

Do windows in removable casts increase local pressure?

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Article points

1. Cutting a window in a cast used to offload a diabetic neuroischaemic foot ulcer is safe if a particular type of cast is used.
2. A window cut on the plantar surface of an offloading cast for diabetic neuroischaemic ulcers does not create hyperpressure on its borders.

Key words

- Cast
- Offloading
- Window

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This article details a trial carried out to establish whether using an offloading cast with a window to treat diabetic neuroischaemic ulcers caused high pressure around the window and whether this pressure, known as the edge effect, carried the risk of developing a new ulcer. The study involved the participation of nine people who received offloading treatment via a cast known as the Ransart boot, which is small, removable, and windowed. The study showed that high peak pressure did not occur around the windows. The author concluded that it was safe to cut a window in this type of cast.

It is accepted that abnormal forces applied to the skin play a key role in the pathogenesis of the majority of ulcers on both the side and the plantar aspect of the diabetic foot, and that these include both direct pressure and shearing forces (Masson et al, 1988). Once an ulcer occurs, it is important to minimise these forces; offloading techniques are an essential part of the routine management of ulcers on the sole and the side of the foot (Caravaggi et al, 2000; Armstrong et al, 2001; Boulton and Armstrong, 2003; Bus et al, 2008). A variety of removable and nonremovable devices have been developed (Katz et al, 2005; Piaggese et al, 2007), each with its advantages and disadvantages.

The use of casts with a window cut under the ulcer are very seldom mentioned in this field. The Scotch cast boot (Burden et al, 1983), as well as the Ransart boot – developed by the author (Dumont et al, 2009) – are the only casts of this kind that are described and studied. Making a window in a cast is generally advised against, due to the so-called “edge effect” (Armstrong and Athanasiou, 1998), in which the window borders are thought to apply high pressure, thus carrying the risk of a new ulcer developing. As no study has ever been published assessing the “edge effect”, although in a number of studies involving the use of windowed casts, no lesion around the windows has been noticed (Burden

et al, 1983; Borssén and Lithner, 1989; Ha Van et al, 2003). Moreover, no real pressure threshold has been defined to establish at which point the risk of developing an ulcer would be greater.

The author undertook this trial to determine whether making a window in a cast increased the risk of lesion around the window.

Materials and methods

This study was conducted in the author’s centre where the Ransart boot (*Figure 1*) is the standard offloading cast used. Patients were included if they had an active ulcer on the plantar aspect of the foot, were aged between 18–85 years, had type 1 or type 2 diabetes, and diabetic peripheral neuropathy (defined as vibration perception threshold ≥ 25 V tested on the hallux by using a biothesiometer [Horwell], or insensitivity to a 10-g monofilament tested at a number of sites on the plantar surface of the foot). Ischaemic patients were not excluded. Patients with active Charcot disease were excluded.

Ulcers were classified according to the University of Texas system (Armstrong et al, 1998a). Depth was judged by inspection and, when appropriate, probing after debridement. Peripheral arterial disease was assessed by the palpation of pedal pulses. Guidelines published by the Infectious Diseases Society of America (Lipsky et al, 2004)

were used to determine the presence of infection. Active infection was not a criterion for exclusion.

Ransart boot

It takes approximately 30 minutes to make a Ransart boot (Dumont et al, 2009). First, the ulcer is covered with a simple protective dressing. A synthetic stocking is placed over the foot and lower leg, which is then encased in a roll of soft cast casting tape. The sole of the boot is reinforced with Scotchcast™ (3M) before applying a roll of Scotchcast™ Soft Cast Casting Tape (3M). The cast is moulded to the foot, with no special protection applied to bony prominences. The cast is left open just below the malleoli and a window is cut out over the ulcerated area as close to the ulcer edges as possible. The edges of the windows are abrupt. The cast is shaped to make easier to remove and is secured with Velcro®.

Ulcer management

Aside from the use of a Ransart boot, ulcers of all participants were managed according to the principles of the International Consensus on the Diabetic Foot (Bakker et al, 2011). Debridement of the wound was performed once a week.

The F-scan

The F-Scan® (Tekscan®) insole pressure assessment system, which has been described elsewhere (Young, 1993), was used to measure plantar foot pressures. The F-Scan pressure insoles were calibrated for each patient according to the manufacturer's specifications and all tests were carried out by the same operator. The procedure was standardised at the beginning of the study using healthy controls.

Before testing, the patients walked for several minutes in order to become comfortable with the system. Patients were asked to walk at their normal cadence and strike length. Data collection began after the second step and continued for at least eight consecutive steps on the same walkway. There were 5–10 trials for each patient. The peak plantar pressure was recorded in kg/cm² around the windows on the four borders and inside the cast approximately 1 cm away from the window edge, all around the perimeter of the window (Figure 2).

Fifty frames were recorded for each step. At each

frame they kept just one value: the highest peak plantar pressure from anywhere within the window border. The same was recorded for the results of the control (represented by the blue border in Figure 2), which is inside the boot 1 cm from, and perpendicular to, the window.

The Student's *t*-test was used to compare two sample means.

Results

The patient demographic data and specific foot histories are shown in Table 1. Nine participants were included in the study (six men, three women; mean age, 59.1 ± 5.7 years). All had type 2 diabetes. This population is representative of those encountered in routine specialist practices in northern Europe and the USA, with the patient characteristics being very similar to those in other series (Oyibo et al, 2001; Jeffcoate et al, 2006).

None of the participants developed a new ulcer in another area of the foot with the reference ulcer, or on the other foot, during the period of the study and no herniation of the wound edges took place. The mean area of the windows was 9.4 ± 1.5 cm².

