Calibration of confounder-corrected R2* for liver iron quantification at 1.5T and 3T: preliminary results

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Target audience: Basic and clinical researchers working on MR relaxometry or iron quantification.

Purpose: Accurate measurement of liver iron concentration (LIC) is needed for detection, staging and treatment monitoring of iron overload. MRI is very sensitive to the presence of iron, and several techniques based on either R2- or R2*-relaxometry have been proposed. R2-based techniques (eg: Ferriscan) (1) have been shown to be accurate at 1.5T, however they suffer from long acquisition times. R2*-based techniques (2-4) can be performed very rapidly (single breath-hold multi-echo 3D-SPGR for whole-liver coverage). However, R2* can be affected by several confounding factors: presence of fat, background B_0 variations and noise floor effects. It is not understood whether variations in acquisition parameters affect R2*-LIC calibration. In this work, we calibrated confounder-corrected R2*-based LIC quantification at 1.5T and 3T using multiple different protocols, with Ferriscan-LIC (1.5T) as the reference standard.

Methods: In accordance with the local IRB, 24 subjects (9 controls/15 subjects with liver iron overload, 13 men/11 women, age 12-70) were scanned at 1.5T (HDxt, GE Healthcare, Waukesha, WI), and 3T (GE MR750) at part of an ongoing study in 60 subjects. Spin-echo data at 1.5T were used as R2-based LIC (Ferriscan) reference to determine R2* vs LIC calibration curves (1). Single breath-hold, multi-echo 3D SPGR sequences (5) were acquired using four different protocols at both 1.5T and 3T: ***Protocol 1*** (axial 8mm slices, 6 TEs) 1.5T: TE_{init}=1.2ms, ΔTE=2.0ms; 3T: TE_{init}=1.2ms, ΔTE=1.0ms. ***Protocol 2***: (axial 6mm slices, 6 TEs) 1.5T: TE_{init}=1.2ms, ΔTE=2.0ms; 3T: TE_{init}=1.2ms, ΔTE=1.0ms. ***Protocol 3***: (coronal 5mm slices, 6 TEs) 1.5T: TE_{init}=1.2ms, ΔTE=2.0ms; 3T: TE_{init}=1.2ms, ΔTE=1.0ms. ***Protocol 4***: (axial 8mm slices), 1.5T: 12 TEs, TE_{init}=0.9ms, ΔTE=0.7ms; 3T: 8 TEs, TE_{init}=0.6ms, ΔTE=0.6ms.

R2* maps corrected for the presence of fat (by performing joint estimation of fat, water, and R2*), background B_0 variations (6), and avoiding noise floor effects (by using complex fitting) were generated for each acquisition. For each R2* map, a region-of–interest measurement (avoiding large blood vessels and bile ducts) was obtained from liver segment 7, which is generally homogeneous and free of artifacts. Linear regression was performed to construct calibration curves for R2* obtained with each of the 8 acquisition protocols, using Ferriscan-LIC as the reference.

Results and Discussion: Figure 1 shows calibration results between R2* and Ferriscan-LIC at 1.5T and 3T. Good correlation was observed, with similar calibration slope and intercept for all protocols at each field strength. Further, slopes at 3T were nearly half those at 1.5T, as expected (7).

Calibrations provided by this study have different slope than previous R2*-LIC calibrations (2-4). This discrepancy could be due to differences in R2* mapping algorithms, or differences in the reference standard, including variability of Ferriscan at high LIC (1). Excluding the highest Ferriscan-LIC value (19.2 mg Fe/g dry tissue), the slopes become nearly 0.032 and 0.016 at 1.5T and 3T, respectively (closer to previous 1.5T studies) (2,3). However, the fact that essentially identical calibrations were obtained with different protocols at each field strength (and consistent between 1.5T and 3T) suggests that R2* can provide accurate and robust liver iron quantification, as long as relevant confounding factors are addressed.

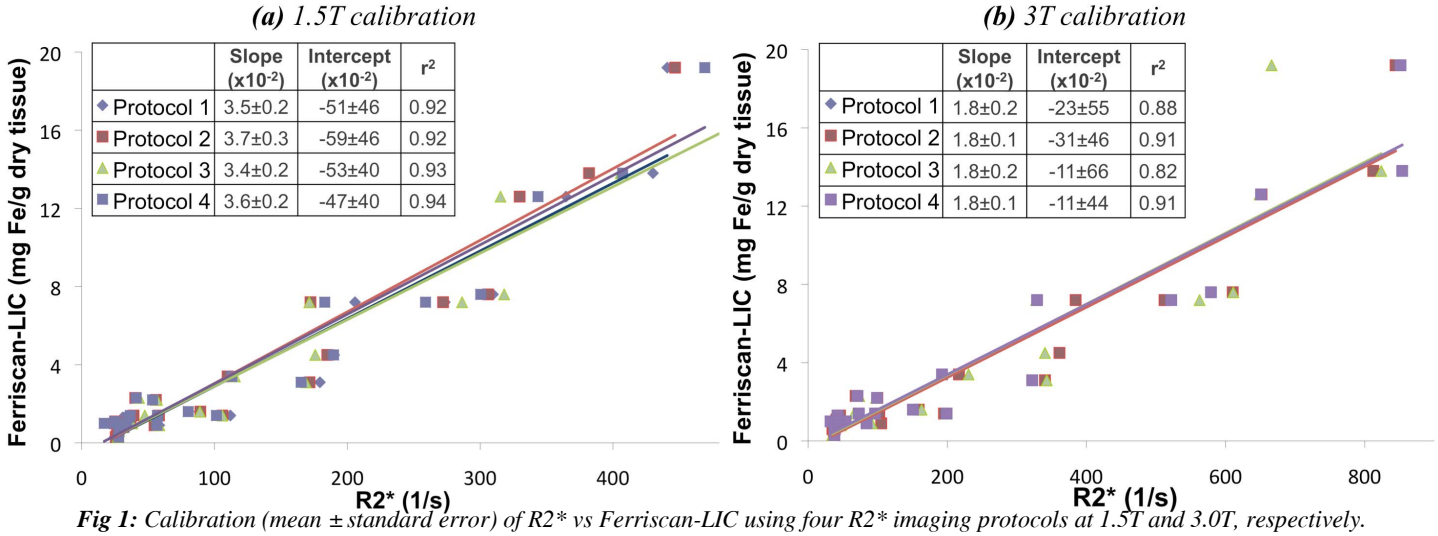

Fig 1: *Calibration (mean ± standard error) of R2* vs Ferriscan-LIC using four R2* imaging protocols at 1.5T and 3.0T, respectively.*

Conclusion: Confounder-corrected R2*-MRI is a promising technique for rapid, accurate, and robust liver iron quantification at both 1.5T and 3T.

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