The Foot 33 (2017) 44–47

Contents lists available at ScienceDirect

The Foot

journal homepage: www.elsevier.com/locate/foot

# Successful treatment of infected wound dehiscence after minimally invasive locking-plate osteosynthesis of tibial pilon and calcaneal fractures by plate preservation, surgical debridement and antibiotics

Giandavide Ieropoli[a], Jorge Hugo Villafañe[b,*], Silvia Chiara Zompi[c], Umberto Morozzo[d], Riccardo D'Ambrosi[e], Federico Giuseppe Usuelli[e], Pedro Berjano[e]

[a] Istituto Ferrero, Alba, Italy
[b] IRCCS Fondazione Don Carlo Gnocchi, Milan, Italy
[c] Medicina dello Sport, Turin, Italy
[d] Ospedale San Lazzaro, Turin, Italy
[e] IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

ARTICLE INFO

*Keywords:*
Osteosynthesis
Fractures
Foot
Tibial pilon
Calcaneaus
Minimally invasive plate osteosynthesis
Infected wound

ABSTRACT

*Objective:* The aim is to present a case series that illustrates possible benefits from combining minimally invasive plate osteosynthesis (MIPO), plastic surgery and antibiotic therapy, in order to treat and eradicate infection in patients with tibial pilon or calcaneal fractures.

*Methods:* Eleven consecutive patients with dehiscence of the surgical wound in outcomes MIPO using a Locking Compression Plate (LCP) for tibial pilon, or calcaneus fractures. The patients had developed a documented infection of the surgical wound. All patients were treated and followed-up by the multidisciplinary team with the orthopedic surgeon, the plastic surgeon and the infectious disease physician. All patients were followed by the plastic surgeon to treat the wound dehiscence, as well as by the orthopedic surgeon until fracture consolidation. The duration of the antibiotic therapy was from 4 to 6 months. After 6 weeks, the intravenous treatment was replaced by oral administration. The follow-up intervals were 15 days, 40 days, and 3 months.

*Results:* The average time of wound closure was 109 ± 60 days. The antibiotics used were chosen according to the antibiogram. The antibiotic therapy had a duration of 4–6 months, and after 6 weeks, the therapy switched to oral administration. At the 3-month follow-up, all patients had excellent outcomes and had returned to their normal activity of daily living.

*Conclusion:* The patients in this study responded positively to a combination of MIPO, plastic surgery and antibiotic therapy, confirming that multidisplinary treatment in association with titanium devices are able to eradicate infection in short time.

## 1. Introduction

Soft tissues around the distal lower limb (distal leg, ankle and heel) are easily compromised by trauma and subsequent operative fracture treatment; in tibial pilon fractures this rate is about 2%, while in calcaneus fractures this percentage can still occur in up to 25% of patients [1–4].

The coverage of these bones is formed by a thin layer of soft tissue, by integuments and tendons, and lacks a complete muscle girdle that can provide mechanical coverage and vasculature [5–7]. The, poorly vascularised tissue covering these areas, mostly suffer the traumatic insult and therefore badly support the ischemic damage due to surgical access, especially if the tissue edema is substantial [8]. Open reduction and internal fixation involve the use of internal fixation devices necessary to stabilize the fracture for a period of time sufficient to allow the consolidation of the bone [9]. In these patients, the fixation device is a foreign body which creates ideal conditions for bacterial contamination. In addition, implants can provide an inert surface prone to induce bacterial adhesion and biofilm production. Previous studies have confirmed that the foreign bodies can complicate effective treatment of infections [10]. As for the infection pathogenesis associated to means of synthesis, these are usually caused by microorganisms growing in biofilms, a strongly hydrated extracellular matrix, which adheres to the surface of implants and fixation devices [11].

* Corresponding author at: Piazzale Morandi, 6 (20161), Milan, Italy.
*E-mail addresses:* ieropoli.giandavide@gmail.com (G. Ieropoli), mail@villafane.it (J.H. Villafañe), silviachiara.z@gmail.com (S.C. Zompi), umberto.morozzo@gmail.com (U. Morozzo), riccardo.dambrosi@hotmail.it (R. D'Ambrosi), fusuelli@gmail.com (F.G. Usuelli), pberjano@gmail.com (P. Berjano).

http://dx.doi.org/10.1016/j.foot.2017.10.001
Received 8 April 2017; Received in revised form 7 August 2017; Accepted 19 October 2017

Biofilms grow slowly and can resist a cellular and humoral immune response, and there are different mechanisms to make the bacteria within the biofilm less sensitive to antimicrobial agents: bacterial adhesion and the low rate of bacterial growth [12].

Bacteria present in biofilm resist antibiotic therapy by two mechanisms, the inability of microbial agents to penetrate the biofilm and the presence of a bacterial population that remains in a stationary phase of growth. The elimination of metabolic substances and/or accumulation of waste products in the biofilm causes those microbes to enter into an adynamic state that makes them become 1000 times more resistant to antimicrobial agents compared to their counterparts which do not form parts of a biofilm [13,14]. Infections after internal fixation are classified into early (less than 2 weeks), delayed (2–10 weeks) and late onset (over 10 weeks) [15]. For these reasons, the presence of a foreign body leads to a significant increase of the rate of infection. Soft tissue management, in these cases, is generally oriented to the early removal of fixation devices in order to treat the underlying infection; if bone healing is not reached, serious complications from an orthopedic and rehabilitation point of view may arise. The aim of the current study is to present a case series that illustrates possible benefits from combining minimally invasive plate osteosynthesis (MIPO), plastic surgery and antibiotic therapy, in order to eradicate infection in patients with tibial pilon or calcaneus fractures.

