

Walking casts: effect on plantar foot pressures

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Abstract—Pressure measurements were made at four sites on the right foot of six normal subjects while they walked in a standard shoe, conventional padded cast, total contact cast, and again in a shoe. No differences in mean relative pressure were found between the padded cast and the total-contact cast. Significant reductions in mean relative pressure were found between the standard shoe and walking casts at the first and third metatarsal head. This study supported the use of walking casts in the management of plantar ulcers. The effectiveness of the cast in reducing plantar pressure was not found to be dependent on the cast padding technique.

INTRODUCTION

Plaster walking casts have been used to promote healing of neuropathic plantar ulcers in patients with diabetes and Hansen's disease since the 1930's. Four rationales have been cited for the effectiveness of walking casts in healing plantar wounds: 1) immobilization, minimizing stretch on the healing wound site; 2) reduction of foot pressures by the total contact plaster fit; 3) control and reduction of edema by the supporting plaster cylinder; and 4) protection from further trauma by the hard plaster shell (1-4, 7, 8, 12).

No data are available to support the rationale that immobilization or protection from trauma contribute to the healing of plantar ulcers within a walking cast. Mooney and Wagner (9) reported on the effectiveness of walking casts in decreasing edema in normal subjects and diabetic patients. The strongest data, however, support the rationale that walking casts promote healing of

ulcers by reduction of pressure. Recent studies show plantar ulcers develop at the areas of maximum pressure on the foot. The first metatarsal head is the most common site, and the remaining metatarsal heads are among the next most common sites of plantar foot ulceration in patients with Hansen's disease and diabetes (6, 14, 15). Pollard et al. (13) demonstrated that conventional walking casts greatly reduce plantar foot pressure and therefore promote healing at areas of high pressure.

Conventional casting techniques incorporate several inner layers of cotton padding to prevent skin breakdown. In the 1960's Brand recommended the use of a total-contact cast using minimal padding over bony areas only and a carefully molded inner plaster shell. The total-contact cast was thought to reduce pressure and friction on the foot and to minimize loosening of the cast from gradual compression of the soft cotton layers (5).

To date there are no data to support the use of a total-contact cast or the effectiveness of one cast technique over another in reducing foot pressures. A major reason has been the unavailability of a suitable pressure transducer (11). We approached this problem by using a thin, flexible transducer, which has a minimal effect on the soft tissue/device interface and provides a repeatable measurement of relative pressure.

The purpose of this study was to compare the effect of a standard shoe, a conventional padded cast, and a total-contact cast on plantar foot pressures during walking. The hypothesis was

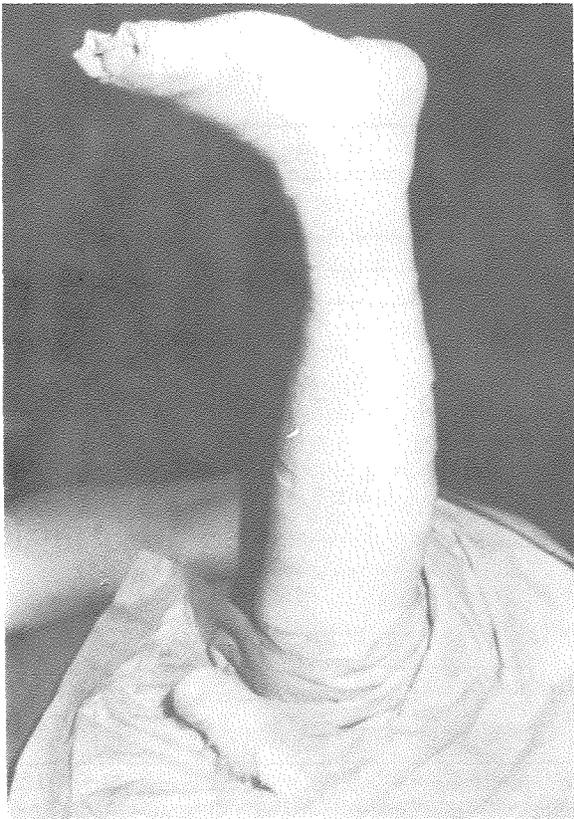


FIGURE 1
Conventional cast padding technique.

that a snug-fitting total-contact cast would provide better contour to the foot and leg and result in lower discrete foot pressures compared with a conventional cast.

