Offloading the ulcerated diabetic heel: A case study

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While total-contact casting is effective in the reduction of plantar forefoot pressures, it appears to be less effective at mitigating pressure in the plantar heel region. The authors report a case of neuropathic heel ulceration in a man with type 2 diabetes who had previously undergone a Chopart amputation. Offloading of the ulcerated heel was undertaken using a modified Bohler walking iron cast and complete and sustained healing was achieved.

Effective offloading is a critical component in the management of diabetes-related neuropathic ulceration. Repetitive trauma and pressure on the ulcer bed are primary factors in delayed healing (Frykberg et al, 2006). As complete non-weight bearing is rarely practicable, pressure is typically reduced by an external mechanism or device.

Total-contact casting (TCC) is widely considered to be the offloading gold standard for neuropathic ulceration (Wu et al, 2005). While TCC is effective in the reduction of plantar forefoot pressures, it appears to be less effective at mitigating pressure in the plantar heel region (Hartsell et al, 2001).

Healing time is significantly longer for heel ulcers than ulcers of the mid- and forefoot (Hartsell et al, 2001). It may be hypothesised that the delay in heel-ulcer healing, relative to ulcers located elsewhere on the foot, is partially attributable to difficulties in effectively offloading the heel using traditional modalities. An alternative to TCC that provides effective offloading in the plantar heel region is called for.

Here, the authors describe an ambulatory means of offloading a neuropathic heel ulcer. A modified version of a Bolher walking iron was used to reduce pressure on a neuropathic heel ulcer, complicated by osteomyelitis, in an individual with a prior Chopart amputation.

Case report

Mr N, a 59-year-old man, attended a teaching hospital podiatry department with two active neuropathic diabetic foot ulcers on his left foot. Mr N was systemically unwell, suffering from fever, rigor and arthralgia.

One ulcer was located on the plantar aspect of the heel, was 4 cm in diameter and probed to bone. This ulcer had been present intermittently over a number of years, with recurrent soft-tissue infection requiring oral and intravenous antibiotics.

The second ulcer, located on the medial aspect of the calcaneus, was an acute wound having only appeared 1 week earlier (1 cm in diameter and 2 cm deep). There was clinical evidence of infection of this wound (marked erythema, swelling and pain over the medial aspect of the calcaneus).

Article points

1. Healing time is significantly longer for heel ulcers than ulcers of the mid- and forefoot and it may be hypothesised that the delay is partially attributable to difficulties in effectively offloading the heel using traditional modalities.
2. A modified version of a Bolher walking iron was used to reduce pressure on a neuropathic heel ulcer, complicated by osteomyelitis, in an individual with a prior Chopart amputation.
3. After 8 weeks use of the cast the plantar heel ulcer epithelised and remained healed at 18-month follow-up.

Key words:

- Heel ulcer
- Modified Bolher walking iron
- Offloading

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Page points

1. Mr N has type 2 diabetes, complicated by peripheral diabetic neuropathy and ischaemic heart disease, and underwent a Chopart amputation of the ulcerated foot almost 40 years prior to presentation in the present case,
2. Traditional forms of removable offloading were impractical given Mr N's residual foot shape.
3. A total-contact cast that incorporated an external device to offload the ulcerated heel was designed based on the Bohler walking iron cast.

History

Mr N has type 2 diabetes (diagnosed in 1997) complicated by peripheral diabetic neuropathy and ischaemic heart disease (myocardial infarction in 2004). Other comorbidities comprise asthma, obesity, sciatica and renal calculi.

Almost 40 years prior to his presentation in the present case, Mr N was involved in a major motor vehicle accident that resulted in severe trauma to his left foot. The distal portion of the foot was unsalvageable and Mr N underwent a Chopart amputation, following which only the talus and calcaneus remained.

Investigations

Blood results were consistent with infection (elevated C-reactive protein [120 mg/L]; white blood cell count [16.10 × 10^9/L]; neutrophil count [11.03 × 10^9/L]). Blood cultures were negative. An abscess collection was suspected over the medial calcaneus and was later confirmed by diagnostic ultrasound (3.5 × 1.5 cm).

