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REDUCTION OF STRAIN CLUSTERS IN INJURED HEEL FINITE ELEMENT MODELS WITH A NEW PRESSURE ULCER DRESSING

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Introduction

Pressure Ulcers (PU) are soft tissue injuries that may occur when high and extended loads are applied to the tissues. The onset of PU has been mechanically explained by excessive shear strains [1]. When the unloading of the tissues is not possible, medical devices such as dressings can be applied to temporally relieve the tissues. However, there is little evidence showing the mechanical efficacy of these dressings to decrease the strains around PU. This study presents a Finite Element (FE) analysis of such efficacy on an asymptomatic heel and injured heels, with two different stages of PU.

Material and Methods

FE models were designed for one asymptomatic subject (Figure 1). Models were designed without PU, with stage-2 PU, and stage-3 PU, with and without the dressing. These models included skin, fat, muscle, and tendon tissues. Bones were supposed rigid. PU were simulated by removing tissues in a sphere portion 3.0 mm deep (stage-2 PU) or 5.0 mm deep (stage-3 PU). Tissues were supposed and defined as isotropic, homogeneous, and hyperelastic. The dressing was composed of two layers, the first one represented a compress modelled with an orthotropic linear elastic material, and the second one is a compressible honeycombed material with a hole under the bony prominence [2]. The dressing was tied to the skin after a prestress was applied. Bones were loaded with a vertical force equivalent to 6 % of the subject's weight. A mattress, with a linear elastic material, was added to the model. Clusters of deformations were defined as groups of adjacent elements with Green-Lagrange maximal shear strains higher than 0.75 and compressive strains higher than 0.45 [3].
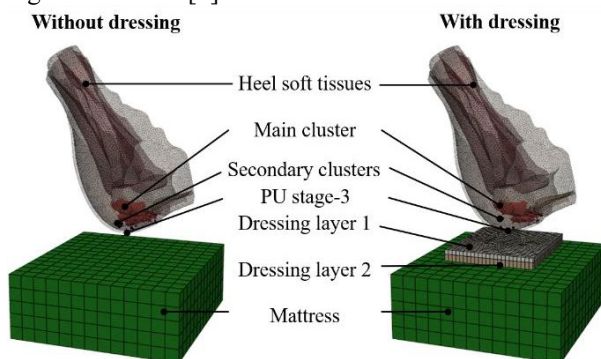

Figure 1: Main clusters in stage-3 PU models.

Results

The volume of the main cluster of deformation decreased in all models when the dressing was added (Table 1 and Figure 2).

Cluster volumes (mm^3)	Without dressing	With dressing
no PU	3,277	1,898
stage-2 PU	2,187	1,280
stage-3 PU	1,891	1,227

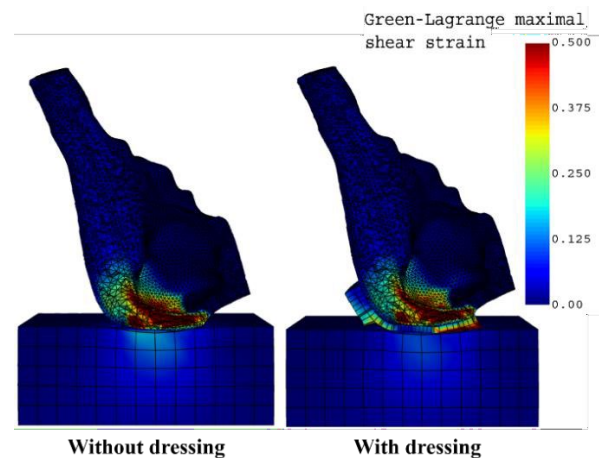*Table 1: Volume of the main clusters of deformations.*

Figure 2: Maximal shear strains in stage-3 PU models.

Discussion

The dressing performed well to reduce the volume of tissues above potentially harmful strain thresholds. Strains levels remain high which means that additional care should be taken on top of the use of dressings. As a perspective, this analysis needs to be computed on more subjects.

References

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2. N. Fougeron *et al.*, *J Tissue Viability*, 31(3): 506–513, 2022.
3. A. Macron *et al.*, *J Tissue Viability*, 217: 81–90, 2019.

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