Wound Healing Complications in Closed and Open Calcaneal Fractures

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Objectives: To determine the rate of serious infection in closed and open calcaneal fractures that were treated with open reduction and internal fixation (ORIF) via an extensile lateral approach.

Design: Retrospective review.

Setting: Level 1 trauma center.

Patients: Two groups of patients with calcaneal fractures treated with ORIF via an extensile lateral approach by the senior author are included. The first group contained 341 closed fractures in patients injured during the period 1994–2000. The second group included 39 open calcaneal fractures in patients injured during the period 1989–2000.

Main Outcome Measurements: The age, sex, pre-existing medical conditions, compliance history, mechanism of injury, soft tissue status, presence of serious infection, and treatment of the infection were recorded for each patient. Data were gathered by review of patient records and by telephone interview when medical records were incomplete. The rate of serious infection in the closed and open samples was determined. A literature review yielded 15 reports that contained sufficient detail to calculate the rate of serious infection.

Results: Of patients, 1.8% with closed fractures and 7.7% with open fractures experienced serious infections that required intervention beyond oral antibiotics. All of these feet eventually healed their incisions and fractures. The calculations from data obtained from the literature review indicate rates of serious infection of 0–20% for closed and 19–31% for open calcaneal fractures.

Conclusions: When done correctly in compliant patients, ORIF for calcaneal fractures via the extensile lateral approach (which allows for restoration of calcaneal anatomy after substantial disruption) does not expose the patient to undue risk of serious infection.

Key Words: calcaneus, fracture, wound healing, ORIF, open reduction, internal fixation

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The orthopaedic community continues to debate whether operative intervention in calcaneal fractures is appropriate.[1,2] One of the principal reasons cited for treating this injury with closed or limited approaches is the belief that operative intervention does not improve the outcome for some patient groups (eg, children[3] or patients with simple fractures[4]). Empirical evidence suggests, however, that restoration of calcaneal anatomy is the only way patients can have a normal gait[5] or normal joint contact pressures.[6] We believe that the accepted treatment of fractures in other weight-bearing joints—anatomic reduction, stable internal fixation, atraumatic surgical technique, and early mobilization—is equally appropriate for calcaneal fractures and that the extensile lateral approach is the best exposure for anatomic reconstruction.

Even when orthopaedic traumatologists acknowledge that restoration of calcaneal anatomy is important, the possibility of serious infection can discourage them from advocating operative intervention. Reports[7–20] in the literature have indicated disparity in the rate of infection associated with open reduction and internal fixation (ORIF), even when an extensile lateral approach is used. The utility of these reports is limited by several factors, including small sample sizes, short follow-up times, multiple surgeons, or multiple approaches. To address these issues, we report herein on the rate of serious infection in 341 closed and 39 open calcaneal fractures treated by the senior author with ORIF via an extensile lateral approach and a two-layer closure.

MATERIALS AND METHODS

Our samples consisted of 341 closed displaced calcaneal fractures in 322 patients injured from 1994 to 2000 and 39 open fractures in 38 patients injured from 1989 to 2000. The open fracture sample includes a larger time frame to increase the total sample size. All fractures were treated by the senior author in a Level 1 trauma facility.

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Sample Selection

All patients with calcaneal fractures that were treated by the senior author from January 1, 1994, to December 31, 2000, were retrieved from our institution's orthopaedic trauma database. A total of 371 fractures initially were obtained; 30 of these were excluded because they were treated with a treatment approach other than ORIF via the extensile lateral approach due to the nature of the injury or patient. No serious infections were seen in these eliminated 30 fractures. The same trauma database was queried for all open calcaneal fractures from January 1, 1989, to December 31, 2000. A total of 46 fractures were obtained, and 7 were eliminated because of a treatment approach other than ORIF through an extensile lateral incision. All necessary amputations were performed emergently. The open sample included 3 wounds classified as O1, 14 as O2, 19 as O3A, and 3 as O3B.[21]

Treatment

All selected fractures were managed with ORIF via an extensile lateral approach. The proximate goal for each reduction was the restoration of (1) calcaneal height, width, and length; (2) the articular surface of the anterior, middle, and posterior facets; (3) the anatomic relationship of all three subtalar joint surfaces; and (4) the correct orientation of the tuberosity. Re-establishing the height, width, length, and tuberosity orientation involved gross anatomic reduction, whereas restoring the relationship of the articular surfaces required microreduction of the anterior fragments to the body and reconstruction of the critical angle of Gissane. Anatomic reduction was achieved in all fractures. All incisions were closed with a two-layer approach, using inverted mattress sutures in the deep layer and a horizontal modification of the Allgöwer-Donati suture in the superficial layer. A bulky dressing was applied, and the limb was placed in a well-padded splint with the ankle in a neutral position and slight forefoot pronation to lock the subtalar joint. Intravenous antibiotics were administered during surgery, and oral antibiotics (typically trimethoprim/sulfamethoxazole [Bactrim DS]) were prescribed for patients whose incisions were not sealed at the time of discharge (usually 3 days after surgery) or who subsequently presented with any symptom diagnostic of infection. Nasal oxygen was used until the patient's oxygen saturation reached 100% on room air. Patients were non–weight bearing for a minimum of 3 months and were seen by a physical therapist while in the hospital and during the transition from non– to full–weight bearing.[22,23]

