coding and secure record storage.

Statistical analysis

Data were analyzed using statistical package for the social sciences (SPSS) version 25.0. Continuous variables were

expressed as mean±standard deviation and compared using independent sample t-tests. Categorical variables were presented as frequencies and percentages and analyzed using the Chi-square test or Fisher's exact test where appropriate. A p value <0.05 was considered statistically significant.

Figure 1 (A and B): Pre-operative X-ray of the complex tibial fracture (case 1).

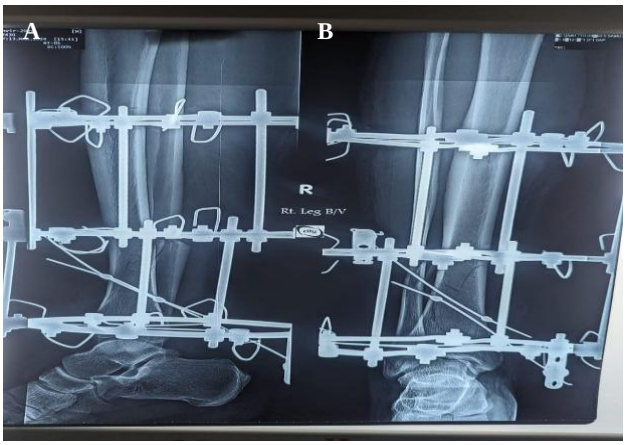

Figure 2 (A and B): Post-operative X-ray showing the application of the Ilizarov circular fixator.

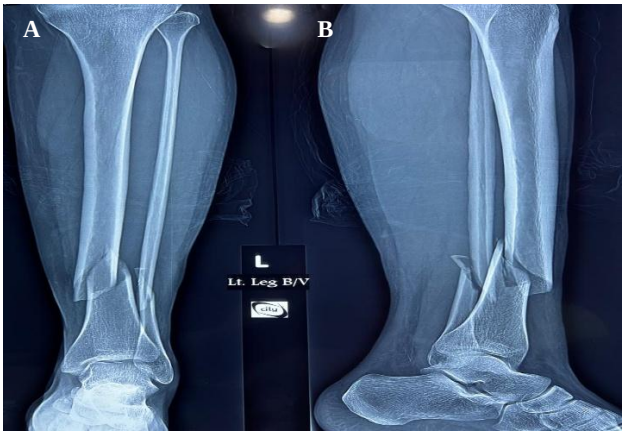

Figure 3 (A and B): Pre-operative X-ray of the complex tibial fracture (case 2).

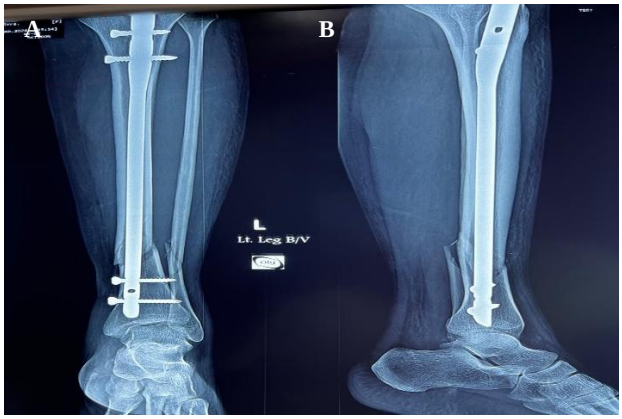

Figure 4 (A and B): Post-operative X-ray showing internal fixation.

RESULTS

Table 1 presents the demographic and injury characteristics of the study population. The mean age was 39.4±8.6 years in the Ilizarov group and 37.8±9.1 years in the internal fixation group (p=0.621). Male patients predominated in both groups. The distribution of fracture type, mechanism of injury and side involved showed no statistically significant differences between groups (all p>0.05).

Table 1: Baseline demographic and injury characteristics.

Variable	Ilizarov (n=15)	Internal fixation (n=15)	P value
Age (years), mean±SD	39.4±8.6	37.8±9.1	0.621
Gender, N (%)			
Male	11 (73.3)	10 (66.7)	0.705
Female	4 (26.7)	5 (33.3)	
Fracture type, N (%)			
Open (Gustilo IIIA/B)	9 (60.0)	8 (53.3)	0.712
Closed	6 (40.0)	7 (46.7)	
Mechanism of injury, N (%)			
Road traffic accident	10 (66.7)	9 (60.0)	0.884
Fall from height	3 (20.0)	4 (26.7)	
Others	2 (13.3)	2 (13.3)	
Side involved, N (%)			
Right	8 (53.3)	9 (60.0)	0.739
Left	7 (46.7)	6 (40.0)	

Table 2 shows the operative and radiological parameters. Operative time was significantly longer in the Ilizarov group (121.6±16.4 minutes) compared to internal fixation (103.9±14.7 minutes; p=0.004). Time to full weight bearing and radiological union were significantly shorter in the Ilizarov group (p=0.006 and p=0.049, respectively).

Differences in duration to clinical union and hospital stay were not statistically significant.

Table 3 presents functional outcomes at 12 months. The Ilizarov group demonstrated significantly higher knee society scores (86.8±7.2 versus 79.4±8.6; p=0.016) and Oxford knee scores (39.6±4.1 versus 34.8±5.3; p=0.009). Range of motion was greater in the Ilizarov group, though the difference did not reach statistical significance (p=0.054).

Table 4 describes postoperative complications. Pin tract infection occurred only in the Ilizarov group (26.7%; p=0.034). Deep infection, malunion, nonunion and knee stiffness were more frequent in the internal fixation group, although differences were not statistically significant.