Mr N underwent a percutaneous bone biopsy after computed tomography (CT) suggested the presence of osteomyelitis in the calcaneus. A trephine needle biopsy under CT guidance was performed and two bone samples were sent for microscopy, culture and sensitivity analyses. *Staphylococcus saprophyticus*, *Staphylococcus cohnii* and *Staphylococcus epidermis* were cultured. The pathogens were sensitive to vancomycin.

Treatment

Infection control

Incision and drainage of the identified abscess adjacent to the medial calcaneus was performed by an orthopaedic surgeon. Management of the osteomyelitis was discussed with Mr N, who was keen to trial antibiotic therapy as opposed to surgical debridement or below-knee amputation. After a consultation with a specialist infectious diseases physician, and taking into account the results of the bone biopsy, Mr N was commenced on intravenous vancomycin (2 g 24-hour infusion) for 6 weeks, following which his regimen was oral doxycycline (100 mg twice daily) and rifampicin (600 mg once daily) for 11 months.

Metabolic control

Mr N's glycaemic control was poor (HbA_{1c} level 9.7% [83 mmol/mol]) and he was obese (BMI 35.4 kg/m^2). Mr N was changed from oral antidiabetes agents (metformin, glicizide) to four-times daily insulin (insulin aspart three times a day; insulin glargine once daily) to optimise glycaemic control. The insulin dosages were adjusted over time and metformin reintroduced, resulting in a significant improvement in Mr N's glycaemic within 4 months (HbA_{1c} level 7.2% [55 mmol/mol]).

A diabetes dietitian initiated a weight-loss meal replacement supplement, which assisted Mr N to reduce his weight by approximately 15 kg over a 3-month period.

Offloading

Traditional forms of removable offloading were impractical given Mr N's residual foot shape. Offloading was initially addressed through the use of crutches and regular peri-wound callous debridement of the ulcer. The medial heel ulcer healed quite rapidly, while the plantar heel ulcer remained static.

Mr N found it difficult to be non-weight bearing with the use of the crutches. After discussions with the plaster clinic technicians and orthotists, a TCC that incorporated an external device to offload the ulcerated heel was designed (*Figure 1*), based on the Bohler walking iron cast that was developed by surgeon Lorenz Bohler in the 1930s to manage calcaneal fractures (Hand, 1935).

The modified cast was changed weekly, at which time peri-wound callous debridement and dressing change was also undertaken. After 8 weeks of this regimen the ulcer epithelised (*Figure 2*).

Mr N was fitted for a custom-made boot and offloading insole by the orthotic department. Mr N was initially encouraged to use crutches intermittently to minimise the load on his heel, however this ceased after a month.

At 18-month follow-up, Mr N's heel remained healed.

Discussion

It is evident from the literature on diabetic foot ulceration that offloading is a key component of successful management. Delayed healing is caused primarily by inadequate or inappropriate wound offloading (Ha Van et al, 2003). The challenge for healthcare professionals is selecting the most appropriate offloading device.

TCC is widely considered the preeminent treatment for offloading the plantar aspect of the foot. However, the effectiveness of TCC for heel ulceration is equivocal. One study showed that TCC reduced forefoot pressure by 64%, however rearfoot pressure actually increased by 37% (Hartsell et al, 2001). Another study assessed the effectiveness of various modalities in reducing peak pressure at the heel. While the TCC significantly decreased pressure at the heel in comparison to baseline (a sports training shoe; $P<0.05$), in absolute terms pressure reduction was only 33% (Armstrong and Stacpoole-Shea, 1999). By comparison, a study using the duplicate patient sample and research methodology found that forefoot pressures were decreased by 84% (Lavery et al, 1997).

