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External fixators in fracture of proximal third tibia.

Orthopaedic

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ABSTRACT

PURPOSE: Evaluate results of External fixators in high energy proximal tibia fractures.
METHODS : Thirty four patients were included in this retrospective study
RESULTS : The IOWA knee score was excellent in 67.64 % (n=23), good in 20.58% (n=7), fair in 5.88% (n=2) and poor in 5.88% (n=2).Mean IOWA SCORE was 92. The knee range of motion was >120 degree in 82% and >100 degree in 94%. The rate of union is 100%.
CONCLUSION: External Fixator is a reliable method for stabilization of high energy proximal tibial fractures. It's a good alternative to other methods of fixation in proximal tibia fracture.

KEYWORDS:

proximal tibia fractures; external fixator; tibial platue Fractures.

INTRODUCTION:
The high-energy proximal tibial fractures like bicondylar fractures and dissociation of shaft from condyles pose management problems. The reasons are associated extensive soft tissue damage, fracture comminution as well as displaced articular fragments.

Closed management is ineffective in reducing and maintaining the joint surface congruency as well as axial alignment and is not recommended for severe soft tissue injuries.

Open reduction and internal fixation with plates though having the advantages of greater visualization of articular surface for restoration of joint congruency has been associated with major wound infections, residual osteomyelitis, late arthritis and even amputation[1,2,3,4]

Transarticular stabilization of the knee with an external fixator has been used to treat fractures of the tibial plateau with severe soft injury, but it has not been frequently employed as definitive treatment[5].

However many investigators have described various types of fixators with or without limited internal fixation[1,2,3,4,6] to avoid extensive soft tissue dissection so as to reduce soft tissue complications. The use of these devices is fast becoming quite liberal today.

We are currently using three types of external fixators in fractures of proximal third tibia. Depending upon type or nature of fracture as per OTA classification[7] (Table 1) the appropriate type of fixator will be applied. So we intend to study the utility of external fixators in high energy proximal tibial fractures.

MATERIALS AND METHODS:
This is retrospective observational study included 34 patients who underwent close reduction and external fixation with Aesculap clamps, Schanz pins, connecting rod or Augmented external Wagners fixator with or without cannulated cancellous screws for proximal third tibial fractures in between 2011 and 2013.

Inclusion criteria were 1. Patients with closed fractures of the proximal third tibia with significant soft tissue injury 2. Patients with compound fractures of the proximal third tibia 3. Patient more than 15years of age. Exclusion criteria were 1. Patients with OTA type 41-A1fracture 2. Patients with OTA type 41-B1, 41-B2, and 41-B3

All patients were evaluated by IOWA knee score. Factors like union of bone, knee joint motion were also considered.

The concerned permission from the ethical committee was taken.

Pre-operative evaluation
The radiographic evaluation was done with Antero-Posterior and Lateral view X-ray of the full length tibia and fibula with knee joint. 3D reconstruction CT scan was done for better understanding of the fracture pattern and intra-articular surface.

Surgical technique
After giving spinal anaesthesia patient, the patient was placed on a traction table for providing ligamentotaxis .A pillow support was given under the thigh and the foot is externally rotated 5^{o}-10^{0}.The fracture position is checked with image intensifier. This gave an idea about which fixator to use.

1aaPercutaneous and intra articular Kirschner wires/ Steinman pin/ 5mm Osteotome were use as joy sticks to aid manipulation of the condylar fragments or depressed plateau fractures and tibial joint surface congruity was achieved.

Closed reduction of condylar fracture components was achieved and retained with large tenaculum reduction forceps. Metaphyseal or diaphyseal fragments, if present was manually reduced and maintained. If necessary, K-wires cannulated cancellous screws or

cortical screws (4mm) were used to fix the condylar fractures.

If necessary, limited incision was used to elevate and reduce the depressed or displaced fragments and to fix the avulsion of Anterior / Posterior cruciate ligaments as well as metaphyseal / diaphyseal fractured fragments.

Selection of fixator

Whether to use Augmented Wagners External fixator or Aesculap External Fixator will depend on requirement of post-operative fracture site compression to achieve bone to bone contact. Especially in severe metaphyseal communition, here we would prefer Augmented Wagners External Fixator. In others who would not require any compression post operatively, the Simple external fixator with Aesculap clamps and rod will be used.

The selected External Fixator system (large) is initially placed to span the tibia with its clamps appropriately positioned and also held parallel to the medial surface of tibia

A) Simple external fixator with Aesculap clamps and rod: After reducing the fracture one proximal most and one distal most pins are applied parallel to the respective joint line. Rest of the pins will be appropriately directed so as to maintain fracture reduction and bone to bone contact.

