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Treatment of Open Fractures of Tibia by Ilizarov Technique

Dr. Laishram Birendro Singh[1], Dr. I. Deven Singh[2], Dr. Ch. Arunkumar Singh[3]
[1](Assistant Professor, Department Of Orthopaedics, JNIMS, Imphal, Manipur, India)
[2](Assistant Professor, Department Of Anatomy, RIMS, Imphal, Manipur India)
[3](Professor & Head, Department Of Orthopaedics, RIMS, Imphal, Manipur, India)

Abstract. *There has been steady increase in the complexity of open injuries to bones especially tibia and joints. Open fractures of tibia are classified into Type I, II, IIIA, IIIB and IIIC. Illizarov method is a popular method of treating open tibial fractures after debridement and open reduction. It has many advantages. Thirty fresh consecutive compound fractures of the shaft of the tibia were treated with Ilizarov external fixator after debridement for the study. In this study, the mode of injury were road traffic accidents in 27 cases (90.0%), sports injuries in 2 cases (6.7%) and firearm injury in 1 case (3.3%). Out of the 30 patients, 24 (80.0%) were males and 6 (20.0%) were females. The duration of treatment with the fixator was 12-23 weeks (average 16 weeks). There were 5 (16.7%) proximal third fractures, 22 (73.3%) middle third fractures and 3 (10.0%) distal third fractures. The operation time ranged from 90 minutes to 120 minutes (average 105 minutes). The duration of treatment with the fixator ranged from 12 to 22 weeks (average 17 weeks). The time to union varied from 21 to 28 weeks (average 24.5 weeks). There was no intraoperative complication. As for the postoperative complications, local pain with motion and local oedema were seen in 4 cases (13.3%) and painful tenting of skin in 7 cases (23.3%). Delayed complications included pin tract infection in 10 (33.3%) patients, loss of 8^0 ankle dorisflexion in 2 (6.7%) cases, shortening of 1 cm was seen in 1 case (3.3%), 2 cases (6.7%) of united in 7^0 recurvatum as calculated radiologically, 3 cases (10.0%) of muscle wasting of the leg from 0.4 to 1.5 cm. No case developed deep infection, non-union or unacceptable malunion. The Ilizarov device is used worldwide for the treatment of fractures. The construct is stable and enables the patient to bear weight on the affected limb a short time after the surgery, even in cases of comminuted fractures.*

Keywords*. Tibial shaft fractures, open fractures, Illizarov ring fixator.*

I. Introduction

The increase in violent trauma that results from road accidents, particularly those involving motor cyclists, has contributed to the steady increase in the complexity of open injuries to bones especially tibia and joints.[1] Open fractures are classified into three major categories, depending on the mechanism of injury, soft tissue damage, and degree of skeletal involvement.[2] Type I open fracture is characterized by a puncture wound 1cm or less in diameter and is relatively clean. Type II open fracture has laceration more than 1 cm long, without extensive soft tissue, flaps, or avulsion, with a minimal to moderate crushing component. The fracture is usually with minimal comminution. Type III open fracture is one that involves extensive damage to the soft tissue, including muscles, skin and neurovascular structures. The type III open fractures are further divided into three subtypes.

Type IIIA is characterized by adequate soft tissue coverage of a fractured bone despite extensive soft tissue laceration or flaps or high energy trauma irrespective of the size of the wound. This includes segment fractures or severely comminuted fractures. Type IIIB is one with extensive soft tissue loss with periosteal stripping and bony exposure. This usually associated with massive contamination. Type IIIC open fracture is associated with arterial injury requiring repair irrespective of degree of soft tissue injury. Different methods for the treatment of open fracture shaft tibia (after debridement & open reduction) include POP cast immobilization, external fixation, open reduction and plating, locked intramedullary nailing. According to Trafton[3], complications include deep infection, acute or chronic osteitis or ostiomyelitis, delayed union, non-union, mal-union, loss of alignment in cast or brace, fixation problems. Gavril A Ilizarov, a Russian physician, devised this method of treatment of open fractures of tibia. The Ilizarov ring supports transfixional K-wire or haft pins, which can be fixed at the many holes site on the 360-degree ring. It has two or more connected rings that form a frame of the apparatus. The rings bear supplementary part of the frame necessary for dynamic bone treatment.[4] The Ilizarov ring faxator has many advantages.[5] They are elastic type of external fixator and allow axial micromotion which are conductive to healing of fractures and regenerate. Forces acting in the circular fixator are in a plane. It is a multilevel and multiplanar fixator. Ilozarov's circumferential rings distribute stresses more evenly across the fracture or osteotomy sites. Therefore, three dimensional correction is possible. Axial distraction or compression angular and translational corrections are all possible using gradual mechanical techniques. Circular fixator is a stable and elastic fixator. These fixators allow immediate weight bearing and

function. As the wires are thin, the holes are small. Circular fixators can have capacity for three dimentional correction. The Illizarov device is able to control shear at the fracture site while allowing axial and bending dynamization producing an ideal environment for bone healing. Wire stoppers add shear reigidity to the system. Circular fixators are better for patients with osteoporosis using wire. The disadvantages of using Ilizarov ring fioxator comprise pain, bulky apparatus, difficulty in assembling, low acceptance by patients and labour-orientedness of the whole procedure to the doctors as well as the patient. The aim of the study was to study the efficacy of Ilizarov technique in the treatment of open fractures of tibia with particular reference to the rate of complication and bony union.

