Diagnosis of Hepatic Fibrosis by Magnetic Resonance Elastography: Sensitivity and Specificity

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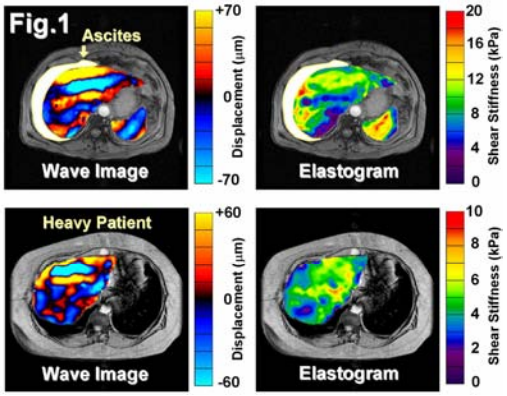
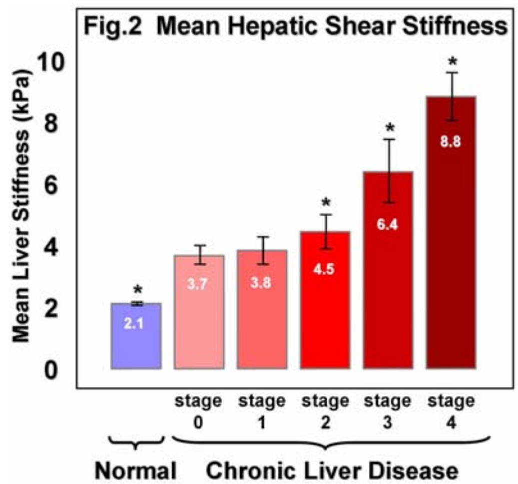
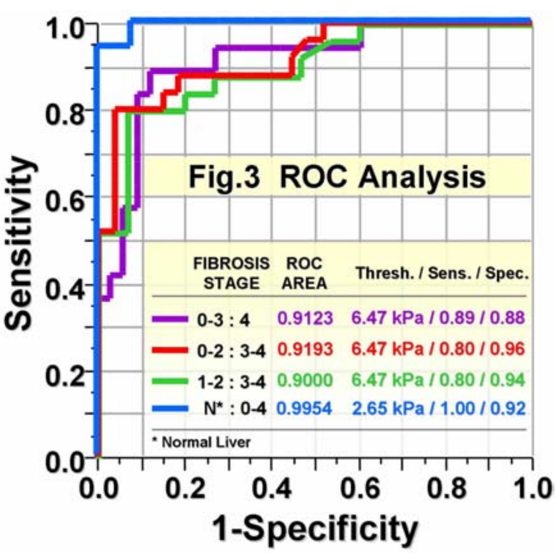


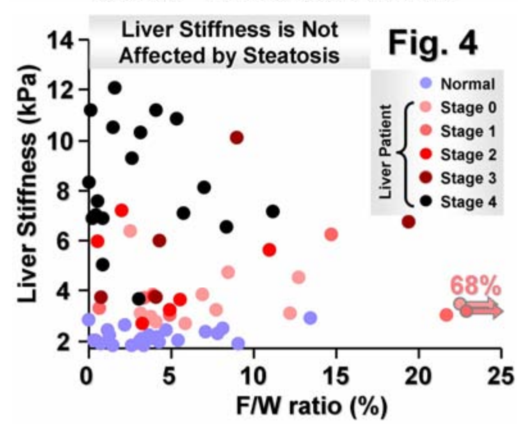
Introduction: Chronic liver disease is a world-wide problem, with many underlying causes. The most important result is hepatic fibrosis, a nonspecific response to chronic liver injury that, if unchecked, can progress to irreversible cirrhosis and high mortality. The current gold standard for diagnosing liver fibrosis is biopsy, which is invasive and associated with sampling error. Conventional imaging modalities are not capable of demonstrating liver fibrosis prior to the onset of cirrhosis. Magnetic Resonance Elastography (MRE) is a technique for quantitatively assessing the mechanical properties of soft tissues and several investigations have demonstrated that it is a promising method for detecting and characterizing liver fibrosis (1-3). If confirmed, this could have a substantial impact on the management of patients with chronic liver disease, where it is crucial to diagnose and treat fibrosis before it progresses to irreversible cirrhosis. The goal of this work was to test a substantially improved version of MRE in a much larger series of patients with biopsy-proven hepatic fibrosis. Since steatosis is commonly present in patients with chronic liver disease, an additional goal was to determine whether fat infiltration could potentially interfere with the detection of liver fibrosis by MRE.

