



REVIEW ARTICLE

# A Narrative Review of the Benefits and Risks of Total Contact Casts in the Management of Diabetic Foot Ulcers



Grace Messenger, MRes<sup>a,\*</sup>, Richard Masoetsa, MSc<sup>b</sup>, Imtiaz Hussain, BSc<sup>a</sup>

<sup>a</sup>Dasman Diabetes Institute, Kuwait; and

<sup>b</sup>Podiatry Department Dasman Diabetes Institute, Kuwait

## KEYWORDS:

Diabetic foot ulcer;  
Total contact cast;  
Evidence-based medicine;  
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**Abstract** Total contact casts are recognized as the gold standard treatment for neuropathic plantar diabetic foot ulceration, endorsed by all national and international consensus papers. Despite this, research has shown that there is a dichotomy between the existing evidence which supports the use of total contact casts in the management of diabetic foot ulcers and its use in clinical practice. This article aims to highlight the benefits, risks, and barriers associated with total contact cast use in the management of diabetic foot ulcers in the clinical setting, with an emphasis on existing research carried out in this field to encourage change in clinical practice and utilization of this effective treatment modality.

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## Introduction

The lifetime risk of developing a diabetic foot ulcer (DFU) is believed to be as high as 12–25% in people with diabetes mellitus.<sup>1,2</sup> DFUs continue to be a leading cause of non-traumatic lower limb amputation<sup>3,4</sup> and precede 84% of lower limb amputations.<sup>5</sup>

Although the development of DFU is multifactorial, there are three main risk factors. Diabetic peripheral neuropathy (DPN) is considered the leading cause of DFU and is the causative factor in 35–45% of all DFUs.<sup>5,6</sup> These neuropathic DFUs usually occur on the plantar aspect of the foot.<sup>7</sup> Peripheral arterial disease (PAD) in combination with DPN accounts for 24%–50% of DFUs and occur on the margins of the foot.<sup>6,8,9</sup>

Mechanical factors, such as foot deformity or limited joint mobility, cause increased plantar forces and tissue damage, resulting in DFU and delayed healing.<sup>10–12</sup> Studies have shown that DFUs occur in areas of highest plantar pressure.<sup>13</sup> However, a correlation between high frictional shear and DFU location compared to high plantar foot pressure has also been reported.<sup>14,15</sup> This suggests frictional shear represents another important factor, but further research is needed to understand this complex force fully. Consequently, one of the most important principles of healing a plantar DFU is reducing or redistributing pressure and shear from the affected site.<sup>4</sup>

A cornerstone in DFU management is pressure reduction through offloading. There are many products available to the clinician to reduce pressure from a DFU, including removable below knee devices and irremovable total contact casts. A total contact cast is a rigid or semi-rigid molded cast which extends from the patient's foot to just below the knee, maintaining contact with the entire plantar

\* Corresponding author. Podiatry Department, Medical Division, Dasman Diabetes Institute, P.O. Box 1180, Dasman 15462, Kuwait.

E-mail address: [grace.messenger@dasmaninsitute.org](mailto:grace.messenger@dasmaninsitute.org)

surface of the foot and lower leg and immobilizing surrounding joints and soft tissue while allowing the patient to remain ambulatory.<sup>16</sup> A total contact cast uses minimal padding to protect the malleoli, tibia shaft and DFU.<sup>17</sup> The use of padding provides total contact to the whole foot while isolating the DFU, and has been found to significantly reduce peak pressure ( $p = 0.008$ ) and pressure-time integral ( $p < 0.0012$ ).<sup>18</sup>

This narrative review of the literature aims to explore the benefits and risks of total contact casts in the management of diabetic foot ulcer.

DFU management is costly with an estimated annual expenditure of between \$9-\$13 billion in the USA.<sup>19</sup> The hospitalization of patients with DFU account for between 73.7% and 80% of the overall expenditure globally<sup>20,21</sup> and, leads to a longer length of stay.<sup>22</sup> Private health insurance pay-outs almost double in patients with DFU when compared to patients without DFU (\$28,031 vs \$16,320 respectively).<sup>19</sup> The estimated cost of a lower limb amputation is between \$35,000-\$45,000,<sup>23</sup> although these figures do not include preceding DFU management or indirect costs associated with loss of productivity, family status or quality of life. Conversely, the use of total contact casts has shown substantial cost savings when compared to other treatments (\$11,946 vs \$22,494 per patient, respectively).<sup>24</sup> In addition, a recent publication highlighted the cost-effectiveness of total contact cast and irremovable cast walkers when compared to removable walkers.<sup>25</sup>

