Laboratory Testing of 4 Sacral Dressings with Physiological Loads Reveals Differences in Strain Relief

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Purpose

To determine if there are differences in strain relief in sacral dressings under physiological loads.

Introduction

Patients who must remain prone for long periods end up placing a high burden on the skin of the sacrum. A class of border dressings has been in use to mitigate the lateral strains on the sacrum while the patient shifts while the sacrum is under load. There a several “substantially equivalent” devices on the market, but their relative performance in strain mitigation is unknown.

The general mechanisms are believed to include at least normal stress reduction by spreading the load over a larger area via a deformable material. Laterally, the devices tend to be more stiff than skin, so they also act to stent the skin somewhat against lateral deformation. Finally, the outer layer tends to be smoother than skin which reduces sliding friction which reduces the amount of strain imparted into the skin.

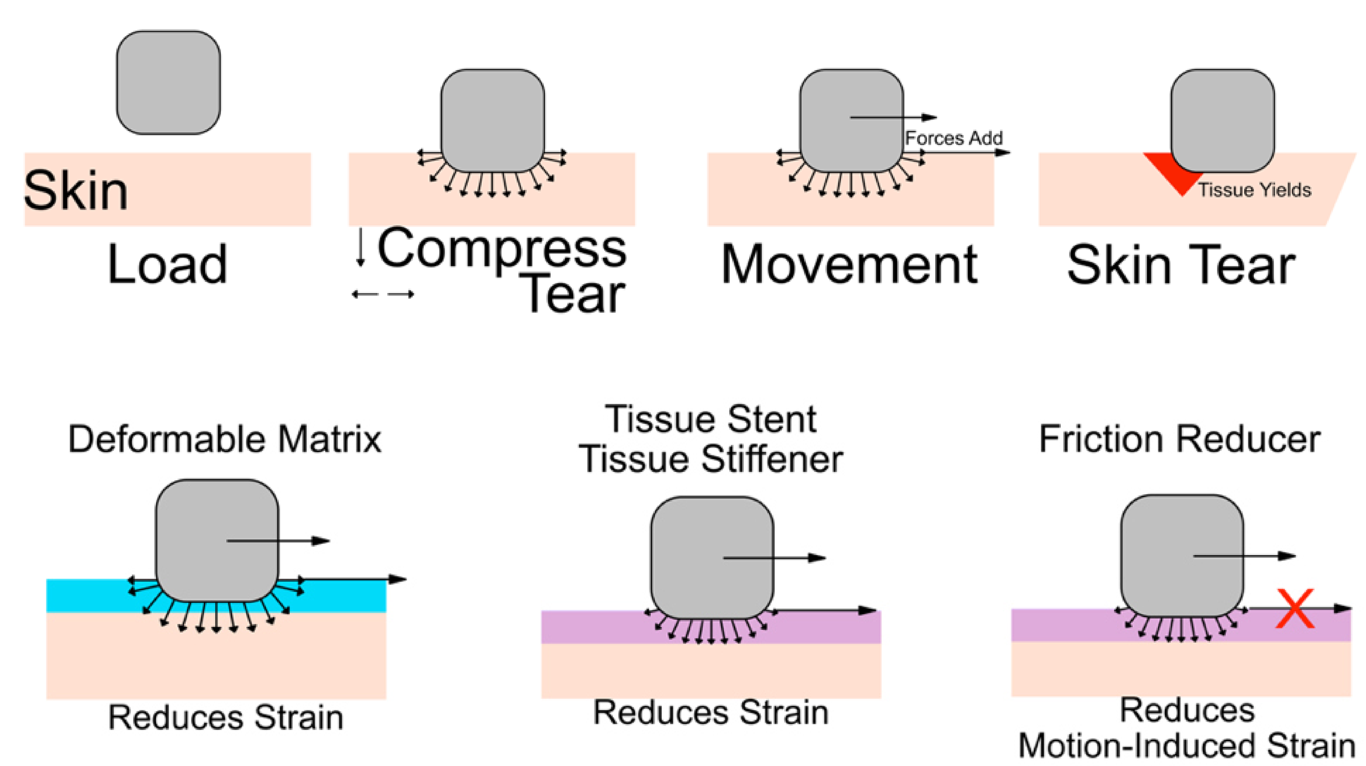

Figure 1: The general mechanics of normal skin loading and means to mitigate loading.

Additional products have begun to enter the market which seek to meet these basal performance goals, and at least one is attempting to add additional function. While the typical formula has been a multilayer dressing with differing materials, a new dressing appears to be comprised of a single material which is translucent. This may enable assessment of the sacrum without removing the dressing.

In previous work, a digital image correlation system was used to compare the performance of existing sacral border dressings in mitigating lateral strain imparted into a silicone-based sheet which served as a non-physiological model for skin (Lee & Gibson 2020). The work presented here increased the input pressures to those seen in patients (Mimura, et al. 2009) to see if the strains varied with increased loads.

