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Evaluation of complex tibial plateau fractures treated with Ilizarov circular fixator

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Abstract

Introduction: Ilizarov circular fixator is now considered as a suitable alternate treatment modality for stabilization of complex tibial plateau fractures. This method of treatment minimizes iatrogenic soft tissue dissection and it's associated complications because of closed percutaneous wire fixation and permits early knee mobilization and weight bearing due to its three-dimensional stability.

Objective: This study was undertaken to evaluate the clinico- radiological outcomes and morbidity of the Ilizarov circular fixator applied for stabilization of complex tibial plateau fractures.

Study Design: Prospective analytic cross-sectional design

Place and Duration of study: Orthopaedic department of Dow Medical College / Dr. Ruth Pfau Civil Hospital Karachi, between November 2015 to September 2018.

Methodology: A total of 21 consecutive patients with complex tibial plateau fracture (Schatzker type V & VI) operated with Ilizarov circular fixator technique, were evaluated clinico-radiologically by using the scoring criteria of ASAMI. Post-surgical complications were noted. Polytrauma patients with multiple fractures, age < 18 years, delayed presentation (> 2 weeks) and fracture with associated vascular injury were excluded from the study.

Results: The minimum follow-up was 3 months after complete frame removal. All fractures were united in average 14.6 weeks (range 12-32 weeks). According to ASAMI scoring system, the final results were excellent to good in 80.8%, and fair in 19%. There was 66.6% pin tract infection in this series. Knee joint osteoarthritis was noted in five patients. We had no instance of postoperative deep infection and neurovascular complications due to Ilizarov fixation.

Conclusions: Primary Ilizarov circular fixator combined with limited internal fixation is a valuable treatment alternate for complex tibial plateau fractures that are not immediately amenable to internal fixation.

Keywords: tibial plateau fractures, Ilizarov, circular fixator, minimal invasive

Introduction

Complex Tibial plateau fractures are relatively rare, accounting for 1% of all fractures in adults [1-3]. Most often, these fractures are seen in young individuals who have sustained a high-energy trauma but in elderly osteoporotic patients may follow minimal trauma.

Currently, complex tibial plateau fractures (Schatzker V & VI), remain technically challenging, even to experienced traumatologist due to intra-articular comminution and extensive soft tissue insult. If it is not treated properly, it may result in long-term pain due to post-traumatic arthritis, knee joint ligamentous instability, deformity, stiffness and even end up in having amputation [4].

The main objectives of treatment are same as for any other intra-articular fracture: to restore joint stability, to restore and maintain articular congruity and alignment of proximal tibia with minimal disruption of soft tissue envelope, to preserve knee joint mobility and to prevent post-traumatic osteoarthritis [4, 5].

These goals should be accomplished with a technique that must be truly minimally invasive and stable enough to allow early painless knee range of motion.

Osteosynthesis with plate and screws permit an optimal visualization and reconstruction of an articular surface but despite the advent of locked plating and "minimally invasive" surgical techniques, poor outcomes were reported continuously [6, 7].

Due to these drawbacks we are routinely using Ilizarov circular fixator at our institution for complex tibial plateau fracture in adult.

This technique minimizes iatrogenic soft tissue dissection and its related complications because of closed reduction and percutaneous wire fixation and permits early knee mobilization and weight bearing due to its three-dimensional stability [3, 8-10].

Recently several studies have evaluated its outcome and reported decreased complication rates in complex tibial plateau fracture in comparison with other methods of fixation [5, 8-17].

Hence to evaluate clinico-radiological outcome and its morbidity, the current study is being carried out.

Material and Methods

This study was a prospective analytic cross-sectional design and done in the Orthopaedic department of Dow Medical College / Dr. Ruth Pfau Civil Hospital Karachi, between November 2015 to September 2018. This study included 21 skeletally mature patients with complex tibial plateau fractures (Schatzker V &VI) [18] either open or associated with a severe closed soft tissue injury, who had been operated with Ilizarov ring fixator using a standard protocol with closed percutaneous wire or combined with limited internal fixation. Polytrauma patients with multiple fractures, age < 18 years, delayed presentation (> 2 weeks) and fracture with associated vascular injury were excluded from the study.

Initial trauma radiographs and / or 3D CT scan of knee if the fracture lines were not clearly delineated were advised. Schatzker classification [18] was used to describe tibial plateau fractures and Gustilo and Anderson classification [19] was used for open fracture.

Sample technique

Non-probability –purposive sampling technique were used to select 21 patients, who sustained complex tibial plateau fractures requiring surgery.

Sample size calculation

Determination of sample size was based on an epidemiological study, where tibial plateau fractures in adult comprise less than 1% of all fractures [1-3].

