ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 07 | July - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ASSESSMENT OF FUNCTIONAL OUTCOMES AFTER MANAGEMENT OF COMMINUTED PROXIMAL TIBIAL METAPHYSEAL FRACTURES USING A CIRCULAR EXTERNAL FIXATOR

Orthopaedics

Dr Vidhu Goel* Junior Resident 3*Corresponding Author

Dr Nikhil Kumar Junior Resident 3

Dr Nipun Patel Senior Resident

Dr Deepak Yadav Senior Resident

ABSTRACT

Background: High-speed road traffic accidents have increased the incidence of complex proximal tibial metaphyseal fractures. Management aims to restore limb alignment, maintain stability, preserve soft tissues, and achieve good functional recovery. Circular external fixation provides stable fixation with minimal soft tissue disruption. **Materials and Methods:** This prospective observational study included 24 patients with comminuted proximal tibial metaphyseal fractures treated at the Department of Orthopaedics, Rohilkhand Medical College and Hospital, between March 2024 and August 2025. Functional outcomes were assessed using the Knee Society Score (KSS) at 6 weeks, 3 months, and 6 months postoperatively. **Results:** All patients were male. The left tibia was involved in 15 patients (62.5%) and the right tibia in 9 patients (37.5%). The mean age was 48.2 years, ranging from 25 to 77 years. Road traffic accidents were the commonest mode of injury. Based on KSS, 10 patients (41.67%) had excellent outcomes, 11 (45.83%) had good outcomes, and 3 (12.50%) had fair outcomes. No poor results were observed. Pin tract infection occurred in 3 patients (12.5%) and was managed with local care and oral antibiotics. One patient (4.17%) developed non-union. **Conclusion:** Circular external fixation is an effective and reliable method for managing complex proximal tibial metaphyseal fractures. It provides stable fixation, maintains alignment, allows early mobilization, and has an acceptable complication rate.

KEYWORDS

Proximal Tibial Fractures; External Fixators; Ilizarov Technique; Tibial Fractures; Treatment Outcome.

INTRODUCTION

In recent years, high-speed vehicle accidents have increased the incidence of complex proximal tibial metaphyseal fractures. These injuries are usually caused by high-energy trauma, particularly bending forces acting on the metaphyseal region of the upper leg.

Treatment remains technically challenging because maintaining proper alignment is difficult due to the difference in medullary canal size between the metaphyseal and diaphyseal segments. Preventing coronal, sagittal, and rotational deformities, along with restoring normal limb length, are essential goals during fixation.

Treatment decisions depend on the patient's age, general health, fracture pattern, displacement, soft tissue condition, associated injuries, and neurovascular status. Conservative methods such as cast or brace immobilization may reduce hospital stay but are associated with higher rates of malunion and other complications. Internal fixation provides anatomical reduction and stable fixation but may further compromise soft tissues, increasing the risk of wound problems, infection, and implant exposure.

Circular external fixation offers a minimally invasive option for definitive management. Tensioned wires provide stable fixation in cancellous metaphyseal bone and support the diaphyseal segment. In fractures extending into the tibial plateau, olive wires in the Ilizarov system help achieve controlled compression across fragments.

Because reduction is achieved with minimal surgical exposure, soft tissue damage and blood loss are reduced. Circular fixators also allow postoperative correction of alignment and controlled compression or distraction when required. Their stability permits early joint mobilization and weight-bearing, while ligamentotaxis helps achieve fracture reduction through gradual distraction.

Accordingly, this study assessed the functional outcomes of high-energy comminuted proximal tibial metaphyseal fractures managed with circular external fixation techniques, including Ilizarov, JESS, and hybrid systems.

MATERIAL AND METHODS

This prospective observational study included 24 patients with comminuted proximal metaphyseal tibial fractures treated at the Department of Orthopaedics, Rohilkhand Medical College and Hospital, between March 2024 and August 2025.

On admission, all patients were initially managed with calcaneal traction, limb elevation, and regular distal neurovascular monitoring. Open fractures underwent immediate wound irrigation and thorough surgical debridement before definitive stabilization. Postoperatively, all patients received prophylactic intravenous antibiotics, including an aminoglycoside and a cephalosporin, for at least three days. Timing of surgery was based on soft tissue condition and general patient status, and written informed consent was obtained from all patients.

Preoperative evaluation included anteroposterior and lateral X-rays of the proximal tibia, 3D CT scan of the knee joint, and routine pre-anesthetic assessment. Surgery was performed under spinal or general anesthesia without tourniquet use.

Articular fragments, when present, were reduced percutaneously under image intensifier guidance using large reduction forceps. Limb alignment was restored by closed manipulation and longitudinal traction. In selected cases, depressed articular fragments were elevated through a small anteromedial cortical window. For JESS fixation, one or two cancellous condylar lag screws were used when articular depression exceeded 3 mm; fractures with minimal intra-articular displacement did not require lag screws.

