

# Revisiting the Total Contact Cast

## Maximizing off-loading by wound isolation

MARC PETRE, BS<sup>1,2,3</sup>  
PAUL TOKAR, RN<sup>1,2</sup>

DEBRA KOSTAR, RN<sup>1,4</sup>  
PETER R. CAVANAGH, PHD, DSC<sup>1,2,3,4</sup>

**A**lthough the benefits of total contact casting for healing plantar neuropathic ulcers are consistent throughout a large body of available literature, the method of cast application varies (1–17). Cast structure at the ulcer site provides one major variance, i.e., should the cast create total contact with the entire plantar surface of the foot or should the wound be isolated? This article aims to resolve this issue by examining the differences in plantar pressure at the wound site between total contact casting using full contact with the plantar aspect of the foot and wound isolation.

### RESEARCH DESIGN AND METHODS

— A total of 10 healthy adult subjects (aged  $28 \pm 13$  years, height  $1.81 \pm 0.1$  m, and weight  $92.6 \pm 18$  kg) with focal areas of pressure (but no history of ulceration) under their metatarsal heads were recruited. For each subject, a region of interest (ROI) was selected to encompass areas of particularly high pressure. This study was approved by the Institutional Review Board of the Cleveland Clinic Foundation, and all subjects signed informed consent forms. A Pliance pressure-sensitive array (Novel) was fixed directly to the subject's foot covering the ROI. The  $16 \times 16$  sensor array had a sensor size of  $19.36 \text{ mm}^2$  and a sampling rate of 50 Hz.

Subjects were timed while they

walked 10 m barefoot with the sensor held in place using thin paper tape. The pace was self-selected but measured to provide reproducible speeds under the different conditions. The subjects were then cast with the sensor in place over the ROI using one of two casting methods, A or B, selected at random. Casting method A created a true total contact cast (TCC), and casting method B created a wound-isolation TCC (Fig. 1). Details of casting techniques are provided in the online appendix (available at <http://care.diabetesjournals.org>). Both methods presented here used fast-setting fiberglass cast materials (3M Health Care). All casts were applied by the same trained personnel with previous TCC experience.

Once the subject was comfortable walking in the cast, he/she was timed walking 10 m in the cast while pressure data were recorded. After the data were collected, the cast was removed with an oscillating cast saw, taking care to avoid moving or damaging the embedded sensor. The second type of cast was then immediately applied with the sensor array fixed in the same position, and the data collection procedure was repeated.

Five steps from the middle portion of the walk were averaged for each trial using Novel step analysis and averaging software. A 5-cm diameter circular area was identified near the center of the sensor array such that

it included the ROI selected for each patient. The peak pressure and pressure-time integral in these regions were calculated. The same regions were used to examine data from barefoot walking, walking in a conventional TCC without wound foam, and walking in a wound-isolation TCC with wound foam. Time-matched trials were used for comparison to eliminate the effects of speed on plantar pressure.

**RESULTS**— The measured in-cast pressures varied with method of application but were, in general, equivalent to results from prior work done using a similar application technique, despite the higher sensor resolution used in the present work, which tends to record greater pressures. The conventional TCC reduced peak pressures to  $98 \pm 30$  kPa, results similar to those reported by Hartsell et al. (15). The wound-isolation TCC reduced peak pressures to  $60 \pm 16$  kPa, results similar to those of Shaw et al. (16). Paired student's *t* tests found a significant lowering of peak pressure by 39% ( $P = 0.008$ ) and pressure-time integral by 25% ( $P = 0.012$ ) compared with the conventional TCC.

**CONCLUSIONS**— Although high barefoot peak pressures have been linked to longer ulcer healing times, there is no quantitative in-cast pressure threshold for ulcer healing. Even without the benefit of such a threshold, it is reasonable to suggest that clinicians should take any means available to lower plantar pressure during the healing process.

