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Functional and Radiological Outcomes of Surgical Management in Schatzker Type V and VI Tibial Plateau Fractures: A Prospective Observational Study

Dr. Vicky Kumar[1], Dr. Devarsh Goyal[2], Dr. Tej Pratap Khuteta[3], Dr. Harshit Kumar[4], Dr. Ravinder Kumar[5]

[1]Post Graduate Resident, Department of Orthopaedics, S.M.S. Medical College & Attached Hospitals, Jaipur, Rajasthan, India
Corresponding Author Email: *dr.vickykmr97[at]gmail.com*

[2]Post Graduate Resident, Department of Orthopaedics, S.M.S. Medical College & Attached Hospitals, Jaipur, Rajasthan, India

[3]Post Graduate Resident, Department of Orthopaedics, S.M.S. Medical College & Attached Hospitals, Jaipur, Rajasthan, India

[4]Senior Resident, Department of Orthopaedics, S.M.S. Medical College & Attached Hospitals, Jaipur, Rajasthan, India

[5]Professor & Unit Head, Department of Orthopaedics, S.M.S. Medical College & Attached Hospitals, Jaipur, Rajasthan, India

Abstract: ***Background**: Schatzker type V and VI tibial plateau fractures are high-energy injuries associated with complex articular disruption and significant soft-tissue compromise. Choosing the appropriate fixation method remains challenging, as it requires balancing anatomical joint restoration with soft-tissue preservation. This study evaluates the clinical, functional, and radiological outcomes of Open Reduction and Internal Fixation (ORIF) versus Ilizarov external fixation in the management of these fractures. **Methods**: A prospective observational study was conducted in the Department of Orthopaedics, SMS Medical College and Attached Hospitals, Jaipur, from January to December 2024. Fifty adult patients (>20 years) with radiologically confirmed Schatzker type V or VI tibial plateau fractures were treated surgically- 24 with ORIF plating and 26 with Ilizarov external fixation- using standardized postoperative rehabilitation. Outcomes were evaluated at 3 and 6 months using the Honkonen and Järvinen (HJ) scoring system for subjective, clinical, functional, and radiological parameters. Knee flexion, weight-bearing progression, and postoperative complications were also documented and statistically analyzed. Results: Most patients were middle-aged males, and motorbike-related road-traffic accidents were the predominant injury mechanism. Functional mobility improved consistently in both fixation groups, with 84% of patients achieving good-to-excellent functional outcomes at 6 months. At final follow-up, knee flexion exceeded 110° in 84% of patients, and radiological outcomes were good in 86%. Complication rates were low in both groups; minor pin-tract infections occurred only in Ilizarov cases, while elective plate removal occurred in plating cases. Overall outcomes were comparable when fixation was selected according to fracture pattern and soft-tissue status. **Conclusion**: Both ORIF plating and Ilizarov external fixation are effective for managing Schatzker type V and VI tibial plateau fractures. A selective, patient-specific approach yields optimal results- ORIF is suitable for closed displaced fractures requiring precise anatomical reduction, whereas Ilizarov fixation is advantageous in open or soft-tissue-compromised injuries. Individualized fixation combined with early rehabilitation supports favourable functional and radiological recovery.*

Keywords: Schatzker fracture, tibial plateau, Ilizarov fixation, ORIF, knee function

