

**Original Article**

**Outcome and safety of Arbeitsgemeinschaft für Osteosynthesefragen external fixator in the management of open tibial fractures by firearm injuries: A study at Liaquat University Jamshoro**

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**Abstract**

**Background:** Tibial fractures are considered as the most common long bone fracture but their treatment and management remains controversial and challenging. The tibia fractures due to firearm injuries, increases the treatment complexity with higher morbidity and mortality rate. In the developing countries, Open tibial fractures are commonly treated by Arbeitsgemeinschaft für Osteosynthesefragen external fixator (AOEF). The aim of the study was to evaluate the results and the consequences by the use of AOEF in the management of open fracture of the tibia caused by firearm injuries and to determine the complications in the routine practice.

**Methodology:** An observational, prospective study was conducted at the Department of Orthopedic Surgery and Traumatology (DOST), Liaquat University Jamshoro, Pakistan during the period of 1 year (2017 to 2018). As per study inclusion/exclusion criteria, 38 patients with Gunshot injury of diaphysis tibia with Gustillo type IIIa and IIIb, age range from 12 to 60 years of either gender were recruited for the study.

**Results:** All 38 fractured cases were treated by AOEF. Of them 32 (84.0%) patients were male while 6 (16.0%) were females, with the mean age of 29.1 ± 9.27 years. The mean time duration for the treatment with AOEF was observed as 19.1 ± 2.72 weeks. Out of all 38, 3 (8.0%) cases with surgical wounds became infected during the study while 2(5.2%) patients went in infective non-union. Knee stiffness was observed in 5(13.0%) patients and 3(8.0%) patients were observed with ankle stiffness.

**Conclusion:** It can be concluded from the study results that AOEF is simple, cost-effective, and minimally invasive, requires less operating time and is safe to apply. It gives good access to soft tissue and excellent results in type GIII-A&B open tibial fractures by firearm injuries.

**Keywords**

Open Fractures, Tibial Diaphysis, Intramedullary Nailing, External Fixation.



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## Introduction

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The tibial bone is one the commonest bones affected by fractures, 40% of the fractures of long bones and mostly all tibial fractures are open fractures<sup>1&2</sup>. There exist a high prevalence of tibial fractures worldwide. Being the most common type of fracture, it is reported that approximately 11-26 patients/per 100,000 are admitted with these long bone fractures per year. The increasing number of road accidents and firearm injuries are the leading cause for the rising prevalence of tibial fracture globally<sup>3-6</sup>.

Firearm injuries are becoming the leading cause of trauma and the most affected anatomical location with such injuries are extremities<sup>7</sup>. The firearm injuries are the global problem associated with significantly increasing morbidity and mortality rate<sup>8</sup>. Although the death rate due to these firearm injuries is rapidly increasing in Pakistan but very limited work has been done to rectify the increasing ratio<sup>9</sup>. The local Pakistani studies also highlighted the contribution of firearm injuries in increased mortality, which in turn prompts the need to work on the issues related to control and management of these injuries<sup>10&11</sup>.

A study regarding tibial fractures associated with firearm injuries showed that approximately 11% of firearm injuries and associated fractures involve tibial bone<sup>12</sup>. The severity of the injury depends on the features of the bullet, its intensity and the characteristics of the tissue it damages<sup>13</sup>. Insufficient blood flow and lack of soft tissues in tibia predisposes tibia open fracture to non-union and increases the risk of development of infections<sup>14</sup>. Such factors make treatment of these injuries difficult and result in confined

treatment modalities<sup>15</sup>. However, it is well established that the open tibial fractures must be handled carefully, hygienic control, fracture stabilization, antibiotics use and early coverage of soft parts are greatly focused during the surgical interventions<sup>16</sup>. These firearm injuries are managed frequently in hospitals under emergency knowing the fact that the wounded tissues and bone are highly prone to infections<sup>17</sup>.

There are many methods for management, including non-surgical procedures like using casts, brace, or interventional attempts like plate insertion, intramedullary nailing and external fixators are also used for treatment of open tibial fractures<sup>17</sup>. However, the selection of the methods are according to the surgeon decision and economic status of patients<sup>18</sup>. The treatment modalities usually vary in different countries depending upon the available facilities and medical instruments. The method selection is usually altered in developing countries because of lack of facilities<sup>19</sup>.

