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Management of Infected Gap Nonunion of Shaft of Femur by Ilizarov Method

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Abstract

Background and objectives: Distraction osteogenesis is one of the discoveries of Ilizarov which can be used to fill the gap in long bones, control infection, stimulate osteogenesis and equalize the limb. A nonunion is said to have occurred once there is clinical and/or radiological evidence of cessation of fracture healing, usually after 6-8 months. A septic nonunion is defined as a nonunion complicated by local infection at the fracture site and in the surrounding tissues. The aim of this study was to evaluate the effectiveness of treating infected nonunion of femoral shaft by using Ilizarov method. **Methods:** in this prospective case series study, 13 patients with infected gap nonunion of femoral shaft were treated surgically with meticulous debridement and bone transport through application of Ilizarov ring fixator. **Results:** The mean age was 30.2 years. The mean length of bone loss was 6.1 centimeters. All patients achieved bony union with eradication of infection. The mean external fixation time was 5.9 months with a mean healing index of 1.1 month/cm. The bone and functional results were evaluated by using Association for the study and application of the methods of Ilizarov (ASAMI) scoring system. The bone results were excellent and good in 84.6%, fair in 15.4% and poor in 0%. The functional results were excellent and good in 77%, fair in 15.4%, poor in 7.7% and failure in 0%.

Conclusions: Treatment of infected gap nonunion of femoral shaft by Ilizarov method provides an excellent result if conducted properly with a good patient education, preparation, surgical techniques and patient follow up.

Keywords: Infected nonunion; Femur; Bone transport; Ilizarov.

Introduction

A nonunion is said to have occurred once there is clinical and/or radiological evidence of cessation of fracture healing, usually after 6-8 months. A septic nonunion is defined as a nonunion complicated by local infection at the fracture site and in the surrounding tissues[1]. Distraction osteogenesis is used not only for limb lengthening but also as a means of filling segmental defect in bone[2]. Bone transport is a useful operation described by Ilizarov. With the advent of bone transport, the surgeon can boldly resect the entire avascular bone & create a large defect. The procedure consists of corticotomy at one end of the long segment of the bone. The intercalary segment is transported; the gap is closed by two methods: gradual method and acute docking method[3]. Acute shortening of more than 4 cm can cause the development of tortuous vasculature & actually produce a low flow state with detrimental consequence. Open soft-tissue wounds when acutely compressed can become notably bunched and dysvascular, with the development of significant edema & the possibility of additional tissue necrosis and infection[4]. Ilizarov experimentally showed that when gradual distraction tension stress applied to the corticotomy site the vascularity of the entire limb is increased, which in turn enhances the ability of the bone ends to unite[5]. Because of difficulty in managing posttraumatic segmental bone defects and the resultant outcome, amputation historically was the preferred treatment[6]. For hypertrophic nonunions with minimal infection, and no sequestrated bone, Catagni recommended compression to increase formation of repair callus and vascularity. He reported that with this technique infection was spontaneously eliminated. Monofocal compression also is used for infected hypertrophic nonunions with deformity. For atrophic nonunions with diffuse infection or sequestrated bone, open resection of the infected segment is performed, and bifocal compression is used[7]. Ilizarov ring fixator is an excellent treatment modality for long bone nonunion with a defect, regarding bone union, deformity correction, infection eradication, limb length achievement and limb function but this needs prolonged learning curve for fresh orthopedic surgeons[8].

Patients and methods

In the current prospective study, 13 patients with infected nonunion of femoral shaft fracture were treated from June 2014 to May 2017. The inclusion criterion was nonunion of femoral shaft fracture complicated by chronic osteomyelitis with gap of the nonunion site of 3 cm or more. Exclusion criteria were metaphyseal, and intra-articular femoral fractures, patients with psychiatric disorders and pediatric age group. The study started after approval of Kurdistan board for medical specialization ethical committee. Written informed consent was obtained from each patient for contribution and publication of their clinical information, radiographs and photographs. The total number was 13 patients with 10 males and 3 females. Their mean±SD age was 30.2±6.3 years (ranged from 21 to 41 years). The initial mechanism of injury was motor vehicle accident in 10 cases and missile injury in 3 cases. They presented with multiple previous surgeries with a mean±SD of 4.2±1.3 surgeries (ranged from 3 to 7 surgeries). The mean±SD length of bone loss in centimeters

