The extended lateral approach for intra-articular calcaneal fractures:

An inverse relation between surgeon's experience and wound complications

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Keywords

Calcaneal fracture; Wound complication; Closure technique; Subcuticular; Surgeon volume

Abstract

Introduction: The current 'Gold standard' in the treatment of displaced intra-articular calcaneal fractures is open reduction and internal fixation (ORIF) via an extended lateral approach. In the current retrospective study we evaluated the results of a consecutive series of patients treated in the same fashion using a subcuticular single-layer closure technique and determine risk factors for the development of wound complications.

***Patients and Methods*:** Retrospective study of a consecutive series of patients treated using ORIF via an extended lateral approach and a subcuticular single-layer closure technique between June 2005 and September 2011. The rate of wound complications was determined. Also, we assessed which patient, fracture and surgical characteristics affected these complications.

***Results*:** During the 75 months study period we operated on 53 displaced intra-articular calcaneal fractures in 50 patients using the extended lateral approach. The incision was closed using the subcuticular technique in 49 cases. In the subcuticular closure group two (4.1%) deep infections and two (4.1%) superficial wound complications (one dehiscence and one infection) occurred. Wound-edge or flap necrosis were not encountered. The use of bone-void filler and the experience of the surgical team were associated with wound complications.

***Conclusions*:** The subcuticular single-layer suture technique is a suitable closure technique in the treatment of displaced intra-articular calcaneal fractures. It is associated with a low complication rate in combination with the extended lateral approach. The effect of bone void fillers on complications should receive more attention in future research. The association between wound complications and the level of experience of the surgical team supports a need for centralization of this complex injury.

Introduction

Currently, open reduction and internal fixation (ORIF) is generally considered the best available approach for restoring the overall anatomy of the calcaneus and to reconstruct the posterior talocalcaneal (subtalar) joint following a displaced intra-articular calcaneal fracture. This technique, combined with the extended lateral incision, provides overall good results considering outcome and the lowest rates of secondary arthrodesis, making it the 'Gold-standard' in calcaneal fracture surgery.

The extended lateral approach has been subject of various different studies, mainly because of the single largest drawback of this technique: the high percentage of superficial and deep wound complications [1-4]. The idea behind the marked number of wound complications is an impaired microvascularization due to the initial trauma [5-6]. This has been confirmed by measuring a significantly reduced pO2 of the lateral skin following a calcaneal fracture [7]. Improvements have been made in the understanding of the vascular anatomy of the lateral aspect of the hindfoot [8-14], while others have emphasized the use of alternate skin incisions [7] [15-18] or percutaneous reduction. Effects of the closure technique on wound healing and complications in the extended lateral approach for displaced intra-articular calcaneal fractures have rarely been reported.

An infrequently used closure technique is the absorbable subcuticular suture of the extended lateral incision [19]. In the current study we investigated the results of the subcuticular single-layer closure technique, which has been the favored technique at our clinic. The second aim was to determine associations between patient, fracture and surgical factors in the development of wound complications.

Patients and Methods

All consecutive displaced intra-articular calcaneal fractures treated between June 2005 and September 2011 with open reduction and internal fixation through an extended lateral approach were included in this retrospective case series. Since June 2005 we started using ORIF with the subcuticular single-layer closure technique. Cases from the same period treated conservatively (N = 24), percutaneously (N = 25) or with a follow-up of less than one month (N = 2) were excluded from further analysis.

Clinical data

The following clinical data were obtained from the electronic hospital database:
Patient characteristics: age at trauma, gender, Body Mass Index, smoking behavior, and diabetes.
Fracture characteristics: affected side and type of fracture (Essex-Lopresti and Sanders classification), difference in Böhlers angle pre and post surgery,
Surgical characteristics: time to surgery, duration of tourniquet use, surgical team and total number of open reduction and internal fixation of calcaneal fractures performed by this team (team strength), use of a bone filler, placement of a closed suction drain, closure technique occurrence of a wound complication, and type of wound complication.

Wound complications were divided into superficial or minor and deep or major infectious complications by applying the criteria of the Centers for Disease Control and Prevention (CDC) for defining a surgical site infection [20]. Minor complications were defined as wound dehiscence or superficial surgical wound infection (proven by culture) treatable with conservative management like oral antibiotics only, without the need for intervention or re-

admission. Major complications were defined as a deep infection, *e.g.*, osteomyelitis, infected implant or plate-fistula, in need for intervention, like intravenous antibiotics, removal of hardware, wound debridement with or without vacuum assisted closure, or re-admission. The differentiation between superficial and deep infection was made by the surgeon or attending physician.

