Outcome of infected non-union of long bone fractures of the lower limb using Ilizarov ring fixator.

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ABSTRACT

Objective: To determine the radiological and functional outcome of Ilizarov ring fixator in the management of infected nonunion of long bones of the lower limb.

Methods: This descriptive study was conducted in Mercy Teaching Hospital Peshawar from 3rd January 2011 to 23rd June 2019. All patients of infected non-union of tibia and femur meeting the inclusion criteria were treated with Ilizarov ring fixator. Post-surgery outcomes were analyzed in terms of bone and functional results as per "Association for the Study and Application of Methods of Ilizarov (ASAMI) Scoring System".

Results: A total of 40 cases including 37(92.5%) males and 3(7.5%) females with the mean age 33.325± 9.4 years (range 3 to 60 years) were included in our study. In 30(75%) cases tibia and in 10(25%) cases femur was involved. Bone defect after radical debridement was 2-centimeter(cm) or less in 25(62.5%) cases and they were treated with monofocal compression distraction technique using Ilizarov ring fixator. In 15(37.5%) cases bone loss after radical debridement was more than 2cm with mean defect 7.06 cm (ranging from 4cm to 12 cm) and they were treated with bone segment transport. Post-operative outcome as assessed with ASAMI scoring system showed excellent radiological result in 35 (87.5%) patients and good in 5 (12.5%) cases. Excellent functional results were noted 30 (75%) cases, good in 9 (22.5%) and fair in 1 (2.5%) case No poor radiological or functional results were reported.

Conclusion: The Ilizarov ring fixator produced excellent and good radiological and functional results in majority of our patients with infected nonunion of long bones of the lower limb. We therefore recommend that Ilizarov should be the first treatment modality to treat infected non unions of tibia and femur.

Key words: ASAMI Scoring System, Distraction Osteogensis, Ilizarov, Infected Nonunion.

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INTRODUCTION

Infected nonunion is associated with infection at the site of nonunion as evident by varying combination of deep abscess, draining sinuses, positive cultures, and serology.[1, 2] Aseptic nonunion in long bone fractures is a well-known complication that can be dealt effectively with internal fixation with or without bone grafting.[1,2] However infected nonunion in weight bearing long bones of tibia and femur present a challenging situation to the orthopedic surgeons.[3-5] These infected nonunion are usually complicated by soft tissue and bone loss, resistant multifactorial infection, limb length discrepancy, deformities, joint stiffness and multiple draining sinuses. A number of different treatment modalities are available to treat infected nonunion but none of them is able to

simultaneously address all the associated complications of infected nonunion.[6,7] The Ilizarov ring fixator however, can be used in a number of ways to treat effectively and simultaneously not only the nonunion but also fill the gap due to bone loss. It can correct deformities, eradicate infection, provides immediate stability that permits early weight bearing.[1,4, 5, 8]

The Ilizarov ring fixator can be used for monofocal or bifocal compression distraction and bone segment transport depending upon the bone defect at site of nonunion.[1, 4, 5, 8] The regeneration of new bone to fill the defect is distraction Osteogenesis and is based upon the "Theory of Tension Stress" introduced by Gavrill Abramovich Ilizarov in 1951.[3, 4, **9-11**] The regeneration of new bone not only covers the bone defect but it also eliminates infection as claimed by Ilizarov that "Osteomyelitis burns in the flame of regenerate." [7,9, 10] This explains the philosophy of infection eradication by this method and that was the reason that Ilizarov himself never used antibiotics in treating bone infections.[10]

Department of Orthopaedics Mercy Teaching Hospital Peshawar is one of the four private teaching departments of Peshawar. Many patients of infected non-union of tibia and femur are presented to Orthopaedic OPD of our institution for treatment. To our knowledge this was the first study in a private sector hospital. The publication of our results will encourage other patients as well as referring surgeons to refer infected non-union patients to our department for treatment. By treating such patients in our department the overburden of patients on our public sector hospitals will be reduced to a greater extent. The objective of our study was to determine the radiological and functional outcome of Ilizarov ring fixator in the management of infected nonunion of long bones of the lower limb.

METHODS

This descriptive study was conducted in Mercy Teaching Hospital Peshawar from 3rd January 2011 to 23rd June 2019. Patients of all age groups who underwent treatment with Ilizarov for management of infected nonunion of femur and tibia, and had completed their follow-up were included in the study. Patients who were operated with Ilizarov in other centers and those lost in follow-up were excluded from study. Approval for this study was taken from the "Institutional Ethics Committee." Informed consent was obtained from all participants of the study.

