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# Study of Effectiveness of Ilizarov Ring Fixator in the Treatment of Infected Nonunion Tibial Fractures

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***Abstract***

*Tibia is a subcutaneous bone and susceptible to nonunion due to various reasons. This study analyses the effectiveness of ilizarov ring fixator in treating infected non unions in tibia.*

***Setting:*** *University affiliated teaching hospital*

***Patients:*** *The study was conducted with 21 cases of infected nonunion of tibia during the period from October 2018 to October 2020 admitted in Osmania General Hospital, Hyderabad.*

***Intervention:*** *All patients treated with ilizarov ring fixator. Seven patients underwent bone transport.*

***Results:*** *final result grading is based on a total of nine parameters which includes clinical, radiological and functional assessment (ASAMI). Results are divided into bone results and functional results. Able to achieve good to excellent bone results in 90% patients and functional results in 85% of patients.*

***Conclusion:*** *The ilizarov technique allows early function of the limb resulting in adequate stimulus for soft tissue and bone healing. It is an effective method of treating infected nonunion of tibia.*

## Introduction

Infected non-union of tibia per se is a challenge to treat. Tibia as a subcutaneous bone causes susceptibility to infection, non-union, fibrosis, sinuses, deformities, shortening and various problems. Compound fractures treated with internal fixation with flap provides poor results due to infection and biofilm formation over the implant **[**1**]**. On the other hand external fixation followed by internal fixation costs around 3 to 6 month and keeps the patient non weight bearing during this entire period. Nonunion is another major problem which occurs in 2 to 15% of cases which increases the treatment cost and duration **[**13**]**.

Treatment of nonunion with Ilizarov Technique is introduced by Prof. Garvil Abramovich ilizarov in 1951 which changed the approach to nonunion and infected compound fractures. Ilizarov External fixation provides correction of all the complications associated with non-union, bone gap, infection, shortening, and deformities. Corticotomy, stable fixation, and bone transport employed reduces or eliminates infection at the same time achieving bone union and correction of limb length discrepancy **[**14**]**.

**Aims and objectives of the study**

1. To study and analyze the effectiveness of Ilizarov fixator method of treatment in infected non- union tibia.

2. The aim of the treatment of infected nonunion is to achieve stable union without residual infection, deformity or shortening

3. The aim of ilizarov method along with the technique of bone transport is to allow the orthopaedic surgeon unprecedented control over osteogenesis, radical debridement of infected bone and soft tissue while maintaining stability, improves the vascularity of local tissues, simultaneous correction of deformity and limb length discrepancy while allowing early post-operative mobilization and rehabilitation.

## Materials and Methods

This study was conducted with 21 cases of infected nonunion of tibia during the period from October 2018 to October 2020 admitted in Osmania General Hospital. The patients age range from 18 to 65 years. There were 16 male and two female patients.

All cases were result of open injuries. Out of 21 cases, 2 cases were due to accidental fall from height and others were due to vehicular accidents. The latency period before applying ilizarov fixator range from 6 to 24 months.

According to Gustilo and Anderson grading 8 cases were grade III, 6 cases were Grade II and 2 cases were Grade I, 12 cases had been treated by debridement and external fixator earlier. 2 cases by long leg plaster and 2 cases by internal fixation.

**Inclusion Criteria**

Age between 18 to 65 years

Both male and female

Infected nonunion of tibia more than 6 months

Bone loss of less than 10 cm

**Exclusion Criteria**

Congenital pseudoarthrosis of tibia

Nonunion of tibia which is not associated with infection

Fresh compound fractures

Infected fractures less than 6 months

**Pre-Operative Assessment:**

The case of infected nonunion were identified using clinical criteria namely mobility at fracture site, duration, presence of non-healing wound, radiological evidence of failed bony union and microbiological evidence of poly-microbiological multi-resistant flora, on doing culture of the discharging pus. The cases were assessed pre-operatively, clinically, radiologically, and microbiologically.

Clinically the mobility at the fracture site, signs of infection and soft tissue condition, limb length discrepancy and adjacent joints were accessed.

Radiologically the status of bone ends, the gap and amount of deformity and signs of infection were noted.

