Objectives

The reader will be challenged to:

- Analyze the mechanical etiology of neuropathic diabetic foot wounds
- Utilize selection criteria for the use of various offloading modalities
- Distinguish the attributes and negative aspects of the most commonly utilized offloading modalities.

Introduction

In general, foot ulcers in people with diabetes result from repetitive moderate stress applied to the plantar aspect of the foot while walking. This mechanism of injury commonly occurs because neuropathy provides a permissive environment for these wounds to occur. Without the ability to adequately respond to noxious stimuli, patients without protective sensation may sustain a breach of the skin, the way sensate persons wear holes in their stockings. As there are no current means available to completely ameliorate the effects of neuropathy, the present tenet for treating and preventing wounds focuses on the redistribution of pressure.

Although many offloading modalities are currently utilized, only a small number of case series exist describing the frequency and rate of wound healing associated with these modalities. This review describes the most commonly used modalities and the evidence that supports their employment.

Total Contact Casts

Total contact casts (TCCs) are considered by most diabetic foot specialists to be the gold standard offloading modality. Plaster casting to treat neuropathic foot wounds was first described by Milroy Paul and later popularized in the United States by Dr. Paul Brand at the Hansen’s Disease Center in Carville, Louisiana. The technique has come to be known as TCC because it employs a well-molded, minimally padded cast that maintains contact with the entire plantar aspect of the foot and the lower leg. TCCs have been shown to reduce pressure at the site of ulceration by 84%–92%, and there

is a large body of work that supports the TCC's clinical efficacy. TCC is quite effective in treating a majority of noninfected, nonischemic plantar diabetic foot wounds, with healing rates ranging from 72%–100% over a course of 5–7 weeks.\textsuperscript{5–10} Averaged throughout gait, peak plantar pressures are highest in the forefoot, while they tend to be generally less significant in the rearfoot and medial arch. Shaw\textsuperscript{11} and Armstrong\textsuperscript{12} have noted that a large proportion of the pressure reduction that occurs in the forefoot of the TCC is transmitted along the cast wall or to the rearfoot. This supports the postulate of several authors who have suggested that the TCC is effective because it permits walking by uniformly distributing pressures over the entire plantar surface of the foot.\textsuperscript{3,5–8,13–15} Figure 1 illustrates healing times of different offloading modalities compared to TCCs.

Total contact casts are effective for a number of other reasons besides their ability to offload. They potentially protect the foot from infection and may help reduce or control edema, which can impede healing.\textsuperscript{16} However, the most important attribute of this modality may be its ability to ensure appropriate patient adherence. In other words, because the device is not easily removable, the patient has no option other than to comply with the regimen prescribed by the clinician.

The above-described advantages make the TCC an attractive choice to offload 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 a skilled healthcare professional or cast technician available with adequate training or experience to safely apply a TCC. Since improper cast application can cause skin irritation and in some cases even frank ulceration, this can be its single biggest negative feature. TCCs do not allow patients, family members, or healthcare 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 (Figure 2).\textsuperscript{17} In addition, TCCs are generally contraindicated for wounds with ischemia, soft-tissue infections, or osteomyelitis.\textsuperscript{18} Total contact casts are best for offloading the forefoot and may not be appropriate for heel ulcers because they may apply extra pressure on the posterior foot.\textsuperscript{12}

Removable Cast Walkers and the “Instant” Total Contact Cast

The removable cast walker (RCW) offers several potential advantages over the traditional
TCC. Removable walkers are, as their name implies, easily removed for self-inspection of the wound and application of topical therapies that require frequent administration. Patients can bathe and sleep more comfortably when wearing these devices. Because they are removable, they can be used for infected wounds as well as superficial ulcers.

Data from gait laboratory studies suggest that the amount of pressure reduction for certain RCWs is equivalent to TCCs. Figures 3 and 4 illustrate mean peak pressure for ulcers under the metatarsal heads using various offloading techniques. In two randomized controlled trials comparing the proportion of healed ulcers treated with the TCC compared with other readily available and popular devices (RCWs, half shoes, and therapeutic depth inlay shoes), TCC healed a higher proportion of wounds compared to other modalities. This was an interesting finding because certain types of RCWs, including one used in one of the above-mentioned trials, often reduce pressure on the plantar aspect of the foot as well as TCCs. If patients do not heal as well in the RCW and yet the RCW offloads pressure about as well as the TCC, a logical explanation for the RCW’s less effective clinical performance is that patients are simply not wearing these devices. Because patients can remove RCWs easily, the best feature of this device is also, paradoxically, its potential downfall. The patient’s ability to remove the RCW eliminates the element of “forced adherence,” which is the finest attribute of the TCC. Patients may remove the RCW for dressing changes, sleeping, and showers, but they can also choose to use the walker only when they leave the house or walk excessively.

