### Methods

**Introduction**

Magnetic resonance elastography (MRE) is capable of generating image contrast based on the viscoelastic properties of tissue by inducing and detecting time harmonic shear waves in the body [1]. Non-alcoholic fatty liver disease (NAFLD) is the most frequent chronic liver disease in children today. Despite its invasiveness, liver biopsy is still the gold standard for the diagnosis of NAFLD. MRE is a noninvasive imaging technique (1) used to probe the biomechanical properties of soft tissues in vivo and it has demonstrate great value in diagnosing liver fibrosis.

**Methods**

50 patients (age range 1-17 years, 10 females) who are overweight or obese (average BMI: 33.9 kg/m²) and exhibit prolonged elevation of serum alanine aminotransferase (ALT) and/or aspartate aminotransferase (AST) (>50 U/l for at least 3 months) were recruited. MMRE (1) was conducted at 1.5 T scanner (Siemens, Magnetom Sonata) using 7 harmonic frequencies (30 to 60 Hz, 5 Hz increment), the abdominal MRE setup is the same as described in (2) and shown in Figure 1. The 3D wave field was recorded using a single-shot EPI sequence with motion-encoding gradients (MEG). Total acquisition time for 9 consecutive slices of 2.7 × 2.7 × 5 mm³ resolution, 7 frequencies, 8 wave dynamics was 5 minutes and 8 seconds. MRE wave data was reconstructed using wavenumber based inversion method as detailed in (3), yielding parameter map of the shear wave speed (c) which represents mainly the liver stiffness and penetration rate (a) which reflect the tissue damping. Hepatic fat fraction (HFF) was also estimated with Dixon method. Liver biopsy was performed for fibrosis and steatosis grading.

![Image of MRE setup and scanner room](image)

**Figure 1.** MRE setup in the control room and scanner room. Mechanical vibration is generated with the non-magnetic driver.

**Results**

Results: Based on histological staging, 27 subjects had no or early fibrosis, 15 subjects with stage 0 (F0), 12 with stage 1 (F1), 9 subjects had stage 2 (F2) moderate fibrosis and 14 subjects had advanced fibrosis with stage 3 (F3). Based on the steatosis grade, the patients are divided into 3 groups, with 10, 17 and 23 subjects having steatosis grade 1, 2 and 3 (S1,S2 and S3), respectively. Fig.1 shows MRE magnitude image, shear wave image at 50 Hz drive frequency, map of shear wave c, penetration rate and HFF in the central slice of one patient with F1 and S2, another patient with F3 and S3. In term of fibrosis, c was significantly higher in patients with F3 (Fig.2c). c was also used for detecting any fibrosis (F > 1), moderate fibrosis (F > 2) and advanced fibrosis (F > 3) with AUROC of 0.79, 0.91 and 0.90, correspondingly (Fig.3a). Regarding steatosis, a was significantly lower in S3 group (Fig.2d) while HFF was elevated with increasing steatosis grades (Fig.2e). Both a and HFF were used to detect moderate steatosis (S > 2). The AUROC for a and HFF are 0.86 and 0.92, respectively (Fig 3b). Additionally, a negative correlation between a and HFF (Person ρ = -0.6, P < 0.0001) was obtained (Fig 3c).

![Image of wave speed obtained from MRE](image)

**Figure 2.**

**Discussion & Conclusion**

Wave speed obtained from MRE is sensitive in differentiating moderate and advanced fibrosis. Penetration rate as another MRE parameter is able to detect moderate steatosis and is negatively correlated with HFF. Both MRE derived mechanical parameters c and a are independently responsive to pathological feature of NAFLD such as fibrosis and steatosis. The mechanical parameters can potentially serve as a complementary imaging marker for the noninvasive assessment of liver fibrosis and steatosis in patients with NAFLD.

![Image of wave speed obtained from MRE](image)

**Figure 3.**

**Publications:**