II. Materials And Methods

Thirty fresh consecutive compound fractures (Fig. 1) of the shaft of the tibia attending Orthopaedic OPD or emergency RIMS Hospital were treated with Ilizarov external fixator (Fig. 2 & 3) after debridement for the study. The exclusion criteria were closed fracture, pathological fractures and type IIIC fractures. The fractures were assessed by AP and Lateral X-ray. Fractures were classified according to Gustilo's fracture classification of open fractures.[2] Patients with compound tibial fractures were taken to the operating room for debridement as soon as possible. These fractures were managed provisionally in long leg posterior slab or long leg posterior cast with a window for dressing changes. Necessary fluids and electrolytes replacement or whole blood transfusion were given as per requirement of each patient. Definitive treatment of fracture was done as routine case usually in a week. Patients were operated under general or spinal anaesthesia. Pre-assembly of the frame was done one day prior to surgery. Distance between the rings was adjusted according to the fracture anatomy. Fracture with minimal comminution and length loss less than 1cm was usually managed with a four ring frame, more complex fracture needed more number of rings. Wires were fixed to the rings with ring fixator bolt after tensioning up to 90-110 kg using a dynamometer. The rings were kept 2 finger breadths from skin all around. Reduction was checked with C-arm image intensifier on the table and adjustments done according at the same setting. The pin tract wounds were dressed by povidone iodine solution 10% and covered with pads. Pin site was cleaned everyday with spirit or povidone iodine. When clot and crust was present, weak solution of hydrogen peroxide (H_2O_2) was applied to remove it. When pin tract wound was inflamed or discharge was present, oral antibiotic was given. Partial weight bearing with axillary crutch was allowed as soon as the patient could tolerate the pain. If the patient complained of pain, stability of the frame and wire was checked. Tension of the wire was checked and retensioning was done when needed. Check X-ray was taken on first or second post operative day and reduction was checked. Minor malalignment was adjusted without anaesthesia. Equinus deformity was prevented by active and passive movement of ankle. If ankle movement was painful, foot was supported with a slipper or boot cast tied to the last ring.

The patients were followed up at an interval of 2 weeks for a minimium period of 8 weeks, thereafter every month for 3 months and subsequently 3 monthly till a period of 1 year at the Outpatient Department of Orthopaedics, Regional Institute of Medical Sciences, Hospital. Check-radiographs were taken on the next day and then at 6^{th} week, 12^{th} week and 36^{th} week. The patients were assessed clinically for the range of movement of the knee and ankle respectively, pain at the fracture site, anterior knee pain, ankle joint symptoms, infection, muscular atrophy, clinical union, difficulty in walking and performing daily routine. Frames were removed after clinico-radiological union. The fracture was regarded to be united (1) if the patient could walk without support after loosening the frame crossing the fracture site and not tender at fracture site (2) if there was no mobility at fracture site after loosening the frame and (3) radiologically (Fig. 4), if there was enough callus across the fracture site and obliteration of the fracture line. The frame was removed (Fig. 5) at the Outpatients Department or in the Operation Theatre once the fracture was united. If the frame was removed before the union of fracture due to infection or frame intolerance patellar tendon bearing POP cast was applied. At the end of follow-up period, the results were grouped into excellent, good, fair and poor using modified criteria of Karlstrom and Olerud (Fig. 6).[6]

III. Results

Thirty open tibial fractures were treated with Ilizarov external fixator from October 2003 to October 2005. The age ranged from 18 to 65 yrs. The patients were divided into 6 age groups (Table 1A). Out of 30 patients, 24 (80.0%) were males and 6 (20.0%) were females, showing male preponderance in incidence (Table IB). The duration of treatment with the fixator was 12-23 weeks (average 16 weeks). Nineteen patients wore a PTB cast for an additional period of 4 weeks.

Table I : Age and sex distribution of tibial fracture

A. Age distribution				B. Sex distribution		
Age (yrs)	No. of cases	Percentage		Sex	No. of cases	Percentage (%)
18-25	11	36.7		Male	24	80.0
26-35	10	33.3		Female	6	20.0

36-45	6	20.0		Total	30	100.0
46-55	2	6.7				
56-65	1	3.3				
66 and above	30	100.0				

In the present study, 11 cases were Type I open fracture (36.7%), 14 (46.6%) Type II open fractures and 5 (16.7%) Type IIIA open fractures (Table IIA).