Materials & Methods

A variation on a system reported previously (Lee & Gibson, 2020), was used with a bead-loaded, custom cast, silicone sheet to monitor the strains in the silicone under physiological loads (Mimura et al. 2009). The silicone was treated with corn starch to keep it from being tacky, and one edge was fixed to the table. The rest of the silicone was allowed to slide along the device's imaging stage. A normal pressure of 172.4 mmHg (23 kPa),was generated using a custom 3D printed sled which held a 5.0 lb olympic-style weight plate. The interface of the sled with the dressing was 1.5 sq. in. The interface was wrapped in cotton-polyester blend sheet material. A stepper motor was used to apply 216 N of external shear force in 0.625-mm steps for 40 steps. The maximum strain was quantified in FIJI and compared by one-way ANOVA (α= 0.05) followed by a pairwise-Tukey HSD *post-hoc* test.

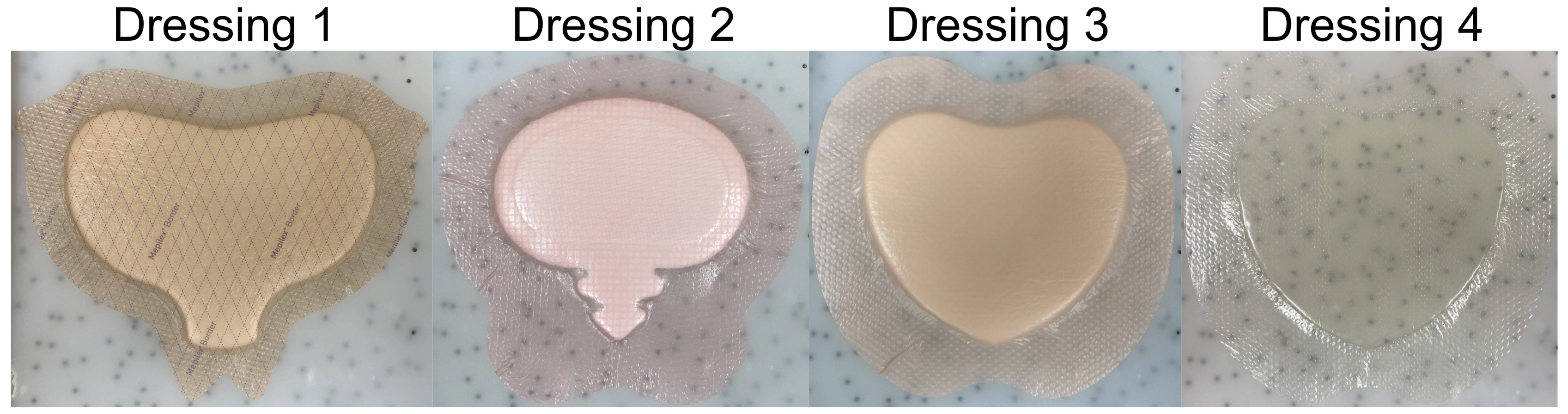

Figure 2: The dressings. Dressing 1: Mepilex® Border Sacrum, Dressing 2: Allevyn™ Life, Dressing 3: Optifoam® Gentle EX, Dressing 4: OptiView™. Images are not to scale. The loading and straining occurred from left-to-right, as pictured, for all dressings.

