In Vivo MR Quantification of Liver Fat Content in Obese Mice: Comparison of Dual-Echo Dixon Imaging, Chemical Shift Selective Imaging and Hydrogen MR Spectroscopy

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INTRODUCTION
During the past decade, there has been evidence of an epidemic increase in the non-alcoholic fatty liver disease. Fatty liver often leads to obesity, insulin resistance and metabolic syndrome. Liver fat quantification has generated considerable interest; it may be of clinical importance to be able to reliably measure liver fat content (FC). Noninvasive analysis of fat quantification by MR would have major advantages. Present study aims to evaluate dual-echo Dixon (in-phase and out-of-phase, IP-OP) MR imaging, chemical shift imaging (CSI), and MR spectroscopy (MRS) in estimating FC in livers of obese and normal mice at high field 7.0 Tesla MR.

METHODS
Experimental paradigm was proposed based on single-voxel proton MRS, water or fat selective CSI method and dual-echo Dixon in-phase and out-of-phase method. Three MR methods were performed to measure FCs in livers of six ob/ob and six wild type (WT) mice using 7T micro-MR scanner. The results were compared to reference standard from mice by histological semi-automatic vacuole segmentation procedure (HIS-S) and liver lipid (LL) chemical analysis. Independent-sample t test, paired-sample t test and correlation test were performed in comparison.

RESULTS
In vivo, liver FC in ob/ob mice measured by all three MR methods was significantly higher than that of WT mice (P < .01). For ob/ob mice, liver FC measured by IP-OP was significantly lower than that measured by CSI and MRS (P = .000) with no significant difference between CSI and MRS (P = .612). CSI and MRS showed a linear correlation with LL (r = 0.996 and 0.912, respectively, P < .05) and with each other (r = 0.937, P < .01). For WT mice, liver FC measured by IP-OP was significantly lower than that measured by CSI (P = .000), but no significant difference compared to MRS and HIS-S (P = .104 and .420, respectively). CSI showed a linear correlation with LL (r = 0.996, P < .05).

CONCLUSION
IP-OP MR imaging underestimated FC, while CSI and MRS are more accurate for quantifying fat in liver. CSI and MRS have the potential to replace HIS-S and LL analysis in longitudinal studies.