Management of post-traumatic extra-articular proximal tibial nonunion by Ilizarov external fixation

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Background
The Ilizarov technique has been used in Egypt for the past 20 years in the management of nonunion of long bones. This method uses fine wires and pins inserted percutaneously, which are attached to provide a strong frame construct. Most tibial and femoral nonunions can be treated successfully by internal fixation. However, proximal tibial nonunion can prove a difficult problem. The Ilizarov method can prove useful for treating these complex injuries.
Objective
The aim was to evaluate and analyze the clinical and radiological outcomes of Ilizarov external fixation in treatment of proximal tibial nonunion prospectively while focusing on its effectiveness, advantages and complication.
Patients and methods
A total of 16 patients (11 male and five female; average age: 33.5 years) who had post-traumatic extra-articular proximal tibial nonunion between April 2010 and October 2011 treated with the Ilizarov technique were included. Intervention method was Ilizarov technique, and main outcome measures include functional and radiological outcomes assessed using the Association for the Study and Application of Methods of Ilizarov criteria.
Results
All 16 patients showed union. None required amputation. According to the Association for the Study and Application of Methods of Ilizarov score regarding bone/radiological results, eleven were classed as excellent, four were good and one patient was fair. Functionally 10 patients were graded as excellent, five as good and one as fair.
Conclusion
The Ilizarov method is a reliable tool allowing early definitive treatment with a low complication rate and a good clinical outcome in treatment of patients with proximal tibial nonunion.

Keywords:
external fixator, Ilizarov, nonunion, proximal tibia

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Introduction

Nonunion of the proximal tibia is a relatively rare clinical entity [1]. The several clinical series that exist in the literature concerning both extra-articular proximal tibia fractures and tibial plateau fractures mostly document nonunion rates less than 3% [2]. As a baseline reference, the nonunion rate was 2.7%, with the majority of fractures healing with 'acceptable' amounts of displacement (20%), shortening (3.5 mm), and angular displacement (<6° in almost 90% of patients) [1–3]. The large bed of cancellous bone in the proximal tibia has a large volume of metabolically active trabecular bone which militates against the development of nonunion [4]. In addition, the proximal tibia has a rich vascular supply from the anterior tibial artery as well as the popliteal artery as demonstrated by Borrelli *et al.* [5]. Many factors can contribute to the development of a nonunion in the proximal tibia. Some factors, such as the soft tissue injury and the extent of bone loss, are dictated by the circumstances at the initial injury. Other factors, such as adequate reduction with apposition of bony surfaces and biomechanical stability of the chosen implant, are surgeon controlled [1,2,4,6,7]. As rare as proximal tibial nonunions are, when they do occur, they present a challenge to the treating surgeon. Incisions, scar tissue, and soft tissue/bony devitalization create an unfavorable environment for further surgery [6,8,9]. In addition, the proximal fragment is often short and compromised by previous hardware tracks, limiting options for revision fixation with good bone purchase [3,7,9]. The importance of preoperative planning, careful soft tissue handling and minimal bone devitalization is

Table 1 Patient's data

Case number	Age	Sex	Site	Number of previous operation	Presence of infection	Limb shortening	Time in frame (weeks)	Follow-up (months)
1	28	Male	Right	3	Septic	–	20	36
2	26	Male	Right	3	Aseptic	3 cm	24	34
3	38	Male	Left	4	Aseptic	3 cm	22	36
4	33	Female	Right	1	Aseptic	–	18	28
5	25	Male	Left	3	Septic	2 cm	20	30
6	29	Female	Right	5	Septic	3 cm	28	28
7	29	Male	Left	2	Aseptic	–	16	32
8	42	Female	Right	4	Septic	–	19	33
9	34	Female	Left	3	Aseptic	–	16	36
10	22	Male	Right	2	Aseptic	3 cm	25	24
11	50	Male	Left	2	Aseptic	2 cm	22	24
12	28	Male	Right	1	Aseptic	–	20	26
13	34	Female	Left	3	Aseptic	2 cm	24	20
14	56	Male	Left	6	Septic	3 cm	28	18
15	27	Male	Right	2	Aseptic	–	20	24
16	35	Male	Right	4	Septic	2 cm	22	19

