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Determination of Pathogens in Postoperative Wound Infection After Surgically Reduced Calcaneal Fractures and Implications for Prophylaxis and Treatment

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ABSTRACT

High rates of postoperative wound infection (POWI) have been reported after surgery for calcaneal fractures. This is a retrospective cohort study to determine the causative pathogens of these infections and subsequent treatment strategies. In addition, microbacterial growth from superficial wound swabs and deep fluid or tissue cultures were compared. Patients with a unilateral surgically treated calcaneal fracture during a 15-year period were included. Patient, fracture, and surgical characteristics were collected from the electronic medical records. An infection was categorized as deep or superficial using the Centers for Disease Control and Prevention criteria. Secondary outcomes were wound edge necrosis and wound dehiscence. The collection of culture swabs, their results, and treatment strategies were documented. Of 357 patients, 92 (26%) developed a POWI; 55 (60%) deep and 37 (40%) superficial. The most frequent causative pathogens were Enterobacteriaceae and *Staphylococcus aureus*. Of the 55 patients with deep infection, 31 (56%) were treated with intravenous antibiotics and surgical debridement, 2 (4%) with intravenous antibiotics, and 22 (40%) with implant removal. In 33 of 92 patients (36%) with a POWI, both superficial and deep cultures were obtained, with a microorganism not cultured from the superficial swab 13 (39%) times. In conclusion, we found that one quarter of patients with operative calcaneal fracture treatment developed a POWI, mainly caused by Enterobacteriaceae or *S. aureus*. Physicians should not rely on the results of superficially obtained cultures for adequate treatment of deep infection. Because the spectrum of sensitivity profiles varies greatly between hospitals and countries, we recommend empiric antibiotic treatment of both gram-positive and gram-negative microorganisms on suspicion of deep infection.

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Patients with a displaced intraarticular calcaneal fracture are often treated surgically to restore anatomy and preserve foot function (1–3). However, high rates of postoperative wound infection (POWI) from 7% to 25% have been reported after calcaneal fracture surgery (4–11). To the best of our knowledge, only limited data are available regarding the causative pathogens of POWI after calcaneal fracture surgery (6,12), with *Staphylococcus aureus* the most common microorganism isolated (12).

On suspicion of POWI, the attending physician can decide to start empirical antibiotic treatment in anticipation of the results of bacterial specification from a tissue culture. The antibiotic regimen can be changed after bacterial specification, which can sometimes require several days to 1 week. Thus, patients do not always receive adequate treatment initially. We only found 1 study of the determination of pathogens and antibiotic resistance in deep infections after operative fixation of fractures (13).

Our aim was to determine the type of causative pathogens of POWI after calcaneal fracture surgery and the subsequent treatment strategies. We hypothesized that most infections would be caused by *S. aureus*. In addition, we compared the microbacterial growth from superficial wound swabs and deep fluid or tissue cultures.

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Patients and Methods

We performed a retrospective cohort study of patients treated at a level 1 trauma center from January 2000 to June 2014 (n = 357). The inclusion criteria were adult patients who had undergone surgery for a displaced intraarticular calcaneal fracture with open reduction and internal fixation using the extended lateral approach or sinus tarsi approach, with percutaneous or external fixation. The exclusion criteria were bilateral calcaneal fracture surgery, the presence of a wound infection preoperatively, reconstructive surgery after initial nonoperative treatment of a calcaneal fracture. The minimal follow-up period was 6 months. The institutional review board approved the study and waived the need for informed consent.

Clinical Data

Data were obtained from the hospital's electronic medical records. A search was performed from January 2000 to June 2014 using the surgical code 338732 (Current Procedural Terminology, American Medical Association, Chicago, IL). In addition, a manual search was performed using the keyword calcaneus. We recorded the patient characteristics (i.e., gender, age at surgery, and type of fracture [open or closed]), surgical characteristics (i.e., type of approach for the primary procedure subdivided as the extended lateral approach, sinus tarsi approach, or minimally invasive or percutaneous approach), and external fixation before open reduction and internal fixation.

Outcomes

The occurrence of POWI, the causative pathogens, and subsequent treatment strategies were documented. Data on wound edge necrosis and wound dehiscence were also collected.

POWI was classified using the criteria from the US Centers for Disease Control and Prevention and further subdivided as deep or superficial (14,15). Superficial wound infections were wounds with signs of infection amenable for conservative treatment with antibiotics. Deep wound infections were confirmed by positive culture findings and defined as osteomyelitis, infected hardware or plate–fistula requiring implant removal, and readmission for intravenous antibiotics or wound debridement with or without local antibiotic treatment with gentamicin beads or vacuum-assisted closure. The medical records and database of the microbiology department were available for data collection regarding the cultures.

Different treatment strategies were distinguished from the medical records. For superficial POWI, oral antibiotics or local nonantibiotic wound care was used, and for deep POWI, intravenous (IV) antibiotics, surgical debridement with IV antibiotics, or implant removal with debridement and IV antibiotics were used.

