REGIONAL CHANGE IN DTI PARAMETERS DUE TO SCANNER UPGRADE: EFFECTS ON TBSS AND ROI ANALYSIS

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Target audience: Researchers using DTI in large cohort studies that include scanner changes.
Purpose: It is well-known that DTI parameters highly depend on model of MR scanner, acquisition technique, and acquisition parameters.[1,2] Thus, hardware and/or software upgrades may have substantial effects in longitudinal studies. To check for possible systematic variation of DTI parameters, DTI measurements were prospectively performed on healthy control subjects before and after a scanner upgrade.

Methods: MRI was performed at two timepoints (mean delay 185 ± 23 days) at two hardware versions of a 3T whole body scanner (GE Signa HDxt and Discovery MR750, Milwaukee, WI, USA) in 13 right-handed male healthy subjects (mean age 33.8 ± 8.6 years). Nine of these subjects were scanned twice before the upgrade (mean delay 13 ± 7 days). DTI EPI acquisition was performed with 5 b = 0 volumes and 30 directions with b = 1000 s/mm^2, 2.0 mm in-plane resolution, 45 contiguous 2.4 mm axial slices, and parallel imaging with ASSET factor 2. The same 8-channel head coil was used. Minor differences after the upgrade were a change in TR (13 s before vs. 6.2 s after upgrade) and a small change in TE (mean TE 87.8 ms vs. 85.9 ms). A major hardware change was a new gradient system design and a different type of fat-suppression (water excitation on HDxt, and fat saturation on MR750) due to limitations of slice thickness with water excitation on the MR750.
DTI data were processed with FSL 5.0.4, resulting in FA, MD, axial diffusivity AD (L1), and radial diffusivity RD (mean of L2 and L3), followed by TBSS analysis of all parameters. Groupwise comparisons were performed with randomise using both an unpaired and a paired design. Regional DTI parameters were extracted from ROIs defined in standard space. Whole brain SNR was computed from pixelwise mean and SD of the 5 b = 0 volumes.

Results: Pairwise comparison of repeated measurements before the upgrade did not show any significant difference. After the upgrade significant differences in FA were observed at tfce-corrected p < 0.01 (Fig.1 left). A small prefrontal cluster had lower FA after the upgrade (< 0.1%), but 26.7% of the skeleton had increased FA, especially located in the body of the corpus callosum. In an unpaired groupwise comparison a smaller area (5.5% of the skeleton) remained significantly increased at this threshold (Fig.1 right).
Analysis of AD, RD, and MD showed differences in the same areas in the skeleton, now with significantly reduced values after the upgrade. Bland-Altman plots (Fig. 2) based on ROIs in splenium, genu, and body of corpus callosum, posterior limb of the internal capsule (PLIC), and extreme capsule, show that the deviating values only partially scale with mean values of FA, MD, AD or RD. Similar plots are obtained using the values on the skeleton within these ROIs (not shown). The body of the corpus callosum is clearly most deviating.
The pairwise comparison of SNR before (19.2 ± 1.2) and after (20.8 ± 2.5) the upgrade shows a minor though significant increase (p = 0.03).

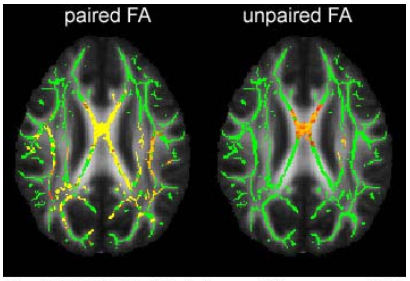

Fig.1: FA MR750>HDxt shown at tfce-corr-p<0.01 using paired (left) and unpaired (right) comparison

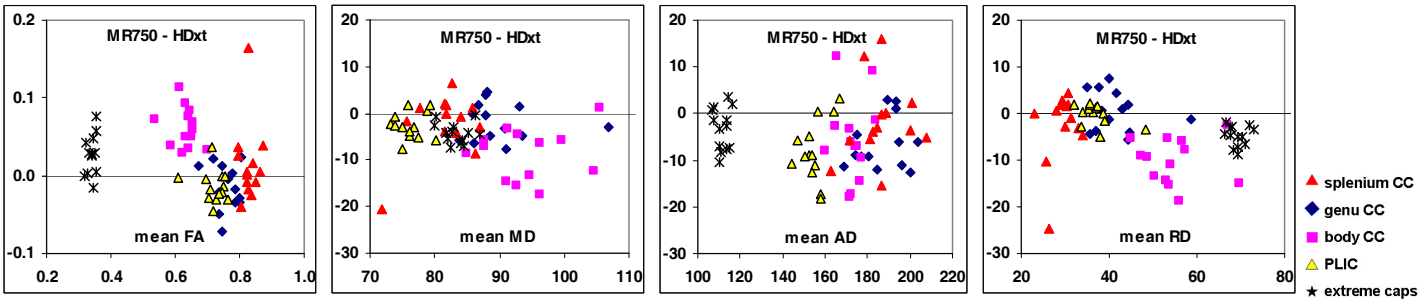

Fig.2: Bland-Altman plots (MR750 – HDxt) of FA, MD, AD, and RD in selected ROIs show increase of FA and decrease of diffusivities especially in body of corpus callosum. Values for MD, AD, and RD are given in 10^{-5} mm^2/s.

Discussion: After the scanner upgrade highly significant differences in DTI parameters were observed using pairwise comparisons, which diminished in extent but remained present in unpaired comparisons (mimicking a cross-sectional study design). Repeated measurements on the same scanner did not yield any significant pairwise difference. It is known that especially SNR can influence DTI parameters, with increased FA at lower SNR.[3,4] However, in this case the marginal increase in SNR coincided with an increase of FA. Moreover, the observed effect was not more prominent for the lower FA values in the extreme capsule. Because of virtually identical pulse sequence design on both scanners, the findings can only be attributed to differences in the gradient systems, most likely in the eddy current behaviour. A limitation of this study is the use of different fat-suppression schemes. This could cause changes in ghosting artefacts on the b = 0 images, and consequently erroneous values of DTI parameters in these regions. However, visual inspection showed that these artefacts were marginally detectable at both scanners, and only partially coincided with the areas of the significant differences.

Conclusions: Pairwise comparisons show striking differences in DTI parameters resulting from a scanner upgrade, in a large area of the TBSS skeleton, confirmed by ROI analysis. These differences remain present in unpaired analyses typical for a cross-sectional study design. This emphasizes the need to include healthy subjects as controls both before and after a scanner upgrade, and to take scanner upgrade into account in the study design.

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