



Research Article

Functional Analysis of Proximal Tibia Fracture Treated by Hybrid External Fixator

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ABSTRACT

Background: Proximal tibial fractures, often from high-energy trauma, involve intra-articular damage, comminution, and soft tissue compromise, posing management challenges. Hybrid external fixation, combining Ilizarov and AO systems, offers stable fixation, early mobilization, and adaptability. This study evaluates its effectiveness in functional recovery, soft tissue healing, and fracture union.

Aim: This study evaluates hybrid external fixator efficacy in proximal tibial fractures, focusing on function, healing, union, radiology, biomechanics, and indigenous clamps.

Results: Among 30 patients (mean age 42.36 ± 6.67), 46.67% were aged 30–40, and 53.33% were males. Schatzker type VI predominated (60%), with Gustilo-Anderson grade IIIA/IIIB equally common (43.33%). Bone grafting (33.33%) and debridement with skin grafting (30%) were frequent procedures.

Methods: On admission, patients received ABC assessment, POP splint immobilization, and radiographs with CT when required. Fractures were classified using Schatzker and Gustilo-Anderson systems. Soft tissues, neurovascular status, and compartment syndrome risk were evaluated. All patients underwent pre-anesthetic investigations and surgery under spinal or general anesthesia.

Conclusion: Hybrid external fixation proved reliable for complex proximal tibia fractures, predominantly from road traffic accidents. It ensured stable fixation, early mobilization, and satisfactory functional recovery. Despite complications like delayed union and pin tract infections, outcomes were favorable, highlighting its effectiveness across diverse patient groups.

Keywords: trauma encountered, multifragmentary fractures, proximal tibia fractures, hybrid external fixator, ligamentous injuries.

INTRODUCTION

Fractures of the proximal tibia are high-energy injuries that pose significant challenges due to intra-articular involvement, depression, and comminution. They usually result from high-impact trauma, such as road accidents or falls from height, often with soft tissue damage and compromised bone integrity. In elderly patients, these fractures typically follow low-energy trauma, like slips and falls, because of osteoporosis and reduced bone strength.¹ Usually caused by axial loading and angular forces, they result in impaction and metaphyseal comminution. Schatzker type I is most frequent, while complex types V and VI account for 15–30%.²

Soft tissue compromise with abrasions, open wounds, blisters, and ligamentous injury complicates proximal tibia fracture management. Even closed cases face wound healing issues. External fixation offers satisfactory outcomes, though maintaining fracture reduction remains a challenge.³

Bicondylar tibial plateau fractures—Schatzker types V and VI or OTA types C1–C3—generally follow high-energy trauma.⁴ These complex intra-articular injuries compromise joint congruity, cartilage, and adjacent structures. Common complications include compartment syndrome, soft tissue damage, knee instability, and secondary osteoarthritis (OA). Conservative management is rarely indicated.⁵

External fixation plays a critical role in trauma care, from damage control to definitive treatment.⁶ Though requiring close radiographic follow-up, its adaptability makes it suitable for diverse fracture patterns. Hybrid external fixation, a non-spanning system using thin wires (sometimes with olives), aids reduction, restores surfaces, and provides stability, especially when internal fixation is contraindicated. This method combines Ilizarov ring and AO rod fixator components with specialized clamps and rods, often supplemented by limited internal fixation.

Hybrid External Fixators offer unique biomechanics, described as “Solid Elastic”—rigid for stability yet permitting controlled micromotion that enhances callus formation.⁷

This study aims to evaluate the efficacy of Hybrid External Fixator in proximal tibial fractures, focusing on outcomes, healing, biomechanics, and indigenous clamps.

MATERIAL AND METHODS

Study Design: This hospital-based prospective study was conducted to analyze the functional outcomes of proximal tibial fractures treated using a hybrid external fixator. Prior approval was obtained from the Institutional Ethics Committee.

Duration of Study: The study was conducted July 2023–December 2024 at J.L.N. Medical College, Ajmer, Rajasthan.

