



International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2018; 4(3): 91-94
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www.orthopaper.com
Received: 19-05-2018
Accepted: 20-06-2018

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A prospective study of hybrid external fixation for proximal tibial fractures

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DOI: <https://doi.org/10.22271/ortho.2018.v4.i3b.19>

Abstract

The treatment of proximal tibial fractures or intraarticular fractures are often challenging. Many surgeons encounter problems with wound healing even in closed tibial fractures because of co-existing soft tissue injuries. External fixation of these fractures have yielded satisfactory results, but some studies had reported problems in the achievement and maintenance of fracture reduction. Hybrid external fixator presents with mechanical characteristics that differ from other systems of external fixator. The mechanical characteristics of hybrid external fixation system can be called as SOLID ELASTIC. It is solid enough for stabilization and providing micromotion which enhances good callus formation the purpose of this study is to assess the utility of this hybrid external fixation system and to analyze the functional outcome, soft tissue healing and fracture union.

Keywords: Hybrid external fixation, proximal tibial fractures

Introduction

Intraarticular fractures of the tibial plateau and periarticular fractures of the proximal tibia, caused by high energy trauma pose a therapeutic dilemma. Such fractures are associated with extensive soft tissue damage with or without compound injury. The management of such high velocity injuries become a challenge to the trauma surgeons.

We present the use of hybrid external fixation system which includes Ilizarov ring fixator and AO rod external fixator connected with indigenously manufactured connecting clamps and short shafts augmented with or without minimal internal fixation^[1].

Aim of the Study

1. To assess the performance of the Hybrid External Fixator in the treatment of different types of proximal tibial fractures
2. To evaluate the functional outcome, soft tissue healing and fracture union and radiological outcome.
3. To evaluate the biomechanical and biological advantage of hybrid external fixator.
4. To assess the utility of the indigenously made connecting clamps.

Materials

From August 2010 to November 2011, 21 cases of periarticular fractures of the proximal tibia were treated by use of 5/8th Ilizarov ring, AO tubular external fixator and with indigenously manufactured connecting clamps & short shaft in a hybrid mode. All cases were prospectively followed up and studied. Almost all the cases (99%) had sustained Road traffic Accidents (high velocity injuries) except one case which had sustained injury by fall of cement wall over her leg. Minimum follow up – 1.5 months, maximum follow up – 12 months, mean follow up – 6.42 months. All fractures were followed according to a protocol. All fractures were treated with either CLOSED REDUCTION AND HYBRID EXTERNAL FIXATION OR WITH MINIMAL OPEN REDUCTION AND A HYBRID SYSTEM. The study group was consisted of 16 males (76%) and 5 females (24%) with an average age for males of 43.06 years (range 25 to 65) and for females of 53.4 years (range 41 to 59). All the patients were in the age group of 26 to 65 years, mean age is 43.09.

Proximal tibial plateau fractures were classified according to the Schatzkar classification and open fractures by Gustilo – Anderson classification. There were four type 4 fractures, four type 5, thirteen type 6 fractures and four Grade 3 B open fractures.

Table 1: Mode of Injury

S. No.	Mode Of Injury	no. of patients	percentage
1.	RTA	19	99%
2.	FALL	2	1%

Table 2: Sex

S. No.	Sex	No. of Patients	Percentage
1	Male	16	76.19%
2.	Female	5	23.80%

Table 3: Age Distribution

S. No.	Age	No. of Patients	Percentage
1.	20 – 30	25	9.25%
2.	31 – 40	5	19.04%
3.	41 – 50	5	23.80%
4.	51 – 60	8	39.09%
5.	61 – 70	1	9.25%

Table 4: Fracture Classification

S. No.	fracture type	No. of Patients	Percentage
1.	Closed	17	80.95%
2.	Compound	4	19.04%

Table 5: Schatzkar Classification

S. No.	Fracture Type	No. of Patients	Percentage
1	S- IV	4	19.04
2.	S- V	4	19.04
3.	S-VI	13	61.90%

The pre-operative radiographs were used to classify the fractures according to Schatzkar's classification system. There were 4

S-4(19.04%), 4 S-5(19.04%), and 13 S-6(61.90%). Seventeen Patients were closed (81%) and 4 four were open fractures (19%). All the open fractures were Gr 3 B compound fractures. Peroneal nerve injury never presented in any patient.

Compound fractures were treated with immediate debridement and hybrid external fixator. Closed fractures were initially treated with limb elevation and splintage to allow for subsidence of soft tissue swelling for 3-5 days. Subsequently fractures were treated by hybrid external fixator. Prophylactic antibiotics were administered intravenously in all cases. In the open fracture cases, antibiotics were prescribed as necessary for the first days and subsequently replaced according to the culture results. All open fractures received initially a combination of a ceftriaxone with an aminoglycoside.

