Removable Fiberglass De-loading Cast for the Management of Neuropathic Plantar Ulceration of the Foot

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Abstract

Background: Neuropathic plantar ulceration of the foot is treated by de-loading the ulcer. The total contact cast is considered to be the gold standard, but it is a labor-intensive procedure and frequent cast changes are needed.

Objectives: To describe an alternative de-loading method using a fiberglass removable walking cast.

Methods: This prospective uncontrolled study comprised 24 diabetic and non-diabetic patients with a single planter neuropathic ulcer. Exclusion criteria included the presence of osteomyelitis or cellulites, peripheral vascular disease, severe foot or leg edema, more than one ulcer on the treated foot, ulcers on the other foot, visual problems, gait instability, and personality or psychiatric problems. All patients were treated with the removable fiberglass de-loading cast. At each weekly follow-up visit the cast was removed. Data were collected using a clinical report form.

Results: The ulcer healed completely in 21 of the 24 patients treated (87.5%). The mean time for healing was 6.8 weeks (range 3–20 weeks, SD = 4.2). New ulcers developed in six patients (25% of the group).

Conclusions: The effectiveness and safety of the method is comparable to that of the total contact cast, but is less labor intensive because the cast is manufactured only once and serves for the whole length of treatment. Improving the technique is expected to lower the complication rate.

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Neuropathic planter ulcers are commonly seen in clinical practice owing to the high prevalence of diabetes mellitus in the western world today. It has been estimated that 25% of diabetic patients will develop foot complications during their lives [1]. Sensory impairment in the diabetic foot includes absence of normal sensation to pain, pressure and proprioception, thus damaging the sensory feedback responsible for self-protective behavior. Foot deformity often coexists due to motor neuropathy and intrinsic muscle dysfunction or Charcot foot. These foot deformities often exacerbate the mechanical stresses and contribute to ulcer formation.

Neuropathic ulcers heal when the area is de-loaded. This is true when no other wound healing-inhibiting factors coexist, such as ischemia or osteomyelitis. Treating neuropathic ulcers with local applications (sometimes very costly) is doomed to fail if the ulcer is not de-loaded. Instructing complete bed-rest or the exclusive use of walking aids is impractical for most patients. It is likely that even brief periods of weight bearing (such as walking to the toilet at night) will delay or prevent healing [2].

The total contact cast is considered by many authorities to be the most effective technique for managing neuropathic planter foot ulcers [3,4].The reported healing success rate is 70%–100% over an average of 36 days [5]. Although effective, the total contact cast is not free of complications. New abrasion wounds and ulcers can be caused by excessive movement of the foot or leg inside a loosely fitting cast (caused by edema subsidence), or by moisture and trauma that may damage the structure of the cast. Abrasive wounds around bony prominences have been reported to occur in 27% of patients treated with total contact casts [6–8]. The total contact cast covers the entire foot including the toes and the ulcers. The cast tends to emit an unpleasant odor owing to the inability of secretion drainage from the ulcer and fungal infections that may occur between the toes [9]. Furthermore, ulcer infections may only be diagnosed once the cast has been removed. The greatest disadvantage of total contact casting is that frequent cast changes are needed and the casting procedure requires expertise and is time-consuming [10]. These factors limit the use of total contact casts, but no other equally effective alternative is in common use. Other de-loading methods have been proposed, including healing shoes, walking splints [11], pneumatic bracing [12], and others. None of the alternative systems has been universally accepted to replace total contact casting.

We present an alternative and comparable method for the management of neuropathic plantar ulcer using a removable fiberglass de-loading cast.

Materials and Methods

This prospective uncontrolled study was conducted between February 2003 and June 2004. Twenty-four diabetic and non-diabetic patients with a single plantar neuropathic ulcer were treated with the removable fiberglass de-loading cast. Data were collected prospectively using a clinical report form. Neuropathy was defined as insensitivity to a 10 g Semmes-Weinstein 5.07 monofilament at the toes and planter aspect of the metatarsal heads [13]. All patients had a full-thickness plantar foot ulceration with no tendon or bone exposed and no clinical or radiologic evidence of soft tissue or bone infection. Exclusion criteria were the presence of osteomyelitis or cellulites, peripheral vascular disease with an ankle/brachial index below 0.6 (in patients where pedal pulses were present no Doppler investigation was done), severe foot or leg edema, more than one ulcer on the treated foot, ulcers on the other foot, visual problems, gait instability, and personality or psychiatric problems.

