Project Summary for EPUAP website

Project Title:

Preliminary evaluation of the clinical relevance of a simplified framework for generating *in silico* models from freehand Ultrasound for monitoring internal tissue strains for the prevention of Pressure Ulcers

Project Team:

Applicants:

- Pierre-Yves ROHAN, Assistant Professor, Institut de Biomécanique Humaine Georges Charpak, Arts et Métiers
- Sam EVANS, Head of School of Engineering, Cardiff University
- Yohan PAYAN, Senior CNRS research director, head of the Computer Assisted Medical Intervention (CAMI) group and deputy director of TIMC-IMAG laboratory.

Other participants involved:

- Bethany KEENAN, Research Scientist at Cardiff University and MR Operator at the Cardiff University Brain Research Imaging Centre.
- Ekaterina MUKHINA, PhD student, European STINTS project (« Skin Tissue INTegrity under Shear ») entitled "Experimental and numerical approaches for biomechanical modeling of the gluteal soft tissue" (under the supervision of Yohan PAYAN, Nathanael CONESSON and Pierre-Yves ROHAN).
- Nathanael CONNESSON, Assistant Professor, TIMC-IMAG laboratory

Project Focus:

Build upon recent developments in Freehand Ultrasound to propose a simplified framework for generating clinically relevant *in silico* models (computer models based on continuum mechanics) from freehand Ultrasound, which will allow for monitoring internal tissue strains for the prevention of Pressure Ulcers in clinical settings.

Introduction:

Our skin continually bears mechanical loads as we interact with the environment around us. Excessive mechanical loads, such as, for example, when patients interact with medical devices and support surfaces, can lead to Pressure Ulcers (PU's). These are likely to deteriorate patient quality of life, especially those with poor mobility and skin sensitivity.

Aetiology studies have established the dependence of tissue viability on both interface loads and time. Using a multi-scale approach, ranging from cell models, *ex vivo* studies with tissues and animal models, it has been shown that there are at least two damage mechanisms responsible for the onset of Pressure Ulcers: ischaemia/reperfusion damage initiated by sustained moderate strains and cells damage initiated by direct (shear) deformation[1–5]. Although evidence for these damage mechanisms is mainly based on studies in murine skeletal muscle tissue, it is reasonable to think that such results can be transposed to humans, but with different strain thresholds. In that perspective, the use of computational simulations - based on nonlinear continuum mechanics - can provide important insights into the underlying mechanisms that go beyond the possibilities of traditional diagnostic tools. t is likely that similar mechanisms play a role in other soft tissues.

As a result, several Finite Element (FE) models of the buttock have been proposed in the literature [6–16] based on MRI or CT scan data. All these studies have consistently shown that local strains can differ considerably from external loads confirming the high impact of tissue geometry, tissue mechanical properties and local inhomogeneities on local strains.

Yet, several barriers exist to the clinical translation of these tools. These include but are not limited to: access and availability of an MRI/ CT scanner, time associated with obtaining ethical approval and recruiting suitable participants/patients, the time involved in image processing (segmentation and meshing) and validation of the FE model. For this reason, the literature to date, only includes the data from one individual [17–19]. Yet the inter-

patient variability cannot be overlooked when dealing with subject specific estimation of internal tissue loading which is obviously directly linked to the morphology of the bones.

Project Aim:

To perform a preliminary evaluation of the relevance of a simplified framework for generating *in silico* models from freehand Ultrasound for monitoring internal tissue strains by comparing US-based FE models versus MRI-based FE models based on the data already acquired and methodologies developed by each collaborator separately. The ambition is to propose a clinically relevant proof of concept for acquiring data in clinical setting.

Key Milestones:

1. Based on a previously acquired imaging dataset on healthy volunteers acquired at Arts et Métiers[20] in a non-weight-bearing sitting posture, propose a methodology for building local FE model of the region beneath the ischium from Ultrasound images only to capture the internal response of the gluteus region.
2. For one of the subjects (male, 27 years old), in addition to the ultrasound and low-dose biplanar X-ray images, MRI pelvic scan are also available in supine position. In line with the work proposed by Al Dirini et al.[17], develop a high anatomical fidelity FE model of the pelvic region.
3. Investigate various levels of simplified frameworks (US-based / MRI-based) and propose a protocol for a simplified framework for generating *in silico* models from freehand Ultrasound.

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