It’s Not What You Put On, but What You Take Off: Techniques for Debriding and Off-Loading the Diabetic Foot Wound

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The basic etiology of neuropathic diabetic foot wounds involves pressure in conjunction with cycles of repetitive stress, leading to failure of skin and soft tissue. The central tenet of any treatment plan addressing neuropathic diabetic foot wounds is the appropriate debridement of nonviable tissue coupled with adequate pressure relief (off-loading). Although numerous advances have been made in the treatment of diabetic foot wounds, including bioengineered tissues, autologous and exogenous cytokine delivery systems, and potentially effective topical antimicrobial modalities, none will succeed without addressing effective debridement and off-loading. Specific debridement and off-loading techniques are discussed, along with available supporting evidence. This includes the use of the “instant” total contact cast, among other modalities.

Neuropathic diabetic foot wounds on the plantar aspect of the foot occur because of a combination of focal pressure and repetitive stress at a given site [1]. The mitigation of either of these variables (pressure or repetitive stress) may reduce risk for ulceration [2, 3]. Mechanical stress that occurs at right angles to the integument is termed “vertical stress.” This tends to damage healthy tissue through repetitive compressive forces. Stress that is imparted parallel to the plantar aspect of the foot is termed “shear.” This tearing of soft tissue is equally damaging and is evidenced by the characteristic undermined nature of the periphery of poorly off-loaded diabetic foot wounds.

Shear and vertical stress work in tandem in the pathogenesis of a diabetic foot wound. In experiments on both nonhuman and human models, Brand [1] showed that the area of maximum soft-tissue damage occurred at the edge, not the center, of pressure application. This tissue damage, secondary to repetitive vertical stress and shear, is widely known as the “edge effect” [4].

The central tenet for healing any wound is pressure redistribution and appropriate debridement. Off-loading is best achieved by spreading force over a wide area of contact while ensuring compliance, such as with a total contact cast or other similar modality [5]. Wound debridement, when systematically done, may be as important as off-loading in reducing the prevalence of chronic inflammatory by-products in a wound [6–8] and, thus, in converting a chronic wound to an acute one [9]. Steed et al. [9], in a post hoc analysis of patients enrolled in a randomized controlled trial of becaplermin, reported that significantly more patients healed in centers where more frequent wound debridement was done. Attinger et al. [10] reviewed debridement techniques for a wide variety of tissues of the lower extremities without specifically focusing on the mechanics of diabetic foot wounds. Although there is a strong suggestion that aggressive surgical debridement of these wounds may be beneficial, there have been few, if any, technical descriptions regarding this aspect of therapy. The American Diabetes Association Consensus Development Conference on Wound Care [11] suggested that...
a wide variety of surgical techniques are used worldwide with apparently no specific documentation of these techniques in the literature. It is therefore our purpose to describe general principles, process, and technique of outpatient surgical debridement used at our institutions to treat neuropathic non-infected, non-ischemic diabetic foot wounds [12].

TECHNIQUE

With the patient seated comfortably, the wound may be approached with either a sterile scalpel and forceps (figure 1) or, for smaller wounds, a tissue nipper (figure 2). The skin may be incised or the nipper may be introduced to the fullest extent of the undermining between the epidermis and dermis (the extent of damage caused by shear). Excision of this undermined tissue should be done circumferentially about the wound until the periphery of the wound exhibits a firm connection between epidermis and dermis. Any nonviable tissue should be removed centrally from the wound, as required, through sharp excision or curettage. Digital pressure may then be applied to the wound to achieve hemostasis. The wound may then be probed to assess involvement of underlying tissue and for the presence of occult infection, followed by appropriate dressing and off-loading. The hallmark of an appropriately off-loaded wound is the noticeable lack of undermining at the wound’s edge at follow-up.

Although many off-loading modalities are currently in use, only a few case series describe the frequency and rate of wound healing with some of the methods frequently used in clinical practice. Here, we describe the most common of these modalities and the evidence supporting their use.

TOTAL CONTACT CASTS

Total contact casts (TCCs) are considered by most diabetic foot specialists to be the reference standard for off-loading [11] (figure 3). Plaster casting to treat neuropathic foot wounds was first described by Milroy Paul and was later popularized in the United States by Dr. Paul Brand at the Hansen’s Disease Center in Carville, Louisiana [13]. The technique is called “total contact casting” because it uses a well-molded, minimally padded cast that maintains contact with the entire plantar aspect of the foot and the lower leg. Total contact casting is effective in treating a majority of noninfected, non-ischemic plantar diabetic foot wounds, with healing rates ranging from 72% to 100% over a course of 5–7 weeks [14–19] (figure 4). Averaged
throughout gait, peak plantar pressures are highest in the forefoot and tend to be generally less significant in the hindfoot and medial arch. Shaw et al. [20] and our own group [21] have noted that a large proportion of the pressure reduction realized in the forefoot region of the TCC is transmitted along the cast wall or to the hindfoot. This supports the postulate that the TCC is effective because it permits walking by uniformly distributing pressures over the entire plantar surface of the foot [13–17, 22–24] (figure 5).

