Non-invasive diagnosis of liver fibrosis - comparison between MR elastography and Supersonic Imaging in an animal study

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Introduction

All chronic liver diseases may lead to liver fibrosis. Liver biopsy is the current gold standard for determining the stage of fibrosis. One-dimensional (1D) ultrasound elastography and 3D MR elastography (MRE) have emerged as new methods to diagnose and quantify liver fibrosis [1, 2]. One-dimensional elastography (Fibroscan) is limited by poor depth penetration, incomplete assessment of the wave field and lack of real-time ultrasonography. Supersonic Shear imaging (SSI) is a new 2D ultrasound elastography method with real-time ultrasound capability, and which overcomes some of the limitations of 1D elastography [3]. In this study, we validate the SSI method, by comparing the elasticity measurements obtained with SSI to those obtained with MRE in a model of dietary steatohepatitis in the rat. The elastography measurements were correlated to the percentage of fibrosis obtained at morphometry.

Material and methods

Animals: Twenty-three Sprague-Dawley rats were fed a choline-deficient diet during two weeks (N=7), five weeks (N=8) and eight weeks (N=8) to induce steatohepatitis [4]. A group of five healthy rats was used as controls. After imaging, the rats were killed and the liver extracted and fixed in paraffin for morphometric analysis.

MRE [5]: The rats were placed under anesthesia in prone position on a piezoelectric based driver which generated mechanical waves at 300 Hz. The full 3D displacement field was imaged inside the liver in the stationary wave regime and used to calculate the shear modulus (Fig. 1a-c) through a full inversion of the wave propagation problem.

SSI [3]: Transient shear waves (with bandwidth frequency of 50 – 300 Hz) were generated inside the liver along a line using the SSI approach with the rats under anesthesia in supine position. Using the same ultrasound transducer array the shear wave propagation was imaged in real time (Fig. 1d-e).

Statistical analysis: The comparison between groups was performed with the non-parametric Kruskall Wallis test, followed by two by two comparisons with the Wilcoxon rank-sum test. The Spearman method was used for the correlations and the Bland-Altman analysis was used for assessing the agreement between MRE and SSI.

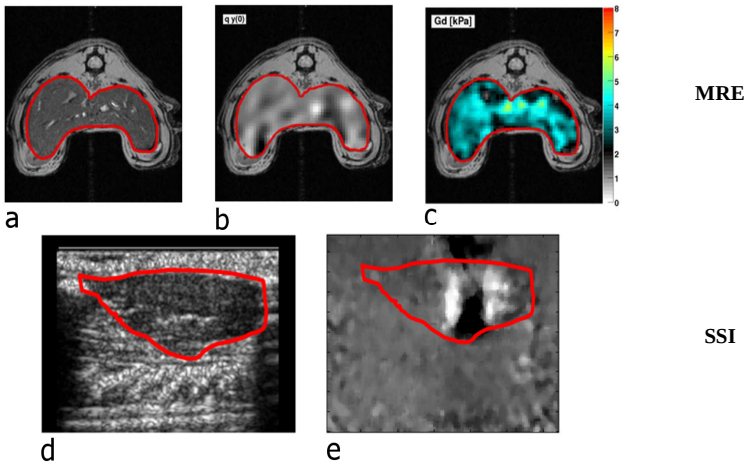

Figure 1: MRE (a – c) and SSI images (d – e) of rat with hepatic steatohepatitis. (a), (b), and (c) respectively show anatomical image, wave image and elasticity map at MRE. (d) and (e) show anatomical and wave image at SSI.

Material and methods

Severe hepatic steatosis appeared at two weeks (P = 0.004) and decreased at eight weeks (P = 0.015). Fibrosis appeared at five weeks (P < 0.001) and remained stable. The elasticity with both MRE and SSI increased significantly at two and five weeks (P < 0.05). Significant correlations were observed between the elasticity measurements and the degree of fibrosis (P < 0.001, r = 0.72 for MRE and P < 0.001, r = 0.77 for SSI). In addition, a significant correlation was observed between the elasticity measurements obtained with MRE and SSI (P < 0.01, r = 0.72). A Bland-Altman analysis revealed that only 7% of the values were outside the 95% limits of agreement (Fig. 2).

It is concluded that both techniques are capable of staging liver fibrosis. Considering MRE as the gold standard, due to its full 3D approach, this study shows the validity of the SSI method to assess the percentage of liver fibrosis in a much shorter time.

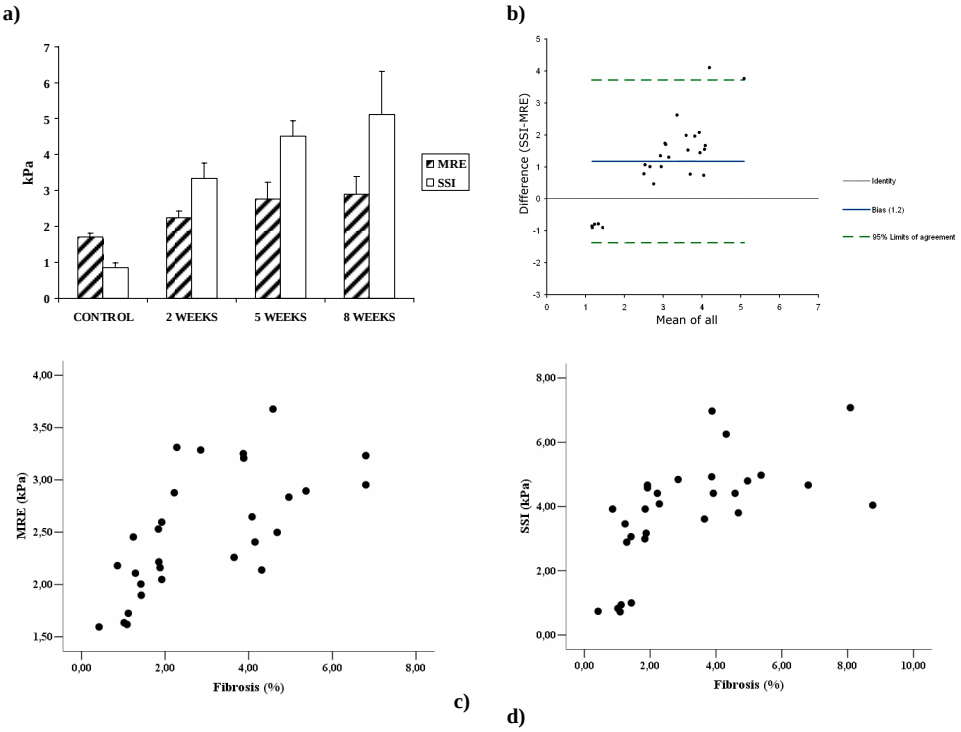

Figure 2: The elasticity increases with the number of weeks (a). Both MRE and SSI give similar results as shown with the bars graph (a) as well as with the Bland-Altman test (b). The elasticity is correlated with the stage of fibrosis (c, d).

References

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