Chapter 7
Hindfoot Operations

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Background

Etiology of Hindfoot Wounds

Wounds about the hindfoot can be caused by a number of problems and are often multifactorial in nature. Heel ulcers represent, by far, the most common category of hindfoot wounds. These ulcers develop for a number of reasons, often due to excess pressure on the heel, a poor healing environment, and decreased protective sensation. Cited risk factors for the development of heel pressure ulcers include diabetes mellitus, old age, living in a nursing home, immobility, spinal cord injury, malnutrition, renal impairment, cigarette smoking, peripheral neuropathy, and peripheral vascular disease [1–3]. The heel is second only to the sacrum as the most common site of pressure ulcer formation, with about one-third of all pressure ulcers being at the heel [1, 4]. Heel pressure ulcers represent a very serious problem; the 6-month mortality rate in patients with advanced heel pressure ulcers has been shown to be as high as 70% [1, 2].

Post-traumatic and postsurgical wounds represent two other categories of hindfoot wounds. Open fractures of the talus or calcaneus, as well as degloving injuries, can lead to significant hindfoot soft tissue loss as well as damage to the remaining soft tissue envelope. Surgical incisions about the hindfoot, most notably for calcaneus fractures and Achilles tendon procedures, also can lead to hindfoot wounds. The anatomy of the hindfoot, particularly the posterior aspect of the heel where

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there is very little tissue between the Achilles-calcaneus complex and the overlying dermis, makes this region particularly susceptible to wound problems [1]. By contrast, the inferior aspect of the heel has far greater soft tissue protection and is therefore far less susceptible to wound problems.

Assessment of Hindfoot Wounds

An important first step when evaluating any hindfoot wound is to determine the underlying cause(s) and any perpetuating factors. Listed below are important parts of the assessment of a hindfoot wound:

- *Overall health and status of the patient* – Overall health and physiologic reserve, living situation, and cognitive status are important factors for assessing and treating hindfoot wounds. Many patients who present with hindfoot wounds have medical comorbidities that have contributed to the development of the wound, ranging from systemic disease such as diabetes to biomechanical factors leading to pressure ulcers.
- *Nutrition* – The nutritional state of the patient is important to assess, as optimal nutrition is critical for wound healing. In addition to the general appearance of the patient, serum albumin and prealbumin can be used to screen for malnourishment. The services of a nutritionist should be sought in the setting of poor nutrition.
- *Wound location* – Is the wound inferior, posterior or on either side of the hindfoot? Location is important due to the anatomic implications, blood flow and treatment options of various hindfoot wounds. The location of the wound may give clues as to its etiology, with pressure ulcers typically located at the posterior heel, for example. Foreign-body-related wounds, in contrast, are often at the plantar surface of the foot.
- *Blood flow* – Assessment of the vascular supply to the wound is a key part of any wound assessment. There is a high correlation between peripheral vascular disease and heel ulcers [2]. Vascular supply to the hindfoot consists of two angiosomes arising from branches of the posterior tibial and peroneal arteries [1]. There is a watershed area between these two vascular supplies at the lateral hindfoot that is prone to postsurgical wound-healing problems. Similarly, the lateral hindfoot is a common site of pressure ulcers. To adequately heal a hindfoot wound, ample vascular supply from either these arteries or from collateral circulation is necessary. The initial assessment of blood flow starts with the appearance, color and warmth of the skin, presence of hair, and assessment of pulses. If there is any concern for inadequate blood flow, more advanced assessment with vascular studies and the involvement of vascular surgery should be initiated. Vascular studies may include ankle-brachial indices, toe-brachial indices, segmental leg pressures, pulse volume recordings, transcutaneous oxygen pressures, or advanced imaging with angiography.

