The use of wound healing casts, Böhler's iron and the biomechanics of offloading

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Total contact casting is the 'gold standard' form of pressure offloading in people with diabetic foot ulcers. Hybrid versions of total contact casts, also known as wound healing casts, are increasingly being used in practice. A Böhler's iron can be used in conjunction with a cast to provide axial offloading where appropriate. Studies have proven the efficacy of both interventions but there is a lack of studies comparing the benefits and drawbacks of different cast systems. Currently cast use is limited as many staff lack the biomechanical knowledge and skills to correctly apply and manage cast systems. As a result, despite proven benefits, casting is rarely used in practice. This article reviews the current forms of casting, its indications and contraindications and the basic biomechanics involved in offloading to encourage healing.

Article points

1. Total contact casting is the 'gold standard' management of pressure ulcers, however it is rarely used.
2. Casting can be used alone, or with a Böhler's iron where axial offloading is required.
3. Staff need training in foot biomechanics and how to apply and manage cast systems if use in practice is to increase.

Key words

- Foot biomechanics
- Offloading
- Total contact cast
- Training
- Wound healing cast

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Total contact casting has proven an effective method of healing plantar ulcers in patients with neuropathy. Total contact casts (TCCs; *Figure 1*), are specially designed to take weight off the foot in patients with diabetic foot ulcers, and have proven very effective in the treatment of this condition.

Despite it being the 'gold standard' management, this defining method of casting is rarely adhered to due to the specialised skills required to apply and manage the casting system. This was evident in the prospective study of 14 European centres, where casts were applied to only 35% of patients with either a forefoot or midfoot ulcer (Prompers et al, 2008). Only 18% of the prescribed casts were TCCs. It was therefore concluded that casting is underutilised in Europe as a result of a 'lack of qualified staff'. The statistics in the United States were indifferent, with an even lower percentage of TCC use in foot clinics (Wu et al, 2008).

Hybrid versions of total contact casts

Hybrid versions of TCCs described as 'wound healing' casts are being applied with more padding to offer greater protection to vulnerable tissue. These casts vary from slipper to ankle and below knee. The method of application is similar to that of a TCC. The elements of padding utilising felt and wool as an interface to the casting material reduce damaging shear, but may reduce the axial offloading in below-knee casts due to lack of circumferential containment.

Several other forms of the TCCs have been developed over time with the aim of expanding its use through the simplification of application techniques and reduction in the number of complications arising from the original TCC. One of the main examples is the instant TCC, which comprises of a removable cast walker encased in a plaster or fibreglass wrap or, in some cases, a cohesive bandage. The healing rates are similar to the typical TCC (Armstrong et al, 2005). Simpler casting modalities remain questionable, however in terms of axial offloading and circumferential containment.

Böhler's iron with casts for offloading

The use of a Böhler's iron in conjunction with a cast will provide axial offloading. Axial load is defined as "a force with its resultant passing through

the centroid of a particular section and being perpendicular to the plane of the section" (Study Stack, 2017).

Dr Lorenz Böhler was an Austrian surgeon specialising in fracture management in the early part of the 20th century. He devised a below-knee offloading device bearing his name in 1932. This was initially a stirrup type device attached to a plaster of Paris below-knee cast. This was a shorter version of the patten-ended calliper as described by Thomas (Rose, 1986). In the case of the patten-ended calliper, the weight of the limb is suspended between the ischial tuberosity and the patten end. In the case of Böhler's iron, the lower limb is suspended from the fibular head through circumferential containment to a similar patten end.

Studies investigating the efficacy of Böhler's iron have included variations of the iron but the general concept of the stirrup design with side supports and a rubber sole plate remains. The distal gap between the cast and the sole plate plays a pivotal role in axial offloading. A significant reduction of forces through the foot in was evidenced in a study comparing Beagle Böhler's iron to a classic below-knee cast (Berwin et al, 2015). However, this study was carried out on healthy individuals and perceived the advantage of such device mainly for fractures. The most recent study used a different version of Böhler's iron but proved its efficacy in addressing wound exudate and healing of diabetic foot ulcers (Saikia et al, 2016). No complications were reported from the use of this type of offloading device.

