Salvage of failed ankle arthrodesis after posttraumatic septic arthritis by Ilizarov external fixator: mid-term results

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ABSTRACT

Background: Failed septic ankle arthrodesis is a challenging problem. This study evaluated the results of salvage revision ankle arthrodesis using Ilizarov external fixation to treat nonunited arthrodesis of posttraumatic septic ankle arthritis and to analyze the functional outcome of this method.

Methods: This prospective study included 14 patients with a mean age of 48 yr. Patients had already undergone a mean of 4.43 previous surgeries at a mean of 17.14 mo from primary arthrodesis. Five patients had associated deformity. The mean preoperative American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score was 23.93. Meticulous debridement was done and an Ilizarov fixator was applied in compression in a one-stage procedure.

Results: The mean follow up period was 41.71 mo with mean external fixation period of 17.29 wk. Successful arthrodesis in perfect alignment was achieved in 13 of 14 patients without additional procedures. One ankle did not go on to union. A chronic discharging sinus persisted in one patient. One infected loose wire was exchanged in two patients. One diabetic patient reported moderate daily diffuse pain. The mean postoperative AOFAS ankle-hindfoot score was 71.57. Patients with successful fusion were satisfied with the procedure.

Conclusions: Using an Ilizarov fixator to salvage nonunited septic posttraumatic ankle arthrodesis was effective, with patients reporting a stable ankle and dramatic functional improvement with minimal complications.

Key Words: external fixator, failed ankle fusion, Ilizarov, revision arthrodesis, septic ankle

INTRODUCTION

Postoperative infection of an ankle fracture is a limb-threatening complication, especially in patients with comorbidities, such as diabetes mellitus. Infection rates range from 1% to 8% with very high rates of up to 60% in diabetics and immunocompromised patients. Treatment is challenging with high infection recurrence and amputation rates.1 Limb salvage by eradication of infection and arthrodesis may be used as an alternative to amputation.3,4

The objective is to eradicate infection by aggressive debridement and to obtain a solid fusion in proper alignment to restore pain-free ambulation in patients with a destroyed, painful ankle joint.4,5 The method of fixation is one of the key factors to achieve a successful arthrodesis.8 Numerous procedures have been demonstrated to achieve fusion.9

Ankle arthrodesis is a daunting endeavour and often must be accomplished in stages.10,11 However, nonunion is still considered the most frequent cause of failure, with an overall nonunion rate of 22.6% (range, 0% to 41%) being reported.7 Failure to achieve arthrodesis may be the result of mechanical factors (inadequate fixation, poor bony apposition, severe bone loss), biological factors (open fractures, talar avascular necrosis, insufficient debridement, diabetes mellitus, sensory neuropathy, smoking, local infection), or patient factors (obesity, noncompliance).5,10,12,13 Fragomen et al.14 reported a 54% nonunion rate in patients who smoke. Revision procedures may be technically difficult with a higher complication rate and decreased patient satisfaction, although union rates range from 77% to 85%.6 In patients with ankle joint destruction after complex fractures and chronic active infection, many arthrodesis techniques become less appropriate, complications occur more frequently, and solid fusion is more difficult to obtain.6,15

Both open and arthroscopic techniques of ankle arthrodesis are described.4,9 In the past 2 decades, arthroscopic ankle arthrodesis has gained popularity. However, it is contraindicated in the presence of infection, significant bone loss, or rigid deformity.16,17 To achieve bony fusion, a radical debridement, stable fixation, and minimal compromise of the marginal blood supply are necessary.18 Popular methods for stabilizing an ankle fusion include crossed lag screws, plate and screws, retrograde intramedullary (IM) nailing, Kirschner wires, and external fixation.6,8,9 Implantated hardware may result in recurrent infection and premature hardware failure from poor bone stock at the site.
of injury, as a result of prior infection and multiple debridement procedures. External fixation is the treatment of choice in such patients to avoid placing inert material in a previously infected region.3,15

The Ilizarov device is advantageous over unilateral external fixators with a more comprehensive and modular nature, making it an ideal fixation tool for patients with complex ankle pathology. Malalignment can be corrected, and its excellent stability allows immediate weight-bearing thereby reducing the risk of nonunion and associated risks of immobilization. Biological enhancement of union is possible through progressive compression of the fusion site with or without a proximal corticotomy and callus distraction.5,6,9 A skinny wire external fixator can be performed in poor bone and soft tissue conditions and can be used in the presence of active infection as a one-stage procedure.10,19 The Ilizarov fixator allows application of dynamic and multidirectional forces to treat all aspects of posttraumatic ankle reconstruction.9 Problems with the Ilizarov frame include its complexity during application, a bulky frame requiring patient compliance, and the risk of specific complications such as pin-track infection.3,9

The purpose of this study was to evaluate the results of revision ankle arthrodesis using the Ilizarov fixator to salvage a failed arthrodesis caused by septic posttraumatic ankle damage.

