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# External Skeletal Fixation of Open Fractures of Tibia
## (A Clinical Study)

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## SUMMARY

*Seventy five open grade II and III tibial fractures were treated with AO/ASIF Tubular External Fixators, and early reconstruction of soft tissue envelope. Once the soft tissue envelope was healed and fracture was sticky, external frame was removed and patellar tendon bearing cast applied. In selected cases (11) intramedullary nailing and bone grafting was done, after healing of pin tracts. All fractures were followed to completion of therapy. Mean union time was 21 weeks in grade II fractures and 30 weeks in grade III fractures. The soft tissue envelope healing time was 6.8 weeks. The infection rate was 9.3%, pin tract infection rate was 2.3%. Malunion rate was 9%. Delayed union occured in 10.7% of cases. Persistent deep infection occurs in 1.4% of cases.*

## INTRODUCTION

Few injuries demand as much clinical judgement and generate as much controversy as the open fracture of the tibia. It requires management of a contaminated soft tissue injury involving skin, muscles, and neurovascular structures, and treatment of underlying fracture, which is also contaminated. Not infrequently other serious injuries make the situation even more complex. The complications of infection, non union and malunion persist despite efforts to prevent and correct these problems[1]. Both tibial anatomy and the nature of open tibial injuries make the tibia especially susceptible to these problems. The lower leg lacks a circumferential muscle envelope and a well collateralized blood supply. The anterior subcutaneous surface of tibia is exposed to injury, while anterior and posterior tibial vessels have relatively few interconnections.

Recently, there has been a heightened awareness of how open tibial fractures should be treated. The concept of rigid fixation was popularized by AO/ASIF group, and although external rather than internal fixation has become the standard treatment method, the overall concept remains unchallenged[2]. In addition to this the use of improved external fixators and a great appreciation of their biomechanical charecterstics has helped surgeons save limbs that previously would have been amputated[3].

Advances in other disciplines have also assisted in the treatment of open tibial fractures. There is a great awareness of the need for good soft tissue cover and recent advances in plastic surgery have resulted in a variety of different flaps being available[4-6]. Additionally there has been a greater interest in the use of antibiotics both in the prophylaxis and in treatment of established bone infections[7,8]. The introduction of antibiotic impregnated beads has altered the treatment of osteomyelitis[9].

These recent innovations in the care of tibial fractures have undoubtedly improved the results in terms of limb salvage, infection and union[10,11]. A half pin frame placed anteriorly is the simplest form of tibial external fixation. The pins traverse the safe anteromedial corridor and so avoid transfixation of musculotendinous and neurovascular structures[12]. The frame has been shown to be mechanically stable when using large pins, stiff components, appropriate pin placement and optional frame geometry[13].

This study presents an analysis of treatment results of open tibial fractures managed in AO/ASIF tubular external fixators.

## MATERIAL AND METHODS

Patients with open tibial fractures who presented to accident and emergency department of Shaikh Zayed Hospital, Lahore between January 1988 to September 1990 were included in this study. Seventy five extremity injuries in 73 patients were evaluated. Patients ranged in age from 9 to 70 years. There were 63 (85%) males and 10 (15%) females. Their open fractures were graded according to the classification of Gustilo et al (1984) as described in Table 1.

**Table 1: Classification of open fractures (Gustilo et al 1984).**

| | |
|---|---|
| **Grade I:** | Clean wound less than 1 cm.<br>No crush injury.<br>Simple fracture pattern. |
| **Grade II:** | Skin wound 1-5 cm.<br>Minimal crush injury.<br>Mild to moderate comminution pattern. |
| **Grade III-A:** | Skin wound greater than 5cm.<br>Moderate to severe crush injury.<br>Markedly comminuted or segmental fracture.<br>But no exposed bone. |
| **Grade III-B:** | Skin wound and fracture pattern as in grade III-A.<br>Extensive soft tissue injury associated with periosteal stripping and bone exposure. |
| **Grade III-C:** | Open fracture associated with arterial injury requiring repair. |

All patients with grade-I injuries (Skin wound less than 1cm, no crush injury and simple fracture pattern) were excluded from the study. All grade-II open fractures and open grade-III fractures were included in the study. Thirty six fractures were open grade-II (Skin wound one to 5cm, minimal crush, mild to moderate comminution pattern). While 39 were open grade-III fractures. Out of which 28 were grade-III A (skin wound greater than 5cm, moderate to severe crush injury, markedly comminuted or segmental fracture pattern but no exposed bone). Nine were grade-III B (as in III A but with exposed bone on completion of debridement) and 4 were grade-III C (with an injury to neurovascular bundle) Table 2.

