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# HYBRID EXTERNAL FIXATION FOR PROXIMAL TIBIAL FRACTURES

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## ABSTRACT

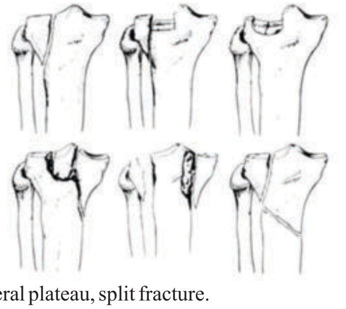
**Introduction:** Intraarticular fractures of the tibial plateau and periarticular fractures of the proximal tibia, caused by high energy trauma pose a therapeutic dilemma. Such fractures are associated with extensive soft tissue damage with or without compound injury. The management of such high velocity injuries become a challenge to the trauma surgeons. The goals of these periarticular fractures management are 1. Restoration of joint congruity by anatomic reduction 2. Stable fixation of fractures thus allowing early movements 3. Proper care of injured soft tissues. In earlier days uniplanar external fixation were used with various complications like pin track infections and decreased stability. In this study 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. The purpose of this study is to assess the utility of this hybrid external fixation system and to analyse the functional outcome, soft tissue healing and fracture union. **Aim and Objective:** To assess the performance of the Hybrid External Fixator in the treatment of different types of proximal tibial fractures, to evaluate the functional outcome, soft tissue healing and fracture union and radiological outcome, to evaluate the biomechanical and biological advantage of hybrid external fixator, to assess the utility of the indigenously made connecting clamps. **Material and Method:** The study included 21 cases of periarticular fractures of the proximal tibia which 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. **Result:** In the present study of 21 cases, the use of Hybrid external fixation, as a definite treatment, for high – energy proximal tibia bicondylar fractures proved to be beneficial.

**KEYWORDS :** Hybrid external fixator, Ilizarov, Intraarticular 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. The goals of these periarticular fractures management are 1. Restoration of joint congruity by anatomic reduction 2. Stable fixation of fractures thus allowing early movements 3. Proper care of injured soft tissues. In earlier days uniplanar external fixation were used with various complications like pin track infections and decreased stability. In this study 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 (2). The purpose of this study is to assess the utility of this hybrid external fixation system and to analyse the functional outcome, soft tissue healing and fracture union.

## CLASSIFICATION
## SCHATZKER CLASSIFICATION



Type I: Lateral plateau, split fracture.
Type II: Lateral plateau, split depression fracture.
Type III: Lateral plateau, depression fracture.
Type IV: Medial plateau fracture.

Type V: Bicondylar plateau fracture.
Type VI: Plateau fracture with metaphyseal-diaphyseal dissociation.

**GUSTILO AND ANDERSON CLASSIFICATION**

Type I
Wound less than 1cm long
Moderately clean puncture, where spike of bone has pierced the skin
Little soft tissue damage No crushing
Fracture usually simple transverse or oblique with little com minution

Type II
Laceration more than 1cm long
No extensive soft tissue damage, flap or contusion
Slight to moderate crushing injury
Moderate comminution
Moderate contamination

Type III
Extensive damage to soft tissues
High degree of contamination
Fracture caused by high velocity trauma
IIIA: Adequate soft tissue cover
IIIB: Inadequate soft tissue cover, a local or free flap is required
IIIC: Any fracture with an arterial injury which requires repair

**SOFT TISSUE INJURY CLASSIFICATION**

The recognition of soft tissue injury that is associated with distal tibia fractures has resulted in the evolution of their surgical treatment (8).

TSCHERNE and GOETZEN Classification

Grade 0: Closed fractures with no appreciable soft tissue injury. Indirect fracture with a simple pattern

Grade 1: Soft tissue injuries with superficial abrasion or contusion of skin. Low or medium energy fracture patterns or evident with displaced fracture fragments exerting pressure on the skin.

Grade 2: Injuries have deep abrasions and local contused skin. These injuries may also demonstrate imminent compartmental syndrome.

Grade 3: These injuries have extensive contusions or crushing and significant muscle destruction and subcutaneous tissue degloving. Compartmental syndrome, vascular injuries, and severe fracture comminution and a high energy mechanism are often identified as part of grade 3 injuries.