The author analysed three steps per patient, with a total of 26 steps for nine patients. Table 2 shows the results of each patient for each recorded step, which were all broadly consistent. The highest level of pressure found around the windows was 6.5 kg/cm², the lowest 1.6 kg/cm², and the mean was 4 ± 1.3 kg/cm². The peak pressure found in the cast 1 cm from the windows was 8.1 kg/cm², the lowest 3.3 kg/cm², and the mean 5.3 ± 1.4 kg/cm². Differences between these values are not statistically different.

Participants with prior Lisfranc or toe amputations were found to have comparable in-cast pressures similar to the other patients, suggesting that when using the Ransart boot the patients' walking pattern did not differ depending on the shape of the foot. Thus, the location of the ulcer does not impact on the results.

Discussion

To date, no agreed pressure threshold has been defined above which the risk of developing an ulcer increases. A range of values have been proposed by various authors, including:

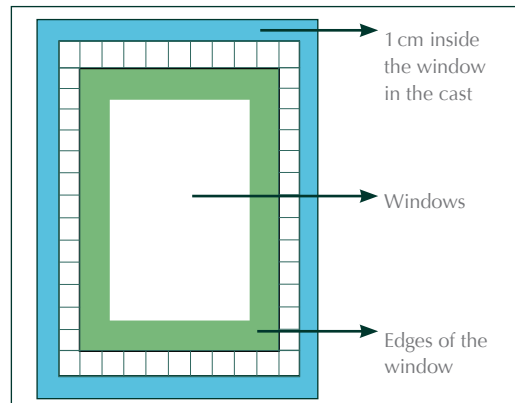
- 6 kg/cm² (Frykberg et al, 1998)



Figure 1. The Ransart boot.

“Although a larger study is needed to confirm the findings reported here, these data suggest that using a window in this type of cast is safe in people with active ulceration and diabetic peripheral neuropathy.”

Figure 2. Schema of where measurements were taken.



- 6.5 kg/cm² (Lavery et al, 1998)
- 7.1 kg/cm² (Armstrong et al, 1998b).

In the present study, the peak pressure found around the windows was 6.5 kg/cm², a value that sits within those suggested above as placing patients at increased risk of developing an ulcer. The peak pressure in the cast, 1 cm away from the windows, was 8.1 kg/cm², higher than that found around the window. These values are the highest recorded in any of the participants, and it should be noted that they occur only during one frame, so for less than one second. Mueller (1999) states: “The longer time the pressure is applied or the more steps a person takes with a given magnitude of pressure experienced on each footstep, the higher the risk for skin breakdown.”

Interestingly, the mean peak pressure in the present study was 4 ± 1.3 kg/cm² around the windows and 5.3 ± 1.4 kg/cm² in the cast, 1 cm away from the window. These values are in the range of pressures found by different authors in shoes and socks. Donaghue et al (1996) used the F-Scan to measure pressure in different types of shoes worn by people with diabetic peripheral neuropathy and found

pressures ranging from 3.98 ± 1.4 to 6.56 ± 2.7 kg/cm². Similarly, Frykberg et al (1998) used the F-Scan to measure pressure in diabetic neuropathic patients wearing socks and the results varied between 4.4 ± 1.9 and 6.7 ± 2.9 kg/cm². Sarnow et al (1994) also used the F-Scan to measure in-shoe foot pressure in people with diabetic peripheral neuropathy wearing shoes or socks; with either shoes or socks alone the highest pressures varied between 5.27 ± 2.39 and 8.77 ± 4.68 kg/cm².

Conclusion

The author evaluated peak pressures in a small, removable, windowed, offloading cast in nine people with active foot ulceration and diabetic peripheral neuropathy managed in a single centre. The peak pressures around the window were not such that they would risk the patient developing an ulcer. Although a larger study is needed to confirm the findings reported here, these data suggest that using a window in this type of cast is safe in people with active ulceration and diabetic peripheral neuropathy. ■

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Table 1. Demographic data of the population and baseline characteristics of their foot ulcer at presentation

Patient number	1	2	3	4	5	6	7	8	9
Age (years)	63	62	62	56	71	55	56	50	50
Sex (male/female)	Male	Male	Male	Male	Male	Female	Male	Female	Female
Neuropathy (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Vascular disease (Y/N)	N	N	N	N	Y	N	Y	Y	N
Foot characteristics	–	L LA	–	L1,2 toe amp	–	–	L LA R2,3,4,5 toe amp	–	Charcot
Texas classification	2A	2A	2A	3B	1C	2B	2C	1C	1C
Ulcer location	1st R MH	5th L MH	5th R MH	L FF	1st L MH	3rd L toe	1st R toe	1st R MH	1st L MH
Area of windows (cm²)	8	8	8	12	12	10	10	8	9

Amp, amputation; FF, forefoot; L, left; LA, Lisfranc amputation, MH, metatarsal head; R, right

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Table 2. Maximum peak plantar pressures (kg/cm²)

Patient number	Step number	Peak pressure around the window	Peak pressure 1 cm inside cast
1	1st	4.40	8.14
	2nd	5.72	6.38
	3rd	4.62	5.72
2	1st	4.08	5.43
	2nd	2.09	4.19
3	1st	4.49	4.64
	2nd	5.77	8.15
4	1st	2.51	3.59
	2nd	3.23	3.59
	3rd	2.51	3.95
	4th	5.03	5.03
	5th	6.10	6.10
	6th	6.10	6.10
5	1st	2.92	4.30
	2nd	3.61	4.30
6	1st	3.16	5.95
	2nd	2.59	5.75
7	1st	4.52	5.60
	2nd	3.61	4.30
	3rd	3.43	7.40
	4th	5.24	5.60
	5th	6.51	7.40
8	1st	3.21	5.57
	2nd	3.47	6.08
9	1st	4.46	4.60
	2nd	1.60	7.30