MR Elastography of the liver: qualitative and quantitative comparison of GRE and EPI sequences.

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Target audience: Clinical scientists and physicists interested in MRE.

Introduction: Magnetic Resonance Elastography (MRE) is a non-invasive imaging method that estimates mechanical properties of tissues. MRE has been recently shown to correlate with the degree of liver fibrosis. The most common pulse sequence used for liver MRE is based on GRE, however, the TE of GRE pulse sequence is prolonged due to the added motion encoding gradients (MEGs), thus GRE-MRE may fail in patients with iron overload. New SE based EPI MRE pulse sequences are affected by T2 but not by T2*. Due to the increased effective TE, fractional encoding concept is applied in EPI pulse sequences in order to achieve short enough TEs. In the fractional encoding method, the period of MEG is chosen to be shorter than period of mechanical motion. Expected tradeoff would be less efficient motion encoding due to mismatched frequencies of MEG and mechanical motion, leading to lower SNR on wave images[1]. The objective of our study is to assess the performances and variability in liver stiffness (LS) measurement using 2D-GRE and 2D-SE-EPI MRE.

Methods: 9 initial patients (M/F 5/4, mean age 56.6 y) were selected out of 77 patients enrolled in this IRB approved study. Etiology of liver disease included HCV (n=5), HBV (n=2), primary sclerosing cholangitis (n=1) and NASH (n=1). Patients were scanned using a 3T MRI system (MR750, GE). Both sequences were acquired in the axial plane, using for 2D-GRE: TR/TE 50/20, 256x80, 4 slices, 10 mm thickness, 60Hz mechanical motion, 60 MEG frequency, ASSET 2; and for SE EPI: TR/TE 1000/55.4, 80x80, 4 slices, 10 mm thickness, 60Hz mechanical motion, 155Hz MEG frequency, ASSET 2. Scan time of EPI MRE was 4 s compared to 14 s for GRE (for each slice). Sequences were acquired during the same MRI exam, with similar FOV and slice location as similar as possible. Liver stiffness values were measured by a single observer and compared between GRE and EPI MRE using Wilcoxon test, Pearson correlation and coefficient of variability. In addition, two radiologists assessed an image quality score on wave propagation images and confidence maps on a scale of 0 to 3 (0: no observable wave propagation/no confidence map; 3: excellent wave propagation in liver/confidence map covering more than 50% of liver slice).

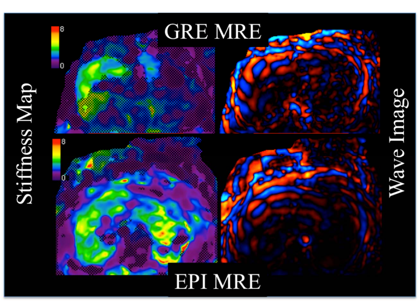
	GRE	EPI	p*
Obs. 1	8.2 ± 1.9	13.6 ± 1.6	0.0023
Obs. 2	7.3 ± 3.5	13.1 ± 2.0	0.0028

Table 1: Image quality scores for liver GRE and EPI MRE (max 15). *Wilcoxon test.

Results: In the 9 initial patients, the subjective image quality was significantly better using EPI for both observers **(Table 1)**, while there were no significant differences in LS values between sequences **(Table 2)**. We observed a significant strong correlation between LS values (r=0.899, p<0.001) obtained with GRE and EPI, with excellent reproducibility between sequences (mean CV 6.10%; range, 0.2%-11.6%).

	EPI	GRE	p
LS (kPa)	3.51 ± 1.03	3.70 ± 1.24	0.16

Table 2: LS obtained using GRE and EPI MRE.



Stiffness maps (left column) and wave images (right column) of a 70 year old patient with cirrhosis. GRE-MRE (top row) and EPI-MRE (bottom row) measured LS were 4.1 kPa and 3.6 kPa. In EPI-MRE, there is a larger coverage of the liver compared to GRE-MRE.

Discussion: Liver shear stiffness measurements were analyzed in 9 patients by using GRE and EPI MRE methods. Although motion encoding efficiency of EPI MRE is lower than GRE MRE, image quality scores of EPI MRE were significantly higher than GRE MRE, with faster acquisition and equivalent measurements in our preliminary population.

Conclusion: In our initial data, EPI-MRE provided faster acquisition and better image quality with equivalent LS values compared to GRE sequence. It remains to be seen whether the failure rate is improved with EPI MRE in a large number of cases.

References:

1 Rump, J., et al., Fractional encoding of harmonic motions in MR elastography. Magn Reson Med, 2007. 57(2): p. 388-95
2 Sudhakar V and Richard E. Magnetic resonance elastography of liver. Magnetic resonance imaging clinics of North America. 2014 22.3: 433-446.
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