**MATERIAL AND METHODS**

This study consists of 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 Schatzker 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. The pre operative radiographs were used to classify the fractures according to Schatzker'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 Group 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 includes PRE-OP CLINICAL EVALUATION by 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 by 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 Schatzker 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 by inclusion criteria including tibial plateau fractures according to Schatzker classification Type 4, Type 5 and Type 6, Proximal 1/4 extra articular tibial fractures (severely comminuted ), Open Proximal tibial fractures according to Gustilo Anderson Classification Gr 2, Gr 3A, 3B, 3C, Proximal tibial fracture with compartment syndrome after Fasciotomy, High velocity proximal tibial fracture in impending compartment syndrome, Patients age over 18 years and ability to walk without assistance before injury and exclusion criteria including Schatzker type 1, type 2 and type 3, More than 2 weeks old fractures, Bilateral tibial plateau fractures, Polytrauma patients with tibial plateau fractures requiring prolonged ICU care, Proximal tibial fractures with neurological disorder, Proximal tibial fractures with paralytic disorder. PREOPERATIVE PLANNING goals of treatment of proximal tibial fractures include restoration of articular congruity, axial alignment, joint stability and functional motion. Fixation must be stable enough to allow early motion & minimize the wound complications. X ray of the tibia with knee joint and ankle joint (AP & LATERAL view) was assessed thoroughly and graded according to the fracture classification. Simple femoral distractor can be used for condyles reduction. The displaced articular fragments were planned for reduction accordingly. Plan and determine proper wire and schanz screw placement or if necessary, plan for mini-internal fixation with cannulated cancellous screws. Frame construction and 5/8th ring with AO rods were planned. SURGICAL TECHNIQUE Reduce the articular surface initially. Ligamentotaxis if needed can be used with femoral distractor. Articular congruity is achieved by elevating the depressed fracture fragments percutaneously under fluoroscopic control. If the articular fragments are displaced grossly reduce with K wire and fix it with 6.5 mm cannulated cancellous screws which will provide interfragmentary compression for the articular fragments (3,4). WIRE PLACEMENT Wire Insertion determine the wire position. Minimum of 2 or 3 wires are needed. Position the wires in the safe zone. Wire should be inserted 14 mm distal to the tibial plateau so that the capsule will not be pierced by wires. We can avoid the secondary pin tract infection and septic arthritis by placing the wires in metaphysis distal to the capsule. Position the wire distal to the cannulated cancellous screws or if possible, through the screw. Direction of Wires - Fibular head to tibia from lateral to medial, anterolateral to posteromedial direction, if possible 3rd wire from posterolateral to anteromedial direction, each wire should be placed 30 – 50 degrees wide apart as possible. Olive wires are used to reduce and compress the fragments (5,6,7). Make a stab incision and insert a protection sleeve. Manually push the wire through the sleeve until it contacts the bone. Drill the wire through the proximal cortex without changing the direction until it pierces the distal cortex. When the wire has pierced the opposite cortex proceed with gentle blows by the hammer. Place the bolt on the wires (central or peripheral). Attach clamps to the 5/8 th ring. First wrench tightens the wire – locking nut on one side and finger tighten the wire locking nut on the other side. Tension the wire with the help of wire tensioner. Wire can be tensioned from 90 – 120 kg. The same way apply another 2 wires in the proper position and direction and then tension it. SHANZ SCREW PLACEMENT Pin Insertion Technique - when inserting schanz screws it is important to know the anatomy and avoid nerves, vessels and tendons, do not place pins or screws into a joint, avoid the fracture focus and haematoma, predrill the cortex.