Majority of fractures (38) were caused by motorcycle accidents. Remainig injuries resulted from pedestrian vehicle accidents (Fourteen), passenger trauma in automobile accident (fourteen) fall from height (six) gunshot injuries (four) industrial crush injury (one) Table 3.

### Pre-operative Management

All patients were examined and evaluated in accident and emergency department. Wounds were examined and covered with sterile gauze and patients were shifted to operation theater for irrigation and debridement of their wounds and application of external fixators. Initial debridement and the application of external fixator was accomplished for all patients in first 24 hours with the exception of 14 patients transferred from other hospitals or dispensaries.

**Table 2: Types of fractures.**

| *Grade* | *No. of Patients* |
|---|---|
| Grade II | 36 |
| Grade III-A | 28 |
| Grade III-B | 09 |
| Grade III-C | 04 |

**Table 3: Mechanisms of injury.**

| *Mechanism* | *No. of Patients* |
|---|---|
| Motorcycle accidents. | 38 |
| Pedestrian vehicle accidents. | 14 |
| Automobiles accidents. | 12 |
| Fall from height. | 06 |
| Gunshot injuries. | 04 |
| Industrial crush injury. | 01 |

**Table 4: Time of application of external fixator.**

| *Time* | *No. of Patients* |
|---|---|
| Within 24 hours of injury. | 61 |
| After 24 hours. | 14 |

All patients received intravenous antibiotics for 72 hours. The initial dose was administered in the emergency room. A cephalosporin was given for the grade-II injuries and a cephalosporin plus an aminoglycoside was given for grade-III injuries. Penicillin was also included in farmyard associated injuries. In those cases in which initial cultures taken in the emergency or operating room were positive, antibiotics were continued for five days. Antibiotics were given for an additional 48 hours with each operative procedure.

**Table 5: Antibiotics used.**

| *Type of Fracture* | *Antibiotic* | *Duration* |
|---|---|---|
| Grade II open. | Cephalosporin | 72 hours |
| Grade III open. | Cephalosporin + Aminoglycoside | 72 hours<br>72 hours |
| Farmyard related. | Cephalosporin + Aminoglycoside + Penecillin | 72 hours |
| Positive culture | According to sensitivity. | 5 days |
| With each surgical procedure. | Cephalosporin | 48 hours. |

## Operative Management Debridement

Each wound was thoroughly debrided under general anaesthesia. All dead and devitalized tissue removed. Each wound irrigated with 8-10 liters of normal saline. All foreign material and nonvital tissue removed. All wounds left open and no attempt was made to close the wound with the first debridement.

## External Fixation

All major fractures were essentially stabilized by AO/ASIF External Fixator. One or two plane unilateral frames were constructed using four basic building blocks of AO/ASIF External Fixator. Four to six Schanz Screws were used for construction of each frame. Schanz Screw had diameter of 5mm, and atleast two screws were placed in each major fragment. Holes were predrilled with 3.5mm drill bit. First screw was placed near the knee joint, second near the ankle and 3rd and 4th screws were placed one above and one below the fracture. Most segmental fractures had one or two additional screws placed with in the free segment. The connecting rods were tubes of various lengths with outer diameter of 11mm. They were placed close to the skin surface. The Schanz Screws were placed in anterior border of tibia in sagital plane but were allowed to vary almost 100 degrees from anterolateral to direct medial, depending upon the soft tissue injury. A strict requirement was to avoid penetration of muscle. For segmental fractures or unstable fractures a second rod is added to the same screws above the first rod or a second frame was constructed 90 degrees to the first frame and then both frames were connected with each other (Triangulation of two plane unilateral frames). At the initial surgery large butterfly fragments were fixed to only one side of major fracture. Screw fixation across the primary fracture site was avoided. If after completion of debridement and application of external fixator, bone was exposed an attempt was made to cover it by rotation of local skin flap or myocutaneous (gastrocnemius) flap.