Source of Data: The study included patients with proximal tibial fractures presenting to Orthopaedics, J.L.N. Medical College, Ajmer.

Inclusion Criteria: it included patients above 18 years, either sex, with periarticular proximal tibial fractures having severe soft tissue injury, including closed Schatzker type V–VI and open Gustilo-Anderson grade IIIA–IIIB fractures.

Exclusion Criteria: it included patients below 18 years, those with associated neurovascular injuries, or individuals medically unfit for undergoing surgical management.

Method: Upon admission, patients were assessed for airway, breathing, and circulation, and the injured limb was immobilized with a POP splint. After stabilization, radiographs of the knee, leg, and ankle were obtained, and fractures classified using Schatzker (closed) and Gustilo-Anderson (open) systems. Soft tissue and neurovascular status were evaluated, with monitoring for compartment syndrome. AP/lateral radiographs and CT were performed as needed, and pre-anesthetic investigations completed before surgery under spinal or general anesthesia.

Routine Investigations: Routine investigations included complete blood count, PT-INR, random blood sugar, renal function tests, and serum electrolytes. Preoperative assessment also involved electrocardiogram (ECG), chest X-ray, and X-ray of the affected joint. Additionally, viral markers were evaluated, including HIV (non-reactive/reactive) and HBsAg (non-reactive/reactive), to ensure comprehensive patient evaluation before surgery.

Follow-up: Patients were followed radiographically every three weeks for the first three months, and thereafter once monthly for a total follow-up duration of nine months.

RESULT AND OBSERVATIONS

Among 30 patients, most were aged 30–40 years (14, 46.67%) and 41–50 years (13, 43.33%), with only 3 (10%) in 51–60 years (mean age 42.36 ± 6.67). Males slightly predominated (16, 53.33%). Schatzker type 6 fractures occurred in 18 (60%) patients. Severe open injuries (GA 3A/3B) affected 13 each (43.33%). Bone grafting (10, 33.33%) and debridement with split-skin grafting (9, 30%) were most frequent.

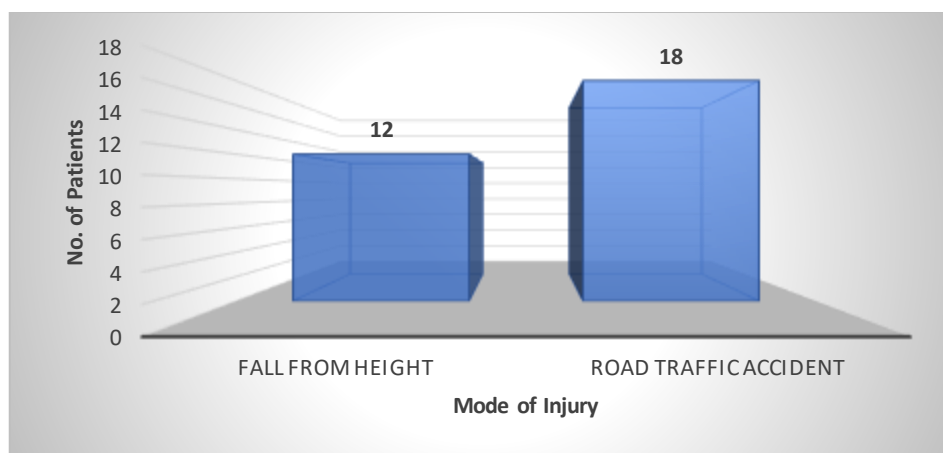


Figure 1: Distribution of patients according to Mode of Injury.

Among the 30 patients, road traffic accidents were the leading cause of injury, accounting for 18 cases (60%), while falls from height were responsible for 12 cases (40%). This distribution highlights the predominance of high-energy trauma mechanisms, particularly from vehicular accidents.

