

## Variation of the skin elastic properties in the presence of pre-tensions: a preliminary study

Pilar Sango-Solanas<sup>1</sup>, Kevin Tse-Ve-Koon<sup>1</sup>, Karine Bruyere<sup>2</sup>, Mélanie Ottenio<sup>2</sup> and Olivier Beuf<sup>1</sup>

<sup>1</sup>Univ Lyon, INSA-Lyon, Inserm, UCBL1, CNRS, CREATIS, UMR 5220, U1294, F-69621 Villeurbanne, France

<sup>2</sup>Univ Lyon, Univ Gustave Eiffel, Univ Claude Bernard Lyon 1, LBMC UMR\_T 9406, F-69622 Lyon, France

Target audience: MR physicists, biomedical engineers, mechanical engineers and biologists.

Purpose: Numerical models of the human body offer great potential in the context of in silico medicine [1]. Many researches are on-going to develop patient specific models for disease prediction, surgery simulation or medical device's development. However, these models use biomechanical properties of tissues, derived from tests on isolated samples, for which the natural deformations and stresses existing in all types of biological tissues are not taken into account [2]. This pre-strain/pre-stress state of biological tissues can be relatively large and must be included in numerical models. A non-invasive experimental method allowing the quantification of the pre-strain or pre-stress state in biological tissues such as MRE [3] would therefore be of great interest to improve human numerical models. In this preliminary study, the elastic properties of the skin tissue were measured by MRE in the absence and presence of pre-tension.

Methods: MRE acquisitions were performed on a preclinical 11.7T MRI scanner (Bruker), with a quadrature 72mm inner diameter volume coil in transmit/receive mode. A piezoelectric actuator (CEDRAT) was used as mechanical transducer driver. A positioning bench allowing to apply a stretching of the studied sample was developed. *Ex vivo* experiments were carried out on a piece of pig skin with and without the application of stretching at a mechanical excitation of 900 Hz. Average relaxation times measured using a RARE sequence with different TEs and TRs were  $[T1, T2] = [1300, 7]$  ms. Mean and standard deviation of shear storage modulus  $G'$  were computed in the skin with a Helmholtz equation inversion algorithm and compared before and after the stress.

Results: Figure 1 shows magnitude and phase images as well as the elastograms  $G'$  of the skin sample at 900 Hz in normal and stretched state.

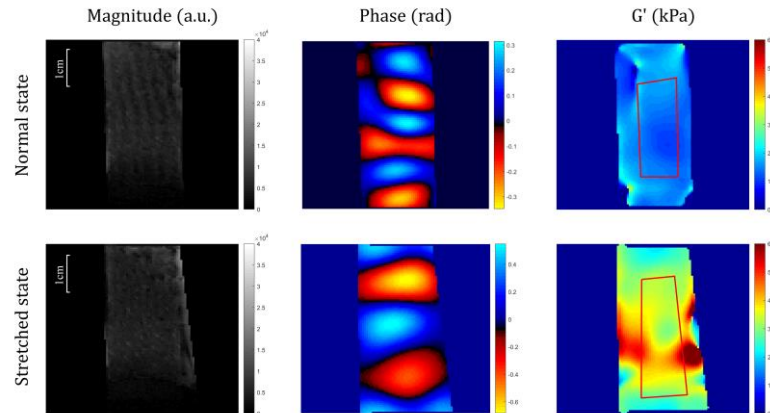


Figure 1. Magnitude, phase images and elastograms of pig skin without (first row) and with stress (second row)

Discussion: The wavelength of the shear wave increased on the stretched acquisition, leading to a greater shear storage modulus  $G'$  measured in the slice direction ( $139 \pm 21$  kPa at normal state vs.  $365 \pm 52$  kPa when stretched).

Conclusion: This preliminary study demonstrated that MRE allows the quantification of skin elastic properties. We were able to measure the variation of elasticity when pre-tensions are applied to the skin sample. An improvement of the positioning system is envisaged to allow the application of different levels of pre-stress/pre-deformation for a better characterization.

References: [1] Viceconti et al., International Journal of Clinical Trials 2016, [2] Ottenio et al., Journal of the Mechanical Behavior of Biomedical Materials 2015, [3] Muthupillai et al., Science 1995.

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