

# Breath-hold Quantitative Liver MR Imaging: Assessment of Hepatic Fibrosis, Iron Content, and Fat Fraction

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**Purpose:** To evaluate the feasibility of fast liver MR evaluation of liver fibrosis,  $R2^*$  which is related to iron content, and fat fraction performed during five breath-holds.

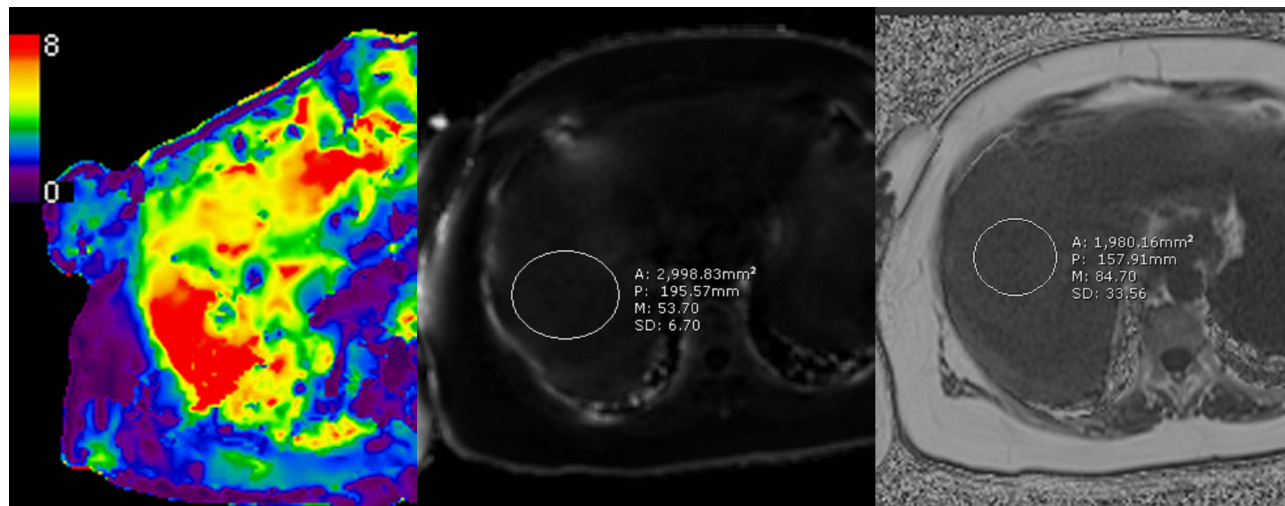
**Background:** MRE is a phase contrast MRI technique that evaluates the stiffness of tissues by directly visualizing and measuring propagated mechanical shear waves in tissues. MRE generates quantitative measurements and colorized spatial maps of shear wave displacement. The initial wave images are processed to generate an elastogram, which displays the quantitative values of the shear modulus of tissues on a color coded spatial map. MRE has been used to evaluate liver fibrosis which shows higher stiffness than normal liver parenchyma [1, 2]. IDEAL Quant is a multi-echo Dixon technique performed during a single breath hold that evaluates liver iron content ( $R2^*$  value) and percentage of fat in the liver (fat fraction). This quantitative liver MR exam will be useful for numerous clinical applications including hepatic steatosis, NASH, cirrhosis, and hemochromatosis.

**Materials and Methods:** Twenty-five patients were referred for abdominal MRI performed in a 1.5T scanner (Signa HD-x GE Healthcare) using a 12 channel phased-array torso coil. MRE was performed using a 19-cm diameter 1.5-cm thick cylindrical passive driver placed against the abdominal and chest wall overlying the liver at the level of the xiphoid process of the sternum. The passive driver was held in place with an abdominal binder. Continuous acoustic vibration at 60 Hz was transmitted from an active driver to the passive driver through a flexible vinyl tube. The propagating shear waves were imaged with a modified phase contrast, gradient-echo sequence for collection of axial wave images. MRE sequence parameters included TR 50 ms, TE 24.6 ms, bandwidth  $\pm 31.25$  kHz, flip angle 30 degrees, matrix size 256x64, and slice thickness 10 mm, gap 1 mm. Four axial MRE slices were obtained each requiring a single 20 second breath hold. MR Elastogram was generated by processing the acquired wave image to produce a quantitative map of tissue shear stiffness measured in kilopascals. Mean shear stiffness of liver parenchyma was calculated by manually drawing a region of interest (ROI) over peritoneal tumors and the liver.

IDEAL Quant is a multiecho Dixon technique for fat-fraction and  $R2^*$  quantification in which 6 echoes are acquired with varying echo times (TE). A 6-pt reconstruction algorithm is used to generate water, fat, fat-fraction images and  $R2^*$  maps, with correction of the  $T2^*$  decay [3], fat spectral peaks [4] and eddy currents induced phase errors [5]. A small flip angle is used for minimizing T1 bias [6]. The  $R2^*$  map is correlated with iron content and is used to correct the Water and Fat images and generate a fat fraction that estimates the percentage of liver involved with fatty infiltration. IDEAL Quant imaging parameters included TR 14, TE 1.59, 3.17, 4.76, 7.59, 9.70, 11.8 msec, bandwidth 125 kHz, ETL 6, flip angle 5 degrees, Nex 0.72, matrix 256x160, and 20 slices with thickness 10mm obtained during a single 24 sec breath hold.

**Results:** The MRE source images successfully reconstructed gray scale and colorized MR Elastograms in all patients. The IDEAL Quant images successfully generated  $R2^*$  and Fat Fraction images. For all patients the mean shear liver stiffness on the MRE was 3.0 (range 1.4 – 6.9 kPa (normal <3.0 kPa)). The colorized MRE images showed increased liver stiffness in 4 patients with known cirrhosis. For all patients the mean  $R2^*$  value was 50.9. 1/s (range 12 – 160 1/s). Two patients demonstrated an elevated  $R2^*$  value with corresponding elevated liver iron content. The mean fat fraction obtained from the IDEAL Quant Fat Fraction images was 6% (range 1.4% - 18%).

**Conclusions:** Rapid quantitative liver MRI can be performed in 5 breath holds evaluating liver fibrosis,  $R2^*$  iron content, and fat fraction.



**Figure 1:** 62 year old male with hepatitis. MR Elastogram (left) shows liver marked liver fibrosis with increased shear stiffness (6.2 kPa) compared to the mean liver 1.8 kPa. Single breath-hold IDEAL Quant  $R2^*$  image (middle) shows a  $R2^*$  value 53.7. The Fat fraction image (right) demonstrates an 8.4% fat fraction,

## References:

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