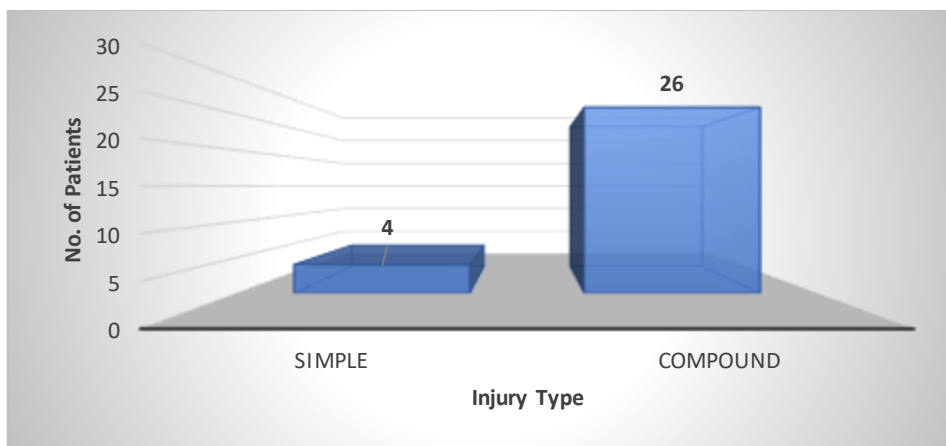


Figure 2: Distribution of patients according to Injury Type.

Among the 30 patients, compound fractures were predominant, accounting for 26 cases (86.67%), while only 4 patients (13.33%) had simple fractures. This distribution highlights the high incidence of severe, open injuries in the cohort.

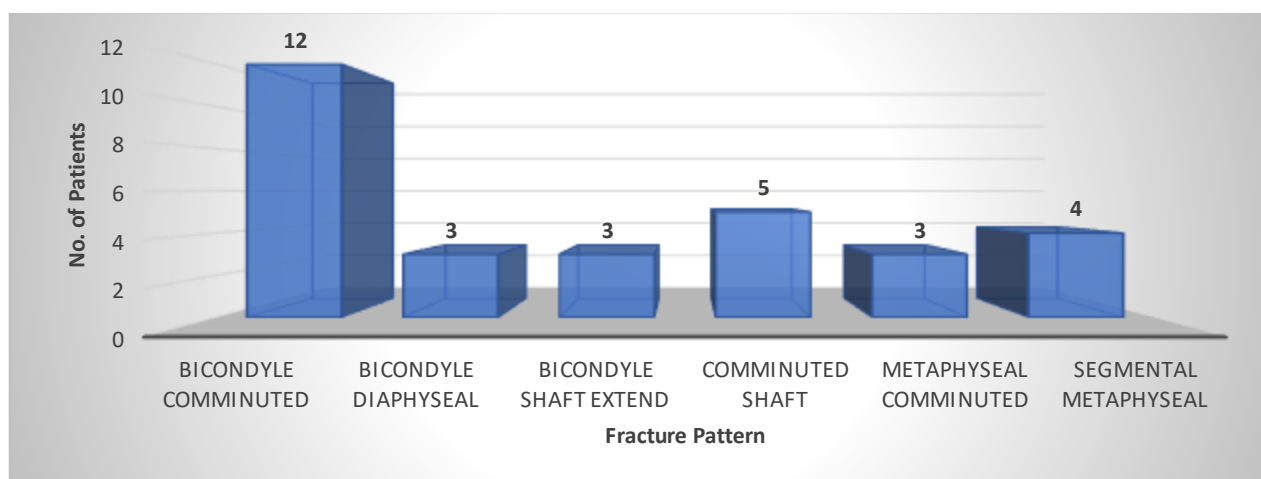


Figure 3: Distribution of patients according to Fracture Pattern.

Among 30 patients, bicondylar comminuted fractures were most common (40%), followed by comminuted shaft (16.67%) and segmental metaphyseal (13.33%), with other complex fracture patterns accounting for the remainder.

