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AUGMENTED WAGNER'S EXTERNAL FIXATOR AS A TREATMENT MODALITY IN COMPOUND TIBIAL FRACTURES

Orthopaedics

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ABSTRACT

Background : Compound tibia fractures are common in high velocity accidents.The treatment of tibial shaft fractures should obtain healed,well aligned fracture,pain free weight bearing and a functional range of movement of knee and ankle joints.

External fixation is a versatile tool for treatment of compound tibial fractures providing stable fixation,preserving soft tissue and bony vascularity,leaving wounds accessible and causes minimal blood loss.

We here modify the classic Wagner's external fixator to include a quarter of Ilizarov ring,Rancho cubes and Aesculap clamps to make it mechanically stable and rigid besides being versatile and patient friendly.We call it Augmented Wagner's External Fixator.It spans across the fracture gap in cases of comminution like internal neutralization plate.Compression can be directed across the fracture getting bone to bone contact without bone grafting.Rotational and translational deformity can be corrected as consolidation progresses.Treatment of compound injuries requires soft tissue coverage,vascular repair and this apparatus permits these to be performed easily.

Methods : Combined i.e. both Retrospective and Prospective study

Duration: February 2005 to December 2009

Number of patients: 25; 15 retrospective and 10 prospective

Scores used: Iowa knee and ankle score

Results : The patients were followed up for an average of 2 years after injury.

According to average of Iowa knee and Iowa ankle score,we had 88% excellent, 6 % good, 4% fair and 2% poor results with an average of 92 and 96 on the knee and ankle scores respectively.

Conclusion : The Augmented Wagner's external fixator is a versatile,user friendly and a reliable tool for stabilization of compound tibia fractures offering advantage of better wound care.

KEYWORDS

Compound fractures,Augmented Wagner's Fixator

Introduction :

Major injuries of the limbs are no longer confined to the battle fields.High velocity injuries producing severe bone and soft tissue damage, have become a common place in most, major accidental units. Complicated open fractures of the tibia and fibula have always been a challenge to the surgical specialities. The results of treatment of open high-energy tibial fractures have improved significantly because of important contributions made by the large trauma services. These good results are a result of various methods, which are followed with their advantages and shortcomings over a period of years.

Conservative management, dynamic tractions, pins and plasters, primary internal fixation, delayed functional bracings are some of the traditional approaches to deal with this problem. The system of 'External fixation' has come as a boon in the treatment of such complicated fractures.

Closed management of compound injuries is ineffective due to the difficult management of the open wounds with use of plaster casts. Use of primary internal fixation as a treatment modality, especially with plate fixation has been associated with an unacceptably high incidence of infection.[1].Primary internal fixation with unreamed intramedullary nailing for compound tibial fractures has been reported with good results in the recent past.[2],[3],[4].

The importance of leaving the wound open, with aggressive and repeated debridements of all devitalized tissue, including large fragments of bone, until closure by delayed primary closure, skin grafting or skin flaps[5],has led to the development of external fixators as a definitive modality of treatment of open tibial fractures.

Many investigators have described various types of fixators with or without limited internal fixation for management of open tibial fractures. These early external fixation devices were expected to provide a measure of rigidity similar to that provided by internal fixation with plate and screws. In the latter instance, fractures unite by the extremely slow process of primary bone healing, without formation of external bridging callus.

It has also been suggested that optimal primary bone healing will not be achieved if movement at the fracture site is more than 5-10 microns[6].In practice it is extremely difficult to avoid a movement of less than 10 microns with any external fixation device, and with this type of equipment, therefore, primary bone healing is discouraged.

On the other hand, the devices originally available did provide a substantial measure of uncompromising rigidity, which, while valuable in the early stages of fracture healing, did not encourage the formation of external bridging callus, which is dependent upon some movement at the fracture site.

It therefore follows that conventional external fixation device may encourage neither primary bone healing, nor external callus formation to best advantage, resulting in prolongation of overall healing time. These features, together with fear of pin tract infection, accounted for the understandable reservations expressed by many surgeons regarding the use of external skeletal fixation.

Also,full ring stabilization is said to be preferable to monolateral shaft stabilization because of the cantilever loading which is accentuated when a proximal ring is attached to a solitary diaphyseal bar.

Moreover, monolateral type construct can't be easily dynamised or compressed. Adjustments,if required for alignment or compression and lengthening are generally unsatisfactory.

