A PROSPECTIVE STUDY OF

HYBRID EXTERNAL FIXATION FOR
PROXIMAL TIBIAL FRACTURES

Dissertation submitted to

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For the award of the degree of

MS ORTHOPAEDIC SURGERY

BRANCH – II

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CERTIFICATE

This is to certify that DR. M.KARTHIKEYAN, post graduate student (2010-2012) in the Department of Orthopaedic Surgery, Government Kilpauk Medical College Hospital, has done dissertation on “A PROSPECTIVE STUDY OF HYBRIDID EXTERNAL FIXATION FOR PROXIMAL TIBIAL FRACTURES” under my guidance and supervision in partial fulfillment of the regulation laid down by the’ “THE TAMILNADU DR MGR MEDICAL UNIVERSITY, CHENNAI 32’ for M.S.(Orthopedic Surgery) degree examination to be held in April 2012.

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DECLARATION

I, DR. M.KARTHIKEYAN, solemnly, declare that dissertation titled “A PROSPECTIVE STUDY OF HYBRID EXTERNAL FIXATION FOR PROXIMAL TIBIAL FRACTURES” is a bonafide work done by me at government Kilpauk medical college hospital between 2010 to 2012, under the guidance and supervision of my respected unit chief & Head of department Prof. K.V.Chandrasekaran M.S.ortho., D.Ortho.

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Introduction
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\(^9\).

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\(^1\).

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 of the Study
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.
Surgical Anatomy
SURGICAL ANATOMY

The tibial tubercle is a large, oblong elevation where the anterior surface of the condyles of the tibia meet and where the patella tendon attaches. On the lateral aspect of the tibial tubercle is Gerdy’s tubercle, where the distal bands of the iliotibial band insert. The anterior crest of the tibia starts at the anterior margin of the medial malleolus. The anterior crest is sinuous and prominent in the proximal two thirds of the tibia, whereas it is rounded in the distal third. The anterior crest provides attachment for the deep fascia. The medial plateau is the larger of the two articular surfaces and is concave in both transverse planes. The lateral plateau is smaller and convex and lies slightly higher than the medial joint surface, which helps in identifying it on the lateral x-ray. When inserting screws from lateral to medial this fact must be taken into consideration in order to avoid penetrating the concave medial joint surface. The intermediate nonarticular intercondylar eminence serves as the tibial attachment for the anterior cruciate ligament. Isolated avulsion fractures of the anterior cruciate ligament are not considered fractures of the tibial plateau.

The tibial tuberosity and gerdy’s tubercle are bony prominences located in the subcondylar region for insertion of the patellar tendon and iliotibial tract respectively. The medial condyle, including its articular surface, is stronger than the lateral. As a result fractures of the lateral plateau are more common and may have articular impaction and fragmentation\(^1\). Medial plateau fractures
occur more often “en bloc” and are invariably associated with more severe injuries as well as with fracture dislocations.
With Muscle attachments and common peroneal nerve
Slope of Tibial Plateau

Normal X-ray

Comminuted Proximal Tibial
Review Of 
Literatures
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 coexisting 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.

V.T.Savolainen et al studied the hybrid external fixation in treatment of proximal tibial fractures and suggested that hybrid fixator is safe as regards of soft tissue healing and the limited number of complications associated directly to this method. They recommended mini open reduction of the fracture with one or two securing transcondylar screws along with hybrid fixator.

Aditya K. Aggarwal et al reported 86% excellent results out of 65 patients in tibial plateau fractures treated by hybrid external fixator.

Weiner LS et al reported the use of combination internal fixation and hybrid external fixation in severe proximal tibial fractures. They concluded with good and excellent results in terms of anatomic stable fixation with less soft tissue dissection and eliminates the need for large implants.
Aggarwal AK, Nagi ON et al reported good to excellent results in hybrid external fixation in periarticular tibial fractures.