Using Fishers' formula

n = Z2 PQ / D2

Where

n is the estimated sample size.

Z2 is the score of confidence interval at 95% and is 1.962.

P is the prevalence in this case at 1% and Q is 1 – P.

D2 is the degree of error, which is 0.052

Therefore

n =1.962 x 0.01 (1 – 0.01) / 0.052

n = 16 patients

Data collection and statistical analysis

The researcher collected data from the patients. Predesigned data collection sheets were used. The data was analyzed using SPSS version 19 and descriptive statistics for sample variables presented in form of tables and graphs.

Surgical procedure & post-operative management

After the initial trauma evaluation in the emergency room, in patients with open fractures, surgery was undertaken in emergency operation theater, wound swab was taken for culture and sensitivity, thorough wound debridement was done, foreign particles and necrotic tissues were removed and wound was closed with loose stitches. The leg was realigned with manual traction and support, and placed in a well-padded splint until definitive fixation was done.

Preoperative antibiotics for surgical prophylaxis were given. *After medical* assessment, if *patient* is *deemed medically stable, he* or she underwent for surgery on elective list.

The risks and benefits of operative procedure and follow-up were explained in detail and written informed consent was taken regarding treatment and photographic documentation. Surgery was done under spinal and / or general anesthesia in a supine position on a fracture table with traction, under C-arm guidance.

The first step was to place the leg on continuous longitudinal traction with the foot in a shoe fixed to a traction table for distraction and reduction of fracture fragments with ligamentotaxis.

A pre-assembled three-ring construct was used in all cases, with an additional ring and one arch attached to the lower femur if the knee was still unstable or there was severe fracture comminution.

Two-rings were placed over the distal tibial fragment keeping the limb in the center. The first Ilizarov ring was positioned at least 2cm distal to the fracture. The second distal Ilizarov ring was positioned above and parallel to the ankle. The third upper Ilizarov ring was positioned at the level of fibular head and parallel to the knee. An advanced hybrid fixation using 5mm half pins and two 1.8mm wires were used in lower two rings. If distraction of fracture fragments did not lead to acceptable anatomical repositioning, the articular surfaces were reconstructed with percutaneous reduction forceps and / or with threaded pin or K-wires as joystick. In 8 cases, a small incision was used to dis-impact a depressed fragment and to fill the gap with bone graft whereas in 6 cases limited open internal fixation with 7.4 mm cannulated screws were done. Once the articular congruity was restored satisfactorily under C-arm, the bone fragments were stabilized with 3 or 4 tensioned olive wires and fixed to the first upper tibial ring.

In 8 patients, due to severe comminution and instability, the additional one ring and arch were attached to the lower femur. The distal femoral ring was stabilized with one 1.8 mm wire and two 5mm half pins and proximal femoral arch was stabilized with two 5mm half pin. Mostly, inter-fragmentary compression of large articular fragments was achieved using olive wires. In most cases, 1 half pin and 2 wires were inserted to the distal fragment and 3 or 4 wires were inserted to the proximal fragment. A single surgeon performed the operations. Postoperative pin sites dressing were done with povidone-iodine solution soaked gauzes. Associated injuries; meniscal, collateral or cruciate ligament were not attended at this stage.

Rehabilitation protocol and outcome assessment

Post-operatively Intravenous antibiotics were infused for 2 - 3 days, followed by oral medications for further 5 -7 days in closed fractures and up to the infected wound healing in open fractures. All patients followed the same rehabilitation protocol during hospitalization. Supervised physical therapy for sitting, standing and weight bearing ambulation as tolerated, was begun from the very first post-operative day using a walker. Sutures were removed in two weeks. The femoral-rings were removed after 4 / 6 weeks to allow early mobilization of knee.

Any displacement, angulation or malalignment discovered postoperatively or during follow up visits was readily corrected by readjustment. Complete Ilizarov Fixator was removed after confirming clinical and radiographic fracture healing.

Patients were followed up at 2, 4, 8, 12 weeks and then every

3 months interval until clinical and radiological fracture union had been established. In the last review visit (minimum of 1 year), the outcome was evaluated using the ASAMI (Association for the Study and Application of the Method of Ilizarov) scoring system (Table I) [8]. The outcome was classified as Excellent, 80–90; Good, 70–79: Fair, 59–69; and Poor, <59 score.

Typical post-surgical complications were noted (i.e., pin tract infection, neuro-vascular injuries, nonunion, mal-union and knee post-traumatic osteoarthritis.

The Fractures were considered healed if radiologically, showed a bridging callus in anterio-posterior and lateral view and clinically, if the fracture was stable and non-tender at fracture site on manual varus / valgus stress and the patients were able to walk without pain after the connecting rods has been removed on dynamization [20].

