In Vivo Isotropic Resolution Diffuson Tensor Imaging of Mouse Brain at 9.4T

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Introduction

Diffusion tensor imaging (DTI) is a powerful tool for investigating the architecture of the neural network and for investigating the connectivity of various regions of the brain. Clinically, DTI has find applications in multiple sclerosis, strokes, brain injuries, Alzheimer's disease, and brain tumors just to name a few. Preclinical studies using i*n vivo* DTI has some success in assessing developmental changes in BALB/cJ mouse brain in autism, to detect axonal injury in a traumatic brain injury mouse model and in neurodegenerative mice. Despite the existing body of work on mouse brain DTI, it is still challenging to perform DTI with high resolution because of the signal-to-noise ratio limitation in mouse brain DTI.

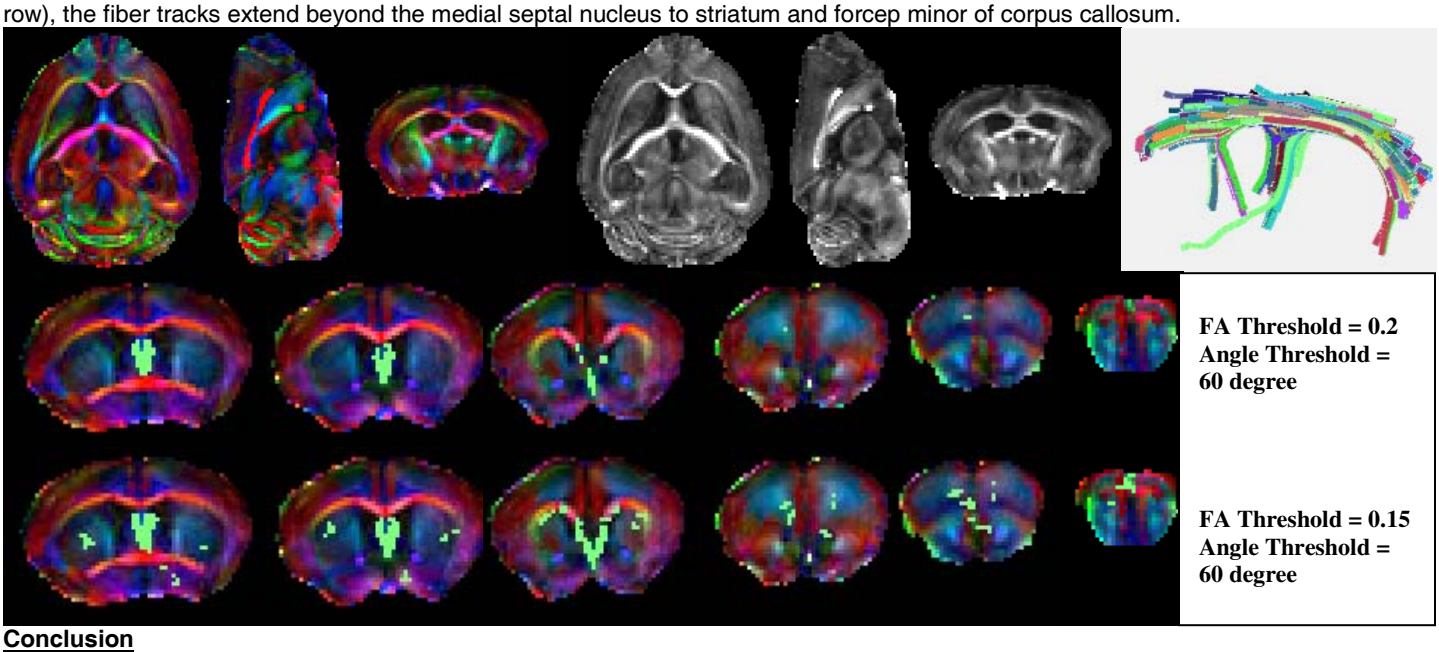
Method

Three normal mice (C57B6) were studied in a Bruker Biospec 9.4T USR system equipped with a 450mT/m gradients. A 72 mm inner diameter quadrature coil was used as radiofrequency transmitter and a 4-element phased array rat brain surface coil (Bruker Inc., Billerica, MA) was used as receiver coil to achieve whole brain coverage and high receiving sensitivity. Elastomer paddings were used on the side of the head to reduce head motion in the DTI experiments. The mouse was put in supine position to avoid head motion due to muscle relaxation during the scan. A diffusion weighting 3D spin-echo segmented echo planar imaging sequence was used to acquire the DTI images. Volume excitation was used to cover the whole brain with a 2D EPI readout to achieve a short echo time and high SNR. Diffusion weighted MRI images sensitized in 30 directions were acquired on the mouse brain with a b-value of 800 s/mm^2 and five b0 images were acquired. The detailed imaging parameters of the protocol are: TR = 1000 ms, TE = 22.96 ms, FOV = 19.2 × 12.9 × 13.8 mm^3, matrix size = 128 × 86 × 92, one average, number of EPI-segments = 3, voxel resolution = 150 × 150 × 150 μm^3, diffusion gradient duration (δ)= 4 ms with a 8.13ms separation (Δ), acquisition time=141 min, without any cardiac or respiratory gating.

DTI-Studio (www.mristudio.org) was used to generate the fractional anisotropy (FA) map and tensor tracking using FACT. algorithm. Prior to diffusion tensor calculation, image registration was performed using AIR[1] using a 6-parameter rigid body transform. All images were coregistered together by minimizing the standard deviation of the ratio between diffusion images and the b0 images.

Result

Representative single subject color-coded FA maps (**Red**: left-right, **Blue**: head-foot, **Green**: anterior-posterior) and grayscale FA maps are shown in the figure below (first row). The fimbria-fornix complex was easily tracked using a FA threshold of 0.25 and angle threshold of 60 degree (first row, right). When the FA threshold for fiber tracking was progressively lowered to 0.2 and 0.15 (second row), the fiber tracks extend beyond the medial septal nucleus to striatum and forcep minor of corpus callosum.



Conclusion

We reported an optimized method for *in vivo* mouse brain DTI at 9.4T providing high quality DTI maps and fiber tracking at high resolution (150 × 150 × 150 μm^3). It compares favorably to methods published so far [2,3] and is the highest resolution reported to date.

References

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