Altered microstructural connectivity of the superior and middle cerebellar peduncles are related to motor dysfunction in children with diffuse periventricular leucomalacia born preterm: A DTI tractography study

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Target Audience: Pediatric neuroradiologists, pediatric neurologists, and neuroscientists interested in pediatric DTI

Purpose: Periventricular leucomalacia (PVL) has long been investigated as a leading cause of motor and cognitive impairment in subjects who were born prematurely. The diffuse PVL, which is more diffusely apparent in cerebral white matter, accounts for the vast majority of PVL cases, and it is known to be a high risk factor of spastic diplegic or quadriplegia cerebral palsy (CP) [1]. Middle cerebellar peduncles (MCP) and superior cerebellar peduncles (SCP) complete a circuit between the cerebral and cerebellar cortices whose main function was suggested to coordinate the motor output of the cerebral cortex. The purpose of this study was to investigate the microstructural integrity of SCP and MCP by using DTI tractography method, and further to detect whether the microstructural integrity of these major cerebellar pathways is related to motor function in children with diffuse PVL born preterm.

Methods: 46 children with diffuse PVL (30 males and 16 females; age range 3-48 months; mean age 22.4±6.7 months; mean gestational age 30.5±2.2 weeks) and 40 healthy controls (27 males and 13 females; age range 3.5-48 months; mean age 22.1±5.8 months) were enrolled in this study. MR-images were acquired on a 3.0 T scanner (Signa HDx, GE Healthcare, Milwaukee, USA). The DTI acquisition consisted of a single-shot spin-echo planar sequences in axial sections, with repetition time ranging from 6.2 to 9.4 seconds and echo time of 80ms. The slice thickness was 3 mm without gap. 40-60 axial slices parallel to the anterior–posterior commissure (AC-PC) line were acquired. The maximum b value was 800s/mm^2, used in a scheme of 15 different gradient directions. DTI Studio software [2] based on the fiber assignment by continuous tracking (FACT) algorithm was used for fiber tracking. Diffusion tensor tractography using multiple regions-of-interest (ROI) were also used to trace the SCP (Fig. I left) and MCP (Fig. I right) bilaterally [3]. The tracking method used a fractional anisotropy (FA) threshold of 0.15 and angle threshold of 60 degrees. All subjects underwent a motor function evaluation using the gross motor function classification system (GMFCS) [4]. Spearman's correlation coefficients were calculated to analyze associations between motor grades and FA values of SCP, MCP.

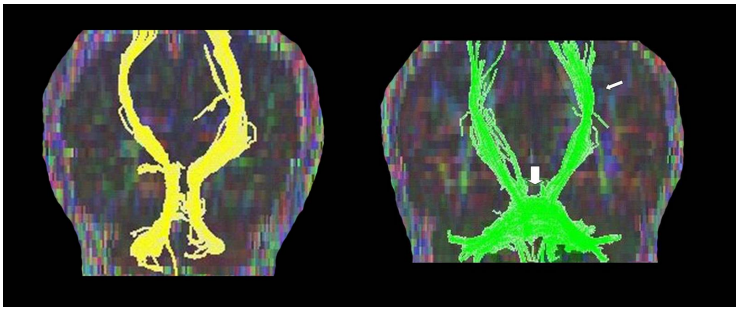

Figure I. Illustration of the DTI-based fiber tracking of the SCP (left), MCP (right).

Results: Table 1 summarizes the averaged FA data in each GMFCS level. Spearman's correlation coefficient between GMFCS levels and the FA values of each tract is shown in Table 2. Significant negative correlations of FA with GMFCS levels were found in bilateral SCP ($p<0.05$) and bilateral MCP (left $p<0.05$, right $p<0.01$).

Conclusion: Tractography approach of DTI was able to detect differences in fractional anisotropy in major cerebellar white matters. The present study provides more information for understanding the pathophysiology of motor impairments in children with diffuse PVL by showing the correlations between the SCP and MCP microstructure injury and GMFCS levels.

References:

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[3] Wakana S, et al., Neuroimage. 2007 Jul 1; 36(3):630-44.

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Table 1: Summary of statistical measurement of FA in healthy controls and each level of GMFCS group. (Data are the mean ± SD)

group	SCP		MCP	
	left	right	left	right
level 1 (n=4)	0.446±0.080	0.451±0.085	0.500±0.071	0.495±0.067
level 2 (n=11)	0.409±0.051	0.411±0.039	0.489±0.069	0.470±0.060
level 3 (n=9)	0.412±0.121	0.441±0.099	0.429±0.145	0.400±0.086
level 4 (n=16)	0.413±0.043	0.415±0.049	0.474±0.067	0.471±0.049
level 5 (n=6)	0.379±0.037	0.394±0.034	0.422±0.046	0.414±0.467

Table 2 Summary of the correlations between GMFCS levels and FA values of each tract in diffuse PVL group. (Spearman's correlation coefficient)

(* $p<0.05$; ** $p<0.01$)

	r	*p*
left SCP	-0.325	0.033*
right SCP	-0.341	0.025*
left MCP	-0.377	0.013*
right MCP	-0.430	0.004**