Indications and contraindications

TCCs and hybrid or wound healing casts are indicated for superficial plantar ulcers (University of Texas classification A1.2.3) (James, 2008). Casting is contraindicated in deep foot ulcers where abscess, osteomyelitis or other deep infection is present. In addition, critical limb ischaemia is also perceived as a contraindication to the use of casting as a treatment measure. It is the authors' practical experience that by offloading using a Böhler's iron that is bivalved for dressing changes, less superficial ulcers can be treated. The authors would not cast using the iron for critical limb ischaemia, however, a few casts have been applied with the iron with osteomylitis present for a limited period of time, in order to prevent catastrophic bone collapse.

Exudate: a challenge

An understanding of the mechanisms that result in the production of exudate is important across all disciplines involved in casting and wound healing. Exudate is derived from fluid that leaks out of capillaries and into body tissues at a rate that is determined by the permeability of the capillaries and the hydrostatic and osmotic pressures across the capillary walls. The relationship between the factors that determine how much fluid leaks out is known as Starling's hypothesis. In a healing wound, the amount of exudate produced will reduce over time; however in non-healing wounds exudate production may continue and may remain excessive due to inflammatory processes. A moist environment is necessary for optimal wound healing. Conditions of extreme wetness, in contrast, will adversely affect the healing outcome. It is the authors' experience that using the Bohler's Iron reduces exudate levels and, therefore, helps to maintain the cast integrity. Exudate may pose a challenge to the integrity of the cast as its presence is often damaging to the felt and padding.

Reducing tissue breakdown by alleviating pressure

Tissue breakdown is related to both the magnitude and duration of pressure. Vertical stress destroys healthy tissue through repetitive compression. Shear stress occurs as deep tissue slides under superficial tissue. It is therefore vital to eliminate pressure on an ulcerated area.

By utilising a TCC, the area of weight bearing is increased. This can reduce the effect of peak plantar pressures by 81–92% at the ulcer site (Shaw et al, 1997). Shaw et al were the first to test the theory of a proximal shift of the load in the foot from the forefoot region to the hindfoot using a TCC. In the same study, they expanded this theory to account for the observed load carriage by the walls of the TCC (Shaw et al, 1997). This hypothesis was further investigated and quantified by Leibner et al (2006), who concluded that load sharing occurs when the proximal cast wall carries approximately 30–36% of the loading during ambulation. The force is transferred to the tibia and this is believed to be just as important as redistribution in offloading ulcers.

Figure 1. A conventional total contact cast.

Figure 2. A hybrid total contact cast with Böhler's iron.

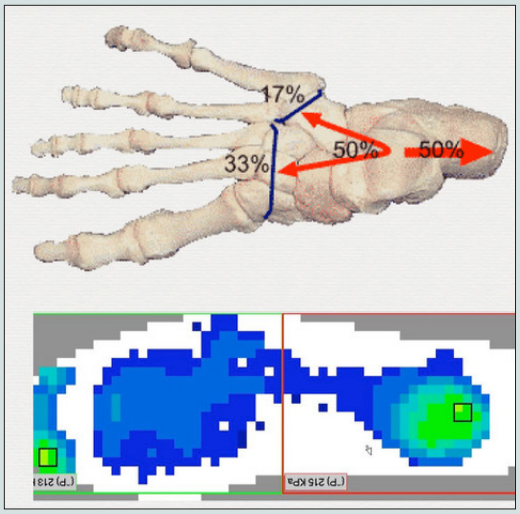

Figure 3. Ideal positioning of subtalar and midtarsal joints (top) leads to correct pressure distribution (bottom).

Biomechanical considerations are therefore important in ensuring the correct positioning of the talocrural, subtalar and midtarsal joints within the cast. The range of motions, flexibility, rigidity and deformities present should be corrected if flexible or accommodated if rigid. Muscle power and proprioception should also be evaluated to ensure that the contralateral limb can cope with the change in dynamics. The positioning of the subtalar and midtarsal joints should result in the redistribution pattern shown in *Figure 3*. These considerations require specialised skills, as well as knowledge of the biomechanics of the foot during cast application in order to correctly position the limb within the cast (Sinacore and Mueller, 2008). This allows for the achievement of the desired pressure redistribution pattern and correct offloading of the foot to be achieved. This will in turn produce optimal healing rates for patients with diabetic foot ulcers.