Data

Data were gathered from the patient's medical records and, when the follow-up time was less than 1 year, from a telephone interview between the senior author and the patient. A minimum follow-up of 1 year was necessary because infections can appear spontaneously months after primary healing is complete. The descriptive statistics of the sample are given in Table 1, including age, sex, pre-existing medical conditions, compliance history, mechanism of injury, soft tissue status, presence of serious infection, and treatment of that infection.

Compliance

Noncompliance was noted when a patient failed to conform to physician orders. Typical noncompliance included smoking before surgery or during the first 3 postoperative months, failure to take prescribed antibiotics, and weight bearing before cleared to do so. In all cases of noncompliance, the events were noted in the medical record (eg, "broken splint due to weight bearing").

Outcome

Patients requiring treatment beyond oral antibiotics were classified as having serious infections. Symptoms included persistent serous discharge, erythema, diffuse cellulites, and other evidence of infection. Treatments for patients with serious infections included courses of intravenous antibiotics appropriate to the infectious organism, irrigation and débridement procedures, and hardware removal (Table 2). Hardware that was removed due to prominence was not counted as indicative of serious infection. All of our patients with serious infections went on to heal their incisions and their calcaneal fractures. No patient required amputation.

Literature Review

We reviewed the (1998 and later) literature on calcaneal fractures treated with ORIF for reports with details that included number of patients and infections, the characteristics of the infection, and the treatment protocols for serious infections. Table 3 lists the studies that met our criteria. We calculated a rate of serious infection for each published study, counting as *serious* any infection that required hospitalization, surgery, or intravenous antibiotics after the initial fixation. We avoided using *superficial* and *deep* as descriptors of infection because the usage of these terms is not consistent in the literature. We assumed that when delivery method was not given, oral antibiotics were administered; that when soft tissue status was not explicitly stated, the fractures were closed; and that ultimate treatments were listed (ie, a patient with an amputation may have had courses of intravenous antibiotics and irrigation and débridements, but was listed only under the amputation category).

Statistical Analysis

We present no statistical analyses due to the small sample size of patients with serious infections.

RESULTS

In this study, 335 of 341 closed fractures and 36 of 39 open fractures healed without intervention other than oral an-

TABLE 1. Patient Characteristics

	Closed	Open
Patient statistics		
No. displaced calcaneal fractures	341	39
No. patients	304	38
No. males	245	24
No. females	59	15
Average age in years (range)	39 (3–74)	38 (5–77)
No. feet of smokers	107	6
No. feet of diabetics	10	0
No. feet of patients with questionable compliance	32	10
No. feet of patients involved in L&I claims	84	7
Injury statistics		
No. left calcanei	165	14
No. right calcanei	176	25
No. bilateral fractures	37	0
No. tongue-type fractures	134	14
No. joint depression fractures	192	23
No. other fracture types	36	2
No. with fracture blisters	32	2
No. injuries caused by falls	276	19
No. injuries caused by motor vehicle accidents	61	18
No. injuries caused by other accidents	4	2
Treatment statistics		
Average time to surgery in days (range)	14 (0–222)	15 (1–29)
No. feet with bone grafts (allograft)	226	24
No. patients who received oral antibiotics at discharge	160*	16†
Clinical outcome		
Average follow-up time in years	1.8 (1–10)	3.1 (1–10)
No. feet with hardware removal	132	19
Average time to hardware removal in years (range)	1.4 (0.7–5.5)	1.6 (0.9–2.7)
No. feet whose incisions healed without intervention	335	36
No. feet requiring intervention to heal	6	3

*Of 333 patients for whom data are available.
†Of 35 patients for whom data are available.

tibiotics. Six closed (1.8%) and three open (7.7%) fractures required additional interventions, although all eventually healed. The care of the patients who required intervention is given in comprehensive detail in this section and summarized in Table 2.