So, we modified the classic Wagner's external fixator to include a quarter of Ilizarov ring, Rancho cubes and if required, Aesculap clamps to make it mechanically stable and rigid besides being versatile and patient friendly. We call this unique fixator Augmented Wagner's External Fixator. This fixator can span across the fracture gap in cases of comminution similar to an internal neutralization plate. Compression can be directed across the fracture site so as to achieve bone to bone contact without additional bone grafting. Rotational and translational deformity also can be corrected as consolidation progresses. Treatment of these complex compound injuries may also require other secondary procedures like soft tissue coverage, vascular repair etc. and this apparatus permits these to be carried out easily.

Review of literature :

Although Alvin Lambotte is credited with the use of transfixing pins attached to an external frame to treat fractures for the first time, interest in external fixators as a means of management was reawakened by Vidal et al.[7] External fixation for the initial management of severe trauma to the lower leg is well supported in literature specifically for its ability to immediately stabilize fracture fragments and still allow access for soft tissue management.[8]

Despite the undoubted value of external fixation in the management of compound tibial fractures, it is important to concentrate on proper technique to avoid malunion and nonunion. The tubular system of AO/ASIF fixator has rapidly gained wide acceptance of the improved pin design and frame biomechanics. However, according to a study by Harkesset al.in 1996, the major deficit of these fixators is that they allow very little adjustment after application, without replacing the pins.[9]

Some of these issues have been successfully managed by the orthofix monotube fixator. This fixator allows compression, distraction, and dynamic axial loading through a telescoping device.[10] However, monotube fixators suffer from an inability to vary pin location substantially compared to monolateral fixators. With pin clusters being fixed at either end of the mono tube body, the surgeon cannot maximize pin spread in relation to the fracture site.[11]

Dynamization at the fracture site allows new bone deposition and a total increase in circulation through the pumping action of the calf musculature.[12]Compression osteosynthesis with constant compressi on on the bone does not cause damage or resorption of the bone tissue. Compression facilitates union in this mechanical environment. An increase in axial loading is accompanied by enhanced blood supply, which activates osteogenesis, as suggested in the study by Wallace et al.[13]

The aims of the treatment in a compound fracture of the tibia include a suitable union, correct aliment, restoration of the mechanism of the knee and the ankle joints, as well as to achieve the normal activity of the patient, as soon as possible, as pointed out by French et al[14] in their study in 2002.

Augmented Wagner's External Fixator and it's parts :

The body of the fixator consists of two square telescoping rods to facilitate compression after the fixator is applied.

Generally four to five clamps instead of two with one clamp at the end of the inner tube being placed at right angles to the others are present. On the body of this clamp can be placed the 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 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 quarter ring which itself is attached to the fixator at right angles

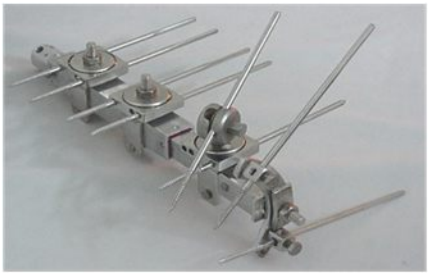


Fig.1 (Augmented Wagner's external fixator)

Other Features:

1. Two sizes of Augmented Wagner's External Fixator have been made.The spread of the small size is 190.5mm-266.7mm and that of large size is 254mm-355.6mm.
2. The weight of the small Augmented Wagner's External Fixator is 850gms(approx) and the weight of the large one is 950gms (approx).
3. The Schanz pins are available with length of threading ranging from 26mm to 75mm with increments of 2mm having a core diameter of 3.2mm and outer diameter of 4.5mm.The square tube of the Augmented Wagner's External Fixator is made of extruded aluminium.
4. Sterilization of the fixator:Standard protocol of precleansing the frame, followed by alcohol wash and sequential povidine-iodine paint with air drying.

Materials and Methods :

Type of study: Combined i.e. both Retrospective and Prospective
Duration: February 2005 to December 2009
Total number of patients: 25; 15 Retrospective and 10 Prospective
Criteria for selecting the patients:

1.) Both males and females included.
2.) Patients from various age groups will be studied.
3.) Patients with clinical evidence of compound fracture of tibia.
4.) X-ray demonstrable fracture of the tibia;proximal,middle or distal third.

Soft tissue injuries were classified according to the system of Gustilo and Anderson[15]

The OTA(Orthopedic Trauma Association)[16],[17]classification of fractures of the tibia;proximal,shaft and distal tibia was used.

