Shear Wave Dispersion Magneto Motive Ultrasound Evaluation through Soft Tissue Mimicking Phantom.

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Introduction: There are several methods in order to analyze the mechanical properties of soft tissue. Elastography is a noninvasive method but it is an operator-dependent method and also is only able to estimate the relative stiffness of adjacent tissues. To overcome this issue, transient elastography (TE) has provided to more information about tissues. Shear wave dispersion magneto motive ultrasound (SDMMUS) is a recent modality which is independent of operator and is able to evaluate the viscoelasticity of tissue labeled with magnetic nanoparticles, changing the frequency applied with an external sinusoidal magnetic field. In this work I use shear wave dispersion magnetomotive ultrasound (SDMMUS) to evaluate the viscoelasticity of tissue labeled with magnetic nanoparticles in gelatin phantoms.

Methods and materials: In this study, we are using an oscillating remote magnetic force to induce a deformation into the structure of the sample labeling with superparamegnetic particles. A linear ultrasound transducer connect to a diagnostics ultrasound system (SONIX RP) to detect the microdisplacement induced into the sample.

2. Experimental setup: The SDMMUS setup that we used, consisted of an excitation coil, function generator and a power amplifier. Tone bursts of 10 cycles of sinusoidal voltage with frequencies from 50 to 250 Hz created the excitation magnetic field. For consistency, the magnetic field amplitude for different frequencies was calibrated to apply 300 mT. This particular magnetic field amplitude provided detectable displacements for the SW evaluation.

3. Soft tissue-mimicking phantom: The phantom was constructed using gelatin powder hydrated with a solution of deionized water and heated to 70º C to disperse the colloid, clarify the solution and release trapped gases. Superparamagnetic particles (Fe_3O_4**)** were added at 45 °C (Superparamagnetic were used commercial magnetic nanoparticles with the size of 20 nm which has bought). The formaldehyde was added when the solution was further cooled to 40ºC. Then, this mixture was placed in a container with dimensions of 75 × 75 × 75 mm, which was fixed to a motor to rotate at 1.2 rpm to prevent deposition of the nanoparticles. The phantom will be homogenously labeled with magnetic nanoparticles in order to evaluate the map of displacement of the internal structure and viscoelasticity properties. The mass concentrations of 4% of nanoparticles and 4% of gelatin were used to phantom.

Results: Shear Wave propagation was observed through the soft-tissue-mimicking phantom for SDMMUS after magnetic excitation of 50 Hz. The figure 1 below, shows images of induced motion in the phantom at two different times after magnetic excitation for SDMMUS.

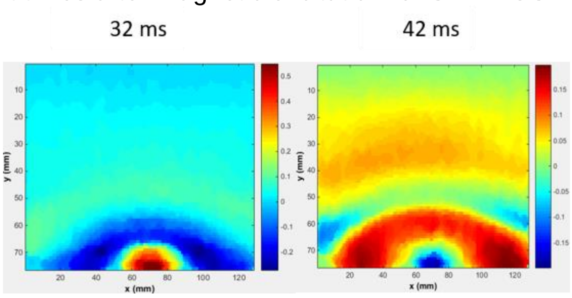

Figure 1: The shear wave propagation through the phantom at 50 Hz in 2 after 32ms and 42ms respectively

Conclusion: This method SDMMUS, was used to estimate the mechanical properties of tissue-mimicking phantoms with different concentrations of gelatin by analyzing the induced SW. I am going to consider different concentration of gelatin to compare SW velocity. Generally, increasing the gelatin concentration leads to phantoms with higher elastic moduli. SDMMUS is a complementary technique that can help to characterize tissues as well as to detect pathologies in early stages because it can achieve molecular imaging level by using appropriate magnetic nanoparticles.

The MMUS imaging system consisted of a magnetic field generator interfaced with ultrasound imaging system the magnetic field was generated by a solenoid with an iron core to focus the field. To control the strength and frequency of the applied magnetic field, the electric current in the solenoid was adjusted using a function generator connected to a current amplifier.>?

Abstract: A magneto-motive technique using mechanically- applied time-varying or pulsed magnetic forces to a specific tissue, induces a small displacement of particles in the surrounding tissue, which can be detected or imaged using traditional imaging modalities, such as optical coherence tomography (OCT) ,ultrasound (US), laser speckle imaging (LSI), and photoacoustic tomography (PAT). Quantification of mechanical properties of soft tissue can be achieved by generating and tracking shear wave (SW) propagation. This shear wave can be generated using a magnetic field pulse over soft tissue labeled with ferromagnetic nanoparticles. The shear wave velocity map will be detected using a pulse receiver ultrasound system. The purpose of this study is using shear wave dispersion magneto motive ultrasound (SDMMUS) as a method to evaluate the viscoelasticity of tissue labeled with magnetic nanoparticles, this will be achieved by changing the frequency applied external sinusoidal magnetic field.