METHOD

Capacitive pressure transducers (Hercules Orthoflex Data System, Allegany Ballistics Lab, Cumberland, MD) 2 mm thick and 1.5 cm in diameter were taped to the first metatarsal head (MTH), third MTH, fifth MTH, and plantar heel of the right foot of six normal subjects. The foot was then covered with a cotton stockinette, which remained undisturbed during the study. Transducers were calibrated according to the manufacturer's instructions prior to testing each subject. Pressure measurements were made using a four-channel capacitive impedance bridge amplifier (Hercules Orthoflex Data System) and an oscillographic recorder (Beckman Type RM Dynagraph Recorder, Beckman Instruments, Schaller Park, IL) while subjects walked sequen-

tially in a standard shoe, conventional padded walking cast (PC), total-contact cast (TCC), and again in the standard shoe. Subjects walked a distance of 23 meters on three consecutive trials for each treatment condition. An assistant was used to pace subjects at their self-selected velocity during all walking trials. Testing order of the TCC and PC was randomly assigned to eliminate systematic error. The second cast was applied immediately after removal of the first. Casting techniques differed primarily in the method used to pad the foot and leg prior to applying plaster. Two rolls of 4-inch cotton webril were wrapped evenly over the foot and leg in the PC (Fig. 1). The TCC utilized $\frac{1}{4}$ inch thick felt pads taped over the malleoli, tibial crest, and dorsum of the foot, and Scifoam (Contemporary Products, Corona, CA) placed over the toes (Fig. 2). The technique of plaster application for the TCC has been described previously (5). Fiberglass resin casting tape (Scotchcast, 3M Center, St. Paul, MN) was used for reinforcement layers in both cast techniques, allowing patients to walk within

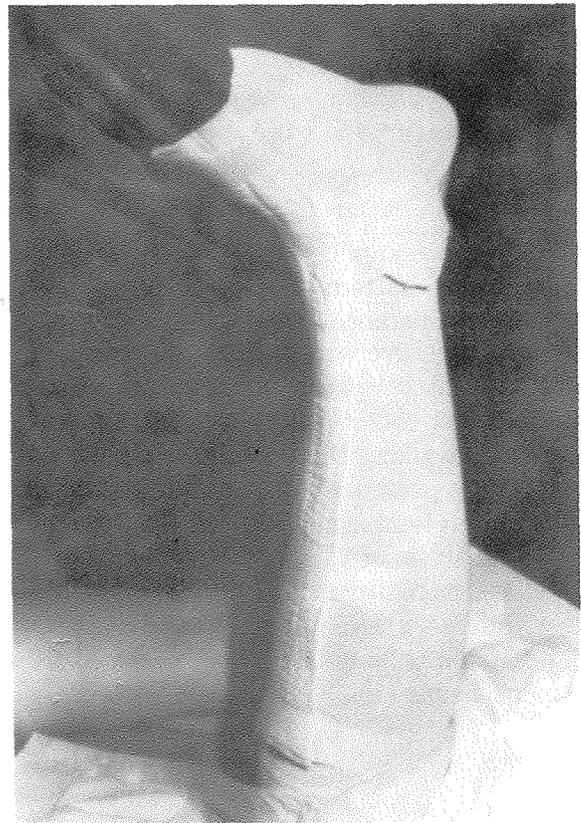


FIGURE 2
Total-contact cast padding technique.

