Effect of Different T_1 Mapping Techniques on a Quantitative Magnetization Transfer MRI Biomarker for Myelin Density

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Introduction

- The quantitative MT (qMT) parameter F (macromolecular pool size ratio) correlates strongly with histological measures of myelin in post-mortem MS brains[1].
- T_1 maps, required for qMT, have recently been observed to vary in white matter (WM) between three commonly used methods at 3T[2].
- Literature WM T_1 values also vary across scanners and sites.
- This study investigated the **effect of three different T_1 mapping techniques on the qMT parameter F**, a biomarker for myelin density, **in white matter of healthy subjects**.

Methods

- Siemens 3T Tim Trio MRI system, 32-channel head coil
- 6 healthy adult volunteers
- Single slice, AC-PC orientation, slightly above the corpus callosum (2x2x5 mm^3)
- White matter tissue masks: 1x1x1 mm^3 MP-RAGE classified using INSECT[3] (WM, GM, CSF). WM masks were resampled to match the qMT slice using a majority voting algorithm.

Pulse Sequences

- B_0 → Two-point GRE phase-difference method
- B_1 → Double angle method
- T_1 → Three methods compared: Inversion recovery (**IR, gold standard**), Look-Locker (LL), and Variable Flip Angle (VFA)
- qMT → Spoiled GRE optimal 10-point protocol[4], Gaussian-Hanning MT pulses, Sled and Pike qMT model[5]

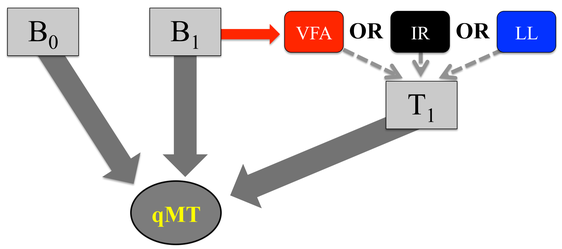

Figure 1. Quantitative MRI protocol processing hierarchy.

Results

Figure 2 shows a single-subject comparison between WM T_1 maps produced using three T_1 mapping methods (IR, LL, VFA), and the qMT F maps produced using each T_1 map.

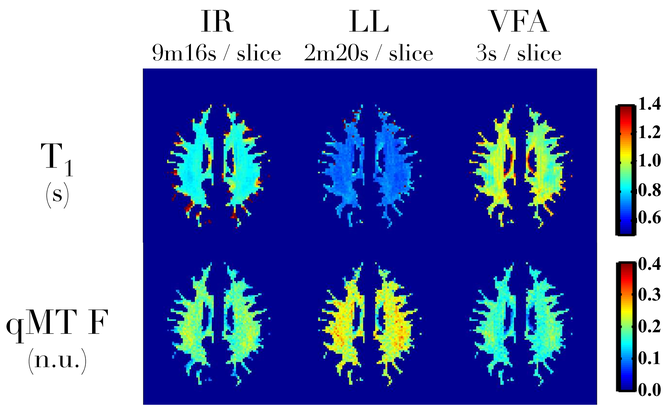

Figure 2. WM T_1 maps T_1 (IR, LL, VFA) and qMT F maps of a healthy adult subject.

Results

Figure 3a shows the pooled 6-subject WM T_1 histograms for IR (black), LL (blue) and VFA (red). Figure 3b shows the pooled WM F histograms depending on the T_1 method used. The T_1 values for each method agree with previously reported values[2]. The differences in F between methods were modest in comparison to those observed in T_1.

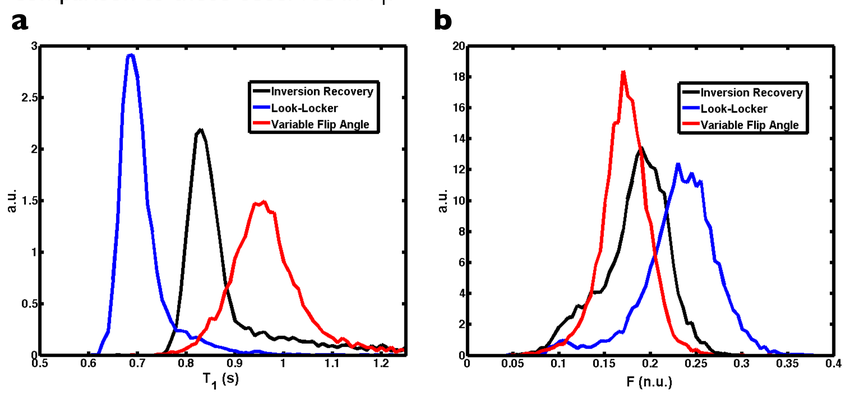

Figure 3. WM T_1 (IR, LL, VFA) and qMT F pooled histograms for 6 subjects.

Results

Table 1 shows the pooled mean, pooled standard deviation, and intersubject standard deviation of F. Relative to IR, LL overestimated F by 27%, and VFA underestimated it by 5%. The pooled VFA histogram was 25% narrower than IR, which which cannot be explained by intersubject variations in F.

Table 1. Statistics of WM F values for 6 subjects using 3 T_1 methods.

T_1	Pooled F Mean	Pooled F SD	Intersubject F SD
IR	0.182	± 0.036	± 0.005
LL	0.232	± 0.041	± 0.008
VFA	0.172	± 0.027	± 0.004

Pooled F SD is the standard deviation of the pooled F values (Figure 2b).
Intersubject F SD is the standard deviation of the mean F between subjects.

Discussion

- Overestimations in WM T_1 measured with VFA (relative to IR) resulted in a 5 % reduction in mean qMT F values (Table 1).
- The 6-subject pooled WM VFA T_1 distribution is broader than IR (Fig. 3a), the VFA F distribution was 25% narrower (Fig. 3b).
- Unlike LL and IR, VFA requires a B_1 map, thus inaccuracies in B_1 propagate through two pathways into F when using VFA.
- These results suggest that VFA may be a better alternative compared to LL for fast qMT mapping, and that gold standard IR T_1 values should be reported when using alternative T_1 methods.

Summary

- This work explored the effect of three different T_1 mapping techniques on the qMT parameter F, a biomarker for myelin density, in white matter of healthy subjects.
- VFA underestimated WM F by 5 % relative to IR, and LL overestimated F by 27 %.
- MS Researchers using qMT should report typical IR gold standard healthy WM T_1 values for their site/scanner when other methods such as VFA are used.

References: [1] K. Schmierer et al., J. Magn. Res. Imag. 26:41-51 (2007) [2] N. Stikov et al., *'Validation of T_1 Mapping Techniques: Are Phantom Studies Sufficient'* Proc. of ISMRM (2012) [3] L. Collins et al. IPMI 1999, LNCS, Vol. 1613, Springer, Heidelberg 210-223 (1999) [4] Levesque I. et al, Magn. Res. in Med 66:635-643 (2011) [5] Sled J. and Pike G. B., MRM 46:923-931 (2001)

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