

Diffusion Study in Human Cervical Spinal Cord *in-vivo* using Biexponential Model

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Introduction: Diffusion weighted imaging (DWI) is used routinely to evaluate neurological disorders. However, it has a limited role in the spinal cord due to technical difficulties. Recent studies have shown that at high b-values diffusion is non-monoexponential in the brain [1] and in the animal spinal cord [3-5]. It can be approximated by a biexponential decay corresponding to fast and slow diffusion components. These two components may elucidate water properties in various compartments of the nervous tissue. To the best of our knowledge DWI of human CSC at high b-values has not been published so far. We report results of transverse diffusion studies in the CSC at high b-values of up to 7000 s/mm², using single shot axial DW-EPI [2] on a group of volunteers.

Methods: Imaging was performed on a standard clinical GE SIGNA LX Echo-Speed scanner. Group of 12 healthy volunteers, 8 women and 4 men, aged from 23 to 39, mean age 32 years ± 5, was used for the study. All volunteers gave their informed consent. A basic high resolution sagittal FSE scan was performed before DWI measurements. Standard, pulse trigger gated, DW EPI sequence was used to measure diffusion along three directions. Imaging was done on single slice at C5 level. Diffusion weighted images were acquired with a 64 x 64 matrix zero filled up to 256x256, FOV = 7 cm, slice thickness = 7 mm, TR = 2 RR, NEX = 8. The b factor varied from 300 to 7000 s/mm² in ten steps. Full scan for all b-values took around 70 min. Data were analyzed off-line using IDL based software developed in-house. Motion, EPI and eddy current artifacts corrections were applied for all DW images. Spine area was divided into four regions of interest located in the Ventral Horn Right (VHR) and Left (VHL) in gray matter and in the Posterior Funiculus Right (PFR) and Left (PFL) in white matter. Signal intensity decays for different b values (Fig 1.), were fitted to the bi-exponential model. Maps of diffusion coefficients and amplitudes of fast and slow component were also calculated.

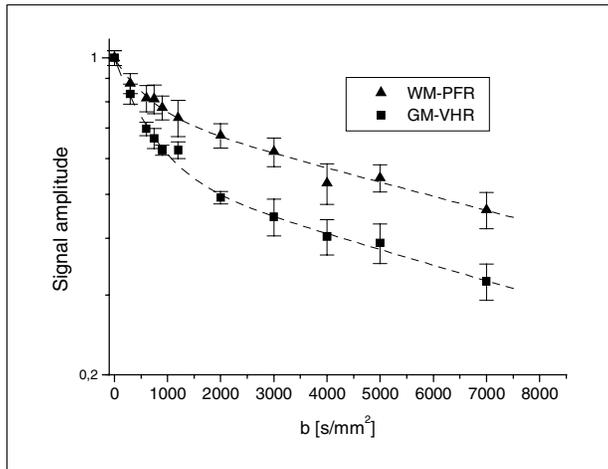


Fig. 1. Dependence of signal amplitude on diffusion weighting along R/L direction in CSC at C5 level in GM – VHR, in WM – FCR (p=0.01).

Results: Diffusion weighted image of the showing anatomical spine details were acquired (Fig.2). Diffusion coefficient values and fractions A_f of fast ADC_f and slow ADC_s component was determined at the GM and WM from signal decay curves (Fig. 1). The average values of diffusion components in the Ventral Horn in GM are: $ADC_f=(1.13\pm 0.11)\times 10^{-3}$ mm²/s, $A_f=(0.58\pm 0.02)$ and $ADC_s=(0.090\pm 0.011)\times 10^{-3}$ mm²/s. For WM in the Posterior Funiculus the corresponding values are: $ADC_f=(1.03\pm 0.08)\times 10^{-3}$ mm²/s, $A_f=(0.41\pm 0.02)$ and $ADC_s=(0.050\pm 0.070)\times 10^{-3}$ mm²/s. Simplified calculations using only low and high b value was also performed to supply data for comparison to the recent diffusion studies using mono exponential models. Our results are within the limits of human brain data [1] and full DTI data for the rat spinal cord at Th7 *in vivo* [4].

Conclusion: We have demonstrated the existence of non-monoexponential diffusion in the human CSC that can be approximated by fast and slow diffusion components.

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References: 1. Clark et al., MRM 44:852-859 (2000), 2. Jasinski et al., Proc. 11 ISMRM 2462 (2003), 3. Inglis et al., MRM 45:580-587 (2001), 4. Elshafiey et al., MRI 20:243-247 (2002), 5. Nossin-Manor et al., MRM 54:96-104 (2005).

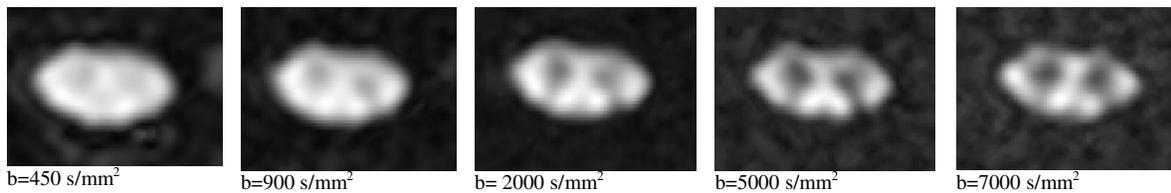


Fig. 2. Diffusion weighted images in transverse direction from a slice through the center of C5 for different b values.