Diffusion MR imaging with anisotropic MPG for better depiction of pyramidal tract

Yuichi Suzuki[1], Yoshitaka Masutani[1,2], Kenji Ito[1,2], Kenji Ino[1], Katsuya Maruyama[3], Thorsten Feiweier[4], Yasushi Watanabe[1], Yoshirou Satake[1], Masami Goto[1], Akira Kunimatu[1,2], Masaaki Akahane[1], Keiichi Yano[1], and Kuni Ohtomo[1,2]

[1]Department of Radiology, The University of Tokyo Hospital, Bunkyo-ku, Tokyo, Japan, [2]Radiology and Biomedical Engineering, The University of Tokyo Graduate School of Medicine and Faculty of Medicine, Japan, [3]Siemens Japan K.K., Japan, [4]Siemens AG, Germany

Introduction

For diffusion MR imaging, directions of motion probing gradient (MPG) are set in an isotropic distribution for depicting various orientations of fibers. When we focus on specific neural fibers, however, their directions are limited. For example, corticospinal tract (CST) and corticobulbar tract (CBT) do not run in the anterior-posterior direction, and we do not need MPG directions of isotropic density. In this study, we designed an anisotropic MPG set for Q-ball imaging (QBI) [1] to depict CBT with tractography. Our goal is to compare the depiction abilities among our anisotropic MPG set and Jones (isotropic) MPG sets [2].

Materials and Methods

Anisotropic MPG Set: The numbers of MPG directions were 60. Among them, 20 axes were isotropic axes (gray lines in Fig.1), and other 40 axes (blue lines in Fig.1) were anisotropic for considering crossing of CBT and superior longitudinal fasciculus (SLF).

Isotropic MPG set: We used 2 sets of the isotropic Jones MPG. One is 120 axes for reference. And the other is 60 axes for comparison.

Acquisition: DWI were acquired from 12 subjects (male; median age 30.5±3.3; range; 25-34years), with the SIEMENS MAGNETOM Avanto 1.5T using a Twice Refocused Spin Echo EPI sequence with b-value=3000 [s/mm^2]; TR/TE = 8000/107 [ms]; FOV 25.6 [cm]; acquisition matrix 86×86; slice thickness; 3.0 [mm]; 50 axial slices; GRAPPA factor=2. These acquisition times were 1126 [sec] for isotropic 120 axes and 546 [sec] for anisotropic and isotropic 60 axes.

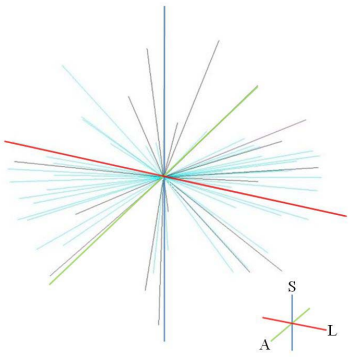

Fig.1. anisotropic MPG set

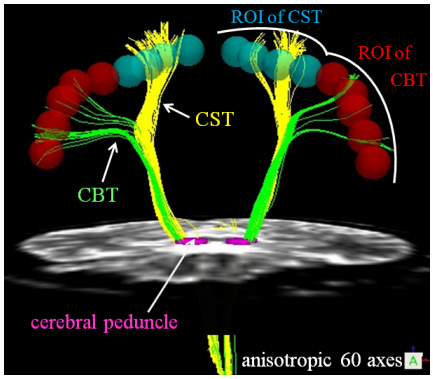

Fig.2. ROI and tractography

QBI and Tractography: QBI analysis and tractography were performed with Diffusion Toolkit 0.6 and TrackVis 0.5.1 (http://trackvis.org/). The regions of Interest (ROI) used for tractography were set at the cerebral peduncle (CBT and CST), at the outside (CBT) and at the inside (CST) of a knob on the precentral gyrus [3] in motor cortex. The ROI in motor cortex were beaded spheres and the radius of a sphere was 6 [mm] (Fig.2).

Evaluation: We first performed visual assessment of the tractography result by each MPG set, and compared the DICE factors of the extracted volume in comparison with the reference result.

Results and Discussion

In visual assessment, our anisotropic MPG depicted CBT and CST in the all cases while the Jones isotropic 60 MPG depicted 100% of CST, but 75% of CBT (Table 1). Therefore, our anisotropic MPG has better depiction ability. And we guessed that because of MPG directions of anisotropic density, the information at intersection of CBT with SLF increased, the visual assessment result and DICE factor was improved. In the comparison of DICE factors, our anisotropic MPG was slightly superior to that of the isotropic MPG (Table 2) though there was no significant difference between each DICE factors. However, it's difficult to declare that the result with Jones 120 axes MPG set (reference) is golden standard. Therefore, examinations with other conditions are required in future works.

Table 1. The result of visual assessment

	CBT			CST		
	Rt	Lt	Total	Rt	Lt	Total
isotropic 120	12/12	12/12	24/24	12/12	12/12	24/24
isotropic 60	9/12	9/12	18/24	12/12	12/12	24/24
anisotropic 60	12/12	12/12	24/24	12/12	12/12	24/24

Table 2. The result of each DICE factors

	CBT			CST		
	Rt	Lt	Average	Rt	Lt	Average
isotropic 60	0.312	0.302	0.307	0.696	0.699	0.697
anisotropic 60	0.365	0.295	0.330	0.620	0.654	0.637

Reference

[1] Tuch DS. Magn Res Med 52(6); 1358-1372, 2004
[2] Jones DK. Magn Res Med 42(3); 515-525, 1999
[3] Yousry TA. Brain 120(1); 141-157, 1997

Acknowledgments

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