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ORIGINAL STUDY

The challenge of the infected pilon tibial non-union: treatment with radical resection, bone transport and ankle arthrodesis

Annelien Brauns, Johan Lammens

From the Department of Orthopaedic Surgery, KULeuven, University Hospital Pellenberg, Belgium

A significant number of patients with pilon tibial fractures develop complications, the most devastating being a combination of infection and non-union with bone loss.

The results of the Ilizarov bone transport technique were retrospectively evaluated in ten patients. All underwent an extensive resection and reconstruction aiming at an ankle arthrodesis. The outcome was registered by clinical and radiographic examination as proposed by Paley's functional and bone results classification.

A good healing at the level of the docking site could be obtained in all patients but with a re- intervention in 8 of the 10. In 5 of these patients, re-intervention with a transcalcaneal nailing leaded to the final healing. Other options are debridement of the docking site (2 patients) and a new Ilizarov procedure (1 patient).

If patients are prepared to participate in a long-term treatment with the risk of multiple interventions a reconstruction can be performed, resulting in a limb with an acceptable function, allowing all activities of daily life and even a professional occupation. To obtain this final result with a definite union at the docking site a secondary retrograde intramedullary nailing is considered a valuable and safe procedure.

Keywords : Pilon tibial ; Non-union ; Bone transport ; Ankle arthrodesis ; Retrograde nailing.

INTRODUCTION

Fractures of the tibial pilon are known for their high complication rates due to soft tissue problems, infection and non-union *(26)*. This high failure incidence confronts surgeons with extreme challenges to regain a limb with an acceptable function. In most cases, there is a severe and unrestorable damage to the tibiotalar joint. Many patients need repeated surgical interventions such as free tissue transfers using muscular flaps to improve the soft tissue quality. In case of failure there are not many options left. Several problems have to be addressed in these complex cases: the destruction of the joint, the diminished bone quality with a persistent non- union, sometimes combined with the presence of sequestrums and occasionally open wounds or draining fistulae. To overcome the combination of all these difficulties, a radical treatment by pilon resection and bone transport was chosen, aiming

■ A. Brauns, MD
■ J. Lammens, MD, PhD
Department of Orthopaedic Surgery, KULeuven, University Hospital Pellenberg, Belgium.
Correspondence : Department of Orthopaedic Surgery, KULeuven, University Hospital Pellenberg, Weligerveld 1, 3212 Pellenberg, Belgium. Tel.: +32 16 338800; fax: +32 16 338348
E-mail : Annelien.brauns@me.com

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at an ankle arthrodesis with maintenance of the limb length. An acceptable functional result and subjective good outcome can be obtained, but it requires a long-term treatment. Patients often need additional interventions especially with regard to the final union of the arthrodesis, as illustrated in this series of ten patients *(11)*.

MATERIALS AND METHODS

From our clinical database of patients undergoing bone transport procedures between January 2005 and December 2013, ten patients (nine male, one female) were identified with sequels of an infected pilon tibial fracture. Their mean age at presentation was 46 years (range 27 till 61). The left side was involved seven times, the right on three occasions. Six patients still smoked actively, two were ex-smokers and only two patients had no nicotine abuse. There was one patient suffering from diabetes. Seven individuals had an ASA classification of I, whereas scores II and III were found in respectively four and one patient, the latter having a concomitant neurotrauma. All were victims of high-energy accidents. The mean delay till presentation in our institute was 14 months.

The initial treatment for closed fractures (6/10) was an open reduction and internal fixation. Open fractures (3/10) were initially treated by an external fixation, which in a second stage was converted to a plate osteosynthesis. Only one patient (1/10) had a conservative treatment with a leg cast. This patient developed an ulcerative wound that surinfected. Radiographically all fractures could be classified as grade III according to Rüedi and Allgöwer (Figure 1) *(23)*.

