
058 **PULSED MAGNETO-MOTIVE ULTRASOUND TO ASSESS VISCOELASTIC PROPERTIES OF SOFT TISSUES.**

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Background: Pulsed magneto-motive ultrasound (PMMUS) is an ultrasound imaging technique capable of detecting magnetic nanoparticles in tissues. Once the nanoparticles are delivered to tissue, an externally applied pulsed magnetic field is used to induce tissue motion detected by an ultrasound imaging system. However, the induced motion will depend on the viscoelastic properties of tissue. Therefore, the PMMUS system can be used to acquire the mechanical properties of tissue.

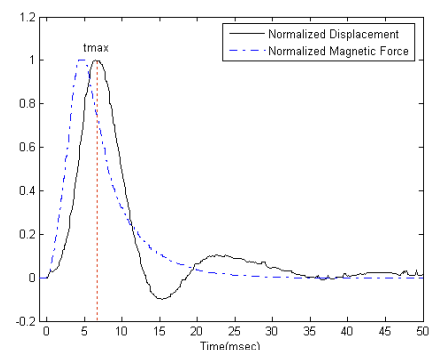
Aims: The goal of this study was to investigate the applicability of pulsed magneto-motive ultrasound to assess the viscoelastic properties of tissues labeled with magnetic nanoparticles.

Methods: The experiments were first performed using rigid metal spheres of various diameters and densities. The spheres were embedded into phantoms made out of gelatin (Type A, Sigma-Aldrich, Inc., St. Louis, MO, USA). Several concentrations of gelatin ranging from 3–6% (by weight) were used. The magnetic field was generated using a pulsed magnetic source (MPG5, SOTA, Inc., Penticton, BC, Canada) that supplied the current to a solenoid (Ledex 6EC, Saia-Burgess, Inc., Fort Worth, TX, USA). The solenoid consisted of an iron core to focus the magnetic field within the region of interest. Magnetic flux density measurements were performed using a Gaussmeter (DSP 475, Lakeshore, Inc., Westerville, OH, USA). The magnetic force was assumed to have the same temporal profile as the magnetic flux density squared. To measure the internal tissue motion, an ultrasound imaging system was constructed based on 25 MHz mechanically scanned single element focused ultrasound transducer (F#=2) interfaced with an ultrasound pulser/receiver (5073PR, Panametrics, Inc., Waltham, MA, USA) operating at 5–10 kHz pulse repetition frequency. The ultrasound signals were acquired using a 12 bit, 100 MS/s data acquisition card (Gage Applied, Inc., Lockport, IL, USA). The displacements were computed using cross-correlation approach. To further demonstrate the capability of PMMUS system to assess the viscoelastic properties of tissue, experiments were performed using tissue-mimicking phantoms with iron-laden inclusions. Specifically, the 5% polyvinyl alcohol (PVA) inclusions contained different concentrations of various magnetic nanoparticles, including carbon coated 20 nm diameter cobalt and nickel nanoparticles.

Results: Our studies clearly demonstrate that the displacements of the spheres/magnetic inclusions are inversely-proportional to the elasticity of the surrounding medium. Under short pulse excitation, the displacement amplitude and the time needed for the displacement to reach its peak can describe the mechanical properties of medium. Generally, the time characteristics of the induced motion depend on the time profile of the magnetic excitation force but are independent of the force amplitude.

Conclusions: The characteristics of the magnetically induced motion in iron-laden tissues are related to the elastic properties of the surrounding medium. Our studies suggest that the PMMUS system, capable of detecting the magnetically induced motion, can be used to assess the viscoelastic properties of the soft tissue.

Figure 1: Temporal behavior of the displacement of a metal sphere in response to pulsed magnetic force. The 3.175 mm diameter sphere was embedded into 3% gelatin medium.



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References:

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