**MATERIALS AND METHODS**

This was a retrospective study conducted after approval of the Research Ethics Committee of the University. Inclusion criteria were failed ankle arthrodesis after post-traumatic septic ankle destruction with a minimum of 2 yr of follow-up. Cases of failed ankle arthrodesis for aseptic conditions such as osteoarthritis or rheumatoid arthritis were excluded from this study. The patients were treated with the same protocol, namely a single-stage procedure of meticulous debridement and application of Ilizarov external fixator in compression.

The study included 14 patients operated from May 2004 to January 2013. The mean age of patients was 48.07 yr (SD 6.33; range: 34–56 yr). The characteristics of patients are summarized in Table 1. Four patients were women and 10 were men. Four patients had diabetes mellitus, and 11 were heavy smokers. All septic ankle pseudarthroses were unilateral, with five left and nine right ankles.

The original trauma was open ankle fractures in eight patients treated by temporary external fixation followed by open reduction and internal fixation (ORIF) and in six patients it was ORIF of closed ankle fractures. All patients had already undergone a mean of 4.43 previous surgical procedures (SD 1.22; range: 3–7 procedures), e.g. ORIF, external fixation, repeated debridement, or implant removal. All had a failed previous attempt at ankle arthrodesis using unilateral external fixators or Kirschner wires.

The duration from the original trauma to revision arthrodesis ranged from 30 to 49 mo with a mean of 40.79 mo (SD 6.17) and a mean of 17.4 mo from primary arthrodesis (SD 17.14; range, 12–26 mo). All patients were using a walker or crutches for ambulation with foot touch or nonweightbearing on the
affected side. All patients had painful stiff ankles with one or two draining sinus(es) (Figures 1 and 2). Four patients had associated equinus deformity. One patient had a valgus heel. We used the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale for assessment. The preoperative AOFAS ankle-hindfoot score ranged from 5 to 35 with a mean of 23.93 (SD 6.84).

Before surgery, the procedure was discussed in detail with the patients. All patients met with other individuals who had Ilizarov fixation to be familiar with the frame. Smoking cessation and good blood sugar control were prerequisites before surgery. Informed consent was obtained from all patients included in the study.

Operative Technique

Patients were positioned supine and a tourniquet was used. A combined lateral and medial approach was used for debridement with adequate thickness of skin flaps. Deep soft tissue and bone cultures were obtained. Sinus tracts were delineated by methylene blue before excision. Internal fixation implants were removed with all necrotic and infected tissues, and articular cartilage to expose healthy vascular bone. The total resection was less than 2 cm in all patients allowing acute apposition and compression. Temporary fixation by Kirschner wires was done and skin flaps were temporarily approximated, then the tourniquet was deflated.

The Ilizarov frame was mounted to the tibia and the foot. One ring block formed by two rings was fixed to the tibia by two Kirschner wires in each ring and one half pin dropped off the ring. The foot frame was formed by a calcaneal half ring with forward extension by two straight plates that were connected by a forefoot half ring or rod to close the construct. This frame was fixed by two crossing olive wires in the calcaneus, a talar wire, and one or two metatarsal wires (Figure 3).

The temporary Kirschner wires were removed and the foot frame was connected to the tibial rings in compression with the ankle in neutral flexion, external rotation (5–10 degrees), and slight valgus (5 degrees) (Figure 4). The position was checked under image intensifier.

Postoperative Care

Antibiotics were given at induction of anesthesia and postoperatively for 6 wk based on the last culture and sensitivity testing of infected secretions. The antibiotic was changed according to the culture results of intraoperative samples. Initially, the antibiotics were given intravenously for 3 wk followed by oral antibiotics for another 3 wk. Weight-bearing was allowed as tolerated on the second postoperative day. Patients were assessed clinically and radiographically weekly for the first month, biweekly for the second month, monthly until fusion, and then every 6 mo. The patients were monitored for pin care, maintenance of position and alignment, progression of fusion,
and the need for further compression, or repeated cycles of compression and distraction to enhance fusion. The Ilizarov fixator was maintained until solid fusion was evident radiographically by loss of lucency and formation of crossing trabeculae (Figure 5). The nuts on the connecting rods were released for 3 wk. The sound fusion was clinically evidenced by painless weight-bearing with a loosened frame. The frame was then removed without additional casting. At the final follow-up, the outcome was assessed by the achievement of radiographic fusion and clinically by the AOFAS ankle-hindfoot scale.