One of the theoretical drawbacks to the creation of a wound cavity is pressure concentration at the cavity edges. This phenomenon was not visible in any of the subjects' pressure distributions. A representative group of pressure distributions displaying no sign of a ring of elevated pressure is shown in Fig. 1. The same result was previously noted by Shaw et al. (16). We believe that pressure concentration is avoided in the wound-isolation TCC by skiving the foam to create a cavity that is more bowl-like than cylindrical. No conclusions about load transfer can be drawn from

From <sup>1</sup>The Cleveland Clinic Diabetic Foot Care Program, Cleveland, Ohio; the <sup>2</sup>Department of Biomedical Engineering, Lerner Research Institute, Cleveland Clinic Foundation, Cleveland, Ohio; the <sup>3</sup>Department of Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio; and the <sup>4</sup>Department of Orthopaedic Surgery and the Orthopaedic Research Center, Cleveland Clinic Foundation, Cleveland, Ohio.

Address correspondence and reprint requests to Peter R. Cavanagh, PhD, DSc, Department of Biomedical Engineering/ND20, The Cleveland Clinic Foundation, 9500 Euclid Ave., Cleveland, OH 44195. E-mail: [cavanap@ccf.org](mailto:cavanap@ccf.org). Web: <http://www.lerner.ccf.org/bme/cavanagh/lab>.

Received and accepted for publication 21 December 2004.

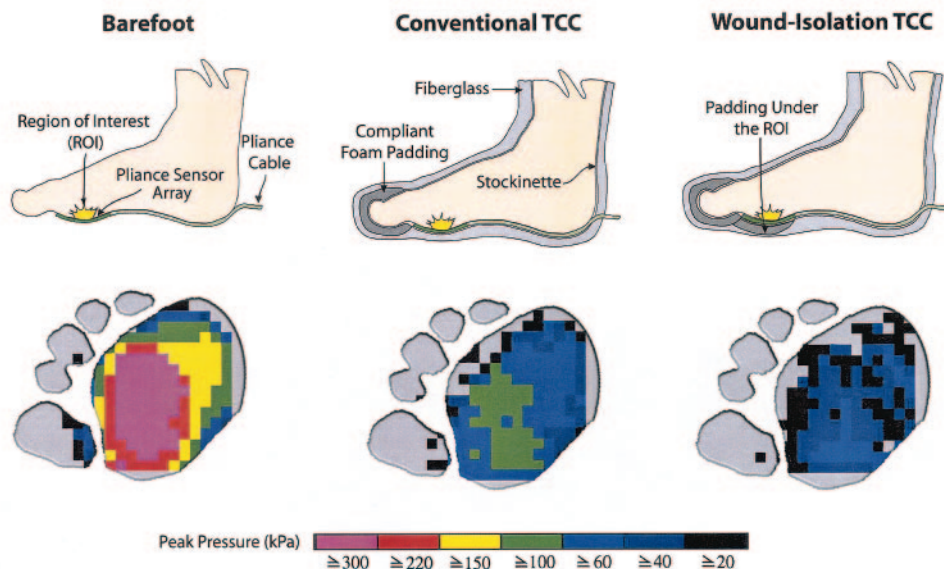
Additional information for this article can be found in an online appendix at <http://care.diabetesjournals.org>.

**Abbreviations:** ROI, region of interest; TCC, total contact cast.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

© 2005 by the American Diabetes Association.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked "advertisement" in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.



**Figure 1**—Schematic representation of the casting methods shown with representative pressure distributions from subject 8.

this study. It is likely that more load was being carried by the midfoot, heel, and/or leg to reduce load, and therefore pressure, on the area of plantar prominence. A larger sensor, such as the Pedar (Novel) would be able to answer this question at the expense of decreased spatial resolution.

The results of this study are, at present, limited to submetatarsal head plantar prominences and associated ulcers. Further exploration of the efficacy of wound isolation in cases of midfoot and heel ulceration is required before similar recommendations can be made for ulcers occurring in these regions. Although casting is a technique prone to variation, plantar pressure measurements within TCCs have been shown to have high repeatability when the casts are applied by experienced technicians (17).

This experiment suggests that the name “total contact cast” is somewhat of a misnomer. To optimize wound off-loading, the cast should provide total contact everywhere except for the wound site, which should be mechanically isolated. These results should be confirmed in a clinical study, which, if other factors (such as patient activity level and ulcer characteristics) are matched, could be expected to show faster healing times in the wound-isolation cast.

