Cross-Validation of the Magnetic Resonance Elastography Technique to measure the Liver Stiffness

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Introduction

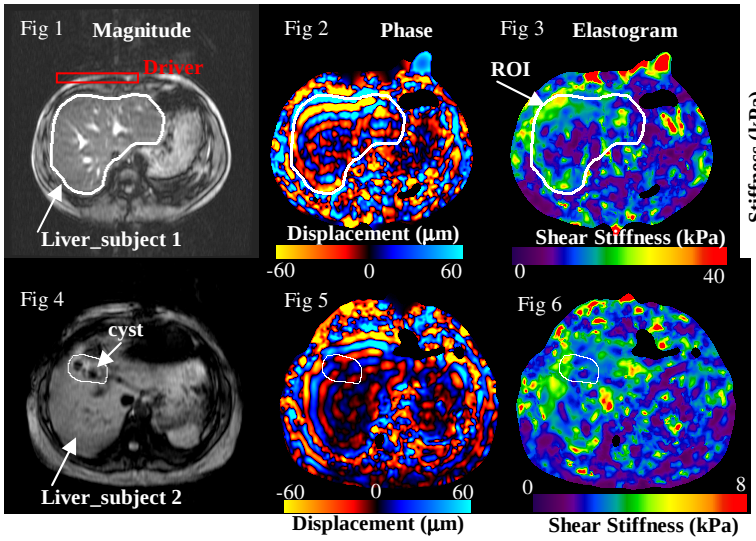
Liver fibrosis is a consequence of most the liver diseases. Histological analysis of liver tissue, obtained by a tissue biopsy, is the current gold standard used to diagnose fibrosis. This technique is invasive and may yield to several complications for the patients. In order to non-invasively depict liver fibrosis, imaging techniques were developed. Recently, ultrasound material called Fibroscan® , was clinically used to measure the liver stiffness by transient elastography [1]. Another imaging technique called magnetic resonance elastography (MRE), still at the clinical research, is able to characterize the stiffness of different soft tissue [2]. Moreover, a recent study showed the assessment of hepatic fibrosis with MRE technique [3]. The purpose of this study is to cross-validate the MRE technique with a routinely used clinical device.

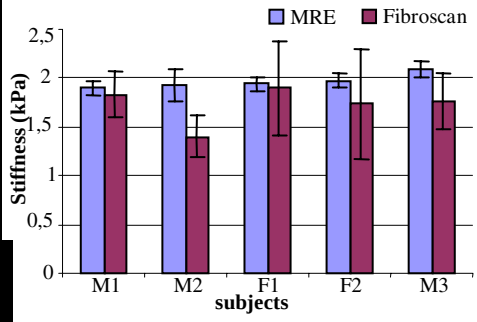
Methods

Five healthy volunteers (3 females (F) and 2 males (M)) underwent firstly a MRE scan and secondly a Fibroscan exam. According to the Ethical rules written informed consent was obtained from the volunteers. During the MRE scan, the volunteers lay supine in a 1.5T General Electric Signa MRI and a cylindrical acoustic driver (diameter: 8cm) was positioned in contact with the abdomen. The acoustic driver had a long hose connected to a large active loudspeaker. This system created a time varying pressure waves propagating shear waves within the hepatic tissue at 60Hz (*f*). The body coil was used and MRE images were collected with a gradient echo technique, TR/TE 100 ms/minimum full, a 256x64 acquisition matrix and a 34 cm field of view. Each scan took 16 s to acquire and four offsets were used. Fig 1 and 2 showed the liver tissue and the shape of the wave propagated inside the hepatic tissue, respectively. The entire shear stiffness (μ) of the liver was measured inside the ROI (Fig.3) of the elastogram, which was generated with an inversion algorithm [4]. During the Fibroscan, the volunteers lay supine in a table with the right arm flexed under the head. A probe (3.5 MHz) was placed against the liver at the same level of the previous liver magnitude acquisition. Then, a pressure was activated on the right lobe, with a button located on the probe, between the intercostals spaces. The total time of acquisitions took 5 minutes and the operator repeats the measurement at least 10 times to get an average of Young modulus (E). The waves are propagated in a depth of 60mm and the Young modulus was calculated with the following equation: $E=3\mu$.

Results

The result obtained with the MRE technique showed that the entire shear stiffness (μ) of the liver (measured inside the ROI of the elastogram) was 1.98 ± 0.07 kPa. The Young's modulus measured with the Fibroscan technique was 5.18 ± 0.58 kPa. Considering that the hepatic tissue was homogeneous and had an isotropic behavior, the shear stiffness (μ) obtained with the Fibroscan should be ($\mu = E / 3$) 1.90 ± 0.47 kPa. The shear modulus obtained with the MRE and Fibroscan techniques are in the same range. For another subject (Fig 4), the liver showed some cysts inside the bladder with the wave circle this obstacle (Fig 5, Fig 6), demonstrating the sensitivity of the wave to the intrinsic structure of the hepatic tissue.





Reference

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Discussion

This study is the first one to compare the MRE and Fibroscan techniques on the same subjects. The originality of this study was firstly to attest the feasibility of the MRE to measure liver stiffness and secondly to show why MRE should be investigated beyond the Fibroscan. The feasibility was proven with similar liver stiffnesses measured between both methods which demonstrate the capability of the MRE technique to measure liver stiffness. Additionally, the MRE liver stiffnesses were in the same range as the study by Yin et al.

However, a greater variation of stiffness was found with the Fibroscan compared to the MRE technique. This variation may be related to the thickness of subcutaneous fat above the ribs, the presence of ascite and the blood flow circulation. In addition, the shift of the probe during the exam using Fibroscan may influence the direction of the wave pressure and consequently the liver stiffness measurement. This demonstrates the sensitivity of the Fibroscan technique to local measurements (due to the focalized transducer) which can only evaluate a fragment of hepatic tissue. This large range of stiffness obtained for the same subject may influence the diagnosis of the fibrosis, which should be confirmed with an additional exam. The MRE technique should be investigated further because MRE can evaluate the morphology of the entire hepatic gland and detect possible anomalies, such liver injury or portal hypertension, within the same examination. Finally, the MRE technique provided elasticity of the entire liver, meanwhile the Fibroscan provided values of elasticity locally.