Table II : Type and location of tibial fracture

A. Type of fracture				B. Fracture location		
Type	No. of cases	Percentage (%)		Location	No. of cases	Percentage (%)
Open Type I	11	36.7		Proximal third	5	16.7
Open Type II	14	46.6		Middle third	22	73.3
Open Type IIIA	5	16.7		Distal third	3	10.0
Total	30	100.0		Total	30	100.0

Of the 30 fractures, there were 5 (16.7%) proximal third fractures, 22 (73.3%) middle third fractures and 3 (10.0%) distal third fractures (Table IIB). In this study there were 18 comminuted fractures (60.0%), 4 Transverse (13.3%), 4 oblique (13.3%), 2 spiral (6.7%) and 2 segmental (6.7%) (Table IIIA). The right side of the leg was injured in 16 cases (53.3%) and the left in 14 cases (46.7%) (Table IIIB).

Table III: Fracture pattern and distribution of side

A. Fracture pattern				B. Distribution of sides		
Pattern	No. of cases	Percentage		Side	No. of cases	Percentage (%)
Comminuted	18	60.0		Right	16	53.3
Transverse	4	13.3		Left	14	46.7
Oblique	4	13.3		Total	30	100.0
Spiral	2	6.7				
Segemental	2	6.7				
Total	30	100.0				

In the present study, the mode of injury were road traffic accidents in 27 cases (90.0%), sports injuries in 2 cases (6.7%) and firearm injury in 1 case (3.3%) (Table IV). Out of the 30 cases, 1 case (3.3%) had clavicle fracture, 1 case (3.3%) had Colles' fracture, 1 case had closed fracture of shaft of humerus and 1 case (3.3%) had bicondylar fracture of tibia (contralateral side).

Table – IV : Mode of injury

Mode of injury	No. of cases	Percentage (%)
Road traffic accident	27	90.0
Sports injury	2	6.7
Fire arm injury	1	3.3
Total	30	100.0

All the 30 cases were debrided on the same day and stabilized with Ilizarov ring faxator after a period of 5 to 10 days from the date of injury. The operation time ranged from 90 minutes to 120 minutes (average 105 minutes). The Ilizarov external fixator was removed when there was clinico-radiological union. The duration of treatment with the fixator ranged from 12 to 22 weeks (average 17 weeks). The time to union varied from 21 to 28 weeks (average 24.5 weeks). The average time of union was 21.5 weeks for Type I open fractures, 22.5 weeks for Type II open fractures and 26.5 weeks for Type IIIA open fractures. The complications of compound fracture of tibia with Ilizarov ring fixator were broadly divided into intra-operative, post-operative and delayed complications. There was no intraoperative complication. As for the postoperative complications, local pain with motion and local oedema were seen in 4 cases (13.3%) and painful tenting of skin in 7 cases (23.3%). Delayed complications included pin tract infection in 10 (33.3%) patients, loss of 8^0 ankle dorisflexion in 2 (6.7%) cases, shortening of 1 cm was seen in 1 case (3.3%), 2 cases (6.7%) of united in 7^0 recurvatum as calculated radiologically, 3 cases (10.0%) of muscle wasting of the leg from 0.4 to 1.5 cm. No case developed deep infection, non-union or unacceptable malunion.

Figure 1. X-ray showing fracture of upper third of tibia

Figure 2. Fixation of Ilizarov ring

Figure 3. X-ray after fixation of Ilizarov ring

Figure 4. X-ray after complete radiological union

Figure 5. Patient after the removal of Ilizarov ring

Figure 6. Full range of movement after ring removal

IV. Discussion

Many methods have been used for stabilization of severe open tibial shaft fractures. Karlstrom and Olerud[6] stated that the treatment of open fractures was often associated with difficulties. The problems are attributable mainly to the injury of skin, soft tissues and severity of the bone damage. In this study, the age of the patients ranged from 18 years to 65 years with an average age of 30 years. In our study, there were 24 (80.0%) males and 6 (20.0%) females. The sex incidence was similar to that of Tucker[7] where number of males was 23 (88.5%) and that of females were 3 (11.5%). Shtarker H et al[8] also reported male preponderance over female in their study. In our series 22 (73.3%) had fractures in the middle third, 5 (16.7%) in the proximal third and 3 (10.0%) in the lower third. This finding is similar to that of Shtarker et al[8] who reported 81.3% middle third, 15.7% proximal third and 3.1% lower third.

