Methods for Myelin Water Imaging

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PURPOSE: Myelin water imaging (MWI) provides a unique contrast for assessing myelination changes in cerebral white matter *in vivo*. We will review the basic concepts of MWI and the various acquisition and analysis strategies for MWI. The assumptions, advantages and limitations of each method will be discussed.

OUTLINE OF CONTENT:

Background: Myelin-associated lipids have short T_2 times (10 μs < T_2 < 1 ms), resulting in a signal that decays too quickly for direct detection using conventional imaging methods. However, myelin has been indirectly imaged using techniques, such as multiexponential T_2 (MET_2) imaging, that exploit the relaxation behaviour of myelin-associated water. T_2 relaxation data, y_i, measured at times t_i, can be described in terms of a multiexponential T_2 decay model: $y_i = \sum_{j=1}^{M} s_j\, e^{-t_i/T_{2,j}}$, where M is the number of logarithmically spaced T_2 times and s_j is the unknown amplitude of the spectral component at relaxation time $T_{2,j}$. The most commonly used fitting algorithm, non-negative least squares (NNLS), can provide a distribution of T_2 components that best fit the data. A summation over all T_2 components provides a relative measure of total water content, and the myelin water fraction (MWF) can be estimated by dividing the portion of the signal with 0 ms < T_2 < 50 ms by the total water content.

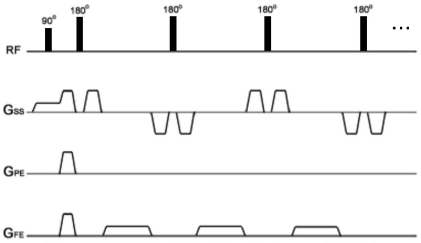

Fig. 1. Multi Echo Spin Echo Sequence (MESE)

Reference Method: The most commonly used sequence for MET_2 mapping is a single-slice multi-echo-spin-echo (MESE) sequence[1]. The sequence consists of a slice-selective 90^0 pulse, a series of non-selective composite RF pulses for spin refocusing and slice-select crusher gradient pulses of alternating sign and decreasing amplitude on either side of each 180^0 pulse for dephasing of flow effects and elimination of contributions from stimulated echoes and contributions from outside the selected slice[2].

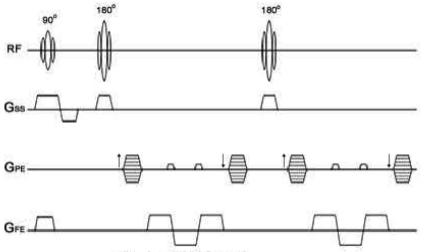

Fig.2. GRASE MRI sequence

3D GRASE: This combined gradient and spin echo sequence uses three, or more, gradient echoes on either side of a spin echo to acquire multiple lines of *k*-space per excitation. Whole-brain MWF maps can be generated using multicomponent analysis of the acquired T_2 decay data[3].

T2-PREP: T_2 decay can also be measured using T_2-preparation (T_2-prep) blocks[4,5]. A T_2-prep block begins with an excitation pulse, is followed by a series of refocusing pulses, and ends with a "flip-back" pulse, leaving the longitudinal magnetization "prepared" with a certain degree of T_2 weighting (dictated by the number of refocusing pulses in the T_2-prep block). Following another excitation pulse, the magnetization can then be sampled. For each repetition, the number of refocusing pulses (during the T_2-prep block) is increased, allowing one to sample the decay of the transverse magnetization at different time points.

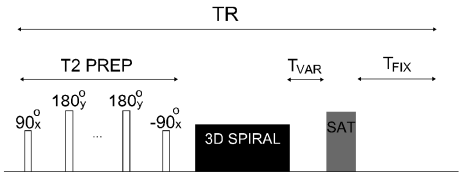

Fig. 3. T2-Prep 3D Spiral Sequence

MGRE: MWF images have also been obtained using multicomponent analysis of T_2^* decay obtained from multi-gradient-echo (MGRE) sequences[6,7].

Multicomponent driven-equilibrium single-pulse observation of T_1 and T_2 (mcDESPOT): MWF maps are obtained by a fitting data acquired with the DESPOT1 and DESPOT2 sequences with a two-pool model of longitudinal and transverse relaxation that includes inter-compartmental water exchange[8].

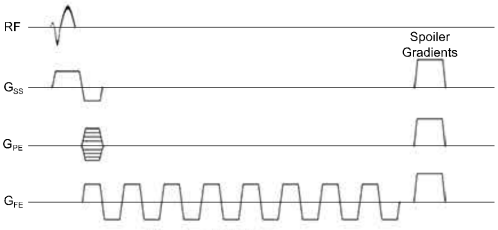

Fig. 4. MGRE Sequence

Linear Combination: By acquiring spin-echo images (at echo-times that are optimized for intra/extra-cellular water and cerebrospinal fluid attenuation) and linearly combining them to generate a short T_2-weighted image (A) and a uniform T_2-weighted image (B), one can obtain a MWF image by taking the ratio of A to B[9].

SUMMARY: In this e-poster we review the major methods of MWI and summarize their advantages, limitations and notable findings.

References: 1. MacKay et al. MRM 1994;31:673-677. 2. Poon and Henkelman JMRI 1992;2:541-553. 3. Prasloski et al. NI 2012;63:533-539. 4. Oh et al. MRI 2006;24:33-43. 5. Nguyen et al. MRM 2012;67:614-621. 6. Hwang et al. NI 2010;52:198-204. 7. Lenz et al. MRM 2012;68:523-528. 8. Deoni et al. MRM 2008;60:1372-1387. 9. Vidarsson et al. MRM 2005;53:398-407.