Results

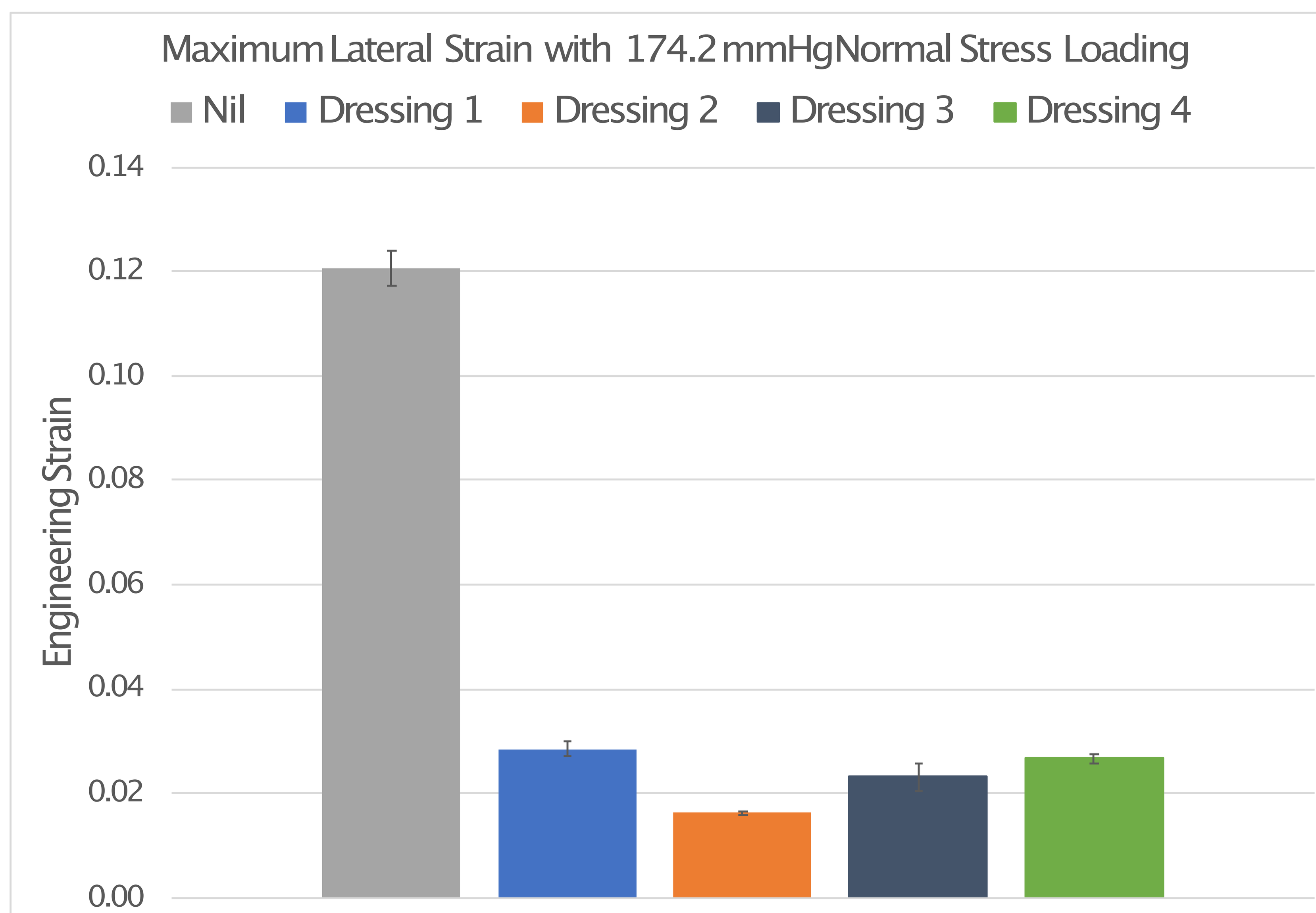

Figure 3: The maximum engineering strain in the silicone.

The mean of the dressings maximum strains were 0.0162, 0.0231, 0.0285, & 0.0267 (nil = 0.1206). The ANOVA revealed very significant differences ($p = 1.09 \times 10^{-13}$). All dressings were substantially better than Nil ($p < 0.00009$). Dressing 2 performed better that all the rest ($p < 0.0131$). While Dressing 3 was better than Dressing 1 ($p = 0.049$). The remaining differential comparisons were not significant ($p > 0.05$).

Dressing	p-value
All vs. Nil	$\leq 9 \times 10^{-5}$
Dressing 2 vs. All	≤ 0.0131
Dressing 3 vs. Dressing 1	$= 0.049$

Table 1. Results from Python's statsmodels Tukey's HSD.

After being under 174.2 mmHg load and subjected lateral strain, every dressing had evidence of load-induced deformation (Figure 4).

Figure 4. After heavy use, the dressings have an impression left by the laterally dragged sled.

Conclusions

In previous work, clinically insignificant load did not lead to any observable differences among the tested dressings. When pressures informed by clinical data were used, detectable differences were found. The maximum difference seen at this maximum load was about 1.6%, (a 2-fold difference), whether this difference is of any clinical relevance is not known.

By gross observation, the maxim performer, was thicker than the other dressings. The consequences of this increased thickness are not known. However, a greater thickness is expected to lead to higher normal strains.

The input normal pressure value used here was informed by clinical data from Mimura, et al. However, the value chosen was from the coccyx, not the sacrum. The sacral maximum was a little more than 1/3rd of the pressure at about 50 mmHg, so these data represent an extreme case. Additional work continues to identify the pressure load at which performance among the dressings begins to differ.

Under the heavier load, all dressings had evidence of persistent deformation. The relevance of these deformations has yet to be determined.

References

1. Mimura M, Ohura T, Takahashi M, Kajiwara R, Ohura Jr. N. "Mechanism leading to the development of pressure ulcers based on shear force and pressures during a bed operation: Influence of body types, body positions, and knee positions." Wound Rep Reg (2009) 17 789–796
2. Lee J and Gibson DJ. "A Comparison of the Biomechanical Protection Provided by 2 Cyanoacrylate-Based Skin Protectants." J Wound Ostomy Continence Nurs (2020) 47(2): 118-123.