The overall complication rate was 40.0% in the Ilizarov group and 53.3% in the internal fixation group (p=0.471).

Table 2: Comparison of operative and radiological parameters.

Variable	Ilizarov (n=15)	Internal fixation (n=15)	P value
Operative time (minutes), mean±SD	121.6±16.4	103.9±14.7	0.004
Mean duration to union (weeks), mean±SD	22.4±3.8	25.3±4.6	0.07
Hospital stay (days), mean±SD	7.8±2.1	9.6±2.8	0.056
Time to full weight bearing (weeks), mean±SD	15.2±2.9	18.7±3.6	0.006
Radiological union time (weeks), mean±SD	21.9±3.5	24.8±4.2	0.049

Table 3: Comparison of functional outcomes at 12-month follow-up.

Variable	Ilizarov (n=15)	Internal fixation (n=15)	P value
Knee society score (KSS), mean±SD	86.8±7.2	79.4±8.6	0.016
Oxford knee score (OKS), mean±SD	39.6±4.1	34.8±5.3	0.009
Range of motion (degrees), mean±SD	124.3±9.5	116.7±11.2	0.054

Table 4: Comparison of postoperative complications.

Complication	Ilizarov (n=15)	Internal fixation (n=15)	P value
Pin tract infection	4 (26.7)	0 (0)	0.034
Superficial infection	1 (6.7)	2 (13.3)	0.553
Deep infection	1 (6.7)	3 (20.0)	0.292
Malunion	1 (6.7)	2 (13.3)	0.553
Nonunion	1 (6.7)	3 (20.0)	0.292
Knee stiffness (ROM <90°)	1 (6.7)	3 (20.0)	0.292
Total patients with any complication	6 (40.0)	8 (53.3)	0.471

DISCUSSION

The present comparative observational study evaluated clinical, radiological and functional outcomes of the Ilizarov method versus internal fixation in complex tibial fractures. Baseline demographic and injury characteristics were comparable between groups, minimizing selection bias and enabling meaningful outcome comparison. Significant differences were observed in operative time, time to full weight bearing, radiological union and functional scores at 12 months.

Operative time was significantly longer in the Ilizarov group. Similar findings have been reported by Korkmaz et al who noted increased surgical duration with circular external fixation due to frame assembly and wire placement complexity.[1] However, longer operative time did not translate into prolonged hospital stay in our cohort. This observation aligns with findings from Subramanyam et al who demonstrated comparable or shorter hospitalization in patients managed with Ilizarov fixation despite technically demanding procedures.[10]

Time to full weight bearing was significantly earlier in the Ilizarov group. The biological fixation principle and axial micromotion permitted by circular frames may enhance early functional rehabilitation, as described by Ilizarov.[8] Metcalfe et al in their systematic review, reported that external fixation often facilitates earlier mobilization compared to internal fixation in high-energy tibial plateau fractures.[11] Early weight bearing is clinically relevant as it may reduce joint stiffness and promote cartilage nutrition.

Radiological union occurred significantly earlier in the Ilizarov group. Catagni et al demonstrated favourable union rates with circular external fixation, attributing results to preservation of periosteal blood supply and minimal soft tissue disruption.[9] Similarly, Baloch et al reported satisfactory union times with Ilizarov fixation in complex plateau fractures.[16] Although our difference in

clinical union time did not reach statistical significance, the trend favoured the Ilizarov method.

Functional outcomes at 12 months, assessed using the knee society score and Oxford knee score, were significantly higher in the Ilizarov group. Hassan et al observed comparable improvements in American knee society scores among patients treated with Ilizarov fixation for complex plateau fractures.[17] Ferreira and Senoge also reported good functional recovery with circular external fixation, emphasizing stable fixation and early motion as contributing factors.[18] The improved scores in our study may reflect earlier weight bearing and potentially fewer deep infections.

Complication profiles differed between groups. Pin tract infection was observed exclusively in the Ilizarov group, consistent with known external fixation–related complications.[3,11] However, these infections were superficial and manageable. In contrast, deep infection, nonunion and knee stiffness were more frequent in the internal fixation group, although not statistically significant. Henkelmann et al highlighted the substantial burden of infection following proximal tibial fractures treated with internal fixation, particularly in high-energy trauma.[6] Similarly, Papagelopoulos et al documented wound complications and hardware-related issues after ORIF.[7]

Meta-analyses have provided mixed conclusions regarding the superiority of one technique over the other. Li et al reported reduced soft tissue complications with circular external fixation compared to ORIF.[12] Naja et al also suggested that external fixation may be advantageous in managing complex fractures with compromised soft tissues.[14] Our findings support these observations, particularly in terms of earlier union and improved functional scores.

Overall complication rates were lower in the Ilizarov group, though not statistically significant. This trend is consistent with the findings of Szelerski et al, who demonstrated favourable outcomes with Ilizarov fixation in complex post traumatic tibial conditions.[19]

The balance between manageable pin tract infections and potentially more serious deep infections associated with internal fixation remains a critical consideration in surgical planning.

Taken together, the present study suggests that while the Ilizarov method requires longer operative time, it may offer advantages in earlier weight bearing, radiological union and functional recovery.

These findings contribute to the growing body of literature advocating biologically friendly fixation strategies for complex tibial fractures, particularly in settings where soft tissue preservation is paramount.

CONCLUSION

The Ilizarov method demonstrated earlier weight bearing, shorter radiological union time and superior functional scores compared to internal fixation in complex tibial fractures. Although operative time was longer and pin tract infections occurred, overall outcomes favoured circular external fixation as an effective and biologically sound treatment option.

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