Mostly, external fixators like Ilizarov or AO external fixator are extensively being used in developing countries but the rate of mal union and infections after firearm injuries are relatively high<sup>19</sup>. The use of external fixator (EF) increases the viability for other additive procedures including wound healing, soft tissue coverage and bone grafting. It is considered as a beneficial and versatile tool for the fracture treatment worldwide<sup>20</sup>.

The objective of the study was to evaluate the safety and management outcomes of AOEF for treatment of open fracture of the tibia caused by firearm injuries at Liaquat University Jamshoro.

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## Methodology

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This observational, prospective, hospital based study was conducted at the Department of Orthopaedic Surgery and Traumatology (DOST), Liaquat University Hospital Hyderabad / Jamshoro from September 2015 to September 2017. A total of 38 patients with Gustillo IIIA, IIIB, open tibia fractures admitted to the department were included in the study sample. All patients with articular surface fractures, previous tibial fracture and neurovascular damages were excluded, while diabetics and immune-compromised patients were also removed from the study sample.

AOEF was applied in emergency operative room. Modular AOEF are used after wound debridement and reduction. 2 proximal and 2 distal pins of 5mm were applied. All the patients were admitted to the casualty department and outpatient department (OPD), where they were evaluated as per study inclusion/exclusion criteria. After initial assessment and management, history taking and physical examination the open wound were covered with sterile dressing and fractures were splinted. Routine investigations were carried out. Postoperative radiographs and clinical assessment was conducted immediately in all cases. Patients were discharged when the wound condition was satisfactory. Then weekly OPD was recommended for a month, and the followed by visits after every 3 weeks for almost 3 months after discharge from hospital. After removal of fixators, sarmiento plaster was applied for 3 to 4 weeks and followed in review clinic from 6 to 12 months.

The data was collected through a case report form (CRF) as per study protocol. Both clinical and radiological assessments were

carried out in the review clinics, to assess wound healing, bone union, duration of hospital stay, weight bearing status after recovery and related complications. The fracture union was expected only when the fracture line disappeared and when there was no movement observed at the site of the fracture clinically.

The ethical approval was taken from the institutional ethics committee (IEC) of Liaquat University and the study was conducted in compliance with International Conference on Harmonisation - Good Clinical Practice (ICH- GCP) guidelines. The IEC reviewed the progress of the study. The confidentiality of the data was maintained. All the authors vouch for the completeness and accuracy of the data and data analysis.

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## Results

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Total 38 cases of gunshot injuries having an open diaphysial fracture of tibia were analyzed in the study on the basis of inclusion criteria. Out of which 32 (84.0%) patients were males and 6 (16.0%) were female i.e. in the ratio of 5:2. All the cases were treated by AO external fixator. The age of the patients ranged from 12 to 50 years with the mean age  $29.1 \pm 9.27$  years. Most of the patients belonged to the age group of 21 to 30 years. Around 24 (63.1%) cases of right tibia fractures and 14 (36.8%) cases with left tibial fracture were reported.

Table I shows the history and the overall outcomes of the patients included in the study. According to the results the time of union for the patients treated by AOEF was  $19.1 \pm 2.72$  weeks. The duration of hospital

stay was  $5.750 \pm 1.569$  days. The time duration between injury and arrival was reported as  $2.815 \pm 3.44$  hours. The external fixator (EF) was applied for a mean time of

17 weeks while the mean duration on patella tendon bearing (PTB) cast was  $5.4 \pm 0.60$  weeks.

