A Comparison Study of Liver R2* Measurement in Pediatric Patients with Iron Overload

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INTRODUCTION

Iron overload is a common occurrence in children with thalassaemia major and sickle cell disease (due to frequent blood transfusions) or hereditary hemochromatosis. In this patient group, a non-invasive means to quantify iron is extremely attractive compared to conventional liver biopsy for determining total body iron. Recent advances in MRI have enabled non-invasive iron quantification [1,2] and a FDA-approved T2-based technique (FerriScan^{TM}) is currently available as a surrogate to liver biopsy. However, more validation data is needed on children, and a very rapid T2*-based acquisition would be even more valuable as sedation could be avoided. In this study, we assess the accuracy of a T2*-based approach to quantify liver iron overload in children and compare a widely used constant offset model against other models for analyzing T2* data.

METHODS

20 patients (age 13±5 years) with iron overload were enrolled in this IRB-approved prospective study. Axial T2 and T2* data were acquired on a 1.5T Siemens (Avanto). The T2 protocol used a multi-slice spin-echo sequence (TR=2500 ms, TE=6,9,12,15,18 ms); liver iron concentrations calculated from the T2 data by FerriScan were used as a reference standard. The T2* protocol employed a multi-echo gradient echo sequence (TR=500 ms, FA=60°, eleven echoes starting at TE=2.39 ms up to 30 ms). The T2* data were then analyzed on a pixel-wise basis using in-house software developed in Matlab (v.7.0). Two curve-fitting models were evaluated: a constant offset ($S=S_o e^{-TE \cdot R2^*}+C$, $R2^*=1/T2^*$) and a truncated model ($S=S_o e^{-TE \cdot R2^*}$), where points with SNR<2 were excluded from the fit [3]. All fitting employed Levenberg-Marquardt non-linear least-squares. ROIs were drawn on R2* maps at the same imaging plane as the FerriScan measurements, encompassing the entire liver and excluding blood vessels and ducts. The iron concentration for each patient was determined from the median R2* through the liver calibration curve described in [2].

RESULTS

Fig.1 shows an anatomical image and the corresponding R2* maps in the liver of a Thalassemic patient. A lower R2* is obtained from the truncated model compared to the constant offset model. This difference can be appreciated by looking at a typical T2* signal decay (Fig.2), where the offset model apparently fits all data points but is biased from the way it handles low SNR data at late echoes. Fig.3 compares in all patients the iron levels obtained from the T2* technique versus standard measurement. The constant offset model generally overestimates (slope=1.07), while the truncated model provides reasonable estimates (slope=0.95) up to moderate iron levels.
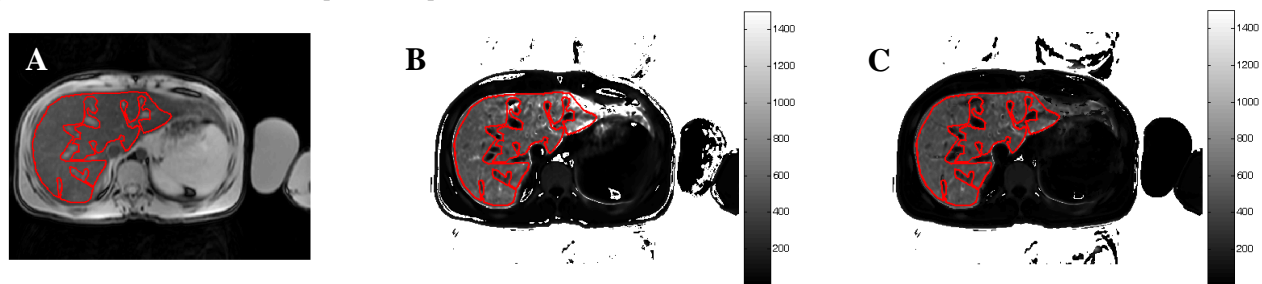

Fig. 1. Anatomical image (**A**) and R2* maps (Hz) derived from the constant offset model (**B**) and the truncated model (**C**). Note a slightly lower R2* in (C).
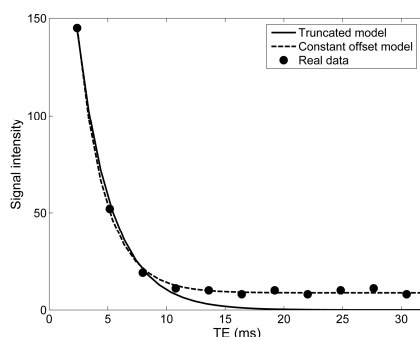

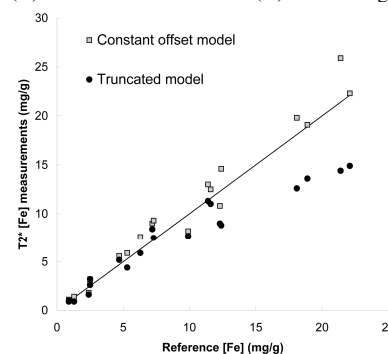**Fig. 2.** Fitting T2* signal decay with both the constant offset and truncated models.

Fig. 3. Comparison of T2* assessment of iron concentration [Fe] versus reference standard (FerriScan) in 20 patients. Line of identity is shown.

CONCLUSIONS

The present investigation demonstrates that a rapid T2*-based approach is as reliable as the accepted but much slower T2 technique for non-invasively quantifying liver iron levels in children with iron overload. Our results confirm other reports that the widely used constant offset model is robust to noise, but we show that it tends to overestimate the true iron content. On the other hand, a truncated model, which has been limited to cardiac iron assessment [3], does not overestimate and is accurate up to moderate iron levels. Further improvement in echo time selection and SNR can extend the R2* range of the truncated model. Future work will focus on optimizing the acquisition protocol and on-going validation.

REFERENCES: [1] St. Pierre et al. Blood 2005; 105:855. [2] Wood JC et al. Blood 2005; 106:1460. [3] He T et al. MRM 2008; 60:350.