- *Sensation* – The presence of sensory neuropathy and the loss of protective sensation are important to assess with 5.07 Semmes-Weinstein monofilament testing. If a patient has peripheral neuropathy of unclear etiology, involvement of a neurologist should be requested.
- *Infection* – The presence of infection is important when assessing a wound about the hindfoot. Systemic signs of infection, such as fever, chills, or generalized malaise can suggest an infection associated with a hindfoot wound. Abnormalities in laboratory work such as elevated erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and white blood cell (WBC) count all may be suggestive of infection. The general appearance of the wound, presence of purulence or erythema, and any odor from the wound are important additional initial assessments. Plain x-rays, either of the foot, ankle, or calcaneus, may reveal bony destruction which would be highly concerning for infection. At times, the use of advanced imaging, such as magnetic resonance imaging (MRI) or tagged white blood cell scan, can assist in determining the presence and extent of infection.
- *Wound extent (size, depth)* – Is the wound limited to the dermis and superficial tissues or does it extend to the muscles, tendons, and bone? It is important to sterily probe the wound to evaluate its depth as just visualizing the wound very commonly leads to an underestimation of wound depth [5]. Furthermore, wounds that probe to bone in the diabetic foot ulcer population have been shown to have a high incidence of underlying osteomyelitis [5]. Exposed tendon, often the Achilles, or bone is very problematic and typically requires treatment with debridement of the exposed tissue and attempts at wound coverage.
- *Pressure on the wound* – Pressure is often a contributing cause of hindfoot wounds and can also be a perpetuating factor for recurrent wounds. It is important to assess for any external source of pressure on the skin and wound, such as might be caused by ill-fitting shoe wear, as well as any internal source of pressure on the skin and wound, such as from underlying bony deformity. At times, there is no definable external or internal source of pressure other than immobilization. This is frequently the cause of hindfoot wounds in patients with limited ability to mobilize, as seen in some elderly patients or those with certain neurologic deficits.
- *Imaging* – Imaging is a very important adjunct to the assessment of hindfoot wounds. Imaging can provide insight into the extent of the wound, other pathology in the area, and the presence and extent of infection. Radiographs can show bony injuries (such as an underlying calcaneus fracture) and can also show bony changes suggestive of underlying osteomyelitis. Computed tomography (CT) better shows bony detail and can show some soft tissue pathology as well. MRI is usually the imaging modality of choice to assess the extent of soft tissue involvement and the presence of infection in either the soft tissues or bone. Tagged white blood cell scans can also be useful to determine the presence of infection, especially when MRI is contraindicated.
- *Wound etiology* – It is critical to determine the cause of the wound, as treatment options may vary depending upon the cause. For example, wounds due to

abnormal bony morphology with normal vascular supply are typically managed differently than those with normal bony anatomy yet with vascular insufficiency.

Treatment of Hindfoot Wounds

Non-operative Treatment of Hindfoot Wounds

Many hindfoot wounds can be effectively treated with non-operative measures. The first step in non-operative treatment is to promote a favorable healing environment by off-loading pressure on the wound, optimizing nutrition, ensuring adequate vascular supply, treating infection if present, and achieving tight glucose control in the case of diabetes. This often requires a multidisciplinary team approach that includes representatives from orthopedic surgery or podiatry, nutrition, vascular surgery, infectious diseases, wound care, endocrinology, primary care, nursing, and orthotics/prosthetics.

There are a variety of ways to offload pressure on a hindfoot wound, including heel elevation and pneumatic boots when in bed and heel off-loading shoes, braces, and orthotics when out of bed and ambulatory. If these measures are inadequate, then the patient may require restricted weight bearing on the affected limb. This can be done with the help of external supportive devices including crutches, a walker, or a wheelchair.

Proper wound care is essential to promote healing. The principles of this include the debridement of any nonviable or infected tissue and keeping the wound clean and protected. There are many dressing supplies available to help with this endeavor, and subatmospheric pressure dressings can be particularly useful.

If the hindfoot wound is infected, antibiotic use is very important. Deep tissue cultures are useful to guide antimicrobial therapy, whereas superficial wound cultures are often polymicrobial and misleading [6].