## Post Operative Management

Post operatively patients limb was elevated, ice packing done and when soft tissue injuries no longer required limb elevation, non weight bearing crutch ambulation started. Partial weight bearing started gradually as tolerated. Patient returned to operation theatre after 2-3 days, and second debridement done and then wound was debrided daily till wounds were clean. Once the wound became clean, split thickness skin grafting was done. When the soft tissue problems were taken care of and wounds were healed, external fixator was usually removed but not before 6-8 weeks and patellar tendon bearing (P.T.B) cast or long leg cast applied.

Bone grafting was performed for major comminution or bone loss when the soft tissue envelope was healed but generally not before six weeks. In selected cases intramedullary nailing with bone grafting performed. Mean time between removal of frame and insertion of intramedullary nail was 4 weeks. After removal of frame long leg or patellar tendon bearing cast applied till all pin tracts healed.

**Table 6: What follows external fixation.**

| Type of Immobilization | No. of Patients |
|---|---|
| Patellar tendon bearing cast. | 67 |
| Long leg cast. | 8 |
| Intramedullary nailing. | 11 |

## RESULTS

Seventy five extremities were included in this study. Those extremities that were amputated on the day of arrival were excluded. Patients who lost to follow up, were also excluded from the study.

Thirty extremities were managed in simple unilateral frames in sagital plane. In 24 patients a second rod was added. Eight patients had placement of a second unilateral frame 90 degrees to the first frame. In three cases fracture extended into the ankle joint necessitating placement of the distal pins in the foot (Table 7).

Each extremity had an average of 5 surgical procedures (Range 2-15) in an attempt to achieve union. Table 8 lists the type and number of each procedure performed.

Bone grafting was done in 24 cases. The average time to bone grafting was 13 weeks (range 6-36 weeks). Bone grafting was done twice in 2 patients. The average time to union after graft was 16 weeks (range 8 to 32 weeks). Bone grafting was indicated for all patients with moderate to severe bone loss or severe comminution. Split thickness skin grafts, were done in 28 cases. Mean time for split thickness skin grafting 14 days, range between 3-34 days. Local skin flaps were rotated in 7 cases. While local myocutaneous flaps were used in 2 cases.

**Table 8: Procedures performed.**

| Procedure | No. of Patients |
|---|---|
| Average number of debridement | 3 |
| (Range of debridements) | 1-8 |
| Split thickness skin grafts | 28 |
| Local skin flaps. | 7 |
| Local myocutaneus flap (Gastrocnemius) | 2 |
| Cancellous bone graft. | 24 |
| Readjustment of external fixator. | 12 |
| Intramedullary nailing. | 11 |
| Placement of antibiotic impregnated beads. | 3 |
| Amputations. | 2 |
| Cross leg flaps. | 2 |

Intramedullary nailing was performed in 11 patients. Mean time between removal of fixator and insertion of intramedullary nail was 4 weeks, range between 3-11 weeks. Two of those developed infection, one requiring removal of nail, reaming of cavity and application of external fixator with antibiotics impregnated beads of bone cement.

Two extremities required amputations; all amputations were done in type III-C fractures, in which vascular repair delayed for more then 12 to 24 hours. No amputation was done for type II and type III-A and type III-B injuries.

Table 9. shows the average time required to achieve major treatment land marks.

Soft tissue healing was achieved in average time of 6.8 weeks, range being 2-25 weeks. Extremities remained in external fixation frame for an average period of 8.6 weeks, range being 6-37 weeks. Union was achieved in average period of 21 weeks in grade II fractures and 30 weeks in grade III fracture. The range of healing time was 12 to 57 weeks.

**Table 7: Type of frame used.**

| Type of Frame | No. of Patients |
|---|---|
| One plane unilateral. | 30 |
| One plane unilateral with double rod. | 34 |
| Two plane unilateral. | 08 |
| Extension pin in foot. | 03 |

**Table 9: Average healing time.**

| Treatment Land Mark | Time |
|---|---|
| Time to soft tissue healing | 6.8 weeks (range 2-25) |
| Time in frame | 8.6 weeks (range 6-37) |
| Time to union Grade II | 21 weeks (12 to 57) |
| Time to union grade III | 30 weeks |

### Complications

Pin tract infection developed in 7 out of 300 pins. These responded well to local cleaning and dressing of pin site and intravenous antibiotics. Only two pins required removal of pins and curettage of pin tract. Wound infection developed in 9 cases. They were treated by debridements, daily dressing and intravenous antibiotics. In 5 cases bone curettage was done. In three cases antibiotic impregnated bone cement. All the infections, except one were erradicated.

