A semiquantitative classification of brain white matter pathways in cerebral palsy using diffusion tensor imaging.

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Introduction: Despite a wide range of accepted treatments for children with cerebral palsy, there is variability in treatment and outcome (1). Conventional MR imaging has begun to address this problem, identifying abnormalities in 70-90% of affected children, which can be used to guide treatment (2). Diffusion tensor imaging (DTI) with color-coded maps (3,4) can identify white matter tracts, offering the potential to provide new information on pathophysiology (5). In this paper, anatomical criteria for identification and assessment of 25 white matter structures on color-coded DTI images acquired at 1.5 Tesla with Sensitivity Encoding (SENSE) technique is introduced, and a semiquantitative classification system to evaluate these fiber tracts is proposed, using information from children with cerebral palsy and unaffected control children.

Methods: DTI [Single shot-EPI; TR/TE of 7622/80 ms; max b value=700 s/mm^2; 30 different gradient directions; 2.3-2.5 mm resolution; 50 axial slices; 5min 24s scan time per sequence; 3 repetitions] was performed at 1.5 Tesla scanner combined with SENSE (6) technique - sense factor (R) of 2.5. Criteria for identification of 25 cerebral structures (inferior, middle and superior cerebellar peduncles, decussation of the superior cerebellar peduncles, ascending sensory and cortico-bulbar/cortico-spinal tracts, uncinate tract/inferior fronto-occipital tract, inferior portions of the cingulum and fornix, cerebral peduncles, uncinate/inferior longitudinal fasciculus, inferior fronto-occipital tract/inferior longitudinal fasciculus, anterior comissure, external capsule, anterior and posterior limb of internal capsule, corpus callosum, tapetum, superior longitudinal fasciculus, thalamus, anterior and posterior thalamic radiation, superior portion of the corona radiata, cingulum and column of the fornix) were established. Five children with diagnosis of cerebral palsy (ages 15 months to 10 years) had these 25 cerebral structures evaluated by a grading system (0=normal, 1= apparently abnormal, 2=severely abnormal-absent). Normative data was obtained from a group of controls including 9 normal children (age range 6-18 years old) and 2 neonates.

Results and Discussion: Preliminary analysis using this classification system showed variability in specific tracts among children with the same diagnosis (Table 1). For example, children with white matter injury associated with periventricular leukomalacia showed variation in size of the corticospinal tracts (Figure 1). With further development on a larger number of children, this semiquantitative method will refine classification of injury of maldevelopment in children with cerebral palsy resulting from different etiological antecedents. This refined neuroimaging criteria can then be used to group children into more comparable groups for study of rehabilitative interventions.

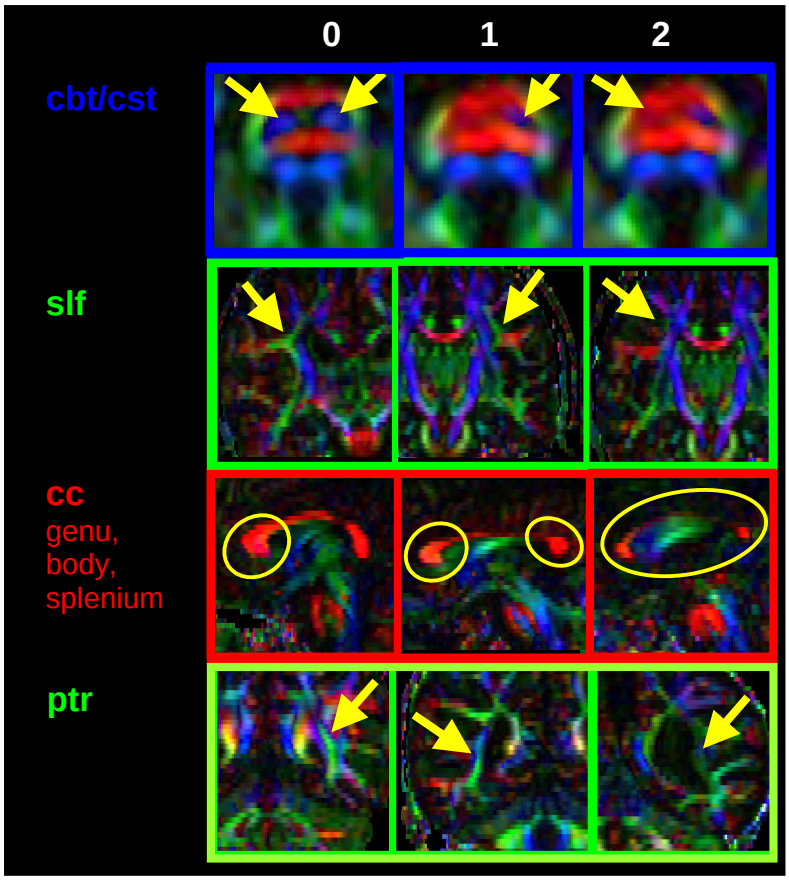

Figure 1. Example of the grading scale for the cortico-bulbar/cortico-spinal tracts (cbt/cst), superior longitudinal fasciculus (slf), corpus callosum (cc) and posterior thalamic radiation (ptr). The cbt/cst are evaluated using 4-5 axial slices at the pons level. Two large anterior bundles (blue), sometimes interdigitated by crossing fibers (red) should be identified. The slf is evaluated by a coronal slice at the level of the middle of the posterior limb of the internal capsule. A triangle-shaped green tract should be identified. The cc is evaluated at its genu, body, and splenium, separately, at the mid-sagittal level. The ptr is evaluated by a coronal slice at the level where the cingulum forms an arch. The ptr is the prominent green fiber bundle located lateral to the lateral ventricle.

Table 1. Example of the grading scale for cbt/cst, slf, cc and ptr in our 5 CP patients.

CP patients	1	2	3	4	5
cbt/cst (right/left)	2/1	0/0	0/0	0/0	0/0
slf (right/left)	2/2	0/0	1/2	1/1	2/1
cc (genu/body/splenium)	2/2/2	1/2/1	1/2/1	1/2/2	0/2/1
ptr (right/left)	2/2	2/2	1/1	1/1	0/0

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