Diffusion Tensor Imaging in Characterizing Cervical Degenerative Spondylosis

S. Hesseltine[1], M. Law[1], G. Johnson[1]

[1]Radiology, NYU Medical Center, New York, NY, United States

INTRODUCTION: Neurosurgical triage of patients with cervical spondylosis is highly dependent on demonstrating abnormal spinal cord signal at conventional MR imaging; however, changes in spinal cord function and clinical symptomatology precede findings of abnormal cord signal. Diffusion tensor imaging (DTI) has been demonstrated to provide physiologic information regarding fiber tract integrity and diffusion on a microscopic level, which precedes changes in T2 signal abnormality [1,2]. The purpose of this study is to spatially compare diffusion tensor metrics of white matter tracts in the cervical spinal cord in normal volunteers with metrics in patients with varying degrees of cervical spondylosis.

MATERIALS AND METHODS: DTI was performed in 41 patients with varying degrees of spondylosis and 9 healthy volunteers, using a pulsed gradient, double spin echo, echo planar imaging (2000/74; 128x128 matrix; 140x140 mm FOV; 10 contiguous 4 mm slices; b= 1000 s/mm^2) at 1.5T. Using a method described by Singh et al [3], a score corresponding to overall severity of cervical spinal canal stenosis was calculated for each patient. We evaluated the DTI characteristics of the spinal cord at the C2-3 intervertebral level. At this level, fractional anisotropy (FA) and mean diffusivity (MD) were calculated within regions of interest at the anterior, lateral, and posterior regions of the spinal cord, with separate bilateral regions of interest at each of these positions (Figure 1).

Fractional Anisotropy

	Anterior		Lateral		Posterior	
	Left	Right	Left	Right	Left	Right
Cases (*n = 41*)	0.49 ± 0.08	0.49 ± 0.08	0.61 ± 0.10	0.62 ± 0.10	0.63 ± 0.10	0.61 ± 0.10
Controls (*n = 9*)	0.49 ± 0.10	0.49 ± 0.10	0.58 ± 0.11	0.62 ± 0.09	0.63 ± 0.05	0.64 ± 0.06
P-values	0.81	0.88	0.55	0.86	0.86	0.26

Mean Diffusivity (x10^{-3} mm^{-2}s^{-1})

	Anterior		Lateral		Posterior	
	Left	Right	Left	Right	Left	Right
Cases	1.00 ± 0.25	0.99 ± 0.22	0.92 ± 0.24	0.91 ± 0.23	0.92 ± 0.29	0.91 ± 0.29
Controls	0.82 ± 0.15	0.86 ± 0.17	0.89 ± 0.13	0.92 ± 0.18	0.86 ± 0.18	0.84 ± 0.21
P-values	**0.009**	**0.08**	0.7	0.85	0.45	0.39

Table 1. DTI metrics at the C2-C3 spinal level in patients with spondylosis and normal volunteers.

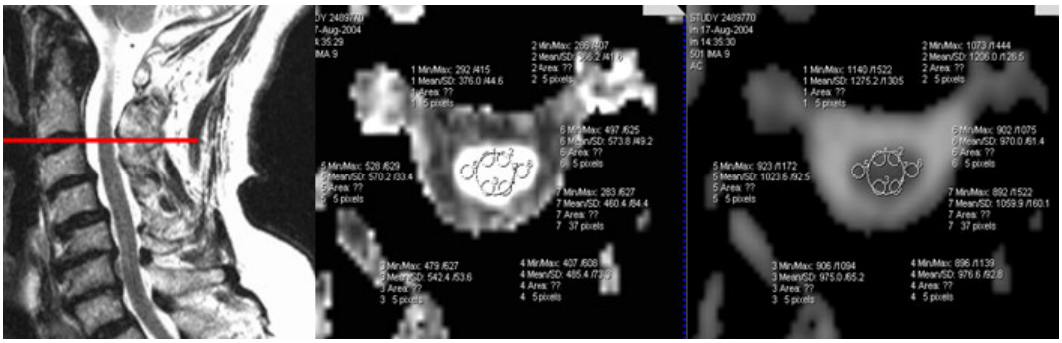

Fig 1. Left—Sagittal T2-weighted MR image of patient with multilevel cervical spondylosis, demonstrating level of DTI interrogation at C2-3 (red line). FA (center) and ADC (right) maps at the C2-3 level demonstrate multiple regions of interest at the anterior, lateral, and posterior spinal cord.

RESULTS: The spondylosis score for our 41 patients averaged 2.0 ± 1.8 (average ± standard deviation). The C2-3 level was remote from the most superior level of pathology in all of our patients, being 3.2 ± 1.8 cervical levels cephalad on average. The average age of our patients was 60.0 ± 18.6 (average ± standard deviation) years vs. 34.3 ± 14.5 years for the control group ($p < 0.0001$); however, there was no significant correlation of measured FA or MD with age ($R = -0.06$ and 0.03, respectively).

The MD values in the anterior spinal cord were significantly higher in the patients with spondylosis compared to controls (0.992 ± 0.234 vs. 0.840 ± 0.154, $p = 0.002$). There was no significant difference in MD in the lateral or posterior regions of the spinal cord, nor was there a significant difference in FA in any region of the spinal cord comparing disease group to controls (Table 1). The anterior FA values were significantly lower than the posterior FA values in both the patients with spondylosis (0.493 ± 0.079 vs. 0.618 ± 0.102, $p < 0.0001$) and controls (0.486 ± 0.094 vs. 0.635 ± 0.051, $p < 0.0001$).

CONCLUSION: The study suggests that changes in MD are present in the anterior spinal cord, even remote from the site of spondylosis. Regional differences in FA in the cervical spinal cord are also demonstrated, with significantly lower FA in the anterior compartment. This may relate to either increased mechanical stress in the ventral spinal cord in spondylosis or relative increased gray matter in the anterior regions of interest. These findings may be valuable in future investigations of DTI characteristics at the site of pathology in patients with spondylosis as well as help in the neurosurgical triage of patients with degenerative cervical spine disease.

REFERENCES:

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