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Original Research Article

Treatment of High Energy Tibial Plateau Fractures using Hybrid External Fixation

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Abstract:

Background: High intensity intra-articular fractures of the proximal tibia combined with significant soft-tissue trauma can be challenging to manage. They require a combination of accurate reduction and minimal invasive techniques to achieve good results. The purpose of this study was to determine whether hybrid external fixation and minimal intervention of these fractures provide acceptable treatment outcome with less complications.

Methods: In this study, we evaluated 25 patients with a median ISS of 14.3 admitted a level I trauma centre, with a bicondylar tibial plateau fracture. Eight patients sustained an open fracture. All patients were treated with a hybrid external fixator. Minimal open reduction and stabilisation with cannulated screws was performed in 14 of them.

Results: Mean follow-up was 12 months (range 10 to 14 months). Radiographic evidence of union was observed at 3.6 months (range 3 to 6 months). Pin track infection was observed in 2 patients (8%).

Conclusion: Hybrid external fixation, with or without open reduction and little internal fixation, was associated with favourable clinical and radiological outcomes and minimal complications when compared to previously reported series with conventional open reduction and internal fixation.

Keywords: Hybrid external fixation, High energy, Tibial plateau fractures.

Introduction

High-energy tibial plateau fractures are serious and complex injuries involving the proximal end of the tibia with intra-articular fractures. They have been associated to significant soft-tissue injury and are difficult to treat. [1] The fracture of the tibial articular surface is caused by the initial axial load and impaction. In most cases, angular forces are added to the initial load, which causes comminution of articular surface and the metaphysis. There seems to be a consistent pattern to majority of complex bicondylar fractures wherein the medial compartment is fractured mediolaterally, with a posteromedial fragment along with varying degrees of multifragmentary lateral depression. [2]

Schatzker's [3] classified these fractures into six groups. Fractures involving both condyles were described as S-V and those separating tibial metaphysis from diaphysis as S-VI. These are the most difficult fracture types, both in terms of osseous damage and the restoration of the soft tissue envelope.

In the initial evaluation, full-length tibia and fibula x-rays should be obtained. The CT-scan is emerging as a valuable investigation to assess the size, comminution, and orientation of articular fragments. This allows appropriate classification and preoperative planning, hence facilitating accurate reduction, particularly for minimally invasive procedures. [4]

These complex fractures have been treated by various modalities over the years. They are associated with fair results and concerning complications. Initially, the preferred modality was simple traction with ligamentotaxis and casting. It was observed that they do not properly accurately reduce the articular surface and lack stability which leads to unacceptable rate of varus/valgus deformity, collapsed articular surface and post-immobilization stiffness. [5] The open surgical methods are known to produce good reduction results but do not protect the previously injured soft-tissue envelope, resulting in significant infection rates. [6]

External fixator emerged as the minimal invasive technique, in the treatment of S-V and S-VI fractures which offer fair reduction results without jeopardising soft-tissue elements. Minimal or

percutaneous internal fixation added to this with cannulated screws and k-wires provides minimum soft tissue damage and greater stability, allowing early mobilization and better range of motion [7].

The purpose of this study was to evaluate if minimal intervention and hybrid external fixation could provide a satisfactory outcome with fewer complications, and to compare our results and complications with previously reported data on internal and external fixation for types V and VI high energy tibial plateau fractures.

Materials and Methods

In this study, we evaluated 25 patients with a bicondylar tibial plateau fracture admitted at a level I trauma centre in Bengaluru. The patients included in this study were over the age 18 years who sustained a bicondylar tibial plateau fracture Schatzker type V-VI, and the ability to walk without assistance before injury. We excluded polytrauma patients with tibial plateau fractures requiring prolonged ICU care and those with floating knee and patients with bilateral tibial plateau fractures. The patients had anteroposterior and lateral radiographs as well as a CT-scan for proper preoperative evaluation of their fracture.

The fractures were treated with either closed reduction or hybrid external fixation in 11 cases or with minimal open reduction and a hybrid system in 14 cases. The soft tissue condition was a main factor in planning the surgery. Eight patients with open fractures were operated immediately with irrigation, debridement, and intravenous antibiotics. Among the 17 closed fractures, 10 cases were operated on the first day after the admission while 7 fractures were operated with an average of 5 days delay (range 3 – 9 days) to allow soft tissue edema to subside.

Prophylactic intravenous antibiotics were administered in all cases. All open fractures received initially a combination of a 2nd generation cephalosporin with an aminoglycoside and Metronidazole as required and subsequently replaced according to the cultures results.

Surgical technique

Surgery was performed under spinal anaesthesia with the patient positioned on the operating table with the knee flexed at 30°. A tourniquet can be used but does not provide any advantage in closed reduction and should be deflated as soon as possible. An image intensifier was used to visualise the fracture reduction. A small incision made over the antero-medial part of the tibial metaphysis and a small window in the tibial cortex was made. A blunt tipped curved 3 mm Steinman pin or a simple pusher inserted through the hole, under image intensifier to correct the depression of articular fragments. In most of the cases, more than one k-wire was required to reduce the articular fracture. Through a small lateral incision, a Kirschner wire was inserted across the tibial plateau to stabilize the reduced fragments and a cannulated screw was introduced over it.

