Mixed-TSE with reduced flip angle TSE readouts: quantitative MRI accuracy and SNR vs. specific absorption rate (SAR)

R. P. Irving[1], O. Sakai[2], and H. Jara[3]

[1]Radiology, Boston University Medical Center, Boston, Massachusetts, United States, [2]Radiology, Boston University Medical Center, MA, United States, [3]Radiology, Boston Unversity, Boston, MA, United States

Purpose: It has been shown, in the context of weighted-MR imaging, that the use of refocusing flip angles (ref-FA) other than 180° in TSE sequences can be advantageous for reasons of imaging speed and specific absorption rate (SAR) without severely affecting SNR or contrast-weighting (**Ref.** 1). The purpose of this work was to study possible tradeoffs between quantitative accuracy, SNR and specific absorption rate (SAR) potentially arising when using ref-FA-TSE readouts in the context of quantitative MRI with the mixed-Turbo Spin Echo (mixed-TSE) pulse sequence (**Ref.** 2). Specifically to measure *in vitro* potential deviations from ref-FA=180° in quantitative PD, T_1, and T_2, when using reduced flip angle TSE readouts.

Methods: We scanned a multi-compartmental phantom consisting of aqueous solutions of sucrose and solutions of guar gum fiber in addition to several common laboratory liquids (copper sulfate, ethanol, isopropyl alcohol, and acetone). These compartments were immersed in a room-temperature water bath in order to improve the homogeneity of the magnetic field surrounding the chambers. Four scans were performed at 1.5T (Philips Medical Systems, Intera MRI scanner) using the mixed-TSE pulse sequence. Scans differed only in the nominal refocusing flip angle of the TSE readout trains, specifically: 180° (SAR 3.7 W/kg), 150° (3.4 W/kg), 130° (2.7 W/kg), and 110° (2.0 W/kg). Quantitative maps of PD, T_1, and T_2 were generated from each scan using model conforming Q-MRI algorithms developed in-house in the MathCAD 2001i (Mathsoft, Cambridge, MA) programming environment. ROI analyses were performed on all maps for all vials.

Results: Visual inspection of Q-MRI maps generated with the four scans reveals that PD and T1 (see **Fig.** 1) map quality is nearly unaffected by reducing the FA of the TSE readouts down to FA=110 °. T_2 maps are minimally affected down to FA 130°; image quality degradation is visually apparent 110°. Results of ROI analysis are shown in **Fig** 2.

PD Measured PD Q-MRI deviations relative to ref-FA 180° do not exceed 3% for all fluid and ref-FA studies (**Fig** 2 top).

T_1 Measured T_1 deviations relative to ref-FA 180° do not exceed 5% for all fluid and ref-FA studies (**Fig** 2 middle). Paradoxically ref-FA 150° produces larger deviations than the lower two ref-FA's. Glycerol was the exception because of its extremely short T_1 (shorter than the echo trains); quantitative values for glycerol's T_1 are not shown in the graph.

T_2 Overall, T_2 deviations relative to ref-FA 180° are more significant than for the other two Q-MRI parameters studied. Specifically in the range $250<T_2<1250$ms in which deviations of up to 30% are measured for the ref-FA 110° (**Fig** 2, bottom).

Conclusion: Reducing the SAR --from 3.7 W/kg to 2.0 W/kg-- of mixed-TSE scans by reducing the refocusing flip angle of the TSE readouts leads to very small deviations in PD and T_1 (<5%) relative to ref-FA = 180°. At 2 W/kg SAR, algorithm corrections may be needed for applications requiring high T_2 accuracy. This could have implications in the conversion of QMRI protocols to stronger field systems (≥3T) as well as for pediatric populations.

References

1. Alsop, DC. The sensitivity of low flip angle RARE imaging. *Magn Reson Med.* 37, 2:176-184
2. Jara, H, Sakai, O, Mankal, P, Irving, RP, Norbash, AM. 2006. Multispectral quantitative magnetic resonance imaging of brain iron stores: a theoretical perspective. *Top Magn Reson Imaging* 17 1:19-30

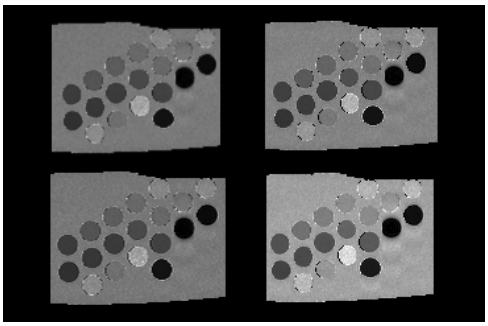
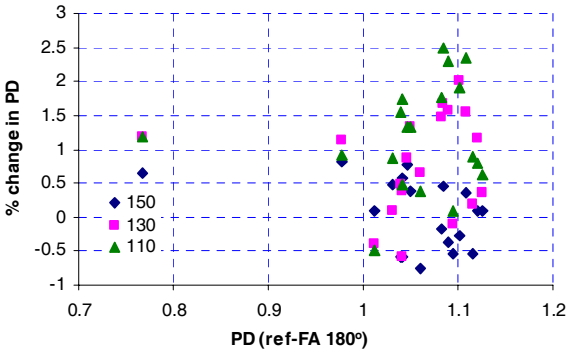
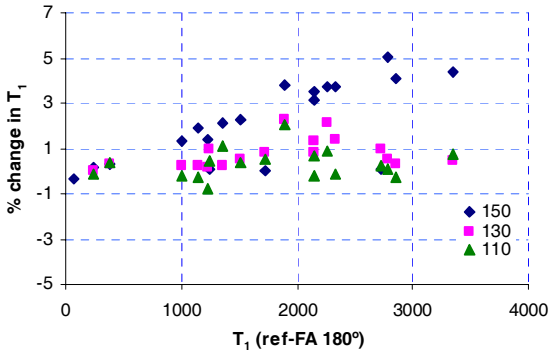


Fig 1: T_1 maps from data acquired with ref-FA 180° (upper left) 150° (upper right), 130°(lower left) 110° (lower right).





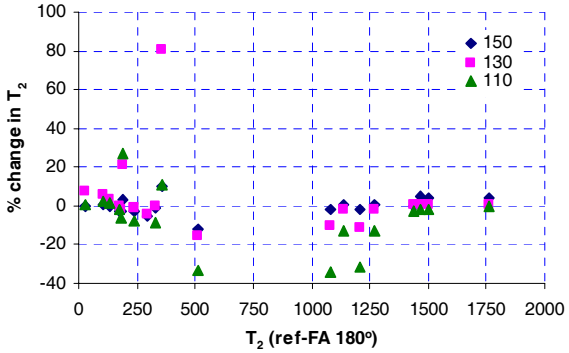


Fig 2. Percent changes in Q-MRI values compared to the value obtained at ref-FA 180° as a function of ref-FA and the value obtained at ref-FA 180°. Top: PD, middle: T_1, bottom: T_2.