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Myelin water fraction and exchange mapping with phase-cycled balanced steady-state free precession MRI

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Myelin water imaging (MWI) is an important tool for quantifying white matter content in the brain. Traditional MWI methodology uses multi-echo spin echo (MESE) data and non-negative least squares regression to estimate myelin water fraction (MWF) [1]. Another biomarker of interest is the rate of exchange between myelin and non-myelin water [2]. Quantification of this exchange rate is of interest because it may be a complementary biomarker to MWF and because the presence of this exchange may cause traditionally estimated MWF to underestimate the amount of myelin [3]. Prior studies have quantified the myelin water exchange rate in white matter tissue using relaxation-exchange spectroscopy [4] and steady-state methods such as mcDESPOT [5]. We expand upon this work to jointly estimate myelin water fraction and exchange using a two-compartment balanced steady-state free precession (bSSFP) signal model by including bSSFP scans with multiple (beyond 0° and 180°) phase-cycling factors to aid the precision of the parameter estimates. We tested our method using simulations, well-characterized phantoms, and brain tissue samples with Alzheimer's Disease pathology scanned using a 7T Varian/Agilent small-animal scanner. We examined the coefficients of variation of these estimates to evaluate their precision. Our next steps include examining correlations between MESE-based and bSSFP-based estimates with myelin-sensitive histological metrics in the tissue samples.

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