**Table I: Mean duration and overall history of the patients admitted.**

	(n=38) Mean + SD
Time b/w injury and arrival (hour)	2.815 + 3.44
Time b/w arrival & primary procedure (hour)	1.595 + 0.97
Time b/w primary procedure & fixation (hours)	1.925 + 0.56
Time of partial weight bearing (in weeks)	5.0 + 0.42
Time of full weight bearing	16.2 + 4.94
Time of Dynamization	13.2 + 2.22
Time of EF applied (in weeks)	17.0 + 2.13
Time in PTB cast (in weeks)	5.4 + 0.60
Time of union	19.1 + 2.72
Total follow up time (weeks)	34.6 + 9.11
Hospital stay (in days)	5.750 + 1.56

\*b/w = between; SD = Standard Deviation; EF = External Fixator; PTB = Patella Tendon Bearing

The severity of the injuries were labelled on the basis of Gustilo Anderson grading. According to the results around 33 (86.8%) fractures were Grade IIIB while only 05 (13.1%) were grade IIIA fractures.

**Table 2: Severity of injury (Gustilo Anderson classification)**

	No. of Patients	Percentage
Grade IIIA	05	13.1
Grade IIIB	33	86.8

Out of all 38 patients, 05 (13.0%) patients had a mild discomfort in ankle motion (mainly dorsiflexion) while 8 (21.0%) patients were observed with limitations in knee motion (mainly during flexion). Moreover, wound condition was also observed in all the cases at the time of admission, results indicated that the Original wound became infected in 06

(16.5%) cases, while 03 (8.%) cases of surgical wound became infected. Most common infection observed was Pin tract infection that was found in 9 (24%) cases. While pin site osteolysis was observed in 8(21%) cases, pin loosening in 8(21%) cases and a few were also observed having pin site inflammation i.e. 6(16%) cases, which was later cured either by oral

antibiotics for a short period of time or by curettage of the outer cortex. 2(5.2%) patients had infective non-union and converted into Illizarrov external fixator,

6 (16%) cases of screw sites infection were observed (3 proximal and 3 distal). Knee stiffness was found in 5(13%) cases while 3(8%) patients had ankle stiffness.

**Table 3: Post-Operative Complications**

Complications (n=38)	N(%)
Infected original wound	06(16%)
Infected Surgical wound	03(8%)
Non union	02(5.2%)
Delay union	02(5.2%)
Infections (Screw-site)	06(16%)
Pin tract infection	09(24%)
Inflammation (pin-site)	06(16%)
Osteolysis (pin-site)	08(21%)
Pin loosening	08(21%)
Pain during walking	06(16%)
Ankle stiffness	03(8%)
Knee stiffness	05(13%)

ankle pain while 34.4% with low back pain, 11.7% with hip pain and only 9.7% of the population had pain in their knees.

## Discussion

Globally, the gunshot injuries are rising due to the increasing violence in the society<sup>21</sup>. Increased terrorist activities and blasts due to ethnic and social disputes have greatly amplified the mortality rate in civil life<sup>22</sup>. The prognosis is usually difficult in early stages under emergency condition which makes the treatment and management more challenging<sup>21</sup>. The incidence of open fractures of the tibia is increasing rapidly mainly due to firearm injuries involving the bones and the associated soft tissues<sup>22</sup>. However, this increasing ratio of severely injured patients under hospital setting, is in turn increasing the economic burden on the community due to restricted clinical

resources<sup>23</sup>. A wide range of methods that are utilized for immediate debridement and stabilization during the treatment of these firearm injuries and bone fractures through external fixation<sup>22</sup>. The EF used for the treatment of open tibial fractures not only manages soft tissue injuries, but also provides efficient bone healing and reasonable fixation<sup>22</sup>.

According to our study results there were 33 patients with grade III-B & 05 with grade III-A fractures (Table 2), mostly resulting from bomb blast and firearm injuries, so great attention was given to the care of soft tissue injuries. A higher

incidence of open tibial fractures was noticed between 30-50 years of age (60%). The male predominance was observed i.e. 32 (84.0%) out of 38 patients were male while only 6 (16.0%) were female. Our male to female ratio was well consistent with other series of similar fractures treated by external fixator<sup>24-27</sup>. Results revealed that type IIIB was the commonest type of fractures followed by IIIA, while patients with IIIC fractures were excluded from study sample. Cole and his colleagues also showed similar trend in their study<sup>28</sup>.

