Comparison of Inversion Algorithms in MR Elastography of the Brain

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Introduction

Magnetic resonance elastography (MRE) is a phase contrast MRI technique capable of quantitatively measuring the shear stiffness of tissues [1]. Various neurological disorders may cause focal or diffuse changes in the shear stiffness of brain tissue, which may be detectable by MRE. Several groups are thus pursuing MRE as a tool to eventually detect these mechanical changes [2-4]. Some preliminary data have been published attempting to find differences between healthy volunteers, multiple sclerosis patients, and an Alzheimer's disease patient [5]. To make MRE a useful diagnostic tool in the brain however, several aspects of the technique must be optimized including the inversion algorithm used and the volume of data acquired. The purpose of this work is to compare 3D local frequency estimation (LFE) and direct inversion (DI) algorithms, and to determine the number of slices necessary to obtain stable stiffness results for *in vivo* brain MRE.

Methods

MRE phase difference images were collected in a healthy volunteer at 3 Tesla on a GE EXCITE scanner after obtaining informed consent. Shear waves of 60 Hz were introduced via a pneumatic driving system with the volunteer supine in a single-channel quadrature birdcage coil. The driving system consists of two passive drums placed posterior to the head, each connected by a 25 foot plastic wave guide to active voice coil drivers operating 180° out of phase, rocking the head in a 'no' motion. Four phase offsets were collected using a multislice gradient echo pulse sequence. Imaging parameters included: TR/TE = 1065/25.9 ms, FOV = 24 cm, 32 slices in 1 pass, slice thickness = 2 mm with 1-mm interslice spacing, 80x80 acquisition matrix, 16 kHz bandwidth, 45° flip angle, and 1 60-Hz 1.6 G/cm motion-encoding gradient cycled in a tetrahedral acquisition to fully sample the vector wave field. The wave data were phase unwrapped, decimated, curl filtered to remove longitudinal wave effects [6], and finally 3D directionally filtered in 20 directions [7]. The filtered wave data were then processed using a 3D LFE algorithm and a DI algorithm operating in a 5x5x3 window [8].

Results

Inversions from the decimated and filtered data are shown in Figure 1. The LFE algorithm requires 28 slices to converge to a stable solution for the central slice of the data volume while the DI algorithm is stable with only 16 slices. The final solutions from the two algorithms demonstrate high correlation. The 2D correlation coefficient between the algorithms with 8 slices is 0.25, while the correlation coefficient with 32 slices is 0.90. Figure 2 is a fast spin echo magnitude image of the processed slice to allow for anatomical comparison.

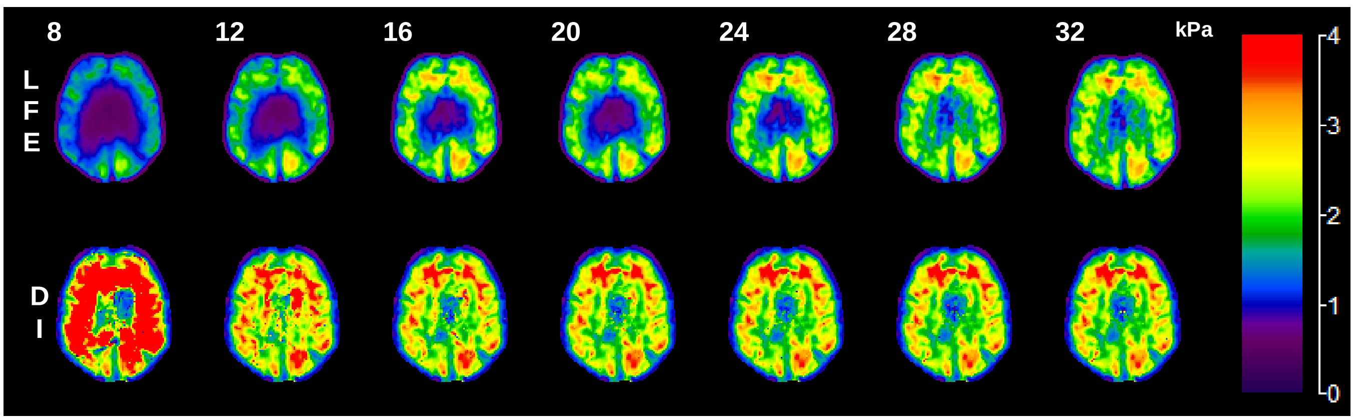

Figure 1. Inversions of filtered and decimated data by the LFE and DI algorithms.

Discussion

The final elastorams show observable correlation with the anatomical image; regions of relatively low stiffness at the edge and center of the slice correspond to gray matter. The 3D DI algorithm required only 16 slices for a stable estimate of the stiffness in the center slice, indicating that fewer slices will need to be acquired if this algorithm is implemented. In turn the acquisition time is reduced, improving patient comfort during the exam.

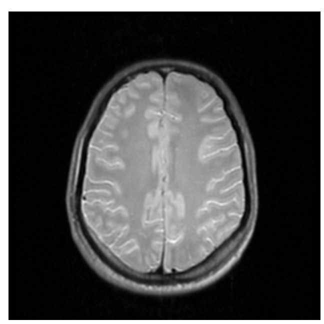

Figure 2. Fast spin echo magnitude image of the processed slice for anatomical comparison.

References

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