Operative technique

In all cases radiolucent table was used with patient in supine position. Patients were operated under general or spinal anaesthesia. The Ilizarov ring fixator was assembled preoperatively or per operatively taking into consideration the degree of bone resection, location of osteotomy and skin and soft tissue condition of the limb. The initial step in treating non-unions with Ilizarov was to remove any previous implants used in treating that fracture.[1,3] Radical debridement was carried with removal of the infected scarred soft tissue and resection of necrotic bone ends. The necrotic bone ends were resected till bone with bleeding margins reached (Paprika sign).[14]The bony margins were smoothen out for proper contact at docking site and during compression. The Ilizarov ring fixator was then applied by passing wires per-cutaneously through bone in safe multiple directions.[3] The involved bone was stabilized when the wires were connected and tensioned to external interconnected rings thus producing a sturdy construct.[1, 3, 4, 9, 12] Each ring was fixed with two smooth wires but in some cases half pins (Schanz screws) were also added to improve stability. In case of femur in the middle and proximal third the rings were fixed to bone with predrilled half pins (Schanz screws). In case of tibia fibular osteotomy was performed after application of Ilizarov frame. Image intensifier was used per-operatively as per need.

The patients were started on broad spectrum antibiotics (injection Cefuroxime 1.2gm Intavenous) immediately after taking sample for culture and sensitivity, and they were changed if needed after culture sensitivity report arrived. In all cases intravenous antibiotics were used for six weeks.

Physiotherapy and toe-touch weight bearing was started on the first post-operative day. Full weight bearing was encouraged and started after two weeks or earlier if the patient could tolerate. X-rays were taken post operatively on the first post-op day to assess the accuracy of fixator applied and then regularly at 2 weeks intervals in the regeneration phase and at monthly interval in the phase of consolidation to observe the quality of regeneration as well as union as per Fernandez Esteve grading.[15] The patients during their post-op stay in the hospital were trained on how to carry out bone segment transport/compression distraction activity on daily basis in increments. They were educated on signs of pin tract infection, physiotherapy of above and below joints, dressing of the wounds and care of pin tracts. In the follow-up visits quality of regenerated bone,

progress in range of motion exercises, signs of pin-tract infection and condition of soft tissue wounds were assessed.

Depending upon the location of non-union and extent of resection, the monofocal compression distraction technique was applied by keeping the Ilizarov fixator initially in compression mode for ten days. The non-union site after this interval was alternatively distracted and compressed, each for one week, at a rate of 1 mm per day (in two equal increments of 0.5 mm12 hourly).

In segment transport technique a sub periosteal osteotomy (Corticotomy) was performed at the time of application of Ilizarov ring fixator. Bone segment transport was started 7 to 10 days after the osteotomy. In most cases the free bone segment that was to be transported was fixed to single ring with two smooth wires and one half pin (Schanz screw). The transport was carried out at a speed of 1 mm per day (in two equal increments of 0.5 mm12 hourly).In cases where the regeneration of new bone was slow the transport of the bone segment was slowed down to 1mm per alternate day (in two equal increments of 0.5 mm12 hourly). After completion of transport to achieve full contact at docking site the docked ends were further compressed at a rate of 0.25 mm per day until the patient feels pain at the docking site. Bone grafting at docking, site was done after completion of bone segment transport where necessary. After completion of bone transport the Ilizarov fixator was kept in place for the duration equal to the time period taken by transport.[16] The Ilizarov frame was removed after union at docking site was confirmed by the appearance of trabeculae bridging at least three out of four cortices at non-union site on anteroposterior and lateral x-rays. No abnormal movements at the site of union, absence of pain on weight bearing and ability of the patient to walk independently without external support further confirmed bone union.[3, 4]In all cases the Ilizarov ring fixator was removed under short general anaesthesia. Pin tracts after wire removal were cleaned with normal saline and dressed properly with povidine iodine soaked gauzes.

Data was analyzed with SPSS (version 24). Frequency and percentages were calculated for important variables like age, gender and side. Data presented in tables where necessary.