TCCs are effective for a number of other reasons besides their ability to off-load. They may help reduce or control edema that can impede healing and, thus, potentially protect the foot from infection [26]. However, the most important attribute of this technique may be its ability to ensure appropriate patient compliance. In other words, the device is not easily removable. Therefore, the patient has no option other than to adhere to the regimen prescribed by the clinician.

Certainly, the above-described advantages make the TCC an attractive choice to off-load the diabetic foot ulcer. However, there are a number of potential negative attributes that may dissuade some clinicians from using this modality. Most centers do not have an available physician or cast technician with adequate training or experience to safely apply a TCC. Because improper cast application can cause skin irritation and, in some cases, even frank ulceration, this can be its single most negative feature. Also, TCCs do not allow patients, family members, or health care providers to assess the foot or wound on a daily basis. Patients have difficulty sleeping comfortably, and they cannot bathe easily without getting the cast wet. Certain designs of TCCs may exacerbate postural instability [27]. In addition, TCCs are generally contraindicated for wounds with soft-tissue infections or osteomyelitis.

**HALF SHOES**

Originally designed to decrease pressure on the forefoot postoperatively [28], the half shoe has become quite popular for treatment of diabetic foot wounds (figure 6). Certainly, these devices are inexpensive and are easy to apply. Chantelau et al. [28] retrospectively compared 22 patients treated with the half-shoe and 26 treated with “routine wound care” and crutch assistance. Patients receiving the half shoe healed faster (70 vs. 118 days), and they developed fewer serious infections requiring hospitalization than did those receiving standard therapy (4% vs. 41%) [28]. In a gait laboratory study comparing half shoes with both TCCs and removable cast walkers (RCWs), half shoes were much less effective at reducing pressure than were TCCs and certain RCWs [25]. Just as is the case with RCWs and the other modalities described herein, studies evaluating outcomes, patient satisfaction, costs, and complications are needed to completely compare half shoes with other frequently used devices.

**HEALING SANDALS**

Application of a rigid rocker to the sole of a specially designed sandal may theoretically limit dorsiflexion of the metatarsophalangeal joints, thereby limiting plantar progression of the metatarsal heads during propulsion in gait. In addition, the molded nature of a “healing sandal” provides for a greater distribution of metatarsal-head pressures and may theoretically provide for a shorter pressure-time integral. This device is lightweight, stable, and reusable. However, production of the rigid sole rocker design and other modifications requires a significant amount of time and experience. Most facilities do not have the time or expertise to modify these devices. Finally, these devices do not off-load as well as other modalities (such as RCWs) that take less effort to produce or procure [29]. Recently, a cross between a healing sandal and an RCW has been introduced. This device, known as the “MABAL” shoe, is removable.
Figure 5. Mean peak pressure for ulcers under the metatarsal heads among various removable cast walkers [25]. Values are given as N/cm². The DH Walker (Royce Medical) is also known as the “Active Offloading Walker.” The other walkers and manufacturers are as follows: 3D walker (DeRoyal Orthopedic); Aircast walker (Aircast, Inc.); Xtra Depth Shoe (PW Minor, Inc.); Cam Walker (Zinco Industries, Inc.)

but perhaps maintains more contact with the foot than does a standard healing sandal. In a study by Hissink et al. [30], this device showed a healing time similar to those seen in studies of TCCs. However, the MABAL shoe also has many of the disadvantages of the TCC and healing sandal, because it requires special expertise for its fabrication and application.

In 1997, Fleischli et al. [31] compared the off-loading ability of TCCs, half shoes, RCWs, rigid postoperative shoes, and felted foam accommodative dressings. The results of this project suggested that TCCs and certain RCWs achieved the best reduction of plantar pressures at the site of neuropathic ulcerations. The half shoe finished a distant third, followed by the felted foam dressing and the surgical shoe (figure 7).

CRUTCHES, WALKERS, AND WHEELCHAIRS

It stands to reason that completely off-loading a foot with crutches, walkers, or wheelchairs would be very effective in promoting healing of the diabetic wound. However, the vast majority of patients for whom these devices are prescribed do not have the upper body strength, endurance, or willpower to use these devices when they do not perceive any limitation in function of their ulcerated limb. Also, some of these devices can put the contralateral limb at risk for ulceration by increasing pressure to the unaffected side [32]. In the case of wheelchairs, most patients’ homes are not designed for wheelchair access, thus reducing their utility in the place where the patient may be most active—at home.

THERAPEUTIC FOOTWEAR (DEPTH-INLAY SHOES)

Therapeutic shoes are prescribed for many patients in an effort to assist in pressure reduction and wound healing. However, these devices have not proven effective in this role. Gait laboratory studies suggest that therapeutic shoes allow up to 900% increased pressure in areas of the forefoot, compared with TCCs and some RCWs [25]. Furthermore, even the most optimistic studies of shoes as a primary off-loading mechanism suggest that half of noninfected, non-ischemic, superficial wounds (University of Texas grade 1A [33, 34]) will heal at 12 weeks [35]. We may, therefore, postulate that the true value of therapeutic shoes and insoles is in the prevention of ulceration, not in the treatment of active ulceration.