Armstrong et al postulated that although the
RCW and TCC may offload equally well, patients, because of their dense neuropathy, might not be wearing their devices and not strictly adhering to their pressure-offloading regimen. In a recently conducted study, Armstrong et al evaluated the activity of patients with diabetic foot ulcers and their adherence to their offloading regime. This study, using accelerometers worn on the patients’ waist and hidden in the RCW, suggested that patients wore their offloading device for less than 30% of their total daily activity.20 This disappointing result has prompted a search for a simpler solution.

Understanding that TCCs are technically difficult and time consuming to apply, in light of the previous data, Armstrong et al have suggested that a potential alternative might be to make the RCW less easily removable. This simple concept, termed an “instant total contact cast,”21 (iTCC) involves simply wrapping the RCW with either a layer of cohesive bandage or plaster/fiberglass (Figure 5); thereby, making it more difficult for patients to remove. The iTCC may have the benefit of adequate offloading as well as adding an element of “forced compliance” to the prescribed course of pressure reduction.

Two recent randomized controlled trials support the above-mentioned postulate. In the first study, subjects given an iTCC appeared to heal as readily at 12 weeks as patients given a standard TCC (80% iTCC versus 74% TCC).22 A second study performed in parallel with this project compared the iTCC with a standard RCW. This study suggested substantial differences in healing at 12 weeks between the irremovable and removable devices (83% versus 52%).23

**Scotchcast Boot**

The Scotchcast boot is an alternative plaster of Paris cast and was developed when fiberglass ma-
materials were introduced. As a substitute for plaster of Paris, Scotchcast is much lighter with high-integral strength. The basic functions of the cast are to reduce the pressure on the lesion, maintain patient mobility, and protect the remaining foot.

The Scotchcast boot is a well-padded cast cut away by the ankle and made either removable or nonremovable 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. A removable heel cap of fiberglass is added for large heel ulcers. The boot is worn with a cast sandal to increase patient mobility, keeping the patient ambulant while protecting the ulcer from any pressure.

Once the ulcer has healed, the patient can gradually start increasing the wear time of normal protective footwear while decreasing the wear time of the Scotchcast boot. The patient usually keeps the boot and the sandal, as this can be worn if an ulcer recurs.

The main advantages of this type of casting is that it is removable, allowing regular inspection and redressing of the wound. However, this advantage is also one of the disadvantages (ie, potential for non-adherence). An alternative cast for the nonadherent patient would be a nonremovable Scotchcast boot.

Although the Scotchcast boot has been used successfully for more than a decade in several UK clinics, predominantly treating neuropathic and sometimes neuroischemic ulcers, no comparisons of healing rates between this type of cast and the more standard casts, such as the TCC, exist. Preliminary data of healing rates ranging from 61% to 88% with a mean healing time of between 10 and 13 weeks have been reported. As with other modalities, a comparison study is warranted to investigate the efficacy of this cast against other currently used methods of offloading.

**Halfshoes**

Originally designed to decrease pressure on the forefoot postoperatively, the halfshoe has become quite popular for treating foot wounds in people with diabetes. These devices are inexpensive and easy to apply. Chantelau and co-workers retrospectively evaluated 22 patients who

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**Figure 4.** Mean peak pressure for ulcers under the metatarsal heads. Reprinted with permission from WOUNDS. 2000;12(6 Suppl B):32B.
Armstrong et al received the halfshoe compared with 26 who received “routine wound care” and crutch-assisted gait. The results from this study suggested that more patients healed faster when using the halfshoe (70 versus 118 days) and that they developed fewer serious infections requiring hospitalization than those receiving standard therapy (4% versus 41%). In a gait laboratory study comparing halfshoes to both TCCs and removable cast walkers, halfshoes were much less effective at reducing pressure than TCCs and certain removable cast walkers. Just as is the case with removable cast walkers and the other modalities described in this review, studies evaluating outcomes, patient satisfaction, costs, and complications are needed to completely study this modality compared to other frequently utilized devices.

