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Shape deformity of the corpus striatum in obsessive–compulsive disorder

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Abstract

Volumetric changes of striatal structures based on magnetic resonance imaging (MRI) have been inconsistent in patients with obsessive–compulsive disorder (OCD) due to methodological limitations. The purpose of this study was to investigate shape deformities of the corpus striatum in patients with OCD. We performed 3-D shape deformation analysis of the caudate nucleus, the putamen, and the globus pallidus in 36 patients with OCD and 36 healthy normal subjects. Shape analysis showed deformity of the striatal structures, especially the caudate nucleus. Outward deformities in the superior, anterior portion of the bilateral caudate were observed in patients with OCD. In addition, an outward deformity in the inferior, lateral portion of the left putamen was also detected. These results suggest that patients with OCD have shape deformities of the corpus striatum, especially the caudate nucleus, compared with healthy normal subjects, and that shape analysis may provide an important complement to volumetric MRI studies in investigating the pathophysiology of OCD.

Keywords: Obsessive–compulsive disorder; Corpus striatum; Shape analysis

1. Introduction

Many studies performed with various methodologies have suggested that symptoms of obsessive–compulsive disorder (OCD) are due to dysfunction of the fronto–subcortical circuitry originating from the prefrontal cortex and the anterior cingulate cortex (ACC), projecting into the caudate nucleus, and finally reaching the thalamic relay. The role of the basal ganglia is to integrate the various inputs arriving from the cortex and to use this information to select certain motor and/or cognitive programs. Of the structures of the basal ganglia, the caudate nucleus is the area that has been implicated most consistently in the pathophysiology of OCD. Functional imaging studies have detected hyperactivities of the bilateral (Baxter et al., 1987, 1988) or right (Molina et al., 1995) head of the caudate nucleus, which might be consistent; however, volumetric changes of the striatal structures based on magnetic resonance imaging (MRI) have been inconsistent in patients with OCD. Robinson et al. (1995) reported that bilateral caudate volumes were reduced in patients with OCD,

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while Scarone et al. (1992) found increased right caudate volumes in patients with OCD. Riffkin et al. (2005) did not reveal any statistical significant differences in OCD, using manual region of interest method and automated voxed based morphometry method. Our group did not also find significant volume differences of the bilateral caudate nucleus or the putamen between patients with OCD and normal controls (Kang et al., 2004). The differences between these volumetric studies with MRI could have been caused by methodological limitations. Recently, interest has been growing in measuring changes in the shapes of specific brain regions. In the shape analysis study with bipolar disorder patients, drug-naïve bipolar disorder patients had shape differences of the striatum, relative to healthy comparison subjects, and that these differences might be modulated by treatment (Hwang et al., 2006). Based on a hypothesis suggested by Van Essen (1997), the shapes of specific brain structures may be determined by the physical properties of neural tissue combined with the patterns of neural connectivity. Therefore, a shape analysis method would be more sensitive for detecting morphological changes of brain regions in patients with OCD, in which abnormalities of the fronto–subcortical circuitry may be involved, compared to conventional volumetric measurements. In addition, a shape analysis method might reliably detect subtle volume changes of small brain regions such as the striatal structures (Levitt et al., 2004). No previous study has reported structural abnormalities of the basal ganglia using a shape analysis method in patients with OCD. In the current study, we hypothesized that patients with OCD would show characteristic differences in the shapes of structures of the basal ganglia compared to normal subjects.

2. Methods

2.1. Subjects

Thirty-six (28 men and 8 women) patients and healthy normal subjects were included in this study. The subjects were the same as in a previous report by our group (Kang et al., 2004). All participants were right-handed. And no differences existed in age or socioeconomic status (SES) (Hollingshead and Redlich, 1958) between the patients and controls. The mean ages of the patients with OCD and the controls were 26.33 years (S.D. = 6.18) and 26.50 years (S.D. = 7.58), respectively. The mean parental SES of the patients with OCD and the controls were 3.00 (S.D. = 0.71) and 2.86 (S.D. = 0.73), respectively. However, the OCD and control groups were significantly different in terms of educational level (13.86 years [S.D. = 2.04] and 15.17 years [S.D. = 1.89], respectively; t = 2.814, df = 70, P = 0.006) and IQ (109.20 [S.D. = 8.41] and 116.64 [S.D. = 10.88], respectively; t = 3.215, df = 70, P = 0.002). At the time of the study, the patients had a mean illness duration of 8.90 years (S.D. = 7.00). Four patients with OCD had a major depressive disorder as a comorbidity, but no other DSM-IV axis I disorder. Eleven patients were drug naïve, and 25 had a history of anti-obsessional medication (six patients had a history of antipsychotic medication). However, all were psychotropic drug-free for at least 4 weeks prior to the measurement of clinical symptoms. In addition, an interval of about 2 weeks had passed between the measurement of clinical symptoms and MRI scanning.

Clinical assessment was conducted using the Yale–Brown Obsessive Compulsive Scale (Y–BOCS; Goodman et al., 1989). The mean scores for obsessive symptoms, compulsive symptoms, and total score were 13.31 (S.D. = 3.54), 11.22 (S.D. = 4.26), and 24.17 (S.D. = 5.94), respectively. To obtain an IQ estimate, the Vocabulary, Arithmetic, Block Design, Picture Arrangement, and Digit Span subscales, which were included in the Korean version of the Wechsler Adult Intelligence Scale (WAIS), were administered to all subjects.

This study was performed according to regulations on the use of human subjects established by our institutional review board. After complete description of the study to the subjects, written informed consent was obtained.

2.2. Image acquisition and processing

We performed MRI scanning of the entire brain, and acquired 3-D T1-weighted spoiled gradient echo MR images using a 1.5-T General Electric SIGNA system (GE Medical Systems, Milwaukee, WI, USA) with imaging parameters of 123 1.5-mm sagittal slices, echo time = 5.5 ms, repetition time = 14.4 ms, number of excitation = 1, rotation angle = 20°, field of view = 21 × 21 cm, and matrix = 256 × 256. MRI data were then processed with the ANALYZE software package (version 4.0, Mayo Foundation, Rochester, Minesota, USA). Images were re-sampled to 1.0 mm^3 voxels, reoriented to the conventional position, and spatially realigned so that the anterior–posterior axis of the brain was aligned parallel to the inter-commissural line, and the other two axes were aligned along the inter-hemispheric fissure. The data sets were then filtered using anisotropic diffusion methods (Perona and Malik, 1990) to improve the signal to noise ratio. In order to extract the brain, tissues exterior to the brain were removed by the semi-automated region growing method. Employing the fuzzy C-means algorithm, the extracted