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Presentation Abstract

Session:	7-13-Imaging for Tissue Biomechanics III
Presentation:	Evaluating ultrasonic techniques for arterial tissue characterization using numerical simulations
Location:	311
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Author(s): **A. Swillens**[1], A. Caenen[1], L. Bostyn[1], D. Shcherbakova[1], C. Papadacci[2], M. Pernot[2], B. Verhegghe[1], P. Segers[1];
[1]Ghent University, Gent, BELGIUM, [2]Institut Langevin, Paris, FRANCE.

Abstract:

Intro

Although arterial stiffness has been shown an important prognostic marker of cardiovascular disease, its direct non-invasive assessment still hasn’t reached clinical practice. In this context, we aim at investigating the performance and robustness of a highly promising ultrasonic imaging technique, i.e. Supersonic Shear wave Imaging (SSI), using numerical simulations. SSI provides a direct way to measure tissue stiffness by creating a mechanical vibration source inside the tissue, radiating low-frequency shear waves (SW). The propagation speed of these SW’s is a measure of local stiffness and can be assessed by imaging the tissue at a high temporal resolution.

Methods

We developed a numerical framework to investigate the effect of the tissue’s geometrical configuration and material properties on SW-propagation, using a 2-step approach: (1) simulation of the mechanical vibration source inside the tissue generating the SW’s using the FOCUS software[1], (2) simulating the SW-propagation in the finite element software (FEM) Abaqus by imposing the acoustical radiation force from step 1 on the tissue. To allow validation of our approach, we performed FEM-simulations in a basic configuration, i.e. a homogeneous slab representative of a home-made gelatin-agar phantom with SiO_2 powder to enhance ultrasonic scattering. By mounting our phantom on a uni-axial mechanical test bench, the visco-elastic material behavior was determined from creep and relaxation tests, and was subsequently imposed in the FEM-model.

Results

The SW-propagation in this FEM-model was validated against experimentally obtained SSI-data and analytical formulations. The wavespeed was 4.72 m/s, the same value as experimentally obtained, and deviating less than 1% from the analytical result. When comparing the wave shape at several

locations along the wave propagation path, the wave shapes matched relatively well with the experimental data when introducing sufficient Rayleigh damping (20%) in the FEM model. Fig.1 shows the comparison of the measured and numerical SW-shapes at 1.86 mm from the center of the acoustic radiation force.

Discussion

Based on these initial but promising results, we are currently advancing our simulations towards the 3D arterial setting where the thin wall and anisotropic material properties induce much more complex wave phenomena (dispersive guided wave regime).