POWER-LAW MULTI-FREQUENCY MRE RECONSTRUCTION

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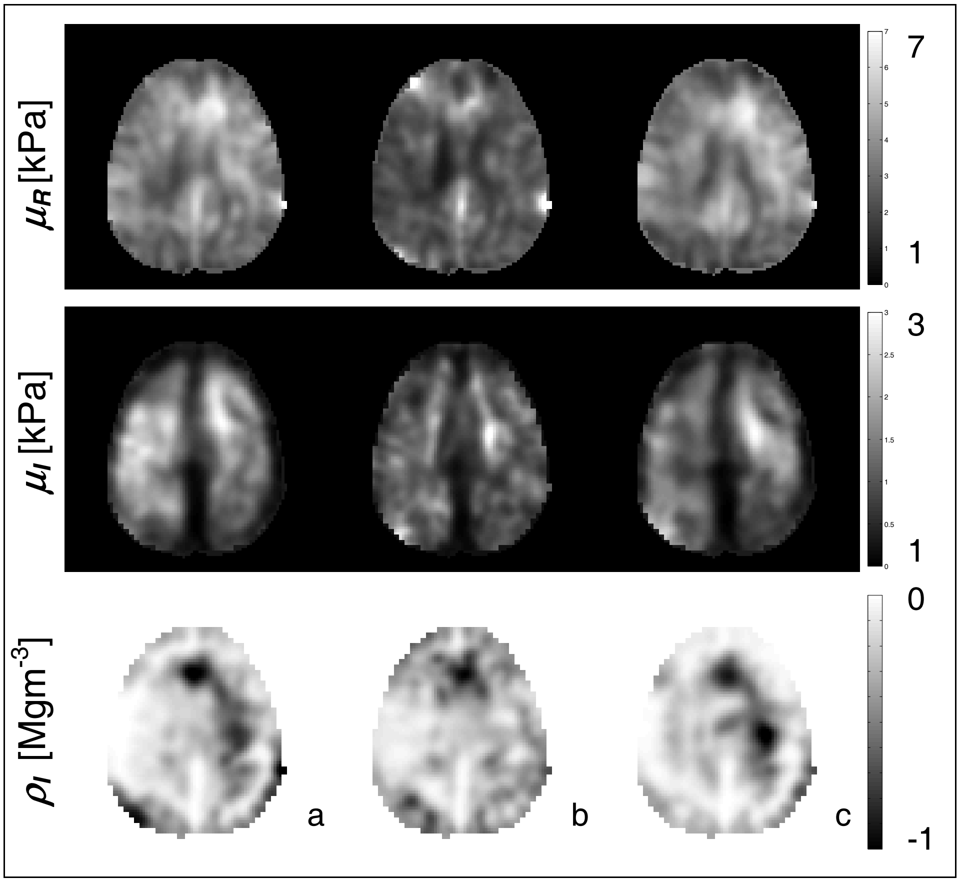
INTRODUCTION: Consideration of the frequency dependent elastic response of biological tissue in magnetic resonance elastography (MRE) has grown in recent years, with multiple studies examining the suitability of power-law models to MRE results [1,2]. The characterization of the dispersion characteristics of the tissue elastic properties supports development of more accurate soft-tissue mechanical models as well as providing additional diagnostic information for clinical applications of MRE. Recently, multi-frequency MRE reconstruction has been proposed, based on simultaneous treatment of multiple displacement sets [3]. While the method presented in [3] does not consider power-law dispersion effects, the use of multiple frequency information is suggested as a way of reducing regions of low-strain signal within MRE images. In addition, a generalized Rayleigh Damping (RD) model has been developed for MRE, allowing a two-parameter model for soft-tissue attenuation [4]. The work presented here demonstrates a combination of these various concepts for treating the energy absorption effects noted in all soft tissue. A multi-frequency, power-law based, RD-MRE reconstruction method has been developed in within a Non-Linear Inversion (NLI) framework.

METHODS: Based on the subzone formulated NLI inversion method [5], the method reconstructs an optimal material property estimate, *θ*, from simultaneous consideration of multiple displacement fields through the objective function shown in Eq. 1. A total of three parameters can be estimated by the technique: μ_R (or G'), μ_I (or G") & ρ_I. Each parameter can be optionally treated by a power law relationship, as shown in Eq. 2. The imaginary density component is treated with an *inverse power-law* relation given the importance this parameter holds at lower frequencies. The results presented here were generated from steady state displacement data sets obtained at 37.5 Hz, 50 Hz and 62.5 Hz, using a *Siemens Resoundant* pneumatic forcing system and a spiral multi-shot readout sequence [6]. Three separate reconstructions were performed: (a) a multi-frequency RD reconstruction without power-law relationships; (b) a multi-frequency RD reconstruction making use of the power-law relations shown in Eq. 2, and (c) a single-frequency RD reconstruction from the 50 Hz data set.

$$\Phi = \sum_f \left\| \mathbf{u^m} - \mathbf{u^c}(\theta) \right\|^2 \quad (1)$$

$$\begin{aligned} \mu_R &= \mu_{R_0} \omega^{\alpha_{\mu_R}} \\ \mu_I &= \mu_{I_0} \omega^{\alpha_{\mu_I}} \\ \rho_I &= \rho_{I_0} \left(\omega^{-1}\right)^{\alpha_{\rho_I}} \end{aligned} \quad (2)$$



RESULTS: Image results from the middle slice of the image volume are shown in the accompanying figure. Results from the different reconstructions are arranged by column, with the power law reconstruction in the middle. The ventricular structure is visible as low shear modulus regions near the center of the brain, while the high rigidity and reduced damping of the falx cerebri are also evident.

DISCUSSION: In general, the two multi-frequency reconstructions (cols a&b) show more well defined features, although the shear modulus values in the non-power-law recon (a) are high. Features in the power-law recon (b) are the best defined of the three images, and show reasonable values for all properties. There is some evidence of low strain-signal regions within the single-frequency recon (c).

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