B) Augmented Wagner's external fixator: Initially proximal and distal most 4.5mm Schanz pin is introduced at right angles to the tibia. The proximal Schanz pin is passed through the posteromedial part of the proximal tibia approximately 1.5 cm from the joint line directing it laterally. The second proximal Schanz pin was introduced from anteromedial part directing it posterolaterally avoiding pes anserinus complex as far as possible. Third proximal Schanz pin was passed anteroposterior through medial tibial condyle. The rest of the pins were appropriately directed to hold the metaphyseal fracture in place. All the nuts of clamps and the bolts of Rancho cubes are fastened. Gentle compression given to bring about bone to bone contact in the region of metaphysis. The External Fixator was finally locked.

C) In hybrid fixation cannulated cancellous or cannulated cortical screws were inserted percutaneously under image intensifier after reduction of condyles and plateau fractures, and then a fixator is applied as mentioned above. Schanz pin are cut with jumbo cutter at level beyond clamps. Reduction was checked under image intensifier before the patient leaves the operation theatre.

Augmented Wagner's External Fixator

We have modified the classic Wagner's external fixator(Figure 1) to include 4 instead 2 clamps, a quarter of Ilizarov ring with Rancho cubes and if required, Aesculap clamp instead of Wagners clamp to make the fixator mechanically stable and rigid besides being versatile and patient friendly. We called this unique fixator as **Augmented Wagner's External Fixator** (Figure 2). It is used in bicondylar fracture with metaphyseal-diaphyseal comminuted fracture, where compression of fracture is contemplated post operatively to bring bone to bone contact.

The body of the fixator consists of two square telescoping rods to facilitate compression after the fixator is applied. Generally 4-5 clamps instead of 2 with one clamp at the end of the inner tube being placed at right angles to the others. On the body of this clamp is placed Ilizarov quarter with 2-3 Rancho cubes. The stud of the body of the Wagner's external fixator clamp is 8mm in diameter and 32mm in length instead of 6mm and 20mm respectively so that an Aesculap clamp can be accommodated when required. The central threaded rod (compression, distraction rod) is of stainless steel SS 304 and is of diameter of 8mm instead of 6mm. The periarticular fixation must consist of at least 3 pins in the same plane but different levels to avoid hitting each other. This is achieved in our study with the help of attaching Schanz pins to an Ilizarov ring which itself is attached to the fixator at right angles.

Post-op rehabilitation

Active physiotherapy and motion of knee with continuous passive motion (CPM) apparatus was initiated from the 2^{nd} – 5^{th} post operative day.

Based on fracture pattern and radiological evidence of healing, toe touch weight bearing and progressive weight bearing was permitted.

Suture removal done after 2 weeks if required.

Follow up

At 2, 4, 6, weeks, 3^{rd}, 6^{th} 9^{th}, 12^{th} month and at yearly interval

RESULTS:

.The IOWA knee score was excellent in 67.64 %(n=23), good in 20.58% (n=7), fair in 5.88% (n=2) and poor in 5.88% (n=2).P value < 0.05 (0.0016) was considered significant. The mean IOWA knee score was 92. The knee range of motion was >120 degree in 82% and >100 degree in 94%. (Figure 3) The mean union period was about 20 weeks and 91 % (n=21) of fractures united within 7 months.

DISCUSSION:

Type of injury

Gustilo RB, Nicolle EA and Anderson JT [9] had classified the compound fractures into Type I, II and III according to the skin, soft tissue and bone injury.

We had 16 patients with closed fracture with soft tissue injury. When classified our patients with compound fracture according to Gustilo classification, five were Grade I, nine of Grade II and four of Grade III A compound fracture tibia. Bal GK et al[8] observed the distribution of grade of injury as 21 closed fractures, 2 type II compound, 7 type IIIA, 3 type IIIB, and one type IIIC compound fractures according to Gustilo Anderson Classification System. According to a study by Karlstrom G and Olerud S[10] , out of 28 cases eighteen injuries were rated as type III and ten were type II injuries. However Gustilo RB and Anderson JT[11] reported 81 % cases in type I and II and 19% cases in type III injuries.

Types of fractures

We classified the type of fractures based on Orthopedic Trauma Association (OTA)[7] classification. According to this classification we had 5 cases of type A2, 6 cases of type A3, 9 cases of type C1, 9 cases of type C2 and 5 cases of type C3.

Bal GK et al[8] also classified the fractures in his study according to OTA classification and included 8 (23.52%) cases of type A3, 2 (05.88%) cases of type C1, 4 (11.76%) cases of C2 and 20 (58.82%) cases of C3.

