Accuracy of liver fat quantification by CT, MRI and US: a prospective comparison with Magnetic Resonance Spectroscopy (MRS)

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Target audience: The presented work will be of interest for Clinicians and Radiologists interested in quantitative biomarkers for fatty liver disease.

Purpose: The hallmark feature of non-alcoholic fatty liver disease (NAFLD) is the accumulation of triglycerides within hepatocytes (steatosis), which can lead to inflammation, fibrosis, and cirrhosis [1]. Magnetic resonance spectroscopy (MRS) is widely considered to be the standard of reference for accurate non-invasive fat-quantification in the liver [2]. The purpose of this study was to evaluate the accuracy of quantitative confounder-corrected chemical shift-encoded MRI [3], dual-energy computed tomography (CT) and ultrasound (US) to quantify hepatic steatosis in comparison to MRS.

Methods: 31 patients (56±5 years, 13m/18f, 27±6 BMI) scheduled for non-contrast screening CT colonography (CTC) were recruited for this prospective comparative study. All patients underwent MRS, MRI and US within 2 hours of CTC. 3 MRS voxels were placed in the left and right lobes of the liver; CT, MRI and US measurements were subsequently co-localized (figure 1). For CT, attenuation (HU) and fat-density (FD) derived material decomposition of DECT images were recorded. For MRI, proton density fat-fraction (PDFF) measured from the quantitative chemical shift-encoded method (IDEAL-IQ) were recorded. For US, shear-wave velocity, signal-to-noise (SNR) and attenuation were also recorded. Data were analyzed using linear regression for each technique compared to MRS. 2-sided paired Student t-tests (0.05 significance level) were used to test the hypothesis that the slope coefficient is zero.

Results: There was excellent correlation between MRS-PDFF vs MRI-PDFF (r^2=0.88-0.97, $p<0.05$) and MRS vs CT-HU (r^2=0.83-0.91, $p< 0.05$). CT-FD showed moderate correlation with MRS-PDFF (r^2=0.40-0.50, $p<0.05$). None of the US based metrics showed reliable correlation with MRS-PDFF (r^2=0.15-0.56, $p>0.05$) (figure 2).

Discussion: This study was a comparative effectiveness study of three advanced non-invasive biomarkers of hepatic steatosis. Quantitative chemical shift encoded MRI and CT attenuation showed excellent correlation to MRS. Material decomposition with DECT (CT-FD) did not improve the accuracy of fat quantification over conventional attenuation. US had poor accuracy for liver-fat quantification.

Conclusion: MRI and CT-HU are accurate biomarkers of hepatic steatosis. Dual-energy material decomposition with CT does not improve the accuracy of CT for quantifying liver fat. US accesses liver stiffness but cannot be used to quantify fatty infiltration of liver tissue. A huge benefit of MRI and CT is the evaluation of the entire liver tissue instead of only small samples like in biopsy and MRS.

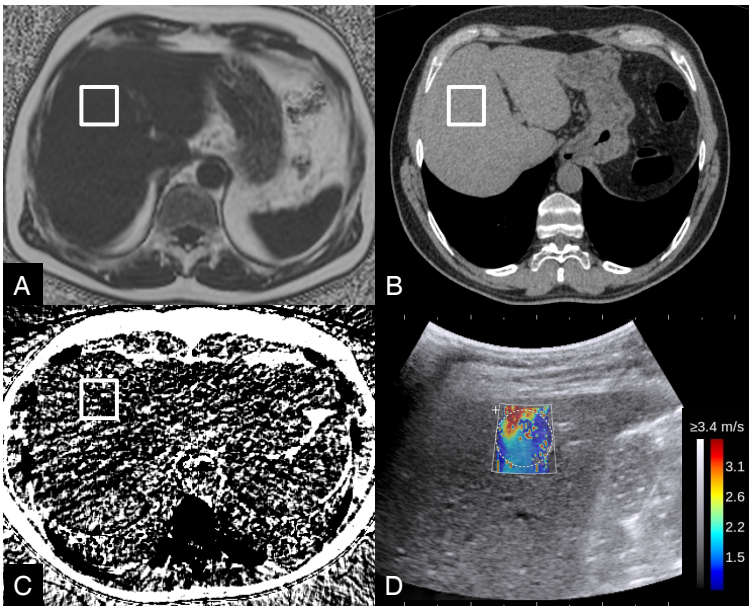

Figure 1: Representative images of a MRI PDFF (A), a CT-HU (B) and CT-FD (C) dataset as well as an US-SW measurement (D). Note the impaired image quality of the CT-FD dataset. Regions of interest co-localized by anatomical structures at different breathing positions.

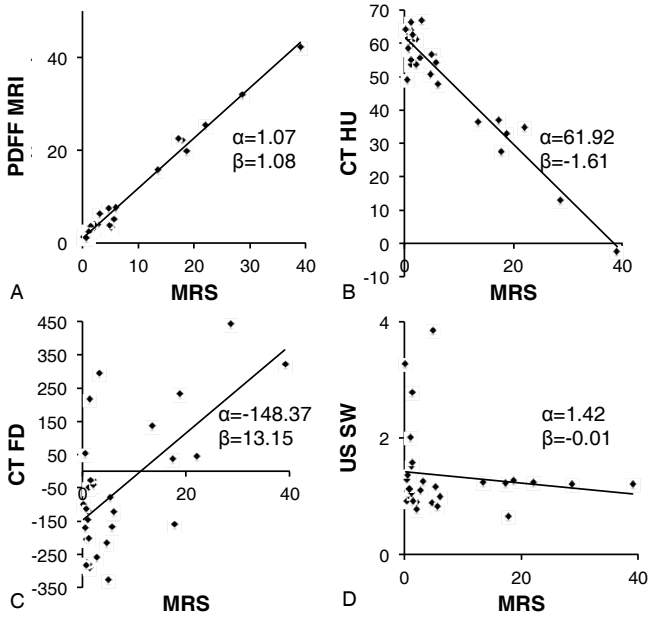

Figure 2: PDFF MRI shows excellent correlation to MRS (A). CT-HU and CT-FD show good and moderate correlation to MRS (B & C) whereas US features only poor correlation (D) to the accepted standard MRS. Representative plots from a region placed in the anterior part of the right lobe. (α: intercept, β: slope)

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