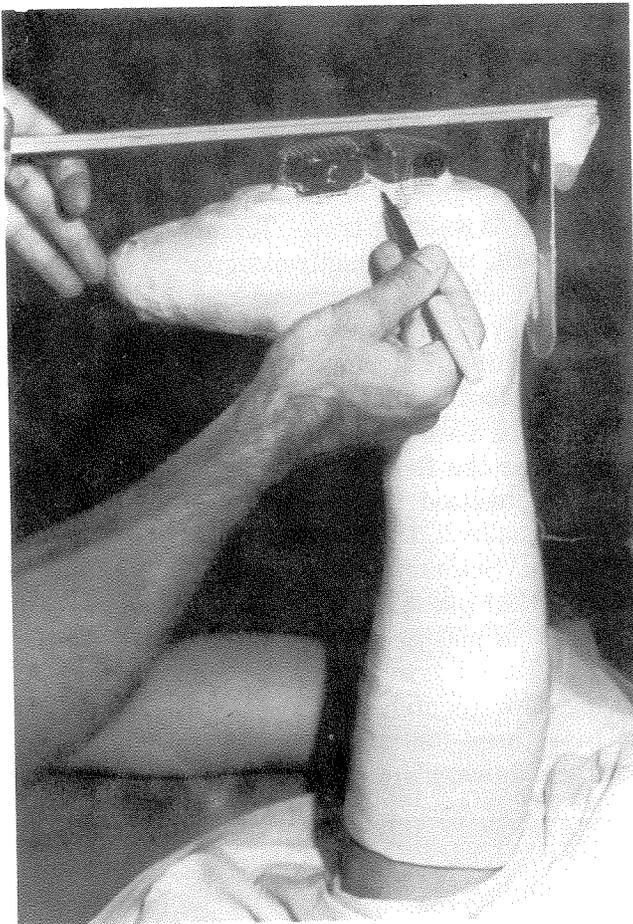


FIGURE 3
Standard placement of walking heel at 40 percent of heel-to-toe length.

30 minutes after application. Walking heels were attached to the bottom of the casts at a point 40 percent of the distance from heel to toe (Fig. 3).

Relative pressure was measured in millimeters of peak-to-peak chart deflection for 36 steps for each treatment condition. The middle distance of the best two walking trials was used for analysis. Mean relative pressure was calculated for each of the four treatment conditions at all transducer sites. An analysis of variance was used to determine whether treatment differences were significant within each site. Duncan's New Multiple Range Test was used for post hoc analysis of treatment means (10).

RESULTS

Analysis of variance (Table 1) of mean relative pressure during walking was significant at the

TABLE 1
Analysis of variance of mean relative pressure by site

Source	DF	SS	MS	F
<i>1st MTH</i>				
treatments	3	3,040	1,010	13.57*
error	20	1,490	74.6	
total	23	4,530		
<i>3rd MTH</i>				
treatments	3	2,820	939	33.47*
error	20	561	28.1	
total	23	3,380		
<i>5th MTH</i>				
treatments	3	128	42.7	2.99†
error	20	285	14.3	
total	23	413		
<i>Heel</i>				
treatments	3	342	114	3.01†
error	20	750	37.9	
total	23	1,100		

* $P < 0.001$ † $P > 0.05$ MTH = metatarsal head, DF = degrees of freedom; SS = sum of squares, MS = mean squares, F = f ratio

first MTH and third MTH. Duncan's test was performed to establish which treatment differed. A significance level of 0.05 was used for comparisons. No difference was found between padded and total-contact casts or between initial and final trials walking in a shoe (Figs. 4-7). Significant differences were found between the mean relative pressure walking in shoes compared with casts. Pressure was reduced in casts 84 percent at the third MTH and 75 percent at the first MTH, as compared with shoes (Fig. 8). Although not statistically significant, relative pressure at the fifth MTH and heel showed reductions of 35 percent and 25 percent, respectively.

