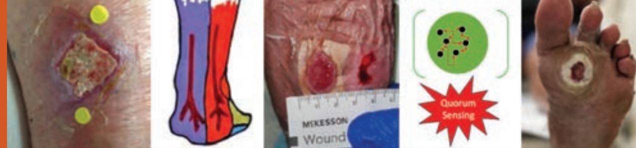

Surgical Off-Loading for Diabetic Wounds

Here's an update on the prevention, treatment and long-term options for wound healing.

BY ROBIN TSAI, DPM AND LAURA SHIN, DPM, PHD

Diabetic wounds are costly and difficult. The economic strain associated with healing diabetic foot ulcers (DFUs) is substantial and multifaceted, impacting individuals and health systems. The typical direct mean cost per patient-year to heal a DFU was $3,368 (ulcer-only).[5] This number, however, does not highlight the change in quality of life, lost productivity, and loss of income during the course of treatment. In another study the expenditure of a DFU occurrence in the initial two years post-diagnosis was $30,724.[6]

Foot ulcerations (DFUs) are a significant complication of diabetes mellitus. DM impacts more than 37 million people in the United States. DFUs are linked to risks such as foot deformities, trauma, and diabetic peripheral neuropathy. Diabetic peripheral neuropathy is the main risk factor, constituting about 35-45%.[2,3] Studies demonstrate that DFUs occur in areas of highest plantar pressure.

A cornerstone principle of healing DFUs is to reduce or redistribute pressure from the ulcerated site, termed off-loading.[4] Although considered as first-line therapy, conservative off-loading entails high recurrence rates at the 1 year (40%) and 3 year (60%) mark; thus, even with resolution of the ulcer, the patient appropriately is termed as "in remission".[20,21]

Wounds that do not have sufficient healing after 4 weeks of standard care must be re-assessed to evaluate underlying pathologies and to determine if further advanced treatments are warranted.

The percentage area reduction (PAR) in wound size after 4 weeks of DFU treatment has been suggested as a clinical parameter to distinguish DFUs that will heal within 12 weeks.[1] Delaying the healing of diabetic foot ulcers (DFUs) significantly increases the risks of diabetic foot infections, leading to the potential for limb loss.

Biomechanical abnormalities or bony deformities create alterations in gait patterns. Unstable gait with neuropathy poses challenges for off-loading, despite appropriate or advanced wound care. Managing diabetic foot ulcerations secondary to biomechanical deformities is as important as addressing the differing co-morbidities such as infection control, vascular disease, and neuropathy itself. These biomechanical etiologies can predispose individuals with diabetes to ulcer development. Surgical measures are considered when conservative approaches have proven ineffective.

Surgical interventions aim to alleviate pressure on the ulcerated area, promoting wound healing, and preventing further complications. Addressing biomechanical etiologies surgically for diabetic foot ulcerations should be considered when there are underlying osseous deformities that contribute to increased plantar pressure. Biomechanical factors play a significant role in diabetic foot pathology, and surgical intervention can help correct these issues to reduce the risk of ulceration and facilitate wound healing. Intervention may prevent further loss of mobility, prevent recurrence, and allow for return to activity.

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Digital Flexor Tenotomies

DFUs are often linked to digital deformities such as hammer, mallet, or claw toes. Areas most commonly affected are distal plantar and dorsal parts of the toes.[7] Involvement of toes constitute a significant proportion of foot ulcers, ranging from 43% to 55.5% of cases. Despite their smaller size and generally quicker healing, they exhibit elevated rates of limb amputations in comparison to ulcers occurring in other foot locations.[8] Conservative treatments of digital ulcers include footwear, toe silicone orthosis, padding, and debridement. The effectiveness of conservative care, however, remains unclear due to limited evidence and poor patient compliance.[9]

Percutaneous flexor tenotomies

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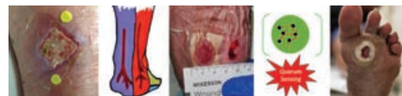