Method

Pre OP Clinical Evaluation

Detailed history was elicited in all patients. All the patients had RTA with high velocity injury. Clinically injury was evaluated as simple or compound injuries. In case of compound injury wound was thoroughly debrided and planned for immediate hybrid fixation. In case of closed tibial fractures the soft tissue injury was assessed and the compartment syndrome was ruled out. Limb was elevated till

the time of surgery.

Radiological Evaluation & Grading

Careful radiological assessment was carried out regarding fracture pattern (simple, comminuted, intraarticular involvement) and any loose fragments presented inside the joint. If any loose fragment was presented inside the joint it was evaluated thoroughly by CT scan. Radiologically the proximal tibial fractures were classified according to Schatzkar types and open fractures by Gustilo Anderson classification. Undisplaced articular fragments were reduced with plain wires and displaced articular fragments were reduced with mini open method.

Selection of Cases

Inclusion Criteria

1. Tibial plateau fractures according to Schatzkar classification Type 4, Type 5 and Type 6.
2. Proximal 1/4 extra articular tibial fractures (severely comminuted)
3. Open Proximal tibial fractures according to Gustillo Anderson Classification Gr 2, Gr 3A, 3B, 3C
4. Proximal tibial fracture with compartment syndrome after Fasciotomy.
5. High velocity proximal tibial fracture in impending compartment syndrome.
6. Patients age over 18 years and ability to walk without assistance before injury.

Exclusion Criteria

1. Schatzkar type 1, type 2 and type 3
2. More than 2 weeks old fractures.
3. Bilateral tibial plateau fractures.
4. Polytrauma patients with tibial plateau fractures requiring prolonged ICU care.
5. Proximal tibial fractures with neurological disorder.
6. Proximal tibial fractures with paralytic disorder.

Preoperative planning, surgery, post-operative management given and the outcome assessed based on Neer's rating system for evaluation of knee³

Results

After analyzing the above characters we have obtained Excellent results in 7 patients (33. 3%), Good in 9 (42.35%), Fair in 4 (19.04%), Failure in 1(4.76%) patient.

Table 6: Results

S. No.	No. of Patients	Percentage	Result
1.	7	33.33%	excellent
2.	9	42.85%	good
3.	4	19.04%	fair
4.	1	1.76%	failure

Union was determined by the presence of a bridging callus on the follow up radiographs and by the clinical impression of stability.

One patient who had severe comminuted fracture involving whole tibia complicated with severe infection in leg and loss of vascularity and finally ended up with amputation. All associated ligamentous and meniscal lesions were repaired at a second stage after fracture healing. All fractures healed, with an average time of treatment with the frame of 18 weeks. The external fixator was tolerated for the entire treatment period in all cases.

Pin track infection occurred in 2 patients. Out of 2 patients one patient got deep infection in knee joint. In 4 patients superficial infection or limited to soft tissues and did not extend to the bone & resolved with pin track care and oral antibiotics. Knee range of motion occurred from 0 – 120 degree to 10 – 90 degree (Average 5 to 105 degrees). In 2 cases varus malunion occurred. However functionally knee ROM and walking were not affected. Early weight bearing by the patient could be the main reason for varus malunion.

Complications

In our case series we encountered the following complications

Table 7

S. No.	Complications	No. of Patients
1.	Varus collapse	2
2.	Deep infection	1
3.	Delayed union	1
4.	Severe septicemia with amputation	1
5.	No complications	16

To summarize, the advantages of hybrid external fixator are

1. Minimally invasive procedure
2. Very good preservation of soft tissues
3. Better anchorage of tensioned wires than half pins in cancellous bone area and they give better stability.
4. Easy application of half pins in diaphysis without neurovascular injury.
5. Early mobilization of knee joint.
6. Good skin care and easy application of flap cover.
7. Good acceptance to patient.

The disadvantages of hybrid fixator are

1. Risk of articular infection if pins are applied very close to joint.
2. Tough to obtain articular reduction.
3. Radio opaque ring obstructs radiological image.

Discussion

High velocity periarticular fractures of tibia closed as well as compound injuries are complex to treat. Management of these fractures are difficult and varies from surgeon to surgeon. Such injuries are usually associated with soft tissue injury and marked comminution of articular surface. Conservative treatment of comminuted high energy proximal tibial fractures as proven to be inferior when compared to operative treatment. Internal fixation, despite the advantages of direct visualization, proper and stable reduction of the articular surface as well as the acute repair of soft tissue injuries, presents also serious disadvantages, including skin and soft tissue necrosis caused by surgical manipulations on an already damaged soft tissue envelope and the high rate of infection, which may compromise the final result. Young and Barrack, in their series of dual plating for complex bicondylar tibial plateau fractures reported an 88% deep infection rate [11, 12]. Steven *et al* presented several transoperative – post operative complications [17]. Certain authors have treated bicondylar tibial plateau fractures by means of a lateral fixed angular plate through a single lateral approach, thus Avoiding medial periosteal stripping [13, 14]. Jiang R *et al*, in their prospective study comparing locked plates, for the repair of bicondylar tibial plateau fractures reported similar results for the two groups [15]. Nevertheless as presented by Higgins *et al*, bicondylar fractures stabilized by means of a fixed angle

platre present a higher rate of subsidence compared to dual plating stabilized fractures [16].