Table 1. Clinical characteristics of patients at recruitment

Age (yrs)	39–79
	Mean 55 ± 11
Gender	17 males
	7 females
Cause for neuropathy	21 diabetes
	2 idiopathic
	1 Cauda equine syn
Location of ulcer	15 forefoot
	5 midfoot
	1 hind foot
	3 transmetatarsal amputation stump
Size of ulcer (estimated)	100–2,800 mm^2
	Mean 530 ± 447 mm^2
Duration of ulcer	2 weeks to 36 months
	Mean 11.5 ± 10.1 months

The following data were recorded: patient's age, cause of neuropathy (diabetic or non-diabetic), date of ulcer development (defined as the first time the patient became aware of the ulcer), location of the ulcer at the forefoot, midfoot or hindfoot, the foot's structural pathology (clawing of the toes, rocker bottom deformity, etc.), size of the ulcer by measuring the greatest length and width in millimeters, time of ulcer closure (defined as the number of weeks from cast application to completed epithelialization of the wound), and complications during the treatment period. The clinical characteristics of patients at recruitment are summarized in Table 1.

Construction technique

Before the cast was made, foot and leg edema was reduced by using an elastic bandage and raising the leg for 2 days. All the fiberglass casts were made by the same operator using the same technique, which involves five stages.

- First stage: a tubular stockinet was placed over the lower limb and stretched to prevent folds. Bony protrusions such as the malleolii, the tibial crest and the medial aspect of the first metatarsal-phalangeal joint were protected using a special protective rubber foam (Microfoam 3M;3M Health Care, USA).
- Second stage: a circular layer of a Softcast 4 inch bandage (Softcast; 3M Health Care) was applied directly over the stockinet without additional natural orthopedic padding.
- Third stage: a posterior L-shaped splint and medial to lateral U-shaped splint made of three to seven layers of a Scotchcast 3 inch bandage (Scotchcast, 3M Health Care) were applied and extended 20 cm above the malleolii. The number of layers (between 3 and 7) was determined by the patient's weight [Figure 1].
- Fourth stage: another circular layer of Softcast 4 inch bandage was applied. All the layers were carefully molded so that the shape of the cast matched the patient's foot and shin perfectly.
- Fifth stage: an anterior split was made by cutting a 2 cm strip from the anterior surface of the cast. The split sharp edges and the proximal and distal edges were padded. A window was cut below the wound, a rubber heel was anchored to the structure, and the whole structure was wrapped with an elastic bandage. The total time needed to fashion the cast was 25–35 minutes [Figure 2].

The patients were instructed to use a cane or a walker and to minimize their walking distance. Two days after the cast was applied it was removed to check for new skin abrasions. Thereafter, the patients came for weekly follow-up visits. At each visit the cast was removed and the wound treated. The wound dressing, comprising a hydrocolloid gel, was changed every other day through the window.

Figure 1. First circular layer, L-splint and U-splint.


Figure 2. The anterior split enables removing the cast by spreading the anterior split and extricating the leg.

Results

The ulcer healed completely in 21 of the 24 patients treated (87.5%). The mean time for healing was 6.8 weeks (range 3–20 weeks, SD = 4.2). The treatment was stopped before complete ulcer healing in three patients. The first patient immersed the cast in water (although this was strictly forbidden) and was excluded, the second patient developed a superficial abrasion wound with surrounding skin irritation on the dorsum of the foot 3 days after cast application, and the third patient developed a full-thickness ulcer on the dorsum of the foot that was discovered 37 days after cast application when the ulcer had almost completely healed.

New ulcers developed in six patients (25% of the group). These included two patients in whom the treatment was stopped (mentioned above), another three patients in whom the treatment was continued until complete healing was achieved after padding was added and the cast modified, and one patient in whom a full-thickness ulcer on the dorsum of the foot was discovered 37 days after cast application when the ulcer was completely healed.

Discussion

The limitations of the total contact cast usage described above call for a modern alternative method for weight-bearing reduction in neuropathic plantar ulceration of the foot.

Caravaggi et al. [14] from Milan conducted a randomized prospective study to compare the effectiveness and safety of a non-removable fiberglass off-bearing cast versus a therapeutic shoe for the treatment of neuropathic foot ulcers. These authors were the first to report the use of fiberglass materials of variable rigidity. They used circular Softcast for the inner and outer layers and Scotchcast splints in between as structural support. In addition to protecting bony protrusions with rubber foam, German cotton was applied on the stockinet. In their study the follow-up ended after 30 days when only 13 of 26 ulcers healed. There were no complications among the 26 patients in the permanent fiberglass off-bearing cast group.

Ha Van and co-workers from Paris [15] recently reported the results of their non-randomized prospective study in which they compared the effectiveness and safety of a non-removable fiberglass off-bearing cast versus a therapeutic shoe to treat neuropathic foot ulcers. They used only the rigid type of fiberglass bandage and massive padding with Soffban bandages. The treatment was successful in 81% of the 42 patients. The mean healing time was 68.6 ± 35 days. Eight patients developed complications: five developed new ulcers, in two patients osteomyelitis was diagnosed, and one had a toe fracture. In three of the patients the time for cast-induced ulcers to develop was 150 days on average.

