

ORIGINAL ARTICLE

EVIDENCE BASED ANALYSIS OF BONE TRANSPORTATION FOR INFECTED NON-UNION OF TIBIA BY ILIZAROV METHOD

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ABSTRACT: Proper decision making and the understanding of the problem of infected non-union of tibia and resection of bone and transportation by Ilizarov method has been an accepted method for this complex issue. We would like to present a series of 22 patients and their outcome by Ilizarov bone transportation for infected non-union. **AIMS:** Our aim in this study is to analyze 22 cases of infected nonunion of tibia with or without associated skin loss managed by the concept of Compression – Distraction Osteogenesis with or without acute docking employed by the Ilizarov apparatus. 1. To evaluate whether the previous surgeries or the duration of treatment have an influence on the outcome. 2. To evaluate whether the infecting organism or the type of infection has an influence on the outcome. 3. To compare various factors like age & sex distribution on both radiological and functional outcome. 4. To evaluate the outcome both radiological and functional outcome in smokers & nonsmokers. 5. This study further aims to compare the results of functional & radiological outcome of the method of Ilizarov done by various others.

KEYWORDS: Infected non-union of tibia, Ilizarov bone transportation.

INTRODUCTION: Nonunion of tibia is a challenging situation for both healing and reconstruction when infection is added. Infected tibial nonunions bring forth many psychological, economical, and social problems by not only the functional inadequacy but at the same time by long healing periods, multiple operations, and long periods of antibiotic therapy.¹

In the last forty years, the late G. A. Ilizarov and his colleagues in the Siberian city of Kurgan have developed a technique for the treatment of chronic osteomyelitis and bone defects created by extensive debridement.^{2,3}

Their method, known as distraction osteogenesis, simultaneously addresses deformity, shortening, loss of bone, function, osteoporosis, and soft-tissue atrophy. We report here the results of the use of this technique for tibial non-unions associated with infection.⁴

SUBJECTS AND METHODS:

PATIENTS:

SURGICAL TECHNIQUE: The cases were taken under general anesthesia. We try to avoid tourniquet in the cases where we plan radical debridement of the infected site.

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Patients were placed Supine on the operating table with a sand bag under the thigh and another one in the heel region for tibia. So that the entire operating table is free for the surgeon. It is also easy for the assistant to hold the leg comfortably.

Hard ware removal & radical resection of dead bone with debridement of the infected scarred soft tissue was performed & representative tissue culture, including the sinus tract for all dead bone were obtained,. Sequestrae and implants were removed and granulations curetted out.

Any obvious unhealthy bone was nibbled off and both ends of the exposed bone were excised till fresh bleeding bone was visible all round. The amount of bone which needed excision was decided at surgery and not preoperative assumptions or investigations. (Fig.1) Cortical bleeding, described as the so- called paprika sign⁵ was accepted as an indication of vital tissue for the tibia whenever the gap was small or negligible the cut bone ends were acutely docked. While doing so any rotational or angular deformity was corrected to the maximum extent possible.

We followed the method of "progressive concentric system "of Benedetti & Arganani^{6,7,8} for Ilizarov. The Benedetti – Argani Technique involves progressive frame construction with each ring similar to original Ilizarov technique.

All operations were done by surgeons trained in the field. Care was taken to avoid damage to vital structures while introducing K-wire by adhering to safe anatomical zones of Ilizarov. We used 1. 8 mm ilizarov wires in our cases. Only hand drills were used. We used full rings, 160 & 180 mm half rings in our cases. Under image intensifier control and with respect to neurovascular anatomy of leg wires are passed manually through safe zones. In addition our surgeons regularly used stimulation of K-wire by low voltage current to detect proximity of wires to nerves.

None of the patients in the study had history of any systemic illness or diabetes. All patients had preoperative antibiotics for a short period and most patients did not require them by suture removal. No long term antibiotic treatment was recommended. Short course of antibiotics were prescribed for troublesome pin tract infections

Post-Operative Protocol: For the first two days foot end was elevated & patient was allowed to sit up on the first day itself.

Once the acute pain subsides quadriceps exercises with full range of movement exercises is started.

