Definitive Treatment of Open Tibial Fractures by Uniplanar External Fixation

Mohamed El Ashhab, M.D., Abd EL Bary Gouda, M.D. and Ahmed Othman, M.D.

ABSTRACT

Background:

External fixation has gained acceptance as the preferred method of early stabilization for open tibial fractures.

Material and Methods:

Unilateral uniplanar AO/ASIF external fixator was used to treat 42 open tibial fractures in 40 cases (2 cases were bilateral) as a primary and definitive method of treatment. According to the system of Gustilo et al., 10 fractures (24%) were grade II and 32 (76%) were grade III (18 grade IIIB and 14 grade IIIB). The safe corridor described by Behrens and Searls (1986) was used for fixator application and the mean follow-up period was 16 months.

Results:

Union was achieved in 95% of fractures at an average time 20 weeks (12 - 36 weeks) with a 5% incidence of nonunion. A good range of knee and ankle motion was achieved at the final follow-up visit. The incidence of complication was not high mainly malunion (7.8%), minor pin tract infection (32.5%) and major pin tract infection (7.5%). Full weight bearing with the external fixator in place was permitted at a mean of 10 weeks.

Conclusion:

Unilateral uniplanar external frame fixation is considered as a good method for definitive management of open tibial fractures for the following advantages: The fixator is cheap, easily applicable with a high rate of success and relatively low incidence of complications and the fixator is relatively comfortable to the patients.

Introduction:

The treatment of open tibial fractures remains controversial. The precarious blood supply and lack of soft-tissue cover of the shaft of the tibia make these fractures vulnerable to nonunion and infection. The rate of infection may be as high as 50% in grade IIIB open fractures. Attempts to reduce these complications have lead to aggressive protocols which include immediate intravenous antibiotics, repeated soft-tissue debridement, stabilization of the fracture, early soft-tissue cover and prophylactic bone grafting.

Initially, the external fixator was used as a first procedure to allow healing of soft tissues, with an internal fixation performed as a secondary procedure after control of the soft tissue problem but as the number of secondary operations better to be diminished, the external fixator is used successfully as both primary and definitive stabilization tool in a considerable number of cases.

External fixation has gained acceptance as the preferred method of early stabilization for open tibial fractures. Amongst the available configurations, the unilateral uniplanar frame is being used most frequently. Two-plane frames are only needed when dealing with severely comminuted fractures or with bone loss.

External fixation of the leg may give uneven results and a high rate of complications. It was postulated that three basic principles can govern the optimal use of these devices. The external fixation frame should avoid damage to vital anatomical structures, it should allow...
access to the injured area and it should meet the mechanical demands of the patient and the injury\(^6\).

The present study assesses the effectiveness of unilateral, uniplanar external fixation as a definitive method of treatment for open tibial fractures.

**Materials and Methods:**

In a prospective study undertaken between July 2003 and December 2006, 42 open tibial fractures in 40 cases (2 cases were bilateral) admitted to Benha University Hospital were treated by unilateral, uniplanar AO external fixator as a primary and definitive method of treatment. There were 30 men (75\%) and 10 women (25\%) ranging in age from 20 to 58 years (median, 35 years). Twenty five cases had right sided affection, 13 had left sided affection and 2 cases had bilateral open tibial fractures. Fractures with severe comminution or with bone loss were excluded.

Most of the fractures were caused by high-energy trauma. Thirty two of the fractures were caused by road-traffic accidents and 10 fractures by fall from a height. Seven cases had associated musculo-skeletal injuries (5 with fracture femur; 3 ipsilateral and 2 contralateral one with Colles’ fracture and one with stable fracture pelvis) which were treated concomitantly. Three cases had injuries to multiple systems which were treated prior to our surgical interference.

In the emergency room, initial attention was given to resuscitation and assessment of the patient general condition and the vital system affection. The open fractures were assessed initially then the wounds were lavaged adequately with sterile saline solution. A clean sterile dressing is then applied to the wounds. The limb was then placed in a well padded plaster splint in a grossly normal alignment. Early intravenous administration of antibiotics should begin in the emergency room against gram-positive organisms e.g: cefazoline 1gm every 8 hours. Coverage for gram-negative organisms, typically with aminoglycosides e.g: Amikacine was used for open fractures with more extensive soft-tissue injury. Prophylaxis against tetanus was given also for all the patients.

