Skin and wound complications after calcaneal fracture fixation.

Ahmed Khedr, Walid Reda, Ahmed S Elkalyoby, Ahmed Hazem Abdelazeem.
Department of Orthopaedics, Cairo University, Egypt.
Correspondence: Ahmed Khedr Email: ahmedkhedr@kasralainy.edu.eg
©The Author(s). This article is an open access publication.

Abstract
Soft tissue complications are one of the most feared complications after operative treatment of calcaneus fractures. The incidence of wound complications is reported to be as high as 32%. The better understanding of the blood supply of the hind-foot together with the development of minimally invasive and percutaneous techniques helped to reduce such complications. Authors have reported on patient and surgery related factors that can contribute to skin and soft tissue complications however; drawing a definitive conclusion about the importance of each of these factors is cumbersome. In this article, we discussed the reported incidence of soft tissue complications associated with operative treatment.

Key-words: Heel fracture - lateral calcaneal artery – Open reduction and internal fixation – postoperative complication – calcaneus.

Introduction:
The goals of surgical treatment of displaced intra-articular fractures of the calcaneus are to restore the calcaneal height, length, and axis together with anatomical reduction of the articular surface (1). Skin and soft tissue complications were one of the most common and most dreadful complications when managing calcaneal fractures especially with the extensile lateral approach (2). Wound complications with operative fixation of calcaneus vary from 0-32% across the literature (3).

Blood supply of the skin on the lateral aspect of the hind-foot:
In the late 1980s, Taylor and Palmer started to popularize the concept of angiosomes to provide a better understanding of the blood supply of the skin. They identified the peroneal artery to be the source of blood supply to the skin of the posterolateral aspect of the lower leg and hind-foot (4). The heel is supplied by 2 overlapping arteries which are the medial and lateral calcaneal arteries. The skin over the tendo-achillies is supplied by the posterior tibial artery and peroneal artery with vascular interconnection between the 2 arteries.

Freeman et al dissected 15 lower limbs and identified the posterior peroneal artery [which was later named the lateral calcaneal artery] at the level of the upper border of the calcaneus to be an average of 3.1 cm posterior to the lateral malleolus, 1 cm posterior to the sural nerve and 1.5 cm anterior to the tendo-achillies (5). They suggested that the incision of the extensile lateral approach of the calcaneus probably divides this artery resulting in skin breakdown. Elsaidi et al in a cadaveric study identified a dangerous triangle between 3 points: the tip of the lateral malleolus, the point of which the lateral calcaneal artery pierces the deep fascia [3–4.5 cm above the midpoint of extending from tip of the lateral malleolus to the point of insertion of the tendo-achillies] and the point at which the artery crosses the line between the tip of the lateral malleolus and the insertion of the tendo-achillies [2.3-3 cm posterior to the tip of the lateral malleolus]. They hypothesized that the vertical limb of the extensile approach can be safely placed posterior to this triangle (6).
**Risk factors for complications:**

**Patient factors:**

**Diabetes:**

Folk et al (7) and Kwon et al (8) found an increase incidence of wound complications with diabetes. Folk et al identified diabetes to increase the relative risk of infection 3.4 times in a cohort of 179 patients treated by open reduction and internal fixation by extensile lateral approach (7). Kwon et al in a series of 405 calcaneal fractures identified increased incidence of wound complications in diabetic patients although this was not statistically significant (8).

**Smoking:**

Several studies show an increased incidence of wound complications with smoking (2, 7–9). Assous and Bhamra compared incidence of wound complications in smokers vs. nonsmokers. Seventy percent of smokers had wound complications in comparison to 15% of nonsmokers (9). Wu et al studied wound complications in 239 calcaneal fractures. They found that the risk of skin complications in smokers in 13.8 times higher than nonsmokers (2).

**Body mass index:**

Shuler et al studied 63 calcaneal fractures and found that high body mass index is associated with delayed healing (10).