Skin and the sinuses were thoroughly cleaned and a sterile swab is used to get specimen for culture and sensitivity from the non-healing wound.

**Operative Procedure**

The main surgical principles in the management of diaphyseal bone infection is through debridement of all nonviable tissue.

The ilizarov technique allows radical, circumferential debridement more than due to the unique technique of bone transport involving gradual transport of an intercalary segment of bone through the limb while simultaneously lengthening the corticotomy gap and closing the skeletal defect. All patients in the inclusion criteria were taken up for study. All were assessed preoperatively. The patients were explained about the procedure and consent was obtained preoperatively. Pre-assembled ring was shown to all the patients well before surgery. They were explained about the additional procedure if needed.

1.8 mm wires are used for adults and 1.5 mm wires are used for children and in small bones. Trocar printed one is used for metaphyseal bone and bayonet points for diaphyseal bone

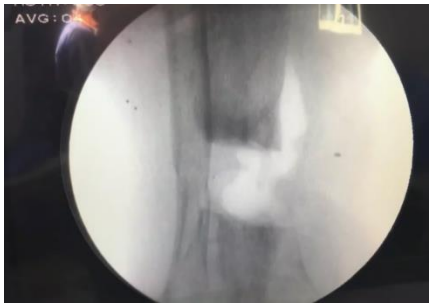
Correct placement of wires is essential to control the movement of bone during the various procedures. The knowledge of cross-sectional anatomy of the limb is used to pass the wires through safe corridors so that neurovascular structures are not injured. The wires should be inserted from the more vulnerable side and drilling should be started only after reaching the bone. Drilling is periodically stopped to prevent over heating of bones as it may cause bone necrosis and loosening of pin and infection

The wire should be placed at right angles to each other for maximum stability. The wires of each pair should be in parallel planes about 0.5 mm apart so that each one should be on either side of each rings

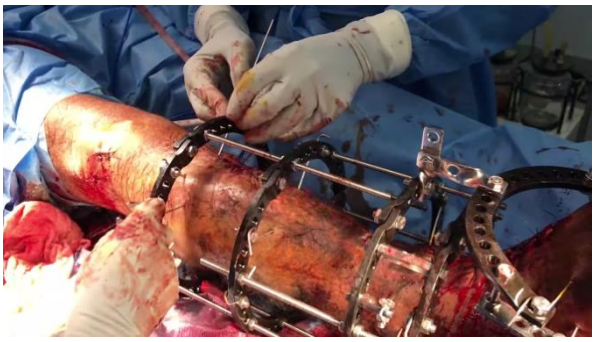
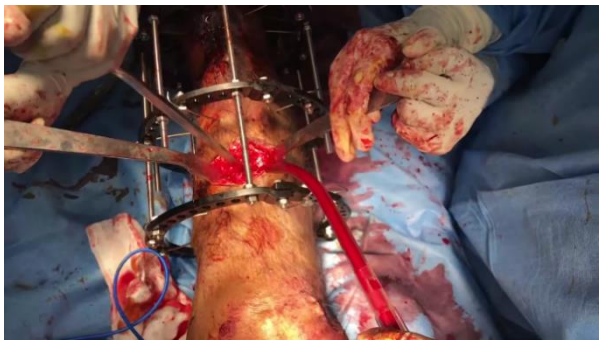
The ends of the wire were tensioned with dynamometer tensioner. Tensile force should be increased in proportion to the weight of the patient. Muscles should be properly positioned to allow maximum excursion of the adjacent joints. Before piercing, each muscle should be stretched to its maximum at the adjacent joints. Synovium and tendons should not be penetrated.

Corticotomy is done by low energy osteotome or gigli saw.





**Post Operative Management:**

The patients were advised weight bearing with the use of crutches on day 1. Distraction was taught to the patient and his relatives and they were treated on an outpatient basis with fortnightly reviews. Clearing of the rings and the wires using povidone iodine and hydrogen peroxide was done by the patient.

**Frame Removal:**

In the X-ray, the regenerate should be remodeled with cortex and medullary canal of almost equal cross-sectional diameter to the host bone corticotomy surfaces prior to frame removal

Dynamisation – The nuts of the frame are loosened and the patient is allowed to walk on the frame. If the patient complaints of no pain, then he is allowed to ambulate in the dynamised frame for about 15 days. Then the frame is removed and a plaster of Paris cast is applied for about a month.