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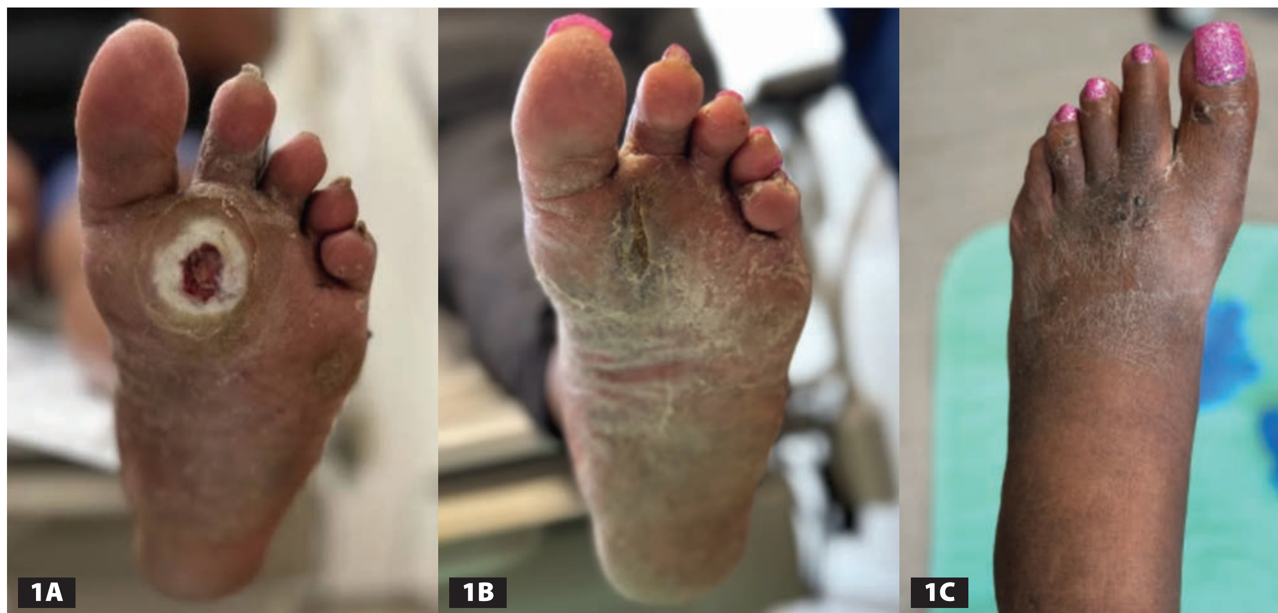
have been effective in preventing and managing digital ulcerations. In an office setting, a 11 blade or 18-gauge needle can be used to minimize incision and tissue loss. Procedures can be done in the office with local anesthetic. Recent literature points to high healing rates of 92% to 100% with mean healing time of 2 to 4 weeks.[10]

an in-office treatment option that allows bone biopsy diagnosis while addressing osteomyelitis and biomechanical etiologies. To perform the procedure, local anesthesia is administered followed by an elliptical fish-mouth-type incision to the distal phalanx with complete removal of distal phalanx and nail bed. Studies have shown in-office Symes procedures are safe, reliable, and cost-effective with low complications.[11-12]

Tendon Lengthening

Achilles tendon lengthening is a fast and effective surgical procedure used to help treat forefoot DFUs, particularly when the ulcers are associated with increased plantar pressure from a tight posterior chord. Stiffness in the triceps surae limits the normal range of motion in the ankle joint, thus leading to high forefoot pressures. Several studies have explored Achilles tendon lengthening in cases where healing was not achieved using off-loading devices such as the total contact cast (TCC) or removable walker. They found 91% to 93% of plantar forefoot ulcers healed with Achilles tendon lengthening in a mean of 6 to 12 weeks.[13-15]



Figures 1A, 1B, and 1C: The patient highlighted in Figure 1A is a 42-year-old-female with a history of type 2 diabetes mellitus with a DFU sub the 2nd metatarsal who failed 5 months of conservative off-loading in an off-loading boot with local wound care. Figures 1B and 1C show clinical images status post 4 weeks after a dorsal approach floating distal metatarsal osteotomy procedure.