most important in these injuries where the soft tissue envelope is already tenuous and compromised by the initial injury or previous surgical procedures [9–12]. Minimally invasive techniques with ring fixators have been introduced as an alternative allowing immediate reduction and stabilization, avoiding deep infection [12]. With the Ilizarov technique, it is always possible to treat the patients with an immediate one-stage procedure [10,12], as reduction is less invasive, with minimal soft tissue exposure and blood loss. This circular fixation is versatile and allows good repeated debridement of the wound [12–14]. If needed, this fixator also allows for adjustment of the alignment and for compression/distraction both during and after surgery [7,8,11,12]. An additional advantage is that the fixation is stable enough to allow early weight bearing [12,13,15].

Patients and methods

From April 2010 to October 2011, 16 patients who had nonunited extra-articular proximal tibial fractures had been treated with Ilizarov external fixation. Eleven (68.75%) of them were males and five (31.25%) were females. Their mean age was 33.5 years (range: 22–56 years). Nine legs were right (56.25%) and seven legs were left (43.75%). The number of previous operations varied from 1 to 6, with the mean of three operations. There were eight (50%) fractures treated initially by plating, three (18.75%) by external fixation, three (18.75%) by plaster cast and two (12.5%) by intramedullary nailing. According to the presence of infection at the time of work, 10 (62.5%) patients had no infection at site of nonunion and six (37.5%) patients did so. According to shortening of the affected limb, seven (43.75%) patients had equal length of their limbs and nine (56.25%) patients had shortening of the affected limb, where five of them (31.25%) had 3-cm shortening and four (25%) patients had 2-cm shortening (Table 1).

Surgical procedure

Preoperative planning was done for all patients both clinically and radiologically. Ilizarov frame was prepared preoperatively which consist of three complete rings, one to be inserted proximal to the fracture and two distal to the fracture with the choosing of appropriate-size half-rings. Same-sized rings were used as they were easier during connection. All patients were treated with combined partial fibulectomy (1–1.5 cm) and an Ilizarov frame without the use of any bone grafts. The osteotomy was made at the junction between upper two-thirds and distal one-third levels. At least 2-cm clearance between leg and each ring is necessary to accommodate swelling. Proximal ring was the reference one. The three rings were connected with four threaded rods. The operations were performed without a tourniquet and without any traction table. Spinal anesthesia was done for all patients, and then removal of implants of previous operations was done. Debridement was done for all infected cases before application of the frame. Refreshment of both bone edges was done. The knee joint was used as a reference joint for the first reference wire. After fixation of the frame to the wire, hybrid fixation of the leg in the form of wires and pins screws in the frame was done. The proximal fragment was fixed first, and reduction of the fracture was done directly and indirectly by the frame clinically and