Application of JESS: Three smooth 3 mm Kirschner wires were inserted into the proximal tibial condylar fragment through safe zones at least 1.5 cm from the joint surface and attached to two concentric half rings. Three additional 3 mm Kirschner wires were passed through the tibial shaft and connected to the proximal assembly. Manual traction and ligamentotaxis were used to reduce the metaphyseal fragments and correct sagittal and coronal angulation. Reduction was confirmed under image intensifier, and the frame was secured with connecting rods and link joints to form a stable external fixation construct.

[Fig-1]: Showing components of JESS assembly.

Application of Hybrid External Fixator: Beaded olive wires were inserted through safe zones in the proximal tibia, keeping at least 1.5 cm away from the articular surface. After tensioning, the wires were fixed to a suitably sized semicircular Ilizarov ring using link joints, providing stable fixation of the proximal fragment. For distal stabilization, two to three anteroposterior Schanz screws were inserted into the tibial diaphysis and connected with a tubular rod assembly, which was linked to the proximal ring. Fracture reduction was achieved through controlled distraction and manual adjustment to restore limb length and correct coronal and sagittal alignment. After confirmation under image intensifier, the construct was secured with connecting rods and universal clamps to form a rigid and stable external fixation system.

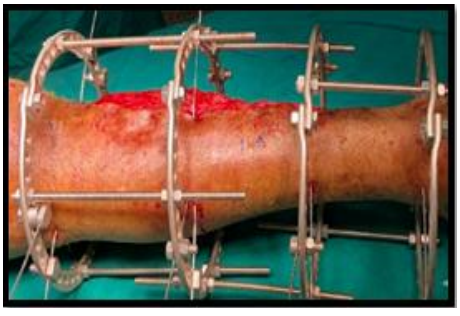
[Fig-2]: Showing components of Hybrid assembly.

Application of Ilizarov: Beaded olive wires were inserted through safe anatomical pathways, at least 1.5 cm below the joint surface, and connected to an appropriately sized circular Ilizarov frame.

Based on fracture type and degree of comminution, one to three additional circular rings were applied along the tibial diaphysis. Each ring was fixed with two to three tensioned wires, and all rings were connected using threaded steel rods to form a stable multiplanar construct.

Additional olive wires were used when required to correct residual fragment displacement. All wires were tensioned to approximately 110 kg with a calibrated tensioning device to improve frame stability and maintain fracture reduction.

.



[Fig-3]: Showing components of Illizarov assembly.

Starting from the first postoperative day, patients began structured physiotherapy with passive and active-assisted knee range-of-motion exercises. Daily pin tract care was performed using hydrogen peroxide and povidone-iodine solution. Touch-down weight bearing was allowed until radiological evidence of fracture union was achieved.

Patients were followed up at 6, 12, and 24 weeks postoperatively. At each visit, fracture healing was assessed clinically and radiologically, complications were recorded, and functional outcome was evaluated using the Knee Society Score (KSS).

The external fixator was removed after clinical and radiological union, following which full weight bearing was permitted. After frame removal, patients used a removable long leg brace temporarily during ambulation while progressing toward unrestricted activity.

RESULT

Between January 2024 and June 2025, 24 patients with proximal tibial fractures classified as AO-41-A3, AO-41-C2, and AO-41-C3 were admitted and treated at Rohilkhand Medical College and Hospital.

All patients were male (100%). The left tibia was involved in 15 cases (62.5%) and the right tibia in 9 cases (37.5%). The mean age was 49.5 years, ranging from 26 to 75 years, with most patients aged 45 years or older. Road traffic accidents were the primary cause of injury (n=15), followed by motorcycle falls (n=9).

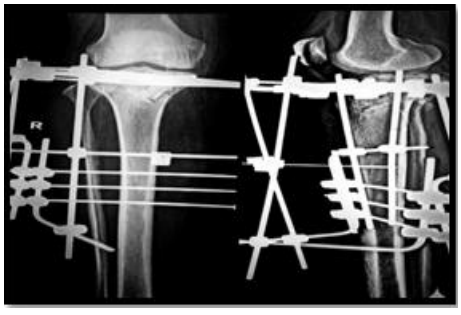
Open fractures were present in 9 patients (37.5%) and were classified by the Gustilo-Anderson system as Grade II (n=2), Grade IIIA (n=3), and Grade IIIB (n=4). Associated fibular fractures were seen in 13 patients (54.2%), and associated head injuries occurred in 2 patients (8.3%). All patients had some degree of soft tissue damage; localized swelling, contusions, or blisters were seen in 7 patients (29.2%). Compartment syndrome was identified in 2 patients (8.3%), requiring immediate fasciotomy and temporary stabilization with a knee-spanning external fixator before definitive hybrid external fixation.