Types of fixators

We used four techniques for fixation proximal tibia fractures as per requirement to maintain reduction. Simple Aesculap fixator was used in 11 patients. Augmented Wagner fixator was used in 6 patients. Hybrid Aesculap fixator (Figure 4) was used in 14 patients and Hybrid Wagner fixator was used in 3 patients.

Hybrid External Fixator is done when type C fractures or when plateau fractures exist. These fractures were supported with cannulated cancellous (4mm) or cortical screws after reduction. Then selection of fixator was made. Augmented Wagner's External fixator was performed in presence of comminuted metaphyseal or diaphyseal fracture, as one may need to compress fracture post operatively to bring about bone to bone contact.

In other cases Aesculap fixator was used.

Knee range of motion

Thirty two (94%) out of 34 patients were having more than 100 degree range of motion and twenty eight (82.35 %) were having more than

120 degree of range of motion in knee. Two patient having less than 70 degree range of motion had associated supracondylar femur fracture. Ramos T et al[12] treated 30 patient of which 25 (83.33%) patient achieved more than 100 degree range of motion.

Duration of Fixator

In the series of Karlstrom et al[10] , 25 (92%) patient's fixators had been removed in 8 months of which 12 (44.44%) were removed within 4 months. In our study, Thirty one (91%) patient's fixators were removed within a period of 7 months. (Table 2)

Complications

1. INFECTIONS

There are reports suggesting reduced rate of infection and improved functional outcome but proximal pin track infection was troublesome. Marsh JL et al [1] reported 2 cases of septic arthritis of the knee in their study of 21 knees. Weiner LS et al [13] too reported 2 cases of septic arthritis in 45 knees. Bal GK et al reported 3 cases of pin tract infection in 34 cases with 1 case having septic arthritis. Babis GC et al [14] reported pin track infection in 3(9.1%) cases and one septic non-union (3%) out of 33 patients. Ramos T et al [12] observed 4% (n=1) pin tract infection in series of 30 patients. We had only one (2.94%) case of pin tract infection which resolved with oral antibiotics and pin removal. We also had one (2.94%) case of pes anserinus bursitis because of proximal posteromedial pin of Augmented Wagners external fixator. Bursitis resolved after removal of pin and with oral antibiotics.

2. STIFFNESS / SHORTENING

They were 2 patients having stiffness at the knee joint. Status of the joint was observed at regular interval from the operation and was labelled as stiff if the range of motion was less than the pre-decided standard value. One patient had ipsilateral supracondylar fracture femur. After rigorous physiotherapy these patients developed range of motion upto 70°.

3. MALUNION

In our series we did not have any case of malunion because of anatomical reduction and rigid fixation.

4. NON-UNION

In our series no patient developed non-union. 93% patients had union within 7 months of time. The mean union period was about 20 weeks.

Comparison with other studies involving use of other fixators for proximal tibial fractures

a) Union rate – (Table 3: Union rate of various series)

It can be seen that the union rate in our series (100%) is better than that of Bonnevialle P [15], Wiener LS[13], Babis GC et al[14],Lang Gj[16].

Orthofix fixator has an advantage of being able to be change to dynamic mode after initial callus formation. The same can be achieved with the help of Augmented Wagner External Fixator. More over Augmented Wagner External Fixator has an advantage that compression can be achieved at the fracture site in addition to biplanar stability of fixation. Compression that is applied through an external fixation system, increases rigidity of fixation provides benefit for bone healing.

The union rate in Wiener LS[13] series appears to be high (96%), but the use of internal fixation devices in compound fractures is limited especially in end bone fractures. Augmented Wagner's External Fixator has an advantage in this respect that it maintains rigid fixation without interfering in the natural bone union process.

Lang GJ[16] series too had a high (93%) union rate but most the cases included in the series were closed fractures. Moreover a large bone fragment is required for adequate purchase, therefore limiting its use in those fractures in which a small fragment is present.

Bonnevialle P[15] series also has better union rate (88%) ,Babis GC[14] has union rate of 96% using Hybrid external fixator.

b) Success rate – (Table 4: Success rate)

In our study with various External Fixators in 34 proximal tibial fractures, twenty three (67.64%) were excellent,7 (20.58%) were good,2 (5.88%) were fair and 2(5.88%) were poor. two cases of knee stiffness, one case of pin tract infection and one case of pes anserinus bursitis were observed.

In a prospective study of 25 proximal metaphyseal tibial fractures by Bonnevialle P et al[15] treated with Orthofix fixator, 11 patients (44%) had excellent functional result (no pain, full range knee motion, normal daily activity); 12 patients (48%) had a good result (episodic pain, minimal knee discomfort, flexion limitation).