Craig S Roberts et al studied strategies to improve frame stability. They concluded the most dramatic improvements in the stability of hybrid frames used for proximal tibial fracture result from addition of an anterior proximal half pin.

Catagni MA et al reported hybrid Ilizarov method combined with minimal internal fixation enables excellent to good results in most cases of complex tibial plateau fractures.

Kumar P, Singh GK, Bajrachary S et al studied the treatment of Grade 3 B open tibial fractures by Ilizarov method external fixator. They suggested that the hybrid external fixator is safe and versatile effective in providing stability and allowing early rehabilitation.

Zeman et al studied the use of a hybrid external fixator for treatment of tibial fractures. The results were excellent in 5, very good in 6, satisfactory in 5 and poor in 3. Two repeat operations out of 19 patients.
Classification
CLASSIFICATION

SCHATZKAR 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\textsuperscript{14}

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 comminution

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\textsuperscript{15}.

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. Compartamental syndrome, vascular injuries, and severe fracture comminution and a high energy mechanism are often identified as part of grade 3 injuries.
Biomechanics
BIOMECHANICS

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 gives solid enough for stabilization and providing micromotion which enhances good callus formation\textsuperscript{9,10}.

Three theoretical and bio mechanical foundation of hybrid external fixator are\textsuperscript{25,27}

1. Minimal damage to vascularity and soft tissue.
2. Solid elastic stabilization.
3. Early recovery of function.

Hybrid system contains two components.

1. Ring fixator
2. AO External fixator

RING FIXATOR

Also called Ilizarov ring fixator or transfixation system. Available sizes used for this hybrid external fixation system is 5/8 ring in 160 mm, 180 mm, 200 mm, 220 mm. The advantages of hybrid external fixation system over open reduction and internal fixation include simplicity of application, adjustability of
construct and increased access for wound care and wound monitoring after fixation is achieved. It gives multilevel, multiplanar and multidirectional transosseous osteosynthesis. It can be used in transfixation of fractures, limb lengthening and deformity correction. We have used as hybrid mode for transfixation of fractures so that it provide stability and elasticity\textsuperscript{11, 12}.

As the ring fixator is an external fixator it gives relative stability. As the pins are inserted across different planes in a multiplanar fixation the construct provides great stability.

The stiffness of the construction can vary depending on the configuration of the fixation the number of rings used and usage of different types of pins such as K wires or shanz screws. Stability depends upon size and position of the rings. The rings closer to the fracture site increases the stability\textsuperscript{31}. Increased ring radius causes reduction in axial stiffness and increased torsional stiffness. The optimum ring selection should be 3 cm minimum distance between the ring and skin. Rings are made up of stainless steel (ASIS 420). Its mechanical resistance is greater than 90 kg/sq mm\textsuperscript{11, 12}.

**AO EXTERNAL FIXATOR**

Stiffness of the frame depends upon the following factors.
1. Distance of the pins/shanz screws from the fracture focus. (the closer the stiffer)

2. Distance of the pins or shanz screws inserted as wide apart as possible. (the further apart the stiffer) Distance of the longitudinal connecting tube from the bone (the closer the stiffer)

3. Number of bars.

4. Configuration (Unilateral/V-shaped/bilateral or triangular frame)

5. Combination of limited internal fixation with external fixation.

Unstable external fixation will delay further healing. However too much stiffness or rigidity of the external fixator construction may also delay fracture healing.
AO TUBULAR ROD SYSTEM

1. Shanz Screws
   These are available in different diameters and lengths and different tips.

2. Rods / Tubes
   Four sizes are available.
   Large (11 mm) with shanz screws from 4 to 6 mm.
   Medium (8 mm) with shanz screws from 3 to 6 mm.
   Small (4 mm) with shanz screws from 1.8 to 4 mm.
   Mini (2 mm) for fingers.