Infections in the Closed Sample

The first patient (A) required an irrigation and débridement of a hematoma 14 days after the initial ORIF. This relatively aggressive treatment was indicated because the patient had concurrent bilateral tibial fractures, was positive for hepatitis B and C, and had a recent history of intravenous drug abuse and needle sharing. After this procedure was completed, the patient exhibited a typical progression of healing. Another patient (B), who was nondiabetic, nonsmoking, and compliant, experienced persistent drainage from the apex of his lateral incision, developed erythema at 4 months, and required hospitalization to administer intravenous antibiotics (cefazolin [Kefzol]). Cultures showed polymicrobial growth. The drainage resolved after the intravenous antibiotic course, and the incision was healed and dry by 7 months after the initial surgery. The next patient (C) with a closed fracture had significant compliance problems, breaking five splints by weight bearing in the first 2 months after surgery. This homeless individual was hospitalized for cellulitis and received intravenous antibiotics (vancomycin and gentamicin). He was referred to a nursing facility until he was able to bear weight and healed without further incident.

TABLE 2. Patients requiring interventions beyond oral antibiotics

	Patient	Complication	Treatment	Comments
Closed	A	Hematoma	I&D	
	B	Erythema	IV antibiotics	
	C	Cellulitis	IV antibiotics	Noncompliance
	D	Deep infection	I&D, IV antibiotics, hardware removal	Posterior sore
	E	Cellulitis	IV antibiotics, hardware removal	Care elsewhere
	F	Cellulitis	IV antibiotics, hardware removal	Noncompliance
Open	G	Deep infection	Hardware removal	
	H	Cellulitis	IV antibiotics	Noncompliance
	I	Cellulitis	Sinus tract excision, antibiotic beads	

Three patients required hardware removal before their surgical incisions healed, although the hardware was retained in each until consolidation of the fracture was complete. The first of these patients (D) presented for initial treatment with a posterior sore on his heel of uncertain etiology and required ORIF for a second metatarsal fracture in addition to the calcaneal fracture. His surgical incision healed well, but he ultimately became infected with *Staphylococcus aureus* through the posterior sore. He developed a deep infection and required two episodes of irrigation and débridement with intravenous antibiotics (vancomycin). His hardware was removed at slightly less than 10 months from the initial surgery, and his foot healed without further complications.

The next patient (E), a diabetic with bilateral fractures, was referred from an out-of-town clinic and consequently received most of his follow-up care in a setting other than our facility. At the time of discharge from the initial ORIF, his incisions appeared to be in excellent condition. At his 6-week and 4-month follow-up appointments with us, however, the apex of the surgical incision on the right foot was not healed completely. He was treated with intravenous antibiotics (cefazolin and gentamicin) for *Staphylococcus* and experienced drainage and intermittent cellulitic symptoms until his hard-

TABLE 3. Reports of Infection Rates for Lateral Extensile ORIF (1998–2002)

Soft Tissue Status	Reference	Sample Size: No. Fractures (No. Patients)	Serious Infection Rates* % (No.)	Average Time of Follow-up in Years
Closed	Stiegelmar et al,[18] 2001	13 (13)	0	5.8
	Huang et al,[14] 2002	32 (30)	0	2.9
	Geel and Flemister,[12] 2000	33 (29)	3% (1)	1.7
	Raymakers et al,[16] 1998	33 (31)	0	4.5
	Assous and Bharma,[9] 2000	40 (40)	20% (8)	2.3
	Tennent et al,[20] 2001	51 (47)	7.8% (4)	3.7
	Strømsøe et al,[19] 1998	52 (46)	5.8% (3)	1.8
	Shuler et al,[17] 2001	63 (62)	7.9% (5)	>0.5
	Naovaratanophas and Thepcharti,[15] 2001	114 (98)	2.6% (3)	6.8
Combined	Al-Mudhaffar et al,[8] 2000	33 (30)	9% (2)	
	Aktuglu and Aydogan,[7] 2002	35 (28)	0	3.2
	Brenner et al,[10] 2001	178 (178)	4.5% (8)	
	Folk et al,[11] 1999	190 (179)	21% (40)	
	Harvey et al,[13] 2001	218 (181)	1.8% (4)	>0.4
Open	Brenner et al,[10] 2001	26 (26)	19% (5)	>0.8
	Heier et al,[24] 1999	35 (?)	31% (11)	4.6

**Serious* infections are those that require a more extensive intervention than the administration of oral antibiotics. These infections are listed variously using terms such as *hospitalization required, surgical procedure,* and *IV antibiotics.* Also included under this category are infections that required hardware removal before the infection would heal. In general, *superficial* infections are those for which oral antibiotics are sufficient. These are not included in this table.

ware was removed 9 months after surgery. After hardware removal, he healed uneventfully.