Operative Treatment of Hindfoot Wounds

Hindfoot wounds are more difficult to treat surgically than many wounds in the midfoot or forefoot. One reason for this is that procedures that reduce pressure on the midfoot and forefoot, namely, Achilles tendon lengthening procedures, do not have the same effect on the hindfoot. Additionally, it is feasible to heel weight bear while treating a midfoot or forefoot wound, but it is much more difficult to forefoot weight bear only while treating a hindfoot wound. And furthermore, the forefoot and midfoot are naturally off-loaded when the lower extremity is elevated or when lying supine in bed, while the hindfoot may continue to receive pressure in these positions. Therefore it is not surprising that healing times, results, and limb salvage

rates are inferior for hindfoot wounds and ulcers when compared to midfoot and forefoot wounds and ulcers [1, 7].

The initial surgical treatment of many hindfoot wounds is a thorough debridement of devitalized or infected tissue. It is important to debride the wound to healthy margins of tissue. This allows characterization of the wound, and in the setting of infection, allows for deep tissue biopsies for microbiology culture. Unfortunately, at times this involves removal of tendon or bone. This may compromise function later but is often a necessary step in effective treatment. Reconstructive efforts, such as tendon transfer to supplement for a compromised Achilles tendon, may be undertaken at a later time when and if the wound has been effectively treated.

Given the high association of hindfoot wounds and peripheral vascular disease, revascularization procedures may be necessary. Revascularization procedures are ideally performed prior to more advanced local surgical treatments beyond a debridement. Revascularization procedures may also be necessary in the setting of traumatic injuries with vascular disruption.

In certain circumstances, bony procedures can be helpful to promote healing of hindfoot wounds. If there is pressure on the skin or wound by underlying bone, then removal of the offending bone can help with the healing process. Additionally, bone removal may be an important part of the treatment if osteomyelitis is present. Bone resection procedures of the hindfoot take three main forms: plantar exostectomy, partial calcanectomy, and total calcanectomy. These three options are presented below.

Plantar Exostectomy

Plantar exostectomy may be performed when there is bony pressure from the calcaneus at the plantar foot, contributing to an ulceration or wound. This excess pressure can occur when there is loss or attenuation of the plantar fat pad and associated soft tissues. Excess pressure can also occur following events that cause abnormal architecture of the calcaneus bone itself, as can be seen with Charcot neuroarthropathy or malunion of calcaneus fractures. A plantar exostectomy removes a prominent part of the calcaneus, typically at the weight-bearing surface, to relieve pressure on the overlying wound or skin.

Case Example

A 63-year-old woman with neuropathy and recurrent foot ulcers presented with a wound at the plantar hindfoot that had been present for more than a year. The plantar hindfoot ulcer persisted despite extensive nonsurgical treatment, including local wound care, prolonged heel off-loading, and the use of custom orthotics with a cut out under the ulceration. She had palpable pulses and no evidence of vascular insufficiency. Plain x-rays and an MRI did not reveal deep infection or osteomyelitis (Fig. 7.1a, b). She underwent a plantar exostectomy of the calcaneus to take pressure off of the hindfoot ulcer. This procedure involved a medial hindfoot incision at

Fig. 7.1 Plantar exostectomy. (**a**, **b**) Preoperative x-ray and MRI without osteomyelitis of the calcaneus. (**c**) Intraoperative fluoroscopic image showing planned level of exostectomy using a small saw. (**d**) Fluoroscopic image after plantar exostectomy

the glabrous/non-glabrous skin junction and the use of a small saw to remove the plantar portion of the calcaneus deep to the ulceration (Fig. 7.1c, d).

Partial Calcanectomy

There are scenarios when a simple plantar exostectomy is insufficient and a larger bony procedure is necessary. At times, to allow for a tension-free closure of a large hindfoot wound, a substantial amount of bone must be resected. Soft tissue coverage options, such as flaps or skin grafts, are often limited at the hindfoot. This is due to a number of factors, including the relatively poor vascular supply to this area and the reality that many of these wounds occur in patients with multiple comorbidities that make flap or skin graft coverage unlikely to be successful. In this setting, a partial calcanectomy may be considered to achieve a tension-free closure. Similarly, if osteomyelitis is present, then a partial calcanectomy may be required to remove infected bone.