1. Introduction

Fractures of the proximal tibia pose a major challenge in orthopaedic trauma due to their complex anatomy and essential role in knee biomechanics. The tibial plateau forms the inferior articular surface of the knee joint and sustains a significant proportion of axial load, contributing to joint congruity and overall limb alignment.[1] Among these injuries, Schatzker type V and VI fractures are the most severe, involving bicondylar disruption with varying degrees of comminution and metaphyseal–diaphyseal separation.[2] These fractures commonly result from high-energy trauma such as road traffic accidents or falls from height in younger patients, whereas elderly individuals may sustain similar injuries even after low-energy mechanisms due to osteoporosis and reduced bone mineral density.[3] The Schatzker classification, introduced in 1979, remains one of the most widely adopted radiographic systems for categorizing tibial plateau fractures into six types.[4] Types V and VI represent the most unstable variants; type V involves bicondylar fractures with preserved metaphyseal continuity, whereas type VI shows complete dissociation between the metaphysis and diaphysis. These injuries are frequently associated with soft tissue compromise including abrasions, contusions, fracture blisters, compartment syndrome, and open wounds, which increases the likelihood of postoperative complications such as infection, non-union, wound dehiscence, and long-term knee dysfunction.[5] Restoration of articular congruity is therefore essential to prevent post-traumatic osteoarthritis and preserve functional outcomes.[6] Traditionally, Schatzker V and VI fractures have been managed with open reduction and internal fixation (ORIF), typically using dual plating to provide biomechanical stability.[7] Although rigid fixation ensures accurate reduction, it often requires extensive soft tissue dissection, potentially jeopardizing already damaged

vascular structures.[8] This contributes to complications including deep infection, implant failure, delayed or non-union, and need for secondary surgical intervention.[9] Infection rates following plating in these fractures have been reported up to 20%, particularly in cases with open wounds or severe edema.[10]

More recently, biologically conservative approaches such as the Ilizarov ring fixator and hybrid external fixation have gained attention.[11] These techniques allow percutaneous reduction and stabilization with minimal incision, helping preserve soft tissue integrity.[12] Additionally, they enable early joint mobilization and weight-bearing, which may reduce joint stiffness and venous thromboembolism while accelerating rehabilitation.[13] However, external fixation requires strict patient compliance and careful pin-site maintenance, and may lead to pin tract infections or residual malalignment.[14]

Despite advancements in fixation strategies, debate persists regarding the optimal surgical approach for Schatzker type V and VI fractures. Outcome variability across studies is influenced by heterogeneity in fracture patterns, patient conditions, and rehabilitation protocols.[15] [16] Postoperative recovery is commonly assessed using the Honkonen and Järvinen Clinical Grading System for functional outcomes[17] and standardized radiological parameters including articular step-off, condylar widening, plateau tilt, and joint space congruity.[18] Considering the ongoing uncertainty regarding best clinical practices, further evidence is required. This prospective observational study evaluates functional and radiological outcomes in surgically treated Schatzker type V and VI tibial plateau fractures at a tertiary care teaching hospital. By analyzing outcomes using validated scoring systems, the study aims to contribute meaningful insight to the ongoing debate on optimal management of complex tibial plateau injuries. Given the ongoing debate regarding optimal surgical intervention for complex bicondylar tibial plateau fractures, this study seeks to offer practical insight into outcome-based fixation strategies tailored to soft-tissue conditions and fracture patterns.

2. Materials and Methods

Study Design and Ethical Approval

This hospital-based, prospective observational study was conducted in the Department of Orthopaedics, SMS Medical College and Attached Hospitals, Jaipur, Rajasthan. The study aimed to evaluate the functional and radiological outcomes of Schatzker type V and VI tibial plateau fractures managed surgically through Open Reduction and Internal Fixation (ORIF) or Ilizarov external fixation. Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC), SMS Medical College under Ref. No. 387/MC/EC/2023, dated 18 January 2024. Written informed consent was obtained from all participants before enrollment in accordance with ethical guidelines.

Study Population and Duration

The study enrolled patients presenting with radiologically confirmed Schatzker type V and VI tibial plateau fractures who required surgical intervention. Recruitment, surgery, and postoperative follow-up were conducted over a 12-month period from January 2024 to December 2024, and each patient was monitored for a minimum follow-up duration of six months.

Sample Size

A total of 50 patients were included using consecutive sampling based on admissions to the emergency and outpatient departments. The sample size was determined considering previously published outcome rates for similar fracture patterns, assuming a 95% confidence interval and an absolute allowable error of 12% to ensure adequate statistical power.

