Comparing diffusion tensor imaging metrics of motor and sensory tracts in children with spastic cerebral palsy and the levels of gross motor function by TBSS and tractography

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INTRODUCTION

Cerebral palsy (CP), caused by a group of non-progressive brain injuries, is associated with motor, sensory and cognitive impairments[1]. Spastic CP, as a special type of CP, mainly presented as motor dysfunction of limbs. Alought clinical features for each child with spastic CP are distinct, it is still unclear what's the relationship between outcomes and appearances of brain injuries on MR images.. However, it is uncertain whether motor or sensory pathway injury is related to motor dysfunction. Diffusion tensor imaging (DTI) has been proved to be a sensitive mothod in detecting white matter (WM) tract variations and can provide more evidence in judging prognosis [2]. So this study aimed toemploy DTI with tract-based spatial statistics (TBSS) and quantitative tractography to further evaluate the correlation between DTI metrics of motor and sensory tracts with gross motor function[3, 4].

MATERIALS and METHODS

This retrospective study included 23 children with bilateral spastic CP (11 females, 12 males, mean age: 12±0.84 months). The children with CP were diagnosed by two pediatric neurologists and were evaluated according to Gross Motor Function Classification System (GMFCS) at two years old. GMFCS level Ⅰ(n=7), level Ⅱ(n=5), level Ⅲ(n=4), level Ⅳ(n=4), level Ⅴ(n=3). GMFCS level Ⅰ-Ⅱis mild motor impairment, and level Ⅲ- Ⅴ is moderate and severe motor impairment. In this study, 3D-MPRAGET1WI, FSE-T2WI and DTI were performed in a 3T scanner (GE, Signa HDxt) with 8-channel head coil. Technical parameters of DTI were as follows:, TR/TE=5500/95ms, thickness=4mm without gap, field of view = 180×180mm^2, matrix = 256×256, b =1000 s/mm^2 with 35 gradient directions. All data was analyzed by FMRIB's Software Library (FSL) and Medical Image Navigation and Research Tool (MedINRIA). TBSS was used to align fractional anisotropy (FA) images of all subjects to the target image. Mean FA skeleton was created on the mean FA image. Each aligned FA image of each subject was projected onto the mean FA skeleton (threshold=0.2). We performed voxelwise correlation analysis between FA values on FA skeleton and GMFCS levels. In MedINRIA, ROIs were drawn on the color-coded FA images. The fibers were traced by connecting adjacent voxels with similar principal eigen-vectors, applying a FA value of 0.2 for continuous fiber reconstruction. Reconstructing fiber tracts include corticospinal tract (CST), superior thalamic radiation (STR) and posterior thalamic radiation (PTR). Meanwhile, FA value, the number of fibers and the volume were calculated. In SPSS v.17, spearman's correlation analysis was used to analyze associations. All tests were considered to be significant at p<0.05.

RESULTS

Voxelwise correlation analysis between FA and GMFCS levels were displayed on TBSS, maps (Fig.1). FA values of most of the WM tracts show a significant negative correlation with GMFCS levels except GCC, PLIC (P <0.05). However, the FA values of CST was more strongly correlated with GMFCS levels (P <0.01). Spearman's correlation coefficient between the depicted tract and GMFCS level is shown in Table1. In CST, There were significant negative correlations between the GMFCS and the FA values (r=-0.868, p=0.000), and the number of fibers (r=0.558, p=0.013), except for the volume of fibers. In STR, there were fair negative correlations between the GMFCS and the FA values (r=-0.518, p=0.023), the number of fibers(r=0.512, p=0.025) and the volume (r=0.561, p=0.013). In PTR, there was also fair negative correlations between the GMFCS and the FA values (r=-0.5, p=0.029), but the volume and number of fibers show no significant correlation with GMFCS levels.

Correlation between GMFCS level and motor–sensory tract parameters (Spearman's correlation coefficient)

	Motor(CST)		Sensory(STR)		Sensory(PTR)	
	r	p	r	p	r	p
FA	-0.868	0.000*	-0.518	0.023	-0.500	0.029
volume of fibers	-0.332	0.165	-0.512	0.025	-0.212	0.383
number of fibers	-0.558	0.013	-0.561	0.013	-0.423	0.071

Table 1 r the correlation coefficient (* P<0.01). CST, corticospinal tract. STR , superior thalamic radiation. PTR, posterior thalamic radiation .

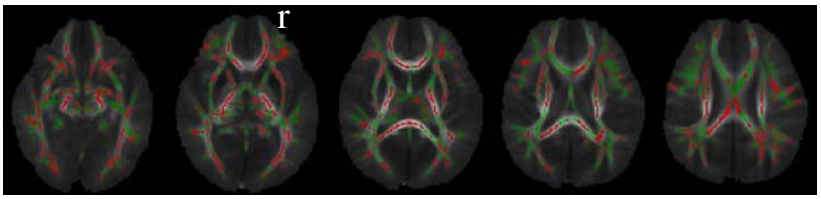

Figure 1 Voxel-wise correlation analysis between FA values and GMFCS levels by TBSS. Red regions showed significant negative correlation between FA values and GMFCS levels (P<0.05). There were no

DISCUSSIONS and CONCLUSIONS

In this study, we used DTI combined with two image analysis technology (TBSS and probabilistic tractography) to investigate the correlation between DTI metrics of motor and sensory tracts with gross motor function since their reliability and reproducibility. FA values of most of the WM tracts show a significant negative correlation with GMFCS levels, and the FA values and fiber count of CST were strongly negative correlated with GMFCS levels, which indicated that the injury of motor tract may be the primary pathologic mechanism of motor dysfunction in children with spastic CP. In addition, there were fair negative correlations between DTI metrics of STR and the FA values of PTR with the GMFCS. We inferred that the sensory tracts may be secondary damage, attenuated by the injury of sensorimotor loops involving CST. This is the first study to analyze the correlation between injury of motor and sensory tracts with motor dysfunction by DTI and TBSS and probabilistic tractography. The results demonstrated that the CST played a significant role in the development of clinical motor and sensory function. In summary, the FA value within CST could serve as an early detection and prognostic evaluation in children with spastic CP.

References1.Rosenbaum P et al. Dev Med Child Neurol,2007;49:8-14.2.Murakami A et al. Pediatrics, 2008; 122:500-506.3.Yoshida S et al. Dev Med Child Neurol, 2010; 52: 935–940. 4. Lee JD et al. Brain, 2011; 134; 1199–1210.