RESULTS

In our study the total number of patients were 40. There were 37(92.5 %) males and 3(7.5 %) female patients. The mean age was 33.32± 9.4 years (range 3 to 60 years). Non-union of tibia was present in 30 cases (75%) and femur 10 cases (25%).Right side was involved in 32(80%) and left in 8(20%) patients. The initial trauma leading to fracture was motor vehicle accidents in 31(77.5 %) patients, gun shot in 8(20%) and bomb blast in 1 (2.5%) patient. Fractures were open in 22(55%) patients and closed in 18(45%) patients at the time of initial presentation. The initial treatment for these fractures before non-union was plating in 14(35%) cases, external fixation in 20(50%), inter locking nail in 2(5%), skeletal traction in 3(7.5%) and back-slab in 1(2.5%) case.

Bone segment transport technique was used 15(37.5%) cases and compression distraction technique in 25(62.5%) cases. The mean bone defect in cases where bone segment transport technique was used was 7.06 cm±2.2 (ranging from 4 cm to 12 cm). Overall the mean duration of treatment and healing was 9.95±3 months (range 6 months to 18 months). However the mean duration of treatment in bone transport cases was 10.33 ±4 months while in compression distraction cases it was 9.72±1 months. The causative organism for infection was Staphylococcus aureus in 22(55%), Pseudomonas aeruginosa in 6(15%), multiple bacteria in 6(15%) patients and no bacterial growth in 16(40%) patients.

We used ASAMI (Association for the Study and Application of the Method of Ilizarov) scoring criteria to assess the outcome in terms of bone union and functional results(Table I).[17] The bone results were excellent in 35(87.5 %) patients and good in 5 (12.5 %) while no fair or poor radiological result was noted. The functional results were excellent in 30(75 %) cases, good in 9(22.5 %) and fair in 1(2.5 %) case.

We documented our complications as per Paley classification into problems, obstacles and true complications.[18, 19] (Table II) According to Paley "Problems" are those that do not need any operative intervention, "Obstacles" need operative intervention and "True complications" are those that could not be resolved before the end of the treatment and will be considered minor if they do not interfere with the outcome of treatment.[18,1] In this study pin tract infection was recorded as the main problem encountered in 18(45%)patients, all of them were of grade IV or less as per Dahl's grading,[15, 20] treated effectively with regular dressings and antibiotics. The Obstacles recorded were breakage of wires in 2(5%) cases which were treated with wire replacement. Drifting of transport fragment in 1(2.5%) case was

treated with revision of one wire. Knee stiffness in 3(7.5%) cases were treated with manipulation under anesthesia. Equinus deformity at ankle in 1(2.5%) patient was treated with tendo-Achilles lengthening. Delayed consolidation at docking site in 5(12.5%) patients were treated with bone grafting. Persistent bony infection despite achievement of union was noted in 2(5%) cases and limb edema noted in 8(20%) cases throughout the treatment but did not affect the outcome and therefore both were recorded as minor true complications. No major true complication was recorded.

Table I: The Association for the Study and Application of the Method of Ilizarov (ASAMI) Scoring System.[17]

Bone Results	**Description**
Excellent	Union is achieved without infection and the deformity should be less than 7 degree and the discrepancy in length of limbs should be less than 2.5Cm
Good	Union is achieved with two of the following: Free of infection, deformity less than 7 degree ,Discrepancy in length of limbs is less than 2.5cm
Fair	Union is achieved with one of the following: Free of infection, deformity less than 7 degree ,Discrepancy in length of limbs is less than 2.5cm
Poor	No union / Refractured OR Union is achieved with infection plus deformity is more 7degree and the discrepancy in length of limbs is more than 2.5cm
Functional Results Description	
Excellent	Active without limping and with minimal stiffness(loss of less than 15° knee Extension or less than 15°dorsiflexion of ankle),without reflex sympathetic dystrophy
Good	Dystrophy, nonsignificant pain Active with either one or two of the following: Limping gait, joint stiffness, reflex sympathetic dystrophy, significant pain.
Fair	Active with three or all four of the following: Limping gait, joint stiffness, reflex sympathetic dystrophy, significant pain
Poor	Inactive(unable to perform routine daily activities)
Failure	Ended in Amputation

Table II: Complications of our study as per Paley classification.

