Functional and radiological evaluation of treatment of infected nonunited fracture shaft femur using Ilizarov external fixator

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Received 01 January 2013
Accepted 22 February 2013

Egyptian Orthopedic Journal 2015, 50:139–143

Background
The treatment of infected nonunion of long bones has always been a challenge for orthopedic surgeons. Treatment goals were eradication of infection and bony union. During distraction osteogenesis, physiological bone loading and mobilization are very important.

Aim
This study aimed at evaluating the functional and radiological outcome of using Ilizarov external fixator in treating patients with infected nonunited fracture femoral shaft.

Patients and methods
Fifteen patients with infected nonunion of the shaft of the femur were included in the study between 2007 and 2009. The mean age of the patients was 39.5 years (range 19–68 years). The follow-up period lasted for 14–36 months with a mean of 25.7 months. Bone and functional results were measured and complications were categorized according to the Association for the Study and Application of the Method of Ilizarov guidelines.

Results
The infection was eradicated in 12 patients before the fixator removal. Excellent radiological bone healing was found in 12 patients, and excellent functional result in eight out of 15 patients. There were a total of 20 complications in 15 patients.

Conclusion
Ilizarov external fixator is an effective method for the treatment of infected nonunited fracture shaft femur with acceptable radiological and functional outcome and low serious complications.

Keywords:
femoral shaft fracture, Ilizarov external fixator, infected nonunion

Egypt Orthop J 50:139–143

1110-1148

Introduction

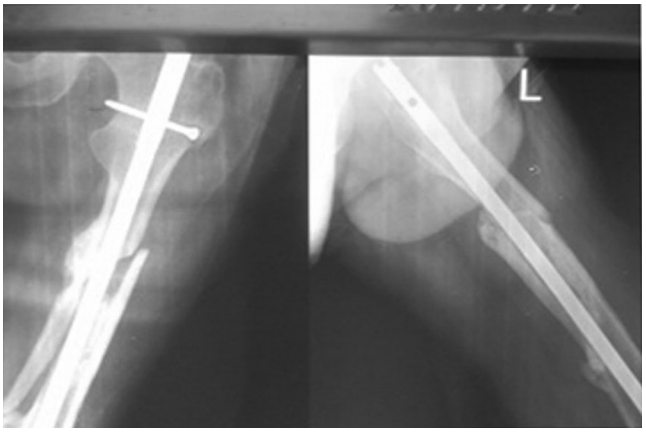
The increasing incidence of high-velocity trauma with massive bone, soft tissues damage, and treatment of infected nonunion of long bones has always been a challenge for orthopedic surgeons [1].

Classic methods for treating infected nonunion of the long bones include wound drainage, debridement of infected soft tissue, sequestrectomy of dead bone, bone graft, and external fixation. Limitations of these methods include persistent bone and soft tissue infections, bone defects, deformities, and refracture [2]. The Ilizarov technique for infected nonunion consists of removal of infected tissues and bone, stabilization with ring fixators, distraction osteogenesis, compression at the nonunion site, and correction of the deformity. Advantages of this method include control of infection in the presence of osteogenesis, minimal interference with normal local healing process due to the structure of apparatus, stability for weight bearing, and early patient mobilization [3]. This study was conducted to evaluate the functional and radiological outcome of using Ilizarov external fixator in treating patients with infected nonunited fracture femoral shaft.

Patients and methods

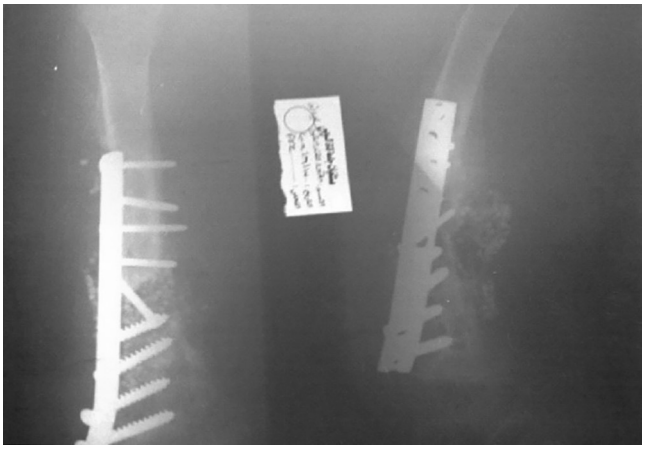
Between 2007 and 2009 15 patients having infected nonunion of the shaft of the femur were treated using the Ilizarov method. All the included patients were males. The mean age of the patients was 39.5 years (range 19–68 years). The causes of injury were motor vehicle accident in 10 patients (66%), motor cycle accident in three patients (20%), a fall from height in one patient (7%), and gunshot in one (7%). Eleven patients (73%) had open fractures and four patients (27%) had closed fractures. All 15 patients had received prior conventional treatments. Seven patients (46%) had tubular external fixators, four patients (27%) had interlocking nail fixation (Fig. 1), and four patients (27%) had plate and screws fixation (Fig. 2). In the presentation, 11 patients (73%) had nonunion with active infection with discharge and four (27%) had no signs of active infections. The follow-up

