Diffusion Tensor Imaging Evaluation of the Cervical Spinal Cord in Spondylosis: Evaluation of Changes in Major and Minor Eigenvalues

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INTRODUCTION: The radiologic characterization of cervical spondylosis remains challenging, as the correlation between anatomic abnormality, clinical disability and spinal cord function is limited. Diffusion tensor imaging (DTI) has shown promise in the evaluation of white matter tract integrity, and has been shown able to detect changes in the spinal cord in spondylosis [1,2], typically consisting of decreased fractional anisotropy (FA) and increased mean diffusivity (MD). These changes in FA and MD may not be sufficient to differentiate between potentially reversible edema and irreversible gliosis in patients with spondylosis. However, the evaluation of major (E1) and minor (E2, E3) eigenvalues, from which FA is calculated, may assist in identifying subgroups of patients. The purpose of this study is to compare diffusion tensor metrics in the white matter tracts of the cervical spinal cord in patients with severe multilevel spondylosis with normal volunteers, evaluating changes in FA and MD as well as the major and minor eigenvalues.

	Anterior			Posterior		
	Cases	Controls	P-value	Cases	Controls	P-value
FA	0.49 ± 0.10	0.56 ± 0.09	0.02	0.57 ± 0.07	0.71 ± 0.09	<0.001
MD*	0.94 ± 0.19	0.82 ± 0.11	0.02	0.87 ± 0.18	0.78 ± 0.11	0.06
E1	1.48 ± 0.30	1.42 ± 0.19	0.41	1.51 ± 0.31	1.57 ± 0.26	0.46
E2	0.77 ± 0.20	0.62 ± 0.12	0.005	0.66 ± 0.17	0.47 ± 0.11	<0.001
E3	0.55 ± 0.15	0.43 ± 0.11	0.008	0.44 ± 0.12	0.31 ± 0.08	<0.001
	Lateral			**Central**		
	Cases	**Controls**	**P-value**	**Cases**	**Controls**	**P-value**
FA	0.59 ± 0.10	0.71 ± 0.05	<0.001	0.52 ± 0.09	0.63 ± 0.08	0.006
MD*	0.82 ± 0.27	0.76 ± 0.11	0.28	0.91 ± 0.19	0.77 ± 0.09	0.05
E1	1.48 ± 0.32	1.51 ± 0.20	0.72	1.50 ± 0.31	1.43 ± 0.22	0.55
E2	0.67 ± 0.25	0.47 ± 0.07	0.001	0.72 ± 0.19	0.54 ± 0.09	0.02
E3	0.40 ± 0.15	0.30 ± 0.10	0.015	0.52 ± 0.14	0.36 ± 0.06	0.003

*($x10^{-3} mm^{-2} s^{-1}$)

Table 1: DTI metrics at the C4-C5 spinal level in 11 patients with severe spondylosis, compared to 10 normal volunteers.

MATERIALS AND METHODS: DTI of the upper cervical spine was performed in 11 patients with severe multilevel spondylosis, with evidence of spinal cord compression on conventional MRI, as well as 10 healthy volunteers, using 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). At the C2-3, C3-4 and C4-5 levels, average FA, MD, and the three principle eigenvalues (E1, E2 and E3) 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.

RESULTS: The average age of the spondylosis patients was 67.2 ± 9.8 years (average ± standard deviation) vs. 33.4 ± 15.2 years in the control group ($p < 0.001$). FA was not significantly different comparing disease to control groups in any of the spinal cord regions at the C2-3 or C3-4 levels, which were generally not affected by spinal cord compression. However, at the C4-5 level which typically demonstrated spinal cord compression in our disease group, significantly decreased FA was demonstrated in all cord regions. There was no significant difference in E1 in any of the cord regions; however, E2 and E3 were significantly increased in disease patients at the C4-5 level (see Table 1).

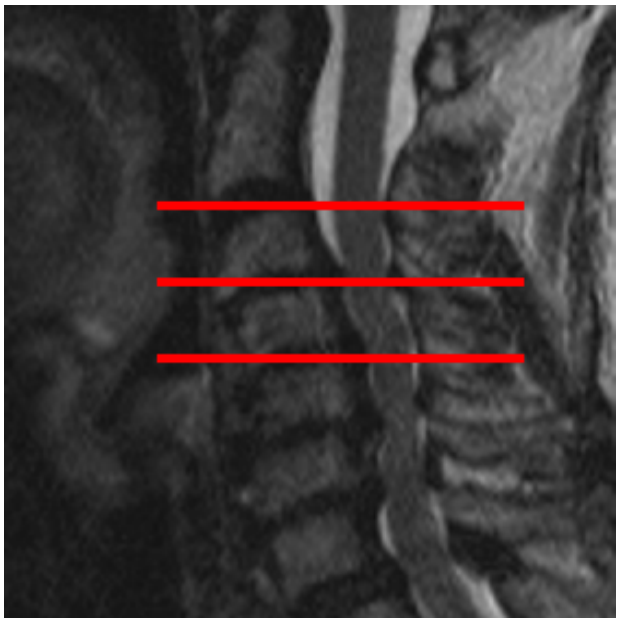

Figure 1. Sagittal T2-weighted MR image of a patient with severe multilevel cervical spondylosis. Analysis of the normal-appearing spinal cord was performed using axial DTI at the C2-3, C3-4 and C4-5 levels (red lines).

CONCLUSION: The study has demonstrated increased minor eigenvalues in the setting of chronic spondylosis, with preservation of the major eigenvalue. In the spinal cord, the minor eigenvalues typically correspond to transverse diffusion, perpendicular to the longitudinal axis of the spinal cord. Animal studies have suggested that increases in the minor eigenvalues occur in the setting of demyelination andincreased axonal diameter; the minor eigenvalues were also affect by additional factors including protein integrity [3]. The increased transverse diffusion seen in the normal appearing spinal cord of patients with cervical spondylosis suggests possible microscopic demyelination and axonal compromise.

REFERENCES:

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