- For the first 5-7 days I. V antibiotics are given.
- We follow the continuous irrigation system for 72 hrs.
- Patients were discharged on the fifth or sixth post-operative day and were followed-up every two weeks special attention on identifying pin-tract infection. Following application of external fixation, the patients and or their caretakers were taught on how to do pin-site dressing using 5%betadine as cleansing solution twice or thrice in week.
- Distraction started after 7-10days at a rate of 1mm per day with 4 quarter turns.
- When regenerate was delayed rate of distraction reduced to 0.5 mm.

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Per day temporarily or stopped for few days;

- x- rays are taken after 2 weeks to look for newly formed bone.(fig. 2)
- After the completion of compression & distraction, consolidation is followed by taking serial x- rays every 2 weeks.
- During bone transport and consolidation patients were encouraged to mobilize the proximal joint (knee).
- X rays were taken to assess union & calcification of regenerate. Dynamization of the frame was done on all patients at this stage except those who had radiological evidence of frank non-union.
- After Dynamization the fixator was removed and union assessed. A POP – PTB brace was given and the patient was asked to walk full weight bearing for 4 to 6 weeks.

RESULTS: The present study constitutes 22 cases of infected non-union of tibia managed by ilizarov bone transportation and outcome the observation is based on the follow up study for 31 months from May 2012 to Jan 2015

- 1. AGE DISTRIBUTION:** In the present series of 22 patients the age of the patients varied from 19 yrs to 62 yrs. The mean age is 38.2 yrs. The maximum numbers of patients are between 20 to 30 yrs.

Since the majority of cases are of young adults in the prime of their lives, these fractures become still more important, considering the fact that they have to lead many more years of active life.

- 2. SEX INCIDENCE:** In the present series of 22 patients there were 5 females 22.7% and 17 males 77.3%.

- 3. SIDE OF INJURED LEG:** In our series the majority of cases are right sided fractures 14 right sided 63.6% and 8 are left sided 36.4%.

The right sided common injury may be associated with road traffic accident being most common as we follow the left sided traffic

- 4. MODE OF INJURY:** In the present series of 22 patients the mode of injury was road traffic accident in 19 patients 86.3% and fall from height in 3 patients 13.7%

The maximum number was by road traffic accident.

Most authors uniformly agree on road traffic accident being most common cause of tibial fractures.

- 5. SMOKING HABITS:** There were 7 smokers out of 22 patients 32% and 15 nonsmokers 68% in our study we had significantly good results in non-smokers compared to smokers.

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6. LEVEL OF INJURY: In our series of 22 patients there were 17 patients 77% with fracture of middle third diaphysis.

7. STAGE OF OSTEOMYELITIS: In our series of 22 patients there were 68% of patients with CIERNY MADER CLASSIFICATION IV-B 15 patients and 7 patients(32%) with CIERNY MADER CLASSIFICATION IV-A.

8. TYPE OF INFECTING ORGANISM: In our series we had.

SI.NO	CAUSATIVE ORGANISM	NO.OF PATIENTS	PERCENTAGE
1	Staphylococcus aureus	9	34.6
2	Staphylococcus epidermidis	7	26.9
3	Anaerobes	2	7.7
4	Pseudomonas	3	11.5
5	Coliforms	2	7.7
6	Other bacteria	2	7.7
7	No growth	2	7.7
	TOTAL	27	100

Table 1

Staphylococcus.aureus was the most common organism.

The infecting organism was Staphylococcus aureus in 10of these patients. In three patients the organism was Pseudomonas, and Staphylococcus. Epidermidis in 3. Two patients had coliforms and two had Klebsiella the infecting organism was unknown in two patients.

9. AMOUNT OF BONE DISTRACTED: The mean amount of bone distracted in our study is 8.43 cm range (3cm- 13cm). (centimeters)

10.DURATION OF DISTRACTION: The mean duration of distraction is 4.15 months or124 days range (2 to 6.5 months).

11.DISTRACTION INDEX: Average no. of days of distraction/average length of bone distracted.

12.The mean duration on fixator is 10.22 months range 5 to 14 months.

13.EXTERNAL FIXATOR INDEX: Average no.of days on fixator/average length of bone distracted.