The soft tissue affection was classified according to the system of Gustilo et al.,\(^7,8\). Ten fractures (24\%) were grade II and 32 (76\%) were grade III (18 grade IIIA and 14 grade IIIB) (Table 1). Fixators were applied within the first 24 hours of admission in 90\% of the cases and in the remaining group, the mean time of intervention was one week (range 5 days to 15 days) after their general condition allowed operative interference. The follow-up period ranged from 12 to 25 months (mean 16 months). Clinical and radiographic evaluation (regarding healing, deformity, complications and motion) were performed at routine intervals (every one month till the 6\textsuperscript{th} month then every 3 months till the end of the follow-up).

**Operative technique:**

Operation was performed within the first 24 hours in most of the cases. Small bone fragments that were stripped of all soft-tissue attachments were removed. The fractures were reduced and stabilized by external fixation using AO/ASIF tubular external fixators. An image intensifier facilitated screw placement. The technique recommended by Hierholzer et al., (1985)\(^9\) was followed. Two Schanz Screws of 5mm diameter were placed in each major fragment. The safe corridor described by Behrens and Searls (1986),\(^6\) was used (Fig. 1). A minimal skin incision was made at the site of insertion of each of the screws. The screw holes were first pre-drilled with 3.5mm bit and then overdrilled in the near cortex with 4.5mm drill bit. The Schanz screws were anchored only in the far cortex. The distance between the two screws in each fragment was at least 3.5cm. The pin length, the distance between the clamp and the bone, was ideally 5.5cm (Fig. 2).

### Table 1: Fracture grading according to Gustilo et al.,\(^7,8\)

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of fractures</th>
<th>%</th>
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<tbody>
<tr>
<td>Type II</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Type IIIA</td>
<td>18</td>
<td>43</td>
</tr>
<tr>
<td>Type IIIB</td>
<td>14</td>
<td>33</td>
</tr>
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</table>
Fig. (1): Safe corridor* for pin insertion in the lower leg. At level A, proximal to the tibial tubercle, pins can be safely inserted within an arc of 220. At level B, just below the tibial tubercle, the safe arc decreases to 140. At C, in the distal third of the leg, the safe arc remains 140, but the anterior tibial vessels and deep peroneal nerves become vulnerable as they cross the lateral tibial cortex. At D, above the ankle joint, the safe arc is 120. At levels E and F, pins in the tarsal or metatarsal bones may be used to splint the ankle joint if neurological or soft-tissue injuries prevent the application of an external support. The dotted area indicates where the tibia lies subcutaneously and pin insertion is safe (Q. from Behrens and Sears, 1986)\(^6\).

Fig. (2): A 25 years old male patient with type II open tibial fracture, union occurred after 12 weeks with no complications.
(a) Preoperative X ray (A.P & Lat).
(b) Postoperative X ray (A.P & Lat).
(c) 9 months follow-up (A.P & Lat).
When dealing with short metaphyseal fragment, fixation was performed with the aid of the pin adjusting clamp (transverse clamp) that was applied perpendicular to the tube through which two Schanz screws were inserted at the same level (Fig. 3, 4).

An adjuvant minimal internal fixation with a single interfragmentary screw was used in 8 fractures (Fig. 4).

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**Fig. (3):** A 45 year old male patient with type IIIA open fracture of the tibia. Union after 23 weeks with no complications.
(a) Preoperative X ray (A.P & Lat.).
(b) Postoperative X ray (A.P & Lat.).
(c) 11 months follow-up (A.P & Lat.).

**Fig. (4):** A 30 years old female patient with type IIIB open fracture of the tibia. Union occurred after 25 weeks with deep infection which improved after treatment. No osteomyelitis.
(a) Preoperative X ray (A.P & Lat.).
(b) Postoperative X ray with one lag screw inserted (A.P & Lat.).
(c) 13 months follow-up (A.P & Lat.).
Postoperatively the leg was maintained in elevation. The initial change of dressing was performed in the operating theatre two days after the operation. Thereafter, all wound dressings were changed daily. Management with antibiotics administered intravenously was started in the emergency room and continued until the soft tissues become stable.