Eligibility Criteria

Inclusion criteria

- Adults aged > 20 years.
- Schatzker type V or VI tibial plateau fractures confirmed on radiological evaluation.
- Patients medically fit for anaesthesia and surgical intervention.
- Patients willing to provide informed consent and comply with postoperative follow-up.

Exclusion criteria

- Ipsilateral lower limb fractures.
- Severe head injury with neurological deficit.
- Open fractures classified as Gustilo-Anderson type IIIC.
- Prior surgery on the same limb.
- Patients medically unfit or unwilling to participate.

Preoperative Evaluation

All participants underwent detailed history taking and clinical examination, including assessment of soft tissue condition, swelling, limb alignment, and neurovascular status. Radiographs of the knee in anteroposterior and lateral views and 3D CT scans were performed to classify fracture morphology and plan surgical management. Baseline laboratory investigations (haematological, biochemical, and coagulation profiles) and pre-anaesthetic evaluations were completed. Comorbidities such as diabetes mellitus or hypertension were optimized prior to surgery.

Surgical Technique

All procedures were performed under spinal or general anaesthesia on a radiolucent table using C-arm guidance.

1) Open Reduction and Internal Fixation (Plating)

ORIF was preferred in closed fractures or where soft tissue conditions allowed safe dissection. A dual-incision or single anterolateral approach was selected based on fracture pattern. The articular surface was anatomically reduced using K-wires, bone levers and clamps, and fixation was achieved using pre-contoured locking compression plates (LCP). Bone grafts were used where required to fill metaphyseal voids. Wounds were closed in layers and covered with sterile dressings.

2) Ilizarov External Fixation

This method was used in open fractures, cases with soft tissue compromise, or severe comminution. Reduction was

achieved via traction and ligamentotaxis under fluoroscopic guidance, and proximal and distal rings were connected with tensioned wires and half pins. Percutaneous screws were placed selectively to assist in joint reduction and stabilization. Open wounds were managed with delayed closure, secondary healing, or flap/grafting as indicated.

Postoperative Protocol and Follow-Up

Patients received intravenous antibiotics for 3 to 5 days postoperatively along with thromboprophylaxis when indicated. Passive and active knee range-of-motion exercises were initiated from the second to third postoperative day in both groups. Weight-bearing was progressed according to fixation stability—typically after 6–8 weeks in plated patients and earlier in Ilizarov-treated cases based on patient comfort and radiological signs of healing.

Follow-up was conducted at 2 weeks, 3 months, and 6 months, where:

- Functional outcomes were assessed using the *Honkonen and Järvinen Clinical Grading System*.
- Radiological outcomes were evaluated using the *Honkonen and Järvinen Radiological Score*.
- Complications such as infection, implant failure, pin-tract infection (in Ilizarov cases), delayed union, non-union, or stiffness were documented.

Statistical Analysis

Data were recorded using Microsoft Excel and analyzed using IBM SPSS Statistics Version 26.0. Quantitative variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Statistical comparisons were performed using the Student's t-test for continuous variables and the Chi-square test for categorical variables. A p-value < 0.05 was considered statistically significant.