Distal Symes Amputation

Flexor tenotomy has shown significant benefit for distal digital ulcerations; however, indications are reserved for the superficial, non-infected, recurrent tip-of-toe ulcers associated with flexible deformities. Prior to tenotomy procedures, considerations of whether hammer digit strengthening would further elongate the digit should be addressed. Distal Symes amputations are an effective method to address rigid non-reducible hammer digit deformities, elongated digits, advanced toenail pathologies, or deep sores of digital tips complicated by osteomyelitis. Long courses of oral or IV antibiotics are commonly used in the presence of osteomyelitis; however, the underlying biomechanical etiology of the ulcer is not addressed.

The distal Symes amputation is

DMMO

Operative off-loading to the central metatarsal heads are indicated often to prevent recurrence or when conservative off-loading has failed. Surgical off-loading methods aim to directly correct the underlying osseous deformity. Minimally invasive distal metatarsal osteotomy (DMMO) has been successfully used in the treatment of plantar metatarsal head ulcerations. Benefits of DMMOs seen by our patients include immediate weight-bearing, minimal disruption to the patient's daily life, reduction of peak pressure to the respective metatarsal head as the cause of recurring DFUs. Floating metatarsal head osteotomies have been found to decrease peak pressure under the head of the osteomized metatarsal by 33% following surgery.[21] (see Figures 1A-1C)

Another RCT comparing Achilles tendon lengthening vs. TCC groups noted 100% ulcers healing in the TAL group with 52% less risk of ulcer recurrence at two years than the TCC group.[16] Therefore, biomechanical evaluation of patients for the presence of soft tissue equinus should be performed as findings can indicate the need for a surgical off-loading approach.

Fat Grafting

Fat pad atrophy (FPA) or distal fat pad migration in the presence of

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neuropathy increases the risk of diabetic ulcer development. FPA in diabetic patients are thought to result from irregular arrangement of collagen fibrils as a result of glycation and reduction of adipocyte size. FPA leaves metatarsal heads vulnerable to increased peak plantar pressure.[18]

Fat grafting has been popular in plastic reconstructive surgery due to its low risk in complications, abundance of availability, and ease of harvest. It has been successfully utilized in contouring procedures for many years; however, use in prevention and treatment in diabetic foot ulcerations has yet to be popularized. Fat grafting, either via auto vs. allograft, reduces peak plantar pressure, friction, and shear forces by creating a cushioning effect and redistributing pressure.

Additionally, adipose tissue contains stem cells that promote tissue regeneration and wound healing. Mojallal, et al. paved the way for the use of autologous fat grafting in wound healing through their observation of enhancement in collagen fiber neosynthesis, vascularization, and the thickness of the dermis and subcutaneous tissue.[17] Studies have shown cases of allograft use in patients in thinning fat pads to have approximately 90% of average tissue thickness maintained after one year.[19]

Charcot Neuroarthropathy

Charcot neuroarthropathy among neuropathic patients often presents with deformity at the midfoot. The rocker bottom deformity is a debilitating condition where subluxation occurs in the midfoot joints, causing high peak plantar pressure at the apex of the deformity. Conservative off-loading often is the first line treatment, but if off-loading measures fail or there is an unbraceable deformity, ulcerations will occur.

Generally, the risk of limb loss and the complexity of surgical correction increase the more proximal the deformity. In the presence of ankle Charcot neuroarthropathy, the risk of amputation increases, the reconstruction is more challenging, and post-operative recovery is delayed.

Charcot neuroarthropathy reconstruction aims to create a braceable and stable plantigrade foot where the patient is able to ambulate following surgery. For the midfoot rocker bottom deformity, a plantigrade foot is achieved by plantar base wedge resection of the apex of deformity with plantar approach. The plantigrade foot can then be fixated via an internal vs. external circular fixator during a staged procedure where concern for infection is present.

It's important to recognize that the decision to pursue surgical off-loading is complex and should be made on a case-by-case basis.

It's important to recognize that the decision to pursue surgical off-loading is complex and should be made on a case-by-case basis. The patient's overall health, wound characteristics, vascular status, and the potential benefits and risks of surgery should all be taken into consideration. **PM**

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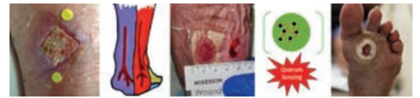

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