Active and passive ankle and knee movements were started within 24 hours and the patients were ambulatory with crutches in five to seven days in unilateral fractures but postponed in those with bilateral tibial fractures and in those with contra-lateral femoral fracture or pelvic fracture.

Partial weight-bearing was permitted as soon as this could be tolerated by the patient. The load was gradually increased and full weight-bearing was allowed only after radiological evidence of healing appears.

Pin entry sites were cleaned daily and covered with povidone-iodine or an antibiotic ointment. While they were still in the hospital, patients were encouraged to become fully responsible for the care of their pin sites and fixator frame and for their programme of rehabilitation.

At the first radiographic indication of periosteal callus formation, the external fixator was dynamized by loosening and tightening the clamps in a cross-wise order as described by Allgöwer and Sequin (1987). The fixator was finally removed when complete bone healing had been achieved.

Results:

Of the 40 patients treated with external fixation, one died due to complications of his associated injuries, one lost to follow up, both of these cases had unilateral tibial affection. The remaining 38 patients with 40 fractures were followed up for 12 to 25 months (mean 16 months).

The hospital stay for the patients averaged 10 days (range 7 to 18 days).

Union:

Union was defined as the presence of bridging callus on two radiographic views and the ability of the patient to bear full weight on the injured extremity, if other injuries allowed.

The time to union ranged from 12 to 36 weeks with an average of 20 weeks. Twenty-two fractures (55%) healed before 20 weeks and 16 fractures (40%) healed between 20 and 36 weeks. Bone grafting was performed for 5 fractures with no radiological evidence of healing after 6 months. This was carried out through a posterolateral approach.

Two grade IIIB fractures (5%) failed to unite inspite of bone grafting. Table 2 shows the time taken for fracture healing and table 3 correlates this time with the type of the fracture.

Wound healing:

We believe that the initial aggressive debridement permits early closure or reconstruction of the soft-tissue by 5 to 7 days.

In our cases, 6 wounds healed by secondary intention, 12 were treated by delayed primary closure, 14 by secondary closure and 10 were covered by tissue flaps (which were done by a plastic surgeon).

Range of motion:

At each follow-up visit the range of motion of the knee and ankle joints were assessed and were compared with the contralateral normal side (in unilateral cases). Regarding the knee

<table>
<thead>
<tr>
<th>Time in weeks</th>
<th>Number of fractures</th>
<th>%</th>
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<tbody>
<tr>
<td>12 - 20</td>
<td>22</td>
<td>55</td>
</tr>
<tr>
<td>20 - 36</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>Non union</td>
<td>2</td>
<td>5</td>
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<thead>
<tr>
<th>Type</th>
<th>Dynamization</th>
<th>Bone healing</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>8 (6-10)</td>
<td>17 (12-30)</td>
</tr>
<tr>
<td>IIIA</td>
<td>11 (7-18)</td>
<td>24 (16-32)</td>
</tr>
<tr>
<td>IIIB</td>
<td>12 (8-20)</td>
<td>26 (20-36)</td>
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</table>
Table (4): Time in weeks to weight-bearing with an external fixator in position.

<table>
<thead>
<tr>
<th>Type of fracture</th>
<th>Partial weight-bearing</th>
<th>Full weight-bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type II</td>
<td>4 (3-7)</td>
<td>8 (7-10)</td>
</tr>
<tr>
<td>Type IIIA</td>
<td>5 (3-8)</td>
<td>10 (8-14)</td>
</tr>
<tr>
<td>Type IIIB</td>
<td>6 (4-8)</td>
<td>11 (8-16)</td>
</tr>
<tr>
<td>All fractures</td>
<td>5 (3-8)</td>
<td>10 (7-16)</td>
</tr>
</tbody>
</table>

Joint, the flexion arc averaged 138 degrees. Motion of the ankle joint averaged 15 degrees of dorsiflexion and 35 degrees of planter flexion.

