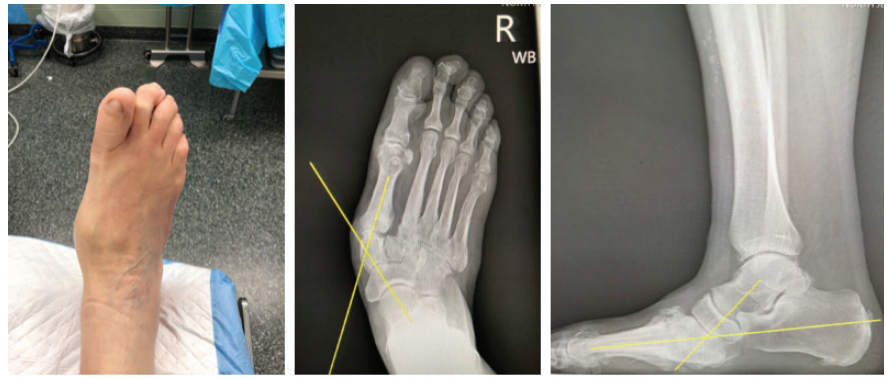

Figure 1a: Charcot midfoot deformity

The At-Risk Diabetic Foot

It's important to know when to perform surgery.

BY NICHOLAS J. BEVILACQUA, DPM

Most patients are familiar with the long-term complications of diabetes. In a recent survey published, patients with diabetic foot ulcers, Charcot, or neuropathic fracture/dislocations reported amputation and infection as their greatest fears. These patients fear infection and amputation more than they fear death, heart attack, stroke, dialysis, and blindness.[1] Some of these fears are well-founded, as approximately 80% of lower extremity amputations are preceded by an ulceration.[2] However, if we, as podiatric surgeons, can assist in preventing an ulceration from forming, or promote wound healing as quickly as possible, we can prevent the majority of amputations, and over time, quell our patients' fears.

Preventing the formation of a diabetic foot ulcer starts by identifying risk factors and recognizing which patients are at risk.

Identifying Risk Factors

Preventing the formation of a diabetic foot ulcer starts by identifying risk factors and recognizing which patients are at risk. The risk factors for ulceration have been well-documented and include vascular disease, peripheral neuropathy, deformity, history of ulceration or amputation, and impaired vision. Vascular disease is a direct pathway to amputation; these patients are identified and referred to a vascular specialist for further evaluation for a possible re-vascularization procedure.

Figure 1b: Charcot ankle deformity

Peripheral neuropathy is a key component of all diabetic foot ulcers. Sensory neuropathy results in the inability of the individual to detect excessive mechanical stress. Motor neuropathy may lead to gait abnormalities and deformities (which further elevate mechanical stress levels).[3] Autonomic neuropathy causes deteriorating skin conditions. Xerosis and plantar fissures are common manifestations of peripheral neuropathy and the incidence of skin changes increases with the duration of diabetes mellitus.[4] However, neuropathy, in isolation, does not cause an ulceration. It is a contributing risk factor, and when present with other risk factors, act together to produce a foot ulcer.

To help provide a practical view of causation for a foot ulcer, Reiber and colleagues applied the Rothman

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model of causation to find the multiple contributing factors.[5] The authors found what they described as the "critical triad" in greater than 63% of ulcers in 148 patients. The critical triad consists of neuropathy, deformity, and trauma. Targeting and removing one or more of these contributing factors may prevent or delay the development of a diabetic foot ulcer.

Figure 2: Limited joint mobility at first metatarsal phalangeal joint (hallux rigidus). This deformity increases the pressure on the distal hallux, often resulting in ulceration.

A foot or ankle deformity may be something very obvious, such as a Charcot midfoot (Figure 1a) or Charcot ankle (Figure 1b) deformity, or it may be something less obvious, such as limited joint mobility at the first metatarsal-phalangeal joint (Figure 2) or ankle joint (equinus deformity). These deformities predispose a person to increased plantar pressures. As noted above, elevated mechanical stress on an insensate foot is the most common pathway to developing an ulceration.[3]

To determine the risk of ulceration in a person with diabetes, a detailed history should include questions about previous diabetic foot complications (previous history of ulceration or lower extremity amputation), which is associated with a greater risk. The feet are carefully evaluated to identify a biomechanical deformity and thorough assessment for neuropathy is performed. As mentioned earlier, if a patient presents with clinical signs of peripheral arterial disease (diminished pulses, atrophic skin changes, and/or loss of hair growth), they are promptly referred to a vascular specialist for further evaluation and treatment.