**Observations and Results**

**Modified Gustilo Anderson Classification [2]**

| **Modified Gustilo Anderson Classification** | **No. of patients** | **Percentage** |
|---|---|---|
| Grade I | 2 | 10 |
| Grade II | 5 | 23 |
| Grade III a | 8 | 38 |
| Grade III b | 6 | 29 |

**Classification**

**Weber and Cech [3]**

| Type | Number | Percentage |
|---|---|---|
| Hyper vascular | 17 | 81% |
| Avascular | 4 | 19% |

**Dror Paley et al (applicable to infected nonunion)**

| Type | Number | Percentage |
|---|---|---|
| Type A (less than 1cm bone loss) | 4 | 19% |
| Al (lax) | 2 | 10% |
| A2-1 (stiff, no deformity) | 1 | 4.5% |
| A2-s (fixed deformity) | 1 | 4.5% |
| Type B (more than 1cm bone loss) | 17 | 81% |
| B1 (bony defect, no shortening) | 3 | 14% |
| B2 (Shortening, no defect) | 3 | 14% |
| B3 (bony defect and shortening) | 8 | 53% |
| Total | 21 | |

**Final Results Grading**

Grading: A.S.A.M.I. grading **[4]**,

The results are divided into bone results and functional results

**Bone Results**

| Grade | Criteria | Number | Percentage |
|---|---|---|---|
| Excellent | Union, no infection, deformity < $7^0$ , LLD < 2.5 cm | 12 | 57% |
| Good | Union + any two of the following- no infection, deformity < $7^0$ , LLD < 2.5 cm | 5 | 23% |
| Fair | Union + any one of the following - no infection, deformity < $7^0$ , LLD < 2.5 cm | 2 | 9% |
| Poor | Nonunion / refracture/ union with infection or deformity >$7^0$ or LLD >2.5 cm | 2 | 9% |

**Functional Results**

| Grade | Criteria | Number | Percentage |
|---|---|---|---|
| Excellent | Active, No limp, minimum stiffness (loss of <$15^0$ knee extension and <$15^0$ ankle dorsiflexion), no reflux sympathetic dystrophy (RSD), insignificant pain | 10 | 47% |
| Good | Active with one or two of the following limp, stiffness, RSD, significant pain | 6 | 28% |
| Fair | Active with three or all of the following | 4 | 19% |
| Poor | Inactive | 1 | 6% |

Thus the final result grading is based on a total of 9 parameters which includes clinical radiological and functional assessment of the patient some of which are subjective and depends on patient assessment. The average duration of treatment for infected no union of tibia is 8.8 months.

Union was achieved in all except two patients. In 2 cases ring was removed due to poor compliance. One among them is a female patient with known HbsAg positive patient with segment fracture. She had bilateral leg fracture. Her left leg was treated with interlocking nail for fracture both bones. She had grade III segmental fracture in right leg. Initially treated with external fixator and lateral converted

into rings. The procedure was explained to her in detail before the ring was applied. She lost the follow-up.

The other case of failure occurred in a case of infected nonunion resulting from a type IIIB compound fracture. He was previously treated with external fixator and split skin grafting. A four ring assembly for bifocal osteosynthesis was applied. Patient demanded removal of apparatus. However with the ring insitu, infection had settled down and posterolateral bone grafting done. Hence frame was removed and long leg cast applied. Patient lost follow up after that.

One case which did not show any new bone formation even after 9 months of the ring application, underwent bone grafting in fixator in situ and union achieved later.

One case with 6cm shortening, malunited with shortening of 3cm due to premature consolidation at the corticotomy site.

One case which implant with segmental fracture had union in the lower fracture. Upper fracture did not unite. This fracture was dynamised and treatment with bone marrow injection and union achieved.

One patient developed Doppler proven pseudo aneurysm from posterior tibial artery and it manifested only 2 weeks after the fixator removal after union had achieved. The vessels ends identified and ligated

Infected nonunion was treated by debridement of infected bone and necrotic tissue and bifocal osteosynthesis and antibiotics. All of the 21 patients with successful outcome had eradication of infection at about half way of the treatment.

