



HAL
open science

Reduction of strain clusters in injured heel Finite Element models with a new pressure ulcer dressing

Nolwenn Fougeron, Grégory Chagnon, Nathanaël Connesson, Thierry Alonso, Laurent Pasquinet, Stephane Auguste, Antoine Perrier, Yohan Payan

► To cite this version:

Nolwenn Fougeron, Grégory Chagnon, Nathanaël Connesson, Thierry Alonso, Laurent Pasquinet, et al.. Reduction of strain clusters in injured heel Finite Element models with a new pressure ulcer dressing. 28th Congress of the European Society of Biomechanics, Jul 2023, Maastricht, Netherlands. hal-04502027

HAL Id: hal-04502027

<https://hal.univ-grenoble-alpes.fr/hal-04502027v1>

Submitted on 13 Mar 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

Nolwenn Fougeron (1), Gregory Chagnon (1), Nathanael Connesson (1), Thierry Alonso (1), Laurent Pasquinet (2), Stephane Auguste (2), Antoine Perrier (1, 3), Yohan Payan (1),

1. Univ. Grenoble Alpes, CNRS, UMR 5525, VetAgro Sup, Grenoble INP, TIMC, 38000 Grenoble, France, 2. Urgo Research, Innovation & Development, 21300, Chenôve, France, 3. Sorbonne Université Médecine; Assistance publique Hôpitaux de Paris (APHP), Service de Diabétologie, Hôpital Pitié-Salpêtrière

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].

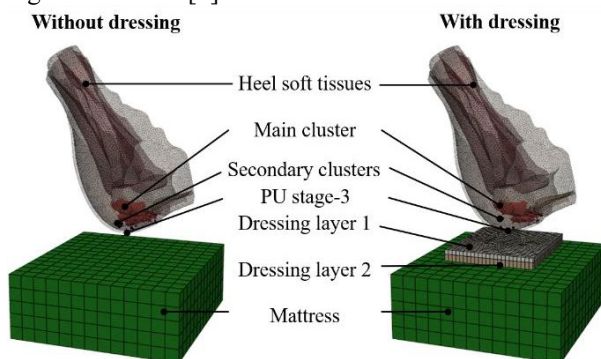


Figure 1: Main clusters in stage-3 PU models.

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.

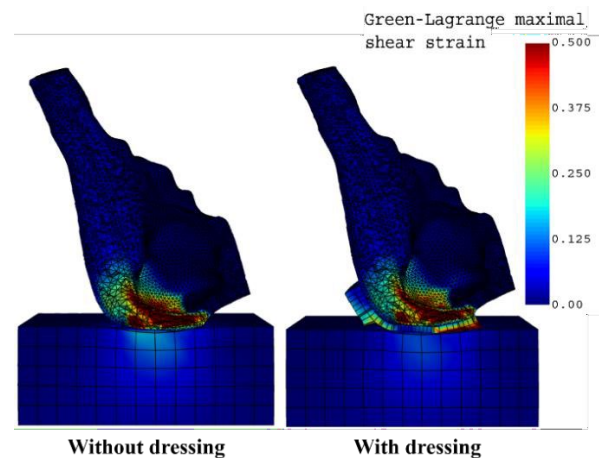


Figure 2: Maximal shear strains in stage-3 PU models.

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

1. K. K. Ceelen *et al.*, *J Biomech*, 41: 3399–3404, 2008,
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.

Acknowledgements

We thank Alessio Trebbi for his help in the acquisition and segmentation processes.