## 2. Methods

### 2.1. Materials and methods

Between July 2007 and December 2011, 11 consecutive patients, between 27 and 63 years of age (mean ± SD age: 45 ± 10 years; 27% female), with dehiscence of the surgical wound after MIPO using a Locking Compression Plate (LCP) tibial pilon or calcaneus fractures were recruited from the Department of Traumatology. Patients with type-IIIB or IIIC fractures, according to the Gustilo classification [15], with infection, with old fractures (> 4 weeks), complex pilon fractures (AO 43C3), talar fracture and pathological fractures were excluded from the study. The causes of the injuries were vehicular accidents (n = 2) and falls (n = 9). Nine patients had calcaneal fractures, and 2 of them had pilon tibial fractures. According to the AO classification, the pilon fractures were classified for one patient as AO 43B3, and for the other one as AO 43C2. The calcaneal fractures were classified according to Sanders classification: 3 were type 2A, 1 was 2B, 4 were 2C and 1 was type 3, see Table 1 [16]. Most fractures were closed and only one was exposed and classified as Gustilo type-II fractures. Six patients injured the left side. Open fractures were classified according to the Gustilo & Anderson classification [15]. The 2 patients with pilon tibial fractures had associated fractures of the distal shaft of the ipsilateral fibula (AO type 42A), which were always treated with LCP.

Informed consent was obtained from all participants, and all procedures were conducted according to the Declaration of Helsinki.

**Table 1**
Classication of fractures.

| Classification of patients fractures | |
|---|---|
| Pilon tibial fractures | AO classification |
| 1 | 43B3 |
| 1 | 43C2 |
| Calcaneal fractures | Sanders classification |
| 3 | 2A |
| 1 | 2B |
| 4 | 2C |
| 1 | 3 |

### 2.2. Intervention

#### 2.2.1. Surgical technique

*2.2.1.1. Pilon fractures*. The synthesis of the fibula returns to the correct length at the ankle and provides stability to the synthesis, and it is considered basic if the fibular fracture is at the same level of the tibial fracture. In both cases we performed first fibula reduction and synthesis due to the type of fracture [17].

The plate osteosynthesis of fibula, if deemed necessary, was performed with standard open. In one case of severely comminuted fracture, a LCP 3.5. mm plate, following the principles of MIPO, was used, trying to exclusively reestablish length and alignment.

*2.2.1.1.1. Osteosynthesis of the tibia*. The choice of fixation for the tibia was based on the typology of the fracture in accordance with AO principles. In comminuted fractures, the fixation was performed with elastic "bridging" technique aiming to a closed fracture alignment and fixation with a 4.5 mm LCP or 3.5–4.5 mm metaphyseal plate, percutaneously. In case of single fractures, a limited access to the fracture site is preferred, in order to place 4.5-mm screws for interfragmentary compression, followed by buttressing with a 4.5 mm LCP or metaphyseal plate, percutaneously inserted [17]. In all cases, closed reduction and minimally antero-medial access were performed.

*2.2.1.2. Calcaneus fractures*. The calcaneal fracture has been treated with a LCP plate inserted through a minimally invasive lateral approach [16].

*2.2.1.2.1. Treatment of infection*. Topical wound treatment was performed as a first step. When it was needed, surgical treatment of the wound was considered. Medical therapy includes measures to maintain a moist environment, reduce infections, pain management, and remove the necrotic material [18]. For these reasons, daily wound care was required for a variable period of time, determined by the site and the extent of the surgical dehiscence injury and the patient's clinical situation.

The choice of antimicrobial agents to reduce or eradicate microorganisms, was made based on the specificity and effectiveness of the agent, its cytotoxicity to human cells, its potential to select resistant strains and its allergenicity. The variety of topical antimicrobials used were chlorhexidine, products containing iodine (cadexomer iodine and povidone iodine) and products made of silver (silver sulfadiazine and silver-impregnated dressings) [19].

Simultaneously, a systemic antibiotic therapy was initiated. The choice of antibiotic was dictated by the result of antibiograms made on every patient. Antibiogram was negative for one patient. See Table 2.

Duration of antibiotic therapy was from 4 to 6 months. After 6 weeks, the intravenous treatment was replaced by oral administration.

Depending on the situation of the wound and the production of exudate, different dressings were used, consisting of polyurethane sponges for topical use [20,21] which are used in advanced dressings associated with silver-based solutions to create the ideal moist environment and reduce bacterial load. See Table 3.

When needed careful surgical debridement was performed by a plastic surgeon [22], performed immediately after the onset of signs and symptoms of infection to avoid the potential formation of biofilms of the pathogen infecting and then the subsequent resistance to antimicrobial therapy. Debridement surgery consisted in removing all the devitalized tissue and debris. Indications for wound revision were local pain, erythema, edema, skin pain, purulent secretion serum and fever for more than 3 days greater than 38.5°.

### 2.3. Study protocol

All subjects were treated by the multidisciplinary team formed by the orthopedic surgeon, the plastic surgeon and the infectious disease physician. Each subject underwent MIPO using for tibial pilon or calcaneal fracture. All patients had developed a documented infection of