Correlation of Clinical Parameters and DTI imaging Features in Multiple Sclerosis

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Introduction: Multiple sclerosis (MS) is a demyelinating disease of the central nervous system that can lead to a continuum of motor deficits including weakness, spasticity, and paresis. Diffusion Tensor Imaging (DTI) can be used in the analysis of MS lesions by tracking water motion in the brain and analyzing connectivity of fiber tracts, which provides more information about the structural composition of the tissue than conventional MRI [1]. The purpose of this study was to investigate the correlation between clinical parameters and DTI imaging features.

Materials & Methods:

Data acquisition: 20 MS patients were scanned with an 8-channel head coil in a 3T MR system (Achieva, Philips Medical Systems). For each patient, neurological status reports and MRI scans were compared. The MR scans consisted of a T_{2W}-FLAIR image to identify MS lesions in regions of interest (ROI) and a DTI scan (4 b-values ranging from 250 – 1000 s/mm^2 with 6 diffusion gradients per b-value, one b=0 s/mm^2 volume, matrix size=128x128, FOV=24x24cm, 30 axial slices, 5mm slice thickness, and SENSE=2).

DTI processing: The diffusion weighted images were corrected for motion and Eddy-current distortions and aligned to the b=0 s/mm^2 volume. Diffusion tensors were computed using non-linear regression [2]. All lesions in the internal capsule, contralateral to the side of the most prominent motor deficit, were chosen for analysis. Objective clinical data from each patient, including Expanded Disability Status Scale (EDSS) scores, timed 25-foot walk test (T25FW), 9-hole peg test (9HPT), and grip strength (GS) were compared to FA-, ADC-measures and lesion volumes. Additionally, a connectivity measure was computed by comparing the similarity of probabilistic tractography images obtained by using brainstem ROIs corresponding to the hemisphere contralateral to the deficit and an internal capsule white matter atlas [3]. The atlas was elastically registered to each patient's data (Figure 1). Connectivity measures were adjusted based on tract length and density features obtained using streamline tractography.

Analysis: FA-, ADC-distributions of the entire internal capsule, the volume of the lesions and the connectivity were compared to EDSS, 25-foot walk test, 9-hole peg test and grip strength by using a linear correlation/regression analysis.

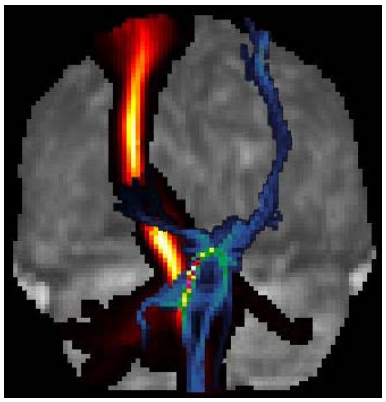

Figure 1. Coronal DTI amplitude image of an MS patient overlaid with expected tracts from a fiber atlas (left) and probatilistic tracts (right).

Results: DTI derived features provide better correlations to clinical scores than conventional MRI-based characteristics such as lesion load and volume. Among the features employed, connectivity is the one that gives the most insight about deficits due to its medium to strong correlation to every clinical test (Table 1). Observing the Pearson coefficients of FA and ADC distributions illustrates that the standard deviations of these scalar measures are more important than their means. The 9-hole peg and grip strength tests turned out to be more associated with imaging values than EDSS and 25-foot walk tests. Figure 2 displays the regression curve between the connectivity features and grip strength. The intercept of the line is very close to zero, a clinically intuitive finding, indicating full motor paralysis in the absence of connectivity. When a multi-variate correlation analysis includes all of the imaging features together, stronger correlations were obtained with each clinical test.

Table 1. Pearson correlation scores between image features and clinical parameters. Light-shaded fields indicate a medium correlation and dark-shaded fields indicate a strong correlation.

	EDSS	T25FW	9HPT	GS
FA mean	0.096	-0.256	-0.012	-0.176
FA std	-0.316	-0.168	-0.565	0.413
ADC mean	-0.185	-0.073	-0.355	0.375
ADC std	0.218	-0.035	0.689	-0.401
Lesion vol.	0.033	0.186	0.395	0.045
Connectivity	-0.424	-0.366	-0.329	0.511
Combined	0.607	0.593	0.736	0.814

Discussion: DTI provides features that are strongly correlated with clinical deficits. This suggests the possibility of using predictive and explanatory models for understanding disease progression. In further studies, a larger patient database will be used to analyze the strength of such models. Additionally, the generation of a new clinical test score, comprised of the existing test scores may provide a better correlation with the imaging features.

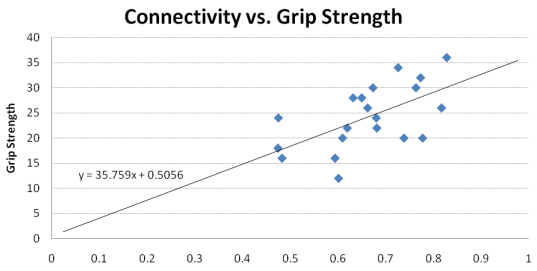

Figure 2. Patient grip strength values plotted against connectivity. The best fit line shows a strong positive correlation.

References: 1. M. Fillipi et al. "Diffusion tensor magnetic resonance imaging in multiple sclerosis", Neurology, 2001. 2. Software by NIH, http://www.tortoisedti.org, 3. Mori et al., "Human White Matter Atlas", Am J Psychiatry, 2007.