In vivo high resolution diffusion tensor imaging of the mouse brain using a cryogenic probe at 11.7 T

Dan Wu[1], Jiadi Xu[2], Michael T. McMahon[2], Peter C. M. van Zijl[2,3], Susumu Mori[2,3], and Jiangyang Zhang[3]

[1]*Biomedical Engineering, Johns Hopkins University School of Medcine, Baltimore, MD, United States,* [2]*F.M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, United States,* [3]*Russel H. Morgan Department of Radiology and Radiological Science, Johns Hopkins University School of Medcine, Baltimore, MD, United States*

Introduction: Diffusion tensor imaging (DTI) is a useful tool to study brain anatomy and pathology in mouse models of diseases. High resolution *in vivo* mouse brain DTI is ideal for noninvasive and precise delineation of mouse brain structures. Collecting these images, however, remains challenging due to the low SNR and lengthy acquisition (both of which are inherent to DTI and worsened with increasing spatial resolution). The use of cryogenic probes (cryo-probes) has been shown to improve the SNR of mouse brain images by 2-3 times when compared to similarly constructed room temperature coils [1]. In this study, we investigated the potential of using a commercially available cryo-probe in combination with fast imaging sequences to achieve high resolution DTI of live mouse brains.

Methods: *In vivo* DTI was performed on a Bruker horizontal 11.7T system equipped with a quadrature surface transmit/receive cryo-probe. Multi-slice DTI was performed using a 8-segment diffusion weighted EPI sequence (TE/TR = 30/14000ms, NEX=1, 12 directions, b = 800 s/mm^2, in-plane resolution = 0.12 mm x 0.12 mm with a partial Fourier acquisition factor of 1.4, 28 slices with 0.5 mm slice thickness, field of view = 15 mm x 15 mm). With respiratory gating, the total imaging time was approximately 40 minutes. 3D DTI was performed using a diffusion weighted gradient and spin echo (GRASE) sequence [2] (TE/TR = 33/250 ms, NEX=2, BIR4 adiabatic pulses for excitation and refocusing, 12 directions, b = 1000 s/mm^2, field of view = 16 mm x 16 mm x 17.6 mm, spatial resolution = 0.125 mm x 0.125 mm x 0.125 mm). With respiratory gating, the total imaging time was approximately 1.5-2 hours.

Results and discussions: The cyro-probe allowed fast multi-slice DTI of live mouse brains at 0.12 mm x 0.12 mm x 0.5 mm with 8-segment EPI and partial Fourier acquisition (Fig. 1B). An average SNR of 150 could be routinely achieved at the dorsal portion of the brain, while the SNR in the ventral part of the brain reduced to 60 -70 (Fig. 1C-D). Major white matter structures could be delineated in the FA and colormap images (Fig. 1B).

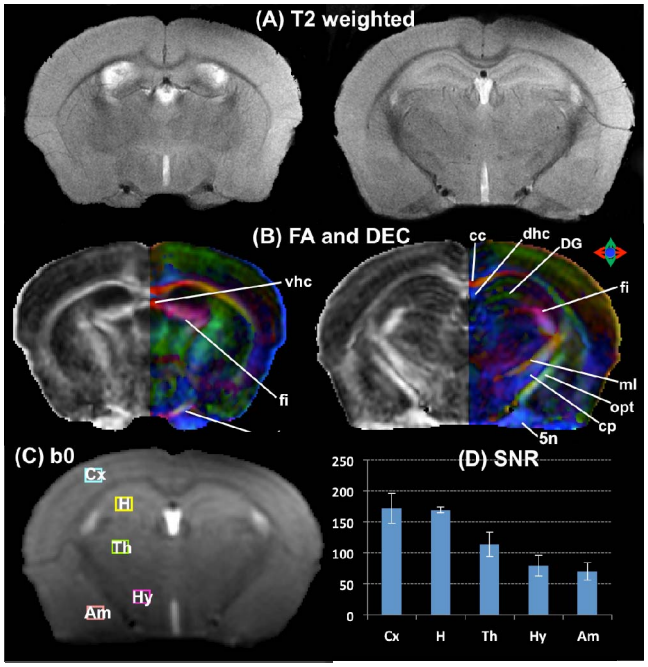

Fig. 1: A-B) In vivo multi-slice T2-weighted, fractional anisotropy (FA), and colormap (DEC) images of a mouse brain. C-D) SNRs measured in several regions of the non-diffusion weighted (b0) image. Abbreviations: 5n - 5th nerve, cc - corpus callosum, cp – cerebral peduncle, DG - dentate gyrus; fi - fimbria; opt- optic tract; ml - medial lemniscus; vhc/dhc:ventral/dorsal hippocampal commissure

With 3D GRASE acquisition, high resolution 3D DTI data (Fig. 2A) could be obtained within 2 hours. With a 0.125 mm isotropic resolution, fine white matter tracts in the thalamus, which were difficult to resolve in 2D images due to low through-plane resolution, could be reconstructed (Fig. 2B). The *in vivo* DTI results offered comparable capability in resolving small structures to previously published *ex vivo* DTI data that were acquired using a 3D diffusion weighted spin echo sequence at the same resolution (Fig. 2C) in approximately 20 hours [3], albeit at lower SNR and with reduced sharpness. The technique will greatly extend our ability to non-invasively examine small white matter tracts to detect potential pathology in various mouse models in vivo.

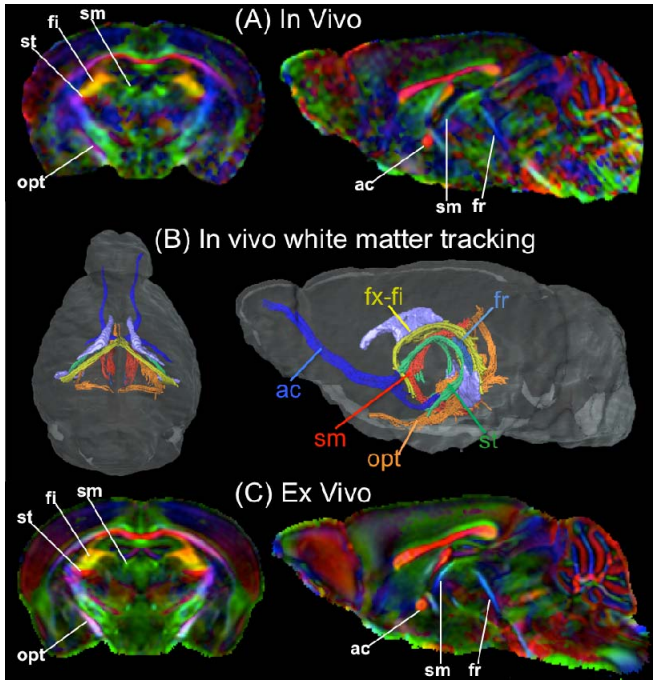

Fig. 2: Comparison of 3D in vivo and ex vivo DTI images of adult mouse brains. The in vivo data (A) were linearly registered to ex vivo data (C). (B) White matter tracts reconstructed from the in vivo DTI data. Abbreviations: ac – anterior commissure; opt – optical track; fx-fi – fornix-fimbria; sm – stria medullaris; st – stria terminalis; fr - fasciculus retroflexus

References: 1. NMR Biomed. 2009 22:834-842. **2.** MRM 2010 64(1):249-61. **3.** Neuroimage 2011 54(1):80-9.

Acknowledgement: This work is supported by NIH grants 1S10 RR028955, R01AG20012, R01EB003543, R21NS059529, R01EB012590 and R21NS065306.