**Acknowledgments**— This study was supported by National Institutes of Health (NIH) Grant no. 5R01 HD037433. M.P. was supported by NIH Grant no. T32 EB04314.

We are grateful to Judy Pflieger, PT, CPed,

and Fiona Adams, PT, for expert training in TCC application.

#### References

1. Kominsky SJ: The ambulatory total contact cast. In *The High Risk Foot in Diabetes Mellitus*. 1st ed. Frykberg RG, Ed. New York, Churchill Livingstone, 1991, p. 449–461
2. Armstrong DG, Nguyen HC, Lavery LA, van Schie CH, Boulton AJ, Harkless LB: Off-loading the diabetic foot wound: a randomized clinical trial. *Diabetes Care* 24:1019–1022, 2001
3. Catanzariti AR, Haverstock BD, Grossman JP, Mendicino RW: Off-loading techniques in the treatment of diabetic plantar neuropathic foot ulceration. *Adv Wound Care* 12:452–458, 1999
4. Lawless MW, Reveal GT, Laughlin RT: Foot pressures during gait: a comparison of techniques for reducing pressure points. *Foot Ankle Int* 22:594–597, 2001
5. Lavery LA, Vela SA, Lavery DC, Quebedeaux TL: Total contact casts: pressure reduction at ulcer sites and the effect on the contralateral foot. *Arch Phys Med Rehabil* 78:1268–1271, 1997
6. Armstrong DG, Stacpoole-Shea S: Total contact casts and removable cast walkers: mitigation of plantar heel pressure. *J Am Podiatr Med Assoc* 89:50–53, 1999
7. Brand PW: The Insensitive Foot (Including Leprosy). In *Disorders of the Foot*. 1st ed. Jahss M, Ed. Philadelphia, W.B. Saunders Company, 1982, p. 1266–1286
8. Coleman WC, Brand PW, Birke JA: The total contact cast: a therapy for plantar ulceration on insensitive feet. *J Am Podiatry Assoc* 74:548–552, 1984
9. Burnett O: Total contact cast. In *Clinics in Podiatric Medicine and Surgery: The Diabetic Foot*. Vol. 4, no. 2. Harkless LB, Dennis KJ, Eds. Philadelphia, W.B. Saunders, 1987, p. 471–479
10. Birke JA, Novick A, Graham SL, Coleman WC, Brasseaux DM: Methods of treating plantar ulcers. *Phys Ther* 71:116–122, 1991
11. Myerson M, Wilson K: Management of neuropathic ulceration with total contact cast. In *The Foot in Diabetes*. Sammarco GJ, Ed. Philadelphia, Lea & Febiger, p. 145–152, 1991
12. Novick A, Birke JA, Graham SL, Koziatke E: Effect of a walking splint and total contact casts on plantar forces. *J Prosthetics Orthotics* 3:168–178, 1991
13. Birke JA, Patout CA Jr: The contact cast: an update and case study report. *Wounds* 12:26–31, 2000
14. Armstrong DG, Lavery LA, Nixon BP, Boulton AJ: It’s not what you put on, but what you take off: techniques for debriding and off-loading the diabetic foot wound. *Clin Infect Dis* 39 (Suppl. 2):S92–S99, 2004
15. Hartsell HD, Brand RA, Frantz RA, Saltzman CL: The effects of total contact casting materials on plantar pressures. *Foot Ankle Int* 25:73–78, 2004
16. Shaw JE, Hsi WL, Ulbrecht JS, Norckitis A, Becker MB, Cavanagh PR: The mechanism of plantar unloading in total contact casts: implications for design and clinical use. *Foot Ankle Int* 18:809–817, 1997
17. Hartsell H, Fellner C, Frantz R, Saltzman C: The repeatability of total contact cast applications: implications for clinical trials. *JPO* 13:4–7, 2001
18. Crenshaw SJ, Pollo FE, Brodsky JW: The effect of ankle position on plantar pressure in a short leg walking boot. *Foot Ankle Int* 25:69–72, 2004