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Indian Journal of Orthopaedics Surgery

Journal homepage: <https://www.ijos.co.in/>

Original Research Article

Hybrid external fixator as primary fixation in the management of proximal tibia fractures in low resource setting –our experience

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ARTICLE INFO

Article history:

Received 05-07-2021

Accepted 20-05-2022

Available online 15-06-2022

Keywords:

Hybrid external fixator

Proximal tibia fractures

ABSTRACT

Background: Tibial plateau fractures consists of 1% of all fractures. The goals in management of such fractures are anatomical reduction and maintaining joint congruity, stable fixation of fracture fragments, restoration of joint alignment with minimal soft tissue dissection and early mobilization.**Aim and Objective:** The purpose of the study is to highlight the technique and assess the utility and functional outcome of hybrid external fixation in periarticular fractures of tibia.**Methodology:** A prospective study to determine the functional and radiological outcome of hybrid external fixation in management of periarticular fractures of proximal tibia which included both open (Gustilo Anderson IIIA & B) and closed injuries (Shatzker 5 & 6) at our institution.**Results:** 81 patients with 36 months follow up showed excellent and good outcome in 88% with Rasmussen's knee score using hybrid external fixator as primary modality of treatment with less than 20% of cases requiring additional procedures and all cases united and there was no case of non union.**Conclusion:** The hybrid external fixator provides proper osseous stability without compromising the soft tissue and allows early mobilization which results in good functional outcome.This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](https://creativecommons.org/licenses/by-nc-sa/4.0/), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.For reprints contact: reprint@ipinnovative.com

1. Introduction

Proximal tibia fractures are commonly associated with high energy trauma and soft tissue injury which makes it more difficult to manage.¹

Management options available are:

1. Conservative management with skeletal traction
2. Open reduction and internal fixation with plates
3. External fixation (uniplanar)
4. Hybrid external fixation
5. Ilizarov ring fixation

In previous decades, these periarticular fractures were managed with uniplanar external fixation with spanning the knee joint leads to high rate of complication such as joint stiffness, pin tract infection, deformity etc.²Although open reduction and internal fixation with plating becomes the gold standard and biomechanically more stable option, it needs extensive soft tissue dissection and high chance of post-operative soft complications.^{3–5}More recently the use of hybrid external fixation was greatly emphasized for the management of periarticular fractures with soft tissue injuries.⁶

The Hybrid External Fixation based on the combination of ring construct in the periarticular region and uniplanar external fixator in the shaft provides stable fixation and spares the joint and allows early mobilization. The hybrid

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construct provides the stability of an ilizarov construct and at the same time is easy to apply and saves valuable intra operative time which reduces the chance of infection drastically

2. Aim and Objective

To analyse the efficacy of Hybrid external fixator in achieving anatomical reduction and stable fixation and early return to function in periarticular tibial fractures.

3. Materials and Methods

This is a prospective study conducted from June 2018 to May 2021.

Total 81 patients with proximal and distal tibia fractures who were admitted in Government Stanley medical college and hospital were included after getting written informed consent. This study also documents the intra operative and post-operative complication. It is a prospective study to determine the functional and radiological outcome of hybrid external fixation in management of periarticular fractures of proximal Tibia.

3.1. Inclusion criteria

1. Patients above 18 years of age on either sex.
2. All periarticular fractures of proximal tibia with severe soft tissue injury where primary internal fixation was not feasible.
3. Closed Tibial plateau fractures (Schatzker 5 and 6)
4. Open fractures (Gustillo-Anderson IIIA & B).

3.2. Exclusion criteria

1. Patients age below 18 years.
2. Patients having associated neurovascular injury.
3. Patients medically unfit for surgery.

3.3. Pre operative protocol

After the admission of patient in trauma ward, initial survey of Airway, Breathing, Circulation was assessed. The injured limb was temporarily immobilized with Thomas splint or POP. After stabilising the general condition and assessing other systems, radiographs of knee, leg, ankle were obtained. CT scans of knee and ankle were taken. Fracture patterns are evaluated and classified by using Schatzker classification and Open fractures are classified under Gustillo Anderson classification. Conditions of soft tissue were evaluated in high energy trauma. Patients were closely monitored for the development of compartment syndrome which is more common in proximal tibia fractures.

