In vivo Regional Diffustion Tensor Metrics of Rodent Spinal Cord

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Introduction: Diffusion tensor imaging (DTI) is increasingly used for probing the integrity of white matter (WM) fibers in spinal cord injury (SCI). Both axonal loss/compromise and demyelination are implicated in SCI. Based on the published studies [1], the individual diffusivities along the principal directions ie along (λ_l) and perpendicular (λ_t) to the length of the spinal cord (or principal eigenvalues) have the potential to improve the pathologic specificity of injured cord tissue compared to anisotropic indices such as fractional anisotropy (FA). However, before such an approach could be adapted for characterizing injured tissue, it is important to determine the regional principal eigenvalues in normal spinal cord *in vivo* and this is the goal of the present studies.

Methods: All MR studies were performed on a 7 T Bruker scanner. A total of five male Sprague-Dawley rats weighing between 300 and 350 g were used in these studies. All MRI studies were performed with the animal under isoflurane anesthesia. During the MRI scan, the animal's body temperature was maintained at 37° C and the heart rate and respiration were continuously monitored. An implanted coil that was inductively coupled to an external coil was used for image acquisition [2]. Respiratory gating was employed for minimizing the breathing artifacts. Diffusion weighted images were acquired using a four-shot EPI sequence with TR/TE of 2000/40 ms from 20 contiguous axial slices, each of 2 mm thick with an in-plane resolution of 200 microns and square FOV of 26.2 mm. Diffusion weighted images were acquired with an icosahedral encoding scheme with 21 gradient directions with alternating gradient polarity [2]. The DTI metrics, FA, D_{av}, λ_l and λ_t were determined from dorsal, ventral, lateral (D-, V-, L-) WM of the spinal cord. ANOVA, corrected for multiple comparisons, was used to determine the differences between mean FA, $D_{av,}$ λ_l and λ_t values among the three regions.

Results: We did not observe any significant difference in the DTI metrics between the left and right L- WM and therefore, have averaged these two values. A spin echo image of the cord with the ROI's is shown in Fig. 1. The mean values of the DTI metrics along with the corresponding standard deviation (SD) and the results of statistical analysis are given in Table 1. The values of λ_l and λ_t along the length of the cord in the thoracic segment (Figure 2) did not show statistically significant variation, indicating the stability of the data.

Discussion and Conclusions: We believe that these are the first *in vivo* DTI studies that have reported regional DTI metrics in WM. Based on the statistical analysis, majority of the DTI metrics vary from region-to region. These variations reflect the heterogeneous nature of the tracts, both in terms of the axonal size and degree of myelination. For example, λ_l is highest in the V-WM through which the vestibulospinal tract, with the largest axonal diameter, projects through. This interpretation is consistent with a recent report that showed a correlation between λ_l and the axonal diameter [3]. The V-WM shows a highest λ_t suggesting that this region may not be well myelinated. Accurate interpretation of the regional differences in the DTI metrics requires detailed histologic studies.

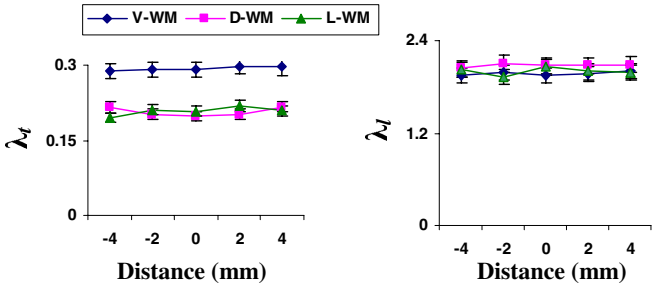

Figure1: Spatial variation in λ_t and λ_l.

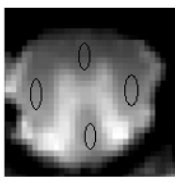

Figure 2. ROI placement

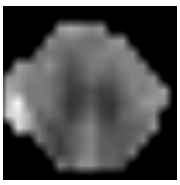

Figure 3: λ_l map

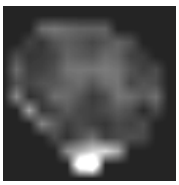

Figure 4: λ_t map

Region	FA	D_{av} [a]	λ_l [a]	λ_t [a]
Ventral	0.83 ± 0.023	0.85 ± 0.133	1.96 ± 0.180	0.30± 0.023
Dorsal	0.89 ± 0.040	0.82 ± 0.112	2.05 ± 0.165	0.21± 0.019
Lateral	0.88 ± 0.059	0.80 ± 0.091	1.90 ± 0.159	0.21 ± 0.021

V-,D-: P=0.001 V-,D-: P=0.004 V-,D-: P=0.004 V-,D-: P=0.001
V-, L-: P=0.001 V-,L-: P=0.001 D-,L-: P=0.027 V-,L-: P=0.001
D-,L-: P=0.02

Table 1. Regional DTI metrics for normal spinal cord. The values represent the mean ± sd. [a] In units of 10^{-3} $mm^{-2}s^{-1}$

References :
[1]Song SK et al. Neuroimage 2005;26:132-40.
[2]Madi et al, Magn Reson Med. 2005;3(1):118-125.
[3] Schwartz ED et al. Neuroreport 2005;16:73-76

Acknowledgements: NIH grants NS045624 and NS 30821