Correlation of Cortical and Subcortical Motor Mapping with DTI- and HARDI-Based Tractography

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Introduction

Diffusion tensor imaging (DTI)-based tractography has become a frequently used intraoperative tool for the resection of lesions in eloquent brain. However, DTI has inherent limitations that preclude the accurate modeling of crossing fiber tracts. In the case of motor tracts, DTI fails to generate lateral fibers to hand and face motor cortices. Next-generation diffusion methods, such as high angular resolution diffusion imaging (HARDI), create more robust representations of white matter tracts that may be more useful in the intraoperative setting. To test this hypothesis, we compared tractography maps derived from conventional DTI versus HARDI to motor sites recorded from cortical and subcortical electrical stimulation mapping (ESM).

Methods

In 5 subjects with brain tumors, we obtained motor tractography maps using DTI and HARDI. Intraoperatively, we mapped motor cortex with ESM, and the stereotactic coordinates of these stimulation sites were recorded. We then determined the proximity of the motor sites to the tractography maps to measure their accuracy in predicting motor tracts on co-registered volumes.

Results

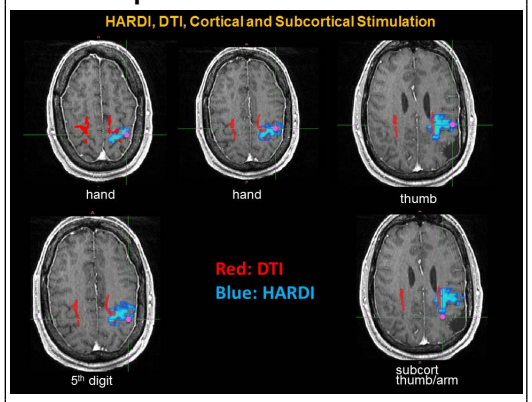
Fourteen cortical (5 face, 9 hand) and 7 subcortical (0 face, 7 hand) motor sites were identified. For cortical sites, the mean minimal distance to any part of the tractography maps was 4.7±4.9 mm (HARDI) versus 14.9±8.4 mm (DTI; p=0.001). For subcortical sites, the mean minimal distance was 3.0±2.3 mm (HARDI) versus 8.7±1.8 mm (DTI; p=0.0003). For face sites, the mean minimal distance was 7.6±3.0 mm (HARDI) versus 22.5±8.8 mm (DTI; p=0.04). For hand sites, the mean minimal distance was 3.1±4.0 mm (HARDI) versus 10.3±4.8 mm (DTI; p<0.0001).

Distance in mm from stimulation sites

	Cortical		Subcortical	
Motor	HARDI	DTI	HARDI	DTI
Face	8.6	29.2		
	7.4			
	9.7	16		
	9.7	13.8		
	2.4	30.8		
Arm/hand	10.6	20	2.2	6.6
	13.5	11.4	2.6	10.2
	0	5.7	0	6.4
	0	11.4	6.2	8.2
	0.98	20.6	1.5	8.98
	2.1	7.4	5.9	11.5
	0.98	14.1	2.6	8.9
	0	2.9		
	0	10.9		

Distances (mm) of intraoperative stimulation from HARDI and DTI maps for all subjects and all motor mapping sites.

Co-registered images of tractography maps and stimulation sites



DTI (red) and HARDI (blue) tractography maps have been registered to a T1-weighted MRI volume. The pink dots represent the stereotactic location of motor stimulation sites. The motor group corresponding to the stimulation site has been annotated for each image. HARDI is more accurate in predicting motor tracts than conventional DTI.

Conclusions

HARDI was more accurate at predicting motor sites than DTI. As expected, tractography maps were closer to subcortical and hand stimulation sites. The distance between stimulation sites and DTI-based tractography was often greater than 1 cm. Thus, conventional DTI should be used with caution as an intraoperative adjunct for guiding lesion resection.

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