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Review Article

Skin and Wound Complications after Calcaneal Fracture Fixation

Ahmed Khedr*, Walid Reda, Ahmed S Elkalyoby and Ahmed Abdelazeem

Department of Orthopedics, Cairo University, Egypt

***Corresponding author:** Ahmed Khedr, Department of Orthopedics, Faculty of Medicine, 4 Hosni Metwali street Elharam, Giza, Egypt 12111

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Abstract

Soft tissue complications are one of the most feared complications after a fracture of the calcaneus and its operative treatment. The incidence of wound complications vary in literature is up to 32%. The better understanding of the blood supply of the lateral aspect to the hind foot and together with the development of minimally invasive and percutaneous techniques helped to reduce such complications. While the literature discussed several patient related factors and surgery related factors that can contribute to skin and soft tissue complications, drawing a definitive conclusion about the importance of each of these factors is still difficult. Prevention of wound complications requires some experience from the surgeon to assess the different risk factors. In many cases, wound dehiscence can be managed by dressings but when infection is suspected, serial debridement with culture specific antibiotics are needed.

Keywords: Heel fracture; Lateral calcaneal artery; ORIF; Postoperative complication; Calcaneus

Introduction

The goals of surgical treatment of displaced intraarticular fractures of the calcaneus are to restore the calcaneal height, length and axis together with anatomical reduction of the articular surface [1]. However, 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]. Better understanding of the blood supply of the skin on the lateral aspect of the heel together with careful assessment of various risk factors before going to operative treatment of calcaneal fractures can reduce the risks of these problems. To achieve these goals, various approaches and methods of fixation were employed for operative fixation of calcaneal fractures [3-9]. Number of minimally invasive techniques and percutaneous methods for calcaneal fixation were developed to decrease the soft tissue injury with operative treatment [7-9].

Wound complications with operative fixation of calcaneus vary from 0-33% across the literature [10-17]. There variations of the reported values in literature variations many factors related to the patient or surgery. The wound complications vary even according to the region of the word in which the study was conducted. Spierings et al. [18] compared the differences in wound complications with extensile lateral approach in different parts of the geographical areas. The highest rate of wound complications was found

in studies from Europe (12.1%), followed by Africa (11.1%), Asia (4.5%), South America (4.4%), and North-America (2.8%). However, the literature reporting wound complications should be carefully assessed .The definition of wound dehiscence, necrosis and wound infection vary from one surgeon to another and from one institution to another [19,20]. Probably adhering to the definitions provided by the Center of Disease Control and Prevention can eliminate some of the confusion about what is reported as infection or dehiscence [21]. The presence of different risk factors that could affect the results vary from one study to another and selection bias can even exist in randomized trials [22]. The surgeon may be unaware of complications or underreport it [23,24].

The operative treatment of calcaneal fractures is associated with skin and soft tissue complications on the lateral aspect of the hindfoot. However, tongue type calcaneal fractures are associated with posterior skin and soft tissue problems. Gardner et al. [25] reported an incidence of 21% posterior skin compromise for patients with 139 tongue type calcaneal fracture. They also reported that patients who received immediate reduction and percutaneous fixation did not progress to soft tissue compromise.

Blood supply of the skin on the lateral aspect of the hindfoot. 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 [26]. The lateral calcaneal artery angiosome extends from the lateral malleolus superiorly to the fifth metatarsal

distally. It supplies the skin of the heel to the medial glabrous junction. The heel is supplied by 2 overlapping arteries which are the medial and lateral calcaneal arteries. The skin over the tendoachillis is supplied by the posterior tibial artery and peroneal artery with vascular interconnection between the 2 arteries [27].

Freeman et al. [28] dissected 15 lower limbs and identified the posterior peroneal artery (which was later name 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, 1cm posterior to the sural nerve and 1.5cm anterior to the tendo Achilles [28]. They suggested that the incision of the extensile lateral approach of the calcaneus probably divides this artery resulting in skin breakdown. Borelli & Lashgari [29] ran a cadaveric study on 24 cadaveric lower extremity specimens to describe the blood supply of the lateral hindfoot. They concluded that the lateral calcaneal artery, the lateral malleolar artery and the lateral tarsal artery were consistently present in the cadaveric specimens. The lateral calcaneal artery which is a branch from the peroneal artery was the main blood supply to the apex of the flap. The study also measured the relation of the lateral calcaneal artery to bony landmarks of the hindfoot.