Plain radiographs of KNEE AND ANKLE- AP and Lateral views along with Computed tomography if required were taken for the cases.

Neurovascular status of the injured limb were assessed. Vascular, Plastic surgeon's opinion were obtained if necessary. All basic investigations required for anaesthetic fitness are worked up and all cases were done under spinal anaesthesia.

3.4. Surgical technique

The position of the patient was supine with a pillow or sand bag under the distal thigh for proximal tibia fracture a.

For open fractures, thorough wound wash were given. The fracture reduction (indirect reduction) with traction-counter traction by ligamentotaxis principle were done under C-Arm fluoroscopy guidance.

After reduction the periarticular fragments were held with pointed reduction clamp placed percutaneously and secured with ilizarov wire. 1.8 mm bayonet wire were applied in the safe zone, 2 cm distal to the joint line.

Olive wires have small beads called "olives". While tensioning the wire olive can pull against a bone fragment. These Olive wires were used, whenever the interfragmentary compression was needed by applying it perpendicular to the fracture plane.

The wire inserted manually by piercing the skin until it hitches the bone cortex. Then it should be drilled. Once the wire passes the outer cortex, then it was hammered to pass through the soft tissue.

First bayonet wire was passed parallel to the joint line from lateral to medial. 5/8 ring or full ilizarov ring of appropriate size was connected and the wires were tensioned. In similar way, another wire was applied within the safe zone with minimum of 30 to 60-degree angulation between two wires. If any skin tethering or stretching by the wire, it should be released by a small incision.

If necessary, one or two additional drop wires can be applied either above or below the ring to increase the stability of the construct.

3.5. Frame assembly

The metaphysio- diaphyseal alignment were corrected with longitudinal traction under C-Arm fluoroscopy guidance. The Schanz pin uniplanar fixator assembly were coupled with the ring assembly with connecting clamp. Reduction was finally checked and frame was tightened.

For additional stability, another connecting rod was connected diagonally between the Schanz pin and the ring assembly.

3.6. Post operative protocol

Day 0:

1. Post-operative antibiotics (intravenous), analgesics, iv fluids.
2. Limb elevation.

3. Monitoring for compartment syndrome
4. Vitals monitoring.
5. Post-operative radiography.

Day 1:

1. Pin site dressing and wound dressing (for open fracture).
2. Continue antibiotics and analgesics.

Day 2:

Physiotherapy

1. Passive knee and ankle mobilization exercise started.
2. Antibiotics, analgesics and limb elevation.

Day 5:

1. Mobilisation started with walker support- non weight bearing.
2. Intravenous antibiotics was stopped and switch over to oral antibiotics and analgesics.

Day 7:

1. Closed fractures without soft tissue complications can be discharged and reviewed in OPD.
2. For open fracture and with soft tissue injury, plastic surgeon opinion was obtained and soft tissue cover were given if necessary.

3.7. Follow up

Patients were followed up with radiographs every 3 weeks up to 3 months and then monthly once for 24 months.

Clinical and Radiological assessment were done to look for the fracture union. Functional outcomes were recorded with RASMUSSEN's scoring system.

Rasmussen's functional knee score functional score included the following parameters (pain, limitation of activity, range of motion, quadriceps power) whereas the radiological aspect evaluates articular depression, intercondylar widening and metadiaphyseal angulation, each having a maximum score of 6 and a minimum of 0. Hence, an excellent Rasmussen score would be 9-10, Good 7-8, Fair 5-6 and poor if the score was <5.

Patient were advised to continue knee and ankle mobilization. Frame were checked for stability and pin site infections.

After achieving callus formation around fracture site and no pain at the fracture site, dynamisation of the hybrid fixator was done by loosening the clamps and allowed full weight bearing. After 2 to 3 weeks of dynamisation. Fixator was removed and patellar tendon bearing cast was applied.

The primary advantage with the hybrid external fixator is that patient is allowed to weight bear while the fracture is still in healing stage which justifies its role in early mobilization.

