

COMPARATIVE OUTCOMES OF ILIZAROV EXTERNAL FIXATION VERSUS DUAL PLATING IN COMPLEX TIBIAL PLATEAU FRACTURES

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ABSTRACT

OBJECTIVES

This study aimed to compare radiological union, functional outcomes, and complication rates between Ilizarov external fixation and dual plating in patients with complex tibial plateau fractures.

METHODOLOGY

This prospective quasi-experimental study was conducted at the Department of Orthopedic Surgery at Nishtar Hospital, Multan. Sixty patients aged 20-70 years with isolated closed Schatzker type V or VI tibial plateau fractures were enrolled using non-probability purposive sampling and allocated into two groups: Ilizarov fixation (n=30) and dual plating (n=30). Functional outcomes were assessed using the Lysholm Knee Scoring Scale, and radiological union was evaluated on biplanar radiographs and classified according to the Hammer criteria. Complications, including infection, were recorded. Data were analyzed using SPSS version 24, with chi-square and independent t-tests applied; p-values ≤0.05 were considered statistically significant.

RESULTS

The dual plating group demonstrated significantly higher Lysholm score compared to the Ilizarov group (86.0 ± 8.44 vs 54.26 ± 8.73; p < 0.001).

Radiological union was achieved more frequently in the dual plating group (96.7%) than in the Ilizarov group (73.3%) (p=0.01). Infection rates were significantly higher in the Ilizarov group (20.0% vs 3.3%; p=0.044).

Functional outcome categories also favored dual plating (p=0.037).

CONCLUSION

Dual plating provided superior functional outcomes, higher union rates, and lower infection rates compared to Ilizarov fixation in the management of complex tibial plateau fractures. These findings support the preferential use of dual plating in patients with acceptable soft-tissue conditions, while Ilizarov fixation remains a valuable alternative in selected cases.

KEYWORDS: Tibial Plateau Fracture, Ilizarov Fixation, Dual Plating, Functional Outcome, Quasi-Experimental Study

INTRODUCTION

Tibial plateau fractures account for approximately 1% of all fractures and represent clinically significant periarticular injuries of the knee. These fractures commonly result from high-energy mechanisms, such as road traffic accidents and falls from height, and are frequently associated with complex fracture patterns, particularly Schatzker types V and VI. Such fractures are often accompanied by extensive soft-tissue compromise, metaphyseal comminution, and joint instability, which substantially complicate surgical management and postoperative recovery.¹ The primary objectives of treating complex tibial plateau fractures include anatomical restoration of the articular surface, achievement of stable fixation, correction of limb alignment, and facilitation of early mobilization to minimize long-term functional impairment. Dual

plating has traditionally been considered the standard approach for bicondylar tibial plateau fractures, as it provides rigid fixation and precise anatomical reconstruction. However, this technique requires extensive soft-tissue dissection, which increases the risk of wound complications, infection, and devascularization of the periosteum.² With the rising incidence of high-energy trauma, particularly from motor vehicle accidents, the management of bicondylar tibial plateau fractures requires a comprehensive assessment of multiple patient- and injury-related factors, including fracture morphology, soft-tissue condition, bone quality, nutritional status, and baseline functional mobility. Schatzker type V and VI fractures are inherently unstable injuries that almost invariably necessitate surgical intervention to restore joint congruity and mechanical alignment.³ The fixation construct must be sufficiently stable to allow early knee

mobilization while maintaining fracture reduction. Two commonly employed surgical strategies for managing these fractures include open reduction and internal fixation (ORIF) using osteosynthesis with dual plating and external fixation using the Ilizarov technique. ORIF with dual plating is often regarded as the ideal treatment modality because it offers direct visualization of the fracture, facilitates accurate articular reduction, and provides absolute stability, thereby promoting reliable fracture union and restoration of joint alignment.^{4,5} Nevertheless, the extensive soft-tissue dissection inherent to this approach can lead to periosteal stripping, compromised cortical blood supply, and an increased risk of infection and soft-tissue necrosis. In recent years, minimally invasive plate osteosynthesis (MIPPO) techniques and the Ilizarov method have been proposed as alternative strategies to mitigate the biological disadvantages associated with conventional ORIF.⁶ Unlike the recommendations of the Canadian Orthopedic Trauma Society, which restrict ORIF primarily to closed fractures, the Ilizarov technique is applicable to both closed and open fractures. A key advantage of the Ilizarov method is preservation of the periosteal blood supply, which supports fracture biology and facilitates early weight bearing, potentially reducing hospital stay and accelerating functional recovery. Additionally, the percutaneous nature of Ilizarov fixation has been shown in some studies to minimize soft-tissue injury and allow multiplanar correction.^{7,8} Despite these advantages, Ilizarov fixation is associated with notable limitations, including a high incidence of pin-tract infections, the technical complexity of frame management, and challenges related to patient compliance. Moreover, meticulous postoperative monitoring is required, and complete restoration of articular congruity may not always be achievable with this technique.⁹ At present, there is no universally accepted standard treatment for unstable bicondylar tibial plateau fractures, and both dual plating and Ilizarov fixation possess distinct advantages and disadvantages. Furthermore, there is a paucity of prospective analytical studies directly comparing these two modalities, particularly in resource-constrained settings. This lack of robust comparative evidence underscores the need for further investigation to guide evidence-based clinical decision-making. Therefore, the objective of the present study is to evaluate and compare the functional and radiological outcomes of Schatzker type V and VI tibial plateau fractures managed with Ilizarov external fixation versus dual plating. The findings of this study are expected to assist clinicians in selecting safer and more effective treatment strategies, ultimately improving clinical outcomes and quality of life for patients with these complex injuries.