**Age:**

Several studies suggest that age was not associated with increased incidence of wound problems (11–13). Gaskill et al compared outcomes calcaneal fractures in patients older than 50 years to outcomes in patients less than 50 years. There were no skin complications in the group of patients less than 50 years and only one case with skin necrosis in patients older than 50 years. Herscovici et al concluded that age doesn’t play a role in developing complications but medical comorbidities probably contribute to postoperative complications (12).

**Open fractures:**

Siebert et al analyzed the data of 36 open calcaneal fractures treated by casting, closed reduction and fixation by k wires or external fixation or ORIF. Soft tissue complication occurred in 23 cases (14). Folk et al identified open fracture to contribute significantly to wound complications where patients with open fractures have a relative risk of 2.8 times of developing wound complications (7).

**Drug abuse:**

Court-Brown et al in a series of 178 patients had statistically higher wound complication rate in drug abusers (13). They pointed that those patients had a higher average deprivation category score than the non-drug addict population suggesting that they were more socially deprived.

**Sander’s classification:**

Kwon et al compared the rate of wound complications in patients with Sander’s grade 1 and 2 fractures to patients with Sander’s grade 3 and 4 fractures and did not find a significant difference between the 2 groups (8). Court-Brown et al did not find correlation between Sander’s classification and would complication rate (13).

**Surgery related factors:**

**Surgical approach:**

The incidence of wound complications with the extensile lateral approach is up to 32% (3,15). The percentage of complication was higher with external fixator than for minimally invasive and percutaneous technique (16). Kline et al compared the incidence of wound complications in patients treated with extensile lateral approach to patients treated with minimally invasive surgery. The incidence was higher in the patients treated by extensile lateral approach (29%) compared to minimally invasive techniques (6%) which was statistically significant (17).

**Duration of surgery:**

Al-Mudhaffar et al, Koski et al and Wu et al identified increased wound complication with prolonged duration of surgery (2,18,19). They concluded that surgeons should aim for operative time less than 2 hours and tourniquet time less than 1.5 hours (18). Wound complications were 7.17 times higher in patients with duration of surgery more than 1.5 hours compared to patients with duration of surgery less than 1.5 hours (2).

**Retraction of the skin flap:**

Wu et al compared static skin retraction (K-wires drilled in the talus and bent) to dynamic retraction
(manual retraction by an assistant). Skin complications were 1.59 times higher with the static than the dynamic retraction (2).

Postoperative drainage:

Stannard and coworkers showed lower incidence of wound dehiscence and infection when negative pressure wound therapy is applied to lower extremity fractures including calcaneal fractures (20). Wu et al identified that patients who were not given postoperative drainage were 8.32 times more likely to develop wound complications when compared to patients who received it (2).

Skin closure:

Shuler et al showed 58% wound complication rate in patients closed by a single layer technique in contrast to 28% of patients closed by double layer technique. The difference between both groups was statistically significant (10). On the other hand, Court-Brown et al compared one to two layered closure and didn’t find a statistically significant difference between the 2 groups (13).

Antibiotics:

Wu et al analyzed data from 239 calcaneal fractures to compare the incidence of wound complications in patients in whom antibiotic was given more than 3 days to patients in whom antibiotic was given less than 3 days and there was no significant difference in wound complications between both groups (2).

Bone grafting:

Wu et al, Shuler et al and Folk et al didn’t identify a significant differences in wound complication rates between patients who received bone graft when compared to patients who did not receive it (2,7,10). Yang et al in a systematic review that included 32 studies with 1281 fractures found a higher incidence of infection in patients with bone graft compared to patients with no bone graft but the difference was not statistically significant (21).

Surgeon’s experience:

Court-Brown et al reviewed 178 calcaneal fractures treated by calcaneal plate fixation using an extensile lateral approach and observed a statistically significant difference in wound infection rate between experienced and less experienced surgeons. The infection rate was 14.3% for the inexperienced group compared to 2.8% for the most experienced surgeon (13). Kwon et al identified a statistically significant less wound complication rate for junior surgeons compared to senior surgeons in their series of 405 calcaneal fractures. However, they noted that senior surgeons in their series had a statistically significant higher utilization of the extensile lateral approach compared to junior surgeons (8).

