# Diffusion Tensor Imaging of the Pediatric Thoracic Spinal Cord Using a Short Echo Time Inner-Field-of-View Sequence

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**Background and Objective**

Diffusion tensor imaging (DTI) of the pediatric spinal cord (SC) has the potential to provide useful information on white matter integrity and to serve as an important biomarker for spinal cord injury (SCI). Studies of the cervical SC in subjects with SCI have shown good correlation between DTI values and clinical examination results (1). In order to continue exploration of the clinical utility of DTI of the SC, it is important for imaging techniques to cover the entire SC. However, extending this technique to the thoracic SC is challenging due to physiological motion from cardiac pulsation and respiration which is more prevalent in the thoracic region. In the cervical SC, the use of an inner-field-of-view (iFOV) sequence has been shown to be effective in producing good quality images (2). The purpose of this study was to implement and evaluate the iFOV DTI sequence for imaging of the pediatric thoracic SC in normal subjects and subjects with SCI.

**Methods and Materials**

*Subjects:* A total of 8 pediatric subjects, 6 typically developing (TD) subjects without evidence of SC pathology and 2 patients with SCI were recruited. Subjects and their parents provided written informed assent and consent of the IRB-approved protocol.
*Imaging*: Imaging was performed using a short echo iFOV echo-planar DTI sequence(3). This sequence was implemented on a 3.0T Siemens Verio MR scanner and optimized for imaging of the thoracic spinal cord. Images were acquired axially along the length of the SC. The following sequence parameters were used: 20 diffusion directions, b=1000s/mm$^2$, voxel size = 1.2x1.2x3mm$^3$, axial slices = 50, TR = 7400 ms, TE = 89 ms, and number of averages = 3. Due to the length of the thoracic SC, imaging was split into two slabs, the first beginning at C7-T1, and the second at T6-T7. The imaging time to collect DTI images was approximately 7 minutes per slab. Sedation and/or anesthesia were not administered to the subjects in this study. Cardiac and respiratory gating were not used in order to minimize scan time.
*Data Analysis:* Image registration was performed using the Automated-Image-Registration (AIR) package implemented in DTIstudio (www.mristudio.org) using a rigid scaled-least-squares algorithm. Regions of interest (ROIs) were drawn on each axial slice along the length of the thoracic SC in the center of the cord, avoiding edges to minimize averaging of the SC with surrounding cereberospinal fluid (CSF). Values for fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD), and radial diffusivity were calculated for each ROI.

**Results and Conclusion**

The iFOV used was effective in acquiring DTI images of the pediatric T-SC with less distortion. Figure 1 shows midline sagittal images reconstructed from axial slices for two slabs collected from a TD subject (Fig 1a: T1-T8; Fig 1b: T7-L1) and from a subject with SCI (Fig 1ac: T1-T10; Fig 1d: T7-L2). Mean indices for typically developing subjects were FA = 0.42±0.05, MD = 0.52±0.09, AD = 0.75±0.09, RD = 0.40±0.05. Subjects with spinal cord injury showed decreases in FA and increases in diffusivity indices with values of FA = 0.24±0.04, MD = 0.63±0.10, AD = 0.79±0.10, RD = 0.56±0.09. Figure 2 shows values for all TD subjects averaged along with those for individual subjects with SCI. The subjects with SCI exhibited decreased FA and increased diffusivity indices when compared to TD subjects. While cardiac gating was not used to keep scanning time to a minimum, it may improve reliability, particularly at lower levels of the T-SC. These results are extremely promising and warrant data collection in a large group of subjects.

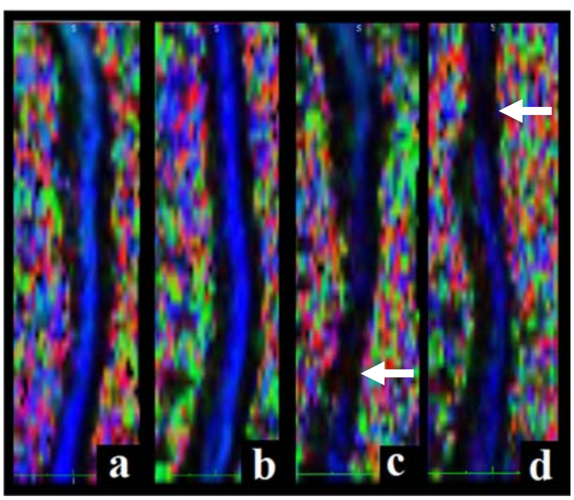


Figure 1 – Midline sagittal color FA maps of first and second slabs of the thoracic SC for a TD subject (a,b) and the first and second slabs for a subject with SCI (c,d). Injury level is visible in both slabs due to overlap between slabs and indicated with a white arrow. Images show good cord/CSF delineation along the length of the thoracic SC.

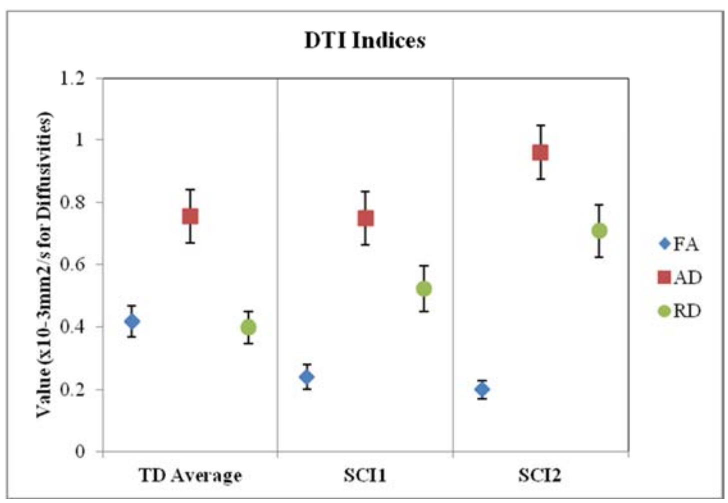


Figure 2 – DTI indices for all TD subjects averaged and for each subject with SCI (SCI1, SCI2). Values shown are averages for the entire cord with error bars shown for standard deviation.

*References: (1)Mulcahey MJ, et al. Diffusion tensor imaging in pediatric spinal cord injury: preliminary examination of reliability and clinical correlation.Spine 2012:37(13);E797-803. (2) Barakat N, et al. Diffusion tensor imaging of the normal pediatric spinal cord using an inner field of view echo-planar imaging sequence. AJNR 2012:33(6);1127-33. (3) Finsterbusch J. High-resolution diffusion tensor imaging with inner field-of-view EPI. JMRI 2009:29(4):987-93.*