Figure 1



Preoperative radiograph of case no. 7.

Figure 2



Preoperative radiograph of case no. 15.

period lasted for 14–36 months with a mean of 25.7 months (Table 1). The bone defects after debridement ranged from 2 to 7 cm with a mean of 3 cm. This study approved by the Ethical committee of Suez Canal University, Ismailia, Egypt.

Radiological and functional results were evaluated and complications were categorized according to the Association for the Study and Application of the Method of Ilizarov guidelines (ASAMI) [4,5].

All patients returned for routine, clinical, and radiological follow-up every month after operation until the Ilizarov device was removed, and every 4 months in the following year. Postoperative radiographs were evaluated for residual malalignment and evidence of union. Radiological union was defined as the absence of a radiolucent line at the site of the nonunion and filling of the bone defect with new bone at a minimum of three cortices on standard anteroposterior and lateral radiographs. Bone healing was evaluated on the basis of union, infection, deformity, and limb length discrepancy and classified as excellent, good, fair, and poor.

The functional results were classified as excellent, good, fair, and poor and evaluated according to five criteria including return to activity:

(a) Observable limping,
(b) Stiffness of knee or hip (loss of >70° of knee flexion, or loss of >15 of extension; loss of >50% hip motion in comparison with the normal contra lateral side),
(c) Soft tissue sympathetic dystrophy,
(d) Pain that reduced activity or disturbed sleep, and
(e) Inactivity (because of unemployment or an inability to return to daily activities due to the injury).

Table 1 Age, cause of injury, type of fracture, prior treatment and follow-up period of the 15 patients included in this study

Patient number	Age	Cause of injury	Type of fracture	Prior treatment	Follow-up period
1	19	MVA	Open	P&S	14 months
2	32	MCA	Open	TEF	17
3	40	MVA	Open	TEF	36
4	21	MCA	Open	P&S	20
5	20	FH	Closed	IN	18
6	50	MVA	Open	TEF	20
7	50	MVA	Closed	IN	28
8	57	MVA	Closed	IN	36
9	30	MCA	Open	TEF	19
10	25	GS	Open	IN	25
11	69	MVA	Closed	P&S	29
12	64	MVA	Open	TEF	30
13	35	MVA	Open	TEF	35
14	40	MVA	Open	TEF	28
15	40	MVA	Open	P&S	30

FH, fall from height; GS, gun shut; IN, interlocking nail; MCA, motor cycle accident; MVA, motor vehicle accident; P&S, plate and screws; TEF, tubular external fixator.

Significant pain, limping, loss of range of motion of adjacent joints, and reflex sympathetic dystrophy.

Surgical procedures

The infected areas were exposed by an extensive lateral approach through the less damaged soft tissues to apply radical debridement involving resection of nonviable bone ends before application of the frame, and removal of all loose implants, all infected and nonviable tissue. In intraoperative cultures, sensitivity was sent and antibiotics were administered accordingly. The bone ends were freshened, the medullary canal reconstituted and open reduction of the main fragments was performed to achieve the best possible contact. To prevent angulation, in cases with femoral infected nonunion, we first used intramedullary femoral

nailing and then applied Ilizarov external fixator and compression distraction was performed along the femoral nail. Frames were assembled preoperatively for all patients and modified intraoperatively if required. In patients with active infection the site of nonunion was exposed and devitalized tissues including unhealthy bone ends were removed. Sclerotic bone ends were excised and the medullary canal was reopened. Cortical bleeding was used to determine the completeness of bone debridement. The average lengths of bone defects after debridement were 3 cm (2–7 cm).

