# White matter variations in children with spastic cerebral palsy analyzed by diffusion tensor imaging with tract-based spatial statistics and probabilistic tractography

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## INTRODUCTION

Cerebral palsy (CP), mainly presented as spastic diplegia or quadriplegia in clinic, is a non-progressive brain injury which is related to multiple impairments in motor, sensory and cognitive [1]. . Alought conventional magnetic resonance imaging (MRI) has been widely used in detecting brain anatomical variations due to CP [2], it is still poorly understood the underlying pathologic mechanism of motor impairment . Diffusion tensor imaging (DTI) has expanded its ability and sensitivity in detecting white matter (WM) microstructural abnormalities and may give more evdiences in exploring the relationship between WM damages and motor disfunctions [3]. This study aimed to investigate the WM microstructural changes in children with spastic CP.employing DTI with tract-based spatial statistics (TBSS) and probabilistic tractography.

## MATERIALS AND METHODS

This study included 23 children with bilateral spastic CP (11 females, 12 males, mean age: 12±0.84 months), and 23 healthy children with matched age and sex (mean age: 12±0.76 months). The children with CP were diagnosed by two pediatric neurologists. In this study, 3D-MPRAGE T1WI, 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 analysis was performed 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 and an average FA image and its skeleton was created. Each subject’s aligned FA images were projected onto the mean FA skeleton (threshold=0.2). Voxel-wise cross-subject statistics was performed to assess differences in FA, axial diffusivity (AD), radial diffusivity (RD) and mean diffusivity (MD) between two groups of chilidren. 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), posterior thalamic radiation (PTR), genu of corpus callosum (GCC), splenium of corpus callosum (SCC). In SPSS v.17，We analyzed the differences of volume and the number of fibers between two groups. All tests were considered to be significant at p<0.05.

## RESULTS

Group comparison of FA, MD, AD, RD values between the CP group and the control group were shown by TBSS maps (**Fig.1**). In CP group, decreased FA and increased MD, RD could be observed in almost all extracted WM tracts except GCC, body of corpus callosum (BCC) and anterior limb of internal capsule (ALIC) (P<0.05). The AD values increased in PTR and SCC withdiscrete appearance (P<0.05). Results ofthe probabilistic tractography in CPs and controls were shown in **Fig.2** and **Fig.3**. In PTR and SCC, the number of fibers and volume was significantly reduced in CP group (P<0.01). There were no significant differences in the other depicted tracts.

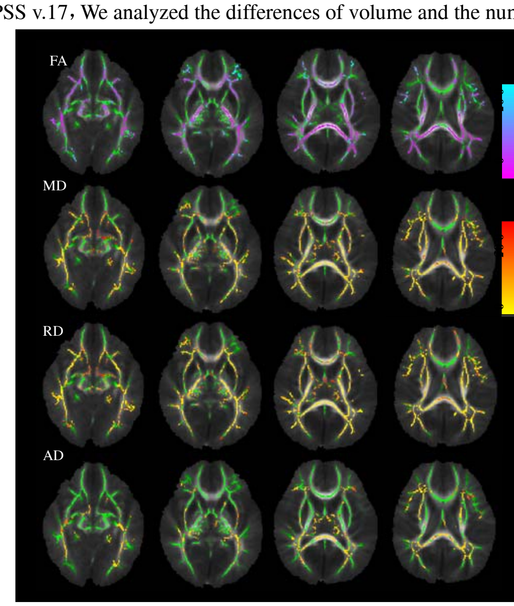
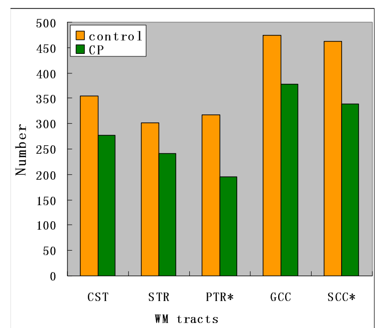



**Fig.1** Group comparison of FA, AD, MD, RD values between CP group and controls using TBSS. Cool regions showed where DTI parameters significantly decreased (p<0.05), Red-Yellow regions showed where DTI parameters significantly increased (p<0.05) in CP group relative to controls. There were no significant differences in green regions.



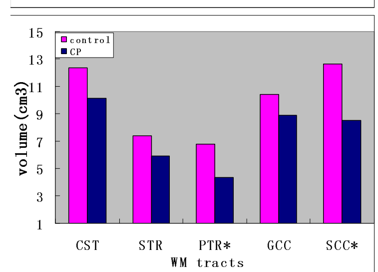




**Fig.2and Fig.3** Comparison of the number of fibers and volume in CP group and controls *p<0.01.

## DISCUSSIONS

This studydemonstrated extensive WM destructions in children with CP. The decreased FA with prominent increased RD might reflected the increased water diffusion perpendicular to organized axonal structures, which mainly due to deficits or delays in myelination[6]. AD also increased in PTR and SCC, reflecting increased water diffusion parallel to axons, might be associated with axonal damages to some extent. Meanwhile, lower FA values and higher MD also incidated the decreased WM volume or fibers loss [7].

The results of probabilistic tractography showed, the volume and fibers loss of CP group was not significant in CST, but obvious in PTR and SCC which reflected that in children with spastic CP, PTR and SCC were more vulnerable as projection and associated fibers in part of sensorimotor loops.

## Conclusions

In summary, DTI associated with TBSS and probabilistic tractography can provide more objective estimation of WM tract injuries through detecting microstructural changes, which will bring us more evdiences to further analyze the pathologic mechanism in children with spastic CP.

**References** 1.Rosenbaum P et al. Dev Med Cbild Neurol,2007;49:8-14. 2.Krägeloh-Mann I et al Dev Med Cbild Neurol, 2007; 49:144-151.3.Murakami A et al. Pediatrics, 2008; 122:500-506. 4. Tusor N et al.Pediatric Research, 2012; 72:63-69. 5.Rha D.-w et al. Neuroradiology,2012; 54:615-621.6. Chang MC et al, Neuroscience Letters 2012,512:53-58. 7.Rose S et al. Brain Connectivity, 2011; 1:309–316.