Category as per Paley Classification	**Name of complication**	**Number of Patients**	**Percentage**
Problems	Pin tract infection	18	45%
Obstacles	Breakage of wires	2	5%
	Drifting of transport fragment	1	2.5%
	Knee stiffness	3	7.5%
	equinus deformity at ankle	1	2.5%
	Delayed consolidation	5	12.5%
True Complications(minor)	Persistent Bony infection	2	5%
	Limb oedema	8	20%
True Complications(major)	None	0	0%

DISCUSSION

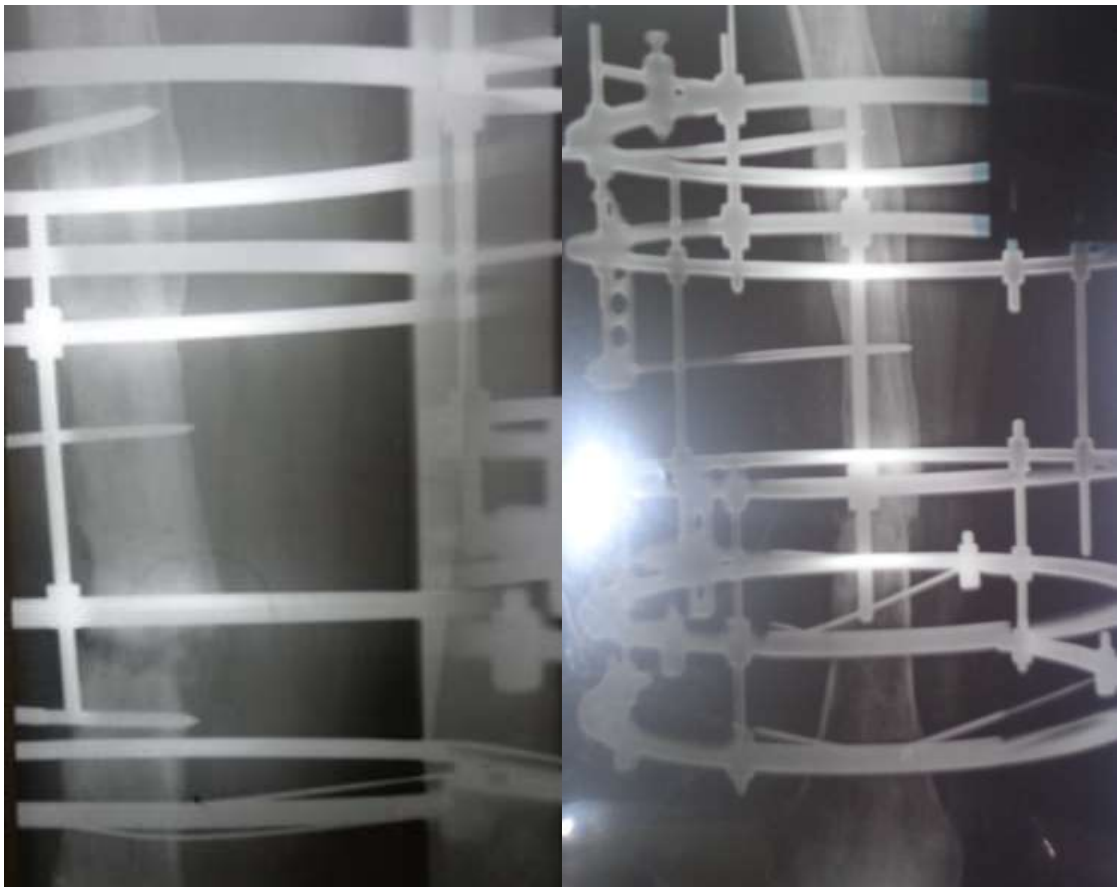
Ilizarov ring fixator has been used in three different ways to treat infected nonunion. These are "acute compression", "bifocal/monofocal compression distraction" and "bone segment transport".[1,16] Acute compression resulting in compression osteosynthesis is suitable for nonunion with no bone defect. However literature does not support the use of this technique alone for treatment of infected nonunion as this has been associated with high rate of recurrent infection and refractures .[1] Compression distraction is another technique in which Ilizarov ring fixator is used for treatment of infected nonunion. In this technique acute compression at site of nonunion is coupled with alternate and gradual distraction and compression at site of nonunion which is called "Monofocal compression distraction." Alternatively

acute compression at site of nonunion is coupled with gradual and controlled distraction at Corticotomy site in the metaphyseal bone away from nonunion site and it is called "Bifocal compression distraction."[1, 3, 16, 22] The upper limit of bone defect to be treated by compression distraction technique is 4-5 cm.[16] Acute compression (shortening) beyond this level results in soft tissue stacking and vascular compromise.[1, 16] The third technique in which Ilizarov is used in treatment of nonunion is "Bone segment transport". Literature revealed that bone segment transport can be used successfully in treatment of both large and small bone defects irrespective of the extent of bone defect.[16,23-25] In this technique corticotomy is performed in the metaphyseal portion of the bone which is followed by gradual distraction at this site after a latency period of 7-10 days.[1,9,16, 23-25] After completion of transport the docking site should be observed for union in serial x-rays at monthly intervals and if there is no evidence of union in three serial x-rays at monthly intervals then the docking site should be grafted.[4,15] The Ilizarov ring fixator should be kept in place after completion of segment transport for time period double of the time taken in the transport of bone segment.[16]