In addition, all-cause DFU healing has been reported to be between 60% and 77%.<sup>26,27</sup> However, total contact casts have shown improved healing rates when compared to other off-loading devices in the treatment of plantar neuropathic DFU, with healing rates ranging from 89% to 92%,<sup>28,29</sup> and in some cases over a significantly shorter period.<sup>16,30</sup>

Despite these benefits, Sinacore<sup>31</sup> reported that 45% of clinics offered no off-loading in the management of DFU. More recently, studies have shown that total contact casts are not regularly used in the management of plantar DFU and footwear modification is the preferred method of off-loading despite its ineffectiveness in reducing plantar pressure and shearing forces.<sup>12,32,33</sup> This is despite total contact casts being recognized as the gold standard treatment for plantar DFU by every consensus committee.<sup>32</sup>

Traditionally, it was believed that a total contact cast worked by equalizing plantar pressure, because the entire plantar surface of the foot was in contact with the internal surface of the cast, creating a larger surface area, redistributing pressure across the whole foot.<sup>17,34</sup> However, other authors have reported a reduction in plantar contact area as the load-bearing capacity of the rigid cast wall suspends the foot.<sup>35</sup> Total contact casts have also shown a greater reduction in plantar load when compared to an ankle or below-ankle devices and removable below-knee walkers.<sup>16,30,35</sup> The cast shank has been shown to remove 30%–36% of the pressure from the foot when compared

to a cast shoe.<sup>33,35,36</sup> Frictional shearing forces are also controlled as the foot is held firmly in position.<sup>35</sup> When compared to shear-reducing walkers, total contact casts are associated with improved healing rates.<sup>37</sup> This suggests there are several mechanisms which reduced pressure and shearing forces and improve DFU outcome and time-to-heal.

It is widely accepted that total contact casts 'force compliance' as patients are unable to remove the cast.<sup>38</sup> Armstrong and colleagues<sup>4</sup> evaluated the difference between computerized accelerometers from waist-worn and those concealed in a removable cast walker in the same patients. The results showed that participants logged greater daily activity levels in the waist accelerometer compared with that found in the removable walker, which only recorded 28% of daily activity.<sup>4</sup> This suggests patients wear removable below-knee walkers less than one-third of the time; whereas, a non-removable device forces compliance continuously. Patients treated with total contact casts are also significantly less active when compared to other off-loading devices, thus reducing the number of cycles of repetitive stress, and improving DFU healing.<sup>16</sup> Shorter stride lengths and reduced walking speeds have also been recorded with the use of total contact casts, reducing vertical forces through the foot.<sup>39</sup>

Total contact casts can be contraindicated in certain circumstances. Some authors only recommend their use in non-infected neuropathic ulcers in the absence of PAD.<sup>37</sup> However, Nabuurs-Franssen and colleagues<sup>30</sup> conducted a study involving 98 patients with a combination of DPN, moderate PAD and infection (PEDIS grade  $\leq 2$ ). In this prospective non-randomized study, the researchers aimed to determine the outcome and complications of total contact casts in patients with DFU complicated by DPN, DPN and PAD, DPN and Infection or DPN, PAD and infection. They managed patients in either one or a combination of traditional total contact cast, removable bi-valve contact cast, and shoe-model cast. The authors found that patients with DPN or DPN and infection or DPN and PAD, healed 90%, 87% and 69% of the time, respectively. Importantly the authors reported rates of new ulceration and pre-ulcerative changes of 9% and 29%, respectively. Although, neither were related to PAD or infection and resolved before the main ulcer healed, suggesting patients with moderate PAD or infection are no more at risk of developing total contact cast complications than patients without PAD or infection. Patients with the triad of DPN, PAD, and infection had poorer outcomes, with healing only occurring in 36% of DFUs. The authors did not allude to the reason for this significant difference. However, it is well established that DFU with PAD and infection have the worst treatment outcomes.<sup>40</sup> Though this trial was non-blinded and non-randomized, the use of total contact casts was found to improve DFU outcome in the presence of moderate PAD and infection and has now been endorsed by the International Working Group on the Diabetic Foot.<sup>41</sup>

However, patients must be monitored carefully, and the clinician should have a high degree of expertise in managing these types of wounds.