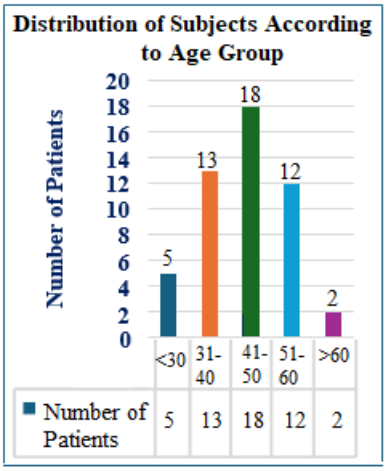
3. Results

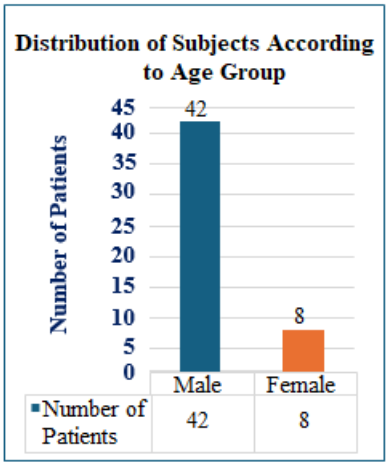
Baseline Patient Characteristics

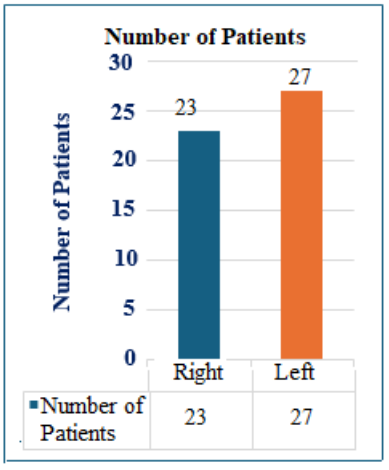
A total of 50 patients with Schatzker type V and VI tibial plateau fractures were included in the study. Most patients were middle-aged, with a clear male predominance. The left side was involved slightly more frequently than the right. Road-traffic accidents, particularly motorbike collisions, were the most common mechanism of injury.

Table 1: Baseline Demographic Profile of Patients (n = 50)

Variable	Category	n (%)
Age (years)	<30	5 (10%)
	31–40	13 (26%)
	41–50	18 (36%)
	51–60	12 (24%)
	>60	2 (4%)
Gender	Male	42 (84%)
	Female	8 (16%)
Side of Injury	Right	23 (46%)
	Left	27 (54%)







Injury Pattern and Soft Tissue Status

Schatzker type VI fractures were slightly more common than type V. Closed fractures were the most frequent presentation, although soft tissue compromise and open fractures were also reported. ACL avulsion was the most common associated ligamentous injury.

Table 2: Injury Characteristics

Parameter	Category	n (%)
Mechanism of Injury	Motorbike Accident	33 (66%)
	Car Accident	6 (12%)
	Fall from Height	4 (8%)
	Pedestrian Hit	4 (8%)
	Crush Injury	1 (2%)
	Others	2 (4%)
Schatzker Type	Type V	23 (46%)
	Type VI	27 (54%)
Soft Tissue Status	Closed	24 (48%)
	Closed + Soft Tissue Compromise	16 (32%)
	Open Fracture	10 (20%)
Associated Injuries	ACL Avulsion	7 (14%)
	PCL Tear	2 (4%)
	Patellar Tendon Injury	1 (2%)
	None	40 (80%)

Surgical Management and Post-operative Course

Both plating (ORIF) and Ilizarov external fixation were used almost equally. Bone grafting was required in nearly half of the patients. At 3-month follow-up, most patients were mobilising on partial weight-bearing, and overall complication rates were low.

Table 3: Surgical Treatment and Post-operative Parameters

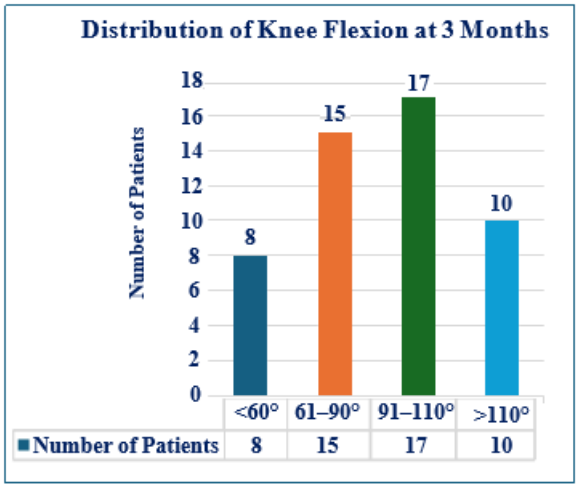
Variable	Category	n (%)
Fixation Method	Plating (ORIF)	24 (48%)
	Ilizarov External Fixator	26 (52%)
Bone Grafting	Yes	24 (48%)
	No	26 (52%)
Weight-bearing at 3 Months	Non-weight-bearing	2 (4%)
	Partial	40 (80%)
	Full	8 (16%)
Postoperative Complications	Pin-tract Infection	5 (10%)
	Elective Plate Removal	2 (4%)
	None	43 (86%)