Methodology In Casualty :

As most patients had high energy trauma,initial resuscitation was done and priority was given to life threatening conditions.

A thorough wound lavage was given using normal saline and an antiseptic solution.

Tension free stay sutures were taken for wounds where skin coverage was easily possible.The neurovascular status of the limb was noted and the limb was covered with sterile dressings and was splinted.

Evaluation :

The radiographic evaluation was done with Antero Posterior and Lateral view X-ray of the full length of tibia and fibula with the knee and the ankle joints.

An appropriately sized Augmented Wagner's External Fixator was then kept ready.The fixation was done immediately in cases with vascular injuries and delayed in those cases with swelling,which was first allowed to subside before fixation was done.

Those soft tissue injuries which required either split skin grafting or flaps,were treated immediately as a primary procedure along with fracture fixation or at a later stage as a second procedure.

Surgical Technique :

The patient is placed on a fracture table for providing desired traction and rotation with image intensifier .The foot is externally rotated 5o.
Leg is appropriately prepared and draped and trolley is kept ready.

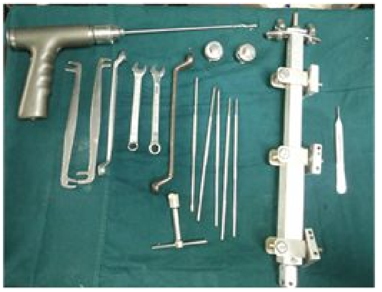


Fig.2 (Set trolley for surgery)

Thorough debridement of the wound is done and antiseptic lavage is given.

Closed reduction of the fracture is achieved manually and maintained, if necessary, using tenaculum forceps.

Percutaneous K wires are used as joy sticks to manipulate the fracture fragments to achieve reduction,if need be.

Limited incisions are used,if necessary, to achieve open reduction of loose fracture fragments and to fix these fragments using 2.5 mm/2.7 mm cortical interfragmentary screws. Limited incisions are also used for fibular fixation using 2.5 mm reconstruction plates.

Maintaining the reduction in place, Augmented Wagner's External Fixator is initially spread to span the tibia with it's clamps appropriately positioned and is held parallel to the medial surface of the tibia.

Fig.3 (Application of Augmented Wagner's External Fixator)

Initially the proximal and distal most 4.5mm Schanz pin is introduced at right angles to the tibia.

A.).In case of proximal fractures,the first proximal Schanz pin is passed from the posteromedial aspect of the proximal tibia approximately 1 cm.[18] from the joint line directing it laterally.The second proximal Schanz pin is introduced from anteromedial part directing it posterolaterally avoiding the pesanserinus complex as far as possible.Third proximal Schanz pin is directed anteroposterior through medial tibial condyle.

B.).In case of distal fractures,3 Schanz pins are similarly used in same plane but at different levels to avoid hitting each other.These 3 Schanz pins are held with a quarter Ilizarov ring.Such a construct offers more rigidity to the distal fractures.

C.).In case of middle third fractures, the Ilizarov quarter ring may not be used as there is no additional periarticular stabilization required.

The rest of the pins are appropriately directed to hold the reduced fracture in place.All the nuts and bolts of Rancho cubes are fastened.Gentle compression is given to bring about bone to bone contact at the fracture site.

The Augmented Wagner's External Fixator is finally locked.
Split skin grafting or flap procedure required for covering the soft tissue injury is performed,either immediately,or the wound is covered with sterile dressings,for a second procedure at a later sitting.

Biplanar radiographs are taken before the patient leaves the operation theater.

A well padded posterior leg splint is applied with the ankle held in neutral flexion.

Post Operative Regimen :

Active physiotherapy and motion of knee with continuous passive motion (CPM) apparatus is initiated from the 2nd – 5thpost operative day, however achievement of larger range of motion (ROM) of knee is not emphasized in early weeks in an attempt to minimize drainage from the proximal external fixator pins.

Similarly,range of motion exercises of the ankle are also started.
Toe touch weight bearing is permitted during the 1st six weeks. Progressive weight bearing is allowed based on fracture pattern and radiological evidence of healing.

Standard pin site care continued on OPD basis.
Fixator is compressed at follow-ups if required to achieve better bone to bone contact as directed by follow-up X-rays.

During follow up detailed examination is done, which includes pain, time required for weight bearing, pin tract infection and stability of fixator.

When there is no pain at fracture site and clinically as well as and radiologically the fracture appears healed then the fixator is removed in OPD.