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was 6.1±2.9 (ranged from 3 to 12 cm). All patients had active infection with draining sinuses. Swabs were taken from their draining sinuses and sent for microbiological exam to find the causative microorganisms and their culture specific antibiotic(s). Meticulous primary debridement of the infected segments of bone was the most crucial step in eradicating infection and achieving union. The bone ends were excised until bleeding points were seen "paprika sign" (punctate bleeding upon drilling with a 2.5 mm drill bit) [9]. Sample from the debrided tissues was sent for microbiological exam. The Ilizarov frame was assembled preoperatively to decrease the operation and anesthesia time. Bone segments were stabilized by multiplaner wires of 1.5 mm diameter and Schanz screw of 4.5-5.0 mm diameters. The wires were fixed under tension (900 Newton) by special tensioning device. The corticotomy sites were made in the metaphyseal region either proximal or distal (monofocal) or both (bifocal) to the nonunion site according to the length of the gap. Whenever a gap was ≥10 cm a bifocal corticotomy was performed[10]. Fluoroscopy was used when wires were inserted in the periarticular region to avoid joint penetration and intra articular wire placement. Postoperatively a culture specific antibiotic was given to the patients. Postoperative analgesia was given according to severity of pain by using visual analogue score[11]. Patients were given Acetaminophen for mild pain 1gm 6 hourly and Tramadol 100 mg for severe pain, mostly at night. No NSAIDs (nonsteroidal anti-inflammatory drugs) were used for pain control because of their known inhibitory effects on fracture healing[12]. Among the cases, two of them were previously treated with conventional external fixator as shown in Figure 1.

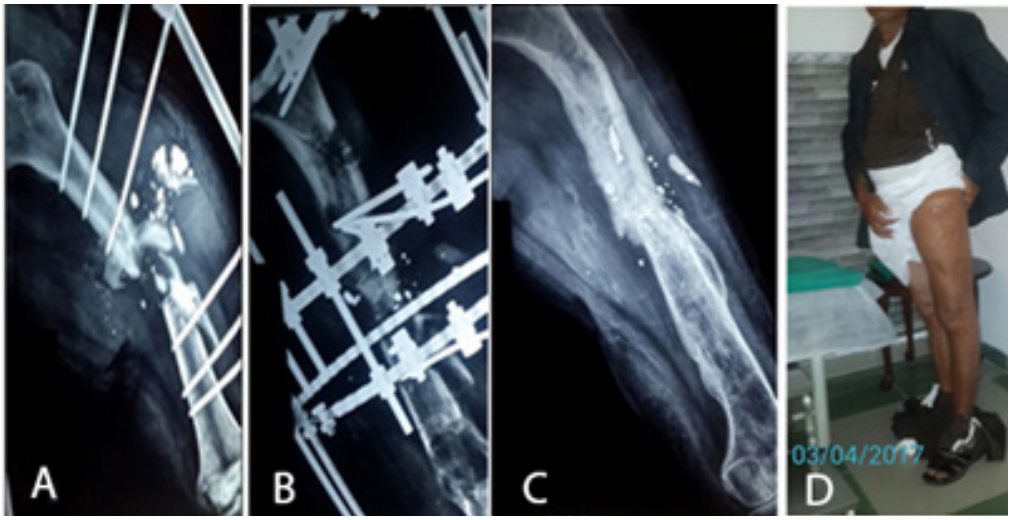

Figure (1): A. Radiograph of infected gap nonunion femoral shaft. B. Bifocal corticotomy sites and compressed docking site. C. Well corticalised distraction sites and united docking site. D. Corrected limb length

In theater under anesthesia the conventional external fixator was removed and debridement of the necrotic bone, tissue and sinuses was performed utilizing the previous incisions then the Ilizarov frame was applied to fix the bone segments. Two corticotomies were performed; one proximal and one distal to the gap. Three of the cases presented with infected nonunions that were treated previously with interlocking nails with their implants in place. The distal screws were removed so as to change the intramedullary nail from a static to a dynamic construct giving room to distraction and compression of bone segments. Wound excision, Ilizarov frame application and supracondylar femoral corticotomy was done. In this group the distraction was done over the interlocking nail and the nail was retained until removal of the frame. The remaining cases presented with fractures that were fixed previously by plates and screws. The plates and screws were removed, wound debridement was done and the Ilizarov frame was applied combined with a supracondylar corticotomy. In all of the cases five days after application of the frames distraction was started by a rate of 1 mm/day in 4 divided increments for the corticotomy sites. All patients were followed up twice monthly with clinical and radiographic examinations during the distraction phase. During the consolidation phase the patients were followed up monthly with clinical and radiological examination. Through all the treatment time the patients were directed to perform supervised physical therapy to avoid joint contractures and muscle weakness. They were taught pin track care and frequent examination of the pin tracks was performed. Any sign of pin track infection (redness, pain and discharge) was dealt with properly by tacking swabs for microbiological examination and guided antibiotic therapy. If the pin track infections were resistant to local care and antibiotic therapy, pin site change under general or spinal anesthesia was considered. When the patients achieved clinical and radiographic signs of union of docking site and consolidation of the distraction site(s) the frame was removed. The difficulties during and after treatment were classified into problems, obstacles and complications as illustrated in Table 1 according to D. Paley's original paper[13]. Bone and functional results were evaluated by using Association for the study and application of the methods of Ilizarov (ASAMI) scoring system as shown in Table 2[14,15].