3. Clamps
   Clamps are central element of modular system.
   a) Universal clamp
   b) Tube to tube clamp
   c) Connecting clamp
      In this system we have used this connecting clamp which was indigenously manufactured.

4. Short shaft
   It is mainly used to connect the side rods to ring in V shaped manner.
DESIGN RATIONALE

The main aim is to hold the fragment in proper alignment while allowing minimal axial dynamization at fracture site. Laryon and Rubin showed that cyclic axial loading of bone is important for maintaining bone mass and remodeling. Woodship, Kenwright and Wolf et al demonstrated that axial micromotion at fracture site increased fracture healing. Fixation of metaphysic with K wire is safer since pin pull out is greatly reduced. Fixation of diaphysis using half pin is safer by decreasing neurovascular damage. Also early range of motion can be started.

STIFFNESS

The slope of load deflection curve of fixation system is known as fixator stiffness. In case of spiral fracture with cortical contact, direct lag screw fixation produces 50 – 70 % of bending stiffness while DCP and external fixator provides 80 – 160 % of stiffness. In axial compression, plate and external fixator provides 90 – 115 % of stiffness and Ilizarov provides 60 – 110 % of stiffness. Lag screw provides 9 % of torsional stiffness and plate and external fixator 40 – 60 % and intramedullary rod 6.5 % of stiffness29,35.

This shows external fixator is very effective for bending and axial loading and ring fixator is very effective in metaphysic for torsional stiffness. Uniplanar fixator is stiffer than Ilizarov in lateral stress whereas Ilizarov is stiffer in AP
bending and torsion. So combination of these both gives stiffness comparative to both of these fixators\textsuperscript{27,32,35}.

**SHEAR STIFFNESS**

Ability of fixator to resist translation shear at fracture site is shear stiffness. Hybrid fixator resists shear forces as other fixators\textsuperscript{7,25}.

**AXIAL STIFFNESS**

Ability of fixator to resist gap closure is known as axial stiffness. Bone contact is most important in giving axial stiffness. Hybrid fixator with good bone contact has axial stiffness less than external fixator and equivalent to Ilizarov fixator. This allows axial micromotion\textsuperscript{7,25}.

**TORSIONAL STIFFNESS**

Ring fixator with K wire increases torsional stiffness than external fixator. Torsional stiffness increases upto 280 with pin angle of 90 deg\textsuperscript{7,25}.
Equipments Required
EQUIPMENTS REQUIRED

1. Ilizarov Ring (160, 180, 200, 220 mm)

2. Ilizarov Wire (Plain & Olive -1.8 mm)

3. Bolt and Nuts (Center and peripheral slot)

4. AO tubular rod (11 mm)

5. Shanz screws (4 – 6 mm)

6. AO Universal Clamps

7. Tube to Tube connecting Clamps

8. Main Connecting Clamp (Ring to Rod)

9. Short Shaft (Connecting side rod to Ring)

10. Wire Tensioner

11. Wire Player & Cutter

12. Spanner (Ordinary & Box Wrench, 10-11, 12-13 size)
EQUIPMENTS

5/8th ring

Connecting Clamp

Tube to tube clamp

Short Shaft

Wire Tensioner

Bolt & Nut

Tube to tube clamp

Shanz Screws

Spanner

AO Clamp
Materials
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%         |

**MODE OF INJURY**

- **99%**: RTA
- **1%**: FALL
Table. 2 Sex

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

![Sex Pie Chart]

- **Male**: 76%
- **Female**: 24%
### 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%      |

![Bar chart showing age distribution](image)
Table. 4 Fracture Classification

| S.No. | FRACTURE TYPE | NO. OF PATIENTS | PERCENTAGE |
|-------|---------------|-----------------|------------|
| 1.    | CLOSED        | 17              | 80.95%     |
| 2.    | COMPOUND      | 4               | 19.04%     |

![Fracture Classification Chart]
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
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 Proxial 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

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 shanz screw placement or if necessary plan for mini internal fixation with cannulated cancellous screws. Frame construction and 5/8 th 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\textsuperscript{10,12}.