X-rays are reviewed for articular displacement and angulation, while clinically stability of the knee and ankle is measured. The Iowa knee score and the Iowa ankle score is used to assess the knee and ankle functions.A score of 90 to 100 is considered excellent, 80-89 points, good and 70 – 79 points, fair;on both the scales.

Observations :

Table I: Location of fracture

	No.of cases	%
Proximal third	09	36
Middle third	12	48
Distal third	04	16

Majority of the fractures were of the middle third of the Tibia (48%)

Table II: Grade of compounding

	No.of cases	%
Grade I	05	20
Grade II	11	44
Grade III	A:06 B:02 C:01	36

Majority of the cases were Compound Grade II fractures (44%).

Table III: Type of fracture (OTA Classification)

	No. of Cases			%
	Subtype 1	Subtype 2	Subtype 3	
Proximal Type A	00	02	03	20
Proximal Type B	00	00	00	00
Proximal Type C	00	03	01	16
Middle third Type A	00	02	01	12
Middle third Type B	01	02	03	20
Middle third Type C	00	04	00	16
Distal Type A	01	02	00	12
Distal Type B	00	00	01	04
Distal Type C	00	00	00	00

Majority of the cases were of Type A Proximal tibia (20%) and Type B middle third tibia (20%).

Table IV: Mode of reduction

	No. of Cases	%
Closed reduction/ percutaneous fixation	14	56
Open reduction	07	28
OR with limited IF	04	16

Open reduction was done mostly for fracture fragment reduction and bone grafting. Of late, with experience, the necessity for open reduction has been reduced to negligible percentage.

Table V: Complications

	No. of Cases	%	
Pin tract infection	02	08	
Soft tissue / bone infection	01	04	
Shortening	-	00	
Wound dehisence	01	04	
Mal union	01	04	
Non-union	-	00	
Stiffness (Knee)	01	04	
Stiffness (Ankle)	-	00	
Schanz pin breakage	-	00	
Knee instability	02	01 (Medial)	08
		00(Anterior)	
		01(Posterior)	
Ankle instability	-	00	
Amputation	-	00	

The Pin tract,soft tissue and infections were treated with appropriate antibiotics and repeated dressings.Two cases of proximal Tibia fracture with intraarticular extension had knee instability.

Table VI: Range of knee motion

	No. of Cases	%
<100°	02	08
100°-120°	02	08
>120°	21	84

In 92% cases range of knee motion was more than 1000.

Table VII: Range of ankle motion

	No. of Cases	%
Dorsiflexion <30°	02	08
Dorsiflexion Full (30°)	23	92
Plantarflexion<50°	03	12
Plantarflexion Full (50°)	22	88

Table VIII: Union (in months)

	No. of Cases	%
< 4 months	03	12
4-7 months	16	64
>7 months	06	24
Non-union	00	00

In 76% cases radiological as well as clinical union was observed within 7 months.

Table IX: Duration of fixator

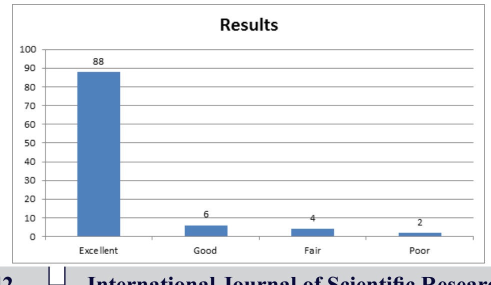
	No. of Cases	%
< 4 months	05	20
4-7 months	15	60
>7 months	05	20

In 60% cases the fixator has been removed between 4-7 months.

Results :

The patients were followed up for an average of 2 years (range 9 months to 4 years) after the injury.

According to the average of Iowa knee score and the Iowa ankle score,we had about 88% excellent, 6 % good, 4% fair and 2% poor results with an average score of 92 and 96 on the knee and ankle scores respectively.



The results were calculated from the IOWA knee and ankle scores as Excellent:90-100; Good:80-90; Fair:70-80; Poor:<70

Fig.4 (Segmental fracture shaft tibia Compound Grade 2 patient A)

Fig.5 (Wound over leg of patient A)

Fig.6 (Post operative X ray patient A)

Fig.7 (X ray after fixator removal patient A)

Fig.8 (Full range of movement post fixator removal patient A)

Fig.9 (Comminuted compound grade 3A fracture proximal tibia patient B)

Fig.10 (Augmented Wagner's External Fixator X ray patient B)

Discussion :

The principles of treating compound fractures of tibia involve preservation of the soft tissue envelope, access to proper wound care, reconstruction of the articular surface in periarticular fractures, restoration of limb access, strong and rigid fracture stabilization, permitting early knee and ankle motion[19],[20].