SCOTCHCAST BOOTS

The Scotchcast boot is an alternative to the plaster-of-paris cast and was developed when newer fiberglass materials were in-
Figure 7. Mean peak pressure for ulcers under the metatarsal heads [31]. Values are given as N/cm².

Figure 8. Scotchcast boot for off-loading pressure from the foot of a diabetic patient with foot ulcers.

introduced (figure 8). Scotchcast is much lighter than plaster of paris and has a high integral strength [36]. The basic functions of the cast are to reduce the pressure on the lesion, to maintain patient mobility, and to protect the rest of the foot.

The Scotchcast boot is a well-padded cast cut away by the ankle and either is nonremovable or can be made removable by cutting away the cast over the dorsum of the foot and making a closure of padding and tape with Velcro straps. Windows are cut over the ulcers as needed, whereas a removable heel cap of fiberglass is added for large heel ulcers. The boot is worn with a cast sandal to increase the patient’s mobility. The Scotchcast protects the ulcer from any pressure while keeping the patient ambulant.

Once the ulcer has healed, the patient can gradually start increase the time wearing normal protective footwear, while decreasing the time wearing the Scotchcast boot. The patient usually keeps the boot and the sandal, because they can be worn if an ulcer reoccurs.

The main advantages of this type of cast is that it is removable, thus allowing regular inspection and redressing of the wound; at the same time, this is one of the disadvantages (i.e., enabling the patient’s noncompliance). An alternative cast for the noncompliant patient would be a nonremovable Scotchcast boot.

Although the Scotchcast boot has been used successfully for more than a decade in several clinics in the United Kingdom, predominantly in the treatment of neuropathic and sometimes neuroischemic ulcers, to date there are no data available comparing healing rates of this type of cast and those of the more standard casts, such as the TCC. Preliminary data of healing rates ranging from 61% to 88% with a mean healing time of 10–13 weeks have been reported [36, 37]. A comparison study is now warranted to investigate the efficacy of this cast against other currently used methods for off-loading.

RCWs

This type of pressure-reduction device offers several advantages over the traditional TCC (figure 9). RCWs are, as their name implies, easily removed for self inspection of the wound and for application of topical therapies that require frequent administration. Patients can bathe and sleep more comfortably. Because RCWs are removable, they can be used for infected wounds as well as for superficial ulcers.

The best feature of the RCW is also, paradoxically, its po-
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Figure 9. Removable cast walkers for off-loading pressure from the foot of a diabetic patient with foot ulcers. A, DH pressure-relief walker. B, Aircast walker.

potential downfall. The ability to remove the device eliminates the “forced compliance” that is the best attribute of the TCC. Patients may remove the cast for dressing changes, sleeping, and showers, but they can also choose to use the walker only when they leave the house or walk excessively. Although data from gait laboratory studies suggest that the amount of pressure reduction for certain RCWs is equivalent to that of TCCs, data supporting their use have been disappointing. In a randomized clinical trial comparing the RCW with the TCC and the half shoe, we reported a significantly greater prevalence and faster rate of healing with the TCC [5]. These results seem puzzling, which has led us to investigate this area further and to suggest a possible solution.

COMPLIANCE WITH REMOVAL DEVICES AND THE “INSTANT” TCC

We have postulated that, although the RCW and TCC may off-load equally well (more or less), patients who have dense neuropathy might not strictly adhere to a standard off-loading regimen. In a recent study [38], we evaluated the activity of patients with diabetic foot ulcers and their adherence to an off-loading regimen. This study, which made use of accelerometers worn on the patients’ waists and hidden on the RCW, suggested that patients wore their off-loading device during <30% of their total daily activity [38]. This disappointing result has prompted us to search for simple solutions.

Understanding that most centers do not have the infrastructure, expertise, and/or personnel to apply TCCs, we have suggested that a potential alternative might be to make the RCW less easily removable. This simple concept, termed an “instant TCC” [39], involves simply wrapping the RCW with cohesive bandage, plaster, or fiberglass (figure 10). This solution could have the benefit of adequate off-loading (on par with the TCC) and adequate adherence to the prescribed course of pressure reduction.

CONCLUSIONS

In conclusion, we believe that although the recent history of the treatment of wounds in general—and of diabetic wounds specifically—has been marked by some exciting advances on the “high tech” front, it is in fact the “low tech” systematic aspects of care that must assume priority. We have often said,
“it’s not what you put on a wound that heals it, but what you take off.” Appropriate wound care, debridement, and pressure reduction have been and will continue to be the cornerstones of treatment. Without these in place, any other advanced modality, however promising or revolutionary, will not be able to achieve its full potential in assisting wounds to heal more rapidly and, ultimately, in preventing needless lower-extremity amputation.

References


26. Mueller MJ, Diamond JE, Sinacore DR, et al. Total contact casting in