Human Cadaver Testing to Determine the Reliability of Heel Boot Positioning or "Grip" of Eight Commercially Available Pressure Relieving Heel Protector Boots.

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BACKGROUND
Support devices, such as pressure relieving boots, reduce the risk of ulceration by reducing friction, shear, and pressure to the at-risk tissues of the heel; however, the functionality of these devices depends on the boot's ability to retain correct positioning (Figure 1A and 1B). High "grip" boots increase the protective ability of the device by holding the limb in position relative to the pressure relieving zones of the device. The "grip" of eight commercially available heel protectors (Table 1) were evaluated by comparing the coefficient of friction between the boot and heel of a fresh female cadaver.

METHODS
Testing was performed on a female cadaver provided by the University of Utah Body Donor Program. The cadaver was 78 years of age, 41.28 kg, 160 cm, with no notable medical history. Following each test run, the heel of the cadaver was inspected for signs of damage.

Samples of each type of boot were modified to include a strap, sewn into pre-existing seams of the boot, positioned uni-axially about the calf of a 50th percentile mannequin calf. For boots that would not allow stitching, a strong double sided adhesive was used to fix the strap to the boot. To reduce friction between the test bench and the outside of the boot, the cadaver was positioned above a thin sheet of Teflon. The left heel of the cadaver was positioned as per manufacturer's instruction (Figure 2); however, the straps of the boots were left un-attached. This was to allow for the evaluation of the boot-cadaver interface material without the variable of the strap.

RESULTS
No abrasion or damage to the skin of the cadaver was observed during testing (Figure 5). The coefficient of friction for each of the eight different commercially available heel protector boots was calculated (Figure 4). The coefficient of friction for each of the eight different commercially available heel protector boots was calculated. Each sample is also identified by the general construction material of the boot. The error bars represent the 95% confidence interval (alpha = 0.05). Refer to Table 1 for the construction material information of each sample.

CONCLUSIONS
As patients shift, the ability of a heel protecting boot to grip the limb and retain optimal off-loading positioning is vital to the function of the device. Correct positioning of the limb is key in relieving pressure, shear, and friction to the heel.

Multiple factors influence the coefficient of friction on a non-flat surface, such as the heel protector boots. Factors such as bulk modulus and the friction of materials may have a positive effect in the retention of correct positioning in heel protecting boots.

Evaluation of heel protector "grip" of the limb is necessary for determining the effectiveness of the device to reduce risk of ulceration to tissue. The results indicate that the architecture and material of heel protectors play a role in maintaining correct positioning. The coefficient of friction of the construction materials along with bulk modulus provide the "grip" necessary to effectively immobilize the boot in respect to the heel.

REFERENCES
1 Anthropometric Data, Introduction to Biomechanics, University of Rhode Island. January 20-26, 2011.
2 BS 3424-10:1987 Testing Coated Fabrics. Method 12A.

Table 1- The construction of each of the eight heel protector boots.

Sample | Construction
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1 | Fabric and Batting with Adjustable Velcro Strap
2 | Fabric and Batting with Adjustable Velcro Strap
3 | Fabric and Batting with Adjustable Velcro Strap
4 | Fabric and Batting with Adjustable Velcro Strap
5 | Fabric and Batting with Adjustable Velcro Strap
6 | Inflatable Air Bladder with Adjustable Velcro Strap
7 | Air and Gel Fluid Bladder with Adjustable Velcro Strap
8 | Foam with adjustable Velcro Strap

![Figure 1A](Figure 1A.png) Correct positioning of the limb decreases pressure, friction, and shear on the at-risk tissue of the heel.

![Figure 1B](Figure 1B.png) Incorrect positioning of the limb creates pressure, friction, and shear on the at-risk tissue of the heel.

![Figure 2](Figure 2.png) The positioning of the calf and heel in the heel protector.

![Figure 3](Figure 3.png) Pulling the boot from the cadaver with the force gauge.

![Figure 4](Figure 4.png) The coefficient of friction for each of the eight different commercially available heel protector boots was calculated. Each sample is also identified by the general construction material of the boot. The error bars represent the 95% confidence interval (alpha = 0.05). Refer to Table 1 for the construction material information of each sample.

![Figure 5](Figure 5.png) No abrasion or damage to the skin of the cadaver was observed during testing.