Anisotropic and isotropic MPG comparison for better depiction of pyramidal tract in the patients

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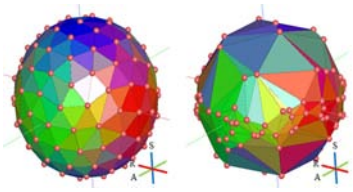
Introduction

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 CST and CBT with tractography. Our goal is to compare the depiction abilities among our anisotropic MPG set and Jones (isotropic) MPG sets [2] in brain disease patients.



(a) Jones 60 axes (b) our 60 axes

Fig.1. The directions of MPG

Materials and Methods

Isotropic MPG set: We used Jones MPG. The numbers of MPG directions were 60{Fig.1 (a)}.

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

Acquisition: DWI were acquired with a SIEMENS MAGNETOM Avanto 1.5T using a Twice Refocused Spin Echo EPI sequence with b-value=3000 [s/mm^2]; TR/TE = 8300/96.4 [ms]; FOV 25.6 [cm]; acquisition matrix 86×86; slice thickness; 3.0 [mm]; 50 axial slices; GRAPPA factor =2. These acquisition times were 583 [sec] for anisotropic and isotropic 60 axes.

Subjects: 17 patients with unilateral cerebral lesions (12 male and 5 female; median age 45.8±16.3; range; 30-86years) were selected for the study. The locations of area and the medical history showed in Table1.

Table1. Subjects list

No.	Sex	Age	Location	Medical History
1	F	33	R frontal lobe	Oligodendroglioma
2	M	40	L temporal lobe	Anaplastic oligodendroglioma
3	F	33	R frontal lobe	Radiation necrosis s/o
4	M	42	R nuclear basalis	Brain tumor, gliosis s/o
5	M	30	L frontal lateral lobe	Oligodendroglioma
6	M	46	L frontal lobe	Glimatosis
7	F	65	L parietal lobe	Meningioma
8	M	32	R temporal lobe	Radiation necrosis s/o
9	F	58	R frontal lobe	Glioblastoma maltiforme
10	M	71	R temporal lobe	Glioblastoma maltiforme
11	M	51	R temporal lobe	Meningioma
12	M	37	R temporal lobe	AVM recurrence after γ-knife
13	M	31	R temporal lobe	Capillary telangiectasia
14	M	86	L lateral ventricle neighborhood	Glioma s/o
15	F	27	R temporal lobe	Pleomorphic xanthoastrocytoma
16	M	47	R frontal lobe	Oligodendroglioma
17	M	49	L parietal temporal lobe	Glioblastoma maltiforme

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 in motor cortex. The ROIs in motor cortex (spherical ROI) were made with VOLUME-ONE and dTV-II.FZR (http://www.volume-one.org) (Fig.2).

Evaluation: We first conducted qualitative assessment of the tractography result by each MPG set, and then visual assessment of each depicted pyramidal tract (CBT plus CST) (Fig.3). Visual assessment was peformed by five radiological technologists, who compared isotropic and anisotropic MPG and determined which one was superior to the other.

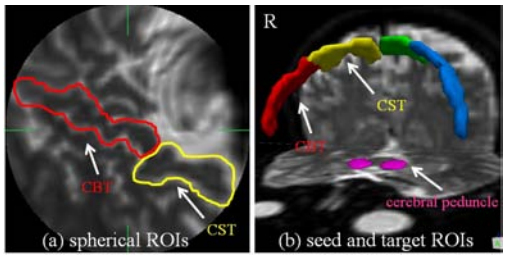


Fig.2. Seed and target ROIs

Results and Discussion

In the qualitative assessment, our anisotropic MPG depicted 100% of CST and 88.2% of CBT while the isotropic 60 MPG depicted 100% of CST, but 64.7% of CBT in the unaffected side. Therefore, our anisotropic MPG has better depiction ability in the unaffected side. In the affected side, however, there was little difference of the qualitative assessment between anisotropic (82.4% in CBT and 100% in CST) and isotropic MPG (88.2% and 100%) (Table2). In the visual assessment, isotropic MPG was superior in the affected side compared to that of our anisotropic MPG in 70.6% (12/17) of the patients. In these patients, mass effect or edema was observed near the pyramidal tract. On the other hand, in patients with no mass effect or edema, our anisotropic MPG was superior to isotropic MPG in 29.4% (5/17) of the patients. (Table3). In conclusion, although anisotropic MPG depicted more pyramidal tracts than isotropic MPG, it may not necessarily provide sufficient information in abnormal brain tissues compare to isotropic MPG, particularly in those affected by severe mass effect or edema, since QBI (anisotropic MPG) tract depiction is theoretically on the assumption of normal fiber tracts.

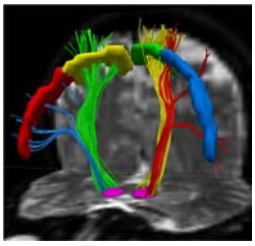


Fig.3. Result image

Table 2. Depiction rate of CBT and CST

	isotropic > anisotropic	isotropic = anisotropic	isotropic < anisotropic
unaffected side	6/17 (35.3%)	1/17 (5.88%)	10/17 (58.8%)
affected side	12/17 (70.6%)	0/17 (0.00%)	5/17 (29.4%)

Table 3. Visual assessment

	CBT		CST	
	isotropic	anisotropic	isotropic	anisotropic
unaffected side	11/17 (64.7%)	15/17 (88.2%)	17/17 (100%)	17/17 (100%)
affected side	15/17 (88.2%)	14/17 (82.4%)	17/17 (100%)	17/17 (100%)

References

[1] Tuch DS. Magn Res Med 52(6); 1358-1372, 2004
[2] Jones DK. Magn Res Med 42(3); 515-525, 1999