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

1. Fibular head to tibia from lateral to medial

2. Anterolateral to posteromedial direction

3. 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\textsuperscript{26,27,37}.

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 pierce the distal cortex. When the wire has pierced the opposite cortex proceed with gentle blows by the hammer\textsuperscript{26,37}.

Place the bolt on the wires (central or peripheral)

Attach clamps to the 5/8\textsuperscript{th} ring.

First wrench tighten 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.\textsuperscript{26,27,28}

**SHANZ SCREW PLACEMENT**

**Pin Insertion Technique**

When inserting shanz screws it is important to

1. Know the anatomy and avoid nerves, vessels and tendons

2. Do not place pins or screws into a joint.

3. Avoid the fracture focus and haematoma.

4. Predrill the cortex.

5. Insert a shanz screw of the correct length.
Apply 4.5 mm or 5 mm shanz screw in the diaphysis of tibia.

Ideal placement is mid diaphysis

Apply the first shanz screw in mid diaphysis.

Connect the AO tubular rod to the shanz 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 shanz screws are placed proximal to the first shanz screw as wide as apart as possible so that frame stiffness and stability will be increased.

Shanz 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 with 5/8 th 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 26,37.
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 shanz screw and the shanz 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 achieved\(^{31,38}\).

The fixation of the fracture provides relative stability and weight bearing allows adequate dynamization of the fracture zone\(^{38}\).
1. Passive and active range of motion exercises in the ankle are started early in 3rd 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.

2. In grossly comminuted tibial plateau fracture movements are started at 2\textsuperscript{nd} week.

3. Non weight bearing crutch walking should be continued up to 8 – 12 weeks.

4. Partial weight bearing is started at 10 weeks post operatively.

5. 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**

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.
COMPLICATIONS

Intra operative complications

Per operative complications

1. Injury to common peroneal nerve (immediate)

2. Pin site infection

3. Septic arthritis

4. Frame loosening

5. Varus collapse of knee joint

6. Delayed union

7. Non union
## CASE REPORTS

### CASE 1

| Name                     | RADHA 55/F                  |
|--------------------------|----------------------------|
| Date of Surgery          | 15.02.2011                 |
| Follow up                | 9 Months                   |
| History                  | H/o fall of cement wall over her left leg |
| Clinical Findings        | Grade 3 B compound #BB Leg, severely comminuted |
| Radiological Evaluation  | Type 6 Schatzkar tibial fracture |
| Surgical Procedure       | Through wound debridement Immediarte hybrid external fixator Rotational flap cover by plastic surgeon |
| Post op follow up        | Uneventful                 |

- Regular dressing given
- Active & Passive non weight exercises done
- Hybrid external fixator removed at 6\textsuperscript{th} month post operatively.
-Recovered very well

| Result                   | Excellent                  |
CASE - 1

Before Debridement

Pre – OP X-Ray

RE – OP X – RAY
CASE - 1

IMMEDIATE POST-OP

AFTER REG. DRESSING

AFTER REG. DRESSING

AFTER SKIN & FLAP COV
CASE – 1 : POST - OP

3 MONTHS

5 MONTHS
CASE 2

Name : PERUMAL 38/M

Date of Surgery : 03.04.2011

Follow up : 7 Months

History : H/O RTA, Two wheeler vs two wheeler

Clinical Findings : Tense swelling presented over the prox 1/3 leg

Distal pulses felt

Active & passive ROM in ankle and toes present

Radiological Evaluation : Type 6 Schatzkar tibial fracture

Surgical Procedure : Hybrid external fixator with mini internal fixation

with 2 no 6.5 mm cannulated cancellous screw

Post op follow up : Uneventful

PO protocol followed.

Pin track infection and deep infection developed,
treated very effectively and settled well.