Partial calcanectomy involves detachment or excision of the terminal Achilles tendon and excision of a substantial, yet subtotal, amount of the calcaneus. When performed in conjunction with an ulcer excision and skin closure, this procedure is eponymously known as a Gaenslen procedure [8]. Case series have shown this procedure to lead to successful wound healing 75–100% of the time, although subsequent procedures are often needed [9–12]. A longer time to wound healing and higher failure rates have been noted in patients with diabetes [12, 13]. Rates of subsequent below-knee amputation have been reported to be 0–29% [9–12, 14]. Although the Achilles is detached and a substantial amount of the calcaneus is excised, overall functional mobility, with the use of a specialized ankle-foot orthosis, has been found to be similar to preoperative function [9, 11, 12]. Postoperative function does not seem to differ much based on whether more or less than half of the calcaneus is excised [14].

Case Example
A 92-year-old woman was admitted to the hospital with a non-healing posterior hindfoot pressure ulcer. She was largely non-ambulatory due to a prior cerebrovascular accident. On examination, the posterior aspect of the calcaneus was exposed with bone easily palpable. Plain radiographs and an MRI revealed extensive osteomyelitis of the calcaneus (Fig 7.2a, b). She underwent an excision of the ulcer and partial calcanectomy (Gaenslen procedure). The wound was approached from straight posterior, excising the margins of the ulceration and using a saw to remove the infected bone (Fig. 7.2c). The proximal part of the incision was closed primarily and the distal part received a subatmospheric pressure dressing. She was treated with postoperative culture-specific intravenous antibiotics.

Total Calcanectomy

Excision of the calcaneus in its entirety is necessary when the extent of osteomyelitis does not allow for the salvage of any of the bone or when a hindfoot wound is so large that the entire calcaneus must be removed to facilitate subsequent closure. There are far fewer cases of total calcanectomy reported in the literature than partial calcanectomy. What can be gleaned from the available cases, however, is that patients are left with a less stable and likely a less functional foot [15]. Midtarsal instability can occur after a total calcanectomy and may require subsequent stabilization [13, 15].

Case Example
A 47-year-old man with diabetic peripheral neuropathy developed a large non-healing hindfoot ulcer. He presented to the hospital with areas of skin necrosis at the hindfoot and exposed calcaneus (Fig. 7.3a). Plain radiographs and an MRI revealed osteomyelitis of the entire calcaneus and part of the talus (Fig. 7.3b, c). Vascular studies were performed, and he was deemed to have adequate vascular supply to heal a hindfoot surgical procedure. A total calcanectomy was performed by using a