4. Results

Out of the 81 patients majority were in the age group of 40-50 years (37%) and most of them were men (82%) which co relates well to the fact that most of these high velocity injuries are common among men in productive age group.

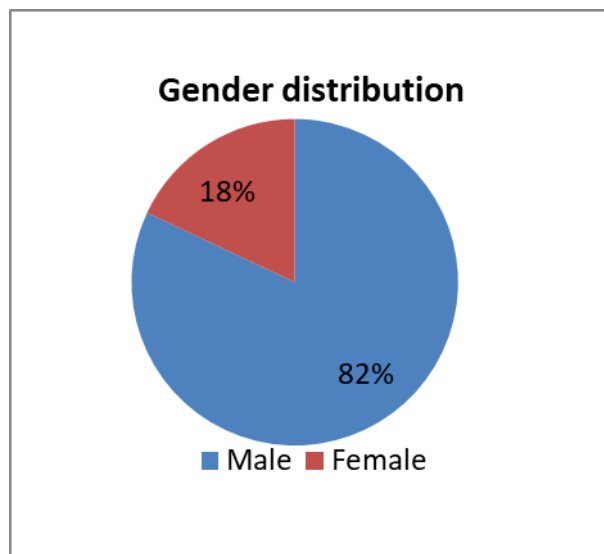


Fig. 1: Gender distribution

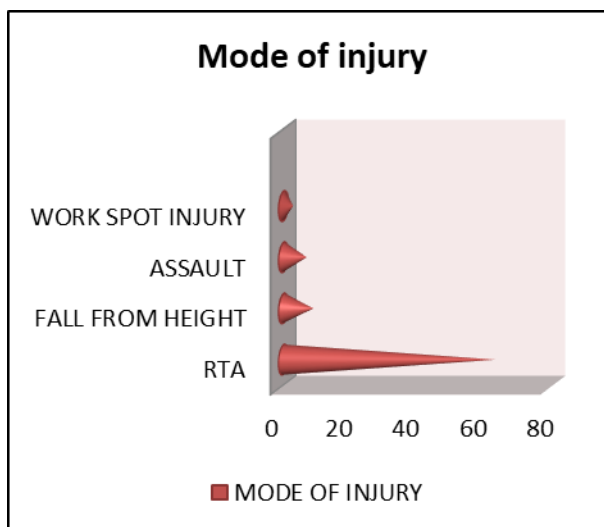


Fig. 2: Mode of injury

Table 1: Frequency percentage of closed and open injuries

Nature of injury	Frequency	Percentage
Closed	33	40%
Open	48	60%
Total	81	100%

The mean age in our study was 45.8yrs .60% of the cases were open injuries which are actually high velocity injuries. Among the open injuries Type II of the Gustelo Anderson Classification accounted for about 50% of the cases justifying the use of hybrid external fixator use.

Majority of the cases(78%) sustained injury following a road traffic injury which co-related to the percentage of open injuries. Right side and left side injuries were almost equivocal with 52% and 48% respectively.

The follow-up period averaged 24 months (range: 18-30 months). There was no incidence of nonunion, septic arthritis or deep-vein thrombosis. The average time for union for proximal tibia was 19 weeks(16-25 weeks).

Table 2: Outcome results in percentage

Results	Frequency	Percent
Excellent	30	37%
Good	42	51%
Fair	6	07%
Poor	3	03%
Total	27	100%

According to Rasmussen's knee functional score, the results were excellent in 37% of cases, good in 51% of cases, fair in 7% of cases, and poor in 3% of cases. The mean duration of surgery was 90min (range: 70-140 min). The mean trauma to surgery interval was 6 days (range: 4-14 days). The average hospital stay was 7 days. The hybrid fixator was dynamized and removed after evidence of bridging callus in x-rays. The external fixators were removed on an average of 3.5 months (range: 2.8-5 months) and were given PTB cast until patient is completely pain free on weight bearing. Additional procedures like Skin graft coverage was needed for 15% of the patients whereas flap cover and ring re-enforcement was needed in 3% of the cases.

