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Evaluation of the Effectiveness of Different Types of Fixation for Tibial Plateau Fractures

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ABSTRACT

Background: Fixation techniques are necessary for the optimum healing and functional recovery following a tibial plateau fracture. Surgeons may use plate, screw, external, or a mix of these and other treatments to fix the fracture, depending on its severity and other patient-specific factors. This study evaluates multiple fixation techniques for functional outcomes, complication rates, and recovery time.

Methods: This prospective observational study at Nalanda Medical College and Hospital in Patna included 100 tibial plateau fracture patients from July 2023 to December 2024. We categorised patients by fixation type using Schatzker. We monitored range of motion, functional scores (Rasmussen and Lysholm), time to union, and complications (infection, implant failure, non-union) throughout six months. We performed descriptive and comparative statistical analyses with a significance level of $p < 0.05$.

Results: Plate fixation had the best results with an average union time of 14.2 weeks, little complications, and good functional recovery. Screw fixation is appropriate for minor fractures, providing maximal range of motion with little issues. External fixation caused more complications, longer recovery times, and worse functional outcomes (33.3% infection, 20% implant failure). Hybrid fixation stabilised complex fractures but was riskier than internal fixing.

Conclusion: Plate fixation is stable and effective for most tibial plateau fractures, while screw fixation is preferable for smaller fractures. External fixation is unpopular due to problems; hybrid fixation may be appropriate for severe fractures. We need less intrusive procedures and longer follow-up to improve results.

Keywords: *Tibial plateau fractures, fixation techniques, plate fixation, screw fixation, external fixation, hybrid fixation, functional outcomes, orthopedic surgery*

1. INTRODUCTION

Tibial plateau fractures are major orthopaedic injuries. In osteoporosis, high-energy trauma like a vehicle crash or low-energy trauma like a fall from a standing height can cause it. Missing treatment for these knee fractures, which damage the weight-bearing area, can limit function [1]. Because of its importance to knee motion and stability, tibial plateau fractures are difficult to repair. Ligamentous injuries, articular surface involvement, and post-traumatic arthritis make these fractures difficult to cure. About 1% of all fractures and 8% of senior fractures are tibial plateau fractures, though this figures vary globally [2]. According to fracture pattern and severity, the Schatzker method classifies these fractures into six types. Due to comminution and soft tissue injury, higher-grade (Type IV–VI) fractures require more difficult repairing techniques than lower-grade (Type I–III) fractures [3]. Fixation selection optimises functional recovery and reduces the risk of non-union, malunion, and post-traumatic osteoarthritis. Modern tibial plateau fracture treatment includes hybrid, external, and internal screw-and-plate fixation [4]. The fixation depends on the fracture type, patient age, bone quality, comorbidities, and surgeon expertise. Restoring joint congruity, alignment, and early mobility with correct fixation prevents joint stiffness and improves long-term

functional outcomes [5].

Tibial plateau fracture surgery aims for stable fixation, early rehabilitation, and joint alignment. Unstabilized fractures can cause osteoarthritis, decreased mobility, pain, and joint instability. Multiple studies have underlined the importance of adapting mending methods to each patient's fracture pattern and treatment goals [6]. Locking compression plates (LCPs) treat complicated tibial plateau fractures. In addition to biomechanical advantages, LCPs are angularly stable. For severe fractures with soft tissue injury, external fixation is minimally invasive [7]. The risk of deep infection is decreased, although delayed healing and pin-site infections are possible. Also popular is hybrid fixation, which combines internal and external fixation methods. These treatments aim to maximise stability and minimise soft tissue concerns [8]. The best fixation technique depends on finding the balance between stability, biological healing, and problem minimisation. Even though fixing methods have improved, the optimum way to treat tibial plateau fractures is still debated [9].

Several tibial plateau fracture repair methods have merits and cons. Plate fixation for tibial plateau fractures is popular. Osteoporosis patients benefit from locking compression plates (LCPs)' angular stability [10]. These plates allow early weight-bearing and good connection. Depressed fractures are reinforced with buttress plates to prevent collapse. Plate fixation is effective, however it dissects soft tissues, which can cause wounds and infections. For simple fractures or when paired with other fixation methods, solitary screw fixation is best. Split or depression-type fractures are best fixed using cannulated screws since they are less obtrusive. In severe bone loss or difficult fractures, they may not be stable [11].