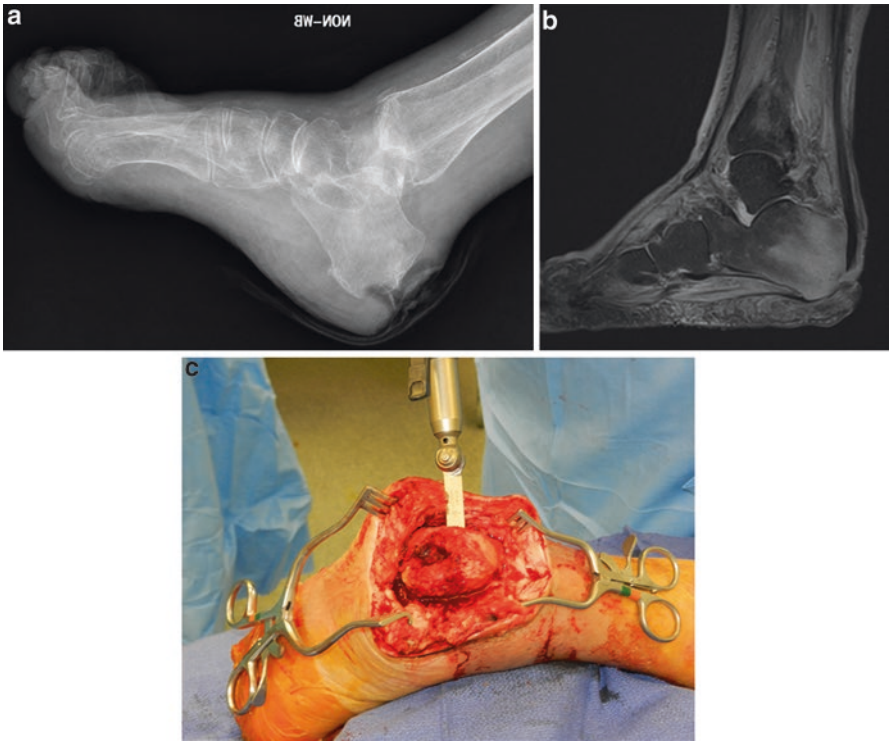

Fig. 7.2 Partial calcanectomy. (**a**, **b**) Preoperative x-ray and MRI showing soft tissue loss of the posterior hindfoot and extensive changes to the calcaneus consistent with osteomyelitis. (**c**) Intraoperative picture showing resection of part of the calcaneus

posterior incision with removal of all devitalized soft tissue, removal of the entirety of the calcaneus, and primary closure (Fig. 7.3d, e). A surgical drain was left in place for several days, and he received culture-specific intravenous antibiotics for 6 weeks. The wound healed well, and he is now ambulating in a specialized prosthetic to accommodate the atypical shape of his hindfoot (Fig. 7.3f).

Amputations

Length-sparing amputations are rarely indicated for the treatment of hindfoot wounds. In fact, most length-sparing amputations rely on either a healthy hindfoot or at least maintenance of the heel fat pad. Yet, several length-sparing amputations involve the hindfoot, and therefore we have chosen to include them in this discussion of hindfoot operations. Importantly, these procedures are typically used for treatment of unsalvageable midfoot or forefoot wounds, not hindfoot wounds.

Fig. 7.3 Total calcanectomy. (**a**) Clinical picture showing the hindfoot wound with areas of necrotic soft tissue and bone. (**b**, **c**) Preoperative x-ray and MRI showing extensive underlying calcaneal destruction from osteomyelitis. (**d**, **e**) Intraoperative pictures showing resection of the necrotic soft tissue and entire calcaneus. The wound was closed primarily over a drain. (**f**) Postoperative x-ray showing resection of the entire calcaneus

The Pirogoff amputation involves an arthrodesis (fusion) of the calcaneus to the tibia with removal of the entire midfoot, forefoot, and talus. This procedure has the advantage of preserving most of the length of the lower extremity.

Case Example

A 67-year-old woman with diabetic peripheral neuropathy developed midfoot Charcot arthropathy with collapse of the midfoot (Fig. 7.4a). She developed a chronic plantar ulceration at the midfoot with extensive osteomyelitis of her