Closed treatment of these compound injuries has had little success and neither is it appropriate considering high chances of infections.

Clifford et al.[21],in a study of 97 open tibial fractures in 95 patients, treated with plate fixation, report an infection rate of 10.3% and an implant failure rate of 11%.Larsson KJ[22],in their series of various treatment modalities for tibial fractures found plate fixation to be unsuitable for open tibial fractures.

Intramedullary fixation of compound tibial fractures also has been described, and has gained popularity with good results. However,it has been associated with residual fracture malalignment and loss of fixation according to Lang GJ[23].

Court-Brown found a higher incidence of infection and pseudoarthr osis in fractures of Type III, where an intramedullary nail was used and the canal reamed.

Delayed intramedullary nailing after primary external fixation for compound tibia fractures has been shown to have a high infection rate of 50% in a study conducted by Fisher et al.[24] and McGraw et al.[25],in two different series.

External fixation offers viable and effective approach for treatment of severe fractures of tibia with added comminution, and extensive soft tissue injury. There are several reports of external fixation with limited internal fixation for articular surface reduction maintenance, in proximal tibial fractures. Excellent results with good access for the wound care and earlier wound and bone healing with external fixation has also been mentioned in many reports in literature.

One of the major concerns with external fixation of proximal tibial fractures is complication related to proximal pin placement. The proximal, medial 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. We have had two cases of proximal posteromedial pin tract infection, which responded well to oral antibiotic therapy.

A complete debridement of the wound at the time of surgery with excision of dead tissue and thorough lavage with normal saline and an antiseptic solution was performed for all compound fractures in our series.

Ories-Perez et al. in their study treated compound type 1 and 2 wounds with debridement and primary suturing,while needed flap surgeries for type 3 fractures,especially type 3 B fractures.

Immediately after the surgery posterior splint (AK slab) was applied. As soon as the patient is relieved from pain toe touch weight bearing was permitted. After 6 weeks progressive weight bearing was allowed based on fracture pattern and radiological evidence of healing.

88% of patients were discharged from the hospital within 3 weeks time depending on the fracture pattern and patients general condition and compliance.

Comparison With Other Studies Involving Use Of Other Fixators For Compound Tibial Fractures:Union Rate

Modality Of Treatment	Series	No.of Cases	Union Rate in Percentage
Augmented Wagner's	Our Series	25	99%
Dispofix	Ories-Perez	67	93 %
Orthofix	Keating	53	91.7%
Modified AO/ASIF	Shabir Ahmed	18	96 %
Mitkovic's ex.fixator	Stojkovic	49	83.68%

Thus when results obtained in present series were compared with the other standard series the union rate is similar.

It can be seen that the union rate in our series is better than that of Ories Perez et al and Keating[26] series. Orthofix fixator has an advantage of being able to change to dynamic mode after initial callus formation. The same can be achieved with the help of Augmented Wagner External Fixator.Compression, applied through an external fixation system, increases rigidity of fixation but in and by itself provides no benefit for bone healing. Therefore, the treating surgeon may find compression useful to increase rigidity of fixation and therefore decrease interfragmentary motion in less rigid fixation configurations, but should not expect enhanced healing when adequate rigidity is provided by the frame-and-pin system.

The union rate in Shabir Ahmed[27]series is also high,using the modified AO/ASIF external fixation device,but the sample size is less in their series.

Use of internal fixation devices in compound fractures is limited especially in end bone fractures. Modified Wagner's External Fixator has an advantage in this respect that it maintains rigid fixation without interfering in the natural bone union process.

We had good / excellent results in 94% of our cases according to Iowa knee and ankle scores. The poor result of 2% was due to the fact that there was associated ipsilateral femoral supracondylar with intercondylar extension fracture with knee stiffness eventually.

In our study with Augmented Wagner's External Fixator in 25 compound tibial fractures, all fractures healed without any subsequent surgery. 76% cases showed radiological union at an average of 20 weeks.

Conclusion :

The Augmented Wagner's External Fixator with limited internal fixation,is a versatile tool and a reliable method for stabilization of high energy compound tibial wounds.

This particular fixator offers advantage of better wound care for soft tissue injuries in compound fractures.

The Augmented Wagner's External Fixator is easy to assemble and does not require any special instrument set.

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