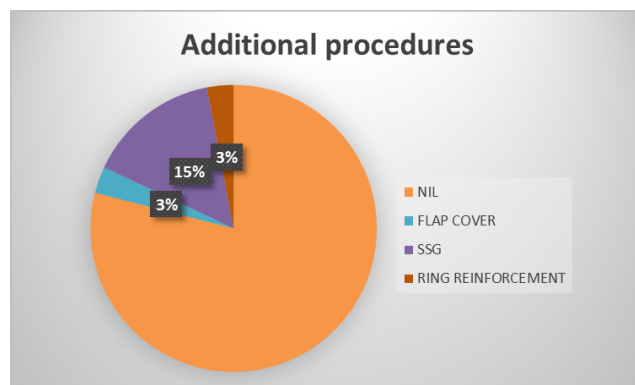


Fig. 3: Procedures required in addition to primary Index surgery

The average total range of knee flexion was 114.5° (range: 0-170°). All patients received physiotherapy after removal of the frame. Extension lag was a common finding.

It was observed in 15% cases; however, they showed gradual improvement of range of motion that was compatible with a normal gait within five months.

In our study, 18% of patients developed pin site infection, which was managed with debridement, antibiotics and pin site care. 3% of patients had hardware failure (broken circular ring) following a slip and fall, which was managed with addition of another circular ring distally. 6% of patients had delayed union which was managed with dynamisation and bone marrow injection. 3% of the patient with proximal tibia fracture developed knee stiffness, which was managed with physiotherapy.

Table 3: Complications in percentage

Complications	No. of cases	Percent
No complications	45	56%
Pintrack infection	15	18%
Knee stiffness	03	03%
Ankle stiffness	06	07%
Delayed union	06	07%
Hardware failure	03	03%
Total	81	100%

At final follow-up, radiographs showed articular depression more than 3 mm in three (12%) cases and less than 3 mm in four (16%) cases which correlated well to the excellent clinical outcome. The quality of reduction increased the functional score. The patients satisfaction was significantly related to functional results ($p < 0.05$).

The principle and protocol for the management of proximal and distal tibia fractures have evolved dramatically. In early 1950,60s most of these fractures were managed conservatively with different traction methods and cast bracing.⁷⁻¹⁰

In 1825, sir Astley Cooper, who first described the proximal tibia fractures.

Anger managed most of the minimally displaced fractures, conservatively with traction and early mobilisation.¹¹

Sarmiento, who managed most of the tibial plateau fractures with functional cast bracing.¹²

Duwelius and Connolly showed good to excellent clinical results in patients treated with Closed Manual Reduction and percutaneous pin fixation and them earlier.¹³

After 1980, operative management with various methods of Internal fixation for fixation of proximal tibia (plateau) fractures became popular. The internal fixation techniques had advantages of proper reduction of joint articular surface, limb alignment(limb length, translation, rotation) and early knee mobilization which shows more favourable outcomes in majority of patients.¹⁴⁻¹⁶

Watsen et al, analysed the biomechanical properties of hybrid fixator and stated that tensioned olive wires with one or two screws provides adequate stability.¹⁷

Anglan, concluded that hybrid ring external fixator provides adequate stability without compromising the soft tissue in the management of periarticular fractures of distal tibia.^{18,19}

Yang M et.al. described the effects of different construct of hybrid fixator in fracture stability and concluded that the bar ring fixator should be reinforced diagonally which will eliminates the deforming force and increase stability.¹⁹

Mahadana et al, in his study, compared the external and internal fixation and reported that hybrid ring external fixation have advantages in terms of soft tissue protection.²⁰

Recently, S.K. Venkateshgupta et al. reported that hybrid ring external fixator in proximal and distal tibia provides good stability and allows early mobilization of joints.²¹

A comparison between our study and other studies clearly shows that our study is in accordance with other major studies. Katsenis et al reported 76% excellent/ good final clinical results in their study.²² Catagni et al reported 50.85% excellent and 45.76% good results.²³

Table 4: Comparison of outcome with other similar studies

Study	Excellent/good	Fair/poor
Katsenis et al ²² 2005	76%	24%
Catagni et al ²³ 2007	96.61%	3.39%
Ariffin et al ²⁴ 2011	90%	10%
Babis et al ²⁵ 2011	85%	15%
Our Study	89%	11%

Ariffin et al. had reported 90% excellent/ good results and Babis et al. reported 85% excellent / good results in their study. In our study the final outcome were 89% excellent / good results and 11% fair / poor results. The results of our study are comparable to similar studies on hybrid fixator shown in literatures as most of these studies used the same outcome measures.