Table (1): D. Paley's classification system for evaluation of complications encountered during Ilizarov method for limb reconstruction.

Problem	Difficulty in the course of distraction or in the period of consolidation which is fully resolved by the end of the treatment period by non-operative means
Obstacle	Difficulty which arises in the course of distraction or in the period of consolidation that is fully resolved by the end of the treatment period by operative means.
True complication	Difficulty that occurs during distraction or in a period of consolidation, and remains unresolved till the end of the treatment, or remains unresolved after the treatment is completed
• Minor complication	Complications do not prevent the achievement of the goal and can be resolved non-operatively.
• Major complication	Major complications require a surgical treatment.
• Permanent complication	Complications cannot be solved, frequently prevent the achievement of the goal, and they are the leading reason for the failure of treatment.

Table (2): Association for the study and application of the methods of Ilizarov (ASAMI) scoring system.
Bone results

Bone results	
Excellent	Union, no infection, deformity < 7°, limb length discrepancy < 2.5 cm
Good	Union+ any two of the followings No infection ,deformity < 7 °, limb length discrepancy < 2.5 cm
Fair	Union + only one of the following No infection, deformity < 7°, limb length discrepancy <2.5 cm
Poor	Nonunion / refracture / union + infection + deformity >7 ° + limb length discrepancy > 2.5 cm
Functional results	
Excellent	Active, no limp, minimum stiffness (loss of < 15 ° knee extension < 15° dorsiflexion of ankle), no Reflex Sympathetic Dystrophy(R.S.D.), Insignificant pain
Good	Active with one or two of the followings ; Limp, stiffness, R.S.D, insignificant pain.
Fair	Active with three or all of the followings ; Limp, stiffness, R.S.D., significant pain
Poor	Inactive (unemployment or inability to return to daily activities because of injury)
Failure	Amputation

Results

All patients achieved bony union with a mean±SD time of 5.9±2.2 months. The mean±SD length of transported bone was 6.1±2.9 centimeter. The mean±SD external fixator index (healing index) was 1.1 ± 0.2 month/centimeter as shown in Table 3. Bone and functional results were evaluated by using Association for the study and application of the methods of Ilizarov (ASAMI) scoring system as shown in Table 2. The bone results were excellent and good in 84.6%, fair in 15.4% and poor in 0% as illustrated in table 4. There was a statistically very highly significant relationship between the age of the patients and bone results (P-value of <0.001), and a very highly significant relationship between external fixation time (month) and bone results (P-value of <0.001). Moreover, the functional results were excellent and good in 77%, fair in 15.4%, poor in 7.7% and failure (amputation) in 0% as shown in Table 5. There was a statistically very highly significant relationship between external fixation time (month) and functional results (P-value of <0.001). The difficulties during and after treatment were classified into problems, obstacles and complications as illustrated in Table 1 according to D. Paley's original paper. Among the 13 patients, 7 of them developed pin track infection, 5 of them were regarded as problem and were treated with local pin track care and oral antibiotics. The other 2 were classified into obstacles and were managed by changing the pin site under anesthesia. Three patients developed knee stiffness; one of them was treated with physiotherapy and it was regarded as problem, the other was treated with manipulation under anesthesia and it was regarded as obstacle and the 3rd patient was treated by surgery (quadricepsplasty) after removal of the frame so his condition was classified under true complication. One patient developed ankle stiffness that was treated with physiotherapy and regarded as problem as shown in Table 6.

Table (3): Length of transported bone segment, external fixation time and Healing (External fixation) index.

Patient Number	Bone transport in centimeters	External fixator time in months	Healing index (External fixation index) (External fixator time in months/bone transport in centimeters)
1	11	10	0.9
2	3	4	1.3
3	4	4	1
4	4	4	1
5	5	6	1.2
6	10	10	1
7	8	8	1
8	4	4	1
9	4	5	1.3
10	5	5	1
11	6	5	0.8
12	6	7	1.2
13	3	4	1.3
Mean ± SD	5.6 ± 2.6	5.9 ± 2.2	1.1 ± 0.2

Table (4): Bone results according to ASAMI scoring system

Bone results	patients	Percentage
Excellent	3	23.1 %
Good	8	61.5%
Fair	2	15.4%
Poor	0	0%

Table (5): Functional results according to ASAMI scoring system

Functional results	patients	Percentage
Excellent	4	30.8%
Good	6	46.2%
Fair	2	15.4%
Poor	1	7.7%
Failure	0	0%