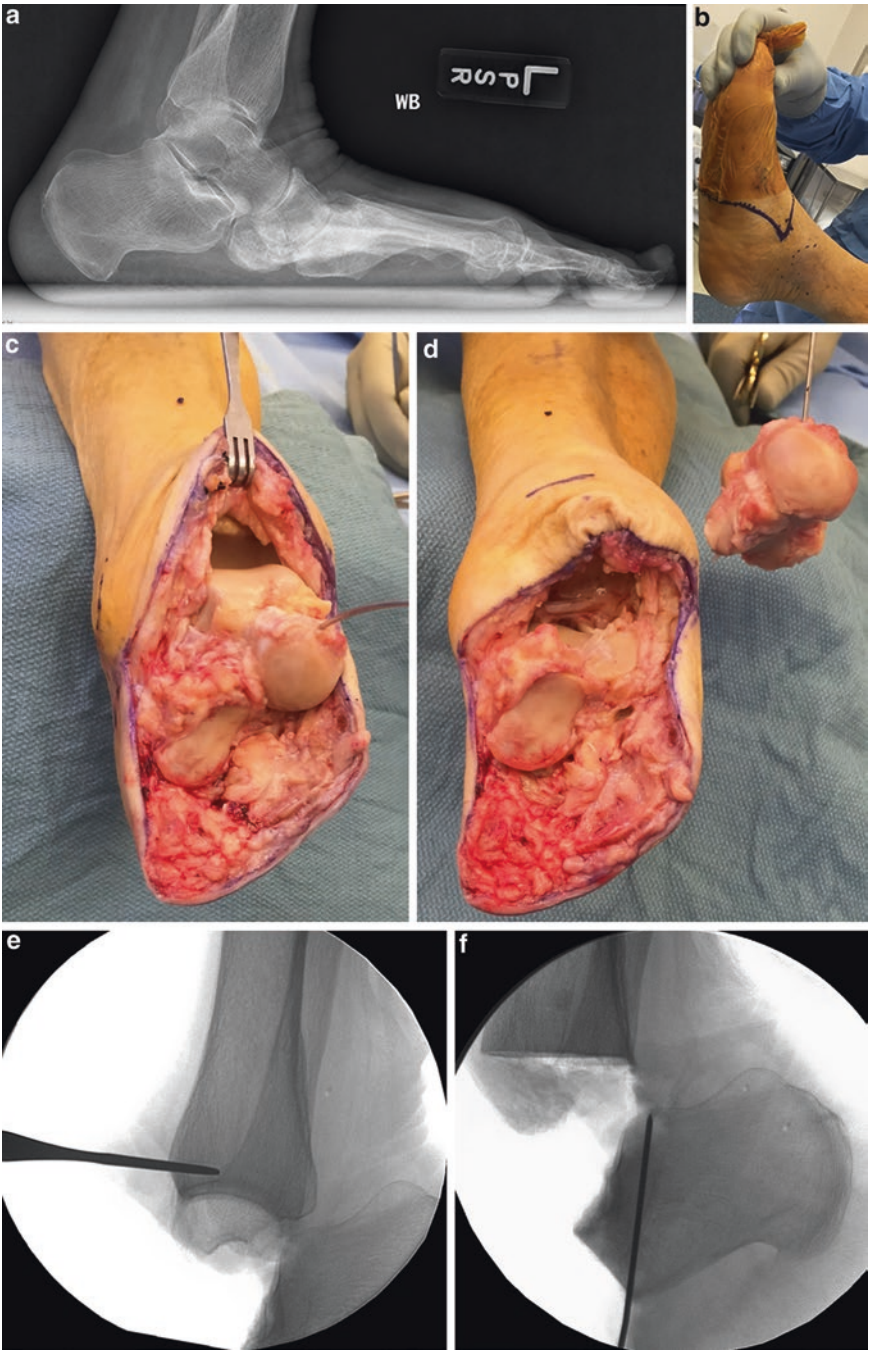

Fig. 7.4 Pirogoff amputation. (**a**) Preoperative x-ray showing midfoot collapse and deformity. (**b**–**d**) Intraoperative pictures showing the incision, disarticulation through the transverse tarsal joint, and resection of the talus. (**e**, **f**) Intraoperative fluoroscopic images showing the osteotomies