Table 1: Distribution of Patients According to Pre-operative Parameter (Gender and Age).

parameter	Pre-op angulation			
	Subgroup	Mean	SD	P-Value
Gender	Female	11.21	3.23	0.35
	Male	12.43	3.86	
Age Distribution	30–40 years	13.64	3.02	0.01
	41–50 years	9.76	3.49	
	51–60 years	12.66	1.15	

The mean pre-operative angulation was slightly lower in females ($11.21^{\circ} \pm 3.23$) than males ($12.43^{\circ} \pm 3.86$), with no significant difference ($p=0.35$). Across age groups, angulation varied significantly ($p=0.01$), highest in 30–40 years ($13.64^{\circ} \pm 3.02$), followed by 51–60 years ($12.66^{\circ} \pm 1.15$) and lowest in 41–50 years ($9.76^{\circ} \pm 3.49$).

Table 2: Distribution of patients according to Post-operative Recovery Parameters.

Post-operative Recovery Parameters	Age Distribution (in years)						P-Value
	30-40		41-50		51-60		
	Mean	SD	Mean	SD	Mean	SD	
PWB	7.14	2.14	7.15	2.47	8	1.73	0.8
FWB	11.85	2.28	12.3	1.97	14.66	0.57	0.12
Fixator duration	9.14	2.14	9.76	2.24	10	1.73	0.69
ROM 1M	43.57	12.77	45.38	9.67	43.33	11.54	0.9
ROM 2M	73.57	12.77	73.07	6.3	73.3	11.54	0.9
ROM 3M	106.42	16.91	106.15	9.6	103.33	11.54	0.93

Post-operative recovery across age groups showed minimal variation. PWB (7.14–8 days, $p=0.8$), FWB (11.85–14.66 days, $p=0.12$), and fixator duration (9.14–10 days) were consistent. ROM improved progressively at 1, 2, and 3 months, with no significant intergroup differences (all $p>0.9$).

Table 3: Distribution of patients according to Post-operative Recovery Parameters.

Post-operative Recovery Parameters	Gender				P-Value
	Female		Male		
	Mean	SD	Mean	SD	
PWB	7.14	2.71	7.31	1.74	0.83
FWB	12	2.9	12.62	1.2	0.43
Fixator duration	9.28	2.72	9.68	1.44	0.61
ROM 1M	49.28	9.97	40	10.32	0.01
ROM 2M	77.85	8.92	69.37	9.28	0.01
ROM 3M	111.42	12.92	101.25	12.04	0.03

Post-operative recovery showed minimal gender-based differences in PWB, FWB, and fixator duration ($p>0.4$). However, females demonstrated significantly better ROM at 1, 2, and 3 months ($p=0.01$, 0.01 , 0.03), highlighting superior functional recovery compared to males, despite similar weight-bearing and fixator outcomes.