The external fixation as a define treatment for the polytrauma patient with multiple osseopus and soft tissue injuries has been described in the literature [37, 38] Certain authoris believe that external fixation should be limited to biocondylar tibial fractures with a compromised soft-tissue envelope, as a temporary stabilizing technique, prior to delinite treatment [11]. In the last 2 decades, the evaolution of devices and techniques of external fixation has led many surgeons to apply the principles of biologic osteosynthesis and minimally invasive surgery for the treatment of comminuted tibial plateau fractures [5, 11]. The development of circular and hybrid frames, the capability of axial, lateral compression and dynamization, the development of olive wires have offered new possibilities to the external fixators for the treatment of complex fractures [12]. Mahadana *et al*, comparing external to internal fixation, concluded that hybrid external fixation possess theoretical advantages in terms of the soft tissues protection; however the benefit over internal fixation is modest as far as accuracy of reduction is concerned [13]. Chin *et al* presented 38.9% good / excellent, and 61.1% fair / poor results in his type V and VI fractures series [14]. Catagni *et al*, in their series of high-energy Schatzker V and VI tibial plateau fractures treated with circular external fixator, reported excellent and good results in 30 (50.85%) and 27 (45.766%) patients respectively [4]. In a similar study on type V and VI tibial plateau fractures, Katsenis *et al* recorded excellent or good final Canadian Orthopaedic Trauma Association, in a multicenter, prospective, randomized clinical trial of 83 S-V, VI tibial plateau fractures treated with internal or external fixation, reported similar quality of osseous reduction and ROM for both groups but lower rate of early postoperative complications and improved HSS scores for the external fixation group at the six months' follow up. However, at the two years' follow up, no significant difference in ROM, HSS scores, WOMAC and SF-36 was observed between the two groups [15]. As far as minor complications are concerned, Hutson *et al*, in a meta-analysis of 16 studies with a total of 568 patients found pin site infection rates of 10% for tibial plateau fractures (45). This number is similar to the rate of pin tract infection.

Uniplanar external fixators do not provide stability to the comminuted fractures. The goal of surgical treatment of these periarticular fracture is to provide stable fixation, thus allowing early joint motion and to obtain articular congruity. Early joint motion is probably the single most important factor in promoting cartilage nutrition. Fixation must be stable enough to allow early motion and to minimize the wound complication [10].

The choice of which hybrid external fixator to use should be made based not only on stiffness but also on ease of clinical application, patient comfort and cost.

In our study 21 cases of tibial plateau fractures were treated by hybrid external fixation. The use of cannulated cancellous screws and olive wires helped in achieving interfragmentary compression and articular congruity. Along with use of 5/8th ring in proximal tibia helped in achieving stable fixation and early joint motion [7, 10].

In present study we obtained the excellent results in 7 patients, Good in 9, Fair in 4, Failure in 1 patient. One patient who had severe comminuted fracture involving whole tibia complicated with severe infection in leg and and landed up with septicemia, finally ended up with amputation. One patient went with varus collapse in knee joint. One patient got

deep infection for which the patient underwent knee aspiration & subsequently sent the specimen for biochemical and microbiological analysis. Then accordingly treated with IV antibiotics and finally recovered satisfactorily with good range of movements.

One pure metaphyseal fracture with severe comminution took long time to consolidate approximately 22 weeks. This finding could reflect the slow healing potential of metaphyseal fracture may be because of increased stability of the frame or due to intactness of the tibia.

The use of small diameter K wires with 5/8th ring in the proximal tibia reduces the complication rate especially pin track infection. Loosening of the wire was not seen in our study. The combination of a 5/8th ring and AO tubular rod does not affect the stability of the construct [6, 8]. Such hybrid combination helps in achieving articular congruity besides providing stable fixation which allows for early movements of the joint. Few hybrid external fixation systems are commercially available, they are very expensive and are not easily available. In this study we have used combination of indigenously manufactured connecting clamps and short shafts along with 5/8th Ilizarov ring and AO tubular rods. Thus this hybrid frame is easy to apply, versatile and significantly less expensive within the reach of poor patients.

Conclusion

The hybrid external fixator method we had applied is safe as regards of soft tissue healing and the limited number of complications associated directly to this method of application. We believe that the use of Hybrid external fixation, as a definite treatment, for high – energy proximal tibia bicondylar fractures proved to be beneficial. So we recommend a mini open reduction with percutaneous cannulated cancellous screw (one or two for securing interfragmentary compression) or olive wires with hybrid external fixator. This is the best method for closed (Schatzker type 4, 5, 6) as well as open proximal tibial fractures.

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