Timing of surgery:

Sanders suggested that surgery should be carried out after edema and swelling subsides and proposed the wrinkle test can be a clinical tool to determine when it is suitable to operate (22). Al-Mudhaffar et al and Wu et al identified increased risk with early surgery (2,18). They reported that time to surgery is a significant risk factor for wound complications and recommended delaying surgery 7 to 10 days after injury (18). Wu et al identified the wound complications to be 5.47 times higher in surgeries performed within the first 3 days of fracture compared to surgeries delayed more than 3 days (2). Kwon et al retrospectively analyzed data of 405 closed calcaneal fracture which received operative treatment. Out of these, 224 received ORIF by an extensile lateral approach, the incidence of wound complication for patients treated between 0-7 days was 34%, for patients treated between 8 to 14 days was 28% and for patients treated after 14 days was 35%. For patients treated by sinus tarsi or percutaneous approaches, the incidence of wound complications in patients treated between 0 to 7 days was 2%, for patients treated between 8-14 days was 8% and for patients treated more than 14 days was 15%. The patients treated 14 days after injury were 3 times more likely to develop wound problems compared to patients who had surgery between 0-7 days and this difference was statistically significant.

Treatment:

Prevention:

Prevention is probably the best way to prevent skin and soft tissue complication following calcaneal fractures. Bergin et al described an inpatient protocol to help to improve the skin condition and compared this protocol to a group of patients who received an outpatient management. The inpatient protocol consisted of applying compressive dressing and ice water inflow wrap with autochill pump for cold therapy. The patients injured extremity was elevated above the level of the heart at all times. The outpatient management included compressive dressing, ice water inflow wrap and elevation but this was not consistent for all patients. The patients who received the inpatient protocol had lower
wound complications and an average of 4 days earlier surgery than patient managed as outpatients (23).

Several authors suggested the use of an external fixator to allow the skin condition to improve followed by definitive internal fixation or as a definitive treatment. Brian et al applied a medial sided external fixator for 10 calcaneal fractures within 48 hours of injury followed by ORIF through a sinus tarsi approach for 8 fractures and primary subtalar fusion for 2 fractures when the skin condition improved. They had no postoperative wound infection of dehiscence (24). For patients with displaced tongue type calcaneal fracture with bad skin and soft tissue condition on the posterior aspect of the heel, immediate reduction and percutaneous fixation can prevent further deterioration of the skin condition (25).

**Treatment of wound dehiscence:**

If gapping of the wound is observed, range of motion exercise should be stopped to prevent further gapping. A course of oral antibiotics can be started. If a hematoma is clinically detected, it should be evacuated to maintain the viability of the skin flap (26). In the event of having more drainage, whirlpool treatment may be needed with the patient placed in a fracture boot (27). Negative pressure wound management can be used. Partial thickness skin injuries usually heal with local wound care. More complex treatment modalities including flaps may be needed for non-healing wounds. The differentiation between wound dehiscence and infection is sometimes not easy and the surgeon should go to surgical debridement in case of any doubt (26).

**Treatment of wound infection:**

If infection with purulent discharge develops, serial surgical debridement and administration of antibiotics guided by the results of culture and sensitivity tests is essential. In early wound infection, the patient may respond well to antibiotics as the bony affection is just superficial osteitis. Attempts can be made to retain the hardware for about 6 month to allow bony union followed by removal of hardware. The resultant wound after hardware removal can be managed by negative pressure wound management and should be assessed by plastic surgeon for the need of free tissue transfer (28,29). If diffuse osteomyelitis develops, removal of the hardware with removal of the necrotic bone should be done with insertion of antibiotic impregnated spacer. The wound should be managed by culture specific antibiotic for 6 weeks. The patient should be admitted for debridement and when culture results are negative, the surgeon can proceed with subtalar fusion. Typically, careful assessment is needed by plastic surgeon to assess the need of soft tissue coverage. In severe life threatening or uncontrollable infection, amputation may be needed (28,27,29).

