R1 determination as an iron quantification method at 3T

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Target Audience Clinicians and engineers interested in imaging and quantifying the amount of iron in iron loaded tissues at 3.0 Tesla.

Purpose The use of MRI in tissue iron quantification is considered an essential component of clinical management. Currently, R2 and R2* imaging has been calibrated to quantify liver iron concentration (LIC). However, R2 and R2* imaging at higher field strengths are a challenge to use because of the rapid signal loss. R1 imaging can be used to quantify iron at 1.5T [1,2,3]. However, the relationship between R1 and iron is shallow and there is intrinsic inter-subject variability in baseline R1, making R1 less suitable than R2 or R2* for iron quantification. At higher field strengths, intrinsic R1 shortens and we propose that this might improve its discriminating ability. Thus, we are systematically comparing liver R1 values at 1.5 Tesla and 3 Tesla.

Methods All patients underwent abdominal MRI scans at 1.5T and 3.0T within three weeks of each other. Scans were acquired on a 1.5T Philips (Achieva, 8 channel torso coil, system 3.2.2) and a 3.0T Philips (Achieva, 16 channel torso coil, system 3.2.2). Liver R1 was measured using a Look-Locker sequence, field of view 30 – 40 cm, 48 x 64 matrix, slice thickness 10 mm, echo time 0.95 ms, bandwidth 4883 Hz/pixel, 7 degree flip angle, and 52 inversion times from 153 – 953 ms. Nine patients participated in this study and completed both examinations (4 male, 5 female, mean age of 19.9 +/- 7.4 with a range of 6 to 29 years old). Patients had thalassemia syndromes (n=4) and sickle cell disease (n=5). LIC was estimated at 1.5T using standard R2 and R2* techniques as previously described (Wood et al, 2005).

Results As seen in figure 1, R1 at 3T was highly correlated at the two field strengths (R^2=0.98), with a slope close to 4. This suggests that a quadratic relationship exists between the two field strengths. LIC estimates in these patients spanned from 0.9 to more than 50 mg/g (12.7 ± 14.1 mg/g). R1 could not be estimated at 3T for the patient with the highest LIC but was successful in a patient with an estimated LIC of 40.3 mg/g dry weight, more than double the capability of current R2* quantification techniques at 3T.

Discussion

We believe that R1 can be used at higher fields to discriminate and quantify iron in patients. It is known that the R1 of non-iron loaded tissues decrease modestly with field strength [4]. However, in our experiment there was a surprisingly profound increase in R1 in iron loaded liver tissue. Since iron appears to be a more powerful modulator of R1 at 3T, making fluctuations in intrinsic tissue R1 less important, R1 imaging may be a more viable method of determining LIC at higher field strengths. Liver R1 measurements were possible up to LIC values of 40 mg/g, suggesting that this can be used to extend the measureable dynamic range of LIC estimates at 3T.

Conclusion R1 measurements may represent a viable modality for LIC quantitation at 3T. Recruitment is ongoing for a sufficiently large sample size to develop a calibration curve and confidence intervals.

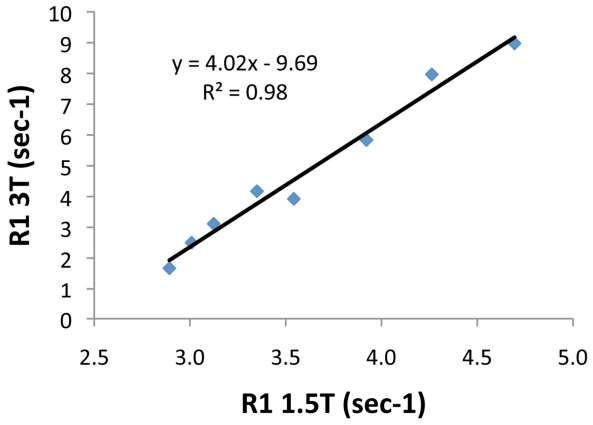

Figure 1 - R1 and 1.5 and 3T demonstrate a linear relationship. Due to the slope of 4, 3T-based measurements are more discriminating of iron load.

References [1] Ghugre et al, MRM, 54(5):1185-93, 2005 [2] Wood et al, Circulation, 112(4):535-43,2005 [3] Wood et al, Mag Res Med, 60(1):82-89, 2008 [4] Korb et al, MRM 48:21-26, 2002