The preassembled sterilized Ilizarov frame was then applied. Rings were fixed to the bone, distally first, then to the middle and proximal sections to maintain the mechanical axis of the femur by keeping the rings parallel to the tibial articular surface of the knee joint (Fig. 3).

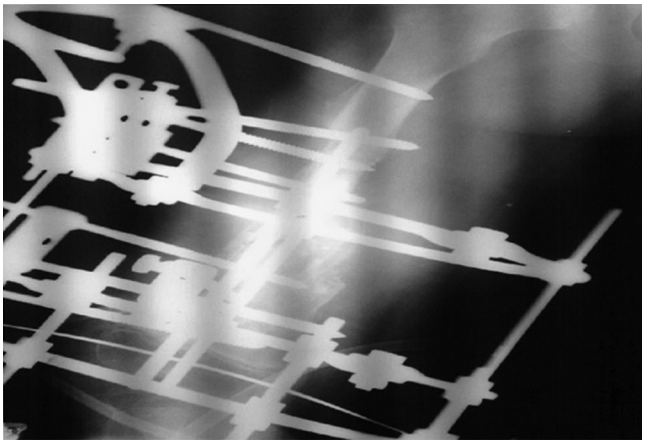
The frames were applied with a varying number of rings, depending upon the size of the limb, site of lesion, and size of bone fragments. Full rings of the middle and distal constructs were reinforced with tensioned 1.8-mm olive wires through the rings. Corticotomy was performed in all cases at the same time as frame application. An intercalary segment of bone, created by corticotomy of either the proximal or distal part of the femoral bone, was stabilized using either wires or a combination of wires and Schanz pins and gradually transported in 10–15 days after the radiographic early evidence of union (Fig. 4).

In osteoporotic bone Schanz pins were applied for additional stability. Compression was planned as follows: in cases with hypertrophic nonunion, 1.0 mm compression per day divided four times (0.25 mm) a day, and in cases with atrophic nonunion, intermittent compression, and distraction on 3-day sessions, 0.25 mm four times a day [6].

Results

The clinical, radiological, functional results, and complications of these patients were evaluated according to the ASAMI (Table 2).

Figure 3



Postoperative radiograph.

Figure 4

Postoperative radiograph.

Table 2 Bone, functional evaluation and guidelines items according to Association for the Study and Application of the Method of Ilizarov guidelines

Bone evaluation	Guidelines items	Patients number [*n* (%)]	Functional evaluation	Guidelines items	Patients number [*n* (%)]
Excellent	Eradication of the infection, bone union, deformities <7°, and limb length discrepancy <2.5 cm	12 (80)	Excellent	Active, no limp, minimal knee stiffness (loss of <15° knee extension), no RDS, and significant pain	8 (53)
Good	Bone union+any two of the following items eradication of infection, <7° deformity LLD <2.5 cm	0 (0)	Good	Active, no limp, pain significant, no RDS and 20° loss of knee extension	4 (23)
Fair	Bone union, persistence of infection, less than 7° deformities and more than 2.5 cm limb length discrepancies	3 (20)	Fair	Active, limping, knee stiffness, RSD and significant pain	3 (20)
Poor	Bone nonunion + infection + deformity >7° + LLD >2.5 cm	0 (0)	Poor	Inactive and unable to return to daily activities	0 (0)

RDS, reflex sympathetic dystrophy; LLD, limb length discrepancy.

Bone healing evaluation

At the latest follow-up evaluation 12 patients (80%) had eradication of the infection, bone union, deformities less than 7°, and limb length discrepancy less than 2.5 cm. This group of patients was rated excellent on ASAMI guidelines. The remaining three patients (20%) were rated fair on ASAMI guidelines. This group of patients had bone union, persistence of infection, less than 7° deformities, and more than 2.5 cm limb length discrepancies (Figs. 5 and 6).

Function evaluation

At the latest follow-up evaluation eight patients out of the 15 patients (53%) involved in this study were active, had no limp, had minimal knee stiffness (loss of <15° knee extension), had no reflex sympathetic dystrophy, and had no significant pain. This group of patients was categorized as excellent in ASAMI guidelines. A group of four patients (27%) was categorized to have good function in ASAMI guidelines. These four patients were active, had no limp, no pain significant, no reflex sympathetic dystrophy, and had 20° loss of knee extension. The remaining three patients (20%) were active and had limping, knee stiffness, reflex sympathetic dystrophy, and significant pain. The last group of patients was categorized as fair in ASAMI guidelines.

