Same Day 1.5T vs 3T Reproducibility of Liver Proton Density Fat Fractions in Obese Patients

Nathan Artz1, William Haufe2, Tanya Chavez2, Gavin Hamilton2, Michael Middleton2, Jeff Schwimmer2, Diego Hernandez3, Ann Shimakawa4, Jonathan Hooker2, Claude Sirin1, and Scott Reeder1,5

1Radiology, University of Wisconsin, Madison, WI, United States, 2Radiology, University of California, San Diego, CA, United States, 3Pediatrics, University of California, San Diego, CA, United States, 4Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, 5Medicine, University of Wisconsin, Madison, WI, United States

Target Audience: Researchers and clinicians interested in liver fat quantification.

Purpose: Non-alcoholic fatty liver disease (NAFLD) is the most common cause of chronic liver disease and can affect up to 75% of the obese population. If left untreated, it can progress to complications such as liver failure, portal hypertension, and hepatocellular carcinoma. Definitive diagnosis of NAFLD currently requires biopsy, which is limited by expense, risk, and sampling variability. In recent years, a number of quantitative MR methods have shown great promise as a non-invasive biomarker of hepatic steatosis, with validation studies performed in phantoms, animal models, and patients. The purpose of this work is to examine the reproducibility of these MR techniques by evaluating hepatic proton density fat fraction (PDFF) measurements across magnetic field strengths, specifically 1.5T and 3T, in an obese population at high risk for NAFLD.

Methods: This study was IRB approved and informed consent was obtained from all 22 subjects (age: 47±1.3 yrs; weight: 115±14 kg; BMI: 45±4 kg/m²). Obese patients approved for weight-loss surgery were scanned on the same day at both 1.5T and 3T (Signa HDx and Discovery 750 respectively, GE Healthcare, Waukesha, WI) within a one hour period. At each field strength, data for three distinct liver fat quantification techniques were acquired. First, a previously described 3D complex-based (MRI-C) gradient echo method was performed at 3T: 6 total echoes in two shots, TR=8.6ms, ETL=3, TEMin=1.2ms, ΔTE=1.0ms, flip=3° full readout, BW=±125KHz, FOV=44cm, slice=8mm, 256x128 matrix, 32 slices, AARC parallel imaging acceleration = 2x2, and a total scan time of 20sec (single breath-hold). Parameters at 1.5T were similar except for the following: TR=170ms, ETL=6, TE=2.3ms, BW=±83kHz, matrix=256x160, total scan of 42 sec (split into three breath-holds). Fat-fraction images for both MRI-C and MRI-M were reconstructed using two separate on-line reconstruction algorithms. Both algorithms use spectral modeling of fat fraction measurements in the right hepatic lobe free from large vessels. Acquisition parameters included: 2048 readout points, 1 signal average, TR=3500, and at 5TEs, all acquired in the same 21s breath-hold.

MRI-M and MRI-C fat-fractions (FF) were averaged across nine ROI’s placed in each of the 9 Couinaud liver segments and were co-localized between 1.5T and 3T. MRS fat fractions were determined as previously described. To compare MRI-M and MRI-C with MRS, additional ROI’s were co-localized with the MRS voxel coordinates. Regression analysis was used for all comparisons.

Results and Discussion: Figure 1 shows MRI-M and MRI-C PDFF maps at 1.5T and 3T for a subject with high fat content in the liver. Excellent agreement was observed between field strengths for MRI-M and MRI-C and very good agreement was observed for single voxel MRS (22.2% at 1.5T; 23.9% at 3T). Regression analysis for all 22 subjects yielded the following: MRS: slope=0.87 (CI 0.77, 0.98), intercept=1.8 (CI 0.5, 3.1%), r²=0.93; MRI-M: slope=1.00 (CI 0.91, 1.08), intercept=1.4 (CI 2.5, -0.3%), r²=0.97; MRI-C: slope=0.92 (CI 0.87, 0.97), intercept=1.2 (CI 0.6, 1.8%), r²=0.99. Table 1 shows regression results for MRI-M and MRI-C vs MRS at both field strengths. Excellent correlation was observed.

None of the three FF techniques achieved perfect agreement (slope=1 and intercept=0) between field strengths, but each demonstrated excellent correlation with slopes near 1 and intercepts near 0. While results are similar, MRS demonstrated the lowest correlation, and the largest divergence from a unitary slope and zero intercept. This is likely due to variations in voxel placement which is an inherent drawback of MRS when performing repeated studies. Future work will investigate the source of the small remaining biases observed with each technique.

Conclusion: MRS, MRI-M, and MRI-C demonstrated excellent correlation with MRS, and very good agreement between same day 1.5T and 3T liver PDFF measurements in obese patients. Although further validation is necessary assessing the accuracy of PDFF measurements with tissue reference standards in the patient population, this study in obese patients indicates that PDFF quantification is reproducible across field strengths.


Acknowledgments: We acknowledge support from NIH (R01 DK083380, R01 DK088925). We also acknowledge GE Healthcare for their support.