Wiener LS et al[13] studied the use of combination of internal fixation and hybrid external fixation in 50 severe proximal tibial fractures. All patients in his series healed; 48 fractures healed in an average of 12 weeks without subsequent surgery. There were two (4%) non-unions requiring bone graft. Grading criteria for the anatomical outcome revealed that there were 17 (34%) excellent results, 24 (48%) good result, 6 (12%) fair result and 3 (6%) poor result.

Bal GK et al[8] in his study with 32 patients using anterior T-Frame external fixator combined with percutaneous internal fixation, observed nine (26%) complications, including one deep infection (septic arthritis) and three pin tract infections, and one each of malunion, non union, refracture, knee stiffness requiring manipulation under anesthesia and deep venous thrombosis.

Marsh JL[1] conducted study of 21 patients showing 11 (52%) patients with excellent results, 4 (19%) good result, 5 (24%) fair result and 1 (5%) poor result.

Comparison with other modalities of treatment

Literature reports on open reduction and internal fixation with plates indicates an occurrence of a significant percentage of infection, wound breakdown, and tibial osteomyelitis .

Moore et al[17] reported 23% infection in bicondylar fractures and noted difficulty in closure of wound and subsequent dehiscence in 8 of the 11 knees treated with medial and lateral plates. Young MJ and Barrack RL[18] reported infection in 7 of 8 fractures treated with medial and lateral plates ultimately leading to 2 amputations.

Bach AW and Hansen ST Jr[19] who compared the external fixation with open reduction and plating of compound fractures evidenced this in a study. They observed infections in 35% after plating versus 19% after external fixation. Moreover osteomyelitis developed in 13% patients with plated tibia compared with 3% of patients with external fixation.

External fixation offers viable and effective alternative for treatment of high energy fractures of tibial plateaus with metaphyseal comminution. The articular surface as well as the metaphyseal / diphyseal portions of the fracture could be reduced and maintained with percutaneous screw fixation with cannulated cancellous or cortical screws(limited internal fixation).

The optimal treatment of complex proximal tibial fractures has been a controversy. There are reports that suggest that final outcome depends more on knee stability that on articular surface restoration. Also that less extensive approaches leads to satisfactory results. With external fixation of proximal tibial fractures, there is complication related to proximal pin placement. The posteromedial pins enter near or through the pes anserinus complex. During flexion and extension, the pes anserinus tendons move around the pins which may increase the risk of inflammation. But we have encountered only a single case in our series.

CONCLUSION:

External Fixator with limited percutaneous internal fixation for intercondylar fractures and metaphyseal fragments is a reliable method for stabilization of high energy proximal tibial fractures.

It's a good alternative to other methods of fixation in proximal tibia fracture.

CONFLICTS OF INTEREST

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

TABLES:

Table 1- Fracture of proximal tibia was classified according to Orthopaedic Trauma Association (OTA) classification.

A. Extra articular fracture		
A1 – Extra articular fracture, avulsion	A2 – Extra-articular fracture, metaphyseal simple	A3 -Extra-articular fracture, metaphyseal multifragmentry
.1 of the fibular head	.1 oblique in the frontal plane	.1 intact wedge
. 2 of the tibial tuberosity	.2 oblique in the sagittal plane	.2 fragmented wedge
. 3 of the cruciate insertion	.3 oblique in the sagittal plane	.3 complex
B. Partial articular fracture		
B1- Partial articular fracture, pure split	B2 – Partial articular fracture, pure depression	B3 - Partial articular fracture, split-depression
.1 of the lateral surface	.1 lateral total	.1 lateral
.2 of the medial surface	.2 lateral limited	.2 medial
.3 oblique, involving the tibial spines and one of the surfaces	.3 medial	.3 oblique, involving the tibial spines and one of the surfaces
C. Complete articular		
C1 – Complete articular fracture, articular simple, metaphyseal simple	C2 –Complete articular fracture, articular simple, metaphyseal multifragmentary	C3 -Complete articular fracture, multifragmentary
.1 slight displacement	.1 intact wedge	.1 lateral
. 2 one condyle displaced	.2 fragmented wedge	.2 medial
. 3 both condyles displaced	.3 complex	.3 lateral and medial

Table 2- Duration of fixator

Karlstrom G et al series[10]	Duration of fixator					
	2 –4 months		4-8 months		>8 months	
	12	44.44%	13	48.14%	2	7.4%
Our series	Duration of fixator					
	<4 months		4-7 months		>7 months	
	14	41.1%	17	50%	3	8.82%