**Prognosis:**

De Groot et al studied the effect of short term complications on long term clinical outcomes. The incidence of superficial wound infection was 5%, deep wound infection was 7%, wound dehiscence was 24% and hematoma requiring evacuation was 3%. Statistical analysis showed that wound complications did not influence long term outcomes (30).

**Conclusions:**

Skin and wound complications remain one of the dreadful complications of operative treatment of calcaneal fractures. The better understanding of the anatomy of the lateral calcaneal artery suggests that the placement of the vertical limb of the extensile lateral approach close to the Achilles tendon may reduce the risk of injury to this artery. Careful assessment of the general and local patient condition together with taking into consideration surgical factors can reduce the risk of surgery. The presence of several risk factors can result in cumulative increase in the risk of developing wound complications. While local wound care can be used to treat wound dehiscence successfully, repeated surgical debridements with culture specific antibiotics and assessment by plastic surgeons may be needed for more complicated cases.

**References**

1. Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clin Orthop Relat Res. 1993;(290):87–95.
2. Wu K, Wang C, Wang Q, Li H. Regression analysis of controllable factors of surgical incision complications in closed calcaneal fractures. J Res Med Sci. 2014;19(6):495–501.
3. Lim E V, Leung J P. Complications of intraarticular calcaneal fractures. Clin Orthop Relat Res. 2001;(391):7–16.
4. Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: experimental study and clinical applications. Br J Plast Surg. 1987;40(2):113–41.
5. Freeman BJ, Duff S, Allen PE, Nicholson HD, Atkins RM. The extended lateral approach to the hindfoot. Anatomical basis and surgical implications. J Bone Joint Surg Br. 1998;80(1):139–42.

6. Elhaiady MA, El-Shafey K. The lateral calcaneal artery: Anatomic basis for planning safe surgical approaches. Clin Anat. 2009 Oct;22(7):834–9.

7. Folk JW, Starr AJ, Early JS. Early wound complications of operative treatment of calcaneal fractures: analysis of 190 fractures. J Orthop Trauma. 1999;13(5):369–72.

8. Kwon JY, Guss D, Lin DE, Abousayed M, Jeng C, Kang S, et al. Effect of Delay to Definitive Surgical Fixation on Wound Complications in the Treatment of Closed, Intra-articular Calcaneal Fractures. Foot Ankle Int. 2015;36(5):508–17.

9. Assous M, Bhamra MS. Should Os calcis fractures in smokers be fixed? A review of 40 patients. Injury. 2001;32(8):631–2.

10. Shuler FD, Conti SF, Gruen GS, Abidi NA. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures: does correction of Bohler’s angle alter outcomes? Orthop Clin North Am. 2001;32(1):187–92, x.

11. Gaskill T, Schweitzer K, Nunley J. Comparison of Surgical Outcomes of Intra-Articular Calcaneal Fractures by Age. J Bone Jt Surgery-American Vol. 2010;92(18):2884–9.

12. Herscovici Jr, D, Widmaier J, Scaduto IM, Sanders RW, Walling A. Operative Treatment of Calcaneal Fractures in Elderly Patients. J Bone Jt Surg. 2005;87(6):1260.

13. Court-Brown CM, Schmied M, Schmidt M, Schutte BG. Factors affecting infection after calcaneal fracture fixation. Injury. 2009;40(12):1313–5.

14. Siebert CH, Hansen M, Wolter D. Follow-up evaluation of open intra-articular fractures of the calcaneus. Arch Orthop Trauma Surg. 1998;117(8):442–7.

15. van Hoeve S, Poeze M. Outcome of Minimally Invasive Open and Percutaneous Techniques for Repair of Calcaneal Fractures: A Systematic Review. J Foot Ankle Surg. 2016;55(6):1256–63.

16. Levin LS, Nunley JA. The management of soft-tissue problems associated with calcaneal fractures. Clin Orthop Relat Res. 1993;(290):151–6.

