

# The theoretical mechanisms for the effectiveness of total contact casting in the management of diabetic foot ulcers

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## ABSTRACT

Total contact casting is being used more widely in clinical practice for the treatment of plantar neuropathic ulcers in those with diabetes. This paper discusses the evidence for its use and offers explanations for the mechanism by which total contact casts are effective.

## INTRODUCTION

Grinfeld (1991), in a review of diabetic foot management, noted that "*Much of what is written in textbooks about diabetic foot ulcers is the result of the personal clinical experience of talented clinicians and teachers who feel strongly about their views. Yet, one group may state dogmatically that a procedure is contraindicated and dangerous, while another views it as the treatment of choice*" (pg 104). The use of total contact casting for the management of diabetic foot ulcers is an example of the dichotomy of views that can exist in the management and where the views of some clinicians are very accepting of this intervention and others are not. Given today's climate of the need for more evidence to underpin clinical practice, this dichotomy of views that exists is of concern.

Total contact casting is generally indicated for the management of plantar neuropathic ulcers and Charcot's neuroarthropathy in those with diabetes mellitus. A total contact cast is a well-moulded fracture cast without most of the protective padding so that complete contact is maintained with the plantar surface of the foot and the shape of the leg. Padding of the kind used in fracture casts is not applied as it compresses and shear stresses are reduced without it. Plaster of paris bandage forms the inner layers to ensure close contact. The outer layers can either be plaster of paris or fibreglass. The use of fibreglass allows immediate ambulation. The presence of sensory neuropathy in those with diabetes increases the risk of skin irritation and iatrogenic problems from the use of total contact casts making appropriate and accurate application crucial to the success or failure of the cast.

## EVIDENCE FOR USE

Many methods are available to reduce plantar pressure on the diabetic foot, including accommodative padding and insoles, ambulatory boots, therapeutic footwear, total contact casting and the use of crutches. Most of these methods of reducing diabetic plantar pressure are not widely based on good evidence, but on small case series, yet they are widely used in clinical practice. Many of the studies are descriptive in nature and not of a prospective randomised nature. Some of the descriptive studies on the use of some of these modalities have reported healing rates substantially longer than that reported for total contact casts (Holstein et al, 1976; Larsen et al, 1982;

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Burden et al, 1983; Bolton et al, unpublished), but they have not been compared to each other in prospective randomised studies. Healing times of diabetic foot ulcers in total contact casts are generally reported to be in the region of 30 to 40 days across nine studies (Table 1). This compares favourably to the reported 87% of 40 lesions healing in 90 days with the use of the ambulatory 'Scotchcast' boot (Burden et al, 1983) and the 130 days for 12 neuropathic ulcers reported by Bolton et al (unpublished), also with the use of the 'Scotchcast' boot. Holstein et al (1976) reported a mean healing time of 110 days with the use of accommodative thermoplastic insoles.

As well as these reported clinical studies on healing rates, plantar pressures have been compared in a number of modalities. Fleischli et al (1997) compared total contact casts, a half shoe (that keeps the forefoot elevated off the ground), felted-foam padding and rigid post-operative shoes. The total contact cast and the removable lower leg walker were more effective at pressure reduction than the felt padding and the post-operative shoes. Shaw (1999), in a small pilot study, was not able to demonstrate any pressure relief from 7mm felt padding. Armstrong et al (1995) found that 1/8-inch donut pads reduced pressure at the first metatarsal head by relatively small amounts, but increased pressure under the areas of the pad. They advanced the concept of the "edge effect" that would hypothetically increase shear stress in the tissues across the pressure gradient of the edge of the pad. It appears that based on this limited evidence, that accommodative padding or accommodation in an insole may not be as effective at reducing pressure and may increase the potential for shear stresses at the site of the lesion.

## MECHANISM OF ACTION

A number of possible reasons exist to explain why healing rates and plantar pressure relief is greater in total contact casts (Table 2). While many of these reasons will also help to explain the mechanism of other modalities, it is suggested here that it is the combination of all the putative mechanisms in one

modality (the total contact cast) that explains their effectiveness. The total and even contact of the plaster with the plantar surface of the foot has the effect of equalisation of pressure on the plantar surface of the foot, thus reducing vertical pressure in areas of higher pressure. This will have the effect of reducing pressure over the ulcer site, but it does not eliminate this pressure. Conti et al (1996) demonstrated that total contact casts reduced pressure under the forefoot. But, Shaw et al (1997) showed the reduction under the forefoot was not due to equalisation but due to a redistribution, however the method used by these authors relied upon substantial padding plantar to the metatarsal heads, which is not commonly employed by most clinicians using total contact casts. The close contact between the cast and the funnel shape of leg allows the leg, via the wall of the cast to take some of the vertical load. Shaw et al (1997) demonstrated that the wall of the cast takes approximately 30% of this load.