Failure of fixation was defined as loss of reduction exceeding 5mm of re-displacement or > 10° of angulation in any direction at the time of union [17]. Pin-track infection was diagnosed clinically by presence of skin erythema and purulent discharge and radiologically by evidence osteomyelitis and loosening of *wire* or *half-pin* [21]. 'Post-traumatic knee osteoarthritis was diagnosed on most recent radiograph, on the basis of reduced joint space, sub-chondral sclerosis, cysts and osteophytes [17].

Table 1: ASAMI Scoring

Table I:ASAMI Scoring Criteria	
Variables	Score
Bone results	
• Union without infection	**30**
• Nonunion or infection	**0**
Radiologic results	
• Good joint line	**10**
• Malalignment <2 mm	**8**
• Malalignment 2–4 mm	**6**
• Malalignment >4 mm	**0**
Knee range of motion	
• >130 degrees	**10**
• 110 degrees–130 degrees	**8**
• 80 degrees–109 degrees	**6**
• < 80 degrees	**4**
Leg length discrepancy	
• No leg discrepancy 10	**10**
• <1 cm	**8**
• 1–2 cm	**6**
• 2–4 cm	**3**
• >4 cm	**1**
Pain	
• Absent	**10**
• After sport activity	**9**
• After long walking	**8**
• Weather related only	**7**
• After short walking	**4**
• Mild activity related	**2**
• Night pain at rest	**1**
Sporting activity	
• Full return to previous sport activity	**10**
• Decreased sport performance	**8**
• Poor sport performance	**4**
• No sport ability	**0**
Subjective patient satisfaction	
• Full satisfaction 10	**10**
• Mild dissatisfaction 8	**8**
• Medium dissatisfaction 4	**4**
• Dissatisfaction 0	**0**
Excellent: Score 80–90; Good: Score 70–79; Fair: Score 59–69; Poor: Score < 59.	

Results

Total 21 patients (5 female, 16 male) with mean 32 years of age (range 19 to 58 years) were analyzed in this study based on the inclusion criteria. 11 (52.3%) fractures had left knee while 10 (47.6%) fractures had right knee involvement. Mean interval between the trauma and Ilizarov external fixation was 8.8 days (range 3 – 14 days). The minimum follow-up was 3 months after complete frame removal (average, 10 months; range, 7 to 18 months). According to the Gustilo and Anderson classification, 4 patients had a grade I and 2 patients had a grade II open fractures. According to the Schatzker classification, 12 fractures graded as type V and 9 as type VI. 14 patients had an associated fibular fracture. 16 patients were involved in a motor vehicle collision, 3 fell from a height, and two were crush injury. Union was achieved in all cases in an average time of 14.8 weeks (range 12-32 weeks). Delayed union was noted in 2 cases, all progressed to union without any additional surgical procedure and bone grafting. According to ASAMI scoring system, the final functional results were excellent in 6 (28.5%), good in 11 (52.3%) and fair in 4 (19%). 20 wires in 14 (66.6%) patients had pin tract infection in this series; Most pin-tract infections healed well with regular dressing and oral antibiotics but in 6 (28.5%) patients eleven affected loose wires and half-pins were exchanged. We had no instance of osteomyelitis or septic arthritis and none of our patients developed neurovascular complications related to unintended penetration of K-wires. 4(19%) fractures were united in mal-union (>10° of varus in three case and $>10^0$ of valgus in one case), but all were completely asymptomatic. Muscle flap coverage and split-thickness skin grafting were not needed. Knee joint post-traumatic Osteoarthritis was noted in five patients; all of them were managed with non-steroidal anti-inflammatory drugs (NSAIDs). In three cases Judet quadricepsplasty was undertaken in whom knee joint flexion was < 80 degree.

Discussion

The main objectives of treatment are to stable, aligned, painless and mobile knee and to minimize the risk of post-traumatic osteoarthritis [4, 5]. Formal open reduction and plate osteosynthesis for complex tibial plateau fracture usually requires extensive dissection of already compromise soft tissue envelope of the proximal tibia, leading to considerable de-vascularization of fracture fragments, thus delaying healing of fracture and increasing the risks of infection and implant fatigue fracture [6, 7, 22-25].

Recently several authors have treated complex high velocity tibial plateau fractures with Ilizarov circular fixator and reported good prognosis for satisfactory knee function [3, 8, 11, 12].

Khan MA *et al.* [9] treated 22 high energy complex tibial plateau fracture by small wire external fixator. He reported 81.8 % excellent to good functional results after a minimal 2 years follow-up and concluded that 'small wire external fixation allows anatomical articular surface reconstruction, stable fracture fragment fixation, early joint movement, and care of soft tissue injuries, without a high rate of complication. Farooq U *et al.* [10] did a study on 40 patients with high grade fracture of tibial plateau treated by closed Ilizarov fixator. They were followed up for 3 months and overall 90% patients had good to excellent range of motion and 92% had good to excellent stability and he concluded that Ilizarov fixation is an ideal treatment method for tibial plateau fracture when open osteosynthesis is contraindicated due to soft tissue trauma,

bone stock deficiency and bony comminution.