Another patient (F) experienced persistent drainage from his incision that required intravenous antibiotics (gentamicin and cefazolin) on two occasions. This patient had significant compliance problems, including refusal to take oral antibiotics consistently, to quit smoking, or to return for follow-up appointments. This patient also had hepatitis C for which he refused treatment, and his wound cultures consistently grew *Staphylococcus epidermidis*. He reappeared at 1 year after his initial surgery and was noted to be cellulitic over the lateral aspect of the incision with a draining wound. His hardware was removed, and he healed without further intervention.

Infections in the Open Sample

Three patients with open fractures required treatment beyond oral antibiotics, including the case of a nonsmoking, compliant patient (G) with bilateral, medially open (O2) fractures. This patient healed his surgical incisions and open wounds by primary intention but spontaneously developed wound drainage in the vertical limb of the lateral ORIF incision 10 months after surgery. He ultimately developed a deep infection. Cultures showed coagulase-negative *S. epidermidis* and *Enterobacter cloacae*. The hardware in his left foot was removed 1 year after initial surgery, and the patient went on to heal his incision uneventfully. The right foot did not develop any wound-healing problems. Hardware on the right foot was removed 15 months after the initial surgery, and the wound healed without intervention.

The next patient (H) was treated for a right open (O3B) calcaneal fracture and left open (O3A) tibial-fibular fracture. Her incisions and her medially open wound healed. She progressed well initially but developed a habit of resting the lateral aspect of her foot against her mattress. Eventually, she developed a pressure sore over the hardware, which became infected. She could not comply with her oral antibiotic regimen. She developed cellulitis in the foot that required two courses of intravenous antibiotics (cefazolin and ciprofloxacin) for *S. aureus* before she healed. Her hardware was removed approximately 2 years after her injury due to prominence, and deep cultures from the lateral wall of the calcaneus were negative for microbial growth. The incision required to remove her hardware healed without incident.

The final patient (I) with an open fracture (O3A) and serious infection experienced intermittent apical drainage that persisted even after hardware removal. Given the option of a free flap for wound coverage, he opted for intravenous antibiotics (cefazolin and gentamicin), sinus tract excision, and antibiotic (tobramycin) bead insertion. The last-mentioned treatment resolved the drainage, and his wound has remained healed for 7 years.

DISCUSSION

Literature Review

The rate of serious infection after ORIF of closed calcaneal fractures via the extensile lateral approach was calculated from the literature and ranged from 0–20% in closed fractures (Table 3). The largest study[15] reported three deep infections in 114 fractures for a rate of 2.6%, which is comparable to our rate. The rates from the other, smaller studies also were similar to ours except for that of Assous and Bharma,[9] in which 8 of 40 (20%) fractures required hardware removal before healing. It is unclear why these investigators obtained a relatively high infection rate, but smoking is implicated as a significant risk factor for infection.

Several calcaneal series contained open and closed fractures, with rates of serious infection ranging from 0–21% (Table 3). The largest series[13] contained some crossover with our series. It differed from our study in that their follow-up time was relatively short (≥5 months), and multiple surgeons were involved. The next two largest studies reported 8 infections in 178 fractures (4.5%)[10] and 40 in 190 fractures (21%).[11] It is unclear why Folk et al[11] experienced relatively high infection rates, although they mentioned diabetes, smoking, and open wounds as risk factors for infection.

Two reports on infection in open calcaneal fractures are available. The study of Brenner et al,[10] mentioned previously, focused on complex foot trauma but included data specific to their calcaneal fractures. They had a 19% infection rate in open fractures treated with delayed soft tissue closure. The report from Heier et al,[24] in which a 31% infection rate was reported, was published only in abstract form, and consequently many details are not available.

Although we were unable to use statistics because our sample sizes for serious infections were too small, we can comment anecdotally on what situations are problematic in this large group of patients. The single biggest issue precluding wound healing without infection is patient noncompliance. One third of our infections occurred in patients with significant noncompliance, including inconsistent use of oral antibiotics. Although noncompliance is a contraindication to surgical intervention, other frequently cited contraindications were managed successfully in this series. For instance, diabetes has been mentioned as a risk factor for infection,[11,20] but none of our 10 patients with diabetes experienced serious infections. Another potential problem is exposure to infections from sources in the body distant from the calcaneus. Intravenous drug use is a known exposure risk, but other seemingly benign behaviors, such as extensive dental work, can pose risks. The patient with the bilaterally open case that we mention may have seeded his calcaneal plate from dental work.

Our infection rates of 1.8% for closed and 7.7% for open fractures are comparable to the low end of the distribution of the series reported in the orthopaedic literature. Our experi-

ences combined with those of other institutions suggest that it is possible to minimize the chance of serious infection after ORIF of calcaneal fractures. We conclude that the possibility of serious infection should not contraindicate treating calcaneal fractures similar to any other fracture in a weight-bearing joint—with anatomic reduction, stable internal fixation, atraumatic surgical technique, and early mobilization.

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