In vivo experimental characterization of the biomechanical response of sacral soft tissues under compression using both B-mode Ultrasound and MRI: preliminary assessment on 2 healthy volonteers

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Introduction: Personalized computational models have the potential of assessing the risk of Pressure Ulcer in clinical situations and could allow the development of an individualized prevention plan. The benchmark imaging modality for the personalized Finite Element (FE) modeling is MRI [1]. Yet, several barriers exist to the clinical translation of these MRI-based FE models. B-mode Ultrasound (US) imaging has shown promising results regarding the assessment of anatomical feature-related risk factors [2]. The objective of this work is to experimentally characterize the response of sacral soft tissues using both B-mode US and MRI. This represents a first step to the evaluation of the relevance of using US-based FE models for monitoring internal tissue strains as an alternative to MRI-based FE models.

Methods: Two healthy male volunteers (mean: 37 y.o., BMI=27.3 kg/m2) participated in the study (MAP-VS protocol N°ID RCB 2012-A00340-43). An experimental setup was designed allowing to load the sacrum with the linear US probe of 8 MHz central frequency using the industrial US device. Setup is charged with different weights (0-1200 g), without applying the shear (Figure 1). Contact area was marked with a pen. The same acquisitions were performed with a 3 Tesla MRI using a 3D-printed copy of the US probe. Images were post-processed and Green-Lagrange shear strains were estimated using 3D image registration (Elastix library) between the unloaded and loaded MRI configurations.

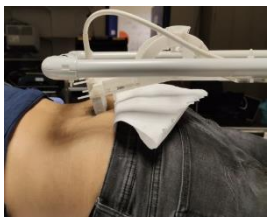

Figure1 Experimental setup at the contact area

Results: Preliminary evaluation of the Green-Lagrange shear strains from 3D image registration (Figure 2) showed the highest values in the skin and adipose tissues in the region of indentation above the sacral vertebra. Non-zero values at the bottom could be due to image border effects or body movement.

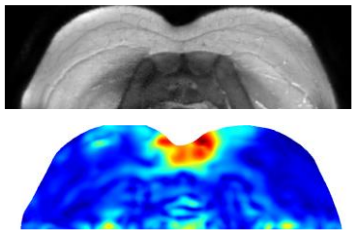

Figure2 a) Transverse plane MRI, undeformed configuration b) Green-Lagrange shear strain from image registration (on undeformed shape)

Conclusions: The experimental setup proposed in this contribution allowed the consecutive acquisition of the US and MRI data at the sacral region with pre-calibrated loads. 3D image registration performed on MRI data shows promising results for strains estimations. Future work will include 3D MRI-based FE modeling and validation of the simulation strain field against the field estimated with image registration. Results of the 3D simulation will be used for the evaluation of the results previously obtained with a 2D US-based FE model.

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References:

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2. Akins et al. Feasibility of freehand ultrasound to measure anatomical features associated with deep tissue injury risk. *Med Eng Phys*. 2016;38(9):839-844.