Changes in Multiple Sclerosis Over 6 Months As Seen With T2 Relaxation and Diffusion Histograms

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Introduction: Using multi-component T_2 relaxation, the myelin water fraction (MWF, which reflects myelin content[1-3]) and the geometric mean T_2 of the intra/extracellular water pool (GMT_2) can be calculated[4, 5]. MWF and GMT_2 provide information about multiple sclerosis (MS) which is complementary to other techniques, such as diffusion tensor imaging (DTI)[6]. In this study, comparisons between histograms derived from normal white matter (NWM), normal appearing white matter (NAWM) and MS lesions were made over a 6 month interval.

Methods: *MR Experiments:* Twelve subjects with relapsing-remitting MS (9F/3M; median EDSS = 3.5; mean age = 48yrs; mean disease duration = 10yrs) and 12 healthy age and gender matched controls were scanned at month 0 and 6 on a Philips Achieva 3.0T system. The 3D T_2 relaxation sequence utilized a 90º excitation pulse followed by 32 slab-selective refocusing pulses flanked by gradient crusher pulses (7 slices, 32 echoes, TR = 1200ms, voxel size = 0.94x1.88x5mm, 10ms echo spacing)[7]. The DTI data, centered at the same location as the T_2 relaxation scan, used a single-shot EPI sequence (13 slices, TR = 2000ms, TE = 55ms, voxel size = 2.1x2.5x5mm, SENSE factor = 2.0, δ = 13.2ms, Δ = 27.4ms, b = 0 & 1000s/mm2, 16 directions, 2 averages). Additional scans included a T_1-weighted turbo field echo (TFE) and FLAIR scans for segmentation of normal white matter for controls, and NAWM and lesion for MS subjects.

Data Analysis: MWF was the area under the T_2 distribution from 0-40ms divided by the total area, and GMT_2 was the mean T_2 on a log scale for 40ms<T_2< 200ms. The diffusion data was registered to the T_2 relaxation data, and fractional anisotropy (FA), mean diffusivity (<D>) and parallel and perpendicular diffusivities ($\lambda_{\parallel}$ = largest diffusion eigenvalue and $\lambda_{\perp}$= average of the 2 smaller eigenvalues) were calculated. Histograms were created for the slices corresponding to the centre 5 slices of the T_2 relaxation acquisition.

Results and Discussion: Figure 1 illustrates the average histograms across all MS subjects and all controls for NAWM, NWM and MS lesion at month 0 and 6. The MWF and GMT_2 histograms showed good separation between NWM, NAWM and lesion but negligible difference between month 0 and 6. Unlike MWF and GMT_2, diffusion metric histograms showed small differences between month 0 and 6 scans especially in $\lambda_{\perp}$. There was very little difference between NWM and NAWM histograms for FA and $\lambda_{\parallel}$. Changes in MWF histograms for individual MS subjects did not mirror changes in histograms of DTI metrics highlighting the complementary nature of the different MR metrics.

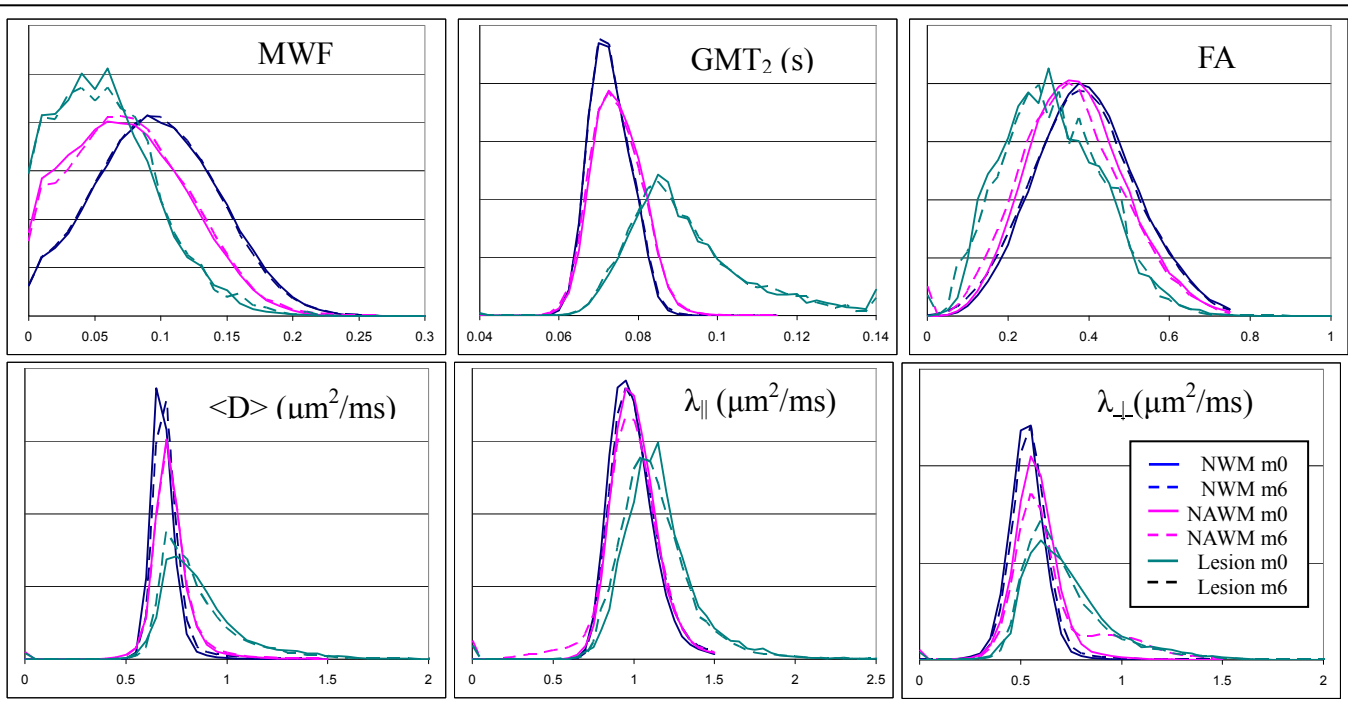

Figure 1: Normalized average histograms for NWM (blue line), and for NAWM (pink line) and lesion (teal line) at month 0 (solid lines) and month 6 (dashed lines), for T_2 relaxation-derived metrics (MWF and geometric mean T_2) and DTI-derived metrics (FA, <D>, $\lambda_{\perp}$, and $\lambda_{\parallel}$).

Conclusion: MWF and GMT_2 histograms were different for MS subjects compared to controls, and thus can be used to observe subtle changes in NAWM myelination. DTI metric histograms differed significantly from MWF histograms, therefore applying multiple MR techniques with different sensitivities to the many pathological features of MS may provide greater insight into MS pathophysiology. T_2 relaxation metrics showed negligible change over six months for NWM, NAWM and lesions whereas small changes were observed in the diffusion metrics.

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References: [1]Laule. Neuroimage. 2008;40:1575. [2]Laule. Mult Scler. 2006;12:747. [3]Webb. MRM. 2003;49:638. [4]MacKay. MRM. 1994;31:673. [5]Whittall. MRM. 1997;37:34. [6]Kolind. Neuroimage. 2008;40:77. [7]Mädler. MRI. 2008;26:874.