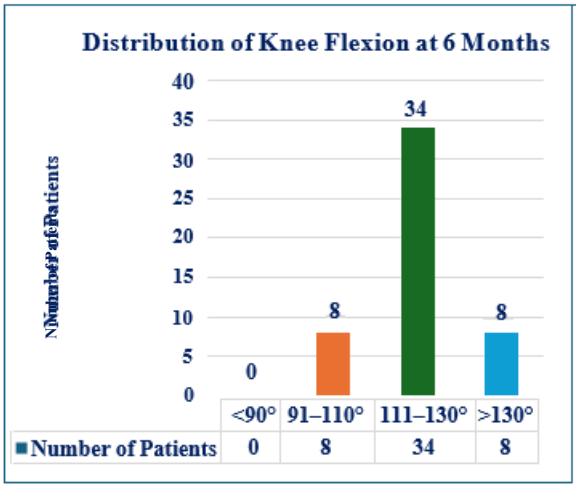
Functional Outcomes

Knee range of motion showed sustained improvement from 3 to 6 months. At final follow-up, all patients achieved flexion above 90°, and most achieved flexion beyond 110°.

Table 4: Functional Outcome Progression Based on Knee Flexion

Knee Flexion Range	3 Months n (%)	6 Months n (%)
<60°	8 (16%)	—
61–90°	15 (30%)	—
91–110°	17 (34%)	8 (16%)
111–130°	10 (20%)	34 (68%)
>130°	—	8 (16%)



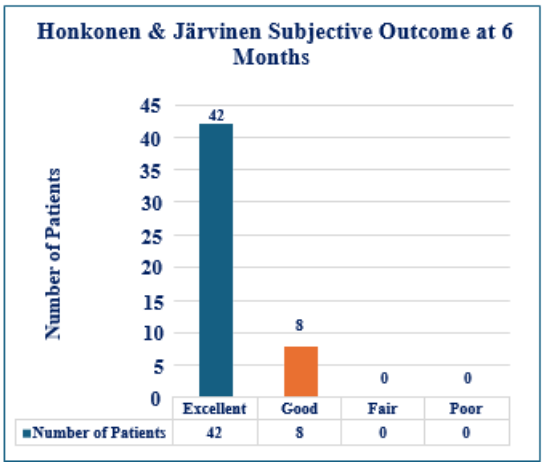


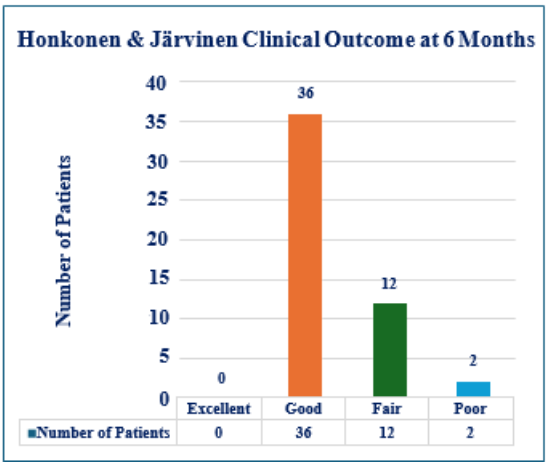
Overall Outcome Summary

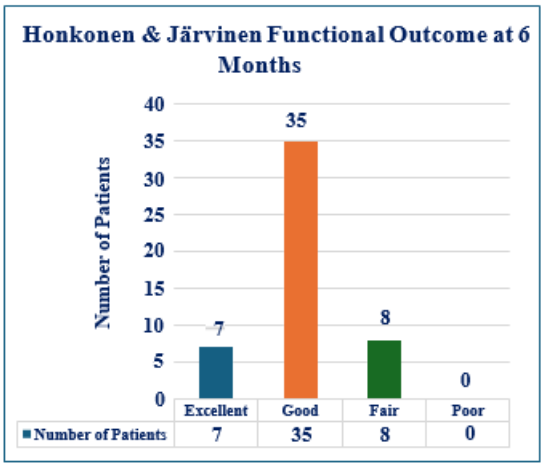
Final outcomes were assessed using the Honkonen and Järvinen scoring system across subjective, clinical, functional, and radiological domains. Most patients demonstrated favourable results at the end of 6 months.