Comparison of casts is required

Total contact casting remains the 'gold standard' form of offloading the limb for ulcer treatment. Proper documentation and investigation of the hybrid versions and their comparison with the conventional TCC technique is warranted alongside the use and investigation of Böhler's iron. This will allow for a better assessment of and reduction in any limitations of the offloading devices, as well as acknowledging their advantages and effectiveness in the treatment of diabetic foot ulcers.

Recommendations

Clinical staff dealing with this cohort of patients need to be appropriately trained and equipped with knowledge of the biomechanics of the foot, the pathologies associated with diabetes and the skills required for correct cast application. Following on from the work of Diabetic Foot Consensus group across the UK, chaired by Rachel Berrington, two pilot diabetic foot casting courses were commissioned to mainly reflect the competencies of podiatrists and orthotists with cast room nurses and technicians attending also. The Scottish Diabetes Foot Action Group is currently pursuing endorsement of a recognised set of competencies and cast forms that are suitable for the treatment of wounds and offloading from all health disciplines involved in the application of casting.

The methodology and understanding of the principles outlined in this paper will hopefully aid the development of guidelines that will help standardise practice that delivers sustainable services. ■

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Participants should read the preceding article before answering the multiple choice questions below. There is ONE correct answer to each question. After submitting your answers online, you will be immediately notified of your score. A pass mark of 70% is required to obtain a certificate of successful participation; however, it is possible to take the test a maximum of three times. A short explanation of the correct answer is provided. Before accessing your certificate, you will be given the opportunity to evaluate the activity and reflect on the module, stating how you will use what you have learnt in practice. The new CPD centre keeps a record of your CPD activities and provides the option to add items to an action plan, which

1. According to a 2008 European study, what percentage of diabetic mid- and forefoot ulcers were treated with contact casting? Select ONE option only.

   A. 20
   B. 35
   C. 60
   D. 75
   E. 90

2. According to a 2008 European study, what APPROXIMATE percentage of diabetic mid- and forefoot ulcers were treated with 'gold standard' total contact casting (TCC)? Select ONE option only.

   A. <1
   B. 5
   C. 25
   D. 50
   E. 75

3. *"A force with its resultant passing through the centroid of a particular section and being perpendicular to the plane of the section."*

   According to Study Stack 2017, which ONE of the following loading forces affecting the foot is being described in the above statement? Select ONE option only.

   A. Axial
   B. Circumferential
   C. Distal
   D. Rotational
   E. Shear

4. When using a Böhler's iron to offload the foot, the weight of the limb is being suspended from which SINGLE anatomical site? Select ONE option only.

   A. Ischial tuberosity
   B. Fibular head
   C. Lateral malleolus
   D. Medial femoral condyle
   E. Tibial plateau

5. In 2015, Berwin et al studied the efficacy of a Beagle Böhler's iron compared to a classic below knee cast.

   Which ONE of the following is the MOST relevant limitation of this study? Select ONE option only.

   A. Duration of study
   B. Non-diabetic population
   C. Poor ethnic mix
   D. UK-centric
   E. Young age group

6. In which ONE of the following situations is it APPROPRIATE to treat a deep diabetic foot ulcer with casting? Select ONE option only.

   A. Critical limb ischaemia
   B. Deep tissue cellulitis
   C. Duration less than six weeks
   D. Foot abscess
   E. Osteomyelitis

7. Which SINGLE hypothesis BEST describes "the relationship between the factors that determine how much fluid leaks out of capillaries and into body tissues"? Select ONE option only.

   A. Cannon's
   B. Harvey's
   C. Krogh's
   D. Schwann's
   E. Starling's

8. What is the meaning of the acronym in the term "CPR for diabetic feet"? Select ONE option only.

   A. Care, Promote health, Review
   B. Checked, Protected, Referred appropriately
   C. Cleaned, Padding applied, Recorded
   D. Cardiovascular, Podiatry, Renal
   E. Claudication distance, Pulses, Reduced sensation

9. According to Liebner et al (2006), during ambulation, when the proximal cast wall carries loading, WHERE is the force transferred to? Select ONE option only.

   A. Calcaneum
   B. Fibula
   C. Hallux
   D. Tibia
   E. Talus

10. According to Munro and Zainab's article, which is the SINGLE MOST likely limiting factor regarding the use of TCC's in clinical practice? Select ONE option only.

    A. Financial limitations
    B. Limited evidence base
    C. Staffing levels
    D. Skills shortage
    E. Time constraints