# Cervical Spinal Cord Evaluation with ECG-Gated Line-scan Diffusion Tensor Imaging and 3D Tractography: Feasibility

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**Introduction**

Among several diffusion tensor imaging sequences for spinal cord, line scan diffusion tensor image (LSDTI) is the simple spin-echo based one and has been usually acquired without cardiac gating because of its relative longer acquisition time than other methods. However, cerebrospinal fluid (CSF) surrounding spinal cord may affect quantitative measurements of diffusion parameters (apparent diffusion coefficient [ADC] and fractional anisotropy [FA]) and description of three-dimensional tractography because they were based on voxel based procedure.

The purpose of this study was to compare line scan diffusion tensor imaging with and without ECG-gating technique and to estimate clinical usefulness of LSDTI with ECG-gating in evaluation of spinal cord pathology in vivo.

**Methods**

First, a total of five healthy volunteers with no history of spinal disease participated in the comparison study. All MR imaging were performed on a 1.5 Tesla MR imager (Signa LX CV/NV, GE Medical Systems, Milwaukee, Illinois). To cover the cervical spinal cord, LSDWI was performed in 3 to 5 sagittal sections.

LSDWI was the line scan spin-echo sequence with a pulsed-field-gradient diffusion preparation pulse employing two different b-values (0 and 700 s/mm2) along six directions. Imaging parameters of LSDWI were as follows: TR/ TE =800 without ECG gating, approximately 1200 with ECG gating / 80 ms, matrix 128x64 (256x256 reconstructed), bandwidth = 3.92 kHz, FOV = 240x120 mm, slice thickness/gap=3/0 mm and b value of 0 and 700 s/mm$^2$ with the maximum b value applied in six directions. Subsequently, apparent diffusion coefficients (ADCs) maps and Fractional anisotropy (FA) were calculated from the obtained LSDWI images on a pixel by pixel basis using a software (Functool 2, General Electronic Medical Systems, Milwaukee, WI). Moreover, three-dimensional tract reconstruction and color schemes of spinal cord to represent the orientation of anisotropic tissues are obtained on a PC using a free software (dTV 1.5, developed by Image Computing and Analysis Laboratory, Department of Radiology, The University of Tokyo Hospital, Japan.).Imaging quality of each LSDTI was qualitatively compared. Mean extended time with ECG gating technique, compared with non-ECG gating was calculated.

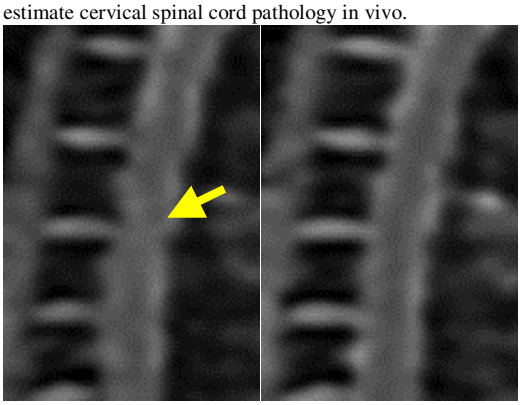
Second, for clinical feasibility study, LSDTI with ECG-gating was performed in eighteen patients with cervical spinal cord disorders (10 men and 8 women, mean age; 46 year-old, eleven with spondylotic myelopathy, three with syringomyelia, two with spinal AVM, one with spinal cavernous angioma and one with multiple sclerosis ). ADC and FA maps were calculated and three-dimensional tract reconstruction and color schemes were obtained as described above. An ROI analysis for spinal cord was performed and compared the quantitative values with those of normal volunteers. Demonstration of spinal cord tracts on 3D tract reconstruction were evaluated by two neuroradiologists qualitatively, referring to clinical symptom or other MR images.

**Results**

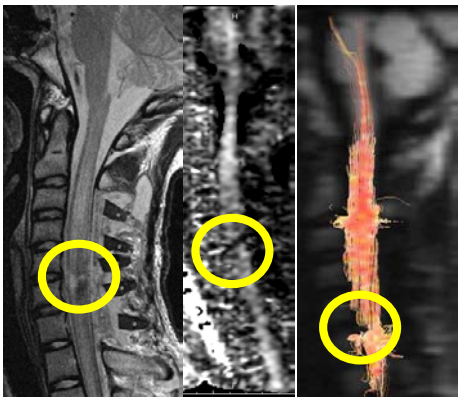
All LSDWI examinations were successfully imaged. Images with ECG-gated technique were all superior to those without ECG –gated in imaging quality (Figure 1). Mean extended time for LSDTI with ECG-gating was approximately two minutes, which were permissible for clinical use. In clinical use, The ADC value of spinal cord in patients with cervical spondylotic myelopathy increased (P<.001, Mann-Whitney U-test) and FA decreased on average, compared with those in normal volunteers. Moreover, Some white matter fibers of cervical spinal cord are seen on 3D tractopgraphy at syrinx level in patients with asymptomatic syringomyelia. Low signal line on FA map may indicate the tear of the white matter fiber in patient with spinal AVM, who presented motor weakness and sensory loss at C5 and distant level (Figure 2). Moreover, white matter fiber tacking is poorly demonstrated at the C5-6 level on 3D tractography. In a patient with asymptomatic spinal cavernous angioma, white matter fiber tacking is demonstrated as normal volunteers.

**Discussion**

ECG-gating technique is preferable to LSDTI. The ADCs and FAs measurements and 3D white matter fiber tracking of LSDTI with ECG-gating were useful to estimate cervical spinal cord pathology in vivo.



(Figure 1)



(Figure 2)

**Figure1.** ADC map without and with ECG gating. Narrowed and irregular shaped spinal cord was shown as psuedo-leison (arrow), due to CSF pulsation. **Figure2.** T2-weighted image, FA map and 3D fiber tractography in patient with spinal AVM with hemorrhage. Hemorrhagic region was seen as low intensity on T2-weigted image (circle), which indicated the tear of white matter fibers of cervical spinal cord at the level.