Acceleration of MR Elastography with Parallel MR Imaging

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Purpose: MR Elastography (MRE) [1] is increasingly being used to measure tissue stiffness in different areas of the body, especially in the liver, for the evaluation of fibrosis and end-stage cirrhosis [2]. Our current MRE technique for liver imaging acquires wave data over multiple breath holds acquired during end expiration. This is necessary because all the required wave phases for a single section cannot be acquired within a single breath hold and the position of the breath hold is more consistent during end expiration. The quality of the elastogram is to some extent dependent on the ability of the subject to suspend respiration in a consistent position. Parallel imaging techniques are widely used to reduce scan time and we sought to apply them to allow an entire data set for MRE to be acquired in a single breath-hold. This would enable the use of breath-holding during **end-inspiration**, which is typically easier for the patient than end-expiration. It has been shown that image phase properties are unaffected by parallel imaging techniques [3], making them compatible with phase contrast applications such as MRE. The purpose of this study was to evaluate the performance of a parallel MRE acquisition technique and compare it to our optimized conventional non-accelerated MRE technique.

Methods: A 2D gradient echo based MRE sequence was modified to enable ASSET (Array Spatial Sensitivity Encoding Technique), a SENSE based parallel imaging technique. Ten normal healthy volunteers were scanned on a 1.5T or 3T Signa HDx MR scanner (GE Healthcare, Milwaukee WI) using the following parameters: TR 50 ms, TE 22 ms, 30^0 flip angle, $\pm$32 kHz receiver bandwidth, 10 mm section thickness, 5 mm section gap, 256x96 imaging matrix, 2X acceleration, 42x32 cm FOV, 17 second scan time for 4 phases per location. The parallel MRE acquisition scan was usually performed during end-expiration whenever possible and during end-inspiration in subjects who had difficulty suspending their respiration. The same protocol was used for the non-accelerated acquisition, with a scan time of 34 seconds acquired in two 17s breath-holds during end expiration for consistency across phases. Image reconstruction and phase difference calculation were performed online, and elastograms were produced using the multi-scale direct inversion (MSDI) algorithm [4]. Images acquired at the same section location for each subject using both methods were compared.

Results: The mean shear stiffness values with and without parallel imaging were 2.5 ± 0.3 kPa and 2.4 ± 0.3 kPa, respectively (mean ± SD). There was no statistically significant difference (p = 0.47) between the stiffness values [Fig.1]. Breath hold artifacts were minimal with the parallel MRE acquisition. Good quality elastograms were obtained with breath holds in both inspiration and expiration for the parallel MRE acquisition. Figure 2 shows the clinical utility of parallel MRE acquisition in a subject who could not hold their breath consistently at the same position. Note the improved image quality of the raw images due to the easier end-inspiratory breath-hold for the parallel MRE acquisition case as well as the quality of the elastogram due to the consistency across phases.

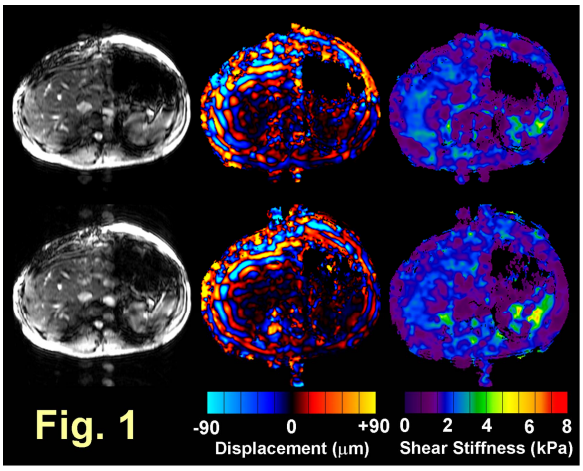

Fig.1. MRE with parallel imaging (top row) and without parallel imaging (bottom row) in a normal volunteer. The top row shows the magnitude images and bottom row the elastograms.

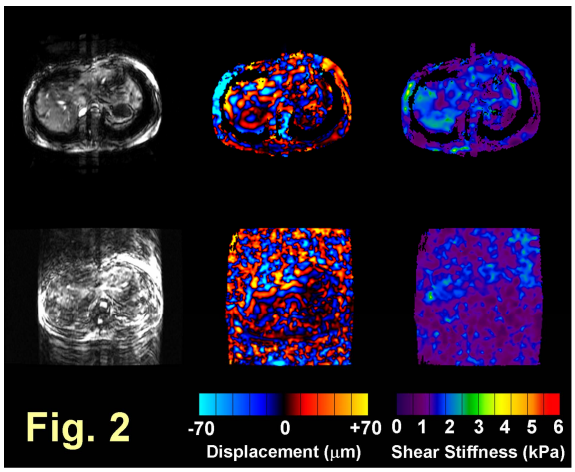

Fig.2. Clinical utility of parallel MRE acquisition (top row) compared to conventional MRE without parallel imaging (bottom row) in a patient who had difficulty in performing breath-hold during end expiration. Note the absence of motion artifacts in the parallel MRE acquisition case and the high quality elastogram.

Conclusion

The results indicate that diagnostic-quality MRE studies of the liver can be readily performed in total acquisition times of 17 seconds or less, using parallel acquisition techniques. The ASSET MRE sequence has enabled the following improvements: 1) an MRE acquisition with four wave phases can be acquired during one breath-hold, 2) MRE can be easily performed during end-inspiration or end-expiration, and 3) multiple MRE sections can be acquired in a single breath-hold acquisition. The results in ten volunteer studies also show that the use of parallel imaging has no systematic effect on measured tissue stiffness values in MRE.

Reference:

1. Muthupillai R. Science 1995.
2. Meng Y, Talwalker JA, Glaser KJ, Clincal Gastroenterology and Hepat 2007;5:1207-1213.
3. Bankson JA, Stafford RJ, Hazle JD., Magn Reson Med. 2005 Mar;53(3):658-65.
4. Oliphant TE, et. Al MRM 2001 45:299-310