Optimizing Lower Extremity Splint Design to Prevent Posterior Heel Pressure Injuries

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INTRODUCTION:

Lower extremity plaster splints have multiple applications, including stabilization of fractures, sprains, and tendon injuries, as well as immobilization after operative procedures and protection for soft tissue rest. Splinting of the lower extremity poses a risk of posterior heel pressure injury. Twelve percent of medical device-related pressure injuries occur secondary to splinting or casting and splint-induced skin ulceration has been reported as the second most common iatrogenic plastic surgery referral. We present the first biomechanical study to measure contact pressure of the posterior heel to identify the optimal splint configuration and positioning for risk reduction of these injuries.

METHODS:

Twenty legs in ten healthy volunteer adults without current foot or ankle pathology were recruited for this biomechanical study. A pressure transducer (Figure 1) was used over the posterior heel to measure peak contact pressure in a short leg splint. Peak contact pressures were measured with 0, 2, 4, 6, 8, and 10 layers of two undercast padding brands, with the heel resting down on the treatment surface, and with the heel floating freely (Figure 2). Pressures were compared to a 32 mmHg threshold (the pressure of dermal arteriolar capillary collapse).

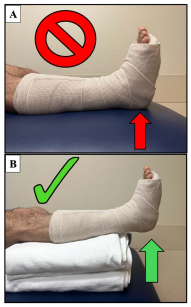
RESULTS:

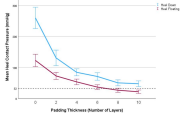
Average contact pressure remained above 32 mmHg when resting the heel down, independent of padding thickness or brand (Figure 3, Table 1). Floating the heel with 8 and 10 layers of thinner Brand 1 padding, and 6, 8, and 10 layers of thicker Brand 2 padding achieved the 32mmHg threshold. For both brands, pressures with 8 and 10 layers of padding were not significantly different and accounted for only about 1% of pressure decline. Additionally, inappropriately bunched or folded padding behind the heel increased contact pressure by 187-575% (median 270%, Figure 4, Table 2).

DISCUSSION AND CONCLUSION:

Our study identifies lower extremity positioning with the heel floating freely as the most important modifiable risk factor for preventing heel ulcers. The average heel contact pressure remained above 32 mmHg when resting the heel down regardless of padding thickness or brand. The optimal splint configuration includes eight evenly applied layers of padding to ensure effective offloading. It is imperative that padding is applied evenly, as inappropriately bunched or folded padding behind the heel can overcome the beneficial effects of additional padding layers.

Lower extremity splints are routinely applied by a range of healthcare professionals. Given their widespread use and the associated risk of iatrogenic pressure injury to the posterior heel, optimizing splint design, technique, and positioning is crucial to minimizing this risk. By addressing mechanical factors that contribute to pressure injury, we can significantly reduce complications and enhance clinical outcomes across various healthcare settings. Educating both patients and healthcare providers on these best practices is essential for improving patient care.





Padding Layers	Pressure (mmHg)	Heel Resting Down: Brand 1 (n=10 legs)	Heel Resting Down: Brand 2 (n=10 legs)	Heel Resting Down: Total (n=40)	Heel Floating Freely: Brand 1 (n=10 legs)	Heel Floating Freely: Brand 2 (n=10 legs)	Heel Floating Freely: Total (n=40)
0	Mean (SD)	NA	NA	269 (110)	NA	NA	123 (65)
	95% CI	NA	NA	206, 332	NA	NA	92, 153
	Range	NA	NA	113, 597	NA	NA	50, 259
	p (NL)*	NA	NA	0.01	NA	NA	0.01
2	Mean (SD)	145 (88)	138 (45)	141 (70)	77 (38)	69 (32)	73 (36)
	95% CI	101, 194	84, 192	106, 176	58, 95	54, 85	62, 85
	Range	48, 407	56, 172	48, 407	26, 176	19, 109	19, 176
	p (NL)*	0.01	0.01	0.01	0.01	0.01	0.01
4	Mean (SD)	96 (57)	75 (28)	85 (51)	65 (38)	45 (32)	55 (38)
	95% CI	41, 115	55, 85	75, 94	15, 79	15, 16	45, 65
	Range	41, 240	15, 130	15, 240	21, 125	15, 97	15, 125
	p (NL)*	0.01	0.01	0.01	0.131	0.001	0.126
6	Mean (SD)	85 (56)	54 (31)	71 (56)	44 (23)	36 (26)	37 (24)
	95% CI	66, 102	45, 75	58, 83	31, 55	21, 43	30, 44
	Range	25, 232	15, 97	15, 232	15, 85	15, 85	15, 85
	p (NL)*	0.01	0.126	0.131	0.01	0.126	0.126
8	Mean (SD)	57 (32)	44 (27)	51 (30)	34 (23)	19 (19)	27 (21)
	95% CI	43, 72	31, 57	41, 60	19, 49	11, 32	20, 33
	Range	12 (14	12 (14)	12 (14	8, 89	5, 71	5, 89
	p (NL)*	0.01	0.126	0.126	0.126	0.126	0.126
10	Mean (SD)	52 (31)	39 (24)	46 (29)	34 (17)	17 (13)	25 (18)
	95% CI	42, 71	29, 48	36, 55	23, 45	11, 24	19, 31
	Range	15, 117	10, 99	15, 118	8, 85	5, 44	8, 44
	p (NL)*	0.001	11.131	17.052	11.731	14.001	11.731

Table 1: The peak contact pressure of the posterior heel in various splint configurations based on heel position (heel floating freely vs. heel resting down), padding thickness (0, 2, 4, 6, 8, and 10 layers of padding), and padding brand. SI conversion factor: To convert pressure (mmHg) to pascals, multiply values by 133. n = number, SD = standard deviation, % = percentage, CI = confidence interval, NA = not applicable, and highlights = average contact pressure measurements at or below the critical 32mmHg threshold, mmHg = millimeters of mercury, p = number of legs under 32mmHg (the pressure of dermal arteriolar capillary collapse) with percentage of legs achieving that threshold

Padding Thickness (Layers)	Padding Type (Brand)	Contact Pressure (mmHg)	Bunched Padding Pressure (mmHg)	Percent Increase in Pressure
4	Brand 1	100	391	284%
6	Brand 2	42	124	295%
8	Brand 1	12	69	575%
8	Brand 2	38	113	303%
8	Brand 1	116	246	212%
10	Brand 1	111	208	187%
			Median	**270%**
			Range	**187%-575%**

Table 2: Peak contact pressure of the posterior heel when inappropriately bunched/folded padding was observed under the heel (n=4 measurements). SI conversion factor: To convert pressure (mmHg) to pascals, multiple values by 133. mmHg = millimeters of mercury, % = percentage.