Table 3- Union rate of various series

Modality Of Treatment	Series	No. of Cases	Union Rate in Percentage
External fixators	Our Series	34	100%
Orthofix	Bonnevialle P[15]	25	88 %
Combined internal and Hybrid External Fixator	Wiener LS [13]	50	96 %
Intramedullary Nail	Lang GJ[16]	32	93 %
Orthofix (Hybrid external fixation)	Babis GC et al[14]	33	97%

Table 4- Success rate of various series

Modality of treatment	Series	No of cases	Result			
			Excellent	Good	Fair	Poor
External fixators	Our Series	34	23	07	02	02
			67.64%	20%	5.88%	5.88%
Orthofix	Bonnevialle P[15]	25	11	12	1	1
			44 %	48 %	4 %	4 %
Combined Internal and Hybrid External Fixator	Wiener LS[13]	50	17	24	6	3
			34 %	48 %	12 %	6 %
Closed reduction & interfragmentary screw fixation of articular fragments with unilateral half pin external fixator	Marsh[1]	21	11	4	5	1
			52%	19%	24	5

FIGURE LEGENDS:

Figure 1- Classic Wagner's external fixator
Figure 2- Augmented Wagner's external fixator
Figure 3- Range of motion of left knee > 100° in 63 year old patient after 14 weeks treated with Augmented Wagner's external fixator
Figure 4 – Patient 43 year old male with Grade II compound proximal tibial fracture treated with hybrid external fixator. a) Pre-operative x-ray b) Post- operative x-ray c) Range of motion of knee > 100° after 12 weeks

FIGURES:

Figure 1- Classic Wagner's external fixator

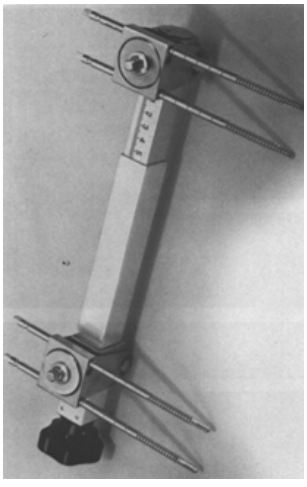


Figure 2- Augmented Wagner's external fixator

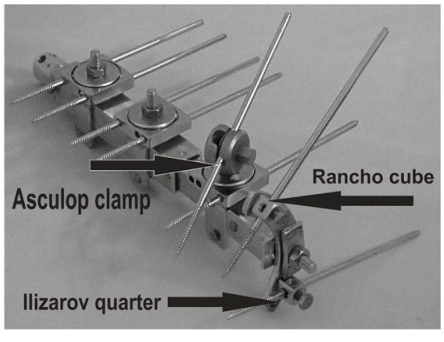


Figure 3- Range of motion of left knee > 100° in 63 year old patient after 14 weeks treated with Augmented Wagner's external fixator

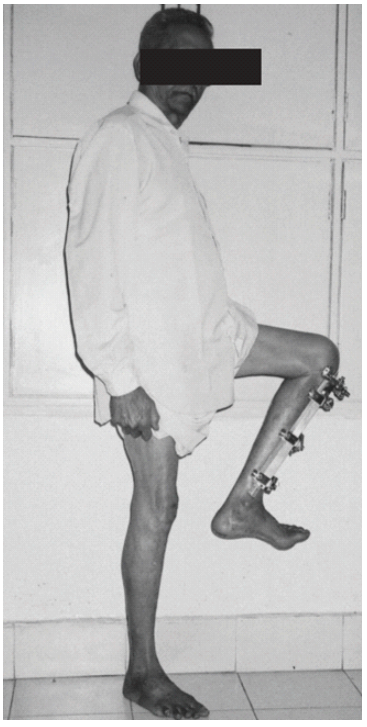
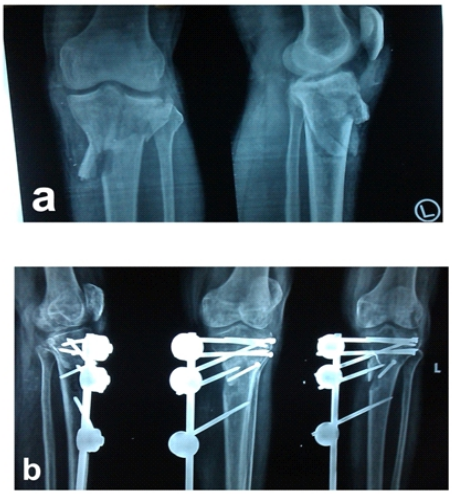


Figure 4 – Patient 43 year old male with Grade II compound proximal tibial fracture treated with hybrid external fixator. a) Pre-operative x-ray b) Post- operative x-ray



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