What is the optimal technique for building a fiberglass off-bearing cast? Should only rigid fiberglass bandages be used (the old way), or is a combination of rigid and flexible materials preferable? A soft cast bandage is composed of fiberglass imbued with a polyurethane resin with characteristics of flexibility and resistance. Softcast is used to build the body of the cast, as an inner and outer layer, with a middle layer made of rigid fiberglass splints for structural support. The flexible Softcast, which comes in contact with the skin, reduces the risk of skin damage. The Softcast also enables muscle contraction, thus reducing muscle atrophy and improving venous return.

Should the device be removable or non-removable? A non-removable device has a major advantage: it cannot be removed by the patient! Removable devices, such as healing shoes, are less effective because they depend on patient compliance. The total contact cast is a non-removable device but has to be replaced every week to prevent complications. A non-removable fiberglass cast that is worn for several weeks has the potential of causing serious side effects in the neuropathic foot. The removable cast, as in our series, is removed by spreading the anterior split and extricating the leg. This requires some strength and the help of another person. None of the 24 patients treated reported removing the cast at home. The anterior split enables removing the cast, but at a price. The edges of the split can cause ulcers on the dorsum of the foot and the anterior aspect of the ankle. Four of the six ulcers in our series developed in this area at risk.

In the cast-manufacturing process, great care should be taken not to create fiberglass folds in the anterior aspect of the ankle by dorsiflexing the foot after the fiberglass bandages are applied. Based on our recent experience, we believe that padding the area at risk with a layer of protective material like plastazote can solve this technical problem.

What is preferable: full contact cast or padding with Soffban bandages? We applied the first layer of Softcast directly on the stockinet after protecting bony protrusions with protective rubber foam (Microfoam). The reason for this was to create full contact between the skin and the Softcast layer, as done in total contact casts. Caravaggi and team [14], in their series of 26 patients treated with non-removable Softcast/Scotchcast fiberglass off-bearing cast, used German cotton as a protective layer between the stockinet and the first Softcast layer. They did not observe any complications after 30 days of treatment; however, since no further report is available we have no information regarding the overall complication rate.

What is the purpose of the window? Creating a window under the ulcer has several advantages: it allows drainage of secretions and minimizes malodor, allows daily inspection of the wound and wound care, and completely negates compressive forces on the ulcer (although shearing forces may increase). Window edema did not develop in any of the patients.

How should large midfoot ulcers be treated? These ulcers do not allow a rubber heel to be attached to the structure. In these cases we use an aluminum stirrup, whereby the whole foot is suspended in the air. This structure is non-removable. The technical issues will be discussed elsewhere.

Conclusions

The removable fiberglass de-loading cast was effective in 87.5% of ulcers treated. New ulcers developed in 25% of the cases. The effectiveness and safety of the method is comparable to that of the total contact cast. Improving the technique is expected to lower the complication rate.

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Capsule

No NO no asthma

Physiological nitric oxide (NO) is strongly associated with asthma, although there has been considerable debate about whether it is present in a protective capacity or contributes to pathogenesis of the disease. Endogenous nitrosothiols (SNO) are NO-carrying molecules present in airway tissue and one, S-nitroso- glutathione (GSNO), is depleted in asthmatics. Que et al. show that modulation of GSNO levels has direct consequences for susceptibility to an asthma-like condition in mice. Animals lacking an enzyme that breaks down GSNO, GSNO-reductase, showed reduced airway hyperreactivity in response to an experimental allergen. Drugs that reduced GSNO levels re-instated asthma susceptibility in these mice, which suggests that accumulated GSNO was directly responsible for protecting the mice. Thus, NO can help protect against asthma, provided that it is "channeled" through SNOs.

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Capsule

Neural degeneration

When the spinal cord is injured, degeneration of the nerve fibers, or axons, is not instantaneous but rather is believed to occur in several stages over a period of hours. In principle, this delay creates a window of opportunity for the administration of therapies to reduce the extent of irreversible damage. Using time-lapse microscopic imaging of living mice expressing green fluorescent protein (GFP) in individual axons, Kerschensteiner and team visualized the axonal response to traumatic injury. Beginning about 20 minutes after trauma, axons were found to die at both proximal and distal ends by a rapid and previously uncharacterized fragmentation process termed "acute axonal degeneration." This was followed by slow axonal retraction and ultimately by fragmentation of the axon's distal ends via the well-known Wallerian degeneration. Although many axons mounted a regenerative response within 24 hours of injury, this response was futile because the axons did not grow back to their original targets. This mouse model will likely prove useful for the testing of new therapies for spinal cord injury.

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