Catagni *et al*. [8] evaluated 59 patients with high grade fractures of tibial plateau treated by external circular fixator and limited open internal fixation. After a minimum one-year follow-up, he reported 96% excellent and good results and concluded that the Hybrid Ilizarov fixator combined with limited open internal fixation for complex tibial plateau fractures enables excellent to good results when used with good indications, surgical planning, and surgeon's experience.

El-Gafary K *et al*. [16] treated 30 high velocity complex tibial plateau fractures by Ilizarov external fixator. After a mean 18 month follow up, according to knee society score, he reported 76.7 % good to excellent result and concluded Ilizarov fixator is a safe and effective treatment option with good functional results for high energy complex tibial plateau fractures.

Singh H at al. [26] reviewed 20 high-energy fractures, treated with a wire based, circular external fixator and he reported 85% excellent or good functional result at a mean 24 weeks follow-up. He concluded that a wire based circular external fixator is a simple, inexpensive and useful technique for high-grade complex tibial plateau fractures.

In our study, we also found similar findings; we achieved union in all cases at average 14.8 weeks (range 12-32 weeks); secondary bone grafting was not needed. Non-union was not noted. At final follow-up, in our study according to ASAMI scoring, 17 (80.8%) patients had excellent to good functional outcome.

The complications unexpectedly experienced in the operative treatment of distal tibia plateau fractures due to Ilizarov wires as reported by various authors are pin tract infections, neuro-vascular injuries and tendon or muscle impingement. The other postoperative complications are knee joint stiffness, osteoarthritis, axial deviation and mal-union. In our study, 20 wires of 14 (66.6%) cases had pin tract infection; Most pin-tract infections settled well with regular pin cleaning and oral antibiotics but in six cases eleven involved K-wires and half-pins were removed or exchanged as fracture healing progressed. We had no instance of postoperative deep infection and neurovascular complications due to Ilizarov fixation. Knee joint osteoarthritis was noted in five patients. However, despite radiographic degenerative changes, no patients to date had required a knee arthroplasty. All of them were managed with NSAIDs, if needed.

Hence, the results noted in this study were comparable to the results published in most other studies [5, 8-17].

Fig 1: Pre-operative photograph: high energy tibial plateau fracture with severe soft tissue injury

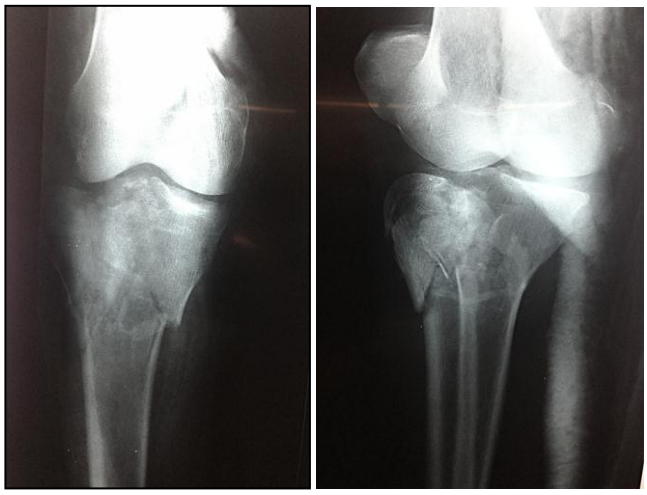

Fig 2: Pre-operative x-ray: AP and Lateral view

Fig 3: PJost-operative x-ray: showing fixation with Ilizarov external fixator

Fig 4: Post-operative x-ray at 6th week after removal of femoral Ilizarov ring showing Good alignment and healing

Fig 5: Post-operative x-ray at 16th week after removal of Ilizarov ring frame showing Good alignment and healing

Fig 6: Functional outcome after 6-months of surgery

Conclusion

The post-operative clinico- radiological outcome indicate that primary Ilizarov circular fixator combined with limited internal fixation is a valuable treatment alternate for complex tibial plateau fractures that are not immediately amenable to internal fixation Although technically demanding, it avoids extensive soft tissue dissection and at the same time offers stable fracture fragments fixation, allowing the early painless movement of the knee joint without high rate of complications.

Limitations of this paper, includes its small sample size and short follow-up period. Also, the exclusion of polytrauma patients with multiple fractures could lead to a selection bias, possibly omitting patients with more severe injuries.

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