METHODOLOGY

This prospective quasi-experimental study was conducted at the Department of Orthopedic Surgery, Nishtar Hospital, Multan, after obtaining approval from the Institutional Ethical Review Board (IERB). A total of 60 patients were enrolled using a non-probability purposive sampling technique, with 30 patients allocated to each treatment group. The sample size was calculated using a two-proportion formula, considering a 95% confidence interval and 80% study power, where the anticipated superficial infection rate was 40.4% for Ilizarov fixation and 2.9% for internal fixation, as reported by Berven et al.¹⁰ Patients of either sex aged 20-70 years presenting with isolated closed Schatzker type V or VI tibial plateau fractures of less than 14 days' duration were included. In contrast, those with open fractures, polytrauma, associated neurovascular injury, ipsilateral limb fractures, previously treated or infected fractures, compartment syndrome, significant comorbidities (including ischemic heart disease and uncontrolled asthma), prior knee trauma or surgery, or unwillingness to participate were excluded. Patients were recruited from the outpatient and accident and emergency departments, and written informed consent was obtained after explaining the study objectives, ensuring confidentiality, and confirming that there was no additional risk. Baseline demographic and clinical data, including age, gender, residential status, diabetes mellitus, hypertension, obesity, side of fracture, and mechanism of injury, were recorded using a structured proforma. Consistent with the quasi-experimental design, patients were allocated to treatment groups based on fracture characteristics, soft-tissue condition, and surgeon discretion, with Group A undergoing Ilizarov external fixation using a three-ring frame with Ilizarov wires and Schanz screws, and Group B receiving internal fixation with dual plating, consisting of a lateral anatomical locking plate and a medial locking T-plate applied using minimally invasive percutaneous plate osteosynthesis under image intensifier guidance. All patients were followed for six months with fortnightly assessments to evaluate clinical and radiological outcomes. Functional outcome was assessed using the Lysholm Knee Scoring Scale (1985 version), which evaluates pain, instability, locking, swelling, limp, stair climbing, squatting, and need for support, yielding a total score ranging from 0 to 100, with higher scores indicating better function.¹¹ Radiological union was evaluated using biplanar orthogonal radiographs and classified according to the Hammer et al. grading system, where grades 1 and 2 were considered healed and grades 3 to 5 unhealed.¹² Data were analyzed using SPSS version 24; continuous variables were expressed as mean $\pm$ standard deviation,

while categorical variables were presented as frequencies and percentages. Functional and radiological outcomes between groups were compared using the chi-square test, and potential effect modifiers-including age, gender, residential status, diabetes, hypertension, obesity, side and duration of fracture, and mechanism of injury-were controlled through stratification followed by post-stratification chi-square analysis. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

In this study, the Dual plating resulted in significantly higher Lysholm scores and superior functional outcomes compared to Ilizarov fixation ($p < 0.001$). Radiological union was achieved more frequently in the dual plating group, with a significantly lower non-union rate ($p = 0.01$). Infection rates were significantly higher in the Ilizarov group, predominantly due to pin-tract infections ($p = 0.044$). Stratified analysis revealed that advanced age, delayed presentation, obesity, and Schatzker type VI fractures adversely affected outcomes. Overall, dual plating demonstrated superior radiological and functional results with fewer complications in appropriately selected patients. Schatzker type V fractures did not demonstrate a statistically significant effect on union, functional outcome, or infection rates ($p > 0.05$). In contrast, Schatzker type VI fractures showed a statistically significant association with poorer functional outcomes and higher infection rates ($p < 0.05$), while their effect on bone union was not statistically significant.