Complications

A total of 20 complications occurred in 15 patients. There were no neurovascular intraoperative complications and no patient developed a neurovascular deficit or a compartment syndrome.

The most common complication was pin-track infection especially in the distal segment as a result of severe osteopenia and poor soft-tissue. Pin track infection occurred in 11 patients. Eight of them responded well to local care and in two patients the wires had to be removed and replaced under local anesthesia. Significant pain requiring analgesia was felt in four patients during the distraction phase. Three patients had limping and knee stiffness. One patient had inequality of greater than 2 cm and femoral bowing of 20°. One patient had femoral refracture which occurred two months after removal of the external fixator, which was treated by reapplication of the Ilizarov frame for 3 months.

Discussion

Infected nonunion is one of the complications of fracture shaft of the femur that makes conventional management methods ineffective and requires several operations and long term treatment. The results of conventional treatment are poor and due to high velocity primary trauma, multiple surgeries, late presentation, bone and soft tissue infection, nonunion, bone loss, osteoporosis, dystrophy, poor vascularity, associated deformities, and shortening [7].

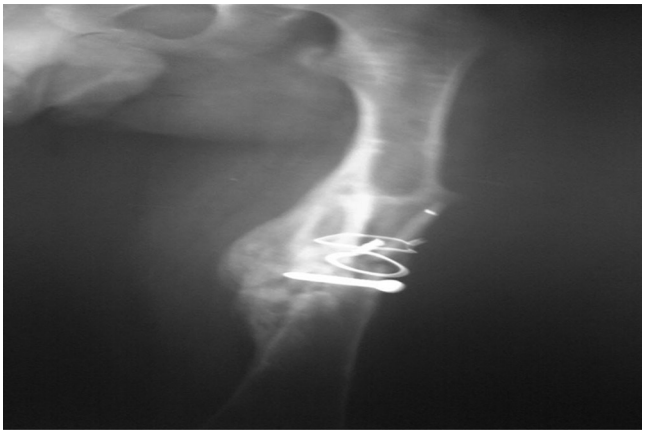
In this study, the treatment goals of patients diagnosed with infected nonunion of the femoral shaft were eradication of infection and bony union.

Biologic methods of treatment like Ilizarov that increases the injured site circulation and osteogenesis are the preferred methods of treatment in these injuries. The primary objective of the Ilizarov technique was to eliminate infection by increasing vascularity of the centre of the infected bone through biological stimulation of a corticotomy. Mechanically, the Ilizarov frame construct is very resistant to torsion and bending but allows axial compression during physiological

Figure 5

Photography of a patient's thigh before removal of the apparatus.

Figure 6



Radiograph after removal of the apparatus.

loading. In all, 80 and 53% of patients had excellent bone and functional results, respectively. The bones results were always better than the functional results, which were keeping with other studies. The functional results depend primarily on the existing damage of nerves, muscles, vessels, joints, and, to a lesser extent, bones. Patients presented had multiple previous surgeries with major damage to vessels, nerves, muscles, joints, and bone, and already had developed a variable amount of joint stiffness.

In this study 12 (80%) and eight (53%) patients had excellent bone and functional results, respectively, three patients (20%) had fair bone results, and four patients (27%) had good function. Three patients (20%) had fair function. A total of 20 complications occurred. Complications are intrinsic to the Ilizarov technique but their frequency and severity decrease with experience.

The results of this study are keeping with the following studies: Manish and colleagues reported on 25 patients. The results were as follows: bone results were excellent in 13, good in one, and poor in 11 patients. Functional results were excellent in six patients, good in nine, fair in four, and poor in six patients. A total of 72 complications occurred (2.88 complications per patient). Union was achieved in all except two patients [8].

Saridia and colleagues reported on 13 patients and reported bone union and elimination of infection in all 13 patients. On the other hand, functional results were as follows: eight patients had excellent, four patients had good and one patient had fair functional results [9]. Urazgildeev and Roskidailo [10] have recently published the results on 30 patients with infected nonunion of the femur with infection eradication rate of 95.9%.

Menon and colleagues in a study with similar results to this study concluded that there was a role for the use of the Ilizarov fixator in resistant long bone diaphyseal nonunion treatment. These studies exemplify the applicability of Ilizarov method in treatment of infected nonunions [11].

Conclusion

Ilizarov technique is a good salvage operation for infected nonunion of the femur. The bone results are usually superior to the functional results. Functional results can be improved by the early use of the Ilizarov technique.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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