The patients had an average of three surgical procedures (range 0 to 5) prior to admission. All patients were diagnosed with osteomyelitis as proven by positive cultures, either taken during previous surgical interventions or from present draining wounds. The bacteriological results are listed in Table I.

At presentation half of them still had an ulcerative wound or a draining fistula (Figure 2). On six occasions the osteomyelitis was already combined with a manifest non-union as the time since fracture

Figure 1. — Typical CT-scan showing destruction of the pilon (Rüedi-Allgöwer type III fracture).

Table I. — Results from wound cultures (n = number of patients).

n	Results from wound cultures
1	Methicillin resistent Staphylococcus areus (MRSA)
2	Staphylococcus aureus
2	Staphylococcus aureus + Coagulase negative Staphylococcus
1	Staphylococcus aureus + Propioneabacterium acnes
1	Staphylococcus aureus + Enterococcus faecalis
2	Coagulase negative Staphylococcus
1	Enterobacter cloacae

was more than one year. The fracture healing of the other patients (4/10) was questionable in view of the infection, the sclerotic bone fragments and the loss of bone substance (Figure 3). In a first stage the pilon was resected, taking away as much tibial bone as necessary to obtain bleeding bone edges. The cartilage of the talus was removed and stabilisation with an Ilizarov frame was performed. After complete healing of the wound and normalisation of the C-reactive protein level, patients were readmitted for a proximal tibial osteotomy. Bone transport was initiated at the seventh postoperative

Figure 2. — Clinical picture with permanent wound drainage.

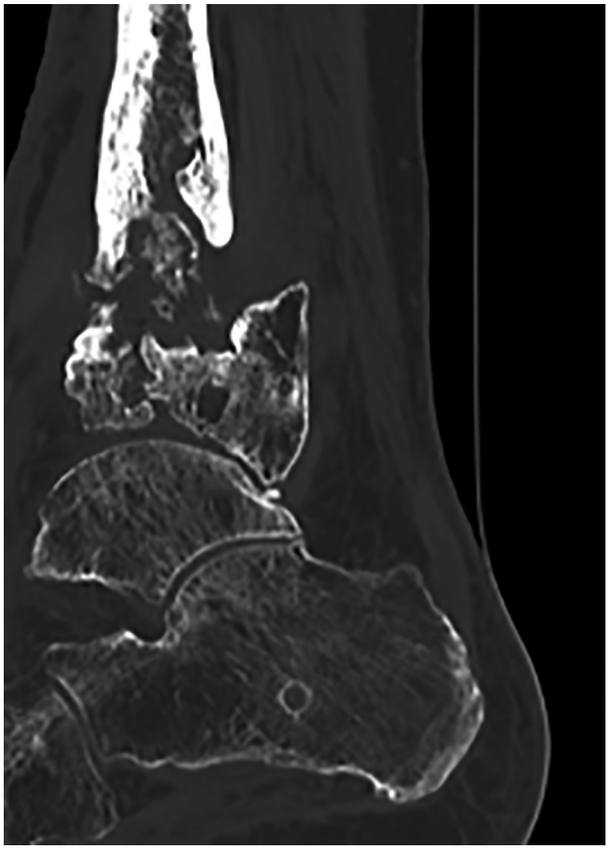

Figure 3. — Infected bone defect after 6 months with evolution to permanent non-union.

day at a rhythm of 3⁄4 millimeters per day till docking at the talus, meaning a repair of two centimeters per month (Figure 4). Next, the frame was adapted for compression at the docking site and proximal distraction if further lengthening was required. If the distraction area showed the first signs of corticalisation the circular fixation was reduced to a smaller monolateral frame according to a previously described technique by Laumen et al *(14)*. At that moment, a debridement of the docking site was performed in two patients. One of these two patients had also an additional fixation across the docking site with 2 Acutrak headless compression screws (Acumed, Hillsboro, Oregon, USA). Once the lengthening area was completely healed, the fixator was removed regardless the healing status of the docking site. The latter was supposed not to heal anymore if no consolidation was installed within the time frame the distraction healed. The non-healed dockings (6/10) were treated in a further stage with a revision arthrodesis, either with a new Ilizarov procedure (one patient) or a retrograde locking nail (Stryker – Selzach, Switzerland) (five patients). At this stage, a new debridement of the docking site was performed combined with limited grafting using the lateral malleolus in four patients. In one patient OP-1 (Osigraft® - Stryker – Limerick – Ireland) was used. In another patient no addition to the docking was made, as there was a perfect apposition of the bone ends.