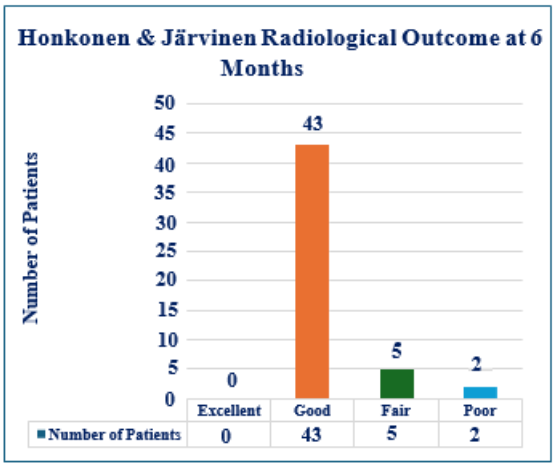
Table 5: Combined Final Outcome Scores at 6 Months (n = 50)

Outcome Domain	Excellent	Good	Fair	Poor
Subjective	42 (84%)	8 (16%)	0	0
Clinical	0	36 (72%)	12 (24%)	2 (4%)
Functional	7 (14%)	35 (70%)	8 (16%)	0
Radiological	0	43 (86%)	5 (10%)	2 (4%)









4. Discussion

In the present study, Schatzker type V and VI tibial plateau fractures predominantly affected middle-aged individuals, with most patients between 41–50 years of age. This trend corresponds with previous studies that reported similar age clustering among working-age individuals exposed to high-energy trauma- Prasad et al.[19], Pun et al.[20], Rohra et al.[21], Debnath et al.[22], Khatri et al.[23] and Oguzkaya et al.[24]

A clear male predominance (84%) was noted in our study, similar to the findings of Prasad et al.[19], Pun et al.[20], Rohra et al.[21], Khatri et al.[23] and Debnath et al.[22] This pattern is widely attributed to greater male involvement in driving, outdoor occupations, and physical activities, which increases exposure to high-velocity injuries.

Motorbike-related road-traffic accidents formed the most common mechanism of injury (66%), which is comparable to observations by Prasad et al.[19], Rohra et al.[21], Khatri et al.[23], Debnath et al.[22] and Oguzkaya et al.[24] reflecting regional dependence on two-wheeler transport and high-velocity collisions.

The distribution of fracture types in our study (46% Schatzker V and 54% Schatzker VI) closely mirrors that reported by Prasad et al.[19], Pun et al.[20] and Rohra et al.[21]. Pandey and Bidary[27] also documented a slightly higher proportion of type VI fractures in their Ilizarov cohort, indicating greater incidence of metaphyseal–diaphyseal dissociation in high-energy trauma.

Soft-tissue injury was present in 52% of patients, supporting the selective use of Ilizarov fixation in such cases. This approach is consistent with the recommendations of Barei et al.[26], Subasi et al.[25], Debnath et al.[22], Oguzkaya et al.[24] and Pandey and Bidary[27] who highlighted the protective advantage of external fixation in compromised soft-tissue settings. Conversely, plating was used in closed displaced fractures, consistent with strategies described by Prasad et al.[19], Rohra et al.[21] and Khatri et al.[23].

Functional recovery improved progressively, and 84% of patients achieved good-to-excellent outcomes at 6 months. These results parallel the functional outcome trends reported by Pun et al.[20], Prasad et al.[19], Rohra et al.[21], Debnath et al.[22] and Pandey and Bidary[27]. The relatively lower number of "excellent" grades is likely due to the strict scoring criteria used rather than inferior clinical performance.

