DTI Study of Corpus Callosum Integrity in Adult Macaques with Neonatal Hippocampal Lesion

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TARGET AUDIENCE

Neuroscientists, clinicians, psychiatrists and MRI physicists.

INTRODUCTION

An earlier study on the impact of neonatal hippocampal (Neo-H) lesions on the integrity of the corpus callosum (CC) and its inter-hemispheric connectivity indicated a reduction in the surface area of the posterior CC [1]. To verify these data, the present study measured the impact of Neo-H lesions on CC using diffusion tensor imaging (DTI).

METHODS

Neo-H lesions were performed via injection of 5.0 µl ibotenic acid bilaterally at 10–12 days after birth[2]. DTI was performed on the animals with Neo-H lesions and sham-operated controls (n = 5 in each group, 8-10 years old) on a Siemens 3T Trio scanner. DTI images were acquired with a dual spin-echo EPI sequence, with 60 diffusion directions, b value = 0, 1000 s/mm^2, TE = 96 ms, TR = 5700 ms, isotropic spatial resolution 1.3 mm. T_1-weighed images were also acquired with 0.5 mm isotropic spatial resolution. FSL (FMRIB, Oxford) and MATLAB (Mathworks, Natick, MA) scripts were custom-developed to process the data off-line. Mean Diffusivity (MD) Maps were nonlinearly registered and skeletonised. The corpus callosum was segmented into 7 segments as shown in Fig. 1. Probabilistic tractography was used to track transcallosal fiber tracts, normalized by total numbers of fibers across the segmented CC and thresholded at 0.2% and then binarized[3]. MD of the skeleton within segmented CC, and transcallosal fiber tracts excluding segmented CC, were averaged (Fig. 1 and Fig. 3a)[3]. Independent t-test was used to examine group differences. Pearson's correlation analysis was used to test the relation of MD of segmented CC with hippocampus volumes measured in 18 months old[4]. $P < 0.05$ was considered statistically significant.

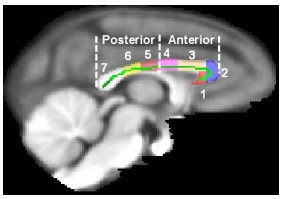


Fig.1 Corpus Callosum (CC) segments labeled with different colors (from 1 to 7 (CC1~CC7): rostrum, genu, rostral body, anterior midbody, posterior midbody, isthmus, and splenium) [5]. MD values were averaged from the skeletonised MD map (green color) within each segment, overlaid on a custom-made T_1-weighted macaque monkey template.

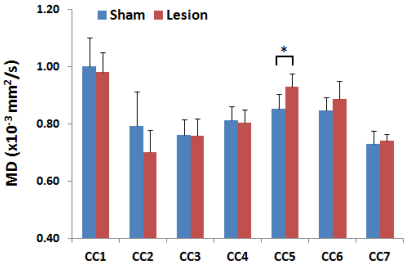
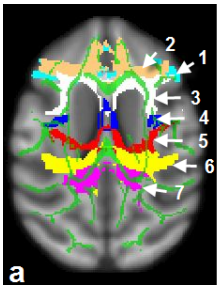


Fig. 2 Comparisons of MD in CC segments between groups. (* $p < 0.05$)



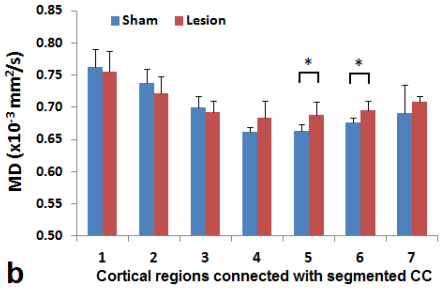


Fig. 3 (a) Cortical fiber tracts in the 7 CC segments highlighted by different colors (arrows). MD was averaged from the skeletonised map (green color) within each CC segment, overlaid on a custom-made T_1-weighted macaque template. (b) Comparisons of MD in transcallosal fiber tracts excluding CC between groups (* $p < 0.05$).

RESULTS

MD was significantly greater in the Neo-H group only in CC5 (Fig. 2). MD in cortical fiber tracts increased significantly only in cortical regions associated with CC5 and CC6 (Fig. 3b). Although MD in the anterior CC2 appeared to be reduced in Neo-H group as compared to controls, the group difference did not reach significance (Fig. 3b).

DISCUSSION AND CONCLUSION

Changes in MD in CC5 are consistent with the reduced surface area of this segment derived from T_1 images taken at 18 months of age[1]. MD data also showed alterations of transcallosal fibers from the posterior parietal and retrosplenial cortex. The results suggest that early hippocampal damage alters the posterior segment of the CC and the transcallosal cortical projections crossing through this segment. Although increased MD may be related to reduction in CC volume [3], the MD changes are consistent with the hypometabolism reported in retrosplenial cortex after Neo-H lesions in monkeys [6] and the deficits in visuospatial relational memory found in the same Neo-H animals [2, 7, 8]. This spatial memory impairment could be related to altered spatial processing functions between the posterior parietal cortex [9], retrosplenial cortex[10] and the hippocampus.

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