The combination of ilizarov ring with the tubular frame does not affects the stability of the fixator.²⁶ The addition of olive wires to the construct helps in achieving the inter fragmentary compression and to restore the articular congruity. The hybrid combination provides adequate stability and allows early mobilization.

Some forms of readymade hybrid external fixation system are available in market, but they are expensive. Latest systems like HEXAPOD, ORTHO SUV frame etc produce excellent results in terms of functional outcome in well trained hands as it has a steep learning curve and involve huge investment. In developing countries like India, those expensive systems are not affordable by poor patients. In our study, we have used the Ilizarov ring and AO tubular rods and clamps for the construct which are easily available and cost effective. The hybrid external fixator has better acceptance than the ilizaro ring fixator where people are reluctant to accept. These frames are versatile, easy to apply, reusable and more economical to reach the poor patients.

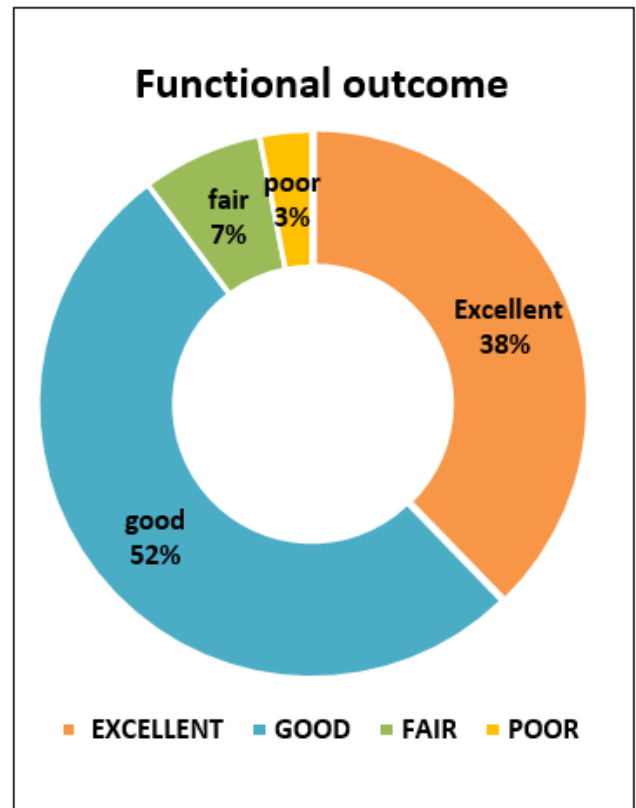


Fig. 4: Final functional outcome

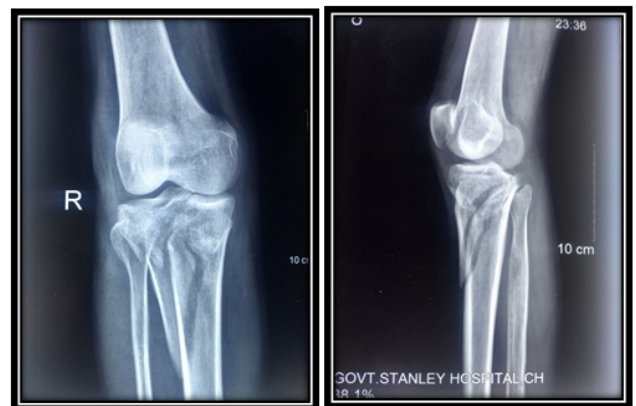


Fig. 5: Case illustrations: Case 1: Pre op

5. Conclusion

Periarticular fractures of proximal tibia are difficult to manage due to severe soft tissue damage, which has its impact in final outcome. The hybrid external fixator provides proper osseous stability without compromising the soft tissue and allows early mobilisation which results in good functional outcome. The complications are mainly the superficial pin track infection which are preventable and if occurs, it is treatable and curable.



