

Spectrally-Modeled Hepatic Fat Quantification by Multi-Echo Gradient-Recalled-Echo Magnetic Resonance Imaging at 3.0T

T. Yokoo¹, M. Shiehorteza¹, M. Bydder¹, G. Hamilton¹, Y. Kono², A. Kuo², J. E. Lavine³, and C. B. Sirlin¹

¹Radiology, UCSD, San Diego, CA, United States, ²Medicine, UCSD, San Diego, CA, United States, ³Pediatrics, UCSD, San Diego, CA, United States

Purpose: To assess *in-vivo* hepatic fat quantification accuracy of multi-echo gradient-recalled-echo (GRE) MR imaging with fat spectral modeling at 3.0 T, using MR spectroscopy as the reference standard.

Introduction: Due to the high prevalence of fatty liver disease (FLD) in the United States and its risk of serious long-term complications, there is increasing clinical need for a noninvasive fat quantification technique to accurately diagnose FLD and guide clinical management. While MR imaging has long been considered the modality of choice for assessment of FLD, human data on the estimation accuracy has been scarce. Several groups recently suggested that accurate fat quantification by MR requires correction of the T1 and T2 (or T2*) relaxation effects as well as modeling of multi-component fat signal [1-6]. Using non-T1-weighted multi-echo GRE imaging and 3-peak fat spectral modeling (*LIPO-Quant: Liver Imaging of Phase-interference related signal Oscillation and Quantification*), high fat estimation accuracy was demonstrated at 1.5 T in fatty liver patients [3,4]. In principle, this general approach would be independent of the field strength and therefore is also applicable at 3.0 T. In this first human study on spectrally-modeled hepatic fat quantification at 3.0 T, we assessed fat estimation accuracy of MR imaging using MR spectroscopy as the reference standard.

Materials and Methods: In this HIPAA-compliant, IRB-approved prospective clinical study, 41 human subjects of age 12-65 (12 with documented FLD, 20 at risk of FLD, 9 with no known risk factors) gave informed consent and underwent STEAM spectroscopy and GRE imaging of the liver at 3.0 T. Spectroscopy used long repetition time (to minimize T1 effects) and multiple echo-times (to permit T2 correction); spectroscopic fat fraction (FF) was calculated from T2-corrected peak areas of water (4.7ppm) and fat (2.2, 1.3, 0.9 ppm). Imaging used low flip-angle (to minimize T1 effects) and multiple echo-times (to permit T2* correction); imaging FF was calculated using (1) standard dual-echo [7], (2) triple-echo [8], (3) multi-echo [9,10], and (4) *LIPO-Quant* with 3-peak fat spectral model (2.2 1.3, 0.9 ppm) [3-6]. The accuracy of imaging FF at the location of spectroscopic voxel was assessed by linear regression analysis with spectroscopic FF as the reference standard.

Results: Regression analyses of the four methods are shown below (**Figure 1**). The diagonal line (intercept 0, slope 1) represents equality between imaging and spectroscopic FFs. The dual-echo method (T2* un-corrected, without spectral modeling) systematically underestimated FF in both intercept and slope, due to T2* and spectral modeling error, respectively. The triple- and multi-echo methods (T2* corrected, without spectral modeling) had intercepts closer to 0, but showed persistent underestimation (slope<1) due to spectral modeling error. *LIPO-Quant* (T2* corrected, with spectral modeling) improved the FF estimation; no significant deviation of the slope from 1 was noted. Minimal intercept error (<1% in FF) was statistically significant at 95% level, but this degree of error is unlikely to be clinically meaningful. These results are qualitatively similar to previously reported 1.5 T data [3,6].

Conclusion: At 3.0T, *LIPO-Quant* MR imaging and spectrally-modeled hepatic fat quantification has no clinically meaningful estimation error compared to MR spectroscopy.

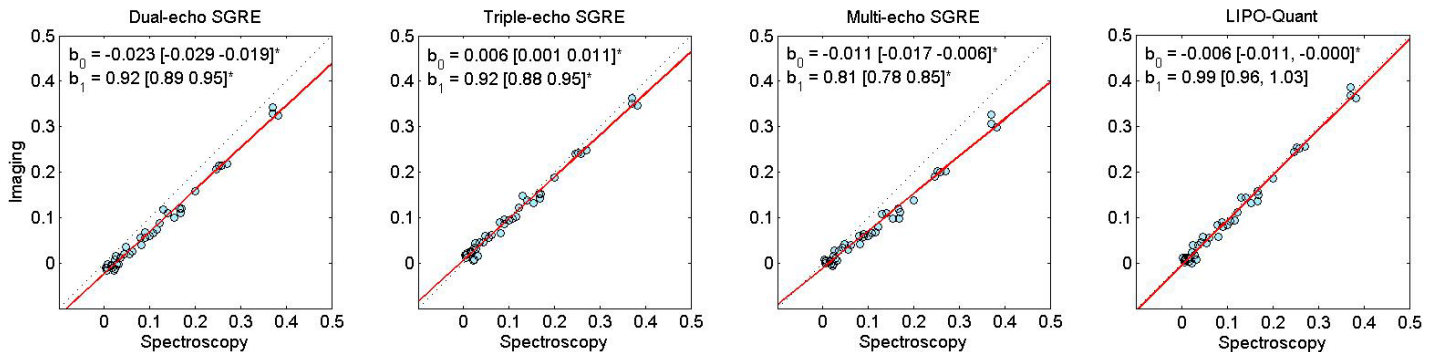


Figure 1: Comparison of imaging vs. spectroscopic fat fraction. Dotted line ($y = x$) is loci of equality. Red line ($y = b_0 + b_1 x$) is the best-fit line through the data points (blue circles).

References:

- [1] Yu et al. Correction for Multiplex Fat Spectrum When Estimating T2* in the Presence of Fat. ISMRM, 2008. (#707)
- [2] Reeder et al. Quantification of Hepatic Steatosis with MRI: the Effects of Accurate Fat Spectral Modeling. ISMRM, 2008. (#709)
- [3] Yokoo et al. Hepatic Fat Quantification by Low Flip-Angle Multi-Echo Gradient-Echo MR Imaging: A Clinical Study with Validation with MR Spectroscopy. ISMRM, 2008. (#706)
- [4] Yokoo T, Barksdale J, Bydder M, Hamilton G, Middleton MS, Bydder GM, Sirlin CB. Effects of T1, T2, and Spectral Complexity on In- and Out-of-Phase Imaging: A systematic approach by computer simulation. ISMRM, 2007. (#1720)
- [5] Brix et al. MR imaging of fat-containing tissues: valuation of two quantitative imaging techniques in comparison with localized proton spectroscopy. *Mag Res Imaging*, 1993; 11: 977-991
- [6] Reference accepted to *Radiology*, available upon request.
- [7] Dixon WT. Simple proton spectroscopic imaging. *Radiology* 1984; 153:189-194.
- [8] Hussain HK, Chenevert TL, Londy FJ, et al. Hepatic fat fraction: MR imaging for quantitative measurement and display--early experience. *Radiology* 2005; 237:1048-1055.
- [9] Fishbein MH, Gardner KG, Potter CJ, Schmalbrock P, Smith MA. Introduction of fast MR imaging in the assessment of hepatic steatosis. *Magn Reson Imaging* 1997; 15:287-293.
- [10] Bydder M, Yokoo T, Hamilton G, et al. Relaxation effects in the quantification of fat using gradient echo imaging. *Magn Reson Imaging* 2008; 26(3):347-59.