Surgical procedure

Pre-operatively the injured leg is elevated on a pillow, or edema is reduced using an intermitted pneumatic pedal compression devise (AV-impulse® foot pump). Frequently patients remained at the surgical ward until surgery. Every day the skin is inspected for the wrinkle-sign. Patient who remained at home were planned for surgery 5-7 days after injury, upon inspection of the skin at the Outpatient Department. Upon receiving a third generation cephalosporin, patients are placed on the contra-lateral side. A tourniquet is subsequently inflated between 250 and 300 mmHg. In most cases a sharp 100 to 110 degrees angled incision is used, with the vertical limb almost on the lateral edge of the Achilles tendon. The straight horizontal limb is placed at the level where smooth skin of the lateral aspect changes into more rough skin from the plantar aspect of the foot (glabrous junction) aimed just below the tip of the fifth metatarsal [15]. Some surgeon dependent minor modifications were: in some cases a more rounded angle, a 90 degrees angle, or incisions more at one third the distance Achilles tendon-posterior aspect of the fibula [21]. A full-thickness flap is then created, which contains the sural nerve and peroneal tendons. This flap is retracted using two or three 2mm Kirschner wires drilled into the talus. With the use of various reduction tools (*e.g.*, periosteal elevator, Steinmann pin from posterior, Schanz pin from lateral/distal tip of the tuberosity, or laminar spreader) the overall anatomy (*i.e.*, height, width, and varus deformity) is corrected. This reduction is provisionally maintained with several K-wires. Subsequently, the posterior

talocalcaneal facet is reduced and held with one or two K-wires. In four cases an augmentation was applied, using a synthetic, biodegradable, calcium-phosphate based bone substitute (Calcibon®, Biomet, Dordrecht, the Netherlands). The procedure is regularly monitored radiographically using lateral, Brodén, and axial views. In all cases a non-locking AO/Synthes® calcaneal plate was used with or without prior placement of one or two compression screws just beneath the subtalar joint surface. A closed suction drain (8Fr) is placed and the skin is closed using interrupted subcuticular Vicryl® 2-0 sutures at approximately 10mm intervals (Figure 1). In order to reduce any remaining tension, and ensure a vacuum for the suction drain, additional Steristrips® might be added at the discretion of the surgeon, which are left in place for three to five days. A Jones-like dressing is applied using sterile gausses, cotton wool and elastic bandage. The leg is subsequently elevated on one or two pillows for three to four days, with the heel free from pressure. The drain is, depending on production, removed after 24 to 48 hours. Active range of motion exercises are started from day three.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS, Chicago, IL). Normality of data was assessed using the Kolmogorov-Smirnov test and by inspecting frequency histograms. The Levene's test was applied in order to assess homogeneity of variance between data. Numeric data were found to be normally distributed and are expressed as mean with standard deviation (SD); categoric data are shown as numbers with percentages. A Student's T-test (parametric, numeric data) or Chi^2 analysis (categoric data) was performed in order to assess statistical significance between groups with and without complications. A p-value <0.05 was taken as threshold of statistical significance.

Results

During the 75 months study period we operated on 55 displaced intra-articular calcaneal fractures in 52 patients (three bilateral) via an extended lateral approach. The incision was closed using the subcuticular single-layer technique in 49 calcaneal fractures (46 patients) and using a different technique in four cases. Two patients had a follow-up of less than one month, without wound complications at that time and were removed from further analysis. The patient, fracture, and surgical characteristics of all 50 subjects with 53 fractures are shown in Table 1.

Out of 49 fractures closed with the subcuticular single-layer closure technique, a postoperative infection developed in four, of which three occurred in smokers. Two patients (4.1%) developed a deep infection which needed surgical debridement and removal of implants. In one of these patients a debridement was performed after 5.5 months because of a fistula towards the implant. The other patient needed several debridements: the first was done at two weeks after the initial procedure, with a sural isle flap as final treatment after four months. Cultures of the wounds in both patients showed an *Enterobacter Cloacae* and a *Streptococcus Constellatus*. Two other patients (4.1%) developed a superficial wound complication which resolved with local measures; one patient showed signs of minor wound dehiscence with negative cultures, the second developed a superficial infection with *Staphylococcus Aureus*. No signs wound-edge or flap necrosis were observed in any of the 49 fractures. In the patients where a different closure technique was used; three were closed using (Allgöwer)-Donati sutures, of which two developed a superficial infection treated with local wound care, and one was closed using a running Monocryl® suture followed by a fistula for which the plate had to be removed.