Definitive surgery was performed after an average of 7 days from admission, ranging from 1 to 14 days. No major surgical complications occurred, no blood transfusions were required, and tourniquets were not used. The average postoperative hospital stay was 5 days, ranging from 2 to 15 days.

At final follow-up, mean knee flexion was 115°, ranging from 90° to 125°. No significant limb shortening or angular deformity exceeding 5° in the coronal or sagittal planes was observed. Functional outcome was assessed using the Knee Society Score (KSS), with a mean score of 79.04, ranging from 65 to 100. KSS outcomes were excellent in 9 patients, good in 11 patients, fair in 4 patients, and poor in 0 patients.

Complications were limited to pin tract infection in 2 patients (8.3%) treated with the Ilizarov construct, which resolved with local care. One patient (4.2%) treated with a hybrid external fixator developed non-union at 6 months and was subsequently managed with internal plating and bone grafting.

[Fig-4]: Preoperative X-ray of a patient (A)



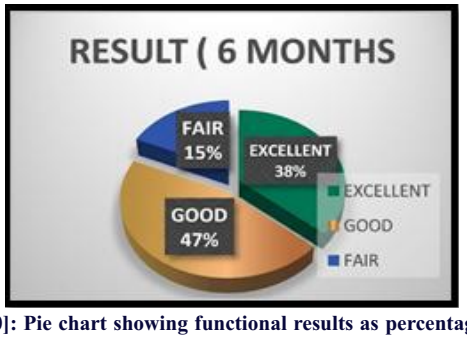
[Fig-5]: Postoperative X-ray of patient (A) treated with JESS at 8 weeks

[Fig-6]: Preoperative X-ray of a patient (B)

[Fig-7]: Postoperative X-ray of patient (B) treated with Hybrid external fixator.

[Fig-8]: Preoperative X-ray of a patient (C)

[Fig-9]: Postoperative X-ray of patient(C) treated with Illizarov external fixator.



[Fig-10]: Pie chart showing functional results as percentage at 6 months.

DISCUSSION

Treating proximal metaphyseal tibial fractures is difficult because recovery depends on soft tissue condition, degree of comminution, and articular surface involvement. The main goals are anatomical alignment, stable fixation for early movement, and preservation of blood supply to bone and soft tissues.

Limitations of Internal Fixation:

Standard methods such as dual plating require large incisions, which may damage compromised soft tissues and strip periosteum from bone fragments. This can lead to tissue necrosis, delayed healing, hardware exposure, deep infection, and osteomyelitis. Even less invasive plating methods like LISS may cause alignment problems or implant irritation.

Advantages of External Fixation:

The Canadian Orthopaedic Trauma Association noted that external fixation may provide fewer early complications and better functional outcomes than internal fixation. It stabilizes fractures with minimal disruption of blood supply, which is important in severe soft tissue injury.

Previous studies support these findings. Zeman et al. reported "very good" to "excellent" results in 58% of hybrid external fixation cases. Aggarwal et al. found "good" to "excellent" outcomes in 86%, while Gupta and Sunil reported "good" or "excellent" results in 19 of 23 patients. Fine-wire systems such as JESS preserve bone blood supply and provide strong periarticular fixation. Tensioned olive wires help in deformity correction and controlled fragment compression.

At least three out-of-plane wires are recommended for stability, as two-wire constructs have shown loss of reduction. In this study, stable six-point fixation was achieved using three proximal wires, sometimes supplemented with cancellous screws for articular compression.

Study Results and Complications:

Hybrid external fixation was used in 10 patients, with 40% excellent and 40% good outcomes, and one non-union. JESS was used in 8 patients, with 75% excellent and 25% good outcomes. Ilizarov fixation was used in 4 patients, with 50% good and 50% fair outcomes, and two pin tract infections. Wires were placed at least 15 mm from the joint to prevent septic arthritis. Although pin tract infection may occur, careful planning and knowledge of anatomical safe zones are essential.

Overall, circular external fixation is an effective, minimally invasive option for complex tibial metaphyseal fractures, although further comparative studies are needed.

CONCLUSION

Circular external fixation is a reliable and effective method for managing complex comminuted proximal metaphyseal tibial fractures. It provides stable fixation, restores anatomical alignment, permits early joint mobilization, allows effective soft tissue management, and has an acceptable complication profile, making it a useful treatment option where internal fixation may carry higher risks.

