Variation of Myelin Water Fraction as a Function of TR

Saeed Kalantari[1], Nazanin Komeilizadeh[2], Irene Vavasour[1], Ramin Sahebjavaher[3], and Alex MacKay[1]
[1]UBC MRI Research Centre, Vancouver, BC, Canada, [2]Simon Fraser University, Burnaby, BC, Canada, [3]Department of Electrical and Computer Engineering, UBC, Vancouver, BC, Canada

Introduction: The myelin water signal from human brain has previously been measured *in vivo* (1). The myelin water fraction (MWF, the proportion of water in brain which has a short T_2 time) is quantitatively correlated to histological staining for myelin in central nervous system tissue (2–4) and hence is considered an *in vivo* measure of myelin content. The main goal of this preliminary study was to investigate the behavior of the measured MWF as a function of TR_{eff} in human brain in vivo. (For multi spin echo sequences the effective TR, TR_{eff}, is the length of time from the last 180˚refocusing pulse to the beginning of the next sequence). Making MWF available in a clinical time frame may require the use of shorter TR times and consequently exposure of the acquired T_2 decay curve to T_1-weighting. Therefore a comprehensive understanding of T_1 relaxation in brain, specifically white matter, has become crucial. The results were expected to address two key questions: 1) Does the measured MWF in white matter depend upon TR_{eff}? 2) Would this experiment enable us to distinguish between fast MW/IEW exchange, which should presumably yield a largely TR_{eff} -independent MWF, and slow MW/IEW exchange, which should lead to an increase in MWF as TR_{eff} is shortened?

Methods: Five normal volunteers (average age = 37.2 years) underwent MR examinations twice on a 3.0-T MR scanner. A multi echo T_2 sequence with 32 spin echoes was repeated at five TR_{eff} times: 165 ms, 265 ms, 365 ms, 565 ms, and 665 ms. A 32 echo sequence was designed to include 16 pulses at echo spacing 10 ms to ensure the capability of measuring the myelin water signal followed by 16 pulses at echo spacing 50 ms. Other multi-echo imaging parameters were: number of slices = 7, slice thickness = 5 mm, FOV = 24 cm, matrix size = 256 x128. The scan time was ~ 13 min for the shortest TR_{eff} of 165 and ~ 42 min for the longest TR_{eff} of 665 ms. For each subject, data acquisition was carried out in two sessions 2-5 days apart. Each subject's images were registered to the TR_{eff} = 665 ms data using FLIRT (5). Regions of interest (ROI) were drawn for five white matter structures: splenium (SP), genu (GU), posterior internal capsules (IC), major forceps (MJ), and minor forceps (MN) and the T_2 decay curve at each ROI was extracted. These T_2 decay curves were analyzed using a NNLS algorithm (6).

Results: Myelin water fraction (MWF) values from each of the five investigated ROI measured at each TR_{eff} depicted in figure 1 show the MWF is a sensitive function of TR_{eff} with increases between the longest and the shortest TR_{eff} of 154 % to 172%.

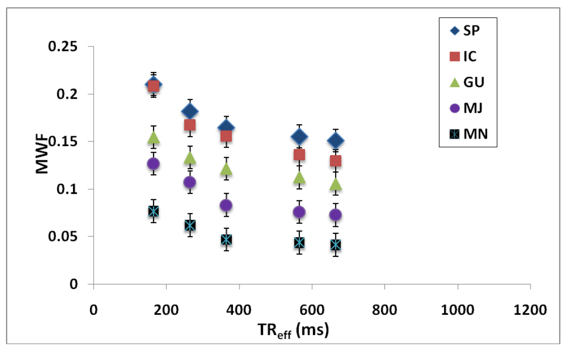

Figure 1. MWF at various TR_{eff}. Standard errors are shown as error bars.

Discussion & Conclusion: The major finding of this study is the demonstration that the measured myelin water fraction increased appreciably with decreasing TR_{eff} when TR_{eff} was shorter than about 600 ms. As the drive to reach faster MWF imaging with whole brain coverage may result in sequences with shorter TR times, it should be noted that going below the 600 ms TR_{eff} threshold could be problematic. We speculate that white matter may present a hybrid behavior (7) which accounts for both the short and long TR_{eff} regimes of the curves. The short TR_{eff} behavior could also arise from cross-relaxation with non-aqueous protons (because the two spin systems are not in equilibrium after the 90˚RF pulse) or it could arise from myelin water protons with a short T_1 time. The long TR_{eff} regime can be accounted for by regions of myelin in which myelin water and intra/extracellular water undergo fast exchange on the T_1 time scale.

References

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