Anatomical Organization of the Blind's Brain: Combined VBM and DTI Analysis

Z. Wang[1], W. F. Baar[1,2,3], R. Kupers[2], T. Dyrby[2], O. Paulson[2], M. Chen[1], C. Zhou[1], and M. Ptito[2]

[1]Radiology, Beijing Hospital, Beijing, Beijing, China, People's Republic of, [2]Danish Research Centre for Magnetic Resonance, Copenhagen University Hospital, Hvidovre, Denmark, [3]Center for Integrated Molecular Brain Imaging, Copenhagen, Denmark

Purpose:

To explore the whole brain grey and white matter organization in a large cohort of congenital blindness (CB) individuals compared to normal-sight (NS) controls using Diffusion Tensor Imaging (DTI) and tractography (DTT).

Materials and Methods:

Thirteen CB and thirteen NS were scanned in this experiment. T1WI, T2WI, and DTI (61 directions; b=1200 s/mm^2) were acquired on a Siemens 3T scanner. T1 and T2 images were segmented using the VBM5 toolbox in SPM5. DARTEL was used for high dimensional inter-subject registration. The diffusion tensor was fitted using the RESTORE algorithm. VBM5 was used for voxel-based analysis for comparing the group differences of gray matter, white matter and FA values. Probabilistic tractography (20 streamlines) implemented in FSL was used to generate anatomical connectivity maps (ACM) using a brain mask as seed ROI. DTIstudio was used for DTT to display the fiber tracts related to the visual pathway, in which two regions of interest (ROI) were defined on the coronal plain for both sides: one covered the whole occipital lobe at middle level of occipital lobe and the other covered the inferior fronto-occipital fasciculus (IFO) at the level through middle corpus callosum.

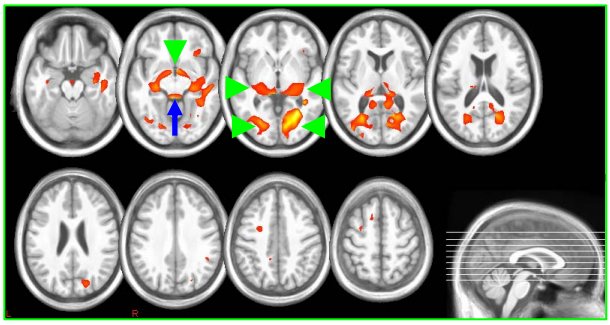

Fig.1 Group Comparison for the White Matter between the subjects with NS and CB, FDR correction with p<0.005. All structures belonging to the visual system showed significant volume reductions, including optic chiasm, lateral geniculate bodies and primary and secondary visual area (green arrowheads). Especially, the volume reduction was found in both superior colliculi (blue arrow).

Results:

All structures belonging to the visual system showed significant volume reductions. All components of the retino-geniculo-striate system including optic nerve, chiasm, lateral geniculate nucleus, optic radiations and visual cortex were reduced. Especially, the volume of the bilateral superior colliculi was decreased (see Fig.1). In the Non-visual areas changes were observed in the posterior hippocampus and parts of the frontal and temporal lobes. All structures belonging to the visual system showed significant reductions of anatomical connectivity (see Fig.2). Most of the NS, 11 of 13, showed the fiber tracts going through the both ROIs. On the contrary, only 2 of 13 CB demonstrated the similar fiber tracts (see Fig.3).

Conclusion:

We show for the first time large reductions in the midbrain visual structures. The tractography results of CB were consistent with our VBM results. Our VBM data however did not confirm the enlargement of the fronto-occipital and the supra-longitudinal fasciculi previously reported.

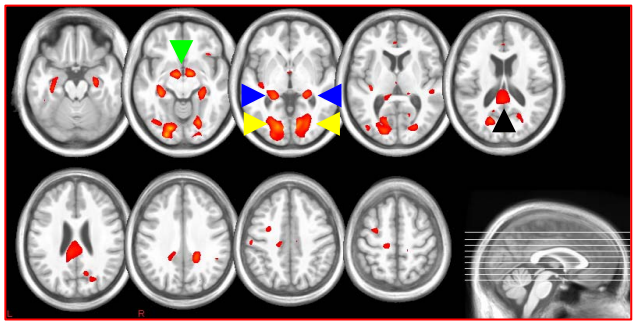

Fig.2 Group Comparison for ACM between the subjects with NS) and CB, FDR correction with p<0.05. All structures belonging to the visual system showed significant reductions of anatomical connectivity. The areas includes: optic chiasm (green arrowhead), lateral geniculate Bodies (blue arrowheads), primary and secondary visual area (yellow arrowheads) and splenium of corpus collosum (black arrowhead).

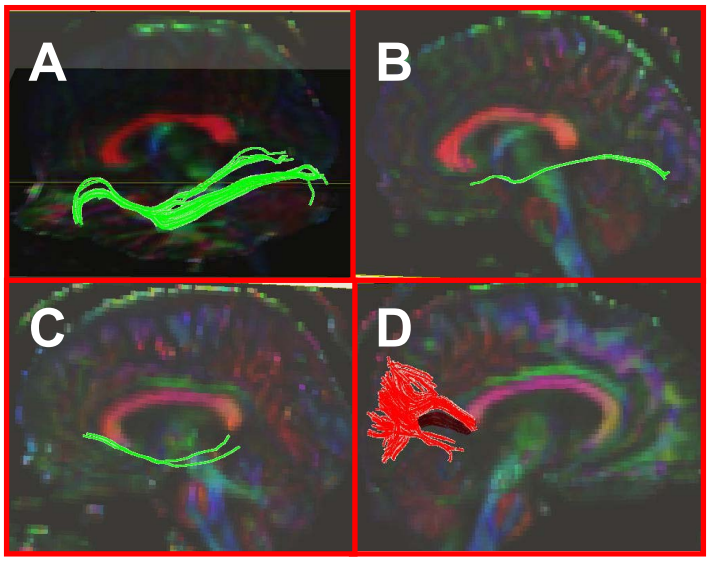

Fig.3 Tractography for the CB and NS. A and B showed the fibers of two NS, which went through the both ROIs. C and D showed the fiber tracts from two CB. C showed the fiber did not reach the occipital lobe. D demonstrated the fibers from the visual area did not go beyond the occipital lobe.