Result : Functional outcome was good.
CASE - 2

PRE – OP

1 MONTH POST-OP

1 MONTH POST-OP
CASE – 2

3 MONTHS POST-OP

5 MONTHS
CASE 3

Name : MURUGAN  25/M

Date of Surgery : 28.01.2011

Follow up : 9.5 Months

History : H/O RTA

Clinical Findings : Closed injury

Radiological Evaluation : Type 6 Schatzkar tibial fracture

Surgical Procedure : Hybrid external fixator

Post op follow up : Uneventful
                     Post op protocol followed

Result : Functional outcome was excellent
CASE 3

Pre – Op

1 MONTH POST OP

3 MONTHS POST OP
CASE – 3

3 MONTHS POST OP

4 MONTHS POST OP

4 MONTHS POST OP

5 MONTHS POST OP
CASE 4

Name : SIVA 35/M

Date of Surgery : 21.05.2011

Follow up : 5 Months

History : H/O RTA

Clinical Findings : Closed injury

Radiological Evaluation : Type 5 Schatzkar tibial fracture

Surgical Procedure : Hybrid external fixator

Post op follow up : Uneventful

Post op protocol followed

Fixator removed at 4 th month PO.

Result : Good
CASE – 4

Pre – op

3 MONTHS POST OP
CASE – 4

3 MONTHS POST OP

4 MONTHS POST OP
CASE 5

Name : MUTHAL 49/M

Date of Surgery : 27.11.2011

Follow up : 12 Months

History : H/O RTA

Clinical Findings : Closed injury

Radiological Evaluation : Type 6 Schatzkar tibial fracture

Surgical Procedure : Hybrid external fixation

Post op follow up : Uneventful

Post op protocol followed

Fixator removed at 5th month

Result : Functional outcome was good
CASE – 5

PRE – OP

POST – OP
CASE 6

Name : MURUGAN 25/M

Date of Surgery : 24.04.2011

Follow up : 2 Months

History : H/O RTA

Clinical Findings : Grade 3 B compound injury

Distal pulses felt

No signs of compartment syndrome

Radiological Evaluation : Type 6 Schatzkar tibial fracture

Surgical Procedure : Immediate Hybrid external fixation

Post op follow up : Uneventful

Septicemia developed inspite of higher IV antibiotic

Finally patient ended up with

Result : Functional outcome was failure.
CASE – 6

PRE – OP

PRE – OP

POST – OP
CASE – 6

POST – OP

POST – OP
Evaluation Of Functional Outcome
EVALUATION OF FUNCTIONAL OUTCOME

Functional evaluation of knee is assessed by so many scoring 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\textsuperscript{21}.

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

| Outcome   | 16 – 20 |
|-----------|---------|
| Excellent |         |
| Good      | 12 – 16 |
| Fair      | 8 – 12  |
| Failure   | 4 – 8   |
Results
RESULTS

After analyzing the above characters we have obtained

Excellent results in 7 patients (33.33%), 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  |
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 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
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\textsuperscript{39,40}. Steven et al presented several transoperative – post operative complications\textsuperscript{45}. 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\textsuperscript{41,42}. 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\textsuperscript{43}. 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\(^{44}\).

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 definite treatment\(^{39}\). 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\(^{4,28,32,39}\). 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\(^{40}\). 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\(^{41}\). Chin et al presented 38.9% good / excellent, and 61.1% fair / poor results in his type V and VI fractures series\(^{42}\). 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\textsuperscript{(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\textsuperscript{(43)}. 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 \textsuperscript{(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\textsuperscript{25,27,32}. 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\textsuperscript{38}.

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\textsuperscript{th} ring in proximal tibia helped in achieving stable fixation and early joint motion\textsuperscript{31,38}.