In our study we utilized two techniques: Monofocal compression distraction (Fig. IA-IF) and bone segment transport (Fig IIA-IIG) in the treatment of infected nonunion of long bones of the lower limb. In this study the youngest patient was a three years old child with infected nonunion tibia with bone defect of 5 cm treated with bone segment transport and excellent results were achieved both in terms of bone union and functional outcome. The oldest patient in this study was a sixty years old male with infected nonunion tibia treated with compression distraction technique and excellent results were achieved both in terms of bone union and functional outcome We have compared our study with some national and international studies on this topic in terms of technique, mean bone defect and outcomes (Table III). We found that our results are comparable to national and international studies.

Small sample size, unequal tibia and femur nonunion cases and absence of control group may be considered as limitations of our study.

Fig. IA IB



IC ID

IE **IF**

Fig. IA-IF: A 30 years old man with infected non union shaft of femur treated with monofocal compression-distraction with Illizarov ring fixator.



Fig. IIA IIB IIC




IID IIE IIF IIG

Fig. IIA-IIG: A 25 years old man with infected non-union tibia treated with bone segment transport.

Table III: Comparison of our results with national and international studies.

Author	Technique used	Number of Patients	Mean Bone defect in cm	Bone involved	Complications per Patient	Treatment Duration in months	Bone results as per ASAMI Score (% Excellent, Good, Fair, Poor)	Functional results as per ASAMI Score (% Excellent, Good, Fair, Poor, Failure)
Our study	**RD^{+}, AT^{++}, MCD^{+++},BT^{++++}**	**40**	**7.06 cm in BT cases**	**Tibia (30) Femur (10)**	**1.00**	**9.95**	**35(87.5%), 5(12.55), 0 (0%), 0(0%)**	**30(75%), 9(22.5%), 1(2.5%), 0(0%)**
Pande H[3] 2017	BCD^{+++++} BT	18	5.13	Tibia (15) Femur (3)	0.77	7.01	10(55.6%), 5(27.8%), 2(11%), 1(5.6%)	7(38.89%), 6(33.3%), 3(16.7%), 1(5.6%), 1(5.6%)
Yin P et al[4] 2015	BT	11O	6.15	Tibia (72) Femur (38)	1.127	-	68(61.82%), 28(25.45%), 12(10.91%), 2(1.82%)	37(37%), 42(42%), 21(21%), 0, 0
Khan MS [5] 2015	CD^{++++++} BT	24 (One lost in follow up due to death)	3.3	Tibia	0.478	8	6(26.09%). 14(60.87%), 1(4.34%),2(8.70%)	8(34.78%), 12(52.17%), 2(8.70%), 0(0%), 1(4.35%)
Xu K[21] 2014	BT	30		Tibia	0.27	10	28(93.33%), 2(6.67%), 0, 0	-
BakhshK [7] 2019	BT	56	4.3	Tibia	0.89	9.3	37(66.07%), 10(17.86%, 6(10.71%), 3(5.36%)	37(66.07%),9(16.07%), 7(12.5%),3(5.36%)

$^{+}$Radical debridement, $^{++}$Antibiotics treatment, $^{+++}$Monofocal compression distraction, $^{++++}$Bone transport, $^{+++++}$Bifocal compression distraction, $^{++++++}$compression distraction

CONCLUSION

The Ilizarov ring fixator produced excellent and good radiological and functional results in majority of our patients with infected nonunion of long bones of the lower limb. We therefore recommend that Ilizarov should be the first treatment modality to treat infected non unions of tibia and femur.It is the most suitable, practical and reliable treatment for infected nonunion of tibia and femur. This treatment modality simultaneously fills the bone defect, achieve union, eradicate infection and correct deformities in infected nonunion of tibia and femur. However to achieve best results it is very important to carry out radical debridement, resect all the necrotic and infected bone segment and correctly apply the Ilizarov ring fixator. It is also equally important to counsel the patient regarding prolonged treatment with Ilizarov ring, educate them about pin tract care, physiotherapy and daily distraction/compression mechanics in increments.

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