Table 1: Demographic and Clinical Characteristics of Study Participants (n=60)

Variable	Ilizarov Group (n=30)	Dual Plate Group (n=30)
Age (years, Mean $\pm$ SD)	40.06 $\pm$ 12.73	48.66 $\pm$ 15.72
Gender		
Male	25 (83.3%)	23 (76.7%)
Female	05 (16.7%)	7 (23.3%)
Schatzker Classification		
Type V	14 (46.7%)	14 (46.7%)
Type VI	16 (53.3%)	16 (53.3%)
Duration of fracture (days, Mean $\pm$ SD)	6.83 $\pm$ 3.63	6.76 $\pm$ 3.84
Mode of Injury		
Road traffic accident	15 (50.0%)	14 (46.7%)
Fall	13 (43.3%)	12 (40.0%)
Assault	02 (6.7%)	4 (13.3%)
Residence		
Urban	10 (33.3%)	10 (33.3%)
Rural	20 (66.7%)	20 (66.7%)
Side of Injury		
Right	13 (43.3%)	17 (56.7%)
Left	17 (56.7%)	13 (43.3%)
Comorbidities		
Diabetes mellitus	08 (13.3%)	06 (20.0%)
Hypertension	22 (36.7%)	38 (63.3%)
Obesity	12 (20.0%)	48 (80.0%)

Table 2: Comparison of Functional Scores between Treatment Groups

Outcome Measure	Ilizarov Group (Mean $\pm$ SD)	Dual Plate Group (Mean $\pm$ SD)	T-Value	P-Value (95%CI)
Lysholm Knee Score	54.26 $\pm$ 8.73	86.00 $\pm$ 8.44	14.31	<0.001 (27.29-36.17)
Hammer Grade Score	2.10 $\pm$ 0.75	2.00 $\pm$ 0.87	0.47	0.637 (-0.32-0.52)

Table 3: Radiological Union and Infection Outcomes

Outcome	Ilizarov Group n (%)	Dual Plate Group n (%)	χ^2 Value	P- Value
Bone Union				
Achieved	22 (73.3%)	29 (96.7%)	6.40	0.01
Not achieved	08 (26.7%)	01 (3.3%)		
Infection				
Yes	06 (20.0%)	01 (3.3%)	4.04	0.044
No	24 (80.0%)	29 (96.7%)		

Table 5: Stratified Analysis of Effect Modifiers on Outcomes (p-values)

Variable		Lysholm Score	Hammer Grade	Union	Functional Outcome	Infection
Age	20-45 years	0.00	0.179	0.153	0.332	0.36
	46-70 years	0.00	0.59	0.012	0.024	0.066
Gender	Male	0.00	0.75	0.028	0.084	0.05
	Female	0.003	0.87	0.217	0.45	0.26
Duration of fracture	Fracture duration >6 days	0.00	0.90	0.009	0.33	0.10
Mode of injury	Assault injury	0.00	0.10	0.033	0.10	0.033
Residence	Urban residence	0.00	0.43	0.025	0.079	0.060
Side of injury	Right-sided fracture	0.00	0.84	0.105	0.020	0.070
Comorbidities	Hypertension (No)	0.00	0.13	0.045	0.13	0.10
	Non-obese patients	0.00	0.44	0.001	0.003	0.022

DISCUSSION

Tibial plateau fractures represent approximately 1% of all fractures and predominantly affect young adult males, reflecting their strong association with high-energy trauma such as motorbike and road traffic collisions. Among tibial fractures, tibial condylar injuries constitute nearly one-quarter of cases, with Schatzker type V and VI fractures representing the most complex patterns due to extensive articular comminution and severe soft-tissue compromise.^{13,14} These injuries pose substantial surgical challenges and are frequently associated with complications, including wound breakdown, knee stiffness, malalignment,