In this study of 30 fractures, there were 18 (60.0%) comminuted, 4 (13.3%) oblique, 2(6.7%) spiral and 2 (6.7%) segmental. This finding is similar to the finding of Shtarker et al[8] who found 20 cases (62.5%) in regard to comminuted fractures. In our study of 30 cases, there were 11 (36.7%) open type I, 14 (46.6%) open type II and 5 (16.7%) open type III A which is comparable with that of Shtarker et al[8]. The period between admission and Ilizarov ring fixation varied from 2 to 10 days with the average of 7 days. It is generally agreed that ilizarov ring should be applied as soon as the general physical condition allowed. However, in this study Ilizarov ring fixation had to be delayed from 2 to 10 days from the date of injury because of insufficient operating days and facilities for emergency Ilizarov ring fixation. The average operating time varied from 90 minutes to 120 minutes. The finding was slightly lesser than that of Tucker[7] who reported that the operating time varied from 120 minutes to 210 minutes, though later it was reduced from 1 to 1.5 hours. The partial weight bearing on crutches was started on the very next day or on the 3rd day and full weight bearing after 2 to 3 weeks. This is comparable to that of Dagher and Ronkoz[9] who reported that partial weight bearing was begum within 1st week of operation and full weight bearing after 2 to 3 weeks. When using a uniplanar external fixator, Court-Brown et al[10] postponed weight bearing until the fixator was removed. In the present study, the patients were discharged from the hospital on an average on the 5th post-operative day. The average duration of hospital stay in this series was 10 days. Split thickness skin grafting was done in 5 cases in those who failed to heal spontaneously. In this series, the Ilizarov external fixator was removed after an average of 17 weeks (ranging from 12 to 22 weeks) which is in line with that of Shtarker et al[8] removed on an average of 16 weeks (ranging

from 11-21 weeks). In our series, the average time of clinic-radiological union was 24.5 weeks (ranging from 21 to 28 weeks). The average time of union was 21.5 weeks for type I open fractures, 22.5 weeks for type II open fractures and 26.5 weeks for type IIIA open fractures. Tucker[7] reported the range of time to union as 12 to 47 weeks, with an average of 25.6 weeks. Shtarker et al[8] reported that the time to union was 21.5 weeks (ranging from 17.5 to 25.5 weeks). Keating[11] reported that the average time to union in reamed and unreamed locking intramedullary nailing in a series was 28 and 21 weeks for type I open fractures, respectively; 28 and 27 weeks for type II open fractures; 34 and 31 weeks for type IIIA open fractures. Weight bearing, to some degree, stimulates bone healing. Hulth[12] reported that the current concept of fracture healing was based on two variables namely blood supply and stability. In the present study, there were 10 cases (33.3%) of pin tract infection, manifested by pain, erythema and purulent discharge around the pin sites which was controlled by oral antibiotic within 10 days. There was no case of deep infection in this study.

Tuker[7] reported approximately 10% of pin tract infection. Holbrook et al[13] evaluated 28 open tibial fractures treated with external fixation and found a 14% rate of deep infection. Keating et al[11] reported a rate of 3.3% in his series of open tibial fractures treated with locking intramedullary nailing. There was no compartment syndrome in this study. Keating[10] reported a rate of 3.3% of incidence of compartment syndrome in their large series of open tibial fracture treated with locking intramedullary nailing. Tucker[7] reported 4 (15.3%) cases of 7^0 or 8^0 recurvatum and shortening of greater of 1 cm occurs in 10% of the cases. The union rate using the Ilizarov fixator was comparable with that of other fixators using larger pins. There was no instance where there was a change to another treatment strategy. The results were excellent in 25 (88.3%) cases and good in 5 (16.7%) cases. Two patients (6.3%) who had united 7^0 recurvatum were placed in good category. They had full range of knee movement, plantar flexion and dorsiflexion of ankle, no muscle wasting and no external rotation deformity. One case (3.1%) had shortening of 1cm of the affected limb was placed in good category. The other 2 cases (6.3%) that had loss of 8^0 ankle dorisflexion were placed in the good category according to the criteria.

V. Conclusion

The Ilizarov device is now used worldwide for the treatment of fractures. The construct is stable and enables the patient to bear weight on the affected limb a short time after the surgery, even in cases of highly comminuted fractures. The Ilizarov fixator allowed significantly more axial motion at the fracture site during axial compression than the other fixators. Unlike standard external fixators that use threaded pins 4, 5, 6 mm in diameter, the Ilizarov fixator uses 1.5 or 1.8mm Kirshner wires to hold the bone fragment in position. The design rational of the Ilizarov fixator is to hold the bone fragments in the proper alignment while allowing axial dynamization at the fracture site. It induces axial micromotion at the fracture site and can accelerate fracture healing. Despite technical difficulties and problems associated with pin-tract infections, the Ilizarov external fexator may be the preferred technique in open tibial fracture because of high union rates, the use of thin K-wires with minimal traumatic effect and more successful functional results.

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