The lateral calcaneal artery emerges from the deep fascia of the leg 15mm proximal to the tip of the lateral malleolus and 33±3mm posterior to the posterior edge of the fibula and 11.5±2 mm anterior to the anterior edge of the Achilles tendon. The artery continues distally to 13.5±2.5 mm anterior to the insertion of the Achilles tendon. The artery curves distally and forward to run at a distance 41±4 mm distal to the most prominent aspect of the distal fibular (a point in the midcoronal plane, 1 cm proximal to the tip of the fibula.) The lateral malleolar artery and the lateral tarsal artery run anterior to the lateral calcaneal artery. These measurements showed that the vertical portion of the extensile incision is very close to the course of the lateral calcaneal artery and thus the artery is vulnerable to injury [29].

Elsaidy et al. [30] 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 (3-4.5cm above the midpoint of extending from tip of the lateral malleolus to the point of insertion of the tendo Achilles) and the point at which the artery crosses the line between the tip of the lateral malleolus and the insertion of the tendo Achilles (2.3-3cm 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.

Kwon et al. [31] designed a cadaveric study involving 20 cadavers to assess the location of the lateral calcaneal artery in relation to the vertical limb of the extensile lateral approach and the modified extensile lateral approach. The vertical limb of the extensile lateral approach was situated midway between the posterior border of the fibula and the border of the tendo Achilles while the vertical limb of the modified extensile lateral approach was situated 0.75cm anterior to the border of the tendo Achilles. Both incisions measured 7cm in length starting from the junction of the glabrous and non-glabrous skin upwards. The number or times when the lateral calcaneal artery crossed the vertical incision were counted. The lateral calcaneal artery was found to cross the incision in 17 out of 20 cadavers (85%) for the vertical limb of the extensile lateral approach and 4 out or 20 cadavers (20%) for the vertical limb of the modified extensile lateral approach. The authors concluded that the risk of injury to the lateral calcaneal artery is significantly lower with the modified extensile lateral approach [31].

Bibbo et al. [32] in a clinical study assessed the importance of the lateral calcaneal artery to the viability of the skin flap of the extensile lateral approach. The patency of the lateral calcaneal artery was assessed before the extensile lateral approach was done for 90 calcaneal fractures. In 85 of them, the artery was patent before the operation. They had wound complications in 6/90 calcaneus fractures. 5 of 6 wound complications occurred in the 5 patients in whom the lateral calcaneal artery was not identified before surgery to be patent.

The better understanding of the anatomy gave surgeons an insight to the skin complications associated with extensile lateral approach. The proximal extent of the lateral approach was classically described to be posterior to the lateral malleolus or midway between the posterior border of the lateral malleolus and the tendo Achillis [3-5]. Probably this was associated with injury to the lateral calcaneal artery and skin complications. Gould and Seligsonwaere the first to propose putting the vertical limb of the incision of the lateral approach just anterior to the Achilles tendon [6]. The authors did not correlate the description of the vertical limb with the blood supply. This description of the lateral approach was before the studies describing the anatomy of the vascular supply to this area of the skin. The horizontal limb of the incision was traditionally described to be at the junction of the glabrous and non-glabrous skin [6]. This does not seem to endanger the skin of the heel as it is supplied by the medial and lateral calcaneal arteries [27].

Risk Factors for Skin and Soft Tissue Complications

Several factors were studied for their relation to soft tissue compromise. It should also be noted that severity of the trauma that led to the fracture should be taken into consideration as a factor affecting the skin. Other patient factors and surgery related factors were extensively studied. There is conflicting data from the different studies about the risk factors for skin complications. Kwon et al. [16] and Wu et al. [2] utilized a multivariate analysis to identify the real contribution of the different risk factor to wound complications but many other studies do not utilize such statistical techniques.

Patient Factors

Diabetes

Folk et al. [15] and Kwon et al. [16] found an increase incidence of wound complications with diabetes. Folk et al. [15] identified diabetes to increase the relative risk of infection 3.4 times in a cohort of 179 patients treated by ORIF by extensile lateral approach [15]. Kwon et al. [16] in a series of 405 calcaneal fractures identified increased incidence of wound complications in diabetic patients although this was not statistically significant [16]. On the other hand,

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Shuler et al. [33] studied 63 calcaneal fractures and did not find correlation between diabetes and wound healing [33].

