REPRODUCIBILITY STUDY OF QUANTITATIVE DIFFUSION CHARACTERISTICS

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Introduction: Diffusivity characteristics derived from diffusion tensor imaging (DTI) quantify random movements of water molecules in a voxel and provide details about tissue structures [1]. The method is used to outline pathological changes in brain structures of patients and alterations of calculated parameters have been evaluated in multiple sclerosis, schizophrenia and Alzheimer's disease [1]. In order to use those values as clinical measures for monitoring diseases longitudinally, the reproducibility of measurements has been addressed previously. The variability of diffusion parameters has been investigated between different pulse sequences, imaging units and between imaging-reimaging [2,3]. Those studies have acquired data with several healthy volunteers in order to estimate the reproducibility of results. We aimed to investigate the DTI parameters during one imaging session of one volunteer. One session consisted of acquiring DTI data ten times consecutively. This method assesses the scanner performance without the other confounding factors, such as different brains or repositioning. Furthermore, the variability of inter-session measurements was investigated with two scanners and enabled to compare the measurements between those scanners.

Methods: Diffusion tensor imaging. DTI data of one healthy volunteer was obtained with a 1.5T (GE Signa) and a 3T (Philips Achieva) magnetic resonance imagers. The session on each scanner consisted of ten successive DTI sequences using a single shot spin-echo EPI pulse and 15 diffusion encoding gradient directions. Other parameters between scanners (e.g. pixel size, TR, slice position) were chosen to be as similar as possible to help facilitate direct comparison.
Analysis of DTI data. The analysis of the imaging data was performed with FSL software (http://www.fmrib.ox.ac.uk/fsl). After the correction of eddy current distortions, the whole brain histograms of fractional anisotropy (FA) and mean diffusivity (MD) were computed for every data set separately. In order to evaluate white matter FA and MD maps the structural image of the same subject was segmented into grey and white matter. Thereafter, the FA and MD maps were masked with the white matter segmentation. The second approach was the comparison of tractography results. The seed voxel for probabilistic tractography was placed in the middle of genu of the corpus callosum on each FA map.

Results: 1. Intersession variability. The whole brain histograms of MD and FA maps overlapped between the sessions. There were no differences between the histogram peaks (p>0.1).

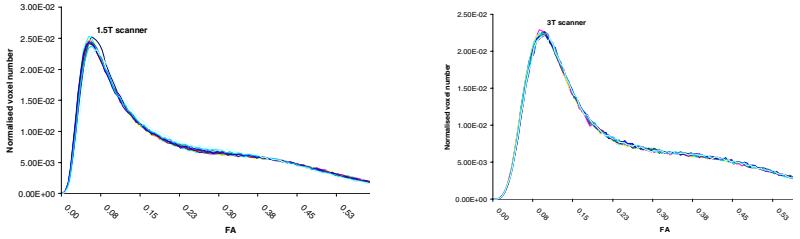
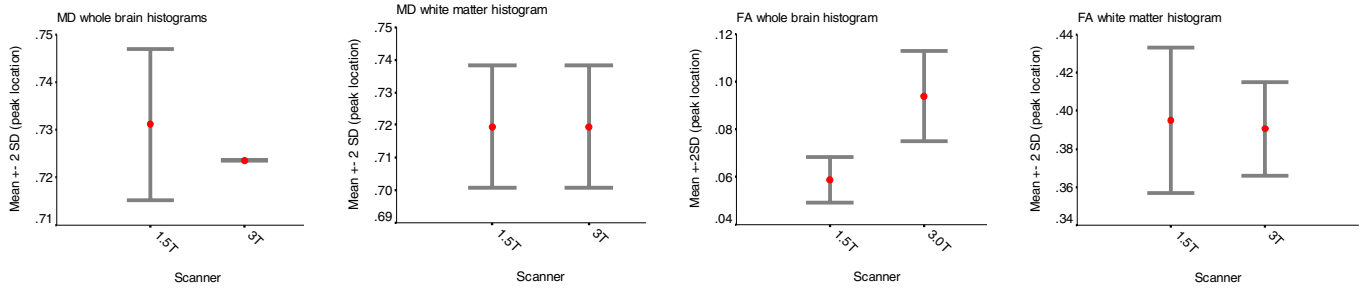


Figure 1- FA histograms from scanners with different field strength. The histograms between scanners exhibit dissimilar peak values and locations.

2. Interscanner variability. The whole brain histograms were compared with non-parametric Kolmogorov-Smirnov test. The MD histogram peak locations were not statistically different (p=0.16), but the peak locations of FA histograms were not reproducible between the scanners (p<0.001). The white matter mask from structural image was used to evaluate only the measurements in the higher FA values. The peak locations of white matter FA histograms showed no statistical difference between the scanners (p=0.5). The following graphs show the diversity between the peak locations of whole brain histograms and reduced variability between white matter segmentations.



The second approach was to evaluate tractography results. We estimated mean values of FA and MD parameters along the resulting path from a seed voxel placed on the centre of genu. The mean FA and MD values were consistent with results from the histogram analysis- showing no statistical difference between the scanners.

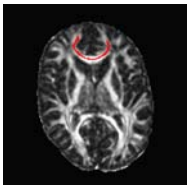


Figure 2- example of tractography result overlaid on FA map.

Conclusions: There were no intersession differences in the whole brain histograms. The scanner performance without the other influencing factors was stable. The analyses show that interscanner variability is evident if whole brain FA histograms are evaluated. The difference in field strength, positioning and many other factors can contribute to this. Our results show that white matter FA values and mean values along tracts are more reproducible even with different field strength, so long as the same imaging parameters are used, such as voxel and matrix size. However, grey matter FA values were different between scanners; as such for longitudinal studies of diseases only white matter histograms or mean values along tractography should be used.

References:

[1] Basser, P.J.et al., *NMR in Biomedicine,* 15 (2002) 456-67.
[2] Cercignani, M., et al., *AJNR Am J Neuroradiol*, 24 (2003) 638-43.
[3] Pfefferbaum, A., et al., *J Magn Reson Imaging*, 18 (2003) 427-33.