High-energy fractures that harm soft tissues may necessitate external fixators. It stabilises sensitive tissues and reduces the risk of further damage. Hybrid or circular external fixators lessen surgical stress while providing sufficient support. However, pin-site infections and joint stiffness may occur following long-term external fixation [12]. For optimal stabilisation with minimal soft tissue risk, hybrid fixation combines internal and external fixation methods. For example, a bicondylar fracture may require internal and exterior fixation. Infection or poor wound healing make soft tissue dissection impractical, so this approach is useful [13]. Patient condition, fracture type, and surgeon preference determine fixing process. According to comparative study, external fixation may be preferable for severe soft tissue damage than internal fixation, which has superior mechanical stability. These techniques are evaluated by fracture healing time, functional recovery, comorbidities, and long-term joint function [14].

There are several ways to heal tibial plateau fractures, thus the optimum treatment is still debated. Nalanda Medical College and Hospital in Patna performs tibial plateau fracture fixation methods, which this study compares. Determine clinical and radiological effectiveness of various mending procedures. Determine the relative risk of complications from different mending methods. Determine how long the fracture will heal to resume your routine. To determine if these strategies prevent post-traumatic arthritis over time. Methodically assessing these aspects will reveal the optimum tibial plateau fracture surgery. The data will help orthopaedic surgeons make evidence-based patient care decisions.

2. METHODS

Study Design and Setting

This 18-month prospective observational study at Nalanda Medical College and Hospital in Patna ran from July 2023 to December 2024. This study compares surgical tibial plateau fracture fixation procedures. Due to their complexity, tibial plateau fractures require a prospective observational design to collect real-time functional and clinical data while maintaining the institution's standard treatment methods.

Sample Size and Selection Criteria

In the study, 100 tibial plateau fracture patients had surgery. Researchers utilise inclusion and exclusion criteria to enrol patients for a representative sample and decrease confounding variables.

Inclusion Criteria

1. Patients diagnosed with tibial plateau fractures, confirmed through clinical and radiological assessment (X-ray and CT scans).
2. Patients aged 18 years or older, ensuring skeletal maturity and the ability to provide informed consent.
3. Patients undergoing surgical fixation, regardless of the type of fixation method used (plate fixation, screw fixation, external fixation, or hybrid techniques).

Exclusion Criteria

1. Patients with open fractures classified as Gustilo-Anderson Grade III, as these cases often require specialized management, including soft tissue reconstruction.
2. Patients with pathological fractures resulting from metastatic lesions or metabolic bone diseases, which may influence bone healing and functional outcomes.
3. Patients with pre-existing lower limb deformities or severe osteoarthritis, which may affect post-surgical mobility and functional recovery independent of the fixation technique used.

Data Collection

We use standardised data collection to evaluate fixation methods. Data collection includes hospital admission, surgery, discharge, and 1, 3, and 6 month follow-up sessions. Age Classifying patients by age allows for age-related healing effects.

This study explores fracture healing gender differences and results.Pre-existing conditions like diabetes, osteoporosis, and smoking history can affect healing time and consequences. Schatzker classifies tibial plateau fractures. Classifying fractures by morphology helps surgeons make informed judgements. Type VI fractures are complex comminuted fractures with metaphyseal-diaphyseal separation, while Type I fractures are splits. This classification helps stratify patients and determine which fixing methods work best for which fractures.

Statistical Analysis

We use statistical tools to compare fixation methods using our data. Standard deviation (SD), frequency distribution, and mean describe patient demographics, fracture types, and fixation procedures. Chi-square tests are suitable for infection rates by fixation type. Analyse continuous variables like group average knee flexion using an independent t-test or analysis of variance. Kaplan-Meier survival analysis can analyse time-to-union variances. Statistically significant results have p-values below 0.05. Multivariate analysis adjusts for age, comorbidities, and fracture severity. Based on evidence, this study will establish the optimum tibial plateau fracture repair method using rigorous statistical methods.

3. RESULTS

One hundred patients who had tibial plateau fractures treated surgically at Nalanda Medical College and Hospital in Patna from July 2023 to December 2024 were the subjects of the study. An analysis of the most important outcomes follows the presentation of the data in tables.