The decision to use a cast may be dependent on the level of exudate present around the wound. Highly exuding wounds may require daily dressing changes. In these circumstances, a bi-valve or removable cast may be considered<sup>42</sup> or the creation of a window at the DFU site<sup>43</sup>

The most common side effects resulting from the use of total contact casts are skin abrasions or iatrogenic ulceration. However one study evaluating the development of iatrogenic ulceration found only 22 new ulcers in a sample of 398 casts, which equates to an iatrogenic ulceration rate of 5.52%, as important, the author reported no deterioration in the pre-existing DFU.<sup>44</sup> Iatrogenic ulceration has also been found to heal before the primary ulcer.<sup>30</sup> To reduce the risk of iatrogenic ulceration padding should be used to protect bony prominences, and patients should be advised to check for signs of bleeding or redness in exposed toes and to protect the contralateral leg with a long sock or pillowcase when in bed to reduce contact with the fiberglass cast.<sup>24</sup> Patients should also be taught to check the integrity of the cast, and the treating clinician should review any problems.

The prolonged use of total contact casts has been associated with muscle atrophy and reduced bone density. To eliminate these problems. Carvaggi et al. (2000)<sup>43</sup> first applied two layers of fiberglass for flexibility and resistance (Softcast 3 M; 3 M Health Care, St. Paul, MN). A second fiberglass bandage for high resistance to loading was used to reinforce the design (Scotchcast 3 M; 3 M Health Care). This was first placed between and extend beyond the two malleoli. A second layer was then applied to the plantar aspect of the cast, which gave the cast a rigid construct. They found that using a combination of rigid and semi-rigid casting materials minimized these complications.<sup>43</sup> In addition, the introduction of a gait rehabilitation programme may reduce the adverse effects of muscle atrophy and loss of bone density, although this has yet to be examined.

Leg length discrepancy can also occur, resulting in either new or worsening postural instability.<sup>45</sup> This should be considered during patient selection. Low-profile casts can be used with a lightweight material to minimize instability,<sup>35</sup> or patients can purchase shoe balancers for the contralateral limb.

The application of a total contact cast requires skill, is labor intensive and takes time.<sup>24</sup> However, with advancements in technology clinicians now have access to instant total contact casts (using fiberglass roll or zip ties to make a removable off-the-shelf below knee walker into a non-removable walker) and total contact cast systems, such as TCC-EZ<sup>®</sup> (Derma Sciences).

These new systems can reduce application time, with one study reporting a mean TCC-EZ<sup>®</sup> application time of 21 min,<sup>46</sup> and have shown equal effectiveness in the

management of DFU.<sup>47,48</sup> Finally, training in the application of traditional fiberglass casts remains readily available.

## Conclusion

DFUs continue to be a leading cause of non-traumatic lower limb amputation. Although no single off-loading device is suitable for every patient and decisions should be made on a case-by-case basis, the benefits of total contact casts far outweigh the risks involved.

This paper has demonstrated that the risk of total contact casts. In most cases, this is minor iatrogenic tissue damage, which can be resolved by proper padding applications, and gait instability as a result of acquired leg length discrepancy, which can be managed by the provision of low-profile casts and shoe balancers for the opposite foot.

On the contrary, the benefit, for most, is improved compliance with offloading, speedy ulcer healing, and the patient can maintain a degree of mobility and continue to be productive in the family/community.

Total contact casts are a gold standard in the treatment of plantar diabetic foot ulcers. However, adequate training in the application of total contact cast is required to reduce complications. Advancements in technology have been made giving clinicians new options such as an instant total contact cast and a TCC-EZ<sup>®</sup>, which are easier and quicker to apply.

The perceived risks and barriers in using total contact cast must be offset by the high cost of DFU treatment and high rate of lower leg amputation and the associated impact on patient morbidity and mortality. Clinicians can no longer ignore the vast body of evidence which supports the use of total contact casts in clinical practice. It is time healthcare professionals utilize this treatment modality as the standard off-loading therapy in appropriate DFU management in line with evidence-based guidance.

## Authors contributions

GM was responsible for writing the manuscript. RM and IH were responsible for reviewing the manuscript.

## Declaration of interest

None.

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