

Initial in vivo validation of a hybrid magnitude/complex MRI-based method for liver fat quantification

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Target Audience

Clinical radiologists; abdominal MR radiologists

Purpose

Hepatic steatosis is a complex phenomenon which can precede liver inflammation, chronic fibrosis, and ultimately liver failure and malignancy. Quantification of hepatic lipid content is an important emerging technique which holds promise for staging the disease as well as assessing response to treatment. We have recently developed a method for measurement of the proton density fat fraction from a multi-echo MRI acquisition. This is a hybrid magnitude/complex data method which takes advantage of the insensitivity to phase error of magnitude-data techniques and the full 0-100% dynamic range of complex-data techniques. The purpose of this study was to validate the proton density fat fraction (PDFFF) measurements derived from this hybrid method against co-localized T₂-corrected single voxel spectroscopy.

Methods

The local institutional review board approved this prospective study. Abdominal MRI examinations from 13 consecutive patients were performed on a 3T MR system (Skyra, Siemens Healthcare). The imaging method was a 3D technique with the following parameters: FA 4°, TR 8.9 ms, first TE 1.23 ms, and 6 echoes collected with ΔTE 1.23 ms. Single voxel spectroscopy (SVS) high-speed T₂-corrected multiecho (HISTO) was performed using a 20x20x20 mm³ voxel placed in the liver, avoiding large vessels, and five echoes were collected (TE 12-72 ms) to perform T₂ correction. A cubic ROI was chosen on the image data set to co-localize with the SVS voxel.

The details of the image reconstruction method are reported in a separate abstract. Briefly, the image reconstruction includes T₂* correction and multi-fat-peak modeling, and derives separate solutions for the R₂* values of fat and water. It uses a two-point Dixon method with flexible echo times to obtain initial guesses for the fat and water signal fractions, and a seed value of 30 s⁻¹ as the initial guess for the R₂* values. Using these initial guess values, Levenberg-Marquardt non-linear fitting is performed in two additional steps to update the fat fraction, water fraction, and R₂* values until a stable solution is reached.

For statistical analysis, linear regression was performed to determine the relationship between the PDFFF measurements obtained using the imaging and spectroscopic techniques. The Wilcoxon signed-rank test was used to determine whether there were significant differences between the measured values, with a p-value of < 0.05 considered significant.

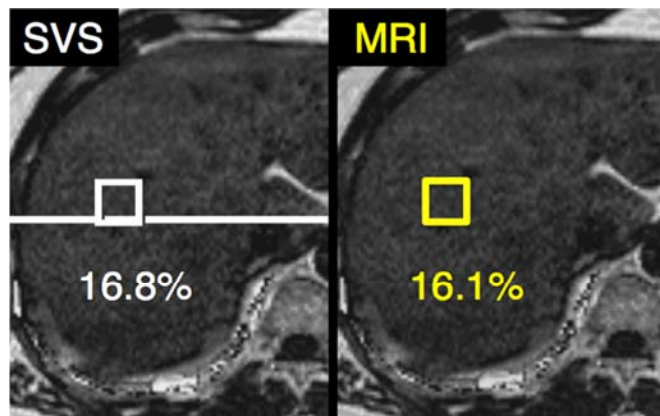


Figure 2: Example of agreement between PDFFF measured by single voxel spectroscopy (SVS) and the MRI method.

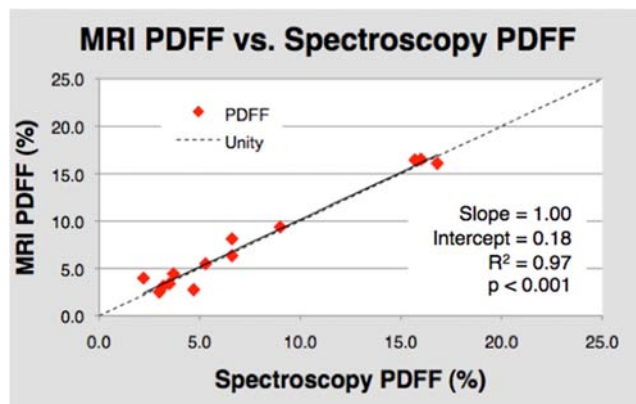


Figure 1: Correlation between proton density fat fraction (PDFFF) as measured using the MRI technique and single voxel spectroscopy.

Results

Results of the regression analysis are shown in Figure 1. There was excellent correlation between the PDFFF values measured using the two methods ($R^2 = 0.97$, slope = 1.00, intercept = 0.18). The Wilcoxon signed-rank test showed no statistically significance between the measurements ($p > 0.2$). There was no significant difference between the slope and 1 (95% CI = 0.88 to 1.12) or between the intercept and 0 (95% CI = -0.92 to 1.27).

A representative fat fraction image from one patient is shown in Figure 2, with PDFFF of 16.8% by spectroscopy and 16.1% by multi-echo MRI.

Discussion

Agreement between the two methods was very strong. The accuracy of the MRI method appears similar to what has been reported with other, well-validated techniques (1-3). The method presented here represents a hybrid technique which leverages the inherent advantages of both magnitude- and complex-data methodologies to arrive at a stable solution for the PDFFF. In addition, the presented method provides R₂* values for both the fat and water compartments, which may prove useful for

measuring the severity and distribution of iron deposition (though we did not examine those values in the current work).

Conclusion

The PDFFF measured using the hybrid technique agreed well with PDFFF measured by single voxel spectroscopy. This technique may have utility for quantifying hepatic steatosis and assessing response to treatment. MRI-based methods such as this one also have advantages over single voxel spectroscopy in that whole-liver coverage is possible, allowing assessment of the variability of disease within the liver as well as the total lipid burden.

References

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