

Implementation of Axial Diffusion Tensor Imaging in the Lumbar Spinal Cord at 3T

T. M. Lindig^{1,2}, S. C. Mang², S. E. Heide^{1,2}, V. Kumar², T. Nägele³, W. Grodd², L. Schöls¹, and U. Klose²

¹Department of Neurology and Hertie-Institute for Clinical Brain Research, University Hospital Tuebingen, Tuebingen, Germany, ²Section of experimental MR of the CNS, Department of Diagnostic and Interventional Neuroradiology, University Hospital Tuebingen, Tuebingen, Germany, ³Department of Diagnostic and Interventional Neuroradiology, University Hospital Tuebingen, Tuebingen, Germany

Introduction: Spinal diffusion tensor imaging (DTI) is limited by severe motion artefacts and a low signal-to-noise ratio (SNR). Current gradient coils, with low-eddy-current designs, open the field for the usage of monopolar Stejskal-Tanner sequences [1]. With these schemes, smaller echo times and therefore a higher SNR can be achieved. Only a few studies of lumbar spinal DTI in humans already exist [2, 3], with a coarse and mainly sagittal acquisition. The aim of this preliminary study was to optimize the sequence parameter for high resolution axial spinal DTI of the lumbar spinal cord and to show relevant clinical implications.

Methods: The capability of monopolar, echoplanar diffusion imaging was evaluated on 7 healthy volunteers with the use of a clinical MR unit operating at 3.0 Tesla (Tim TRIO, Siemens, Erlangen, Germany) together with a 8-channel spinal coil. The imaging sequence was optimized for both a high SNR and a high axial in-plane resolution (acquisition parameters: TE = 92ms; FOV = 108x88mm; matrix size = 128x104; six directions; b-value = 1000s/mm²; slice thickness = 6mm; slices = 1; averages = 32; pulse or respiratory triggering; total measurement time ca. 4 and 12 minutes respectively). Finally, a 25 year old patient suffering from glioblastoma with new spinal metastasis (Fig. 1) was investigated to evaluate its exact location to the spinal cord. Anatomical T1 and T2 weighted images together with contrast agent were used as positive controls.

Results: We could show that the monopolar Stejskal-Tanner sequences can be used for spinal DTI. The occurrence of any relevant spatial distortions was not observed. Although pulse triggering, used for healthy volunteers with an inconspicuous spinal canal, already led to a relevant reduction of spinal movement artefacts, a substantial movement relict remains. Therefore, a linear manual movement correction was applied after visual inspection. The initially (in T1 and T2 weighted images) indistinct extra-axial position of the tumor mass could be clearly shown in the diffusion weighted images and was verified through the administration of contrast agent. The FA map (Fig. 5) illustrated good consistency to the contrasted image (Fig. 4). At the height of the metastasis (Fig. 1a) DTI showed a clear displacement of the spinal cord without any tumor infiltration evident. Within two circular ROIs, positioned in the compressed (FA 0.86 ± 0.06) and in the upper, normal appearing spinal cord (FA 0.7 ± 0.03), significantly higher FA values were observed in the squeezed compared to the uncompressed spinal tissue. A previously known intra-spinal edema (Fig. 2) could be identified in the diffusion image (Fig. 3) by significantly lower FA values (FA 0.48 ± 0.05).

Conclusion: The feasibility of highly resolved DTI of the human lumbar spinal cord could be demonstrated with good anatomical consistency. Spinal DTI can yield additional information regarding tumor infiltration of the spinal cord, most relevant to diagnostics and therapy planning. With a short total acquisition time (dependent on the trigger and the number of averages used) a vital precondition for any broader clinical applicability is given.

References: [1] Stejskal E.O. & Tanner J.E., J Chem Phys, 42:288 (1965); [2] Figley C.R. et al., AJNR, 29(8):1450-4 (2008); [3] Ellingson B.M. et al., AJNR, 29(7):1279-84 (2008);

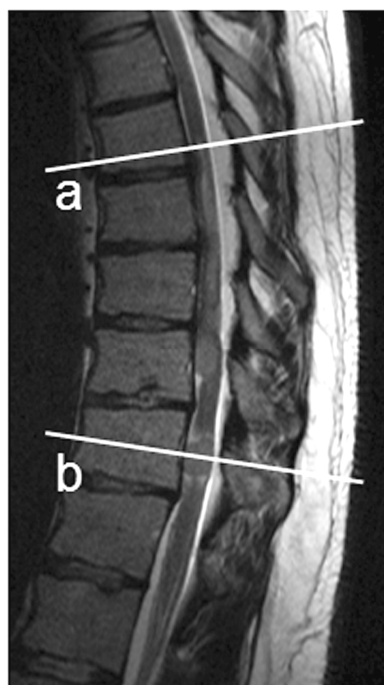


Fig. 1: Sagittal T2 weighted localizer of the lower thoracic and lumbar spine showing two metastasis at the Th10 and Th11 vertebral level; white lines indicate the axial slice position



Fig. 2: Axial T2 weighted image showing an intra-spinal edema at position fig.1a

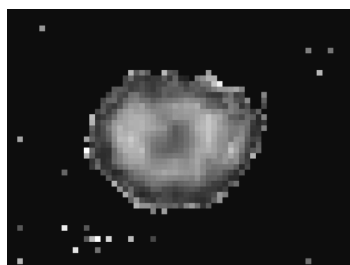


Fig. 3: Axial FA map of the spinal cord at position fig.1a showing low FA values at the site of the edema



Fig. 4: Axial T1 weighted image acquired with contrast agent showing a hyper-intense extra-axial lesion at position fig.1b

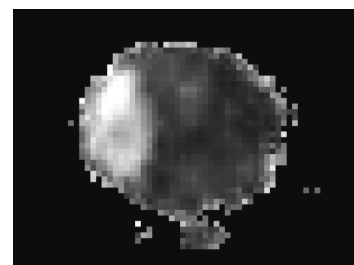


Fig. 5: Axial FA map at position fig.1b with good anatomical consistency to fig.4 showing high FA values in the displaced and compressed spinal cord