Analysing mcDESPOT data with an arbitrary number of T2 components

Jing Zhang[1] and Alex L. MacKay[1,2]

[1]Department of Radiology, University of British Columbia, Vancouver, British Columbia, Canada, [2]Department of Physics and Astonomy, University of British Columbia, Vancouver, British Columbia, Canada

Target audience Those working with MR techniques for measuring myelin content.

Purpose Multicomponent driven equilibrium single pulse observation of T_1/T_2 (mcDESPOT) is a myelin water fraction mapping technique and it has been applied for detection of demyelination in MS lesions and NAWM[1]. mcDESPOT derives two-component relaxation information from spoiled and fully balanced steady-state (SPGR and bSSFP) imaging data acquired over multiple flip angles. However, the two water-pool model may be inadequate to address the complex nature of water pools in brain. In this study, we tested a model containing an arbitrary number of T_2 components using a non negative least squares algorithm.

Methods Conventional mcDESPOT measurements were performed on a 3.0T whole body MR scanner (Achieva 3.0T, Philips Medical Systems, Best, The Netherlands) using an eight-channel phased-array head coil for reception and the internal quadrature body coil for transmission. Three steps were taken in the analysis of the data: a) DESPOT-HIFI to obtain single component T_1 and B_1 maps[2]; b) DESPOT-FM to obtain the B_0 map[3]; c) with known T_1, B_1 and B_0 maps, a multi-component T_2 (40 T_2 times from 5ms to 2 second) relaxation model was introduced to fit the mcDESPOT curve using the nonnegative least-squares algorithm[4].

Results An example of a T_2 distribution from a brain tissue (genu of corpus callosum) is shown in Figure 1. Three different water environments can be observed in this T_2 distribution: myelin water, intra/extracellular water, and CSF. Myelin water fraction (MWF) was calculated by MWF=myelin water / total water and we assumed the signal range lower than 10ms was the myelin water signal. The calculated MWF map from the T_2 distributions is shown in Figure 2. The MWF analyzed by the conventional mcDESPOT method is also shown in figure 2 for comparison.

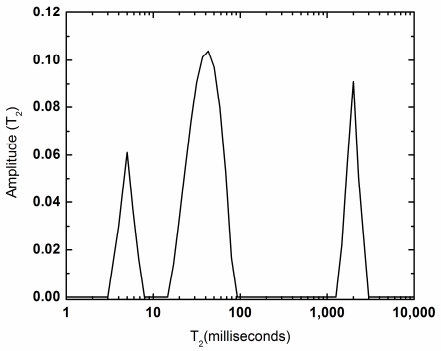

Figure 1. Representative T_2 distribution from brain tissue derived from the nonnegative least squares algorithm for

Discussion The multi-component T_2 distribution showed three pools, suggesting that a two-pool model may be inadequate for addressing the complex water distribution in brain. The MWF map created from T_2 fitting of mcDESPOT curve showed significant lower MWFs compared to values arising from the conventional two-pool model mcDESPOT analysis. Unlike for the case for the two pool model fits of the mcDESPOT data, the myelin maps created by NNLS did not exhibit evidence of MWF being constrained at the parameter limit. We did not consider the possibility of magnetization exchange with the multi-component T_2 distribution model; however, exchange is believed to play a minor role the determining the MWF in the two pool model fit.

Conclusion In this work, we analyzed mcDESPOT data using a T_2 relaxation model with an arbitrary number of components. The results show that a two pool model may be unable to describe the complex water environments found in brain. MWF values obtained the NNLS T_2 distribution of mcDESPOT were smaller and closer to values obtained from the literature[4].

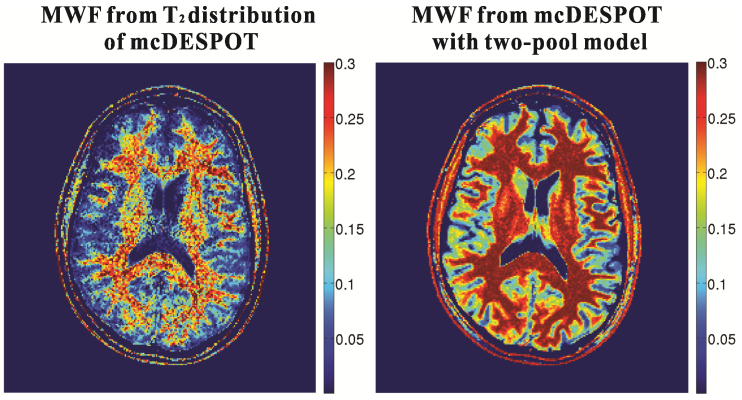

Figure 2. Representative axially-oriented slice through the myelin water fraction from T_2 distribution and two-pool model of mcDESPOT.

References

1. Deoni SCL, Rutt BK, Peters TM. Rapid combined T1 and T2 mapping using gradient recalled acquisition in the steady state. Magnetic Resonance in Medicine. 2003;49:515–26.
2. Deoni SCL, Transverse Relaxation Time (T2) Mapping in the Brain With Off-Resonance Correction Using Phase-Cycled Steady-State Free Precession Imaging. Journal of Magnetic Resonance Imaging. 2009; 30: 411-417.
3. Deoni SCL, High-Resolution T1 Mapping of the Brain at 3T with Driven Equilibrium Single Pulse Observation of T1 with High-Speed Incorporation of RF Field Inhomogeneities (DESPOT1-HIFI). Journal of Magnetic Resonance Imaging. 2007;26:1106-1111.
4. Whittall KP, MacKay AL, Graeb DA, Nugent RA, Li DK, Paty DW, In vivo measurement of T2 distributions and water contents in normal human brain. Magnetic Resonance in Medicine. 1997; 37: 34-43.