The Infected Calcaneus

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KEYWORDS

• Infection • Calcaneus • Angiosomes

Infections in and around the calcaneus can be quite challenging for the patients and physicians involved. These infections arise because of multiple potential etiologies, including chronic pressure, trauma, and postsurgical wound-healing complications. The impediments to healing can be equally as diverse depending on the patients' comorbidities, such as smoking, diabetes, and open injury.[1] In this article the authors review the anatomy of the calcaneus and surrounding soft tissue, patient risk factors, and various treatment options that can be used through a multidisciplinary approach. The common limiting factor for most of these patients is the delicate soft-tissue envelope, and occasionally, the lack thereof. The ultimate goal is an infection-free limb with durable soft-tissue coverage and maximal maintenance of function.[2]

ANATOMY

Bone

As the strongest bone in the foot, the calcaneus has a unique role in gait because it accepts axial load during heel strike then later transmits forces to the forefoot during push off.[3] The calcaneus has four articular surfaces. The anterior, middle, and posterior facets that articulate with the talus allow heal inversion and eversion, which thereby enable accommodation of uneven surfaces. The calcaneal cuboid articulation plays an important role anteriorly in supporting the lateral column.[4] The sustentaculum tali, which projects anteromedially from the sulcus calcanei, supports the talar neck above via the anterior and middle facets; it also allows passage of the flexor hallucis longus below and is stabilized medially by the talocalcaneal ligaments.[4] The sulcus calcanei forms the inferior border of the medial tarsal canal and the lateral sinus tarsi, which contains the interosseus ligament connecting the talus and calcaneus. The Achilles tendon inserts on the posterior tubercle, whereas the medial and lateral processes provide origins for the abductor hallucis and abductor digiti quinti muscles, respectively.[5] The lateral surface also has grooves for the traversal of the peroneal

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tendons with the peroneal tubercle separating the peroneus brevis above from the peroneus longus below at this level. The thickest cortex can be seen along the superior neck on a lateral radiograph and marks the crucial angle of Gissane,[6] which normally ranges from 120° to 145°. The relation of the top of posterior facet to the superior aspect of the posterior tuberosity and top of the anterior process of the calcaneus can also be evaluated on a lateral radiograph and delineates Bohler's angle, which is normally 25° to 40°.[7]

Vascular

The concept of angiosomes was popularized by Taylor and Palmer in 1987 after serial cadaveric arterial injections to determine regions of direct perfusion and anastomoses between such territories.[8,9] An angiosome is a region of tissue supplied by a named artery. They define the anastomoses between these angiosomes as choke vessels, which are more commonly known as watershead areas.[10] In 1997, Taylor and colleagues further examined the angiosomes within the leg, which enhanced our insight into potential flap options and strategies for surgical incisions.[8]

The peroneal artery plays a prominent role in calcaneal wound healing as it supplies the lateral aspect of the ankle and hindfoot via the calcaneal and anterior perforating branches. When evaluating the ankle and foot, there are predictable interconnections between the three main arteries: the posterior tibial (PT); anterior tibial (AT); and peroneal (P), which can provide back-up flow should any major vessel be disrupted. At the Lisfranc joint, the PT and AT connect via the lateral plantar (PT) and dorsalis pedis (DP) (AT). There are potentially three communicating branches between the posterior tibial and peroneal arteries: 5 to 7 cm above the ankle, near the ankle, and the Achilles insertion. The lateral malleolar branch off the tibialis anterior artery also connects with the perforating anterior branch off the peroneal artery. The venous drainage is via the lesser saphenous vein, which accompanies the calcaneal artery. The glabrous junction marks the transition between the lateral calcaneal artery (P) and medial calcaneal artery (PT) angiosomes. By making the incision at the junction of these angiosomes, blood flow is maximized to the healing surgical wound.[10] Before considering any flap coverage in these patients, it is important to be cognizant of the vascular status of the limb.

RISKS FOR WOUND HEALING

Operatively Treated Calcaneal Fractures

Folk and colleagues[1] looked at early wound complications in 190 operatively treated calcaneal fractures and found a 25% wound-complication rate with 21% requiring surgical treatment. They found the predictive variables in their study were smoking (37 out of 118 patients; $P = .03$; relative risk [RR] = 1.2); diabetes (7 out of 9; $P = .02$; RR = 3.4); and open injuries (13 out of 18 fractures; $P < .0001$; RR = 2.8).

Abidi and colleagues[11] also looked at wound healing risk factors in 63 subjects with 64 calcaneus fractures that underwent open reduction and internal fixation. They found a higher incidence of wound complications in those closed via a single-layer technique as opposed to the double-layer technique used in subjects later in their series (58% vs 28%; $P < .04$). The single-layer technique consisted of alternating horizontal and vertical mattress sutures. The double-layer technique added a deep layer consisting of interrupted 2–0 PDS or 0 Dexon sutures that were each tagged and tied after all were placed. They also found that smoking ($P < .05$) and body mass index ($P < .01$) positively correlated with delayed wound healing. Use of a drain did not significantly correlate with a decrease in wound complications, but 89% of their wounds were drained; therefore, this may have been secondary to sample size.[11] Looking at