delayed union, and post-traumatic osteoarthritis, emphasizing the need for an optimal fixation strategy. Open reduction and internal fixation (ORIF) with dual plating has traditionally been regarded as an effective method for stabilizing highly unstable bicondylar tibial plateau fractures by allowing accurate reduction of the articular surface and restoration of mechanical alignment. Despite these biomechanical advantages, the technique necessitates extensive soft-tissue dissection, which has been consistently associated with higher rates of wound complications and infection. To mitigate these risks, alternative fixation strategies-including unilateral locking plates and external fixation using Ilizarov or hybrid constructs-have been explored, with some studies reporting comparable clinical outcomes between internal and external fixation modalities.^{15,16} The present quasi-experimental study demonstrated significantly better radiological union rates, lower infection rates, and superior functional outcomes in patients treated with dual plating compared to those managed with Ilizarov fixation. These findings contrast with several previously published studies that reported no statistically significant differences between the two techniques. Oguzkaya et al. found comparable WOMAC, KSS-F, KSS-Knee, and Oxford Knee Scores between the Ilizarov and double-plating groups in Schatzker type V and VI fractures, suggesting functional equivalence between the fixation methods.¹⁷ Similarly, Ghori et al. reported no significant differences in functional activities such as walking, squatting, jumping, and duck walking between patients treated with ORIF and those treated with Ilizarov fixation.¹⁹ Conversely, Ahmed et al. observed superior union rates in patients treated with Ilizarov fixation compared to ORIF in a randomized controlled trial, reporting 90% good union in the Ilizarov group versus 60% in the ORIF group.¹⁸ These discrepancies may be attributable to differences in study design, sample size, fracture severity, surgical expertise, and postoperative rehabilitation protocols. In contrast, our findings suggest that, when dual plating is performed using minimally invasive techniques and careful soft-tissue handling, it can yield favorable outcomes with acceptable complication rates. Other regional studies have produced mixed results. Jafree et al. reported a higher proportion of excellent outcomes in patients treated with hybrid Ilizarov fixation compared to locking plate fixation, highlighting the potential benefit of external fixation in selected patient populations.²⁰ Zafir et al. reported excellent union rates and favorable Rasmussen functional scores in patients treated exclusively with hybrid Ilizarov fixation, further supporting its role as a viable alternative, particularly in cases with compromised soft tissues.²¹ However, these studies were largely descriptive and lacked direct comparative analysis, limiting the generalizability of

their conclusions. Meta-analytic evidence also remains inconclusive. Gawalkar et al. found no significant difference in WOMAC scores between the plate fixation and hybrid Ilizarov fixation groups.²² Tripathy et al., in a comprehensive meta-analysis, reported better overall functional outcomes with external fixation but no statistically significant difference when categorical functional outcomes were analyzed.²³ The heterogeneity of included studies, variations in outcome measures, and inconsistent reporting of complications likely contributed to these conflicting results. The ongoing debate regarding optimal management of high-energy bicondylar tibial plateau fractures underscores the complexity of these injuries. While rigid internal fixation offers the advantage of precise anatomical restoration and early mobilization, it carries inherent risks when soft tissues are compromised. Conversely, external fixation preserves fracture biology and minimizes soft-tissue disruption but may be associated with higher infection rates, patient discomfort, and challenges in achieving optimal articular congruity.²⁴ Locking plate technology and hybrid fixation methods have further expanded the available treatment options, yet high-quality comparative data remain limited.²⁵ Importantly, much of the existing literature consists of case series with heterogeneous inclusion criteria and outcome measures, limiting meaningful comparison between fixation strategies. Furthermore, the success of each technique is closely linked to the surgeon's expertise, underscoring the importance of context-specific evaluation. The increasing adoption of multicenter "one arm-one center" study designs reflects recognition of this issue and allows for assessment of reproducibility and technique-specific outcomes when performed by experienced surgeons. In this context, the present study contributes valuable prospective comparative data from a single tertiary care center, demonstrating that judicious dual plating, applied in accordance with minimally invasive principles, can achieve superior functional and radiological outcomes with fewer complications than Ilizarov fixation. These findings support the selective use of dual plating in patients with acceptable soft-tissue conditions while reinforcing the role of Ilizarov fixation as a useful alternative in carefully selected cases.

LIMITATIONS

Postoperative rehabilitation and analgesic protocols were not strictly standardized, which may have influenced functional recovery. Radiological assessment of fracture union was not performed by blinded, independent observers, potentially introducing observer bias. Follow-up was limited to six months, precluding assessment of long-term outcomes such as post-traumatic osteoarthritis and implant-related

complications. Additionally, fracture comminution severity and surgeon-dependent technical variations were not quantitatively controlled, and these factors may have influenced outcomes.

CONCLUSIONS

The study concludes that there is no universally better approach to fixing these injuries, and the ideal treatment for each case depends on the specific circumstances. Ultimately, the surgeon's skill and experience, as well as their ability to address and resolve any issues that may arise from the therapy, are the determining factors in making the ultimate choice.

CONFLICT OF INTEREST: None

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The authors accept responsibility for all aspects of the work and will ensure that any concerns regarding the accuracy or integrity of any part are properly investigated and resolved.



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