In our study it is $10.22\text{months} \times 30 \text{ days}/8.43\text{cm} = \text{mean external fixator index is } 36.37\text{days/cm}.$

These were assessed based on the criteria laid down by ASAMI.⁹

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A. Excellent –when the following criteria are met:

1. Union.
2. No infection.
3. Deformity of $<7^\circ$ and.
4. Limb Length discrepancy of < 2.5 cm.

B. Good- when there is,

1. Union +any two of the following: Absence of infection,. Deformity of $<7^\circ$ and Limb Length discrepancy of < 2.5 cm.

C. Fair - when there is,

1. Union +only one of the following: Absence of infection,. Deformity of $<7^\circ$ and Limb Length discrepancy of < 2.5 cm.

D. Poor - when there is,

Nonunion/ refracture/ union+ infection+ deformity $<7^\circ$ + Limb Length discrepancy of >2.5 cm. Of the 22 patients who completed treatment 12 had excellent bone results, 7 had good results, 3 had fair, and none had poor results. Infection was eradicated in all none had abscesses or infection or draining sinus at the site of nonunion

Out of 7 patients with good results 4 had valgus deformity 1 of them had varus deformity& 2 of them had shortening of more than or equal to 2.5 cms. All 3 patients with fair results had valgus deformity & shortening of more than or equal to 2.5 cms. There are no patients with poor results. Valgus deformity $>7^\circ$ &shortening are most commonly encountered in our study. Union was achieved in all patients & after removal of fixator there were no cases with residual infection. Bone grafting or B.M.P injections were not used in our treatment. In case of hypotrophic regenerate formation we with-held distraction for few days

The results are classified into bone results and functional results by Association for the Study and Application of the Method of Ilizarov (ASAMI)^{10,11} scoring system.

RADIOLOGICAL OUTCOME:

SI. NO	NAME OF STUDY	EXCELLENT	GOOD	FAIR	POOR	TOTAL
1	OUR STUDY	12 (54%)	7 (32%)	3 (14%)	0 (0%)	22 (100%)
2	Dendrinos GK, et al ⁴	14 (50%)	8 (28%)	1 (4%)	5(18%)	28 (100%)
3	Maini et al et al ¹²	21 (70%)	3 (10%)	0 (0%)	6 (20%)	30 (100%)

Table 2

COMPARISON OF OTHER STUDIES:

Sl. No	Author	Treatment time (months)	Total cases	Infected cases	Union attained	Infection eradicated
1	Schwartzmann ¹³	7.5	14	28.57%	93%	100%
2	Dagher ¹⁴	7.7	9	44.44%	100%	100%

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3	Cattaneo ¹⁵	9	28	100%	100%	78.57%
4	Green ¹⁶	9.6	17	52.94%	94.12%	-
5	Dendrinis ⁴	10	28	75%	100%	100%
6	Polyzois ¹⁷	10	25	66.67%	90.4%	100%
7	Tucker ¹⁸	11.5	7	71.43%	100%	14.28%
8	Naggar ¹⁹	16.5	10	100%	72.73%	100%
9	Ciorny ²⁰	17	21	100%	90%	100%
10	Present study	10.22	22	100%	100%	100%

Table 3

FUNCTIONAL RESULTS: as per criteria laid down by ASAMI⁹

- a. Excellent:** when the following criteria are met,
 1. Active,
 2. no limp,
 3. minimum stiffness(loss of <15° knee extension/15° dorsiflexion of ankle),
 4. no reflex sympathetic dystrophy(RSD),
 5. Insignificant pain.

- b. Good:** when the following criteria are met, active, with one of the following limp, stiffness, RSD, significant pain.

- c. Fair:** when the following criteria are met, Active, with three or all of the following, Limp, stiffness, RSD, significant pain.

- d. Poor:** Inactive (unemployment or inability to return to activities of daily living).

- e. Failure:** amputation, in our study we had.

FUNCTIONAL GRADING: To make this assessment an objective one, we gave one point each for the various factors like limp, pain, deformity, joint stiffness and inability to return to prefracture profession. In addition, we allotted one point each for proximal and distal joint stiffness as a two joint stiffness would be incapacitating to the functional efficacy of the patients. Based on our point system, we had 14 excellent functional results, 6 good, 2 fair and four poor. If the ASAMI criteria had been strictly adhered to 6 patients have been rated good, & 14 had excellent results which gives a total of twenty favorable (good + excellent) functional results.

