Repeatability of MRI-based liver fat and iron quantification using a multistep adaptive fitting algorithm

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Target Audience

Clinical radiologists; abdominal MR radiologists

Purpose

Accurate and precise non-invasive quantification of liver fat and iron is an important emerging technique which holds promise for characterizing disease, assessing response to treatment, and estimating prognosis. Chemical-shift based MR imaging is suitable for routine clinical application because of accessibility, ease of use, and whole-liver coverage[1]. These techniques are evolving to become robust to MRI vendor, system, field strength, site, and operator. The recently described multistep adaptive fitting approach has been validated, however the robustness of proton density fat fraction (PDFF) and R_2* measurements focused on directly comparing agreement has not been established [2,3]. The purpose of this study was to assess the repeatability of simultaneous liver PDFF and R_2* measurements using the multistep adaptive fitting algorithm.

Methods

The local institutional review board approved this prospective study and waived the requirement for written consent. Between July 2014 and October 2014, 81 patients who presented for clinical abdominal MRI were enrolled. Abdominal MRI examinations were performed on a 3T MR system (Skyra, Siemens Healthcare), and a whole liver volume acquisition was achieved using a six-echo 3D spoiled gradient echo acquisition two times on the same day. The patients were removed from the scanner in between acquisitions and repositioned, to change the spatial relationships of the patient, coil, and main system. The torso array coil was disconnected/reconnected to a different plug in order to force the scanner to reacquire all adjustment data. Imaging parameters included: TR 8.9 ms, first TE 1.23 ms, FA 4^o, 6 echoes with ΔTE 1.23 ms. Inline image reconstruction was performed using the multi-step adaptive fitting algorithm, including T_2* correction, multi-fat-peak modeling, and the single R_2* value for fat and water. This algorithm uses a two-point Dixon method to obtain initial guesses for the fat and water signal fractions, and a seed value of 30 s^{-1} for the R_2* value. Then, Levenberg-Marquardt non-linear fitting is performed iteratively to update the fat/water fractions and R_2* values until a stable solution is reached. For the PDFF and R_2* measurements, 2.0×2.0 cm^2 regions of interest (ROIs) were placed on the first PDFF map, then duplicated onto the first R_2* map, then visually colocalized on the second PDFF and R_2* maps. Mean PDFF and R_2* values between the first and second acquisition were compared using the Wilcoxon signed-rank test, intraclass correlation coefficients (ICC), linear regression, and Bland-Altman analysis. $P < 0.05$ was considered to be statistically significant.

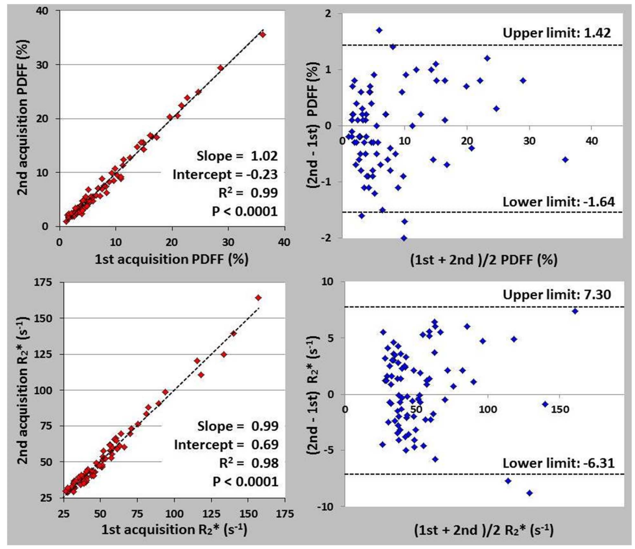

Figure 1: Linear regression and Bland-Altman plots comparing between first and second acquisition for the PDFF (upper row) and R_2* (lower row) measurements.

Results

For the PDFF and R_2* measurements, the Wilcoxon rank sum test showed no significant differences between the first and second acquisitions (p=0.16-0.25). Agreement of PDFF measurements between the two acquisitions was excellent (ICC=0.99, 95% CI=0.98-1.00) with strong correlation (R^2=0.98, slope=0.98, p<0.0001), and Bland-Altman analysis showed excellent agreement (Figure 1). Agreement of R2* measurements between the two acquisitions was also excellent (ICC=0.99, 95% CI=0.98-1.00) with strong correlation (R^2=0.98, slope=0.98, p<0.0001), and Bland-Altman analysis also demonstrated excellent agreement (Figure 1). Representative PDFF and R2* maps are shown in Figure 2, with similar values of PDFF and R_2* between the first and second acquisitions.

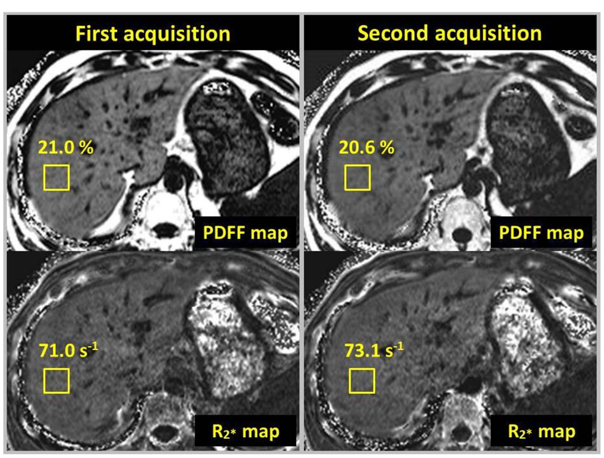

Figure 2: Example of PDFF and R_2* maps between the first and second acquisitions.

Discussion

MRI-based lipid and iron quantification of the liver is an efficient evaluation of those features of liver disease. In longitudinal clinical trials using the multistep adaptive fitting algorithm, changes in PDFF of +/-1.53% and changes in R_2* of +/-6.8 s^{-1} can be assumed to be due to actual tissue changes, rather than variability due to the technique, with 95% confidence.

Conclusion

The PDFF and R_2* measurements agreed well with both first and second acquisitions in the same patients. Simultaneous fat and iron quantification can be performed repeatably using this chemical-shift based MRI method.

References

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