RESULTS

The mean defect length to be reconstructed was 7 centimeters (range 4-12), necessitating a mean distraction period of 4 months (range 3-6) till arrival

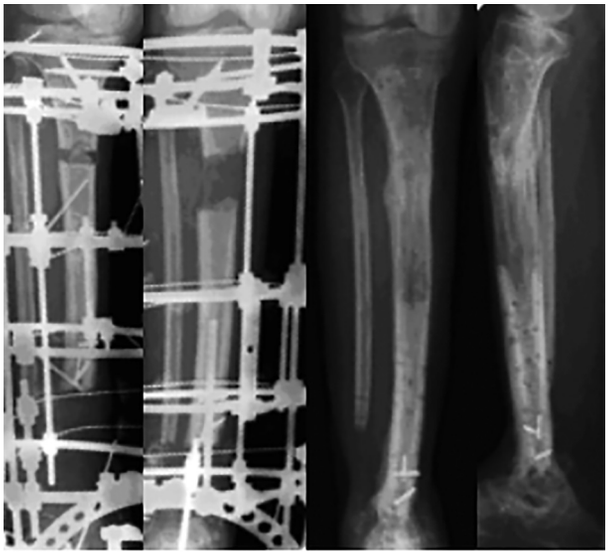

Figure 4. — Bone transport with spontaneous healing of the docking site.

at the docking site. In two of the patients an additional distraction was performed because of preexisting limb length discrepancy. Due to the preservation of the initial length or this extra lengthening the mean limb length difference was limited to 0.85 centimeters (range 0-2) in nine patients with ASA I or II score. The patient with the ASA III score had a leg length difference of 2.5 centimeters. The total period of external fixation, both circular and unilateral, averaged 15 months (range 11-22) corresponding to a mean lengthening index of 2.3 months per centimeter (range 1-4). Several problems were encountered during this period, such as superficial pin tract infection (5 patients), oedema (3 patients) and knee joint contracture (1 patient). At removal of the frames, healing of the docking was only achieved in four patients including the two who underwent a debridement. The other six patients still had pathological mobility at the tibiotalar joint. During the interval between removing the frame and nailing, patients were protected during walking (walking boot, orthopaedic shoes or cast immobilization). Moreover, one of these patients developed an axial deviation of the distraction regenerate for which a new Ilizarov procedure, correcting the alignment with new compression at the docking after debridement, resulted in a complete healing. The remaining five underwent a pantalar fusion using a retrograde Stryker hindfoot nail (Stryker, Selzach, Switzerland), which resulted in a solid fusion in all of them (Figure 5). Table II resumes the interventions during the various phases of treatment.

According to Paley's scoring system *(21)*, bone evaluation results were excellent in seven patients, good in two and fair in one patient. All patients had intact soft tissue coverage with closure of all wounds or fistulae and without any further wound problems at follow-up.

At final review (minimum five and a half – maximum twelve years) there was no single relapse of infection, which means absence of clinical symptoms of infection and normal inflammatory indexes. Nine out of ten patients were able to perform all activities of daily life. Mild pain was still present in two patients. There was no need for crutches or walking aids, except for the patient with the ASA III score. She used a wheelchair most of the time due to the sequels of the neurotrauma. Eight of the ten patients (including the ASA III patient for limited ambulatory activities) preferred the use of orthopaedic shoes for walking long distances. Six patients still had a professional activity, three had retired. One did not return to the previous working activities, being the patient with the neurological sequels. According to Paley's classification for functional results five patients had an excellent score, four a good and one a fair result.

