Actively decouled two coil system enables in vivo DTI of mouse cervical spinal cord at 4.7 T

J. H. Kim[1], J. Haldar[2], Z-P. Liang[2], and S-K. Song[1]
[1]Washington University School of Medicine, St. Louis, MO, United States, [2]University of Illinois at Urbana Champaign, Urbana Champaign, IL, United States

Introduction

Rodents have been widely used as the animal model of various human diseases and injuries. With the readily achievable gene manipulation, transgenic mice have been employed to study diseases like amyotrophic lateral sclerosis, multiple sclerosis, or spinal cord injury (1). For the in vivo examination of degenerative disease, MRI has been extensively used in human patients and animal models. Recent work suggests that *in vivo* MR-diffusion measurements can detect disease in brain and spinal cord white matter with appropriate histology validation (2-4). Since neurodegeneration may be extended from the brain to the cervical spinal cord, a reliable methodology of in vivo DTI for cervical spinal cord is needed. EPI-DTI has been used to obtain diffusion measurements from rodent spinal cords at highg field strengths, 7, 9.4, and 12 T, taking the advantage of short data acquisition time. Here we present in vivo DTI measurements for mouse cervical spinal cord at magnetic field strength of 4.7 T using the custom-made actively decoupled volume and surface coil. Homogeneous B1 magnetic field and improved SNR were expected by using volume and surface coil as RF excitation and signal receiver, respectively. The acquired DTI maps (relative anisotropy (RA), axial ($\lambda\|$) and radial ($\lambda\perp$) diffusivity, and trace of the diffusion tensor (Tr(D)) provide detailed structural information on brain stem and cervical spinal cord.

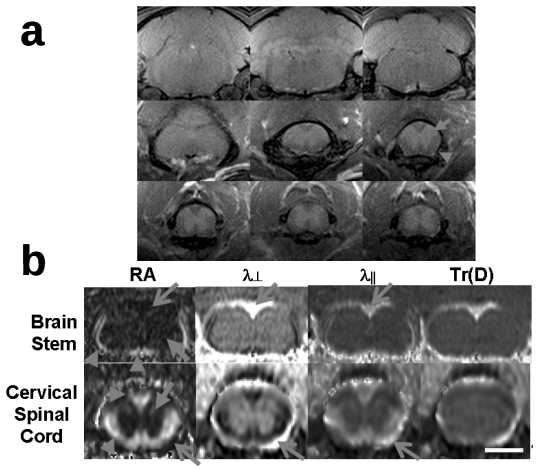

Figure 1. T2 weighted images (panel a) and DTI maps (panel b) are shown. The arrow head, filled arrow head, and non-filled head arrow indicate white matter, gray matter and CSF.

Methods

Five 8-week-old wild type mice underwent *in vivo* DTI evaluation at brain stem and cervical spinal cord with a 4.7 T magnet. DTI data were acquired using actively decoupled volume (8-cm inner diameter, RF exciatation) and saddle type surface coil (1.5 cm x 1.0 cm, signal receiver). The overall set up is similar to that described previously (2). A spin-echo diffusion-weighted sequence was modified to acquire 9 transverse images with respiratory gating. All images were obtained with acquisition parameters of TR 1.2 sec (gated acquisition), TE 38 msec, Δ 21 msec, δ 6 msec, slice thickness 0.5 mm, 1.0 mm gap, field-of-view 1.5×1.5 cm^2, data matrix 128×256 (zero filled to 256×256), total data acquisition time ~ 1.0 hrs. (Gx,Gy,Gz) = (1,1,0), (1,0,1), (0,1,1), (-1,1,0), (0,-1,1), and (1,0,-1), and b = 0 and 1.014 ms/μm^2. Image resolution was $117 \times 58 \times 500$ μm^3, with four scans averaged. After *in vivo* DTI measurements, diffusion indices including diffusion ellipsoid were generated in pixel by pixel basis with Matlab code.

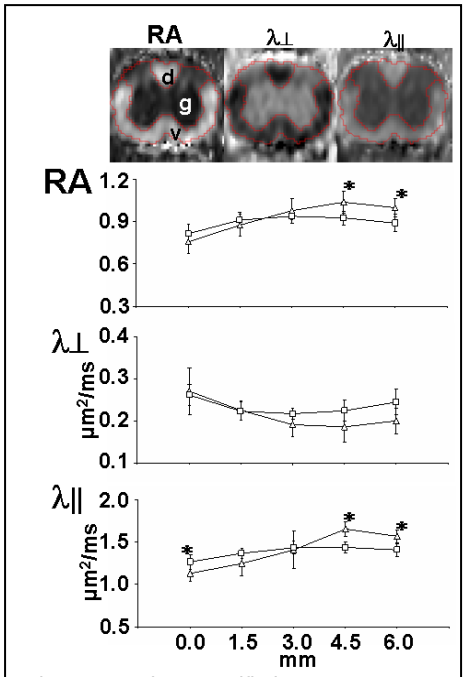

Figure 3. The quantified DTI parameters from cervical spinal cord are shown. The triangle and square represent dorsal and ventrolateral white matter. C1 cervical spinal cord was assigned as 0.0 mm. Both RA and $\lambda\|$ showed spatial dependence in dorsal white matter. * : $p < 0.05$

Results and Discussion

With actively decoupled two coil system, high quality data (SNR ~ 50) have been routinely acquired for full diffusion tensor experiment performed within one hour. The gray-white matter tissue contrast was clearly seen from T2 weighted anatomical image, anisotropy, and directional diffusivity maps. The contrast was not clear in the mean diffusivity map (Fig.1). The coherence of axonal fiber tracts is easily seen from color coded principal eigenvector map (Fig. 2). In white matter of both brain stem and cervical spinal cord, high anisotropy was observed resulting from high axial diffusion and low (lower than gray matter) radial diffusion (Fig. 3). The quantified DTI parameters of cervical spinal cord showed consistent ratio between white and gray matter compared to previously reported thoracic cord study (4), i.e., Relative anisotropy, 3; radial diffusivity, 0.5; and axial diffusivity, 1.5. The present results show the feasibility of in vivo DTI for mouse cervical spinal cord using actively decoupled two coil system at 4.7 T.

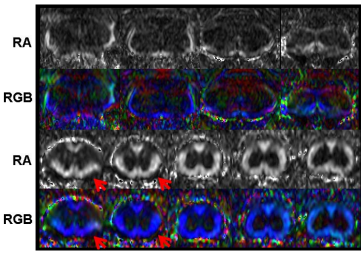

Figure 2. RA and color coded principal eigenvector RGB maps are shown. Red, green, and blue represent x, y and z direction.

References

1. Cross *et al.*, Neurology, 1993. 2. Kim *et al.,* Neurobiol. Dis., 2006, 3. Song *et al.*, Neuroimage, 2003. 4. Loy *et al.,*J. Neurotrauma, 2007.

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