Hybrid external fixator was applied after closed or minimal open reduction of fracture fragments. A ring of appropriate size was positioned at the level of the fibular head. The wires were applied in the transverse plane, consisting of 2 wires from lateral to medial and one from antero-lateral to postero-medial. Each of the wires were tensioned to 1,400 N and locked to the frame. The body of the external fixator was applied on the ring on the antero-medial aspect of the tibia and the metaphyseal fracture was reduced accurately. The assembly of the frame is shown in figures 1 and 2. The fracture has to be reduced before fixation of the hybrid system. After achieving satisfactory reduction, the system was locked. The reduction confirmed under C-arm. If alignment was not satisfactory, a minimal exposure of the fracture site was performed to achieve the desirable reduction. For mini open exposures, wound was closed primarily. Surgical debridement was done for open fractures. Post-operatively, regular pin care dressings were done and passive range of motion of the knee was started immediately. Patients were discharged depending on their general condition around the 5th postoperative day. Patients were followed up every week in open fractures and after a month in closed fractures. Partial weight bearing on the operated limb was advised and instructed to perform pin site care. Progressive full weight bearing was started depending on the radiographic appearance of callus. The external fixator was planned to be removed around 3 months after surgery based on the radiologic appearance of union.

Results

The study group was consisted of 21 males (84%) and 4 females (16%). The average age in the study was 38.3 years (range 18 - 62 years). High energy trauma was the mechanism of injury in all the patients from a road traffic accident.

Follow-up evaluation was available for all fractures. The clinical impression of stability and radiograph appearance of bridging callus on follow-up, determined union. Knee Society clinical rating system [8] was used to evaluate patients during follow-up. The criteria included pain, ability to perform sport activities, range of knee movements, radiological results, and overall patient's satisfaction. The results were classified as excellent in 14 patients (56%), good in 8 patients (32%), fair in 2 patients (8%), and poor in 1 patient (4%). The average time of treatment with the frame of 3.6 months and healing was noted in all patients (Figures 3,4,5,6). The external fixator was tolerated

for the complete duration of treatment by all patients. We noted 2 cases of superficial pin track infections (8%), not extending to the bone. Both the patients were treated with oral antibiotic and local pin care and did not require any re-admission. A total of 21 (84%) patients regained functional use of the knee joint, without pain or instability. The range of knee motion was gradually increasing at consecutive clinical evaluations. At the final follow-up at one year, range of motion averaged 110° of flexion (range 75° to 125°).