17. Howard JL, Buckley R, McCormack R, Pate G, Leighton R, Petrie D, et al. Complications following management of displaced intra-articular calcaneal fractures: a prospective randomized trial comparing open reduction internal fixation with nonoperative management. J Orthop Trauma. 2003;17(4):241–9.

18. Harty M. Anatomic considerations in injuries of the calcaneus. Orthop Clin North Am. 1973;4(1):179–83.

19. Benirschke SK, Kramer PA. Wound healing complications in closed and open calcaneal fractures. J Orthop Trauma. 2004;18(1):1–6.

20. Kline AJ, Anderson RB, Davis WH, Jones CP, Cohen BE. Minimally Invasive Technique Versus an Extensile Lateral Approach for Intra-Articular Calcaneal Fractures. Foot Ankle Int. 2013;34(6):773–80.

21. Al-Mudaffar M, Prasad C V, Mofidi A. Wound complications following operative fixation of calcaneal fractures. Injury. 2000;31(6):461–4.

22. Koski A, Kuokkanen H, Tukiainen E. Postoperative Wound Complications after Internal Fixation of Closed Calcaneal Fractures: A Retrospective Analysis of 126 Consecutive Patients with 148 Fractures. Scand J Surg. 2005;94(3):243–5.

23. Stannard JP, Robinson JT, Anderson ER, McGwin G, Volgas DA, Alonso JE. Negative pressure wound therapy to treat hematomas and surgical incisions following high-energy trauma. J Trauma. 2006;60(6):1301–6.

24. Stannard JP, Volgas DA, McGwin G, Stewart RL, Oabrenskey W, Moore T, et al. Incisional negative pressure wound therapy after high-risk, lower extremity fractures. J Orthop Trauma. 2012;26(1):37–42.

25. Yang Y, Yu G, Zhao H, Zhou J. Treatment of displaced intraarticular calcaneal fractures with or without bone grafts: A systematic review of the literature. Indian J Orthop. 2012;46(2):130.

26. Sanders R. Intra-articular fractures of the calcaneus: present state of the art. J Orthop Trauma. 1992;6(2):252–65.

27. Bergin PF, Psareddilis T, Krosin MT, Wild JR, Stone MB, Musapatika D, et al. Inpatient Soft Tissue Protocol and Wound Complications in Calcaneal Fractures. Foot Ankle Int. 2012;33(6):492–7.

28. Farell BM, Lin CA, Moon CN. Temporising external fixation of calcaneal fractures prior to definitive plate fixation: a case series. Injury. 2015;46 Suppl 3:S19–22.

29. Gardiner MJ, Nork SE, Barei DP, Kramer PA, Sangeorzan BJ, Benirschke SK. Secondary soft tissue compromise in tongue-type calcaneus fractures. J Orthop Trauma. 2008;22(7):439–45.

30. Clare MP, Sanders RW. Management of Expected Adverse Outcomes and Unexpected Complications in Calcaneal Fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tornetta III P, editors. ROCKWOOD AND GREEN’S FRACTURES IN ADULTS. Eighth. Lippincott Williams & Wilkins; 2015.

31. Richter M, Kwon JY, DeGiovanni CW. Calcaneal fractures: intraarticular calcaneal fracture. In: Browner BD, Jupiter JB, Krettek C, Anderson P, editors, Skeletal Trauma: Basic Science, Management, and Reconstruction. Fifth Edit. Philadelphia: Elsevier; 2015. p. 2283–314.

32. Sanders R. Displaced intra-articular fractures of the calcaneus. J Bone Joint Surg Am. 2000;82(2):225–50.

33. G C. Classification and treatment of chronic osteomyelitis. In: McC. Evarts C, editor. Surgery of the musculoskeletal system. New York: Churchill Livingstone; 1990. p. 10–35.

34. Clare MP, Crawford WS. Managing Complications of Calcaneus Fractures. Foot Ankle Clin. 2017;22(1):105–16.

35. De Groot R, Frima AJ, Schepers T, Roerdink WH. Complications following the extended lateral approach for calcaneal fractures do not influence mid- to long-term outcome. Injury. 2013 Nov;44(11):1596–600.