T1 independent, T2* Corrected Chemical Shift Based Fat-Water Separation with Accurate Spectral Modeling is an Accurate and Precise Measure of Liver Fat

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Introduction: As the incidence of non-alcoholic fatty liver disease parallels the obesity and diabetes epidemic, accurate quantification of hepatic steatosis is urgently needed for early detection and treatment monitoring. T1 independent, T2* corrected chemical shift based fat-water separation methods with accurate spectral modeling of fat, such as quantitative IDEAL (Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation)1,2,3,4 have been shown to provide accurate fat quantification over a range of fat-fractions6,7. The purpose of this work is to determine the precision and accuracy of quantitative IDEAL for quantifying fat in patients, using single voxel MR spectroscopy (MRS) as a reference standard.

Methods: Forty consecutive patients (20 male, 20 female) referred for liver MRI (all indications) were recruited for this study after obtaining informed consent and IRB approval. Mean age was 50.7 years (range, 23-78). Imaging was performed at 1.5T (Signa HDx, GE Healthcare, Waukesha, WI) using an eight-channel phased array cardiac coil.

Two repeated measurements with MRI and MRS were made to assess repeatability (precision). Between time points, patients sat up and then lied down, new localizers were acquired and the MRI and MRS sequences were re-prescribed. Breath-held MRI fat-fraction images were acquired over the entire liver using an investigational version of a 3D spoiled gradient echo (SPGR) EPI acquisition5. Single voxel breath-held MRS (STEAM) data were acquired without water suppression. The voxel was placed in the posterior segment of the right hepatic lobe while avoiding large vessels in the same attempted location for both acquisitions.

Using MRS as a reference, MRI provides very precise fat-fractions as shown by the regression between MRI measured at the MRS voxel location and MRS (Figure 3); excellent agreement was seen for Reader 1 for both time points, where $r^2 > 0.95$, slopes were not significantly different from 1, and the intercept for Time 1 was not significantly different than 0.0 (p-values are Bonferroni-corrected since two readers were tested). Using 5.56%10 as the threshold of a diagnostic indicator of steatosis. Further, Reader 1 measured an ROI at the location of the MRS voxel. Accuracy was assessed through regression of MRI fat-fraction at the location of the MRS voxel compared with MRS. Using an average fat-fraction across the liver from the 9 ROI, sensitivity and specificity were calculated through regression of MRI fat-fraction at the location of the MRS voxel compared with MRS. Using MRS as a reference, MRI provides highly accurate measures of fat-fraction using MRS as a reference standard, as seen by the regression between MRI measured at the MRS voxel location and MRS (Figure 3); excellent agreement was seen for Reader 1 for both time points, where $r^2 > 0.95$, slopes were not significantly different than 0.0, and the intercept for Time 1 was not significantly different than 0.0 (p-values are Bonferroni-corrected since two readers were tested). Using 5.56% as a diagnostic cutoff, the sensitivity and specificity of quantitative IDEAL was 92% and 96%, respectively.

Discussion: Fat-fraction, when measured with T1 independent, T2* corrected quantitative IDEAL with accurate spectral modeling is a highly precise and accurate method of quantifying liver fat, using MRS as a reference standard. This method provides reliable in vivo fat quantification in patients and is highly promising as a quantitative biomarker of liver fat.


Acknowledgements: This project was supported by the NIH. We gratefully acknowledge support from GE Healthcare.