Transcranial ultrasound shear wave elastography for brain tissue viscoelastic mapping

Meng Han[1], Fan Wang[1], Ayache Bouakaz[2], Mingxi Wan[1]*, [1]Department of Biomedical Engineering, School of Life Science and Technology, Xi'an Jiaotong University, Xi'an 710049, People's Republic of China, [2]*UMR 1253, iBrain, Université de Tours, Inserm, Tours, France*

Background, Motivation and Objective

The material properties and in particular mechanical properties of brain tissue are prone to change due to external loads or diseases and can be measured with MR elastography (MRE). However, the use of MR systems is limited and restricted to only dedicated clinical centers. In this study, we explore the potential of ultrasound and ultrafast shear wave elastography to measure viscoelastic properties of brain tissue.

Statement of Contribution/Methods

Shear waves were generated using a low frequency loudspeaker with a bandwidth from 60 to 4000 Hz and a function generator triggered by the US imaging system. The loudspeaker is affixed with a tuned flexible hose, connected by a Plexiglas dome. The imaging system was a Verasonics platform with a 3-MHz array probe. Validation was carried out using a 3D printed skull mimicking the human skull properties (density, attenuation) and a tissue mimicking phantom made of gelatin and agar (5%, 1%). Ultrafast US sequences were acquired at 2000Hz while imaging through the temporal window and RF data were stored. Displacements were assessed based on a correlation between successive echo images using a 1D correlation algorithm.

Results/Discussion

100 frames RF data were acquired using a 100 Hz shear wave propagating through the phantom without and with skull model, respectively. The images show that the axial displacement of the shear wave propagated from the bottom to the top of the phantom. Compared with the displacement measured in the phantom without skull, the displacement for the phantom with skull is relatively small, but still can be quantified. The estimated shear wave velocity in the phantom without and with skull model was is 2.4m/s and 2.2m/s respectively and the shear modulus of the phantom was 5.53kPa or 4.65kPa respectively. The preliminary results indicate that the shear wave generated by the device can be detected even while imaging through the skull and its propagation velocity is directly related to viscoelasticity. The method has the potential for brain tissue viscoelastic mapping.

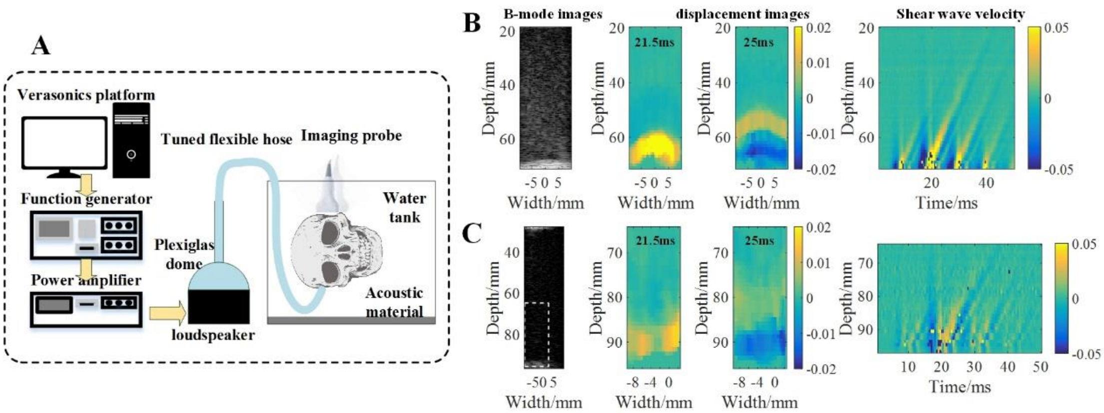

Fig. 1. A. Schematic illustration of the experimental setup, B. B-mode image, displacement and shear wave velocity in the brain phantom without skull, C. B-mode image, displacement and shear wave velocity in the brain phantom with skull present; the displacement images corresponding to the region marked by white lines in the B-mode images