High Resolution $^1$H MRI of Postmortem Human Brain Sections Performed at 21.1 T

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**Introduction**

In this study, the first quantitative MRM evaluations of human pathological tissue at 21.1 T, the highest magnetic field available for MRI, are presented. This field strength provides improved sensitivity and enhanced contrast, particularly for those mechanisms that exploit differences in magnetic susceptibility between tissues and pathologies. Specimens harvested from human patients displaying differing degrees of Alzheimer and Parkinson related pathology were analyzed.

**Experimental**

Prior to imaging, fixed postmortem human samples of *substantia nigra* (SN), *globus pallidus* (GP) and hippocampus (HC) were washed in phosphate buffered saline (PBS) and immersed in Fluorinert (FC-43, 3M Corp). All MR data were acquired using a 21.1-T vertical magnet equipped with a Bruker Avance III console and Mini0.75 gradient system. Utilizing a 33-mm birdcage coil, high resolution $^1$H scans were acquired at 14°C. Three-dimensional Fast Low Angle Shot (FLASH) scans were acquired over 4 hours at the isotropic resolution of 50 $\mu$m. $T_2/T_2^*$ relaxation were quantified using multi-slice spin-echo sequences (MSSE) and multiple gradient echo (MGE) sequences at a resolution of 100x100x550 $\mu$m.

**Results and Discussion**

3D micrographs of neurodegeneration display heterogeneity in MRM contrast that appears related to iron distribution, particularly for specimens expressing higher degrees of Parkinsonism. Meanwhile, Alzheimer’s specimens displayed pronounced alterations in tissue microstructure. Pathological sections of SN and GP demonstrate a significantly stronger $T_2/T_2^*$ contrast in the structures and surrounding fiber tracts, possibly due to accumulation of iron. Pyramidal tracts of the brainstem demonstrate $T_2/T_2^*$ increases for all pathologies compared to controls. The putamen shows decreased $T_2$ while the external GP displays decreased $T_2^*$ for all pathologies. Statistical significance also was found between hippocampal control sections and all other pathologies for $T_2$ in gray matter and CA1, while $T_2^*$ values display significance in CA2 and 3. Parametric maps (Fig 1B&C) display additional differences between pathologies not evident from an ROI analysis.

**Conclusions**

Because of its specificity and spatial resolution, histological and immunological staining continue to be the standard for pathological evaluation. However, MRM offers additional complementary information that is disease specific and possibly elucidates severity. Quantitative analysis of relaxation proved very sensitive in identifying control versus pathological tissue, while parametric mapping demonstrated the potential for categorizing severity. As a pathological tool, MRM has potential to elucidate the extent and severity of such neurodegeneration.

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**References**