Comparison of MR elastography and FibroScan for the non-invasive assessment of liver fibrosis

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Introduction

The noninvasive assessment of liver fibrosis is important because chronic liver diseases affect hundreds of millions of patients worldwide. In hepatitis C, as well as for other diseases (chronic hepatitis B and non-alcoholic steatohepatitis), therapy has improved dramatically but still is applied selectively, for reasons of toxicity and cost, combined with limited efficacy. Currently, the golden standard for the diagnosis and staging of liver fibrosis is the histo-pathological analysis of biopsy samples. However, this method is invasive and has a poor reproducibility that may be explained by the heterogeneity of liver fibrosis, the small size of hepatic samples, and the inter- and intra-observer variability in the histologic examination. Recently, one-dimensional ultrasound elastography (FibroScan) and magnetic resonance elastography (MRE) have been proposed to assess liver fibrosis by determining tissue elasticity (1-3). The purpose of this study was to compare MRE with FibroScan for the assessment of hepatic fibrosis in patients with chronic liver disease.

Material and methods

This prospective study included 48 consecutive adult patients who had liver biopsy for suspicion of chronic liver disease. The cause of chronic liver disease was viral hepatitis in 39 patients (chronic hepatitis C in 37 and chronic hepatitis B in 2), alcoholic in 6, α_1-antitrypsin deficiency in 1 and unclassified in 2 patients. These patients had the same day MRE and FibroScan. For MRE, low-frequency longitudinal mechanical waves of 65 Hz were transmitted into the right liver by a transducer placed against the last ribs at the back of the patient in supine position (4). The shear waves were obtained by mode conversion at interfaces and were separated from the longitudinal contribution by applying the curl operator on the total displacement vector field. Images were obtained on a 1.5-T whole-body MR scanner (Gyroscan Intera; Philips Medical Systems, Best, The Netherlands) using a four elements torso coil. The MRE sequence was a motion-sensitized spin-echo sequence with sinusoidal displacement encoding gradients that were synchronized to the mechanical excitation. Five sagittal slices through the right liver were acquired with a slice thickness of 4 mm, field of view of 250 mm, matrix size of 64^2, echo time of 61 ms, repetition time of 431 ms, two signal averages and respiratory gating with a navigator on the right hemidiaphragm. Four dynamics were obtained to assess the amplitude and phase of the displacement in one direction. The motion encoding gradients were applied successively in the three orthogonal directions to capture all the components of the three-dimensional displacement vector. Afterwards, the phase images were analyzed with the Voigt model to obtain shear elasticity (μ ,kPa) and viscosity (ς, Pa.s) maps. Liver elasticity was also evaluated with FibroScan (EchoSens, Paris, France). This technique measures the velocity of the shear wave, which is directly related to Young's elastic modulus (kPa). The stage of fibrosis was evaluated histologically according to the METAVIR semi-quantitative scoring system which ranges from F0 (no fibrosis) to F4 (cirrhosis).

Results

The measurement with FibroScan could not be performed in six patients who were obese or had ascites. These patients were excluded from the analysis and the final study group included thus 42 patients. According to the Metavir scoring system,12 patients (29%) had a stage of F0, 7 (17%) F1, 6 (14%) F2, 7 (17%) F3, and 10 (23%) F4. The MRE elasticity and viscosity, and FibroScan elasticity measurements are presented in Table 1. All these parameters increased according to the stage of liver fibrosis, and were correlated to the fibrosis stage: $r = 0.95$, $P < .001$ for MRE elasticity; $r = 0.81$, $P < .001$ for viscosity; and $r = 0.72$, $P < .001$ for FibroScan elasticity. The areas under the ROC curves are shown in Table 2. The most discriminant cut-off values of MRE elasticity were 2.4 kPa for $F \geq 1$, 2.5 kPa for $F \geq 2$, 3.1 kPa for $F \geq 3$, and 4.3 kPa for $F = 4$.

Discussion

These results show that MRE is an accurate non-invasive method to stage liver fibrosis and that the measurements of elasticity obtained with MRE have a larger area under the ROC curve than the elasticity measurements obtained with FibroScan . The MRE elasticity measurements allowed to clearly separate the intermediate fibrosis stages and more precisely F2 from F1. This high accuracy is clinically important because, according to the American Association for the Study of Liver Diseases, patients with hepatitis C genotype-1 infection should be treated only when substantial fibrosis ($\geq$ F2) is observed. The viscosity measurements were less accurate than the MRE elasticity measurements to stage liver fibrosis. The better results of MRE relative to FibroScan can be explained by two reasons. First, the volume assessed with MRE is much larger than the volume evaluated with ultrasound elastography. Second, MRE allows to assess the whole three-dimensional displacement vector induced by the mechanical waves. The results of the present study suggest that MRE is more accurate than FibroScan to stage liver fibrosis.

Tables:

Table 1. The MRE elasticity (μ) and viscosity (ς), and the FibroScan elasticity were calculated for each fibrosis stage.

	F0	F1	F2	F3	F4
MRE elasticity (kPa)	2.1 ± 0.2	2.3 ± 0.1	2.6 ± 0.2	3.4 ± 0.4	5.4 ± 0.6
MRE viscosity (Pa.s)	1.8 ± 0.4	1.8 ± 0.5	1.9 ± 0.7	2.9 ± 0.7	4.8 ± 1.3
FibroScan Elasticity (kPa)	5.1 ± 1.3	6.6 ± 3.2	5.4 ± 1.4	14.2 ± 9.4	31.0 ± 21.9

Table 2. Areas under the ROC curves with 95% confidence intervals in parentheses for MRE elasticity and FibroScan elasticity.

	F ≥ 1	F ≥ 2	F ≥ 3	F = 4
MRE elasticity	0.96 (0.91-1.0)	1.0 (1.0-1.0)	1.0 (0.99-1.0)	1.0 (1.0-1.0)
FibroScan elasticity	0.78 (0.64-0.92)	0.81 (0.68-0.95)	0.93 (0.82-1.0)	0.98 (0.95-1.0)

References

1. Huwart L et al. NMR Biomed 2006;19(2):173-9.
2. Sandrin L et al. Ultrasound Med Biol 2003;29(12):1705-13.
3. Rouviere O et al. Radiology 2006;240(2):440-8.
4. Sinkus R et al. Magn Reson Med 2005;53(2):372-87.