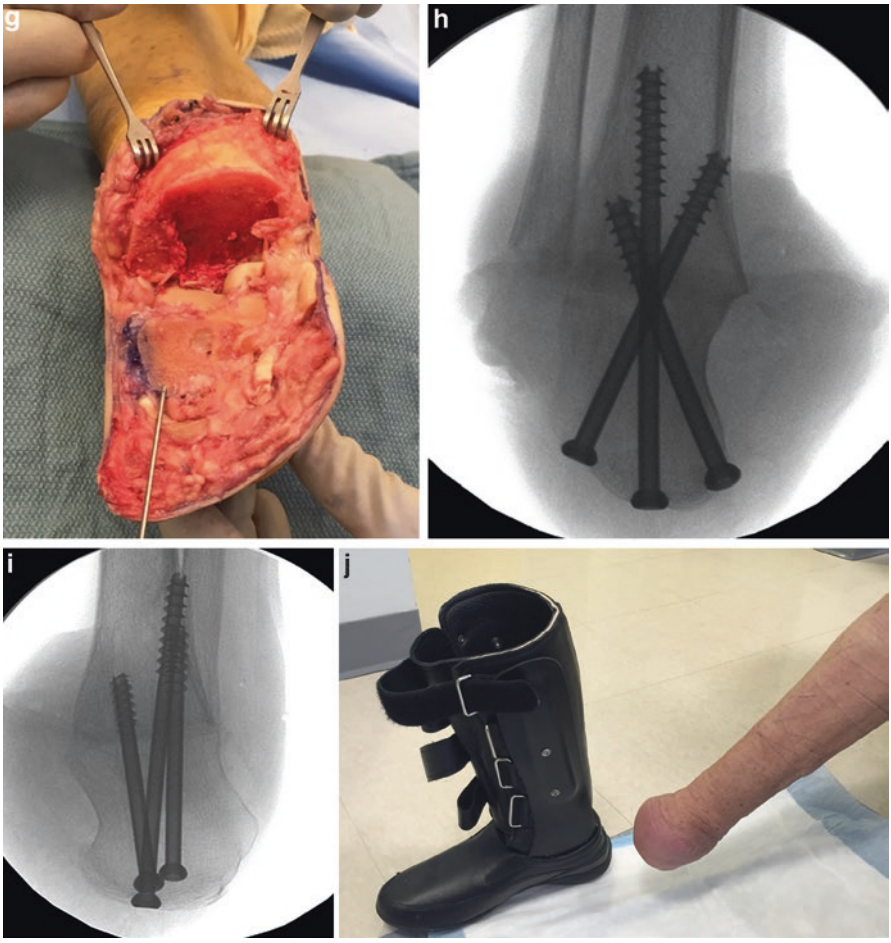

Fig. 7.4 (continued) of the tibial plafond and calcaneus in preparation for arthrodesis. (**g**) Intraoperative picture showing the tibia and calcaneus prepared for arthrodesis. (**h**, **i**) Intraoperative fluoroscopic images showing the tibiocalcaneal arthrodesis. (**j**) Postoperative clinical picture showing the healed amputation with custom made brace

midfoot. She underwent a Pirogoff amputation, which involved a fish-mouth-shaped incision and subsequent disarticulation of the foot through the transverse tarsal joint (Fig. 7.4b, c). The talus was subsequently removed (Fig. 7.4d) and the tibia and calcaneus cut to facilitate the tibiocalcaneal arthrodesis (Fig. 7.4e–g). Large diameter screws were used to fix the arthrodesis site (Fig. 7.4h, i). She healed well and at 5 months postoperatively was ambulating with the use of a custom brace (Figure 7.4j).

Another length-preserving amputation is a Syme amputation, which is an amputation at the level of the ankle joint. With this procedure, the foot is removed, and the distal tibia is beveled to become a weight-bearing stump. The calcaneal fat pad and plantar hindfoot are then secured to the distal tibia, becoming the weight-

bearing portion of the extremity. Thus, as with a Pirogoff amputation, a Syme amputation requires an intact heel pad.

The most common and useful amputation for the treatment of hindfoot wounds is a below-knee amputation. This can be considered as the initial procedure in the case of an extensive hindfoot wound deemed unsalvageable or a hindfoot wound associated with significant infection, neurovascular injury, or extensive bony injury. Below-knee amputation is also useful when limb salvage surgery has failed to give the patient a satisfactory result. Below-knee amputation can lead to a better and more functional result than extensive limb salvage and thus should not necessarily be viewed as a failure.

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