It has been suggested that one of the mechanisms by which a TCC reduces pressure is load distribution, where plantar load is dispersed over a greater surface area by conforming the cast to the entire plantar aspect of the foot, thus reducing localised pressure at the ulcer site (Leibner et al, 2006). Additionally, Shaw et al (1997) report that the shank of a TCC offloads approximately 30% of the plantar load. In short, TCC reduces plantar pressure by approximately one-third of the total load by absorbing weight through the cast wall (Hartsell et al, 2001)

In the present case the benefits of load distribution could not be realised, given that the heel was the only plantar weight-bearing area as well as being the site of active ulceration. The authors felt that the approximately 30% load reduction offered by traditional TCC was unlikely, in isolation, to provide sufficient pressure relief to heal the ulcer. Thus, a more innovative solution was required and a modified Bohler walking iron was used in this case study. The cast customisation in the present case was found, retrospectively, to be similar to that used by Tamir and Daniels (2007).

Figure 1. Mr N's offloading device, a modified Bohler walking iron cast. The external device was composed of a custom-made aluminium steel alloy frame (medial and lateral bars) and a platform (approximately the size of the heel) made of ethyl vinyl acetate with a non-slip rubber base. The apparatus was integrated into a traditional total-contact cast (TCC; fibreglass, plaster, foam padding and a cotton sock liner) with the bars placed just distal to the knee. Importantly, a gap of 5–10 mm was left between the TCC and the superior aspect of the platform to avoid weight-bearing during walking.

Tamir and Daniels (2007) propose that their "stirrup cast" offloads 100% of the compressive pressure around the heel by transferring the pressure through the upper portion of the cast and reducing sheer forces on the heel fat pad (Tamir and Daniels, 2007; Tamir et al, 2007.)

The primary difference between the cast described in the present case and that reported by Tamir and Daniels (2007) is the use of a cast window over the ulcer site. Tamir and Daniels' (2007) rationale for a cast window was to allow

Figure 2. Mr N's epithelised ulcer, 8 weeks following the addition of the modified Bohler walking iron cast to his wound care regimen.

"Healing of neuropathic heel ulcers in people with diabetes may be delayed by the lack of effective local offloading, especially in comparison with the ulceration of the fore- or midfoot."

for wound inspection and drainage, a need that has been acknowledged by other authors (Halanski and Noonan, 2008). In a later article Tamir et al (2007) took advantage of the cast window to apply vacuum-assistance closure as an adjunct therapy to aid wound healing.

It is important to note that a cast window has the potential to cause serious complications. Of primary concern is irritation at the window margins resulting in secondary ulceration (Sinacore, 1996; Ha Van et al, 2003). Armstrong et al (1995) studied the impact of apertures applied to the plantar surface of the foot (specifically in relation to felt and felted foam) and found that while a significant pressure reduction could be achieved centrally with an aperture, a cast window significantly amplified the vertical and shear stress at the periphery. Furthermore, a cast window allows undesirable patient access to the wound and facilitates interference in the wound management plan – increasing the risk of infection and delayed healing. Therefore, where weekly wound inspection and dressing changes are appropriate (e.g. wounds with minimal exudate), including a cast window appears to the authors to be an unnecessary and risky addition.

A Chopart amputation such as Mr N experienced is now a relatively rare procedure. However, people with diabetes and foot disease frequently undergo ray, or partial ray, amputation in an effort to salvage limbs. These types of amputations can result in increased pressure on the heel, particularly during the rehabilitation phase when patients may be advised to bear weight on the rearfoot, which may exposed them to heel ulceration. Therefore, the modified Bohler walking iron cast described here may have a role in a broader range of cases involving amputation of part or all of the fore- or midfoot as an offloading device to facilitate wound healing.

Conclusion

Healing of neuropathic heel ulcers in people with diabetes may be delayed by the lack of effective local offloading, especially in comparison with the ulceration of the fore- or midfoot. This delay places people at greater risk of infection, osteomyelitis and amputation. Innovative offloading methods are required to reduce pressure at the heel and facilitate wound healing. An experienced orthotist should be consulted early in a foot ulcer's natural history for their input with regard to offloading options. A modified Bohler cast may be considered an effective means for offloading neuropathic heel ulcers. ■

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