Statistical Analysis
The descriptive statistics were done in the form of frequencies and percentages for categorical variables (sex, side, smoking, and diabetes mellitus), and means, standard deviations (SD), and ranges for continuous variables (age, time from injury, previous surgeries, follow-up duration, external fixation period, leg-length discrepancy (LLD), and AOFAS ankle-hindfoot scores). Statistical analysis was done to compare the mean preoperative and postoperative AOFAS ankle-hindfoot scores. The level of significance was set at \( P < 0.05 \). The descriptive and statistical analyses were performed with IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

**RESULTS**
The results are summarized in Tables 2 and 3. Patients were followed for a mean of 41.71 (SD 11.88; range 24–67) months. The mean external fixation period from the date of surgery to fixator removal was 17.29 wk (SD 2.97; range 14–24 wk). Gradual correction of postoperative residual valgus or equinus deformity was done in three patients. Successful revision arthrodesis was achieved in 13 of 14 patients without additional procedures (Figures 6 and 7).

<table>
<thead>
<tr>
<th>Patient</th>
<th>Follow up (mo)</th>
<th>External fixation period (wk)</th>
<th>Leg-length discrepancy (cm)</th>
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<th>Malalignment</th>
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One patient with persistent pseudarthrosis was mobilized in a lower leg orthosis refusing another surgical revision. Three patients needed a debridement procedure for infection while the frame was in place. A chronic discharging sinus persisted in one patient. Ten patients had pin track infections successfully treated with oral antibiotics and daily local pin site care. One infected loose wire was exchanged in two ankles. Mean LLD was approximately 1.64 cm (SD 0.36; range: 1–2 cm). A shoe-lift was used in six patients. The remaining patients with successful fusion were able to wear normal shoes and none required a walking assistance device.

At the final follow-up, the AOFAS ankle-hindfoot score ranged from 31 to 83, with a mean of 71.57 (SD 15.17) and statistically significant improvement from the mean preoperative score of 23.93 (SD 6.84; range: 5–35) (P < 0.001). The mean AOFAS domain scores were 34.29 (SD 7.56; range: 20–40) for pain, 27.93 (SD 7.39; range: 6–33) for function, and 9.64 (SD 1.34; range: 5–10) for alignment (Table 3). One diabetic patient reported moderate daily diffuse pain. That patient also had associated manifestations of diabetic neuropathy. Seven patients reported mild discomfort. Three patients used a cane for outdoor activities. Patients with successful fusion stated they were satisfied with the procedure except the one with persistent pain who was dissatisfied.

**Radiographic Analysis**

The radiographs were reviewed for fusion, position, and alignment. Thirteen patients showed sound fusion evidenced by the crossing trabecula. Perfect alignment was achieved in all fused ankles. The seven patients with mild discomfort had radiographic evidence of subtalar osteoarthritis.

**DISCUSSION**

This study was performed to evaluate the clinical, functional, and radiographic results of revision ankle arthrodesis by the Ilizarov fixator in a group of 14 patients who presented with the complicated problem of failed arthrodesis after septic posttraumatic ankle damage. In this series, union was not obtained in one diabetic patient who was a smoker and could not tolerate the frame more than 9 wk. Revision arthrodesis often is more difficult than the primary procedure because of infection, loss of bone stock, or soft-tissue compromise. Suda et al.\(^1\) reported union in 62% of primary ankle arthrodeses, and only 39% showed union in the case of revision arthrodesis in their series of 79 patients treated by the AO external fixator. Kitaoka et al.\(^2\) evaluated the results of revision arthrodesis with an external fixator in 26 patients and achieved union in 20 patients. Easley et al.\(^3\) reported fusion with revision tibiotalar arthrodesis in 36 of 45 patients. The high rate of fusion in our study may be explained by meticulous debridement, stable fixation, early weight-bearing, and postoperative compression or cycles of compression-distraction with strict smoking cessation and good glycemic control. This rate is comparable to the fusion rate in other studies of revision ankle arthrodesis reported by Cheng et al.\(^4\) (17 of 18 cases),
Eingartner and Weise (15 of 16 cases), and O’Connor et al. (12 of 14 cases). Midis and Conti and Katsenis et al. reported a 100% success rate in ten ankle revisions and 21 revisions, respectively.

