

The Relationship of Sex Differences to the Anatomy of the Corpus Callosum in the Living Human Being

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Abstract: The area of the midsagittal section of the corpus callosum, particularly in the region of the splenium was found to be greater in women than in men. The magnetic resonance imaging of seventy adults was examined and showed the same association previously observed, between sex differences and area of the corpus callosum and its splenium. The quantitative results

supported a relationship between variations in callosal anatomy and sex differences in human beings. Findings are discussed in the light of the related literature.

Keywords: Brain, corpus callosum, magnetic resonance imaging, sex differences, splenium

INTRODUCTION

The corpus callosum is a major transverse commissure connecting the cerebral hemispheres. Position and size of the corpus callosum is well appreciated in median sections. The anterior end is called "the genu", the median region "the corpus" and the posterior region "the splenium". Nerve fibres of the corpus callosum radiate into the white area of each hemisphere dispersing to the various regions of the cerebral cortex (16). Recent reports describe sex differences in the shape and surface area of the human corpus callosum (15). The sexual dimorphism is striking in the splenium (8). In examining corpora callosa, we observed sex differences in the shape, splenial width and posterior fifth distance. Quantitative evaluation confirmed this observation. The purpose of this report is : (1) to present the results of callosal anatomy in association to sex differences in this study, and (2) demonstrate the help of magnetic resonance imaging (MRI) in demonstrating sex differences on neuroanatomy and neurophysiological functions of the corpus callosum.

MATERIALS AND METHODS

We examined the MRIs of seventy adults for possible differences in the shape and size of the corpus callosum between different sexes. There were 30 women and 40 men with ages ranging from 20 to 55 years (mean:34 years). The magnetic resonance images of the midsagittal plane of each human brain was examined by a 0.5 tesla MRI unit at the Radiology Department MRI centre of Atatürk University. The subjects had "normal" scans according to the radiologist's reports. The out line of the corpus callosum was drawn on white drawing paper.

A line was drawn along the bottom of each callosal tracing (Fig.1), perpendiculars were extended from this line at the rostral and splenial edges to define the maximal callosal length (AE line). Perpendiculars were also drawn at points 50 %, and 80 % along the AE line defining points D and P respectively. Then transverse lines were extended at the rostral and splenial edges to take into account the widths of the splenium and the genu (GF and BC distances respectively). HI distance of the corpus

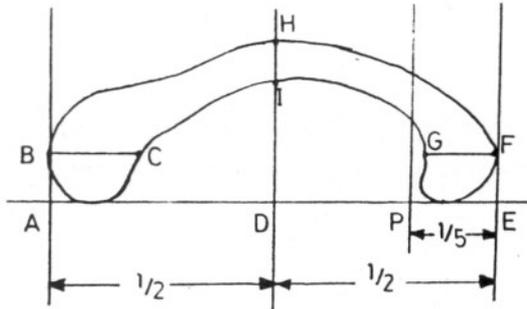


Fig. 1: Method of morphological analysis of the corpus callosum

callosum on the perpendicular midline was also measured to find the width of the corpus. Standard millimetric grid paper was used for evaluation of the surface area of the corpus callosum. All measurements were obtained without any information on the sex of the subjects.

RESULTS

Gross morphological examination revealed a sexual dimorphism in the shape of the splenium (Fig.2). The female splenium was more bulbous, the male was tubular and relatively continuous in width with the body of the corpus callosum (Fig.3, Fig.4). Quantitative analyses of the splenial distance confirmed the visual observations ($t=4.55$; $P<0.0001$) (Table1). The posterior fifth distance was determined to be the most representative of splenial distance. No sex difference was found in the absolute length of the corpus callosum and the other parameters. However, measurements in relation to the average splenial widths of the genu and the corpus were

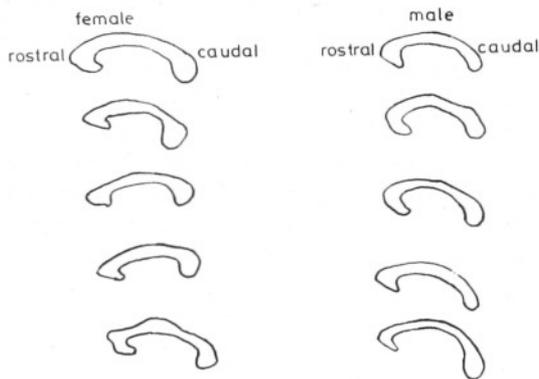


Fig. 2: Sexual dimorphism in the splenium. The female splenium is more bulbous and larger than the male.

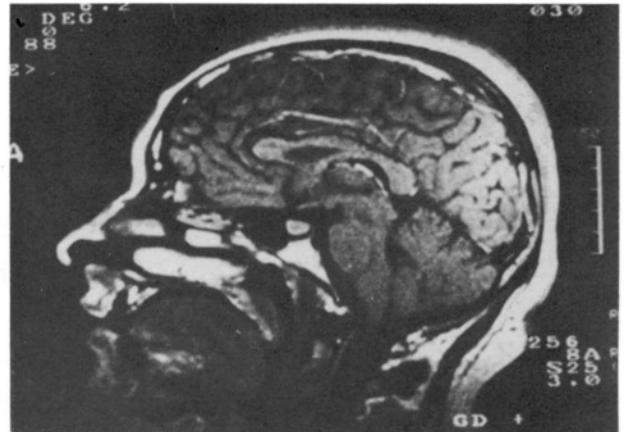


Fig. 3: MRI of the midsagittal plane of a woman's brain, showing a more bulbous shape.