Smoking

Several studies show an increased incidence of wound complications with smoking [2,15,16,34]. Assous & Bhamra [34] compared incidence of wound complications in smokers vs. nonsmokers in patients who were operated upon for ORIF of calcaneal fractures by the same technique. Seventy percent of smokers had wound complications in comparison to 15% of nonsmokers [34]. Wu et al. [2] 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]. Folk et al. [15] reported current smoking as a significant risk factor for wound complication with relative risk 1.2. Nevertheless history of smoking more than ten pack-years was a significant predictor for wound complications (relative risk 1.2) [15]. Kwon et al. [16] identified smoking to increase the odds ratio of wound infection 1.9 times which was statistically significant in their series of 405 calcaneal fractures [16]. However, Court et al. [35], Koski et al. [36] and Tennent et al. [37] failed to show increases risk of skin complications with smoking [35-37].

Body mass index

Shuler et al. [33] studied 63 calcaneal fractures and found that high body mass index is associated with delayed healing.

Age

Several studies suggest that age was not associated with increased incidence of wound problems [15,35,38,39]. Gaskill et al. [38] 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. The 2 groups had comparable functional outcomes and complications [38]. Herscovici et al. [39] reported the results of 44 surgically treated calcaneal fractures in patients 65 years or older, five of the patients had wound edge necrosis, 1 had cellulitis, 1 had heel ulcer and 3 had osteomyelitis. The patients who had wound edge necrosis and osteomyelitis had medical comorbidities. The authors concluded that age doesn't play a role in developing complications, but medical comorbidities probably contribute to postoperative complications [39]. Similarly, Court et al. [35] in a series of 178 patients did not show evidence of increased wound complications with increasing age [35]. Folk et al. [15] in a study of 190 fracture concluded that age is not a significant predictor of wound complications [15].

Open fractures

Siebert et al. [40] 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 [40]. Folk et al. [15] 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 [15].

Drug abuse

Court B et al. [35] in a series of 178 patients had statistically higher wound complication rate in drug abusers. 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. [15] 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 [16]. Court et al. [35] did not find correlation between Sander's classifications and would complication rate [35]. Van et al. [17] in a systematic review of minimally invasive and percutaneous technique identified a statistically significant correlation between wound complications and Sander's classification.

Surgery Related Factors

Surgical approach

The incidence of wound complications with the extensile lateral approach is up to 32% [10-16]. For minimally invasive and percutaneous techniques, Van Hoeve et al. [17] conducted a systematic review on minimally invasive techniques that included 46 studies. They included studies that used external fixators, minimally invasive technique, percuatnoues reduction and screw fixation, arthroscopy and different augmentation techniques reported an incidence of wound complication between 0 and 33% with a median of 3%, and the percentage of complication was higher with external fixator than for minimally invasive and percutaneous technique [17]. Kwon et al. [15] retrospectively analyzed data of 405 closed calcaneal fracture which received operative treatment. The overall wound complication for fractures treated by extensile lateral approach was 32.1% compared to 8.3% for patients treated with sinus tarsi or percutaneous approaches (odds ratio 5.3; 95% confidence interval 2.9-9.5; P<.001) [16]. Kline et al. [41] 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 [41].

Duration of surgery

Al Mudhaffar et al. [42], Koski et al. [36] and Wu et al. [2] identified increased wound complication with prolonged duration of surgery [2,36,42]. Al Mudhaffar et al. [42] studied 33 calcaneal fractures treated operatively, 6 of them developed wound complications. The operating time and tourniquet time were significantly higher in these patients. They concluded that surgeons should aim for operative time less than 2 hours and tourniquet time less than 1.5 hours [42]. Similarly, Koski et al. [36] studied 148 fractures and concluded that prolonged operative time is associated with higher skin complications [36]. Wu et al. [2] studied 239 calcaneal frac-

tures and identified an increased risk of wound complication with prolonged surgery. 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. [2] 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 et al. [43,44] showed lower incidence of wound dehiscence and infection when negative pressure wound therapy (NPWT) is applied to lower extremity fractures including calcaneal fractures [43,44]. Wu et al. [2] identified that patients who were not given postoperative drainage were 8.32 times more likely to develop wound complication s when compared to patients who received it.

Closure of the skin

Shuler et al. [33] 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 [33]. On the other hand, Court et al. [35] compared one to two layered closure and didn't find a statistically significant difference between the 2 groups [35].