In the current study, the average external fixation period of 17.29 wk also was consistent with data reported in the literature. Midis and Conti reported an average external fixation period of 12.8 (range: 9–20) weeks in revision cases. Cheng et al. reported an average time to fusion of 4.8 (range: 2.5–10) months in revisions with 3 fixation methods. Kawoosa et al. achieved arthrodesis at an average of 14 (range: 12–18) weeks.

Amputation may eventually be needed in recalcitrant cases. DeVries et al. reported amputation in 21 limbs of 179 tibiotalocalcaneal arthrodeses. Moore et al. reported amputation in three of 32 cases of septic ankles, and Easley et al. reported amputation in five of 45 revisions, but none of our patients had amputation. No bone graft or bone transport was needed in these patients, and the total resection was less than 2 cm. We relied on postoperative compression or cycles of compression and distraction. Supplemental bone graft and, recently, a trabecular metal spacer have been used to achieve ankle arthrodesis. However, this should be avoided in patients with active infection. Cheng et al. did not use bone graft in their series. Thus, it appears that a bone graft is not always necessary, even in revision ankle arthrodesis. Kolling et al. reported an average shortening of approximately 25 mm (range, 20–40). Bek et al. reported average leg-length discrepancy of 1.4 cm (range, 0.9–2.9).

A two-stage procedure has been recommended in septic ankles with the use of a spacer for 6 wk. In the current series, arthrodesis was achieved by a single-stage procedure, and infection control was achieved in all patients except one. Salem et al. reported persistent infection in three ankles; two of which healed after repeated debridement. Gessman et al. reported persistent infection in two of 37 cases. Richter et al. reported persistent infection in nine of 45 patients.

Malalignment causes soft-tissue imbalance and has adverse effects on the neighboring joints leading to hindfoot pain. All fused ankles in this series were in an acceptable position. The versatile Ilizarov frame allowed postoperative fine tuning of the position and alignment. Eylon et al. reported one varus malunion in 17 ankles fused by Ilizarov fixator. Gessman et al. reported equinus in seven, valgus in two, and varus in one of 37 cases. Midis and Conti reported one varus malalignment in ten revisions.

The postoperative AOFAS ankle-hindfoot score in this series ranged from 31 to 83, with an average of 71.6. The lowest score was for the patient with pseudarthrosis. This average score was less than that reported by Smith et al. who reported a score of 84 ± 12 after primary arthrodesis by
screws. However, they did not explain the highest score in spite of loss of points for the ankle motion. Because ankle motion was eliminated by arthrodesis, the 14 points allocated for ankle and hindfoot motion were eliminated, leaving a maximal attainable score of 86.\(^5\)\(^6\)\(^13\)\(^27\)\(^28\) Fragomen et al.\(^{14}\) reported a score of 71, and Gessman et al.\(^{19}\) reported a score of 67.9 using an Ilizarov fixator for primary arthrodesis. In a mixed series of primary and revision ankle arthrodesis, Kawoosa et al.\(^{27}\) had a score of 78.37. Midis and Conti\(^{25}\) reported a score of 73, and Cheng et al.\(^{4}\) reported a score of 70.9 in revision cases.

The strength of this study lies in having a homogenous group of patients with failed ankle arthrosis after septic posttraumatic damage with a minimum of 2 yr follow-up treated by the same protocol of one-stage revision arthrodesis. Some reports used different treatment modalities to achieve arthrodesis in the same series.\(^4\) Other studies presented both primary and revision arthrodesis.\(^5\)\(^6\)\(^13\)\(^27\)\(^28\) Moreover, some studies are heterogeneous, mixing septic and nonseptic etiologies.\(^4\)\(^6\)\(^14\)\(^26\)\(^28\)

The limitations of the study include the retrospective nature of the study, lack of a control group, and the small number of patients. The small number of patients in the study was due to the rarity of the condition selected for inclusion criteria.

In conclusion, with failed septic ankle arthrodesis, revision arthrodesis by Ilizarov fixator appears to be optimal treatment achieving a stable, mostly pain-free ankle and dramatic improvement in function of such patients. The Ilizarov fixator provides stable fixation allowing early weight-bearing and allows postoperative compression and correction of alignment.

REFERENCES