Reduction of Plantar Pressure Using a Prototype Pressure-Relieving Dressing

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I t is accepted that pressure relief is among the most important aspects in treating diabetic foot ulcers. Clinically, a variety of off-loading devices are used to redistribute pressure away from the area of ulceration to improve wound healing. The incorporation of pressure-relieving properties in a wound care dressing for the treatment of foot ulcers is a new and interesting concept, although currently there is no dressing available that contains specific pressure-relieving qualities.

We therefore aimed to investigate the efficacy of a prototype pressure-relieving dressing (PRD) designed to off-load pressure under individual plantar metatarsal head areas. To establish the pressure-reducing efficacy, the PRD was investigated in patients with intact feet only.

RESEARCH DESIGN AND METHODS — The study had institutional review board approval, and all participants gave informed consent. Eighteen diabetic patients with peripheral neuropathy but without active foot ulceration were recruited from the Manchester Diabetes Centre. Other inclusion criteria were peak plantar pressure >500 kPa and no peripheral vascular disease.

Participants visited the gait laboratory on 3 consecutive days. Dynamic plantar pressures were measured during barefoot walking using the optical pedobarograph (1). Following baseline plantar pressure measurement on day 1, the metatarsal head with the highest plantar pressure was covered with the prototype PRD, after which pressure measurement was repeated. The center of the dressing pad was applied over the bony prominence of the target metatarsal head with the pressure-relieving cushion surrounding the target metatarsal head. On day 2, plantar pressures of both feet were measured. On day 3, plantar pressures of both feet were measured and were measured again after the PRD was removed.

The PRD tested was a sterile dressing with combined absorbing and pressure-relieving properties designed especially for Wagner grade I or II diabetic foot ulcers. The dressing design permits the wound area to be covered by the absorbing part of the nonadhesive dressing pad. The pressure-relieving part is formed in a U-shape around the dressing pad and placed on the intact skin. The pressure-relieving part is made of transparent silicone with a built-in “woven-tread” to maintain shape and thickness and has an average thickness of 4 mm.

All participants were issued a pedometer on the 1st and 2nd day (Touchpad Pedometer 347; Sportline, Yonkers, NY), and the number of steps taken in each 24-h period was measured. For the statistical analysis, a paired t test was used to assess the difference in plantar pressure ($\alpha = 0.05$).

RESULTS — The 18 patients were predominantly male ($n = 15$) with type 2 diabetes ($n = 12$), age $69.1 \pm 9.0$ years (means $\pm$ SD) and diabetes duration $20.4 \pm 12.0$ years.

Half of the dressings were placed at the second metatarsal head ($n = 9$), with 22% ($n = 4$) on the first and third metatarsal head and one on the fifth metatarsal head. A mean pressure reduction of 30% was observed at the dressing site ($817.2 \pm 139.3$ vs. $573.2 \pm 166.1$ kPa, $P < 0.0001$) (Fig. 1). A significant pressure reduction of 26% was maintained over the next 2 days ($P < 0.0001$). Mean pressure returned to baseline levels once the PRD was removed ($764.3 \pm 177.3$ kPa). The metatarsal head medial and lateral to the PRD showed a mean pressure reduction of 16% (491.5 ± 192.3 vs. 410.5 ± 188.9 kPa and 439.3 ± 54.5 vs. 370.0 ± 91.7 kPa, respectively, $P < 0.05$), with a 20% pressure reduction at day 2. There was no change in peak pressure at the control metatarsal head ($601.8 \pm 184.7$ at day 1 vs. $599.1 \pm 169.3$ kPa at day 2).

The average number of steps taken per day was 6,849.8 ± 3,610 (range 1,146–13,384). There was no relation between the percentage of pressure reduction and the average number of steps taken ($r = 0.16$, $P = 528$).

CONCLUSIONS — We demonstrated a 30% pressure reduction by the prototype PRD at individual metatarsal head sites. The limitation of this study was that the pressure-reducing efficacy of the PRD was only tested on intact feet and that foot pressures were only measured using a pressure plate and not inside participants’ footwear. However, a strength of this study was that pressure-relieving quality was measured on 3 consecutive days.

A mean pressure reduction of 30% compares well with other protective shoes or off-loading techniques as evaluated with both pressure plate and pressure in-shoe devices (2–7). The prototype dressing was not only effective at reducing pressures at the target metatarsal head, but also at neighboring metatarsal heads. However, there was no pressure redistribution to other foot regions as other areas showed no increase in pressure. This suggests that the PRD would be ideal for patients with high pressure at individual metatarsal heads, in contrast to other usu-
ally more “bulky” off-loading devices. Therefore, in addition to foot ulcer treatment, this type of dressing could also have a role in preventative treatment where individual high-risk metatarsal head sites can be identified and targeted with minimal changes to the patient’s lifestyle.

The prototype PRD reduced pressure over at least 2 days, with no drop in pressure relief after the 1st day and no relation to level of activity. Felted-foam dressings have also proven to be effective in pressure reduction for 3 days in diabetic patients with neuropathic foot ulcers (8). It is expected that the PRD would effectively reduce pressure for at least the same duration; however, if used in patients with active foot ulceration or as a protective measure, it is recommended to change the dressing at least every 3 days.

It is clear that the pressure-relieving effect of a dressing can only be minor compared with other more traditional off-loading techniques. For the same reason, the PRD is not intended as an alternative, but as a supplement to existing devices. The PRD could, for example, be suitable in cases where the patients do not accept special shoes or insoles to assure pressure relief when shoes are taken off, in cases where minor off-loading is necessary, or for preventative and protective purposes.

In conclusion, the results of this study have shown the efficacy of a novel pressure-relieving dressing to reduce pressure at individual metatarsal heads in patients at risk of diabetic foot ulceration. The pressure relief was maintained over 2 days. The effectiveness of pressure-relieving dressings in patients with active foot ulceration needs to be evaluated in future studies.

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References

Figure 1—Peak plantar pressures of all participants walking barefoot without (baseline and day 3 without PRD) and with (days 1, 2, and 3) the prototype PRD.