Table (6): Problems, obstacles and true complications according to D. Paley with their treatments

Complications	Type of complications	Number of patients	Treatment method
Problem(s)	PTI*	5	Oral antibiotic and proper hygiene
	Knee stiffness	1	Physiotherapy
	Ankle stiffness	1	Physiotherapy
Obstacle(s)	PTI*	2	Change of Schanz pin
	Knee stiffness	1	Manipulation under anesthesia
True complication(s)	Knee stiffness	1	Quadricepsplasty

Discussion

Infected nonunion of long bone fracture imposes a difficult challenge to the orthopedic surgeon throughout the world even in the era of advanced surgical instruments, techniques and antibiotic therapy[16]. The late presentation, infection, gap at the fracture site, joint contractures, disuse osteoporosis, soft tissue problems and deformities of the limb make the management more difficult[17]. The bone transport technique relies on the biological property of bone to regenerate when it is subjected to tension/compression stresses. The Ilizarov frame provides a stable elastic construct that allows controlled distraction through a low energy corticotomy site that will be followed by intramembranous ossification of the distraction site. The hypervascular status of the distracted segment produced by the biological stimulus of the corticotomy will help in eradication of the infection as well as union of the docking site eliminating the needs for bone graft in most of the cases[18]. This prospective case series study was performed to delineate the efficacy of bone transport technique in managing fracture femoral shafts complicated by infected nonunion with gap at the fracture site. In this study 13 patients were enrolled with a mean age of 30.2 years (ranged from 21 to 41 years); a mean bone defect of 6.1 cm (ranged from 3 to 12 cm). All of the patients achieved radiological and clinical union with eradication of the infection proved clinically, radiologically and by laboratory results with an external fixator time mean of 5.9 months and a healing index of 1.1 months/cm. In order to further evaluate the results of this study to outline a standardized clinical treatment protocol the author compared the results of this study with other international results. Peng Yin and Lihai Zhang with their associates conducted a retrospective study of literatures from the PubMed, Cochrane Library, EMBASE, and other relevant English orthopedic journals between January 1995 and April 2013. The literature search recognized 337 data records of long bone transport, and finally 22 studies and a sum of 426 patients were included in the systematic review. They calculated the following data: The mean±SD age was 33.8±4.7 years; the mean±SD bone defects was 6.5±1.9 cm; the bone union rate was 96.9%; the mean±SD external fixation (healing) index was 1.6±0.6 month/cm; the good and excellent rate in bone results was 87.4%; the good and excellent rate in functional results was 74.2%; the average of poor rate in functional results was 7.9%; and the average of amputation rate was 4.9%[19]. In the current study, the results were close to the afro mentioned results of Peng Yin and Lihai retrospective study as the mean bone defect was 6.1±2.9 cm; the bone union rate was 100%; the mean±SD external fixation (healing) index was 1.1±0.2 months/cm; the good and excellent bone results were 84.6%; the good and excellent

functional results were 77% and the amputation rate was 0%. The higher rate of union and lower rate of amputation of the present study when compared to Yin and Lihai study was thought to be due to the low number of patients (13 patients) in the current study when compared to their retrospective systematic review (426 patients). The bone results are usually higher than the functional results because the criteria of functional results depend mainly on the soft tissue condition of the limb. The resultant scars, muscle damage and fibrosis of previous multiple surgeries and chronic infection will affect the functional abilities of the limb. The bone and functional results were significantly affected by the age of the patient and the external fiaxtor time with significant P-values Ś0.001. This could be related to the biological potential of healing and rehabilitation in young patients when they are subjected to limb reconstruction procedures using Ilizarov method, type of the bone (femur), site and number of corticotomies (metaphyseal versus diaphyseal) as all have shown to have positive impact on fracture healing and limb rehabilitation[20]. In femur shaft whenever bone transport is performed, there is a chance of axial mal alignment at the docking site, to prevent this Boutsiadis A, Iosifidou E and their associates described a technique of distraction over an intramedullary nail21. Limb reconstruction and deformity correction using Ilizarov method needs a good patient education and compliance by both the patient and the family because the patient will take a great deal of contribution in the treatment by performing daily distraction of the Ilizarov apparatus and complying with the physiotherapy program. This was the reason behind exclusion of patients with psychiatric problems and mental disabilities. The limitation of this study is the low number of the patients.

Conclusions

Ilizarov method provides an excellent method for treating infected gap nonunion shaft of femur if conducted properly with a good patient education, preparation, surgical techniques and follow up. It can achieve eradication of infection, stimulation of osteogenesis, correct any associated deformity, equalize limb length and good functional results.

Conflict of interest: None

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