**Malunion:**

Malunion was defined as varus or valgus angulation of more than 5 degrees, anteroposterior angulation of more than 10 degrees, or shortening of more than one centimeter. Angular malunion between 5° and 10° occurred in 3 fractures (7.8%) (2 varus and one valgus). Shortening less than 2 cm occurred in one leg (2.5%). There were no rotational deformities.

**Weight bearing:**

Table 4 illustrates the time from injury to weight-bearing with the external fixator in position correlating this with the type of the fracture. The fixators were removed after complete fracture healing and no refractures were reported.

**Infection:**

Minor pin tract infection, presenting as a discharge with cellulites, were seen in 13 fractures (32.5%). Major pin track sepsis warranting removal and reinsertion of the pin at another site occurred in 3 fractures (7.5%). No patient developed chronic osteomyelitis.

**Discussion:**

The tibial shaft is one of the most common sites of an open fracture. The type of treatment selected for open tibial fractures depends on the individual characteristics of the fracture and soft tissue injury making experience and clinical judgment an important part of the over-all treatment.

Nowadays, open tibial fractures are considered an indication for operative fixation. The choice of the technique for stabilization of open tibial fractures remain a difficult challenge for the Orthopaedic surgeons.

Application of a plate provides rigid fixation of an unstable fracture and this reduces the problem of nonunion and malunion. The stripping of soft tissue required for application of a plate, however, has led to an unacceptable rate of infection. This relatively high rate of infection makes the use of a plate an unattractive treatment option.

The use of reamed IM nails in the management of open tibial fractures is contentious. While reamed nails offer improved stability of the fracture, their use carries a risk of increasing infection and nonunion as a consequence of disturbing the endosteal blood supply.

In four of the studies comparing external fixators with the unreamed nails of which three were randomized prospective trials comparing external fixation with the modern unreamed IM nails and the other of external fixation with the use of Enders nails. There was no statistically significant difference between these two methods of stabilization with respect to union, delayed union, deep infection and chronic osteomyelitis. The use of external fixation was associated with a statistically significant increased rate of malunion and further surgery whereas unreamed nailing showed a statistically significant increased rate of failure of the implant. However, Boynton et al. reported a nonunion rate of 10% with unreamed nails in grade IIIB injuries.

External fixation offers several advantages in the treatment of open tibial fractures. Including its relative ease of application and the limited effect on the blood supply of the tibia, external fixators provide rigid fixation with a relatively low rate of deep infection. Generally, there is good access to the soft-
tissues and most forms of external fixators do not substantially impair the range of motion of the knee or ankle joint\(^{(24)}\).

Unilateral, uniplanar AO/ASIF external fixation provides good early stability so that patients could walk with full weight-bearing at a mean of 10 weeks after injury\(^{(23)}\).

Early weight-bearing and patients' ability to return to their daily activities allowed early discharge from the hospital. The average time for union to occur was 20 weeks (12-36 weeks) with a relatively small incidence of nonunion (5%), malunion (7.8%), superficial pin tract infection (32.5%) and major pin tract infection (7.5%). No implant failure or refractures were found in our cases.

Our results compare well with those of other series of similar fractures treated by external fixation\(^{(26,27)}\) even superficial and deep pin-tract infection are less in our series.

Pin tract infection can be substantially decreased by three ways. Firstly, by the reduction of soft tissue irritation around the pins; this can be done by pin placement only where the tibia is subcutaneous, by using fewer, stiffer pins which have smooth shafts at skin level and by careful correlation of the stiffness of the frame to the mechanical demands of each patient and his injuries. Secondly, by the pre-drilling of each pin track with a sharp drill bit protected by a drill sleeve which eliminates heat necrosis of soft tissues and bone. Thirdly, by effective pin and frame care.

**Conclusion:**

Unilateral uniplanar external frame fixation is considered as a good method for definitive management of open tibial fractures for the following advantages: The fixator is cheap, easily applicable with a high rate of success and relatively low incidence of complications and the fixator is relatively comfortable to the patients.

**References:**

15. McGraw, J.M. and Lim, E.V.: Treatment of open tibial shaft fractures. External fixation and second-


