Cranial nerve tractography with 3T PROPELLER Diffusion Tensor Imaging

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[Introduction]

Cranial nerves are small nerves that control various sensory and/or motor functions and these nerves emerge from the brainstem. Conventional anatomical scan such as T1/T2 weighed MRI is commonly used to identify these nerves, but sometimes it is difficult to track the pathways due to complex structure. To visualize complex fiber structure, Diffusion Tensor Imaging (DTI) has been successfully demonstrated in elsewhere. 3Tesla MRI has high signal to noise ratio (SNR) comparing to lower field (1.5T) MRI, so it is expected that small neuro anatomy such as cranial nerves can be visualized by using high SNR of 3T. Single shot Echo Planar Imaging (ssEPI) based DTI acquisition is commonly used to suppress image ghost caused by phase shift induced from patient motion. Although ssEPI made great success in DTI and DTT application, it is sensitive to magnetic susceptibility and image distortion artifact or signal loss may result, especially at high field strength such as 3T. PROPELLER-DWI [1] is a FSE based diffusion acquisition sequence and PROPELLER based diffusion tensor image acquisition technique was used to avoid severe susceptibility effect on high field MRI. In this paper, 3T PROPELLER-DTT was studied to show its usefulness for cranial nerves tractography.

[Materials and Methods]

Diffusion Tensor Images were acquired on 3T MRI (SIGNA HD ver.12, GE Healthcare, Waukesha, WI) with 8ch Head Phased array coil. Three healthy male volunteer was scanned by PROPELLER based DTI and EPI-DWI. The following scan parameters were used for PROPELLER-DTI acquisition. (TR 6000ms TE 50ms, FOV22cm, thickness 3mm or 2.5mm, bvalue=800, etl=16, bw=62.5kHz, matrix 256, NEX2, centric view ordering, MPG encoding gradient 6). And the following scan parameters were used for EPI-DTI (TR 12000ms TE70ms, FOV24cm, thickness 2.6mm, bvalue=1000, NEX2, ASSET reduction factor 2). For images acquired with EPI technique, image distortion was corrected with mutual information based algorithm on Functool2 (GE Healthcare). All fiber tracking was performed on “volume-one” and “dTV-II” software, which can be downloaded from the following URL (http://www.ut-radiology.umin.jp/people/masutani/ dTV.htm). Two different tracking algorithms were compared, one is tracking to the direction of the principal axis of diffusion tensor (“basic”) and the other is tracking to the direction determined according to anisotropy of the diffusion tensor (“advanced”). In the latter technique the tracking direction is kept in the last position if the tensor is in low anisotropy [2]. Seed and Target ROIs were placed on isotropic diffusion image based on anatomical knowledge to tracking cranial nerves. PROPELLER-DTI data set and EPI-DTI data set was processed and results were compared and analyzed. Region of Interests (ROI) were placed carefully at middle cerebellar peduncle and noise area, to measure MR signal intensity, then image SNR was compared.

[Results]

No significant distortion was observed in the vicinity of the pons or midbrain in PROPELLER-DTI comparing to high spatial resolution anatomical T1 weighted image, while severe distortion was observed in DT-EPI images. Slice coverage was limited to 10-12 slices with 12sec of Repetition Time due to SAR safety limit (2.0W/kg) in PROPELLER-DTI, although the volume of interest in this study could be covered with this limitation. Total scan time was 25min for PROPELLER-DTI. Figure 1 illustrated the tracking result of PROPELLER-DTI data and Figure2 illustrated the result of EPI-DTI. In all three cases, Optic nerve [II], Trigeminal nerves [V] and Vestibulocochlear nerve [VIII] were tracked with PROPELLER-DTT. In contrast to PROPELLER cases, the trigeminal nerve was clearly tracked around the area proximal to the pons in intracranial nerves with EPI based DTT, while the tract was ended in the middle of fibers or tracked to wrong fibers. With the “basic” tracking scheme, both PROPELER-DTT and EPI-DTT was not continued and ended in the middle of the fiber. With the “advanced”, cranial nerves were visualized. SNR ratio between DT-EPI and PROPELELLER-DTI was 3.5.

[Discussions and Conclusion]

Although image SNR of DT-EPI is more than three times higher than PROPELLER, the fiber tracking results of cranial nerves with PROPLELLER-DTT was similar or even superior than the one of EPI based technique. It is suggested that this is due to signal loss by magnetic susceptibility around small cranial nerves in EPI data set. The resultant tractography image was depended on the tracking algorithm. The “tracking2” provided superior tracking results. This algorithm is more robust to image noise and partial volume effect. In PROPELLER-DTT, spatial resolution is much higher then the one of EPI, the fibers to track in this study is still smaller than this resolution. So the robustness to partial volume effect helped to improve the tracking result. We conclude that 3T PROPELLER-DTT is useful for small neuro fibers such as cranial nerves.

[Reference]

[1] MRM 47(1):42-52, 2002 [2] Medical Imaging Technology,20:5, 584-592, 2002 [3] http://www.ut-radiology.umin.jp/people/masutani/dTV.htm

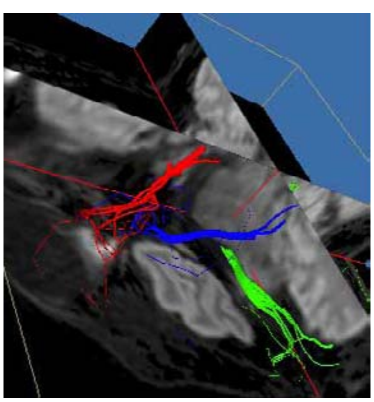

Figure 1 PROPELLER-DTI tracking result. Red: (Optic nerve [II]), Green : (Trigeminal nerves [V]), Blue : (Vestibulocochlear nerve [VIII])

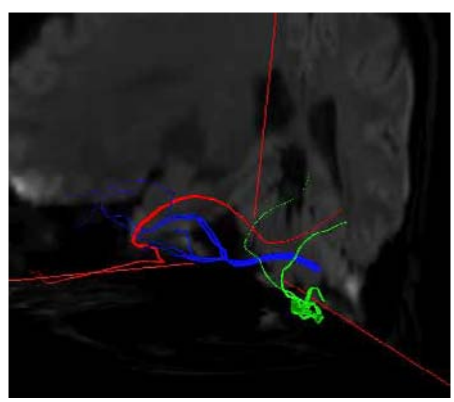

Figure 2 DW-EPI tracking result. Red: (Optic nerve [II]), Green : (Trigeminal nerves [V]), Blue : (Vestibulocochlear nerve [VIII])