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Research article

The cortical surface correlates of clinical manifestations in the mid-stage sporadic Parkinson's disease

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HIGHLIGHTS

- Correlation between CDT and Frontal-Sup-Orb-L, Frontal-Sup-Medial-L, Frontal-Mid-Orb-L and Rectus-L.
- Correlation between SVFT and Frontal-Mid-L and Frontal-Inf-Tri-L.
- Correlation between DF and Frontal-Sup-R, Frontal-Mid-R and Frontal- Sup- Medial-R.
- Correlation between Webster and Occipital-Mid-R, Angular-R, Temporal-Sup-R and Temporal-Mid-R.
- Cortical surface alterations were the pathological base of some sPD clinical manifestations.

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ABSTRACT

The alteration of pathological cortical surface may lead to the corresponding clinical manifestations of sporadic Parkinson's disease (sPD). Therefore, we investigated the correlates of cortical surface and clinical manifestations in the mid-stage sPD. Sixty seven mid-stage sPD patients and thirty five matched controls were performed the corticometry of magnetic resonance imaging (MRI) and the assessment of clinical manifestations including the demographic and disease-related characteristics, and underwent the final analysis of the correlates between cortical surface and clinical manifestations. The result revealed a significant correlation between CDT and Frontal-Sup-Orb-L, Frontal-Sup-Medial-L, Frontal-Mid-Orb-L and Rectus-L; SVFT and Frontal-Mid-L and Frontal-Inf-Tri-L; DF and Frontal-Sup-R, Frontal-Mid-R and Frontal-Sup-Medial-R; Webster and Occipital-Mid-R, Angular-R, Temporal-Sup-R and Temporal-Mid-R respectively in the mid-stage sPD patients. Our data suggested that the alterations of cortical surface in the left Frontal-Sup-Orb, Sup-Medial, Mid-Orb, Mid, Inf-Tri and Rectus, the right Frontal-Sup, Mid, Sup-Medial, and Occipital-Mid, Angular, Temporal-Sup and Temporal-Mid were the pathological base of some clinical manifestations including the cognitive impairment, the space structure, memory, attention, the abstract thinking, design, layout, utilization, digital, calculation, the time and spatial orientation concept, the operation sequence recognition and the partial motor dysfunctions in the mid-stage sPD, and that the dysfunctions of these brain regions contributed by the cortical surface lesion were closely correlated with some clinical manifestations of mid-stage sPD.

1. Introduction

The diagnosis of sporadic Parkinson's disease (sPD) is mainly based on clinical features, up to now, has not the reliable imaging diagnostic evidences yet. The most commonly used imaging

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techniques in the diagnosis of sPD are the positron emission tomography, the single photon emission computed tomography and the conventional magnetic resonance imaging (MRI), but they are only used in the clinical differential diagnosis. However, following the advances in the structural and functional imaging of MRI, its functions detecting the brain morphometric changes in sPD have been largely improved [1,2]. MRI has found some evidences that have a potential to provide some objective diagnostic evidences for sPD through detecting the brain morphometric alterations [3–5]. The brain morphometric quantitative characteristics might be used as the indicators of biological or pathological states of sPD. In neuroimage, the brain morphometry is a kind of measure derived from the MRI imaging that can reflect the presence of diseases or their severity and that can be used for diagnosing, assessing the prognosis or monitoring the responses to therapeutic interventions. The brain morphometric alterations are expected to in vivo detect the neuropathological features and the pathogenesis of neurodegeneration, the correlate of the complex clinical manifestations with the brain pathologic alteration, the disease status and the objective imaging diagnostic evidences in sPD.

Functional MRI (fMRI) was able to in vivo detect changes at various levels of the central nervous system, including the cortical volume, thickness, surface, connectivity, density and so on. The techniques of fMRI contrasts and image analysis have largely improved the visualization of the brain morphometry. The microstructural cortical lesions can be detected through identifying the changes such as the volume, thickness, surface, connectivity and density using the quantitative fMRI imaging [6]. The quantitative fMRI imaging includes the following techniques such as the relaxometry, susceptibility-weighted, diffusion and magnetization transfer imaging, tractography, the diffusion tension imaging, the magnetic resonance spectroscopy, the resting state functional imaging and so on. These imaging methods can assess and investigate the brain morphometric alterations of sPD patients such as the cortical volume, thickness, surface, connectivity (Anatomical and functional connectivity) and density. It is clear that they have the potential functions to quantify the pathology, to follow the disease progression and to provide some objective diagnostic evidences for sPD [7].

