Optimization of diffusion tensor MR imaging data acquisition parameters for brain fiber tracking using parallel imaging at 3T

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Purpose

The purpose of this study was to optimize the parameters of diffusion tensor (DT)-MRI for brain fiber tracking [1] using 2 mm thickness, that was allowed by the high signal-to-noise ratio at 3T combined with the 8-channel phased array head coils. This protocol optimization was performed for clinical use. Therefore, the scan time was set below 4 minutes for clinical feasibility.

Materials and methods

Six healthy volunteers were included in this study. All scans were performed on a 3-Tesla MR scanner ("Trio;" Siemens AG, Erlangen, Germany) using a receive only 8-channel phased array head coils. DT-MRI was obtained using the parameters as follows; Single-shot spin-echo type echo-planar imaging, TR of 7700 ms, TE of 67 - 87ms depending on b-factors, 128 x 128 matrix, and 60-2 mm axial slices to cover whole brain. The MPG in 6 or 12 orientations were applied. The 128 x 64 points were recorded using parallel imaging technique, GRAPPA[2].

The brain fiber tracking was performed using the free software dTV (version 1.5), which can be downloaded at http://www.utradiology.umin.jp/people/masutani/dTV.htm

1) *Optimization of b-factor;* The b-factor was varied from 300 to 1700 sec/mm^2 at every 200 sec/mm^2 step. Tractography was generated in each data sets for pyramidal tract and trigeminal nerve visualization.

2) Optimization of number of motion probing gradient orientation (MPG) ; The number of MPG orientation was compared between 6 and 12.

3) *Optimization of number of averaging;* The DT-MRI data with 1 and 3 averaging were compared for b-factor of 700 sec/mm^2 and 6 directions of MPG based on the results of 1) and 2). Scan time of 1 averaging was 1 m 49 s, and that of 3 averagings was 3 m 30 s.

Results

1) Optimization of b-factor; Percentage of voxels reached to the target from seed ROI was 5% by b=300, 6% by b=500, 13% by b=700, 8% by b=900, 7% by b=1100, 3% by b=1300, 2% by b=1500, and 1% by b=1700 sec/mm^2 (Fig.1). Symmetric visualization of bilateral pyramidal tract was obtained b-factors of 700, 900 and 1100 sec/mm^2. Excellent visualization of trigeminal nerve was obtained b=500 and 700 sec/mm^2. With the b-factor of 900 sec/mm^2 and above, thickness of trigeminal nerve decreased due to susceptibility related distortion and decreased signal to noise ratio.

2) *Optimization of number of motion probing gradient orientation;* For the visualization of pyramidal tract, percentage of voxels reached to the target from seed was 11.7 % by 6 directions and 12.5 % by 12 directions. Fiber tracking images of bilateral pyramidal tract by 2 methods are comparable. For the visualization of trigeminal nerve, an image with 6 diredctions seems to be better than that with 12 directions. Thus, DT-MRI with 6 directions of MPG were employed for further study.

3) Optimization of number of averaging; The visualization of pyramidal tract and trigeminal nerve was comparable between the images with 1 averageing and 3 averagings.

From the results of present study, b-factor of 700 sec/mm^2, 6 directions of MPG, and 1 signal averaging is selected as the method of choice for clinical DT-MRI protocol.

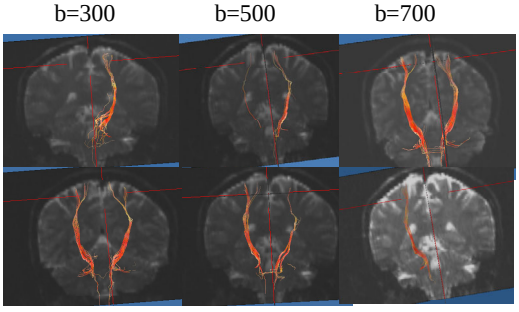

Fig. 1 Tractography of pyramidal tract by various b-factors

Conclusion

Brain fiber tracking from the DT-MRI data obtained with 2mm slice thick, b-factor of 700 sec/mm^2 using parallel imaging technique and 8 channel array head coil at 3T is feasible in less than 2 minutes scan time in healthy subjects.

References

1. Yamada K, Kizu O, Mori S, et al. (2003) *Radiology* 227; 295-301

2. Griswold MA, Jakob PM, Heidemann RM, et al. (2002) *MRM* 47; 1202-1210