Sex differences in the human corpus callosum microstructure: T2 myelin-water imaging versus diffusion tensor imaging

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Introduction:

The corpus callosum (CC) plays an important role in relaying sensory, motor and cognitive function between the cerebral hemispheres. Females seem to employ a greater degree of bilateral hemispheric activity than males (1) and also have a larger callosal area in proportion to brain volume (2) which suggests that a larger number of fibres are passing through. We have previously shown that fiber density is higher in females compared to males in subdivisions of the CC using diffusion tensor imaging (DTI) (3). We hypothesize that these sex differences are due to a difference in myelin content. Short-T2 myelin-water imaging has previously been used to shed light on brain microstructure (4-5). In this study we have compared short T2 myelin-water imaging to DTI in the corpus callosum of healthy volunteers.

Materials and Methods:

Eight healthy age matched volunteers (4 male, 4 females, age 19-31 years) underwent MR imaging. All subjects were right-handed with no known neurological disease. DTI was performed using 15 non-collinear directions of diffusion sensitization with an echo planar readout (b-value=0 and 1000s/mm2, matrix =128x128, FOV of 240mm; slice thickness 2mm, number of slices 60~64, TE=74ms, 4NEX). In addition to the DTI images, a 5 echo myelin-water imaging protocol was adapted to this study as described previously (4). Imaging parameters used for the 5 echo multi-slice spin echo images were as follows: TE/TR = 8,23,33,74,110/698,713,723,764,800, NSA = 2, FOV = 24 cm, matrix = 128x128, bandwidth = 15.6 kHz and 6 slices (4mm thickness with a 1 mm gap). Total scan time was 30 min for both DTI and myelin-water images. DTI datasets were spatially registered using AIR (vs 3.0) and post-processed using DTI Studio (vs 2.4). Regions of interest (ROIs 18 pixels and 8 pixels, 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. For each ROI, the average fractional anisotropy (FA), the fiber density index (FDi) (7), and the average myelin-water content were computed (4). An unpaired Students t-test was used to compare all variables between male and female volunteers.

Results:

There was no significant difference in FA between sexes. Significant group differences were found in the CC2 area of the corpus callosum for both myelin-water and FDi ($p<0.05$). In addition a significant difference was found for myelin-water in CC7 ($p<0.05$) but only a trend was seen for FDi ($p<0.1$). A more detailed overview of the results for FA, FDi and myelin-water for all subjects in all areas of the corpus callosum is shown in Figure 1.

Discussion:

These findings suggest that male fibers are less densely packed compared to female fibres but contain more myelin as reflected by the difference in myelin-water values. Although significant group differences were only found in the corpus callosum-genu (CC2), a larger study may shed light on subtler sex differences in other areas. This is currently under investigation in our institution.

References: (1) Crow et al. Neuropsychologica 1998; (2) Mitchell et al. AJNR 2003; (3) Kassner et al. , ISMRM 2007 #1578; (4) Vidarsson et al., MRM 2005;(5) Laule et al. Neurotherapeutics 2007; (6) Witelson, Brain 1989; (7) Roberts et al., AJNR 2005

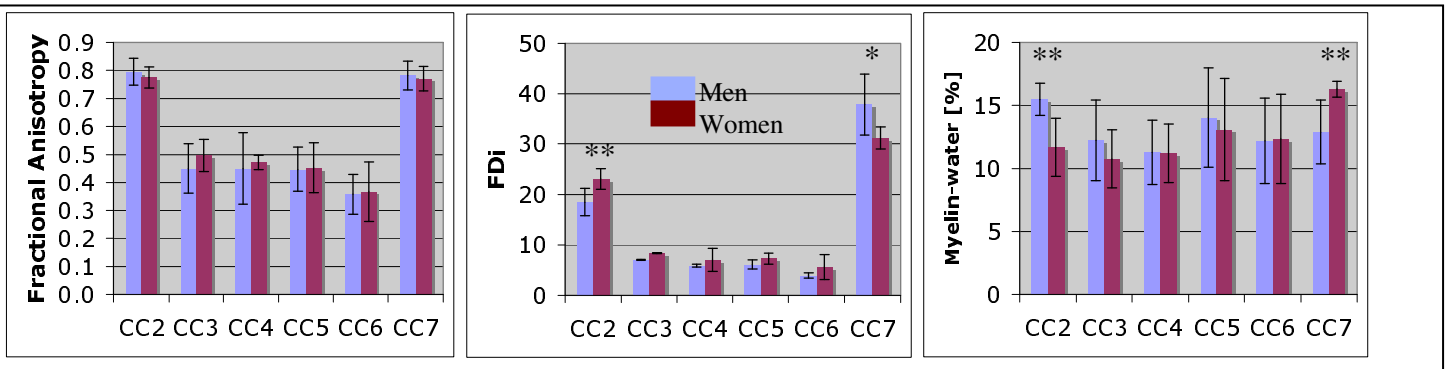

Figure 1. Illustrates the sex differences in FA, FDi , and myelin-water percentage. CC2 does show significant differences in FDi and Myelin-water indicating denser fibers for women than for men. * indicates a statistical trend (p-value < 0.1) and ** indicates statistical significance (p-value < 0.05).