DISCUSSION

This study demonstrates the effectiveness of walking casts in reducing foot pressure in a population of normal individuals. These findings support the rationale that walking casts promote healing of neuropathic plantar ulcers by redistributing the forces on the bottom of the foot. The present findings as well as those of Pollard and

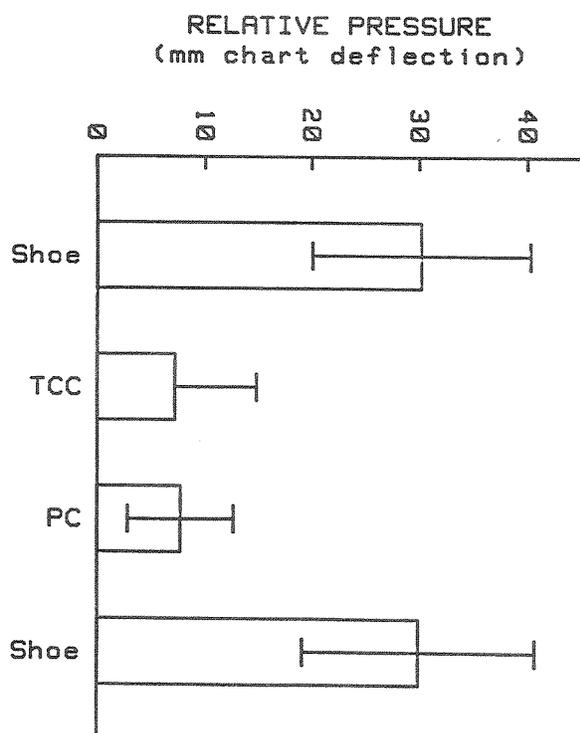


FIGURE 4
Mean relative pressure at the 1st metatarsal head for each of 4 walking trials.

associates (13) show greater pressure reduction at the first and third MTH as compared to the fifth MTH and heel. Further study is needed to determine if the rate of healing using walking casts is dependent on the ulcer location.

The method of padding in walking casts had no effect on the pressure distribution over selected areas on the bottom of the foot in this investigation. The influence of time could not be evaluated since pressure measurements were made within 1 hour after cast application. A PC may have been less effective in reducing foot pressure over time due to looseness from compression of the cotton padding. Shear stress (friction) may also be reduced in a snug-fitting TCC. Since the transducers used in this study only measured normal stress (pressure), further investigation is needed to determine whether friction is decreased in a TCC. Measurement system unreliability was a potential source of error that would have limited the ability to detect differences between casts. This is an unlikely explanation for the results obtained since initial and final walks in the standard shoe did not differ significantly at any site.

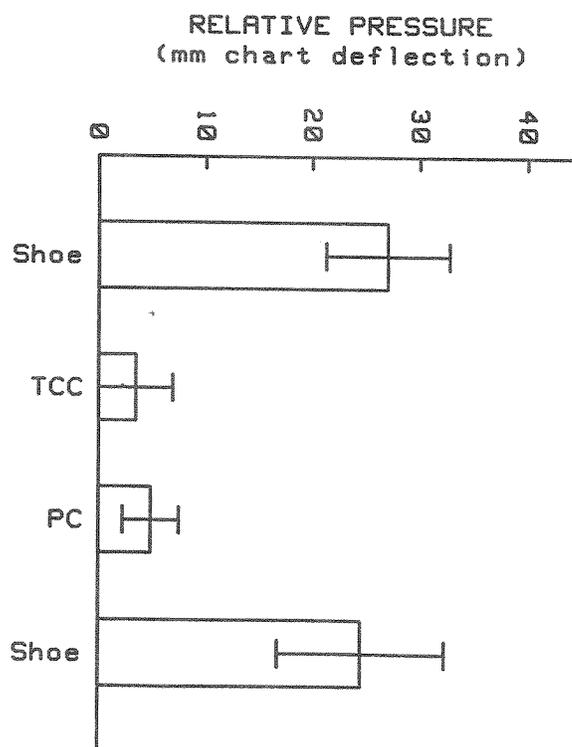


FIGURE 5
Mean relative pressure at the 3rd metatarsal head for each of 4 walking trials.