Materials and Methods: All experiments were implemented on a 1.5 T whole-body GE imager (Signa, GE Medical System, Milwaukee, WI, USA), using the body coil. Volunteers and patients were imaged in a supine position, with a 19-cm cylindrical passive pneumatic driver placed against their anterior body wall. Continuous vibrations at 60 Hz generated shear waves throughout the tissues of the abdomen. A gradient echo based MRE sequence with flow compensation was used to collect axial wave images with following parameters: FOV = 32~42 cm, Flip angle = 30°, Slice thickness = 10 mm, TR/TE = 50/32 ms, Matrix = 256×64, 1 pair of trapezoidal motion encoding gradient; 4 phase offsets. Acquisition time was 40 seconds, split into 4 periods of suspended respiration. Quantitative elastograms of the liver were obtained by processing the MRE wave images with an LFE inversion algorithm (4). Hepatic fat / water ratios were calculated from a separate gradient echo acquisition, using a 3-point Dixon method. At the time that this abstract was written, a total of 20 normal volunteers and 57 patients with biopsy proven fibrosis had been evaluated.





Results: The passive driver system provided excellent shear wave illumination throughout the entire abdominal area in all subjects, including large patients and those with ascites (Fig.1). Compiled measurements for each grade of fibrosis are shown in Fig.2. Liver stiffness increased systematically with biopsy-proven fibrosis stage. ROC analysis, shown in Fig.3 demonstrated that with a cutoff value of 2.65kPa, MRE has a sensitivity approaching 100% for diagnosing all grades of liver fibrosis, and an ROC area of >0.99 (blue curve). The ROC analysis also demonstrated an ability to discriminate between varying degrees of fibrosis (purple, red, and green curves). Measurements of fat/water ratio (Fig.4) showed that hepatic stiffness does not appear to be influenced by varying degrees of steatosis in any group ($R^2 < 0.05$).



Discussion and Conclusion: The revised MRE technique was well tolerated by all of the patients and volunteers, requiring less than one minute of acquisition time to generate a diagnostic result. The results of this study confirm that measurement of hepatic shear stiffness by MRE is highly effective in the diagnosis of liver fibrosis. In this series of 77 examinations, ROC analysis predicted that if a threshold value of 2.65 kPa is used as the upper limit of normal mean hepatic stiffness, the technique will diagnose patients with all grades of fibrosis with a sensitivity of nearly 100% and a specificity of 92%. ROC analysis also indicated that hepatic shear stiffness measurements can discriminate between fibrosis stages (0+1), 2, 3, and 4. The presence hepatic steatosis has little or no effect on liver stiffness measurements. Overall, these results provide strong motivation for wider evaluation of hepatic MRE in patients with suspected hepatic fibrosis, sparing them the discomfort and risk of complications associated with liver biopsy, and potentially increasing the reliability of diagnosis by reducing sampling errors.

References: [1] R. Muthupillai, Science 1995, 269: 1854-7. [2] O. Rouviere, M. Yin, et al. 2006, Radiology 240(2): 440-8. [3] L. Huwart, 2006, NMR Biomed 19(2): 173-9. [4] A. Manduca, Med Image Anal 2001, 5(4): 237-254.