Characterization and Limitations of Diffusion Tensor Imaging Metrics in the Cervical Spinal Cord in Neurologically Intact Subjects.

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Introduction

Presently, it is unclear if DTI performed on a standard clinical scanner produces data of sufficient quality to identify differences in DTI metrics *throughout the cervical spinal cord (CSC)*. In this study, we performed DTI on neurologically intact subjects of different ages, and measured diffusivities of the gray matter and white matter tracts within individual segments of the CSC.

Methods

Twenty-five healthy subjects (22 -85 years old) were studied. A single-shot, twice-refocused, SE-EPI technique was used to obtain **axial images throughout the CSC (C1–T1) on a 1.5T clinical MR scanner.** DTI metrics were calculated for the whole CSC, GM and individual WM funiculi. Signal-to-noise ratios (SNRs) and mean DTI metrics were measured for segmental groups- upper (C1-3), middle (C4-6) and lower (C7-T1) CSC. Age-related changes in DTI measures were also analyzed.

Age groups (years)	Male	Female	Total
20-29	2	1	3
30-39	2	3	5
40-49	-	1	1
50-59	2	1	3
60-69	1	3	4
70-79	3	2	5
80-89	2	2	4

Table 1. Demographic data

Results

FA, MD and tADC showed significant differences between GM and individual WM funiculi (Tukey test, P<0.05) throughout the CSC.

DTI metrics of white matter funiculi and gray matter of the cervical cord (C1-T1)

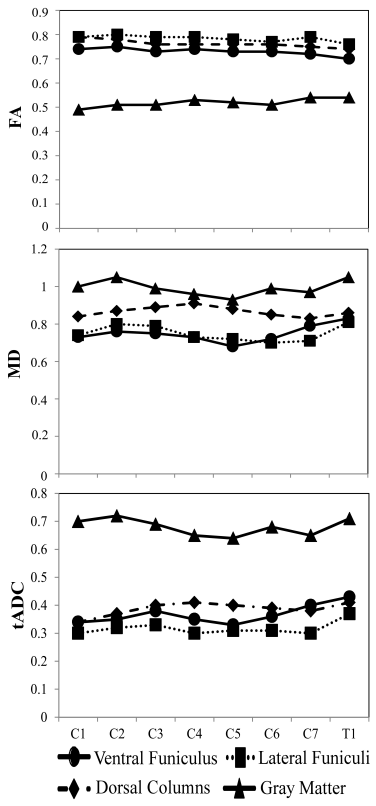

Fig 1. Mean FA (fractional anisotropy), MD (mean diffusivity, x10-3 mm2 s-1) and tADC (transverse apparent diffusion coefficient, x10-3 mm2 s-1) of white matter funiculi and gray matter

The ***median SNR was significantly decreased in the middle and lower segmental groups*** as compared to the upper levels (5.5 vs 10.7, p<0.001), contributing to poor spatial resolution of the cord structure in the lower CSC.

Comparison of axial T2W MR images and FA maps throughout the CSC

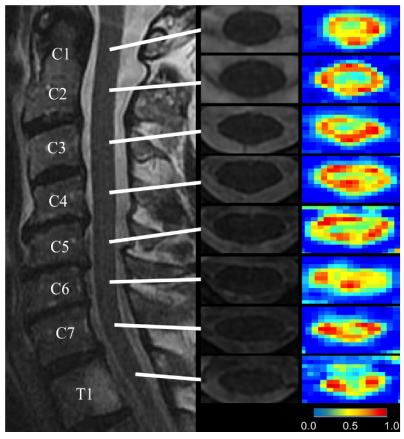

Fig 2. Sagittal T2W MR image (left) of the cervical spine in a representative subject with the corresponding axial T2W images at each cervical level (middle). Corresponding FA maps (right) showing lower anisotropy in the central gray matter and higher anisotropy in white matter tracts. Lower cervical segments show poorer spatial resolution as compared to superior levels.

DTI was sensitive to age-related changes in FA within the CSC- particularly in the upper and middle cord. *In the lower cord, significant age-related changes were not observed, probably due to the low SNR.*

Changes in FA with age

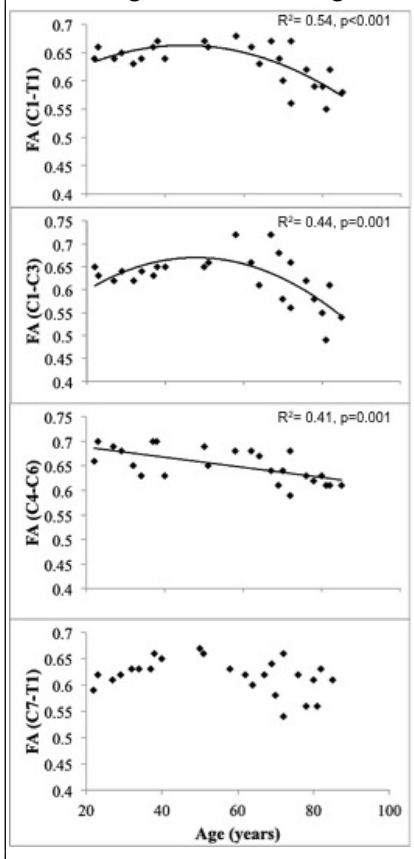

Fig 3. Age-related changes in mean FA: A. Cervical cord (C1-T1); B. Upper cord (C1-C3); C. Middle cord (C4-C6); D. Lower cord (C7-T1)

SNRs across cervical segmental groups

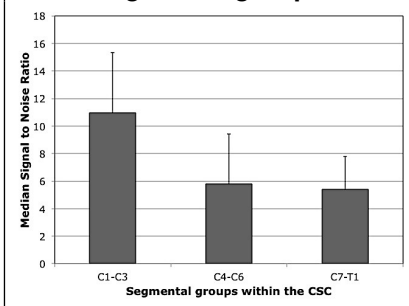

Figure 4. Comparison of median signal-to-noise ratios between the upper (C1-C3), middle (C4-C6) and lower (C7-T1) segmental groups. Error bars represent interquartile range.

Conclusions

This study systematically characterizes changes in **DTI metrics throughout the CSC** in neurologically intact subjects using a standard clinical scanner. Although DTI reliably differentiates GM and individual WM funiculi across the CSC, **technical issues limit lower CSC characterization** and need to be refined. While DTI metrics may be used to define cord pathology, **variations in metrics due to age and signal quality** need to be accounted for in clinical DTI studies.

Acknowledgements

VA Rehab R&D, Bryon Riesch Paralysis Foundation Endowment