

Fractional anisotropy correlates with total IQ and visual perception in young adults born with very low birth weight

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Introduction

Perinatal brain injury caused by very preterm birth with very low birth weight (VLBW, ≤ 1500 g) is associated with permanent changes in white matter integrity and connectivity, and to a variety of neurodevelopmental problems including cognitive impairments and visual perceptual deficits. The neuroimpairments evolve in childhood and adolescence and seem to persist into adulthood. The aim of this study was to examine the relationship between white matter integrity and cognitive and visual perceptual function in VLBW young adults.

Materials and Methods

Forty-nine subjects born with VLBW were scanned on a 1.5 T Siemens Magnetom Symphony at ages 18-22. The protocol consisted of a T1-weighted MPRAGE, and a DTI single-shot balanced-echo EPI acquired in 12 non-collinear directions with $b=1000$ s/mm² and an isotropic resolution of 2.2 mm. DTI analysis was performed with the tools from the FMRIB software library (FSL), and voxelwise maps of fractional anisotropy (FA) were calculated by fitting a diffusion tensor model to the raw diffusion data in each voxel. General cognitive function was assessed with Wechsler Adult Intelligence scale III, and reported as total IQ. The Motor Free Visual Perception Test (MVPT) was used as a measure of visual perceptual function. Tract-Based Spatial Statistics (TBSS) was carried out to explore the relationship between FA and total IQ and MVPT.

Results

More than half of the VLBW subjects obtained a subnormal IQ score, indicating a persisting and global disadvantage regarding cognitive ability. The FA-IQ and FA-MVPT correlation analyses demonstrated extensive overlap in white matter regions with positive correlations between FA, and IQ and MVPT scores. These overlapping regions encompassed the corpus callosum and the long as well as short association tracts in the VLBW group (Figure 1). In the FA-IQ correlation additional positive correlations were found in right uncinate fasciculus, left anterior inferior longitudinal fasciculus and in the short association fibers in the right hemisphere. The FA-MVPT correlation analysis revealed additional effects in the anterior and posterior corona radiata, genu of corpus callosum, right cingulum, left uncinate fasciculus/inferior longitudinal fasciculus, and short association fibers in left hemisphere.

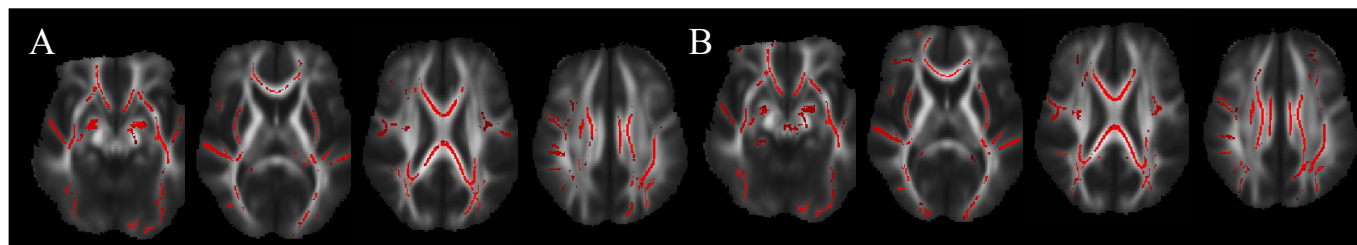


Figure 1. TBSS analysis identified significant positive correlations between FA and total IQ (RED) (A) and MVPT (RED) (B) in large areas of the white matter in the VLBW group ($p < 0.05$, nonparametric permutation test, corrected for multiple comparisons). Background image is the mean FA of all subjects in the study. Images are shown in radiological convention, i.e. the right side of the subjects is on the left side of the images.

Conclusion

The widespread correlations between FA and total IQ and visual perception scores detected in the young adult VLBW group demonstrate the pervasive nature of the reduction in cognition and perception in this group. White matter maturation is slow, particularly in the prefrontal lobe, which was relatively unaffected in the current correlation analyses. The early neurodevelopmental changes induced by preterm birth with VLBW in the more posterior and central white matter structures thus appear to be at the core of the cognitive problems experienced by this group.