In the final analysis, 2 patients had significant functional impairment and all patients were able to use the limb well at the time of review. The true angle and plane of deformity was calculated from the true anteroposterior and lateral views as described by Dror Paley.

Duration of follow up of the patients ranged from 3 months to 1 year. At the last follow up all patient with successful outcome except those two required any orthotic aids. All successful cases returned to full-fledged daily activities and most are leading economically productive life. Two patients had length discrepancy more than 1 cm which was acceptable to the patient.

## Discussion

Dr. Dror Paley **[**5**] [**12**]**1989,et al treated twenty-five patients aged 19-62 years for tibia non-union (22 atrophic, 3 hypertrophic) with bone loss (1-23 cm, mean 6.2 cm) by the Ilizarov technique and fixator. Thirteen had chronic osteomyelitis, 19 had a limb-length discrepancy (2-11cm), 12 had a bony defect

(1 - 16cm) and 13 had a deformity. Six had a bone defect with; no shortening, 13 had shortening with no defect, and six had both a bone defects, limb shortening, and deformity can all be addressed simultaneously with the Ilizarov apparatus. Bone defects were closed without bone grafts by the Ilizarov, bone transport technique of sliding a bone fragment internally, producing distraction osteogenesis behind it until the defect is bridged (internal lengthening i.e., Bone transport). Length was re-established by distraction of a percutaneous corticotomy. Infection was treated by radical resection of the necrotic bone and internal lengthening to regenerate the excised bone. Union was achieved in all cases. The mean time to union was 13.6 months, but it was only 10.6 months if the time taken for unsuccessful compression-distraction of the non-union is eliminated from the calculation. The bone results were excellent in 18 cases.

Tsang et al[6] treated 32 infected tibial nonunions with exchange nailing but achieved success in only 35%, rising to 61.3% after 2 exchanges. They concluded that the Ilizarov method may be the preferred option in infected cases.

Conway et al[7] reported on their experience of using antibiotic coated nails in treating 43 infected nonunions. A single procedure secured infection-free union in 60%. Infection recurred in 30% of this group. Twelve of the 22 cases with a bone defect (51%) required further surgery to secure union or eradicate recurrent infection. Of note, 12/13 (93%) of the cases requiring further surgery had an associated bone defect. There were no cases of infection recurrence in cases without a bone defect. This may strengthen the argument for Ilizarov techniques when infected nonunion is associated with a bone defect.

Induced membrane techniques as originally described by Masquelet et al[8] have also been used. Morelli et al reviewed 30 years of articles on the induced membrane technique and found only 65 cases reported with individual patient data.[9] Forty-seven percent were for septic bone defects, and union was achieved in 88%, with 93% infection-free, but with a 53% complication rate.

A recent study by Morris et al[10] reporting on 12 patients treated with the induced membrane technique after trauma found that only 5 cases achieved union (42%). A further 5 patients experienced infective complications during treatment, with 2 requiring amputation because of severe infection.

Karger et al[11] reported a series of 84 cases, of which 50% were infected. Although union was obtained in 90%, this was after a mean of 6.11 interventions and a mean of 14.4 months after the first stage reconstruction. Furthermore, the authors advised that weight-bearing was delayed until union had been achieved at a mean of 17.4 months. Average frame times for bifocal compression/distraction and bone transport in our series were 9.4 and 10.7 months, respectively. Our patients are mostly able

to weight bear at an early stage, which may prevent other complications, such as muscle wasting and disuse osteopenia.

## Conclusion

The ilizarov technique allows early function of the limb resulting in adequate stimulus for soft tissue and bone healing. Proper selection of patients by avoiding extremes of age, and assessing compliance by the patients is essential for the successful application of the ilizarov technique. Proper placement of K wires and rings is essential for maintaining adequate rigid fixation. Physiotherapy and functional use of the limb from the first week after application of the fixator is essential for successful treatment of the nonunion. The ilizarov technique is the treatment of choice for infected nonunion of long bones. Proper understanding of the biological and biomechanical principles of ilizarov method and their careful application give excellent results in almost all cases of infected non union.

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