Three patients had an open fracture and one had diabetes. No wound complications occurred in these patients. None of the patient or fracture characteristics were associated with the development of an infectious complication. Nicotine abuse was not associated with complications; however, all deep infections occurred in smokers.

Fifteen surgeons performed the operations in pairs of two, during which one of four senior surgeons was present in all cases. There was no association between surgeon and the occurrence of a wound complication, nor could a learning curve be detected when comparing the first half of the patients with the second half considering complications. However, a strong association was found between the total number of procedures performed by the surgical team (team strength) and the number of complications. In the group with a wound complication the mean overall number of previous interventions by the surgical team was 13±8 fractures versus 22±9 fractures in the group of patients without a complication ($p = 0.026$; two-sided Student's t-test; equal variance not assumed).

The use of bone-void filler was significantly associated with an increased rate of infectious complication ($p < 0.001$).

Discussion

The extended lateral approach is the preferred approach in the treatment of displaced intra-articular calcaneal fractures [22]. The main limitation is the high rate of wound complications (Table 2). In the current study less than ten percent superficial and deep infections were observed when using a subcuticular closure technique with absorbable sutures. In one previous study a subcuticular closure technique in two layers was used, with one deep interrupted and one subcuticular running Monocryl® suture [19]; one out of 20 patients (5%) developed a superficial wound complication [19].

A potential limitation of the current retrospective series could be the large number of participating surgeons. Even though all procedures were performed under the supervision of one of four senior trauma surgeons, it cannot be ruled out that there were differences in the approach varying from a more direct (closer to the peroneal tendons) lateral approach [21 23] to the true extended lateral approach as described by Freeman and Atkins [15]. The latter is currently the favored approach at our clinic. With the extended lateral approach, as propagated by Atkins, one makes the incisions at the exact inter-angiosome plane where the peroneal artery (lateral calcaneal branch) and the posterior tibial artery (lateral plantar branch) angiosomes meet. The angiosome concept, derived from the work by Salmon, Taylor and Attinger [8-11], has proven helpful in the creation of the (free) lateral calcaneal flap [24]. This knowledge has been put to use in the development of the extended lateral approach [7 13 15]. Using this approach has fewer wound complications, which, more recently, has led to the propagation of the improved extended lateral approach in elective surgery to the hindfoot [25].

The strength of the current investigation is that is a consecutive group of patients, treated by different surgeons, which might make the results more generalizable. However, this study showed a statistically significant association between complications and the experience of the surgical team, in contrast to the findings by Koski *et al.* [3]. In the literature from the same time-period as our inclusions, the number of wound complications ranges from zero to approximately 14 percent for deep infections and up to 21 percent superficial wound complications in closed fractures (Table 2) [1-4 26-27]. The exact closure technique is infrequently reported in these studies. The lowest complication rates are described in the largest series, suggesting a surgeon-volume effect [28-29]. Few other associations with wound complications were identified in the current study, which is partly due to the low number of complications in a relatively small group. The current study lacked statistical power to associate smoking with deep wound complications.

Throughout the years different modified lateral approaches have been propagated for the surgery of displaced intra-articular calcaneal fractures [16-17 30]. The lateral approach has evolved from a more direct incision close to the fibula following the peroneal tendons incision [31-33], to the incision popularized in the nineties at approximately 1 cm anterior to the Achilles tendon and proximal to the glabrous skin of the sole of the foot [23 34], and finally into the current extended lateral approach [15 25]. The type of approach has been linked to the number of wound complications [7 15]. Other factors that might influence wound healing are higher energy trauma [26], open fractures [2 27], smoking [1-2 35], diabetes [2 36], comorbidity in general [37], overcorrection of height [38], delay in surgery beyond five days [1 3] or beyond 14 days [36], extended duration of surgery or tourniquet use [3 26], or too early surgery [26], and closure technique [1]. The association between surgical complications and the above named factors

could not be confirmed in the current study, which, for smoking, is in agreement with previous studies [3 18 29 36].

As the subcuticular single-layer closure technique is currently the most frequently used closure technique at our clinic, we were unable to aid in the discussion whether or not closure technique is as important as discussed [29]. However, our complication rates, especially superficial wound infection and wound dehiscence compare favorably to the literature, which is probably largely due to a carefully selected type of extended lateral approach according to Atkins. An important finding in the current study was the association between the use of calcium phosphate bone void filler and wound complications in 75% of these cases. A trend towards more wound complications has been shown previously with the use of bone substitutes, but never reached statistical significance due to small sample sizes [39-40].