Figure 1: Hybrid External fixator frame

Figure 2: Hybrid External fixator frame assembly

Figure 3: Pre-operative radiograph

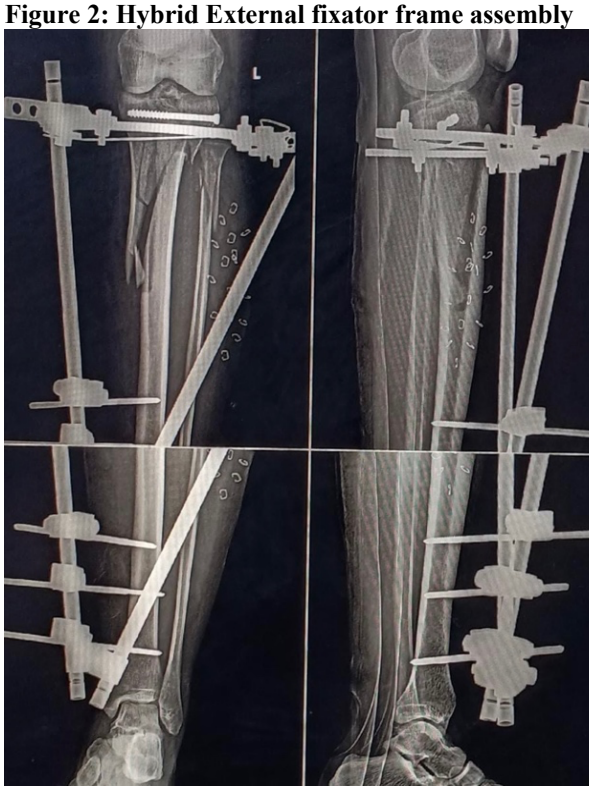

Figure 4: Post-operative radiograph with Hybrid Ex-fix in situ

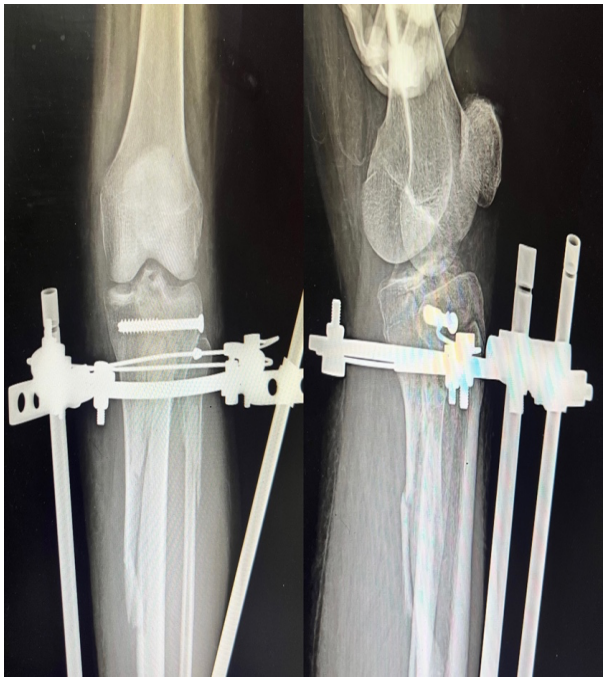

Figure 5: Follow up radiograph at 6 weeks showing signs of fracture healing with Hybrid Ex-Fix in situ

Figure 6: Follow up radiograph at 3 months after removal of Hybrid Ex Fix system showing satisfactory fracture union.

Discussion

The role of the soft-tissue envelope in plateau fracture healing has been studied in the literature. It has been established extensively damaged soft-tissues have been associated with poor results. [9] Several methods have been proposed to treat these complex injuries. They include limited open reduction and stabilisation with percutaneous screw, indirect reduction and application of a hybrid or circular external fixation device, and open reduction and internal fixation.

External fixation has been described as a definitive treatment for polytrauma patients who have multiple osseous and soft tissue injuries. It can be considered for bicondylar tibial fractures with a damaged soft-tissue environment as a temporary stabilising approach prior to definitive treatment. The development of circular and hybrid frames, the ability of axial, lateral compression, and dynamization, as well as the introduction of olive wires have given external fixators exciting possibilities for treating difficult fractures. In a study done by Mahadena et al. [10] comparing external to internal fixation, determined that hybrid external fixation has theoretical advantages in terms of soft tissue protection however, it is limited in terms of accuracy of reduction. Catagni et al. [11] studied high-energy Schatzker V and VI tibial plateau fractures treated with circular external fixator, reported excellent and good results in 50.85% and 45.76% patients respectively and concluded that hybrid Ilizarov method combined with minimal internal fixation enables excellent to good results in most cases of these fractures. Katsenis et al. [12] recorded excellent or good final clinical results in 76% patients. In another similar study they reported 38.9% good/excellent, and 61.1% fair/poor results. [13] In a prospective, randomized clinical trial of 83 type V, VI tibial plateau fractures by Hall JA et al. concluded circular external fixation as an attractive option for these complex fractures. They reported similar quality of bony reduction and ROM for both internal and external fixation groups but lower rate of early postoperative complications and improved HSS knee scores for the external fixation group at the six months follow up. However, these outcomes were not significantly different at two years. [14]

Internal fixation has the advantages of direct visualization, accurate reduction of articular surface and acute repair of soft tissue injuries. They also present with serious disadvantages caused by surgical damage on an already injured soft-tissue envelope and the high rate of infection which may compromise the final result. In a study by Tscherne et al. [15] compared the results of conservative and surgical management for tibial plateau fractures reported improved range of motion, decreased percentage of malunion and 5% reoperation rate for the surgical group. Stevens et al. [16] presented several intra-operative and postoperative complications. Young and Barrack [17] reported an 88% deep infection rate in dual plating these

fractures. The use of a lateral fixed angular plate through a single lateral approach avoids medial periosteal striping. [18] In a prospective study by Jiang R et al. [19] comparing locking plate to dual plates for the repair of bicondylar tibial plateau fractures reported similar results for the two groups. However, Higgins et al. [20] demonstrated that dual-plate fixation allows less subsidence in these bicondylar tibial plateau cadaveric model when compared to isolated locked lateral plates.

In this study, hybrid external fixator was used as a definite treatment for both closed and open Schatzker V, VI tibial plateau fractures. Open reduction and minimal internal fixation by means of K-wires or screws were performed when necessary prior to external fixation application. We observed 2 cases of pin tract infection (8%) in our study. Hutson et al. [21] in a meta-analysis of 16 studies with a total of 568 patients found pin site infection rates of 10% for tibial plateau fractures. We observed good tolerance to the external fixation device in all our cases.

Conclusion

Schatzker's type V and VI tibial plateau fractures are serious injuries that lead to complex fracture patterns and can cause significant long term complications. We observed that Hybrid external fixation as a definitive management to be advantageous and valuable. They provided stable fixation of the bone while preserving the surrounding soft tissue envelope thus facilitating early mobilization, and satisfactory outcome.

Limitation: Our study group is made up of high energy plateau fractures with a high complication rate, the average follow-up of 10-12 months may be regarded insufficient to note the complication of post-traumatic osteoarthritis.

Authors' contribution: All authors contributed to draft the manuscript. Dr. Karan C L: Conceptualization, study design and methodology, Dr. Vivekanand: Data curation, Dr. Akshaya: Reviewing and editing. All authors read and approved the final manuscript.

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