Antibiotics

Wu et al. [2] 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. [2], Shuler et al. [33] & Folk et al. [15] didn't identify a significant difference in wound complication rates between patients who received bone graft when compared to patients who did not receive it [2,15,33]. In the series of Wu et al. [2], autogenous, allograft, or artificial bone was used [2]. In the series of Folk et al. [15] hydroxyapatite synthetic graft, coral graft and auto graft were used. In the series of Shuler et al. [33] autograft or allograft was used. Bibbo et al. [45] and Yang et al. [46] found an increased incidence of wound complications in patients in whom bone graft was used but this was not statistically significant [45,46]. Bibbo et al. [45] compared the wound complication rate in 33 fractures which had an intraoperative bone defect and received human DBM-calcium sulfate mixed with vancomycin to 11 fractures which had no appreciable bone defect at time of surgery and were not grafted. The wound complications were higher in patients who received the graft but the difference was not statistically significant. It should be noted that the authors stated that all patients who had wound complications had more severe fractures and worse soft tissue condition [45]. Yang et al. [46] 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.

Surgeon's experience

Court et al. [35] reviewed 178 calcaneal fractures treated by calcaneal plate fixation using an extensible 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 [35]. Kwon et al. [15] 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 [16].

Timing of surgery

Sanders [47] 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 [47]. Al Mudhaffar et al. [42] and Wu et al. [2] identified increased risk with early surgery [2,42]. Al Mudhaffar et al. [42] studied 33 calcaneal fractures treated operatively, 6 of them developed wound complications. They reported that time to surgery is a significant risk factor for wound complications and recommended delaying surgery 7 to 10 days after injury [42]. Wu et al. [2] 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]. On the other hand, Court [35] and Folk [15] didn't find a significant difference between early and delayed surgery [15,35].

Court et al. [35] reviewed 178 calcaneal fractures treated by calcaneal plate fixation using an extensible lateral approach and did not find difference in wound complication with delaying calcaneal fracture treatment. It should be noted that the authors stated that the timing between injury and surgery was determined by the treating surgeon without giving details of when the surgeon felt it is safe to go for surgery [35]. Folk et al. [15] in a study of 190 fracture concluded that delay in surgical treatment is not a significant predictor of wound complications [48-54]. Kwon et al. [55] retrospectively analyzed data of 405 closed calcaneal fracture which received operative treatment. Out of these, 224 received ORIF by an extensible lateral approach, the incidence of wound complication for patients treated between 0 to7 days was 34%, for patients treated between 8 to 14 days was 28% and for patients treated after 14 days was 35%. The difference in the rate of wound complications was not statistically significant. It should be noted that fracture severity defined by Sanders classification was statistically similar at all time points. 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 sig-

nificant. Again, the injury severity by Sanders classification was similar for the 3 groups [16].

Treatment

Prevention

Prevention is probably the best was to prevent skin and soft tissue complication following calcaneal fractures. Proper assessment of the local skin condition together with general patient factors is essential. Although there is conflicting evidence about many of the factors that cause skin complications, the presence of more than one risk factor in a patient may produce an additive effect [39]. Factors related to surgery should also be taken into consideration to minimize the effect of the surgical trauma on the soft tissue.

Bergin et al. [48] 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 (webril and elastic band) and ice water inflow wrap with auto chill 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.

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 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 [49]. Corina et al. [50] and Magnan et al. [51] suggested the used of external fixator as a definitive treatment for displaced intraarticular fractures and reported low wound complications and good clinical outcomes [50,51]. Besh et al. [52] described the use of a hinged external fixator as a temporary or definitive treatment of calcaneal fractures [52].

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. Immobilization in a cast with a window to allow damp-to-dry dressing changes. A course of oral antibiotics can be started [53,54]. If a heamatoma is clinically detected, it should be evacuated to maintain the viability of the skin flap [55]. In the event of having more drainage, whirlpool treatment may be needed with the patient placed in a fracture boot [53,54]. Negative pressure wound management can be used [44]. Partial thickness skin injuries usually heal with local wound care. More complex treatment modalities including flaps may be needed for nonhealing wounds [11,56]. The differentiation between wound dehiscence and infection is sometimes not easy and the surgeon should go to surgical debridement in case of any doubt [55].

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 [54,57]. 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 [53,56]. 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 [53,54,56].

Prognosis

De Groot et al. [58] studied the effect of short term complications on long term clinical outcomes. There series included 39 patients with 45 displaced intraarticular fractures. 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 [58]. Backes et al. [59] analyzed data from 94 calcaneal fractures and identified that although outcome scores were lower for patients with postoperative wound infection than patients who did not have infection, the difference was not statistically significant.

Conclusion

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 tendo Achilles rather than midway between the lateral malleolus and the tendo Achilles may reduce the risk of injury to this artery. The literature still provides conflicting data about the contribution of different risk factors. Therefore, careful assessment of the general and local patient condition together with taking into consideration surgical factors can help to avoid these complications. Probably 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 with infections.

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