

Diffusion Tensor Imaging Characteristics of Normal Human Cervical Spinal Cord at 3T

K. K. Tha¹, S. Terae², K. Ishizaka², T. Okuaki³, M. Hirotsu⁴, K. Kobayashi², M. V. Cauteeren⁵, and H. Shirato¹

¹Dept. of Radiobiology and Medical Engineering, Hokkaido University Graduate School of Medicine, Sapporo, Hokkaido, Japan, ²Dept. of Radiology, Hokkaido University Hospital, ³Medical Satellite Yaesu Clinic, ⁴Dept. of Neurology, Hokkaido University Graduate School of Medicine, ⁵Philips Healthcare Asia Pacific

Background & Purpose: Recent development of reduced field-of-view MRI using outer volume suppression has allowed DTI (rFOV-DTI) of cervical spinal cord in axial sections, at 3T¹. With this technique, major DTI indices can be evaluated for each component of the cervical spinal cord {i.e., white matter columns and central gray matter (CGM)}. This study was aimed to establish the DTI characteristics of each component of normal human cervical spinal cord at 3T, using rFOV-DTI.

Methods: rFOV-DTI of cervical spinal cord was performed to 43 right-handed normal subjects (21 men and 22 women; age range = 24-68 years). Imaging parameters were: TR/TE = 2219/81 ms, NEX = 8, FOV = 60 x 32 mm, acquisition matrix = 29 x 76 mm, pixel size = 0.8 x 0.8 mm, b = 1000 s mm⁻², no. of diffusion gradients = 6, plane = axial. The major DTI indices – longitudinal ($\lambda_{//}$), transverse (λ_{\perp}) and mean diffusivity (MD) and fractional anisotropy (FA), were derived, for each component of cervical spinal cord at each vertebral level. Variation in absolute values of major DTI indices among the components, variation with vertebral levels, laterality, gender and age-related variations were determined. One-way ANOVA with post hoc Bonferroni test, t-test and Pearson's product-moment correlation analysis were used to determine statistical significance.

Fig 1

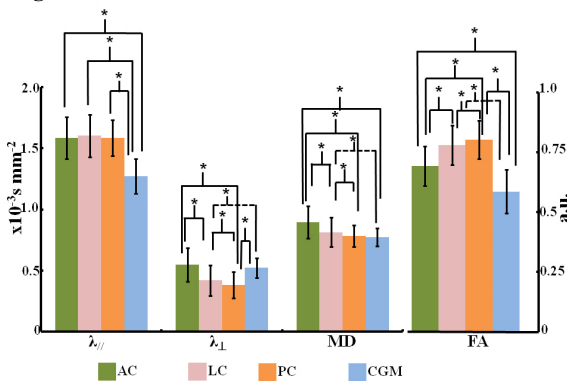


Fig 2

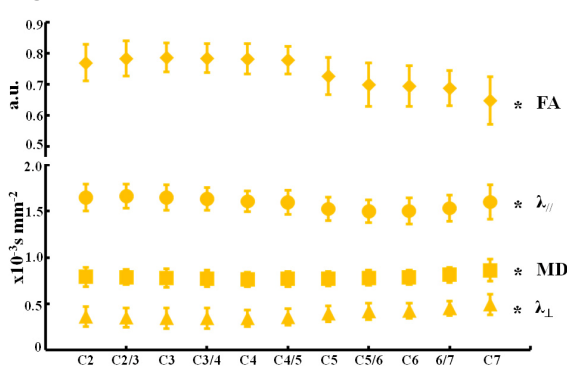
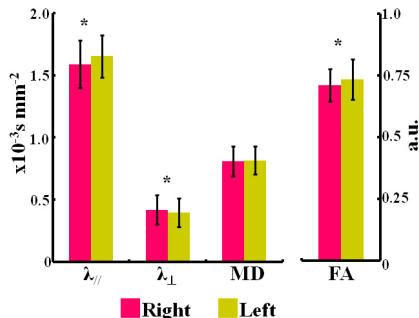


Fig 3



Results & Discussion: Except $\lambda_{//}$, the absolute values of all other major DTI indices varied significantly among white matter columns (Fig 1). Larger FA and smaller λ_{\perp} values were achieved by posterior column (PC), which is composed of abundant small-sized myelinated axons². The reverse was true to anterior column (AC), which has less abundant and large-sized myelinated axons². CGM had smaller FA and $\lambda_{//}$ than white matter columns and had equally large λ_{\perp} as AC — thought to be owing to its composition of less organized neurons². The absolute values of each component also varied with vertebral levels (Fig 2) – the upper levels had at least larger FA, $\lambda_{//}$ and smaller λ_{\perp} . Branching of brachial plexus is considered to be responsible for this². Laterality of the absolute values was also observed (Fig 3). The dominant (right) side had lower FA values of white matter columns including lateral column (LC) – in contrary to what can be speculated from the reported FA values of corticospinal tracts of brain³. It is speculated that smaller FA values of white matter columns of the right side be due to more abundant branching of fibers. In addition to these findings, there were also gender-related (men having smaller MD) and age-related variations (moderate negative relationship between $\lambda_{//}$ of PC, λ_{\perp} and MD of CGM, and age) in the absolute values of major DTI indices – possibly due to different fiber composition and accumulation of cytoskeletal proteins or axonal degeneration with gliosis, respectively^{4,5}.

Conclusion: The absolute values of major DTI indices of cervical spinal cord vary among the components, vertebral levels, age and gender. Handedness might affect the values. Normative values are necessary in interpreting the major DTI indices of diseased spinal cord. Knowledge about normal DTI characteristics is essential for interpretation of major DTI indices in diseased states. This study determined the DTI characteristics of normal human cervical spinal cord at 3T.

References: (1) Wilm BJ, et al. Magn Reson Med 2007; 57: 625-630. (2) Standring S. Gray's anatomy 2009; 257-271. (3) Westerhausen R, et al. Neuroimage 2007; 37: 379-386. (4) Souma Y, et al. Okajimas Folia Anat Jpn 2008; 85: 107-109. (5) Takahashi K, et al. Acta Neuropathol 1975; 31: 151-158.

Figure Legends: The mean values of major DTI indices of, each component of cervical spinal cord (Fig 1), PC of each vertebral level (Fig 2), and bilateral LC (Fig 3). Error bars indicate standard deviation. * indicates statistical significance.