The reduction in shear stress by the use of a total contact cast may be an important factor. Dinsdale (1974) was able to induce an ulcer in the skin of swine with a vertical pressure of 290mmHg, but a pressure as low as 45mmHg was sufficient when friction was present. Davis (1993) proposed a concept of what he termed the "wrinkled carpet" effect in which the tissues are either "bunched up" or stretched, depending on the direction of the shear stress. The total contact cast would help to reduce the so-called, "wrinkled carpet" effect and shear stress that may be responsible for the tissue damage. Brand, in some unpublished work (Tredwell, 1994), using pressure pads on pigs was able to demonstrate some tissue destruction after 5 to 7 hours. While the pressure was greatest at the centre of the pressure pads, the greatest tissue damage was at the periphery of the pads, where there was increased shear stress between the area under pressure and the area not under pressure. The use of the total contact cast will have the effect of reducing this

**Table 1: Healing times in total contact casting .**

Author	Types of Ulcer	Mean Healing Time	Percent Healed
Myerson et al, 1992	Wagner grades 1-2	Forefoot: 30 days Rearfoot: 63 days	90%
Helm et al, 1984	Wagner grades 1-3	38.3 days	73%
Laing et al, 1991	Not specified	44 days	78%
Baker, 1995	Not specified	79 days	84%
Mueller et al, 1989	Wagner grades 1-2	42 days	90%
Sinacore et al, 1987	Not specified	43.6 days	82%
Walker et al, 1987	Wagner grades 1-3	Forefoot: 30.6 days Rearfoot: 42.1 days	Not specified
Armstrong et al, 1998	Wagner grade 1	38.8 days	100%
Lavery et al, 1997	Wagner grade 1	Midfoot: 28.4 days	100%

**Table 2: Putative mechanisms by which total contact casts are effective in the management of diabetic foot ulcers.**

Down loading of lesion/even distribution of plantar pressures  
Leg of cast takes weight  
Eliminates propulsive phase  
Shorter cadence  
Patient compliance  
Reduces leg and wound oedema  
No edge effect  
Reduction in shear stress  
Protection from further trauma

“edge effect” on the plantar surface of the foot. It is possible that this “edge effect” or “wrinkled carpet effect” may be increased with the use of accommodative padding.

The total contact cast has the effect of reducing foot and leg oedema, which is why the cast generally needs to be replaced weekly. The presence of this oedema is widely considered to be an impediment to healing. Oedema reduction by the use of a foot compression device has been shown to be associated with improved healing (Armstrong and Nguyen, 2000). While total bed rest is the most effective way to off load the diabetic ulcer, it could be considered as not as effective at reducing lower limb oedema unless the limb is kept elevated. For this reason, many consider total contact casting to be the “gold standard” that other modalities should be compared to, however a recent Cochrane Centre review of the quality of evidence did not support this (Spencer, 2000). While the reduction of leg and foot oedema has been widely considered, little or no consideration as been given to the concept of wound oedema. The total contact cast does not eliminate all pressure from an ulcer due to the “total contact” with the plantar surface of the foot, but reduces the pressure on the ulcer to the same level as the surrounding tissues. This has the hypothetical effect of reducing wound oedema and this could be assumed to have a positive effect on wound healing.

Biomechanically, the total contact cast could be assumed to have the effect of eliminating the propulsive phase of gait which should have the effect of further reducing peak plantar pressures under the forefoot. Cadence could also assumed to be reduced, which should further reduce stresses on the foot. There is also an element of forced compliance in the use of total contact casts. In most other modalities that are used to down load the diabetic foot, the patient can remove them and ambulate without them. For example, just one trip to the bathroom in the middle of the night with the foot unprotected may be all that is needed to undo any benefit obtained from the modality. The total contact cast is also effective as protecting the foot from further trauma.

## DISCUSSION

Little evidence is available on the cost effectiveness of total contact casts, but Myerson et al (1992) noted in their discussion that the average total cost for outpatient treatment with a total contact cast until the ulcer is healed is approximately the cost for one day as an in-patient. Cost benefit modelling techniques are required to compare the cost benefit of different approaches (Payne, 1999). For example, cost benefit modelling can be used to determine whether total contact casting should be used at the initial presentation of a neuropathic ulcer or reserved for the ulcer that has not healed after a certain period of time.

Total contact casts are not suitable for all diabetic foot ulcers. They are contraindicated for infected and ischaemic lesions and osteomyelitis. Those who are claustrophobic do not tolerate casting well. Those with casts will have more difficulty bathing and sleeping. There may be muscle atrophy with long-term cast use, which has consequences for rehabilitation following healing. The casts are difficult and time consuming to apply.

These problems have lead clinicians to look for other devices or make modifications to the total contact cast that are capable of giving similar plantar pressure relief and are more convenient to use. These other approaches may not cover all the hypothetical reasons as to why total contact casts may be effective (Table 2). For example, one commercial brand of removable walker has been shown to reduce pressure as much as the total contact cast (Fleischli et al, 1997). However, while it can give the same magnitude of pressure relief, it has not been compared to the total contact cast in a clinical trial. Modification to the total contact cast, such as bivalving it or using a window so the wound can be observed is often used by clinicians. However, the use of bivalving could be assumed to affect the ability of the wall of the cast to carry some of the load, the ability of the cast to reduce leg oedema and patient compliance may be a problem. The use of a window in the cast to observe the wound may be assumed to have negative effects due to the “edge effect” and wound oedema.

## CONCLUSION

More, good quality research is required before clear conclusions can be drawn about the effectiveness of total contact casting and the mechanisms by which they are assumed to be effective. Clinicians involved in the management of diabetic foot ulcers need to consider the evidence and the hypothetical mechanisms as to why total contact casts are effective and make informed decisions for the implementation of this evidence into clinical practice.

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