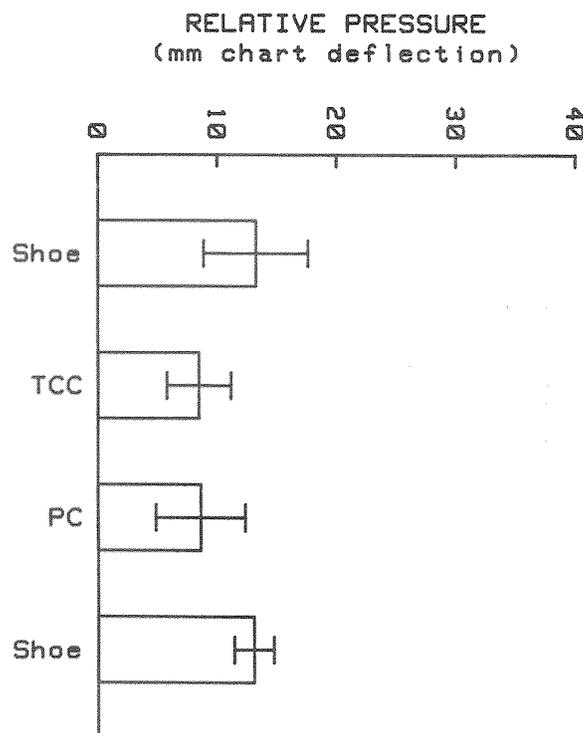


FIGURE 6
Mean relative pressure at the 5th metatarsal head for each of 4 walking trials.

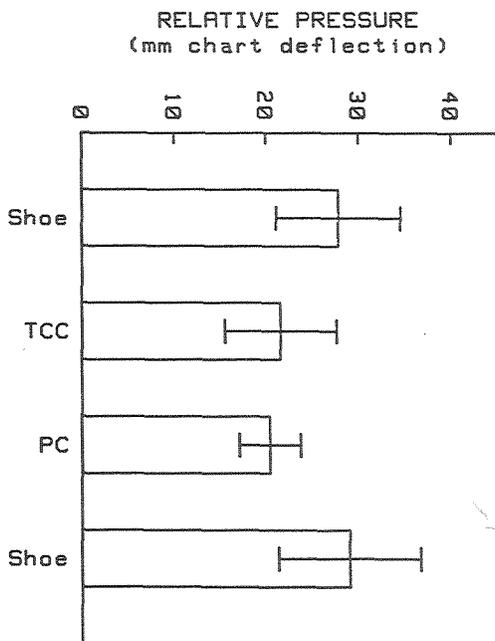


FIGURE 7
Mean relative pressure at the heel for each of 4 walking trials.

CONCLUSIONS

Within the limitations of this study it is possible to conclude that 1) walking casts are effective in reducing pressure at the first and third MTH and 2) there is no difference in the pressure distribution between padded and total-contact casts.

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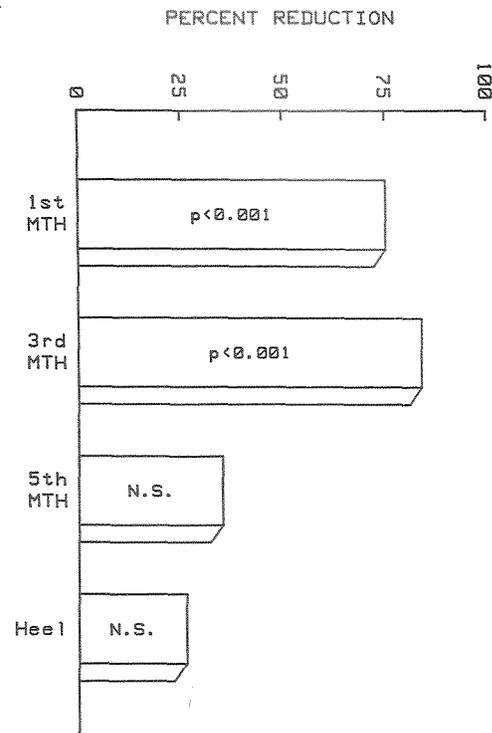


FIGURE 8
Reduction of pressure while walking in casts compared with walking in shoes for each of 4 transducer sites.