Figure 1

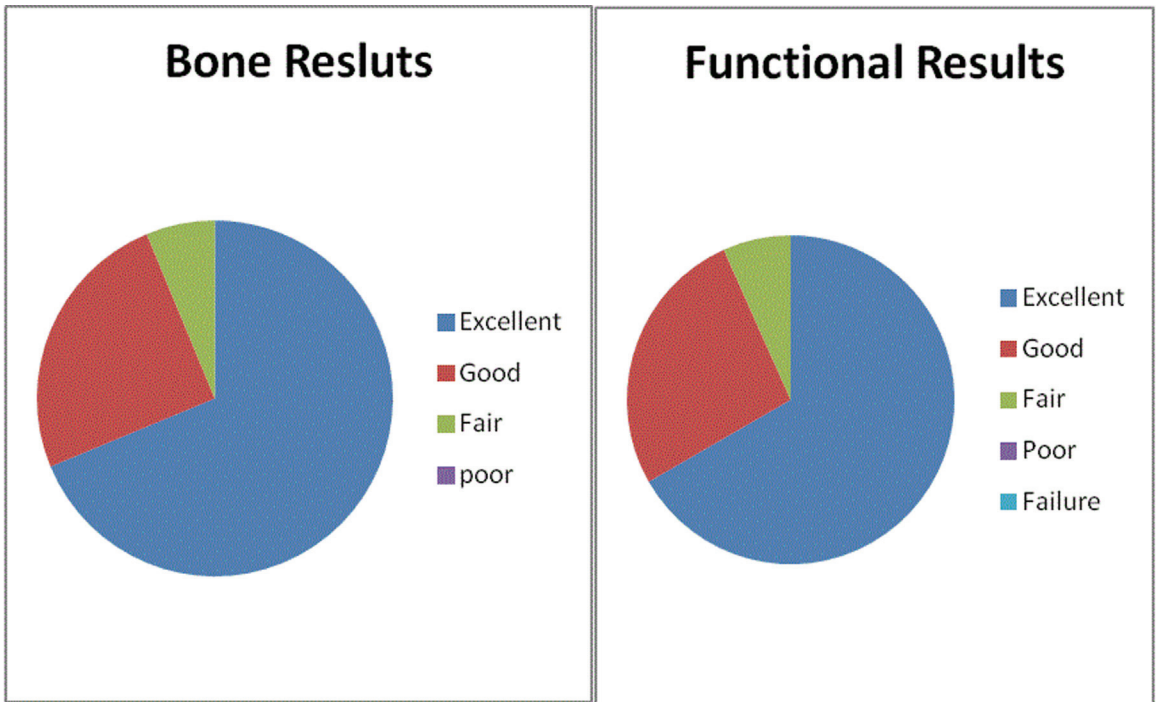

Diagram shows the results according to Association for the Study and Application of Methods of Ilizarov scoring system.

radiologically and then distal fragment was fixed lastly. Adjustment of the frame was done to obtain acceptable reduction of the fracture. All steps of fixation of the frame into bone, adjustment of the frame and reduction of the fracture were done under the guide of C-arm set.

Results

Results of 16 patients were evaluated in terms of union rate clinically and radiologically, limb-length discrepancy, joints (knee and ankle) motion and final angulations in sagital and coronal planes. Evaluation of the procedure was done preoperative, during the course of treatment and after removal of the frame during the follow-up period clinically and radiologically. The patients were followed clinically and radiologically after 2, 4, 8, 12 weeks, 6 months, and 1 year. Additional clinical and radiographic assessments were made when necessary to evaluate fracture healing. The clinical assessments for union were mainly based on complete absence of pain and tenderness at the fracture site after the connecting rods had been removed. Stability was detected at the fracture site when stressed manually. Clinical assessments included comparative measurement of bilateral legs length, deformities (angulations/rotation) and also joints (knee and ankle) motion assessments. At the final postoperative follow-up, the patients were evaluated subjectively for satisfaction regarding pain on walking, standing, need a support of cane or pain at rest. According to bone results, we have 11 patients who had excellent results (68, 75%), four patients who had good results (25%) and only one patient who had fair result (6, 25%). Functional results were reported in this work as 10 patients were recorded as excellent result (62, 5%), five patients were recorded as good result (31, 25%) and one patient was recorded as fair result (6, 25%). We did not record any case of poor result in both bone and functional results (0%) according to Association for the Study and Application of Methods of Ilizarov scoring system (Figs 1, 2 and Table 2).

Discussion

The Ilizarov technique, pioneered in Soviet Union in 1950, with the new concept of distraction histogenesis, is a valuable addition to the surgeon option for nonunion treatment [16]. Although frequently applied to the most difficult nonunion with bone loss, infection and shortening associated with or without other deformity, this treatment has often made the difference between amputation and functional restoration of the extremity [12,16–18]. Nonunion after proximal tibial fracture is an unusual complication [1,3,16,19] as the proximal tibial metaphysis is a broad surface of well-vascularized cancellous bone with good healing potential. The rationale is that a healed fibula distracts a greater percentage of the load as well as resisting

Figure 2

First row (a) shows plain radiographies of preoperative implant failure. Second row (b) shows three photographs during the course of treatment. Third row (c) shows plain radiographies during the course of treatment. Fourth row (d) shows three photographs during follow-up after removal of the frame. Last row (e) shows plain radiographies after removal of the frame.