**Table 10: Complications.**

| | |
|---|---|
| Pin tract infection | 7 |
| Wound infection. | 9 |
| Change of fracture position in frame | 9 |
| Change of fracture position in P.T.B cast | 14 |
| Malunion | 7 |
| Delayed Union. | 8 |

**Table 11: Type of fractures went in Malunion**

| *Type of Fracture* | *No. of Patients* |
|---|---|
| Grade II | 03 |
| Grade III-A | 02 |
| Grade III-B | 02 |

**Table 12: Criteria for satisfactory position of healing.**

| *Position* | *Angulation* |
|---|---|
| Varus | 0 degree |
| Valgus | 5 degrees |
| Anterior | 10 degrees |
| Posterior | 10 degrees |
| Shortening | 01cm |

In 9 cases position of fracture changed while extremities were still in external fixation frame. Frames were readjusted and fractures realigned. In fourteen patients fracture alignment lost while in patellar tendon bearing casts. They were treated by intramedullary rods or by realignment in P.T.B. cast. Seven fractures resulted in malunion.(Table 11). The criteria for satisfactory position of union were 0 degree varus, 5 degrees valgus, 10 degrees anterior or posterior bow and 1cm shortening. (Table 12). In twelve cases union was delayed for more than 8 months. They were treated by bone grafting or/and intramedullary nailing.

**Table 13: Comparison of results.**

| *Study* | *Time to Union* |
|---|---|
| Melendez & Colon (1988) | 22.6 weeks |
| Steinfield et al (1988) | 21.9 weeks |
| Edwards et al (1988) | 9 months. |
| Present study | 21 weeks. |

**Table 14: Comparison of results.**

| *Study* | *Pin Tract Infection* | *Deep Infection* | *Malunion* |
|---|---|---|---|
| Melendez & Colon (1988) | 17% | 11% | 4.5% |
| Steinfield et al (1988) | 0.5% | 7.1% | 23.3% |
| Edwards et al (1988) | 9% | 15% | 3% |
| Present study | 2.3% | 12% | 9.3% |

## DISCUSSION

Seventy five extremities were treated in external skeletal fixators. The results compared well with published reports using external skeletal fixators for open fractures of tibia[15-17]. With AO/ASIF tubular external Fixation System it is possible to adhere to safe and effective external fixation techniques, avoid damage to vital structures, provide wound access and adapt the fixator so that it is biomechanically compatible with the fracture.

Anterior placement of the frame has dramatically reduced pin tract complications. The pin tract infection is 2.3% which compares favorably with other published reports[17,15]. Moreover placement of Schanz Screw in sagital plane greatly increase the stiffness of the frame.

The wound infection rate was 12%, which was compareable to other published report[15-17].

The seven malunions comprised of two grade-III B fractures, two grade III-A fractures and three high grade-II fractures. The two grade-III B fractures were bone grafted. These were two of three fractures that were placed in an initially unacceptable position in the frame and went on to union in this position.

Of the two grade-III A fractures, one was initially placed in unacceptable position and both were judged to have severe comminution. These were two of the patients with severe comminution who were not grafted because of lack of compliance with follow up appointments.

The final three malunions were actually high grade-II injuries with moderate comminution. None of these three patient was bone grafted, and all were in an initially acceptable position. All slowly progressed while in plaster casts to malunion by deformation at the site of bony defect. A change in position in fourteen of seventy five (18.7%) fractures on removal of frame and a final malunited position in seven cases are serious shortcoming of this management protocol. Although increased time in the fixator might also improve these problems of position, it may also increase pin tract problems and rate of non union.

Soft tissue envelope healed in mean healing time of 6.8 weeks. While the fracture union achieved in mean time of 21 weeks in grade II and 30 weeks in grade III fracture, which compares well with[15] who reported union time of 22.6 weeks[16], who reported fracture healing time 21.9 weeks.

The seventy five extremities discussed here represent over 320 separate operative procedures. This is a tremendous commitment of resources. However of the 75 extremities 64 have united, perform functionally and are free of infection. Only two extremities required amputation (in Type III-C).

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