Characterization of ultrashort T2* components in brain myelin
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Introduction

Myelin plays an important role in normal development, facilitating rapid neuronal signaling over short distances. Loss or abnormal myelination leads to neurodegenerative orders such as multiple sclerosis and Alzheimer's disease. Ex vivo studies have shown the potential of a new imaging biomarker in brain myelin arising from methylene protons associated with the myelin membrane, offering a new way to image myelin directly. Here, we characterized this "ultrashort" component using a novel ultrashort echo time (UTE) relaxometry method. Components of the signal such as magnitude, relaxation time, and frequency shift were measured in healthy volunteers. When fit to a multi-component signal model, we found significant variations in the ultrashort component fraction and frequency shift in different brain regions as well as lower measured T1 values suggesting that these components are associated more directly with myelin bound methylene protons.

Methods

Whole brain relaxometry was performed on a GE MR750 3T MRI scanner using a 3D UTE pulse sequence with a non-selective hard pulse excitation. The delay between excitation and readout was shifted between TRs to acquire 8 different sets of TEs within a single scan ranging from: 24μs to 4.4ms. UTE scans were taken at multiple flip angles (6, 12, and 18 degrees) and T1 maps were calculated using the variable flip angle method. All sets of data were reconstructed at water and fat frequencies to correct for off-resonance blurring. The data were fit to a multi-component signal model to estimate the ultrashort fractional component (ratio between fat component and water component signals), component relaxation times (T2* and T1), and frequency shifts.

Results and Discussion

Ultrashort-T2 fractional component was significantly higher in both corticospinal tracts compared to white matter in the XY plane (e.g. corpus callosum, internal capsule, post-thalamic radiation). We hypothesize that the significantly elevated fractional component values in corticospinal tract are due to 1) high myelin volume per axon and 2) high density of axons in the chosen ROI. No significant differences in measured T2* relaxation times between any of the brain regions were observed. The frequency shift in the corticospinal tract and body and splenium corpus callosum was significantly lower compared to other white matter tracts in the XY plane. Additionally, measured T1 values associated with the ultrashort (fat) component were significantly lower compared to T1 values associated with the long component (water) suggesting that this signal is originating from myelin bound methylene protons.

Conclusion

This work presents a characterization study of ultrashort-T2* components (methylene myelin protons) in the brain using a novel ultrashort echo time (UTE) relaxometry method. Future studies should include experiments from more volunteers and B1 correction to get better representative T1 values. These characterizations will help optimize future ultrashort-T2* component MRI studies and eventually serve as a better marker for imaging and characterizing myelin in various disease states.