We had 1 patient with knee stiffness & 3 patients with equinus deformity. The equinus deformity was present in patients with distal third fractures. There are 3 patients with limp. The knee stiffness was managed by physiotherapy. One patient developed knee stiffness by using hybrid ilizarov fixator for femur for an associated ipsilateral femur fracture. After removal he was advised active range of motion exercises of knee joint. The range of movements achieved was 0-90 degrees

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STATISTICAL DATA ANALYSIS:

STATISTICAL ANALYSIS: Statistical analyses were performed using SPSS windows version 12.0 software (SPSS Inc, Chicago. Illinois). All continuous variable were reported as mean, standard deviation and it's analyses by one way analysis of variance and categorical variables by Chi-square with Yate's correction. P value < 0.05 was considered significant

Radiological out come in smokers & nonsmokers:

Radiological out come	SMOKER/ NON-SMOKER		Total
	NON SMOKER	SMOKER	
Excellent	11	1	12
Good	4	3	7
Fair	0	3	3
Total	15	7	22

Table 4

P value = 0.007*

Here the p value is less than 0.05, so we conclude that there is significant difference between the radiological results according to smoking habits.it takes longer duration for consolidation in smokers.

Functional out come in smokers & nonsmokers:

Functional results	SMOKER/ NON-SMOKER		Total
	NON SMOKER	SMOKER	
excellent	12	2	14
Good	3	3	6
Fair	0	2	2
Total	15	7	22

Table 5

P value = 0.028*

Here the p value is less than 0.05, so we conclude that there is significant difference between the functional results according to smoking habits.it takes longer duration for consolidation in smokers.

There were 7 smokers out of 22 patients 32% and 15 nonsmokers 68% in our study we had significantly good results in non-smokers compared to smokers it was comparable to the study by D.R. Marsh, S. Shah, J. Elliott, N. Kurdy et al (1997)²¹ study where there were 34% smokers 9 patients and 66% nonsmokers 17 patients out of 27 patients.

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We agree with other authors that the outcome both radiological & functional is dependent on the smoking habit of the patients. We also advise smokers to quit smoking at the time of treatment.

DISCUSSION: From our experience in management of chronic septic with Ilizarov fixator we arrived at the following conclusions.

1. The Ilizarov fixator is a successful system in treating infected nonunion and has been instrumental in achieving union in 100% and eradicating of infection at 100% of patients which compares favorably with other reported series.
2. There is a high incidence of distal joint stiffness and muscle contracture which compromises distal joint function.
3. There was high rate of pin tract infections. No nerve or vascular injury was encountered during or after surgery. None of the patients in our series required amputation.
4. No statistical correlation was found while comparing age of the patient, type of infection & infecting organism with bone result & functional result.
5. Heavy smoking appeared to have a deleterious effect on the maturation of new bone formed by callus distraction, independent of the severity of the presenting problem. This has been the subjective impression of many surgeons who use the ilizarov method, and it seems advisable to recommend stopping or reducing cigarette consumption before starting bone transportation.

The main advantages of this method are;

1. Spontaneous control of infection in presence of osteogenesis even without the need for the use of antibiotics, as infection dissolves in osteogenesis.
2. Provision of needed stability for weight-bearing and patient mobilization, again an important factor in induction of osteogenesis and union.
3. Minimal tissue destruction with least interference with normal local healing process due to the structure of apparatus, which is itself helpful in reunion.

The disadvantages include:

1. Long duration of treatment.
2. Extensive physiotherapy.
3. Preoperative counseling & explanation to the patient regarding long duration of treatment.

To finalize we conclude that keeping in mind the gravity of the issue and the complexity and morbidity associated with alternative treatment modalities Ilizarov fixator could well be the treatment option of choice for management of infected nonunion with several advantages and certain set-backs in the treatment of tibial infected nonunions where other methods have failed (fig. 3).

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Fig. 1: excised segment



Fig. 2: X-ray during distraction



Fig. 3: Final range of movement

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