O31 Axon Diameter Mapping of Pig Spinal Cord Using d-PFG Filtered MRI

Michal Komlosh[1], *Evren Ozarslan*[1], *Martin Lizak*[1], *Peter Basser*[1]
[1] National Institute of Health

Introduction: White matter in the spinal cord consists of packs of long aligned nerve axons that conduct information between the brain and other parts of the body. The ability to measure an apparent fiber diameter and its spatial distribution within the spinal cord is of particular interest because axon diameter scales with the velocity with which information propagates along nerves. Double pulsed field gradient (d-PFG)-based sequences [1], in which two single PFG blocks are applied consecutively, can be used to measure microstructural features such as fiber diameter [2,3], cell eccentricity [4,5], and local anisotropy [6]. In this study, we mapped the apparent mean diameter within fixed pig spinal cord using d-PFG filtered MRI.

Materials and methods: A formalin-fixed pig spinal cord was rehydrated and put in a 10 mm Shigemi tube (Shigemi Inc.) with the spine's white matter aligned with the z-axis of a 7 T vertical-bore Bruker DRX system. To account for any deviation of the fiber orientation from the z-axis, a 21-direction diffusion tensor imaging (DTI) experiment was performed first with the parameters: $\delta = 3$ ms, $\Delta = 50$ ms, G between 0 and 110 mT/m, and the imaging parameters were: TR/TE = 3000/59.3 ms, FOV = 11 mm, matrix size = 128×128, and slice thickness = 4 mm. Next, D-PFG filtered MRI was performed with the same imaging parameters except TR and TE, which were set to 3500 ms and 7 ms, respectively. The two wave vectors were applied sequentially while the angle between them was varied between 0 and 360°. The diffusion encoding pa-

rameters were: $d = 3.15\,\mathrm{ms}$, $D = 60\,\mathrm{ms}$, and G was between 0 and $664\,\mathrm{mT/m}$. A recently introduced theoretical framework [7], which makes it possible to calculate the MR signal attenuation due to restricted diffusion within a pack of cylinders, was fitted to the data by also taking into account a possible free water compartment [8]. A pixel by pixel analysis was applied to create a pore diameter map within the white matter region of the spinal cord.

Results and Discussion: The calculated fiber diameter from the d-PFG filtered MRI experiments range is from 3 to 5.5 μm, which is the expected range for such a specimen [9]. The relative sizes of the axons generally follow the expected known anatomy of the spinal cord white matter. However, histological staining could help substantiate these findings.

Conclusion: d-PFG filtered MRI is a powerful tool for mapping the axon diameter, and potentially other microstructural features of tissues.

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