Table 1: Demographic and Clinical Characteristics of Patients

Characteristic	n (%)
Total Patients	100
Age Group	
18-30 years	25 (25%)
31-50 years	40 (40%)
>50 years	35 (35%)
Gender	
Male	65 (65%)
Female	35 (35%)
Comorbidities	
Diabetes Mellitus	15 (15%)
Hypertension	20 (20%)
Osteoporosis	12 (12%)
Smoking History	18 (18%)
Fracture Classification (Schatzker Type)	
Type I	12 (12%)
Type II	25 (25%)
Type III	18 (18%)
Type IV	20 (20%)
Type V	15 (15%)
Type VI	10 (10%)

Since 40% of tibial plateau fractures occur in middle-aged adults, high-energy trauma or car accidents may cause them. Male prevalence (65%) is likely due to higher involvement in activities with a higher injury risk. Many patients had diabetes, hypertension, and osteoporosis, which may have slowed healing and caused problems. Type II Schatzker fractures, which make up 25% of all fractures, are more common than Types V and VI.

Table 2: Distribution of Fixation Methods Used

Fixation Method	n (%)
Plate Fixation (Locking/Buttress)	45 (45%)
Screw Fixation (Cannulated/Lag)	20 (20%)
External Fixation (Monolateral/Circular)	15 (15%)
Hybrid Fixation (Plates + External Fixation)	20 (20%)

Plate fixation was the most common therapy for Schatzker Types II–IV fractures, accounting for 45% of cases. Screw fixation was most common for Type I and Type II split fractures (20%). Low-invasive initial techniques like external fixation (15%) were most popular for high-energy trauma (Type V and VI). Hybrid fixing (20%) mixed plates and external fixators for increased stabilisation.

Table 3: Functional Outcomes and Healing Time Across Fixation Methods

Outcome Parameter	Plate Fixation (n=45)	Screw Fixation (n=20)	External Fixation (n=15)	Hybrid Fixation (n=20)	p-value
Mean Time to Union (weeks)	14.2 ± 2.1	12.8 ± 1.9	16.5 ± 3.2	15.8 ± 2.8	0.03*
Mean Knee ROM (degrees)	120.5 ± 8.2	125.2 ± 7.5	110.3 ± 10.1	115.7 ± 9.5	0.02*
Rasmussen's Knee Score	28.4 ± 3.2	30.1 ± 2.8	24.7 ± 4.5	26.2 ± 4.0	0.04*
Complication Rate (%)	10%	5%	25%	20%	0.01*

Complex fractures and soft tissue injuries likely caused the shortest screw fixation time (12.8 weeks) and the longest external fixation period (16.5 weeks). Screw fixation had the highest knee ROM (125.2°) and external fixation the lowest (110.3°), suggesting that less intrusive approaches may preserve joint mobility better. Rasmussen's knee tests showed that screw fixation (30.1) was more effective than external fixation (24.7), suggesting that screw fixation was best for less complex fractures in terms of function. In more intrusive operations, infections and implant failures were common, including external fixation (25%) and screw fixation (5%).

Table 4: Postoperative Complications Among Different Fixation Methods

Complication Type	Plate Fixation (n=45)	Screw Fixation (n=20)	External Fixation (n=15)	Hybrid Fixation (n=20)
Infection	2 (4.4%)	1 (5%)	5 (33.3%)	4 (20%)
Implant Failure	1 (2.2%)	0 (0%)	3 (20%)	2 (10%)
Non-union	1 (2.2%)	0 (0%)	2 (13.3%)	1 (5%)
Joint Stiffness	3 (6.6%)	1 (5%)	4 (26.6%)	3 (15%)

External fixation had the highest infection rate (33.3%), likely due to prolonged pin-site exposure. Implant failure was highest in external fixation (20%), possibly due to mechanical stress and poor patient compliance. Non-union was most common in external fixation cases (13.3%), highlighting the challenge of achieving adequate fracture healing in severe injuries. Joint stiffness was most frequent in external fixation (26.6%) and hybrid fixation (15%), suggesting that early mobilization is more challenging in these methods.

4. DISCUSSION

Interpretation of Findings

This study compared tibial plateau fracture fixation procedures. With the highest knee range of motion (125.2°) and shortest mean time to union (12.8 weeks), screw fixation demonstrated the best functional outcomes. In most severe fractures, plate fixation yields good functional ratings and 14.2 weeks of recovery. The most prevalent external fixation problems were implant failure (20%) and infection (33.3%), which slowed healing and impaired function. Hybrid fixation—plates and external fixators—performed intermediately for major, high-energy fractures. This study found that external fixation caused a surprising number of problems, including infections and implant failures. Extreme soft tissue injuries often require external fixation, however research suggests that long-term use can pose hazards and require further treatments. Even though less invasive, screw fixation only worked on Schatzker Type I and II fractures, showing that it was not broadly applicable to more complex fracture patterns.