The EF was applied for a mean time of 4.25 months (Table I). The duration was set in accordance with the previous literature and evidences, on the basis of which the EF is usually removed after a minimum time of  $14.1 \pm 1.8$  weeks<sup>29</sup>. The mean time taken for bone union as observed in our study was  $19.1 \pm 2.72$  weeks upon treatment with AOEf. This is consistent with other local and international studies<sup>30-34</sup>. According to a study the time taken for the union of bones was 25.6 weeks<sup>31</sup> while for the patients with a single injury a total of 21.9 weeks was estimated and 25.7 weeks for the patients with multiple injuries as reported in another study<sup>33</sup>. All these results correlate well to this study.

In the present study, the average length of the hospital stay observed among the study participants was similar to the standard stay range (Table I). This matches with the study by Norris on soft tissue injury<sup>35</sup>. Same observation of 6 days hospital stay was seen in the study by Soleimanpour<sup>36</sup>. In this study, pin tract infection was observed in 9 (24.0%) cases. However our results are supported by other studies, a similar trend

of pin tract infection is evident from the previous literature i.e. Pedro and his colleagues observed 20.5% pin tract infection among his study subjects<sup>37</sup>. According to a local study conducted at Peshawar, pin tract infection was most common complication (47.4%) and the major cause reported was poor compliance of patients<sup>24</sup>. In contrast a study done by Hay and his colleagues reported lesser incidence of pin tract infection in European population i.e. only 10.4%<sup>38</sup>, that is mainly due to proper follow up visits in review clinics and the patient compliance<sup>38</sup>. Among the major post-operative complications, pin loosening was reported in 8 (21.0%) cases which were later cured by other alternatives. (Table I), whereas Khan and his fellows reported that 16 patients (53.33%) were observed with pin loosening<sup>39</sup>.

Major complication with bone fractures and injuries is the non-union of bones, the EF is considered as the best option for dealing with non-union. In this study only 2(5.2%) patients went in infective non-union and later on achieved union with secondary procedures (Table I). A similar sequence rates of non-union in type III open tibial fractures are reported in other related studies<sup>24&40</sup>. In a study conducted by Ghaloo, 4 patients (11.1%) were observed with non-union of bones<sup>41</sup> while 60% in another study<sup>42</sup>. The decreased incidence of non-union reported in this study was due to early covering of soft tissues and weight bearing. Delayed union was observed in only 2 cases and is comparable to those mentioned in the previous literature<sup>42</sup>. In contrast with other study results, mal-



union was not observed in any of the study subjects. A study revealed mal-union in 41.5% of the participants<sup>42</sup> while 50% mal union was reported by another study<sup>43</sup>.

In the current study, wound condition at the time of admission was observed in all the cases, 26 (68.4%) were found clear. While original wound became infected in 6 (16.5%) cases and 3 (8.0) cases of surgical wound became infected during the study. In a local study conducted at Liaquat University of Medical and Health Sciences, Jamshoro, superficial wound infection was observed in 3 cases while deep wound infection in 2 cases, both deep infections further developed non-union<sup>44</sup>. Similar trend was observed in other studies<sup>37,45-47</sup>.

The other findings of this study revealed that 5 (13.0%) patients had a restricted ankle motion (mainly dorsiflexion) while 8 (21.0%) patients reported limited knee motion. Similar findings were reported by Khan in his study, 7 cases (23.33%) had ankle stiffness, and same rate of knee stiffness was recorded<sup>39</sup>. Study conducted by Thakur showed Ankle stiffness in 10.9%<sup>48</sup>, which is lower than our study. Another study conducted at Peshawar revealed ankle stiffness as the major complication<sup>24</sup>. Our joint stiffness rate was slightly less, it was mainly due proper follow-up visits, early mobilization and range of motion (ROM) exercises, and physiotherapy when needed.

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## Conclusion

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This study concluded that grade III-A & B open tibial fractures caused by firearm

injuries are the critical surgical emergencies that require early surgical treatment, debridement and management to avoid infections. The application of AOEF is safe and cost-effective, it is simple to use, minimally invasive and require less operating time. Moreover, it gives good access to soft tissue and can be used as definite and successful management. It gives excellent results in grade III-A & B open tibial fractures by firearm injuries.

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## Conflicts of Interest

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None.

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