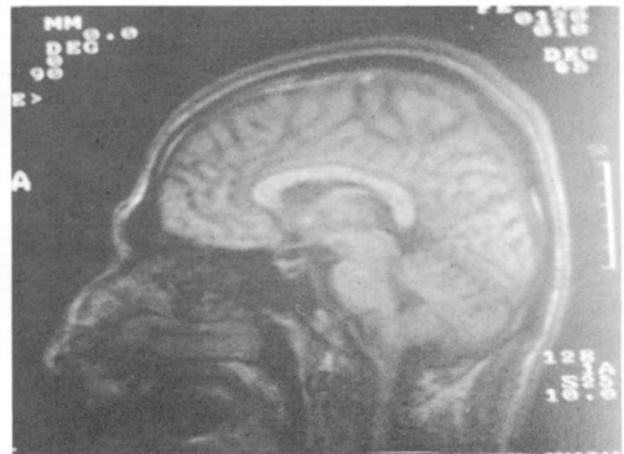


Fig. 4: MRI of the midsagittal plane of a man's brain, showing a more tubular shape.

greater in females than in males. The average total callosal area was slightly greater in males (Table 1). A discrepancy appeared in the shape of the splenium of three subjects, one female splenium displayed a more tubular shape and those of two males displayed a more bulbous shape.

DISCUSSION

In 1982, de Lacoste-Utamsing and Holloway (8) examined sex differences in the corpus callosum and evaluated four measurements which included the area of the corpus callosum; the Maximum Splenial Width (MSW); the area of the posterior fifth and subjective gender classification based on the shape of the splenium. MSW was determined by finding the maximum distance perpendicular to the tangent of the bisecting line in the posterior fifth of the corpus callosum. de Lacoste-Utamsing and

Table I. Quantitative aspects of sexual dimorphism in the human corpus callosum. Statistical comparisons between male and female made with t - test.

Sex Descriptors	Absolute Length (cm)	Width of Genu (cm)	Width of Corpus (cm)	Width of Splenium (cm)	Distance of Posterior Fifth (cm)	Total Callosal Area (mm ²)
MALE						
Mean	8.74	1.49	0.76	1.32	1.52	728.10
Standard deviation	0.967	0.834	0.422	0.611	0.258	13.4
Standard error	0.25	0.22	0.11	0.16	0.067	3.4
Range	8.41-9.24	0.99-1.98	0.66-0.99	1.32-1.65	1.32-1.65	577.17-1034.6
FEMALE						
Mean	8.77	1.51	0.83	1.67	1.86	716.8
Standard deviation	1.65	0.681	0.373	0.852	0.489	10.6
Standard error	0.37	0.15	0.083	0.19	0.11	2.4
Range	7.92-10.56	1.32-1.98	0.66-0.99	0.99-1.98	1.65-1.98	566.2-1078
t	0.50	0.25	-1.47	1.89	4.55	1.14
p	0.62	0.80	0.15	0.068	0.0001*	0.26

Holloway (8) observed that the MSW was significantly greater in females (8). Each investigator correctly identified the gender of the corpus callosum of each subject based on its shape (1). While some investigators (2, 9, 10, 18) have made similar measurements in this area, others have (5,6,14) made different measurements.

We observed that there was a significant association between the shape of the splenium and the gender of the subject. Our seventy measurements of the posterior fifth distance utilizing the paired t-test were sexually dimorphic. A few studies (4, 5) reported that gender can not be absolutely determined by the shape of the posterior corpus callosum, nevertheless, each study reporting subjective gender classification based on the shape of the splenium was able to identify correctly the gender in more than half of their subjects (1, 2, 12, 14, 19). Byne et al (5), and de Lacoste et al (7) reported that the area of the corpus callosum is larger in females. Most studies (1, 9, 12, 13) report that the area of the corpus callosum is greater in males. The average of total callosal area was slightly larger in men than in women in our case.

Discrepancies in the literature may arise from differences in age distribution, differences in actual

measurements of the corpus callosum, relatively small numbers of patients, differences in the general health of subjects, limited resolution of an MRI and possible failure to obtain a precise midsagittal section of the corpus callosum (1). Furthermore, factors such as genetic and racial constitution, handedness of the subjects (13, 17) and the environment may influence the shape and size of the corpus callosum (3, 11). In our study, evaluations with relation to the shapes of the corpus callosums demonstrated significantly a more bulbous splenium in women.

When examined MRIs of seventy adults and used several criteria for possible sex differences in the corpus callosum, we observed that the splenium was consistently wider in females than in males. Only one female had a more tubular splenium and two males more bulbous-shaped ones. The average splenial width and the posterior fifth distance of the corpus callosum exhibited a significant sex difference. The controversy concerning sex differences in the corpus callosum may decrease with studies using measurements on a large number of subjects. In addition, MRI may be useful in demonstrating sex differences in neuroanatomical and neuropsychological function and the role of the environment in the process of sexual differentiation.

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