Comparison with Existing Literature

According to other study on tibial plateau fracture fixation, the treatment works. According to [15] plate fixation is still the gold standard for most fractures due to its stability and reliability. Particularly Schatzker Types II-V. [16] discovered that screw fixation protects anatomical alignment and minimises soft tissue displacement, resulting in the maximum functional recovery. Current literature acknowledges external fixation's challenges. According to a meta-analysis by [17], external fixation is often transitory and more likely to cause pin-site infections and malalignment. This study found that external fixation is best employed for transient stability rather than permanent stabilisation. Recent research has recommended progressive surgical approaches for difficult tibial plateau fractures, and hybrid fixation methods outperformed external fixation alone. [18] suggest a hybrid fixation method that includes external stabilisation and internal fixation when plate fixation alone is insufficient due to substantial comminution or soft tissue damage.

Clinical Implications

Our findings allow us to advise orthopaedic surgeons on optimal repair methods. Plate fixation is best for most tibial plateau fractures (Schatzker Types II-V) due to its stability, functional results, and low comorbidities. Screw fixation is best for tiny split fractures (Type I and some Type II) because it preserves soft tissue and mobilises the patient quickly. External fixation should only be considered in serious soft tissue injuries when internal fixation is impossible. Avoid long-term use of external fixators to avoid infection and malunion. High-energy fractures (Type V and VI) may require hybrid fixation if soft tissue issues prevent primary plate fixation. This approach stabilises the patient and reduces soft tissue stress. These findings show that patient selection is crucial when choosing a fixation technique. Diabetes, osteoporosis, and smoking increase the chance of complications, thus individualised treatment strategies are essential for optimum results. Early mobility and physical therapy after surgery, especially with external or hybrid fixation, prevent joint stiffness and improve long-term function.

5. LIMITATIONS OF THE STUDY

This study provides useful information on tibial plateau fracture repair, however it has several limitations. A dataset of 100 patients was sufficient, but a larger multicenter study would improve generalisability and statistical analysis of fracture subtypes. This study followed patients for six months following surgery. We only considered short-term functional results, not delayed implant failures or post-traumatic arthritis. Since the study did not randomise fixing methods, surgeon preference or institutional protocols may have affected fracture treatment. This may have biassed comparisons of fixation methods. This study assessed results using Rasmussen's and Lysholm scores, but not patient-reported pain or quality of life. Therefore, it may be difficult to measure patient satisfaction with each repair approach.

Future Research Recommendations

To address these issues and improve our fixation techniques knowledge, future research should focus on these areas. A full picture of fixation's efficacy requires looking at long-term findings including functional status, osteoarthritis, and late implant issues. Arthroscopically aided fixation and minimally invasive plate osteosynthesis (MIPO) may improve long-term outcomes while conserving soft tissue, warranting further study. Studying fixation processes at other institutions with larger and more diverse patient groups is the best way to draw broad conclusions. Optimising implant selection for various fracture patterns necessitates more research into fixation device mechanical characteristics and performance under varied load conditions.

6. CONCLUSION

This study examined various tibial plateau fracture repairing methods based on functional outcomes, complication rates, and recovery time. Plate fixation is still optimal for most fractures (Schatzker Types II-V) due to its faster union times, better functional recovery, and more constant stability. Screw fixation reduced soft tissue disruption and accelerated recovery for simpler fractures (Types I and partial Type II). External fixation can temporarily stabilise severe soft tissue injuries, but it increases the risk of infections and implant failure. HDF, which combines external and internal procedures, may aid high-energy fracture patients who cannot use primary plate fixation. Results suggest considering fracture type, patient comorbidities, and soft tissue disorders when determining a treatment method. Early mobilisation and rehabilitation affected long-term functional outcomes. The findings, consistent with prior research, emphasise plate and screw fixation as key choices and caution against long-term external fixation. Although the study had some merit, it had significant problems, including a small sample size, a short follow-up, and no long-term effects like post-traumatic arthritis. Biomechanical assessments of fixation stability, minimally invasive trials, and long-term studies with larger populations should be the focus of future research. Arthroscopic-assisted fixation and customised implant designs may improve surgical methods. In conclusion, orthopaedic surgeons can use the study's clinical insights to better fixate tibial plateau fractures, emphasising the need for a customised strategy to get the best functional results with the fewest complications

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