Fig. 9: Clinical outcome – Functional knee ROM

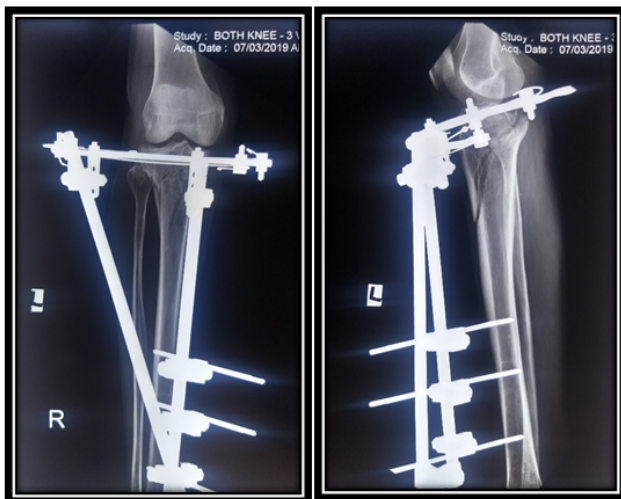


Fig. 6: Immediate post op

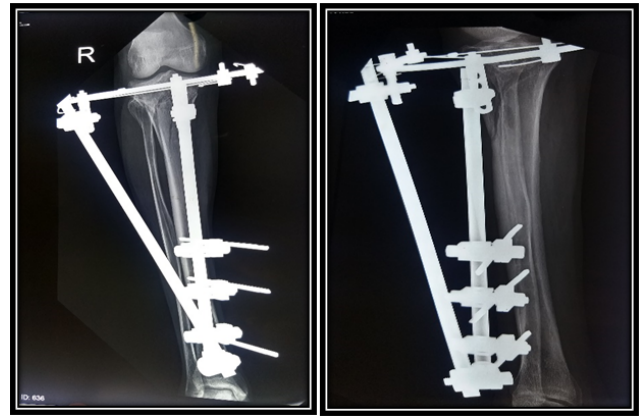


Fig. 7: 3 months Follow up

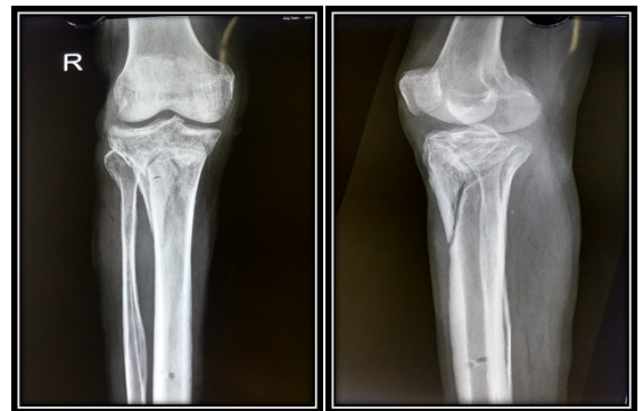


Fig. 8: After fixator removal

The hybrid external fixation is a safe, cost and minimally invasive with optimal outcome in the management of high energy periarticular fractures of proximal and distal tibia in terms of minimal soft tissue complication, good union with acceptable articular reduction and favourable outcome.

The hybrid external fixation is a viable option in the management of periarticular fractures of tibia, especially open fractures and closed fractures with soft tissue compromise.

6. Source of Funding

This research work did not receive any specific grant from funding agencies in the public, commercial, or not for profit sectors.

7. Ethical Statement

This study has been approved by the Institutional Ethics Committee.

8. Conflicts of Interest

All authors declare that they have no conflict of interests.

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Cite this article: Thangamani SK, Arunagiri G, Rajendran P, Chinnadurai MK, Thirumeni T. Hybrid external fixator as primary fixation in the management of proximal tibia fractures in low resource setting –our experience. *Indian J Orthop Surg* 2022;8(2):124-130.