Radiological outcomes showed good alignment in 86% of patients. Comparable results were reported by Pun et al.[20], Debnath et al.[22] and Pandey and Bidary[27], while variations in a small subset of fair/poor grades in our study were similar to those noted by Subasi et al.[25] and Oguzkaya et al.[24] in highly comminuted fracture patterns.

Complication rates in this study were low, dominated by minor pin-tract infections in Ilizarov- treated patients and elective plate removal in ORIF cases. Similar complication patterns were reported by Pun et al.[20], Debnath et al.[22] and Pandey and Bidary[27]. In contrast, Barei et al.[26] and Subasi et al.[25] recorded higher infection rates in high-risk open fractures, underscoring the importance of adhering to soft-tissue-based fixation selection.

Overall, the present study supports the conclusion emphasized across the literature that both Ilizarov external fixation and ORIF plating are effective options for managing Schatzker type V and VI fractures. When fixation choice is individualized based on soft-tissue status and fracture morphology, both methods can restore joint congruity, facilitate early mobilization, and achieve favourable functional and radiological outcomes.

5. Clinical Implications

The present study demonstrates that both ORIF plating and Ilizarov external fixation can achieve favourable functional and radiological outcomes in Schatzker type V and VI tibial plateau fractures when fixation selection is individualized to fracture morphology and soft- tissue status. ORIF enables restoration of the articular surface with rigid fixation, enabling precise reconstruction in closed fractures with minimal soft-tissue compromise. In contrast, Ilizarov fixation provides biological fixation with minimal dissection and is particularly advantageous in cases with open wounds, severe soft-tissue oedema, or high infection risk. Early mobilization was feasible with both modalities, and complication rates were low in each group, supporting the principle that optimal implant selection is patient- and fracture-specific rather than technique-dominant. In settings where soft-tissue conditions are favourable, plating remains

a reliable option; however, Ilizarov fixation should be considered the preferred modality in high-risk soft-tissue injuries or open fractures to minimize wound complications and facilitate early rehabilitation.

6. Limitations and Future Directions

This is a single-center study with a modest sample size (n = 50) and a six-month follow-up period, which may not fully reflect late complications, functional divergence, or the development of post-traumatic osteoarthritis. No comparative randomization was undertaken between ORIF and Ilizarov techniques, and potential confounders such as bone mineral density, body mass index, rehabilitation compliance, and surgeon-specific expertise were not stratified. Furthermore, no cost-effectiveness or quality-of-life analysis was performed. Future research would benefit from multicenter randomized trials with larger cohorts, standardized physiotherapy protocols, and long-term follow-up (≥24 months). Comparative evaluation of modern hybrid fixation techniques, augmentation strategies (e.g., bone substitutes), posterior column stabilization, and early weight-bearing protocols may further refine decision-making and optimize outcomes for complex bicondylar tibial plateau fractures.

7. Conclusion

Schatzker type V and VI tibial plateau fractures represent high-energy injuries with complex articular and metaphyseal disruption, frequently accompanied by soft-tissue compromise. In the present study, both ORIF plating and Ilizarov external fixation resulted in favourable clinical, functional, and radiological outcomes at six months when fixation selection was individualized to fracture pattern and soft-tissue status. ORIF provided rigid anatomical reduction and was effective in closed displaced fractures, whereas Ilizarov fixation enabled stable biological reconstruction in open or high-risk soft-tissue injuries while minimizing wound-related complications. Knee motion and function showed progressive improvement with early rehabilitation in both groups, and overall complication rates were low.

These findings support a selective, patient-specific fixation strategy rather than a single universally superior technique. Optimal outcomes in complex bicondylar tibial plateau fractures are achieved not by implant choice alone, but by meticulous attention to soft-tissue condition, accurate reduction of the articular surface, stable fixation, and structured physiotherapy. Continued long-term follow-up is warranted to evaluate the development of post-traumatic osteoarthritis and to further refine fixation protocols.

Conflict of Interest: The authors declare that they have no conflict of interest related to this research.

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