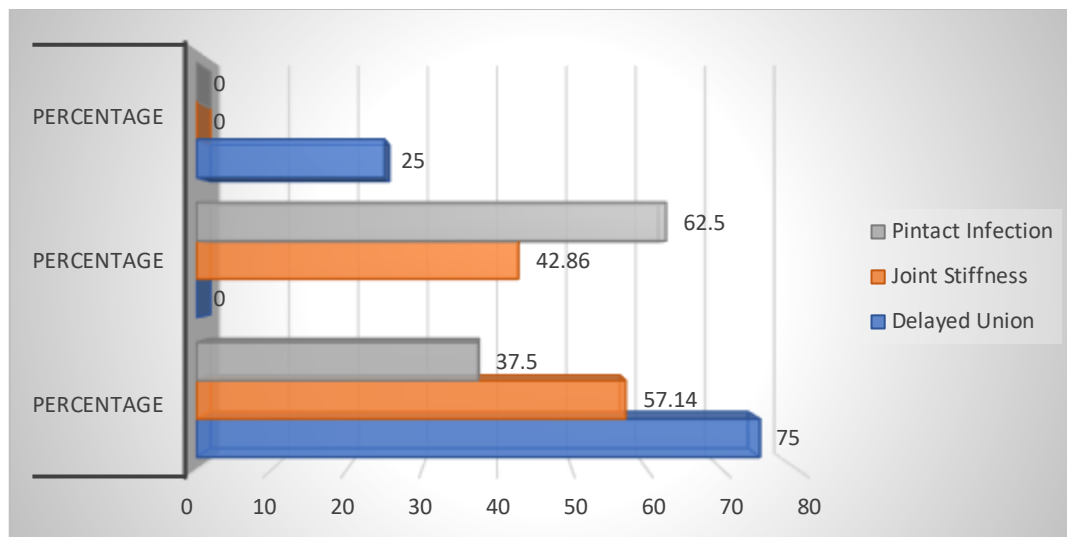


Figure 4: Distribution of patients according to Complications.

Among 30 patients, complications were most common in the 30–50 age group. Delayed union (4 cases) occurred mainly in 30–40 years, while stiffness (7) and pin tract infections (8) predominated in 41–50 years. Eleven patients reported no complications, with only 10% affected in 51–60 years.

DISCUSSION

Fractures of the proximal tibia, often from road accidents or falls, are difficult to manage, especially Schatzker types V and VI with soft tissue compromise. External fixators aid reduction through ligamentotaxis, olive wires, and mini-incisions, ensuring stability, early mobilization, and improved outcomes, as highlighted by previous studies.⁸

In this series, road traffic accidents were the leading cause (18, 60%), followed by falls (12, 40%), reflecting high-energy trauma. **Subash Y et al⁹** reported 80% RTAs and 20% falls, while **Thangamani S K et al¹⁰** noted 92.6% RTAs, reinforcing vehicular trauma as the predominant cause.

In the present study, 86.67% of cases were compound fractures, indicating high-energy trauma with severe soft tissue damage. Similarly, **Juneja J et al¹¹** reported 62% compound injuries, aligning with our findings. In contrast, **Subash Y et al⁹** observed 80% closed fractures, highlighting variability due to trauma mechanisms and demographics.

In the present study, bicondylar comminuted fractures were most common (40%), reflecting complex injury patterns. Similarly, **Subash Y et al⁹** reported 63.3% bicondylar and 36.7% metaphyseal-diaphyseal fractures, while **Kumar V et al¹²** noted 52.6% bicondylar with significant comminution, underscoring the prevalence of multifragmentary intraarticular injuries in high-energy trauma.

In the present study, the mean age was 42.36 ± 6.67 years, with most patients between 30–50 years. **Subash Y et al⁹** similarly reported an average age in the early–mid 40s. Regarding gender, males slightly predominated (53.33%), a trend also noted by **Juneja J et al¹¹** with 79% males.

In this study, post-operative recovery metrics like PWB, FWB, and fixator duration showed minimal variation across age and gender groups. **Shrimal A et al¹³** reported fixator durations most frequently between 12–14 days. Similarly, **Subash Y et al⁹** emphasized comparable recovery outcomes, reinforcing that age and gender exert limited influence on rehabilitation. In this study, post-operative ROM improved steadily across age groups with no significant differences. **Subash Y et al⁹** similarly reported average knee ROM of 0–100° with occasional extensor lag, while **Shrimal A et al¹³** documented higher flexion in open fractures, with an overall mean ROM of $115.52^\circ \pm 13.32^\circ$.

In this study, complications included delayed union, joint stiffness, and pin tract infections, mostly among patients aged 30–50 years. **Juneja J et al¹¹** reported 19% complications, including knee stiffness and delayed union. Similarly, **Thangamani S K et al¹⁰** noted 56% without complications, with pin tract infection being most frequent (18%).

CONCLUSION

Hybrid external fixator proved effective for complex proximal tibia fractures, mostly from road traffic accidents. Predominantly managing open bicondylar injuries, it ensured stable fixation, early mobilization, and consistent recovery across age and gender. Despite complications like pin tract infections and delayed union, outcomes remained favorable, with satisfactory function and manageable soft tissue challenges.

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