Patients with neuropathy and a biomechanical deformity are at increased risk for developing an ulcer as the causation pathway. If the deformity is unstable or there are signs of impending skin breakdown, "prophylactic" surgery should be considered. Prophylactic diabetic foot surgery is defined as a procedure performed to reduce risk of ulceration or re-ulceration in a person with loss of protective sensation but without an open wound.[6,7] The goal of prophylactic diabetic foot surgery is to eliminate a deformity, thereby removing a component cause of ulceration.

Patients with neuropathy and a biomechanical deformity are at increased risk for developing an ulcer as the causation pathway.

The benefits of prophylactic diabetic foot surgery become evident when treating a patient with diabetes, neuropathy, and hallux rigidus.

The benefits of prophylactic diabetic foot surgery become evident when treating a patient with diabetes, neuropathy, and hallux rigidus. The limited range of motion at the first metatarsal-phalangeal joint creates an increase in pressure at the distal hallux during ambulation. The increase in mechanical stress results in sub-dermal trauma, inflammation, and eventual ulcer formation.[3] A joint arthoplasty may be performed to increase motion at the metatarsal-phalangeal joint, thereby reducing the distal pressure and lowering the risk of skin breakdown.[8] In this case, an important component of the critical triad (deformity) has been removed, thereby lowering the risk of developing a diabetic foot ulcer.

Active Charcot Foot

Next, consider a patient with active Charcot; ideally, the clinical signs of active Charcot are recognized early, and an immobilization/off-loading plan should be initiated to prevent deformity and subsequent ulceration. However, at times, patients may present with instability of the foot and/or ankle joints, and/or a deformity with a high risk of developing a wound; in these cases surgical intervention should be considered.[9] Charcot foot and/or ankle reconstruction is associated with a high complication rate; therefore, the surgeon must consider the risks versus benefits. The goals (and benefits) of Charcot foot reconstruction are to restore anatomic alignment, thereby creating a stable, plantigrade foot that can be fitted with shoes or braces, enabling ambulation.

Oftentimes, corrective osteotomies are performed and multiple joints are fused proximal and distal to span the zone of injury. Stable internal and/or external fixation is employed using the superconstuct principles. Locking plates provide robust fixation and may be used to span the zone of injury; however, applying a locking plate requires extensive dissection. Intramedullary fixation, on the other hand, allows for a more biologically friendly approach and provides simultaneous compression across the fusion site and spans across the zone of inju-

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ry. Mateen, et al. recently reported positive outcomes after minimally invasive midfoot Charcot reconstruction.[10] A minimally invasive approach is an attractive option for Charcot reconstruction, as this technique offers minimal disruption of soft tissue envelope and vascularity.

A growing trend is to include a subtalar joint fusion alongside the medial and lateral column fusion.[11] Manchanda and colleagues reported an advantage of including a subtalar joint fusion in their midfoot reconstructions. By creating a rigid construct of the hindfoot, the authors found an 80% less complication rate than with intramedullary fixation alone.[12]

Interestingly, a recent publication described the use of a tibiotalocalcaneal (TTC) fusion with intramedullary nail fixation for the treatment of midfoot Charcot neuroarthropathy.[13] Midfoot osteotomies were performed solely to remove any bone prominences; however, no fixation was used. The study population (12 patients) had 100% limb salvage and remained ulcer free during the study period. The authors found that creating a rigid construct of the hindfoot and ankle allows for the stabilization of the midfoot and prevents the progression of midfoot Charcot.[13] The results of this study indicate that TTC fusion for a midfoot Charcot deformity is a reliable treatment option and produces a stable, plantigrade, and brace-able foot.

Prophylactic and Curative Pedal Surgery

In patients presenting with a neuropathic foot ulcer (in addition to addressing and locally treating the wound), an appropriate off-loading plan should be implemented. Ideally, patients are placed in a non-removable knee-high off-loading device, such as a total contact cast (TCC) or a removal knee-walker rendered non-removable to promote healing.[14] If a non-removable device is contraindicated or not tolerated, consider a removable knee-high walking boot.[14] Although these devices are effective at off-loading and promoting healing, the ulcer recurrence rate is unacceptably high.[15]

Oftentimes, healing the wound is not the difficult part, but keeping it healed is. These off-loading modalities do not eliminate the underlying deformity and after healing, the contributing factors remain. This is another indication for prophylactic diabetic foot surgery. Frigg, et al. recommend surgically correcting foot deformities immediately after primary healing (after treating with an off-loading device), rather than waiting for ulcer recurrence.[15]