In conclusion, the subcuticular one-layer suture technique is a suitable closure method following the extended lateral approach in the treatment of displaced intra-articular calcaneal fractures. It is associated with a low complication rate. The effect of bone void fillers on complications should receive more attention in future research. The association between wound complications and the level of experience of the surgical team supports the necessity to centralize treatment of this complex injury.

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Table 1. Patient, fracture, and surgical characteristics of 50 included patients with 53 fractures

Item		N
Gender [1]	Male	39 (78.0% of patients)
	Female	11 (22.0% of patients)
Age (years) [2]		40.3 ± 13.7
Affected side [1]	Left	23 (43.4% of patients)
	Right	30 (56.6% of patients)
BMI (kg/m^2) [2]		23.9 ± 3.8
Smoking [1]	No	26 (52.0% of patients)
	Yes	24 (48.0% of patients)
Diabetes [1]	No	49 (98.0% of patients)
	Yes	1 (2.0% of patients)
Böhler (degrees) [2]	Pre surgery	-0.55 ± 12.65
	Post surgery	25.64 ± 5.42
	Increase	26.12 ± 11.71
Essex-Lopresti [1]	Joint-depression	25 (47.2% of fractures)
	Tongue-type	18 (34.0% of fractures)
	Comminuted	10 (18.9% of fractures)
Sanders [1]	Type-2	38 (71.7% of fractures)
	Type-3	11 (20.8% of fractures)
	Type-4	3 (5.7% of fractures)
	Unknown	1 (1.9% of fractures)
Surgical delay (days) [2]		9.2 ± 4.3
Tourniquet time (minutes) [2]		135 ± 35.5
Closure technique [1]	Subcuticular	49 (92.5%
	Other	4 (7.5%)
Bone filler [1]	Yes	5 (9.4% of fractures)
	No	48 (90.6% of fractures)

Data are shown as [1] numbers or as [2] mean with standard deviation

BMI, body mass index.

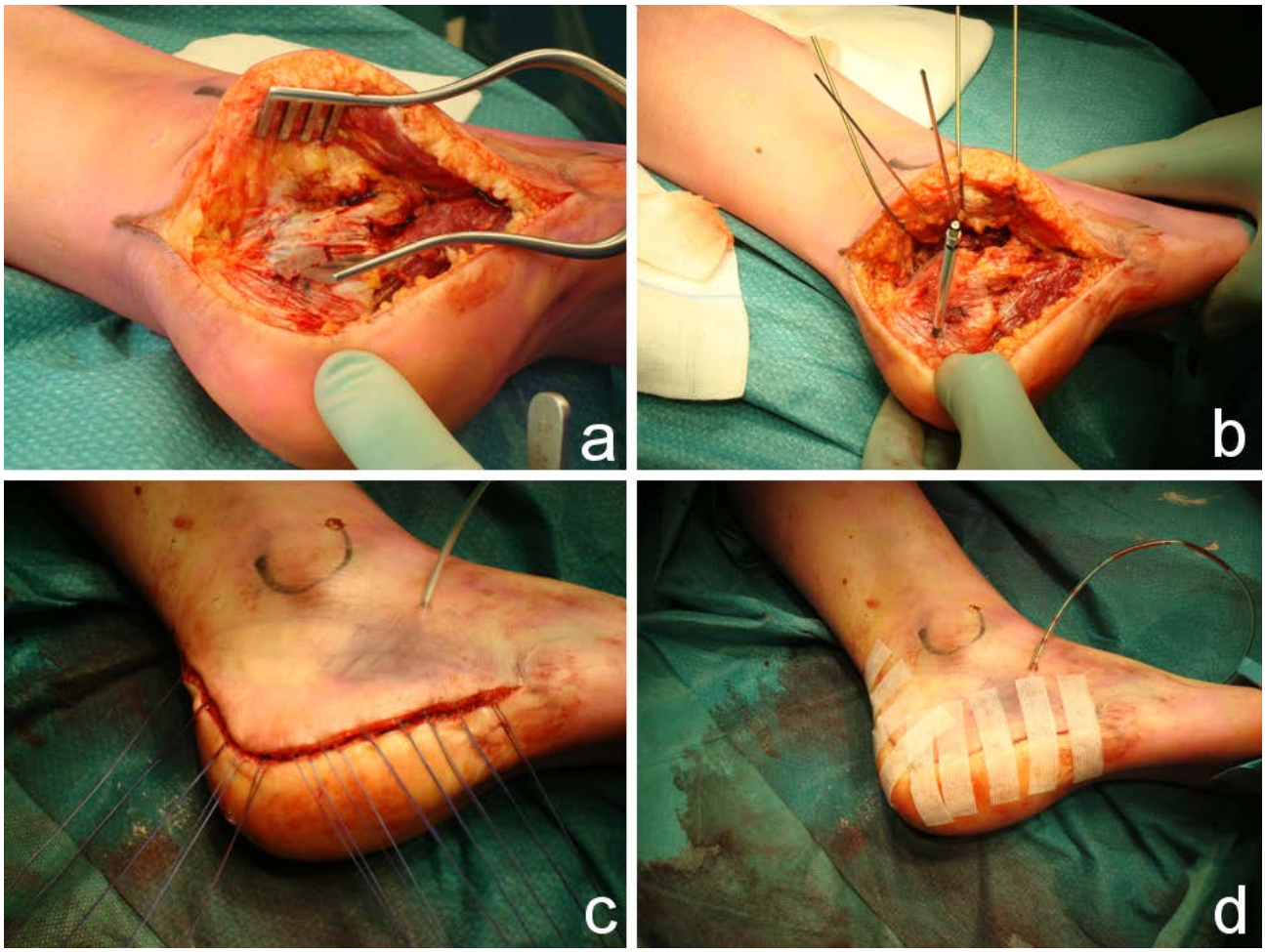
Table 2. Literature overview on closure technique and wound complications in extended lateral approach (studies with more than 25 patients) from 2005 to 2011