Table 2 Results using Association for the Study and Application of Methods of Ilizarov scoring system

Bone results			
Excellent	Union, no infection, deformity <7°, limb-length discrepancy <2.5 cm	11	68.75%
Good	Union + any two of the following: absence of infection, <7° deformity and limb-length inequality of <2.5 cm	4	25%
Fair	Union + only one of the following: absence of infection, deformity <7° and limb-length inequality <2.5 cm	1	6.25%
Poor	Nonunion/re-fracture/union+infection+deformity >7°+limb-length inequality >2.5 cm	–	0%
Functional results			
Excellent	Active, no limp, minimum stiffness (loss of <15° knee extension/<15° dorsiflexion of ankle), no reflex sympathetic dystrophy (RSD), insignificant pain	10	62.5%
Good	Active, with one or two of the following: limp, stiffness, RSD, significant pain	5	31.25%
Fair	Active, with three or all of the following: limp, stiffness, RSD, significant pain	1	6.25%
Poor	Inactive (unemployment or inability to return to daily activities because of injury)	–	0%
Failures	Amputation	–	0%

compression at the tibial nonunion site [13,18,20,21]. Better tibial healing may not be fully elucidated, but previous clinical studies on the successes with partial fibulectomy and cast treatment seem to support this hypothesis [1,3,9]. Cattaneo *et al.* [22] reported that circular external fixation using the Ilizarov apparatus combined with internal bone transport or compression-distraction techniques was used to treat 28 patients with infected nonunions or segmental bone loss of the tibia. In all patients, their infected extremities healed without the addition of cancellous bone graft, microvascular fibular, or soft tissue grafting. In the current series, our bone results were little better than the functional results. This demonstrates that an excellent bone result does not necessarily guarantee good function. In this work, four patients have shortening less than 3 cm at the end of follow-up. Three of them were considered as good bony results. Two patients have persistent infection which is deep infection treated during the course of follow-up by surgical debridement followed by umbrella of antibiotics according to the results of culture and sensitivity. Only one patient of them was considered as good result and the other is combined with shortening less than 3 cm was consider as fair. The functional result is affected by the soft tissues, that is, conditions of the muscles, vessels and the joints. The effects of smoking on the outcome of ring fixation have already been reported [23]. Six of our follow-up male patients were still smokers despite being warned of the risk of a poorer result. One person was a regular substance abuser at the time of treatment. Our numbers were too small to establish whether there was a difference in outcomes between smokers and non-smokers. Three patients were active with limping in the affected leg and two patients were active with minimum stiffness of knee joint. All these five cases were considered as good functional result. Only one patient was active and had limping, persistent stiffness of the knee, and significant pain, so considered as fair result. In aforementioned patient with fair result, the reasons were multifactorial. Most of them were the open fracture and internal fixation, which landed into infection, had history of other major chronic illness and had history of multiple surgeries. Considering the amount of previous surgeries and number of complications, the patient having the end result of fair grade seems quite reasonable [24].

Conclusion

The Ilizarov external fixator method is a reliable procedure that permits definitive treatment for nonunited extra-articular proximal tibial fracture, enabling the possibility of early weight bearing. It allows for less soft tissue dissection and represents a reliable method for achieving stabilization and healing of extra-articular proximal tibial nonunited fractures with a minimum of soft tissue complications. Consolidation and concomitant deformity correction and lengthening if necessary are obtained, without the need for bone grafting or other further surgical intervention.

Treatment of nonunion of extra-articular proximal tibial fracture with the Ilizarov method is a viable alternative to amputation.

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Conflicts of interest

There are no conflicts of interest.

References

1 Martinez A, Sarmiento A, Latta LL. Closed fractures of the proximal tibia treated with a functional brace. Clin Orthop 2003; 417:293–302.

2 Bhandari M, Audige L, Ellis T, Hanson B. Operative treatment of extra-articular proximal tibia fractures. J Orthop Trauma 2003; 17:595.

3 Ricci WM, O'Boyle M, Borrelli J, Bellabarba C, Sanders R. Fractures of the proximal third of the tibial shaft treated with intramedullary nails and blocking screws. J Orthop Trauma 2001; 15:264–270.

4 Wu CC. Salvage of proximal tibial malunion or nonunion with the use of angled blade plate. Arch Orthop Trauma Surg 2006; 126:82–87.

5 Collinge CA, Sanders R, Dipasquale T. Treatment of complex periarticular fractures using percutaneous techniques. Clin Orthop 2000; 375:69–77.