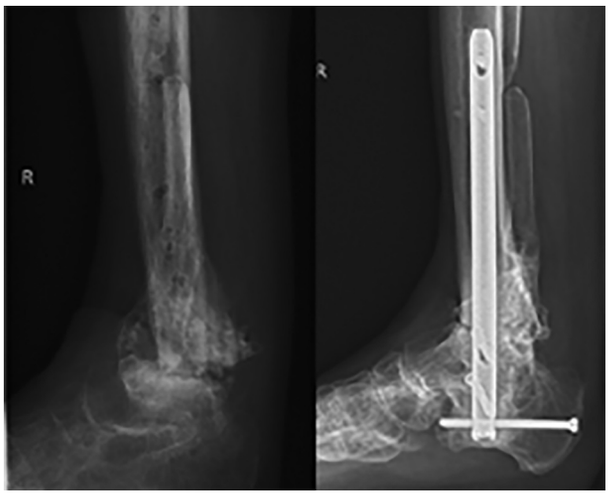

Figure 5. — Non-union of docking with final healing after retrograde nailing.

Table I. — Table stipulating which interventions were necessary in the various stages

	Debride-ment of docking site#	Consolidation after transport$	Revision arthrod-esis	Interventions during arthrod-esis
1.	N	N	IM nail	Debridement + grafting"
2.	N	N	IM nail	Debridement + grafting
3.	N	N	IM nail	Debridement + grafting
4.	N	N	IM nail	OP-1
5.	N	N	IM nail	/
6.	N	N	Ilizarov*	Debridement + grafting
7.	Y	Y	/	/
8.	Y + 2 screws	Y	/	/
9.	N	Y	/	/
10.	N	Y	/	/

N = No; Y = Yes; IM nail = intramedullary nail; OP-1 = Osigraft. #Debridement of the docking site when circular fixation was reduced to a monolateral frame.
$The fixator was removed once the lengthening area completely healed, regardless the consolidation of the docking site.
*One patient developed an axial deviation of the distraction zone for which a new Ilizarov procedure was necessary to correct the alignment, debride and compress the docking site.
"Debridement of the docking site during revision arthrodesis combined with limited grafting using the lateral malleolus.

DISCUSSION

Despite an initially successful osteosynthesis, fractures of the pilon tibial are prone to an unpredictable outcome. Especially in case of soft tissue damage the risk for deep infection remains high, with in some studies estimated incidences up to 43 percent in patients with diabetes *(10)*. A two-step approach with initial external fixation and later open reduction with plate fixation may reduce this complication rate. This is not a guarantee for un uneventful outcome, as illustrated by this series of ten patients, of whom three were initially treated with an external fixator *(6)*. Deep infections, sometimes extending into the joint, require an aggressive debridement, which can result in a complete resection of the pilon *(20)*. This makes a tibiotalar arthrodesis mandatory, but with the particular difficulty of the extensive bone loss. The concomitant soft tissue damage and diminished blood supply limit the possibilities for autologous bone grafting and muscle flap transfer. Several authors consider an Ilizarov treatment as the treatment of choice for well-elected complicated cases *(3,13)*. In a comparison between acute shortening and lengthening versus bone transport for the management of tibial non-unions Mahaluxmivala et al. concluded that there is no difference in consolidation pattern between both methods of treatment *(19)*. In small bone defects, acute shortening and lengthening is preferable to bone transport because of shorter external fixation time and fewer additional procedures to maintain alignment and achieve union. However, acute shortening of more than four centimeters can cause blood flow problems, oedema, wound bunching and tissue necrosis. These risks make bone transport more appropriate and the treatment of choice for this series of patients, with a mean resection of seven centimeters *(2)*. Schottel et al. also described bone transport as an effective treatment in distal tibial periarticular nonunions *(24)*. Being in a general good condition without important co-morbidity and a local intact sensory supply to the sole of the foot, our patients were good candidates for this highly demanding procedure, which is a very long-term process, often requiring several surgeries *(15)*.

