Gender differences in water diffusion of the corpus callosum: a diffusion tensor imaging study

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Introduction

The corpus callosum (CC) plays an integral role in relaying sensory, motor and cognitive information between homologous regions in the two cerebral hemispheres. Women seem to employ a greater degree of bilateral hemispheric activity than men and also seem to have greater verbal ability (1). Additionally, women have a larger callosal area proportional to cerebral volume (2) which suggests that a larger number of fibers are crossing through and hence capacity for interhemispheric transfer is enhanced. We therefore hypothesize that we can document these differences using diffusion tensor imaging and also quantify the differences between healthy male and female white matter of the corpus callosum using a quantity, FDi (fiber density index).

Materials and Methods

Twenty healthy volunteers (11 males, 9 females, age 22-34 years) underwent MR diffusion tensor imaging. All imaging was performed on a 1.5T MRI system (GE TwinSpeed Excite, Release 11.0, GE HealthCare, Milwaukee, WI) equipped with an 8-channel head-coil. Images were acquired parallel to the anterior-posterior commissure line (AC-PC), and the midline was aligned to the vertical line of the images at the time of data acquisition. Diffusion tensor imaging was performed using 15 non-collinear directions of diffusion sensitization with an echo planar readout (b-value=0 and 1000s/mm^2, matrix =128x128, FOV of 240mm; slice thickness 2mm, number of slices 60~64, TE=74ms, 4NEX).

DTI data sets were spatially registered using AIR (Automated Image Registration version 3.0) (3) and post-processed using DTI Studio (Processing Tools and Environment for Diffusion Tensor Imaging, version 2.4, Jiang H. and Mori S., Dept of Radiology, Johns Hopkins University). Fractional anisotropy (FA) was calculated on a pixel by pixel basis (4), and fiber tracking using the FACT algorithm (5) was then performed reconstructing all possible fibers through the image set from all pixels above an FA threshold of 0.2. Since all pixels with sufficient FA (typically several thousand pixels) are considered as possible sources of fiber paths, it is thus quite conceivable for multiple fiber paths to pass through any given pixel. Regions of interest (ROIs 18pixels and 8pixels, respectively) were placed in six subdivisions of the corpus callosum according to the Witelson scheme (6): CC2-Genu, CC3-Rostral body, CC4-Anterior midbody, CC5-Posterior midbody, CC6-Isthmus, CC7-Splenium. These regions were interrogated to obtain the mean value of fractional anisotropy and also to determine the number of white matter fiber paths passing through them. From this latter measure an index of fiber density, the FDi, was constructed by determining the mean number of fiber paths passing through each pixel in the ROI (7).

All ROIs were placed independently by 3 readers and the two quantities, FA and FDi, were independently determined. Concordance between readers for each quantity was assessed using the intraclass correlation coefficient (ICC). Mean values of FA and FDi for six subdivision of corpus callosum ROI were determined by averaging the corresponding measure from the three separate raters. Statistical significance was determined using an unpaired student's t-test.

Results

All readers were in good agreement (ICC=0.93). There was no significant difference in FA between genders (see figure 1). FDi, however, showed significant elevation in females compared to males in CC2 and CC6 (see figure 2).

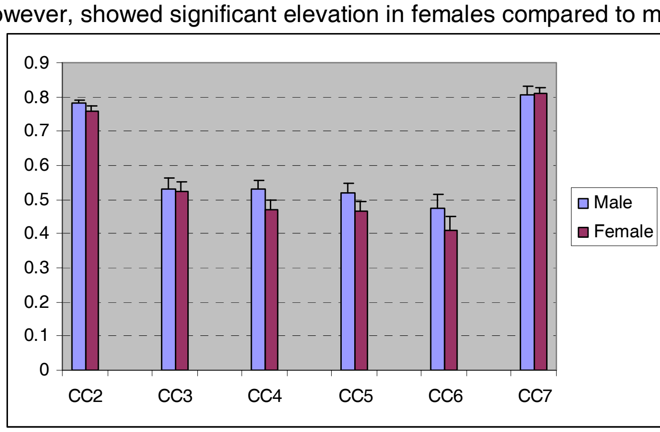

Figure 1. Average male and female FA for each of the CC subregions

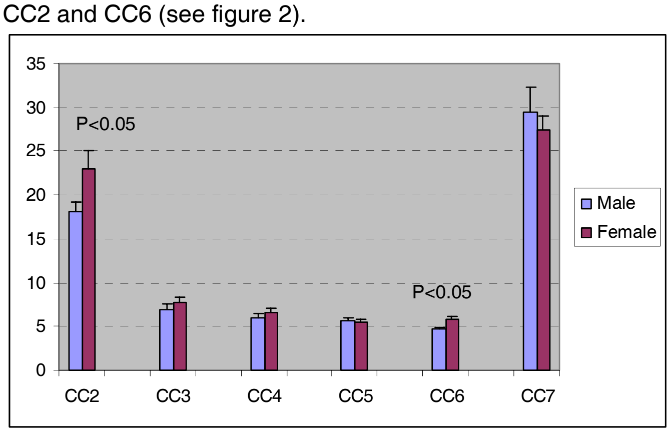

Figure 2. Average male and female FDi for each of the CC subregions

Discussion

While FA revealed no significant gender differences for any segment of the corpus callosum, the fiber density index revealed sexual dimorphism in callosal fiber arrangements particularly in CC2 and CC6, not in the splenium. These findings are consistent, both qualitatively and in the magnitude of the male versus female fiber density difference with the post-mortem study of J. R. Highley et al (8).

References

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