6 Borrelli J Jr, Prickett W, Song E, Becker D, Ricci W. Extraosseous blood supply of the tibia and the effects of different plating techniques: a human cadaveric study. J Orthop Trauma 2002; 16:691–695.

7 Barei DP, Nork SE, Mills WJ, Henley MB, Bernirschke SK. Complications associated with internal fixation of high-energy bicondylar tibial plateau fractures utilizing a two-incision technique. J Orthop Trauma 2004; 18:649–657.

8 Lonner JH, Siliski JM, Jupiter JB, Lhowe DW. Posttraumatic nonunion of the proximal tibial metaphysis. Am J Orthop 1999; 28:523–528.

9 Toro-Arbelaez JB, Gardner MJ, Shindle MK, Cabas JM, Lorich DG, Helfet DL. Open reduction and internal fixation of intraarticular tibial plateau nonunions. Injury 2007; 38:383.

10 Gardner MJ, Toro-Arbelaez JB, Boraiah S, Lorich DG, Helfet DL. Surgical treatment and outcomes of extraarticular proximal tibial nonunions. Arch Orthop Trauma Surg 2008; 128:833–839.

11 Rozbruch SR, Herzenberg JE, Tetsworth K, Tuten HR, Paley D. Distraction osteogenesis for nonunion after high tibial osteotomy. Clin Orthop Relat Res 2002; 394:227–235.

12 Sen C, Kocaoglu M, Eralp L. The advantages of circular external fixation used in high tibial osteotomy (average 6 years follow-up). Knee Surg Sports Traumatol Arthrosc 2003; 11:139–144.

13 Hosny G, Shawky MS. The treatment of infected nonunion by compression-distraction techniques using the Ilizarov external fixator. Int Orthop 1998; 22:298–302.

14 Pheifer LS, Goulet JA. Delayed unions of the tibia. J Bone Joint Surg 2006; 88:206–216.

15 Sanders DW, Galpin RD, Hosseini M, MacLeod MD. Morbidity resulting from the treatment of tibial nonunion with the Ilizarov frame. Can J Surg 2002; 45:196–200.

16 Madhusudhan TR, Ramesh B, Manjunath K, Shah HM, Sundaresh DC, Krishnappa N. Outcomes of Ilizarov ring fixation in recalcitrant infected tibial non-unions – a prospective study. J Trauma Manag Outcomes 2008; 2:6.

17 Kocaoglu M, Eralp L, Rashid HU, Sen C, Bilsel K. Reconstruction of segmental bone defects due to chronic osteomyelitis with use of an external fixator and an intramedullary nail. J Bone Joint Surg Am 2006; 88:2137–2145.

18 Cavusoglu AT, Er MS, Inal S, Ozsoy MH, Dincel VE, Sakaogullari A. Pin site care during circular external fixation using two different protocols. J Orthop Trauma 2009; 23:724–730.

19 Pelissier P, Masquelet AC, Bareille R, Pelissier SM, Amedee J. Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. J Orthop Res 2004; 22:73–79.

20 Zhang X, Liu T, Li Z, Peng W. Reconstruction with callus distraction for nonunion with bone loss and leg shortening caused by suppurative osteomyelitis of the femur. J Bone Joint Surg Br 2007; 89:1509–1514.

21 Tranquilli Leali P, Merolli A, Perrone V, Caruso L, Giannotta L. The effectiveness of the circular external fixator in the treatment of post-traumatic of the tibia nonunion. Chir Organi Mov 2000; 85:235–242.

22 Cattaneo R, Catagni M, Johnson EE. The treatment of infected nonunion and segmental defects of the tibia by methods of Ilizarov. Clin Orthop 1992; 280:143–152.

23 McKee MD, DiPasquale DJ, Wild LM, Stephen DJ, Kreder HJ, Schemitsch EH. The effect of smoking on clinical outcome and complication rates following Ilizarov reconstruction. J Orthop Trauma 2003; 17:663–667.

24 Soomro ZA, Soomro ZA, Samo SA. Management of infected nonunion tibial shaft by Ilizarov method. J Pak Orthop Assoc 2013; 25:29–33.