Culture Swabs

In the case of suspicion of a superficial POWI, bacterial specimens were obtained by wound swabs (using cotton-tipped swabs in Amies transport medium; Medical Wire & Equipment, Corsham, UK). In the case of suspicion of a deep POWI, tissue or purulent fluid samples were collected in sterile containers during surgical debridement or implant removal for ongoing infection. The specimens were sent to the laboratory for aerobic and anaerobic culture. The wound swabs were cultured on several agar plates (Biomerieux, Marcy l'Etoile, France) and incubated for 4 days. The pathogens, including *Staphylococcus aureus*, *Streptococcus*, *Pseudomonas*, and yeasts, were identified by mass spectrometry (Malditof; Bruker, Karlsruhe, Germany). Flora considered as commensal bacteria were also recorded (e.g., skin flora or coliform rods). Tissue and fluid samples were cultured on several agar plates and in a thioglycollate broth and incubated for 7 days. All bacterial growth was identified and reported. Gram staining was performed for all tissue and fluid cultures and for wound swabs only when a slide was sampled.

If bacterial growth was observed in the wound and intraoperatively collected samples, only the result of the intraoperative tissue culture was used for determination of the causative organism.

Surgical Procedure

Single-dose IV prophylactic antibiotics were administered to all patients preoperatively (1500 mg cefuroxime or 1000 mg cefazolin). Patients with an open fracture received extended IV antibiotic prophylaxis for a maximum of 3 days (cefazolin for Gustilo grade 1 and 2 and cefazolin and gentamicin for grade 3) on hospital admission. Wound closure was performed with either subcuticular Vicryl sutures combined with Steri-Strips (3M, St. Paul, MN) and/or Allgöwer-Donati Ethilon sutures (Ethicon, Division of Johnson & Johnson, Somerville, NJ), with placement of a closed suction drain (8 Fr) according to surgeon preference. This drain was removed postoperatively when drainage was <30 mL in the previous 24 hours or after a maximum of 48 hours. All patients were hospitalized after primary surgery. The patients were discharged when their pain was under control. All patients remained non-weightbearing for a period of 8 to 12 weeks postoperatively.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences, version 22.0 (IBM Corp., Armonk, NY). Normality of continuous data was tested using the Kolmogorov-Smirnov test and by inspecting the frequency distributions (histograms). Descriptive analysis was performed to compare the baseline characteristics between patients with and without POWIs. Categorical variables are presented as counts and proportions and continuous variables as mean ± standard deviation or median and interquartile range (IQR), as appropriate. A χ^2 test was used to test for differences in categorical variables and an independent *t* test or Mann-Whitney *U* test for differences in continuous variables, where appropriate. Univariate analysis was performed to compare gender, age, fracture type, and type of approach for patients with and without POWI and with and without deep POWI. Statistical significance was defined at the 5% ($p \leq .05$) level.

Results

A total of 357 patients were included. The baseline characteristics are listed in Table 1. Of these 357 patients, 92 (25.8%) had a POWI, of which 55 (60%) were deep and 37 (40%) were superficial (Fig. 1). Of the 21 patients with an open calcaneal fracture, 14 (67%) had a POWI, of which 71% were deep and 29% superficial. In contrast, 78 of 336 patients with a closed fracture (23%) developed a POWI, of which 58% were deep and 42% superficial ($p \leq .05$; Table 1). A total of 21 patients (6%) had wound edge necrosis or wound dehiscence without signs of infection.

The 3 most frequently cultured microorganisms in patients with a POWI were Enterobacteriaceae, *S. aureus*, and *Streptococcus*. In patients with a deep POWI, the corresponding proportions were 56%, 33%, and 7% and in patients with a superficial POWI were 38%, 51%, and 3% (Fig. 2). In 36 cultures (41%), growth of >1 microorganism was

Table 1
Baseline patient characteristics (N = 357 patients)

Baseline Characteristic	Patients	POWI	*p* Value (2 Sided)	Deep POWI	*p* Value (2 Sided)
Patient			NS		NS
Male gender	245/357 (68.6)	60/245 (24.5)		40/55 (16.3)	
Age (y)	12-77 (44)	14-75 (46)		14-69 (44)	
Fracture*			< .001		< .001
Open	21/357 (5.9)	14/21 (66.7)		10/21 (47.6)	
Closed	335/357 (93.8)	78/335 (23.3)		45/335 (13.4)	
Treatment†			.006		NS
ELA, STA, percutaneous	343/357 (96.1)	84/343 (24.5)		46/343 (13.4)	
External fixation	12/357 (3.4)	8/12 (66.7)		7/12 (58.3)	

Data presented as n/N (%) or range (median).
Abbreviations: ELA, extended lateral approach; NS, not significant; POWI, postoperative wound infection; STA, sinus tarsi approach.
* Missing data for 1 patient.
† Missing data for 2 patients.

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