At present, the voxel based morphometry (VBM) is a better technique to assess the cortical morphometry based on the delineation of cortex and normalization [8]. In addition, a technique of structural analysis using the MRI anatomical scans known as corticometry has recently been used in investigating the local cortical thickness and surface. The analysis of the local cortical surface can assess the local cortical folding and give access to the geometrical properties of cortex. Therefore, the analysis technique combined VBM and corticometry allows for enhancing the reliability and sensitivity in investigating the alteration of cortical surface [9]. In order to investigating the correlations between the cortical surface and the clinical manifestations of sPD, and further finding some objective diagnostic evidences of MRI for sPD, therefore, we measured the cortical surface and analyzed the correlations between the alterations of cortical surface and the clinical manifestations in sPD.

In this study, we aimed to detect the alterations of brain cortical surface between the sPD patients and the controls from the Han population of Chinese mainland (HPCM) using fMRI. For the evaluation of the brain cortical surface, we adopted a voxel-based analysis technique of the fMRI anatomical scans known as corticometry, because this method has a high sensitivity for identifying the cortex deficit, and also has recently been extensively used in investigating the local cortical surface by some researchers [9]. In the analysis of cortical surface, we conducted the measure of cortical surface in the regions of interest (ROI) to evaluate the changes of cortical surface. Meanwhile, we comprehensively evaluated the demographic characteristics and the disease-related characteristics of our studied subjects. This study aimed to attempt to detect whether or not the alteration of cortical surface in some brain regions was related to some clinical manifestations in sPD using fMRI methods, to find the more brain pathological evidences of sPD, and to provide some objective diagnostic imaging criterions for sPD.

2. Materials and methods

2.1. Patients

A total of 67 patients and 35 sex- and age-matched controls were included in the final analysis. The demographic and clinical disease-related characteristics of the two groups were presented in Table 1. These age- and sex- matched control subjects had not the history of neurologic or psychiatric diseases. sPD was diagnosed by three experienced neurologists according to the United Kingdom Parkinson's Disease Society Brain Bank criteria [10].

2.2. Assessment of Disease-related characteristics

Webster scale consists of the ten symptoms e.g. the bradykinesia of hand (Writing), rigidity, posture, the sway of upper limb, gait, tremor, the facial expressions, seborrhagia, language, the self-care ability, each symptoms is divided into grade 4 according to the severity scale, the scores were between 0 to 3 points from light to sever. 0 score is normal, 1–10 score is light, 11–20 score is moderate, 21–30 score is sever motor impairment.

Digit-span task consists of the forward digit span task (DF) and the backward digit span task (DB). Participants are presented with a series of digits such as '8, 2, 4' (DF) or 4, 2, 8 (DB) and must immediately repeat them back. If they do this successfully, they are given a longer list. The length of the longest list a person can remember is that the person's DF or DB.

Verbal fluency tests are a kind of psychological test in which participants have to say as many words as possible from a category in a given time (Usually 60 seconds). This category can be semantic, such as animals or fruits, or phonemic, or words that begin with letter *p*. The semantic verbal fluency test (SVFT) is sometimes described as the category fluency test or simply as 'freelisting'. The commonest measure is the total number of words in a given time, the other analyses include the number of repetitions, and the number and length of the words clusters from the same semantic or phonetic subcategory [11].

The person undergoing CDT (Clock drawing task or test) is asked to draw a clock, puts in all numbers, sets the hands at ten past eleven. There are a number of scoring systems for this test, but the scale method of 0–4 score is extensively used in the practice because of the simple, sensitive and easy perform. There are 5 items, each item is 1 score, e.g. 1 score for the clock circle, 1 score for all the numbers being in the correct order, 1 score for the numbers being in the proper special order, 1 score for the two hands of the clock, 1 score for the correct time [12]. All items perfectly finished are 4 score, not any items perfectly finished is 0 score. 4 score is normal, 3 is light, 2 is moderate, 0–1 is severer cognitive impairment, the CDT and MMSE score have a better consistent, such as CDT 0 = MMSE 3-5, CDT 1 = MMSE 14, CDT 2 = MMSE 19-20, CDT 3 = MMSE 23-24, CDT 4 = MMSE 30.

The severity of sPD symptoms was assessed according to the Hoehn and Yahr scale and UPDRS-III which examined at 12 hours of off medication [13]. The sPD patients who had the 2.5–3 score of Hoehn and Yahr and the 31–45 score of UPDRS-III were recruited as the mid-stage sPD cases. Participants were excluded if they had a history of the traumatic brain injury, stroke or any other neurological disorders. This study was approved by the institutional review