REFERENCES

1. Egol KA, Tejwani NC, Capla EL, Wolinsky PL, Koval KJ. Staged management of high-energy proximal tibia fractures (OTA types 41): the results of a prospective, standardized protocol. Journal of Orthopaedic trauma. 2005; 19(7):448-55.
2. Gupta A, Anjum R, Singh N, Hackla S. Outcome of distal both bone leg fractures fixed by intramedulary nail for fibula & MIPPO in tibia. Archives of Bone and Joint Surgery. 2015 Apr;3(2):119.
3. Rockwood and Green's Textbook of orthopaedic fractures in adults, sixth edition; volume 2; 2003-5
4. Young M, Barrack RL. Complications of internal fixation of tibial plateau fractures. Orthopaedic review. 1994 Feb;23(2):149.
5. Yilmaz E, Belhan O, Karakurt L, Arslan N, Serin E. Mechanical performance of hybrid Ilizarov external fixator in comparison with Ilizarov circular external fixator. Clinical Biomechanics. 2003 Jul 1;18(6):518-22.
6. Fleming B, Paley D, Kristiansen T, Pope M. A biomechanical analysis of the Ilizarov external fixator. Clinical Orthopaedics and Related Research®. 1989 Apr 1;241:95-105.
7. Babis GC, Evangelopoulos DS, Kontovazenitis P, Nikolopoulos K, Soucacos PN. High energy tibial plateau fractures treated with hybrid external fixation. Journal of orthopaedic surgery and research. 2011 Dec 1;6(1):35.
8. Zeman J, Matejka J. Use of a hybrid external fixator for treatment of tibial fractures. Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca. 2005;72(6):337.
9. Mohd. Zahid, Sherwani MKA, Yasir Salam Siddiqui, Mazhar Abbas, Naiyer Asif, Amir Bin- The role of the Jess (Joshi's External Stabilization System) fixator in the management of tibial plateau fractures which are associated with severe soft tissue injuris. Journal of Clinical and Diagnostic Research 2010;4:3356-3361.
10. Hall JA, Beuerlein MJ, McKee MD. Open reduction and internal fixation compared with circular fixator application for bicondylar tibial plateau fractures: Surgical technique. JBJS. 2009 Mar 1;91(Supplement_2_Part_1):74-88.
11. Subasi M, Kapukaya A, Arslan H, Ozkul E, Cebesoy O. Outcome of open comminuted tibial plateau fractures treated using an external fixator. Journal of Orthopaedic Science. 2007 Jul 1;12(4):347-53
12. Babis GC, Evangelopoulos DS, Kontovazenitis P, Nikolopoulos K, Soucacos PN. High energy tibial plateau fractures treated with hybrid external fixation.J OrthopSurg Res. 2011;6:35-41
13. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clinical orthopaedics and related research. 1989 Nov 1(248):13-4.
14. Kim PH, Leopold SS, Gustilo-Anderson Classification, 2012, Clin Orhtop Relat. Res.470(11): 3270-3274.
15. Ruffolo MR, Gettys FK, Montijo HE, Seymour RB, Karunakar MA. Complications of high-energy bicondylartibial plateau fractures treated with dual plating through 2 incisions. J Orthop Trauma. 2015;29:85-90.
16. Jiang R, Luo CF, Wang MC, Yang TY, Zeng BF. Acomparative study of less invasive stabilization system (LISS) fixation and two-incision double plating forthe treatment of bicondylartibial plateau fractures. Knee. 2008;15:139-43
17. Canadian Orthopaedic Trauma Society. Open reduction and internal fixation compared with circular fixator application for bicondylartibial plateau fractures. Results of a multicenter, prospective, randomized clinical trial. J Bone Joint Surg Am. 2006;88:2613-23.
18. Hall JA, Beuerlein MJ, McKee MD. Open reduction and internal fixation compared with circular fixator application for bicondylartibial plateau fractures. Surgical technique. J Bone Joint Surg Am. 2009;91:74-88.
19. Zeman J, Matejka J. Use of a hybrid external fixator for treatment of tibial fractures. Acta Chir Orthop Traumatol Cech 2005;72(6):337-43.

20. Aggarwal AK, Nagi ON. Hybrid external fixation in periarticular tibial fractures. Good final outcome in 56 patients. Acta Orthop Belg. 2006 Aug;72(4):434-40.
21. Gupta SV, Sunil G. Management of tibial metaphyseal fractures by hybrid external fixator. Open Journal of Orthopedics. 2014 Mar 5;2014.
22. Kataria H, Sharma N, Kanojia RK. Small wire external fixation for high-energy tibial plateau fractures. J Orthop Surgery. 2007;15:137–43.
23. Watson JT, Coufal C. Treatment of complex lateral plateau fractures using Ilizarov techniques. Clinical Orthopaedics and Related Research (1976-2007). 1998 Aug 1;353:97-106.