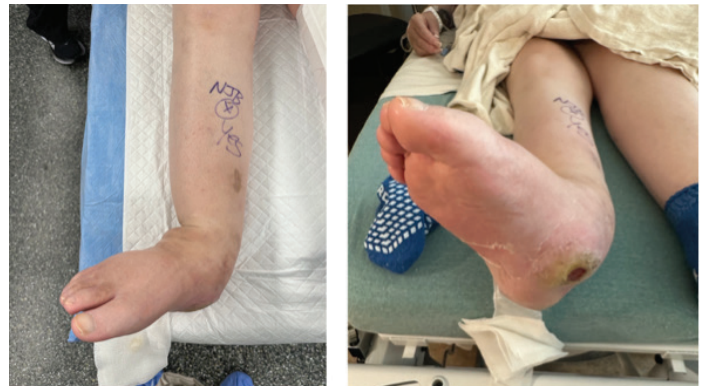

Figure 3a: Patient with an unstable Charcot ankle deformity with a chronic non-healing ulcer. This patient had previous (failed) attempts at reconstruction and was then "offered" a below-the-knee amputation.

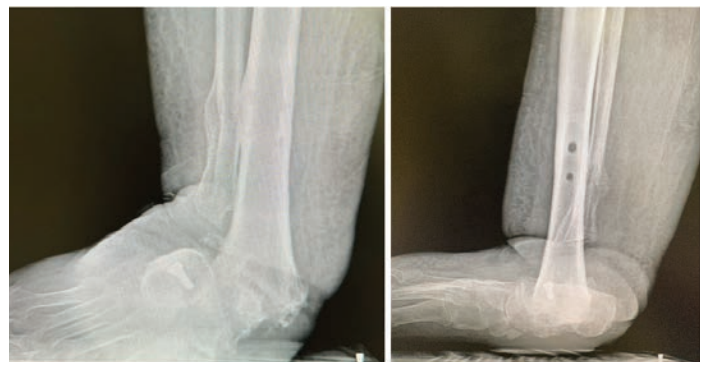

Figure 3b: Radiographs demonstrating severe ankle deformity.

Figure 3c: Patient underwent a talectomy and tibiocalcaneal fusion with external fixation.

In situations when non-surgical off-loading treatment fails to heal the wound, a "curative" surgical procedure should be considered to promote and sustain healing of the ulcer. Curative foot surgery is defined as a procedure performed to assist in healing an open wound.[6,7] It is often performed to provide a cure by joint resection, removing bone prominence, and, if osteomyelitis is present, removing infected bone. Curative diabetic foot surgery eliminates the deformity, resulting in more rapid healing and fewer recurrences.[16] Researchers have described various surgical procedures to assist in wound healing. Recently, the IWGDF published updated guidelines on off-loading neuropathic foot ulcers and provided recommendations for surgical off-loading.[14]

The authors recommend procedures for certain pathologies. For example, in a patient with a

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neuropathic plantar metatarsal head ulcer, the authors recommend considering an Achilles tendon lengthening as well as a metatarsal head resection or a metatarsal osteotomy. For patients presenting with a neuropathic hallux ulcer, the authors recommend considering a joint arthroplasty, and for those patients with neuropathic distal toe ulcers, they recommend using a digital flexor tenotomy to promote and sustain healing.[14]

A well-performed corrective foot surgery in this high-risk patient population can have a great impact in preventing wounds and promoting wound healing.

Charcot neuroarthropathy can result in permanent deformity of the foot and/or ankle and as a consequence, can cause ulceration which can lead to osteomyelitis, further increasing the risk for lower extremity amputation (Figures 3a-e). At times, a staged approach is necessary—first, to clear the infection and second, to obtain a functional stable, plantigrade foot. Surgical treatment for Charcot neuroarthropathy with osteomyelitis in patients with diabetes demonstrated a relatively high success rate for a range of procedures, including debridement with exostectomy, fusion with internal and/or external fixation, and when necessary, advanced soft tissue reconstruction.[17]

Summary

In conclusion, a well-performed corrective foot surgery in this high-risk patient population can have a great impact in preventing wounds and promoting wound healing. Surgery addresses the underlying deformity and changes the structure and function of the foot, providing a more permanent solution. Surgery targets and removes a component cause (deformity), potentially preventing or delaying the development of a diabetic foot ulcer. If ulcer formation can be prevented, the majority of lower extremity amputations will diminish, thus alleviating patients' fears. **PM**

Figure 3d: Four-month post-operative clinical photo demonstrating a well-healed soft tissue envelope, a stable, plantigrade foot, and good alignment of the foot upon the leg.

Figure 3e: Post-operative radiographs demonstrating a well- aligned tibiocalcaneal fusion.

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