Sex differences in the mid-sagittal area of corpus callosum in the human brain image obtained at 4.7T

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Introduction

It was claimed that human corpus callosum (CC) showed sex differences, as in the larger splenium in females than in males [1]. The sexual dimorphism, however, has remained controversial, in spite of a considerable number of studies derived from neurological interests in the tissue which plays a role of interhemispheric communication [2,3]. One of the foci of above arguments lies on whether there is a sex difference in the mid-sagittal area. The accurate evaluation of the area is dependent on the accurate extraction of the mid-sagittal plane in the image [3]. In the present work we propose an automated extraction method of the mid-sagittal plane based on a coregistration procedure. For the obtained result we examined the brain size dependence of the CC area, demonstrating a new type of sex difference.

Materials and Methods

All the brain images were collected on 33 male (age range: 21-65 years) and 36 female (age range: 23-55 years) subjects. Three-dimensional MDEFT images were obtained on a 4.7T/92.5cm MRI system (Varian, Palo Alto) with optimized parameters for 4.7T [4]. Segmented probability images were obtained for grey matter (GM), white matter (WM), and cerebrospinal fluid (CSF) using a previously reported procedure [5]. For automated extraction of the mid-sagittal plane of CC a WM probability image was coregistrated with the WM template image in SPM99 software. The mid-sagittal plane was defined as the center plane of the coregistrated image. Finally, unwanted WM tissues surrounding CC was manually eliminated. The cross-sectional area of CC was calculated by summing the product of WM probability and the pixel area in the selected CC. We also calculated total tissue volumes in GM, WM, and CSF by summing the product of each tissue probability and the voxel volume through the brain. The intracranial volume was obtained by binarizing the sum of the probability image of each tissue.

Results and Discussions

Figure 1 compares the mid-sagittal CC areas obtained by an automated extraction procedure and by a manual extraction. These values are well consistent with a correlation coefficient of 0.97. Thus, we used values obtained by the automated method hereafter. The mean CC area was $5.44\pm0.98cm^2$ in males and $5.35\pm0.64cm^2$ in females, and they were not significantly different. The CC area did not show particular age dependence either in males or females. To avoid an effect of differences in the brain size on the CC area, we normalized the absolute CC area by the intracranial volume (ICV) in each subject. The mean normalized area of 3.87×10^{-3} in females was significantly larger than the value of 3.45×10^{-3} in males. There was a criticism, however, that the difference detected in the CC area normalized by ICV was not still fair because the female brains distributed in the smaller size than the male brains. Therefore, the comparison should be performed at the similar brain size. We examined this criticism by plotting the absolute CC area in males and females as a function of ICV (Fig. 2). The area of CC showed a positive correlation with ICV in males ($R = 0.48$, $P<0.01$), while no correlation was found in females ($R = 0.25$). As a result, the female CC area was larger than the male CC at the small brain group, but it could have been inverted at the large brain size group. This result suggests that a simple comparison in the absolute or normalized CC area is not meaningful. We have no idea for now why the female CC is less dependent on the brain size than the male CC. This new type of sex difference was further confirmed by the absence and presence of the correlation of the CC area with the total WM volume in females and males, respectively.

The sex difference in the size of CC could be related to the behavioral and neuropsychological difference between males and females. To confirm this hypothesis further investigation is necessary.

Conclusion

Relationship between the mid-sagittal area and the brain size demonstrated a new type of sex difference that female CC is less dependent on the brain size. This result suggests a simple comparison either in the absolute or normalized CC area is not meaningful.

References

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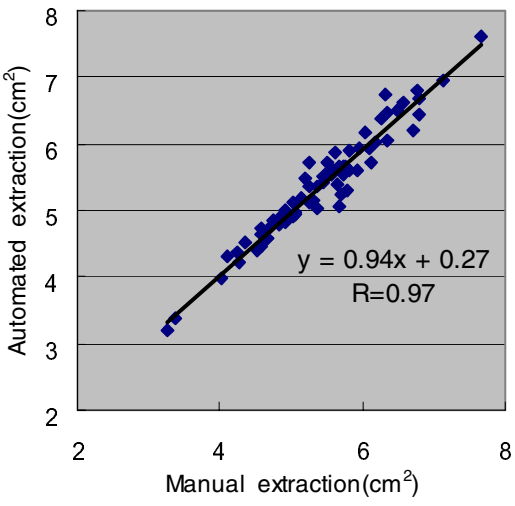

Fig.1. Correlation of mid-sagittal CC area obtained by automated and manual extraction methods.

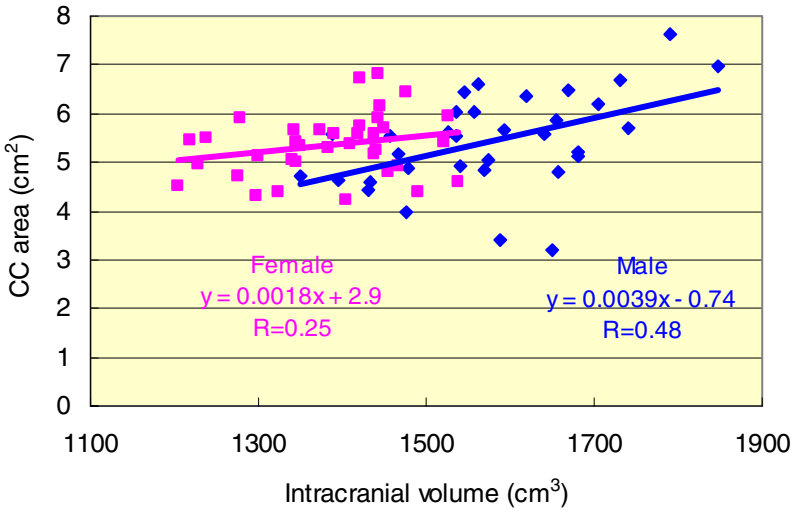

Fig.2. Relationships between the CC area and the intracranial volume in male and female brains.