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 metapyseal 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\textsuperscript{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\textsuperscript{th} ring and AO tubular
rod does not affect the stability of the construct$^{29,35}$. Such hybrid combination helps in achieving articular congruity besides providing stable fixation which allows 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
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 (Schatzkar type 4, 5, 6) as well as open proximal tibial fractures.
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Annexures
Clinical Case
Proforma
CASE PROFORMA

SL NO:

IP NO:

Patient Name:

Age/Sex:

Occupation:

Address:

Phone No:

Date of Injury:

Mode of Injury:

Fracture Classification:

Schatzkar Type:

AO:

Simple/compound:

Gustilo Anderson Grade (If Compound):

Fracture Pattern:

TIBIA/FIBULA

Unicondyle

Bicondyle

Metaphysis
| **Comminuted** |
|----------------|
| **Distance from Tibial Plateau** : |
| **Fracture Level of Fibula** : |
| **Soft Tissue Injury Classification** : Grade 0/ Grade1/ Grade 2/Grade 3 |
| **Associated Injuries** : |
| **Medical Co-morbidities** : |
| **Interval b/w Injury & Surgery** : |
| **Previous Procedures** : |
| **Pre-op Angulation** : Varus / Valgus / Anterior / Posterior |

**Hybrid External Fixator Design:**

| Ilizarov Ring Size : |
| No of AO Rods : |
| No of Olive wires Used : |
| No of Ilizarov wires Used : |
| No of Shanz screws Used : |
| No of Hybrid Clamps : |
| No Short Shafts : |
| No of Tube to Tube Clamp : |

**Immediate Post – op Range of Movements:**

| 1 Month Post Op ROM : |
2 Months Post Op ROM :

3 Months Post Op ROM :

Wt Bearing Started On

   Partial Weight bearing :
   Full weight bearing :

Any Complication :

Any Secondary Procedures :

Follow Up/Review :

   Review 1 :
   Review 2 :
   Review 3 :

Final Outcome :

Functional Knee Outcome Score :
Consent Form
CONSENT FORM

I, Mr./Mrs.________________________ hereby declare that the procedure I am going to undergo is hybrid external fixation for proximal tibial fracture with or without internal fixation as a part of a study. I am aware that I am a part of the study and I have been thoroughly explained about its merits and demerits. The procedure is done with the intention of doing best to stay as a part of the study and come for regular follow ups.

Witness 1

Witness 2

Signature of the Patient

Place:

Date:
Master Chart
| S. No. | Age | Sex  | Mode of Injury | SCHATZKER CLASSIFICATION | GUSTILO & ANDERSON CLASSIFICATION | FOLLOWUP (MONTHS) | COMPLICATIONS                      |
|-------|-----|------|----------------|---------------------------|----------------------------------|------------------|-----------------------------------|
| 1.    | 59  | Female | RTA           | Ty - 6                   | Closed                           | 7                | -                                 |
| 2.    | 41  | Female | RTA           | Ty - 4                   | Closed                           | 9                | -                                 |
| 3.    | 51  | Male   | RTA           | Ty - 4                   | Closed                           | 10               | -                                 |
| 4.    | 25  | Male   | RTA           | Ty - 6                   | Gr - III B                       | 2                | Severe septicemia with amputation |
| 5.    | 25  | Male   | RTA           | Ty - 6                   | Closed                           | 9.5              | -                                 |
| 6.    | 49  | Male   | RTA           | Ty - 6                   | Closed                           | 12               | -                                 |
| 7.    | 55  | Female | RTA           | Ty - 6                   | Closed                           | 5                | Varus collapse                   |
| 8.    | 38  | Male   | RTA           | Ty - 6                   | Closed                           | 7                | -                                 |
| 9.    | 55  | Male   | RTA           | Ty - 6                   | Closed                           | 15.5             | -                                 |
| 10.   | 55  | Female | Fall          | Ty - 6                   | Gr - III B                       | 9                | -                                 |
| 11.   | 35  | Male   | RTA           | Ty - 4                   | Closed                           | 5                | -                                 |
| 12.   | 38  | Male   | RTA           | Ty - 6                   | Closed                           | 1.5              | Deep infection                   |
| 13.   | 65  | Male   | RTA           | Ty - 6                   | Closed                           | 2                | -                                 |
| 14.   | 44  | Male   | RTA           | Ty - 5                   | Closed                           | 7                | -                                 |
| 15.   | 52  | Male   | RTA           | Ty - 6                   | Closed                           | 8                | Varus Collapse                   |
| 16.   | 57  | Female | Fall          | Ty - 6                   | Closed                           | 5                | -                                 |
| 17.   | 34  | Male   | RTA           | Ty - 5                   | Closed                           | 4.5              | Delayed union                    |
| 18.   | 48  | Male   | RTA           | Ty - 4                   | Gr - III B                       | 3                | -                                 |
| 19.   | 33  | Male   | RTA           | Ty - 5                   | Closed                           | 7.5              | -                                 |
| 20.   | 46  | Male   | RTA           | Ty - 6                   | Closed                           | 3                | -                                 |
| 21.   | 51  | Male   | RTA           | Ty - 5                   | Gr - III B                       | 2.5              | -                                 |
| No. | Age  | Sex | Mode of Injury | SCHATZKER CLASSIFICATION | GUSTILO & ANDERSON CLASSIFICATION | FOLLOWUP (MONTHS) | COMPLICATIONS | RESULTS     |
|-----|------|-----|----------------|---------------------------|------------------------------------|------------------|--------------|-------------|
| 1.  | 59   | Female | RTA           | Ty - 6                    | Closed                             | 7                | -            | Excellent   |
| 2.  | 41   | Female | RTA           | Ty - 4                    | Closed                             | 9                | -            | Good        |
| 3.  | 51   | Male   | RTA           | Ty - 4                    | Closed                             | 10               | -            | Good        |
| 4.  | 25   | Male   | RTA           | Ty - 6                    | Gr - III B                         | 2                | Severe septicemia with amputation | Failure     |
| 5.  | 25   | Male   | RTA           | Ty - 6                    | Closed                             | 9.5              | -            | Excellent   |
| 6.  | 49   | Male   | RTA           | Ty - 6                    | Closed                             | 12               | -            | Good        |
| 7.  | 55   | Female | RTA           | Ty - 6                    | Gr - III B                         | 5                | Varus collapse | Good        |
| 8.  | 38   | Male   | RTA           | Ty - 6                    | Closed                             | 7                | -            | Excellent   |
| 9.  | 55   | Male   | RTA           | Ty - 6                    | Closed                             | 15.5             | -            | Good        |
| 10. | 55   | Female | RTA           | Ty - 6                    | Gr - III B                         | 9                | -            | Good        |
| 11. | 35   | Male   | RTA           | Ty - 4                    | Closed                             | 5                | Deep infection | Fair        |
| 12. | 38   | Male   | RTA           | Ty - 6                    | Closed                             | 1.5              | -            | Excellent   |
| 13. | 65   | Male   | RTA           | Ty - 5                    | Closed                             | 2                | -            | Good        |
| 14. | 44   | Male   | RTA           | Ty - 6                    | Closed                             | 7                | -            | Excellent   |
| 15. | 52   | Male   | RTA           | Ty - 6                    | Closed                             | 8                | Varus Collapse | Excellent   |
| 16. | 57   | Female | RTA           | Ty - 6                    | Closed                             | 5                | Delayed union | Good        |
| 17. | 34   | Male   | RTA           | Ty - 5                    | Closed                             | 4.5              | -            | Good        |
| 18. | 48   | Male   | RTA           | Ty - 6                    | Closed                             | 3                | -            | Fair        |
| 19. | 33   | Male   | RTA           | Ty - 5                    | Closed                             | 7.5              | -            | Excellent   |
| 20. | 46   | Male   | RTA           | Ty - 6                    | Closed                             | 3                | -            | Fair        |