**Healing Sandals**

Applying 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 a greater distribution of metatarsal head pressures and may theoretically provide for a shorter pressure-time integral. This device is lightweight, stable, and reusable. It does, however, require a significant amount of time and experience to produce the rigid-sole rocker design and other modifications. Most facilities do not have the time or expertise to modify these devices. Finally, these devices do not work as well as many other modalities that take less effort to produce. Recently, a cross between a healing sandal and a removable cast walker has been introduced. This device, known as the MABAL shoe, is removable, but perhaps maintains more contact with the foot than does a standard healing sandal. In a study by Hissink et al, this device showed a similar time to healing when compared to studies of TCC. However, this potentially promising device also has many of the downfalls of the contact cast and healing sandal, as it requires special expertise for its fabrication and application.

**Felted Foam**

Felted foam is another frequently used offloading technique, which is fashioned by fixing a bilayered felt-foam pad over the plantar aspect of the foot with an aperture corresponding to the ulcer site. There is always a concern when applying an aperture around a wound that “the edge effect” will increase shear and vertical forces at the wound’s periphery. This approach is frequently used at some diabetes centers with anecdotal reports of success, but to date, there are no controlled studies at these centers describing outcomes associated with this padding technique.

In 1997, Fleischli et al conducted a study comparing the offloading ability of TCCs, halfshoes, RCWs, rigid postoperative shoes, and felted foam accommodative dressings. The results of this project suggested that TCCs and certain RCW achieved the best reduction of plantar pressures at the site of neuropathic ulcerations. The halfshoe finished a distant third, followed by the felted foam dressing and surgical shoe.

**Crutches, Walkers, and Wheelchairs**

It would stand to reason that completely...
offloading a foot with crutches, walkers, or wheelchairs would be very effective in promoting healing in the diabetic wound. However, the vast majority of patients for whom these devices are prescribed do not have the upper body strength, endurance, or will power to use these devices when they do not perceive any limitation in function in their ulcerated limb. Additionally, it should be noted that some of these devices can, in fact, place the contralateral limb at risk for ulceration by increasing pressure to the unaffected side.34 In the case of wheelchairs, it is prudent to understand that most patients’ domiciles are not designed for wheelchair access; thus, reducing their utility in the place where they may potentially be most active—at home.

Therapeutic Footwear (Depth Inlay Shoes)

Many patients are prescribed therapeutic shoes in an effort to assist in pressure reduction and wound healing. However, these devices have not proven to be effective in this role. Gait laboratory studies suggest that therapeutic shoes allow up to 900% more pressure in areas of the forefoot compared to TCCs and some RCWs.4 Furthermore, even the most optimistic studies using shoes as a primary offloading mechanism suggest that half of noninfected, nonischemic, superficial wounds (University of Texas Grade 1A35,36) will heal at 12 weeks.37 Therefore, the true value of therapeutic shoes and insoles might be in the prevention of ulceration and not offloading an active ulceration.

Conclusion

It is important to understand that while the recent past history of treatment of wounds in general—and wounds in people with diabetes specifically—has been marked by some exciting advances on the high-technology front, it is in fact the low-technology systematic aspects of care that must assume priority. We often are heard saying, “It’s not what one puts on a wound that heals it, but what one takes off.” Appropriate wound care, debridement, and pressure reduction have and will continue to be the cornerstones of treatment. The key to successful pressure reduction possibly lies more in patient adherence than in the prescribed offloading devices. Persons with diabetes who have lost the “gift of pain” may not always adhere to the offloading regimen. Combining an effective, easy-to-use offloading device that ensures patient compliance with advanced wound healing modalities may form a formidable team in healing ulcers and potentially averting lower-limb amputations.

Take-Home Messages for Practice
- With sufficient vascular supply, appropriate debridement, and infection control, the primary mode of healing a diabetic neuropathic foot ulcer is pressure dispersion.
- The key to successful pressure reduction possibly lies more in patient adherence than in the prescribed offloading devices.

Self-Assessment Questions

1. Which of the following devices provides the greatest amount of pressure reduction at the site of ulceration?
   A. Instant total contact cast
   B. Scotchcast boot
   C. Healing sandal
   D. Halfshoe
   Answers: 1-A, 2-D

References

5. Armstrong DG, Lavery LA, Blishman TR. Peak foot