Clinical studies report an average tibial healing index between 1.0 and 1.8 months per centimeter for simple limb lengthening. This is not applicable to bone transport, where previous surgeries and infection compromise the biology of the operated limb, leading in our series to a mean lengthening index of 2.3 months per centimeter *(12)*. Furthermore, smoking has a deleterious effect on the bone healing potential, probably attributing to the long healing time, as six out of the ten patients were active smokers *(22)*. The most challenging in bone transport is not the reconstruction of the defect, but to obtain union at the docking site, a problem for which several measurements have been advocated *(7)*. Extensive resection till viable and bleeding bone ends, avoidance of periosteal stripping, keeping the bone in good alignment and adequate compression

at the docking have all been taken into account, but nevertheless six out of the ten patients in the present series ended up with a non-union *(16)*. Only in two patients (2/10) there was an immediate solid fusion of the docking within three months. Two (2/10) healed during the Ilizarov treatment after a new debridement. One of these patients also had an additional placement of two compression scews. The other six patients (6/10) required a re-intervention. As there was no problem of insufficient bone stock, copious grafting using iliac crest grafts was considered unnecessary. A wide exposition of the docking site was deliberately avoided because of the complex history with extensive scarring, putting the limb at risk in case of a large surgical exposure to this area. Instead a limited approach with minimal grafting was performed, based on the fact that in patients submitted to nailing reaming performs an additional grafting. This principle was already advocated for the treatment of non-unions in the eighties *(25)*. Moreover some extra grafting was performed by adding the lateral malleolus in 4 patients for optimal filling of the docking site.

In none of the patients any relapse of infection or wound problem was noticed. This indicates that the bone transport does not only cure the bone but also eliminates soft tissue problems and underlying osteomyelitis.

In case of failure of the treatment of tibial non-unions, especially in combination with recurrent infections, below-knee amputation is sometimes proposed as an alternative to reconstruction. Different studies comparing the outcome of reconstruction versus amputation indicate that treatment and rehabilitation time are longer for patients undergoing reconstruction, but the impact on lifestyle is much higher in case of amputation *(1,5,9)*. Hertel et al. reported that the frequency that amputees had to be retrained to a different professional activity or had a lifetime pension because of permanent disability was three times higher than for patients with reconstructions *(8)*. On the contrary, a large American multicentre study by Bosse et al. did not show a difference in outcome after two years *(4)*. However, taking health-care economics into account, the two-year financial impact of amputation (including prosthesis related costs) was substantially higher than for limb reconstruction, especially if these expenses are projected on a lifetime *(18,27)*. Subsequent studies about reconstruction with Ilizarov bone transport show results in favor of reconstruction, both regarding results and costs *(17)*. Clear comparisons between ankle or pantalar arthrodesis and below knee amputation seem not to be available in literature. But it is acceptable that a pain free limb with good soft tissue coverage, without sensory disturbances and a good proprioception has a better outcome than an amputation, despite the loss of hind foot mobility. This view is supported by our limited study of ten patients who were all very satisfied about their limb preservation, offering them a considerable quality of life.

CONCLUSION

The repair of infected pilon tibial fractures with severe bone loss is very challenging. Bone transport with subsequent arthrodesis offers a very acceptable outcome. Neither the eradication of the infection, nor the reconstruction of the bone loss, but to obtain a union at the docking site is the most problematic part of bone transport. In case of failed healing, intramedullary nailing seems a very good option to obtain final consolidation. A retrograde transcalcaneal nail is proposed as the method of choice as all patients undergoing this treatment, obtained a fully consolidated, stable and infection free limb.

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