Study (reference)	Fractures (N)	Approach	Days to surgery	Closure technique	Major complications[a] N (%)	Minor complications[b] N (%)
Jarde 2005	27	Direct	N/A	N.A.	2 (7.4)	2 (7.4)
Schofer 2005	50	Zwipp	9	N.A.	0 (0)	6 (12)
Herscovici 2005	37	Seattle	15.1	N.A.	3 (8.1)	5 (13.5)
Koski 2005	148	L-shaped	7.8	2-layer	20 (13.5)	15 (10.1)
De Paula 2006	71	L-shaped	3.9	N.A.	4 (5.6)	10 (14.1)
Bibbo 2006	44	ELA	N.A.	N.A.	3 (6.8)	2 (4.5)
Besse 2006	31	Atkins	6.1	1-layer i.r.	2 (6.5)	6 (19.4)
Queitsch 2006	58	ELA	8,5	N.A.	1 (1.7)	4 (6.9)
Jain 2007	48	Seattle	7	N.A.	1 (2.1)	4 (8.3)
Hollawell 2008	20	ELA	N.A.	2-layer s.c.	0 (0)	1 (5)
Jiang 2008	74	ELA	N.A.	N.A.	0 (0)	0 (0)
Johal 2009	52	Atkins	8	2-layer	2 (3.8)	0 (0)
Rak 2009	76	Seattle	8	N.A.	8 (10.5)	8 (10.5)
Potter 2009	81	N.A.	N.A.	N.A.	3 (3.7)	N.A.
Court-Brown 2009	178	ELA	5.2	Miscellaneous	10 (5.6)	35 (19.7)
Demcoe 2009	278	ELA	N.A.	N.A.	9 (3.2)	57 (20.5)
Grala 2009	42	ELA	11	N.A.	0 (0)	2 (4.8)
Kienast 2010	137	ELA	7.2	N.A.	2 (1.5)	7 (5.1)
DeWall 2010	42	Seattle	13.6	N.A.	6 (14.3)	9 (21.4)
Kinner 2010	44	Zwipp	7	N.A.	1 (2.3)	4 (9.0)
Makki 2010	47	Atkins	10.1	N.A.	3 (6.4)	2 (4.3)

a. Major complication; Deep wound infections, flap necrosis, osteomyelitis, secondary surgery needed; b. Minor complication; Superficial infection, dehiscence, wound edge necrosis, cellulitis

N.A., not available; ELA, extended lateral approach not otherwise specified; i.r. interrupted; s.c., subcuticular. A list of references is available upon request.

Figure 1. Extended lateral approach with subcuticular single-layer closure technique



a. development of full-thickness flap; b. no-touch retraction of lateral calcaneal flap; c. subcuticular single-layer closure; d. situation prior to applying dressings