insert a schanz screw of the correct length. Apply 4.5 mm or 5 mm schanz screw in the diaphysis of tibia. Ideal placement is mid diaphysis Apply the first schanz screw in mid diaphysis. Connect the AO tubular rod to the schanz screw with AO universal clamp which is to be connected to the 5/8 th ring with indigenous hybrid connecting clamp. It is the monoaxial hybrid connecting clamp. Another 2 schanz screws are placed proximal to the first schanz screw as wide as apart as possible so that frame stiffness and stability will be increased. Schanz screws are connected with the tubular rod with the help of AO connecting clamps. Reduction of the metaphysis to the diaphysis is achieved by indirect reduction technique, using the fixator. Reduction is confirmed by C- arm image. Tighten the hybrid connecting clamp. Two side rods on either side are connected with5/8th ring with the help of short shaft proximally, and the same are connected to central rod with tube-to-tube clamp distally. The whole frame is finally tightened. POST OPERATIVE MANAGEMENT Pin Track Care - the reaction at the pin insertion site depends upon the position and stability of the pin. Normally the majority of the patients learn to take care of the pin sites on their own. Pin track care starts with correct pin insertion. Pre drilling is recommended for the conventional schanz screw and the schanz screw should always be inserted by hand to reduce the thermal necrosis. Undue soft tissue tension around the pins must be released during surgery. In cases of persistent pin track infection, the pin has usually lost its firm hold in the bone. A seam of bone resorption can be seen on the X rays and mechanically pin appears to be loose. This problem can be solved by removing such a loose pin and placing a new one at another site. Pin track care consisted of daily performed thorough pin care, from the first postoperative day, with hydrogen peroxide and betadine. Dynamization non weight bearing followed by partial and full weight bearing is the most effective method of dynamization. As the healing progresses, the load is increased until full weight bearing is achieved31,38. The fixation of the fracture provides relative stability and weight bearing allows adequate dynamization of the fracture zone - Passive and active range of motion exercises in the ankle are started early in 3 rd post op day whereas in knee joint Range of motion exercises are started at 1st week. Static Q exercises should be done along with knee joint ROM exercises, In grossly comminuted tibial plateau fracture movements are started at 2nd week, Non weight bearing crutch walking should be continued up to 8 – 12 weeks, Partial weight bearing is started at 10 weeks post operatively, full weight bearing is started at 14 – 24 weeks, Every 4 weeks patient should be followed up for functional, clinical and radiological outcome. Frame Removal done after strong evidence of adequate callus formation from 12 weeks to 24 weeks frame can be loosened under minor OT. The patient is advised to walk after frame loosening. Stability is assessed clinically. After clinical and radiological evidence of union frame can be removed under local or regional anaesthesia. Pin site wound care should be given.


**Before Debridement** **Pre – OP X-Ray**


**PRE OP X RAY**


**IMMEDIATE POST-OP** **AFTER REG. DRESSING**


**DRESSING** **AFTER SKIN & FLAP COV**

**POST – OP X-RAY**


**3 MONTHS**


**5 MONTHS**


**EVALUATION OF FUNCTIONAL OUTCOME**

Functional evaluation of knee is assessed by so many scorings system like WOMAC, The Mean Knee Society Score, Functional Grading Method of Hohl and Luck and Neer's Rating System. We followed the Neer's Rating System for evaluation of Knee (9).

| NEER'S RATING SYSTEM PAIN | |
|---|---|
| No pain in all range of movements | 4 |
| Pain with normal daily activity | 3 |
| Minimal activity causes pain | 2 |
| Pain at rest | 1 |

| | |
|---|---|
| MOVEMENTS (In degrees) | |
| Flexion > 110-degree | 4 |
| Flexion 90 – 110 degree | 3 |
| Flexion 70 – 90 degree | 2 |
| Flexion < 60 degree | 1 |
| FUNCTION | |
| Full weight bearing, Normal gait | 4 |
| Limping, no restriction of activity | 3 |
| Requires walking aid | 2 |
| Cannot walk | 1 |
| SHORTENING (cm) | |
| – | |
| 0 0.5 cm | 4 |
| 0.5 – 2.5 cm | 3 |
| 2.5 – 5 cm | 2 |
| >5 cm | 1 |
| ANGULATION (Degree) | |
| None | 4 |
| <10 degree | 3 |
| 10 – 15 degree | 2 |
| >15-degree | 1 |
| OUTCOME | |
| Excellent | 16 – 20 |
| Good | 12 – 16 |
| Fair | 8 – 12 |
| Failure | 4 – 8 |

## RESULTS

After analysing 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. Patient results are given in master chart. 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 degrees 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.

## 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[10,11]. Steven et al presented several transoperative – post operative complications. 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 striping[12,13]. 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 [18]. Neverthless as presented by Higgins et al, bicondylar fractures stabilized by means of a fixed angle plate present a higher rate of subsidence compared to dual plating stabilized fractures [19]. The external fixation as a define treatment for the polytrauma patient with multiple osseous and soft tissue injuries has been described in the literature [14,15] Certain authors believe that external fixation should be limited to bicondylar tibial fractures with a compromised soft-tissue envelope, as a temporary stabilizing technique, prior to definite treatment [16]. In the last 2 decades, the evolution 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 [17]. 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[20]. Mahadena et al, comparing external to internal fixation concluded that hybrid external fixation possesses 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[21]. Chin et al presented 38.9% good / excellent, and 61.1% fair / poor results in his type V and VI fractures series [22]. 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[23]. 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 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. 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 this 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.

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 5/8$^{th}$ ring in proximal tibia helped in achieving stable fixation and early joint motion [24].

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 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 wit 5/8$^{th}$ 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 5/8$^{th}$ ring and AO tubular rod does not affect the stability of the construct[25]. 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 5/8$^{th}$ 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

We conclude that, 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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