Changes in Speech Characters of Patients With Parkinson's Disease After Bilateral Subthalamic Nucleus Stimulation

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Summary: Objective. To investigate the effects of bilateral subthalamic nucleus deep brain stimulation (STN-DBS) on acoustic characteristics of speech in Chinese patients with Parkinson's disease (PD).
Methods. Eleven patients (five men and six women) diagnosed with PD participated in this study. Motor disabilities and speech samples were evaluated and recorded under six different conditions according to the states of medication and stimulation. Motor disabilities were evaluated with the Unified Parkinson's Disease Rating Scale (UPDRS). Acoustic signals were recorded from the subjects during production of sustained vowels /a/, /i/, and/u/; repetitions of /pataka/; and sentence production tasks. Acoustic analysis was performed with the *Multidimensional Voice Program* (*MDVP*), the *Motor Speech Profile* (*MSP*), and *Computerized Speech Lab* (*CSL*) (Kay Elemetrics, Lincoln Park, NJ).
Results. Based on the UPDRS III scores, the motor ability of the patients improved. There was almost no change in the speech score, which was also supported by the instrumental analysis of PD speech. This indicated that bilateral STN-DBS was associated with a significant improvement in the patients' motor disabilities but did not have much influence on speech performance during the short time after the stimulation switch was turned on. Furthermore, gender-related differences for speech performance were demonstrated, with the vowel /i/ being more sensitive.
Conclusion. These results are consistent with previous studies that have reported disparity between limb and speech improvements after neurosurgical intervention for PD, such as STN-DBS. The long-term effects of STN-DBS on Parkinsonian speech of Chinese patients should be studied further.
Key Words: Parkinson's disease–Dysarthria–Subthalamic nucleus (STN)–Deep brain stimulation (DBS).

INTRODUCTION

Parkinson's disease (PD) is a progressive neurological disease resulting from loss of neurons in the substantia nigra. These neurons are associated with the production of the neurotransmitter dopamine, which is important in the regulation of basal ganglia motor loop function.[1] Typical motor symptoms of PD include resting tremor, rigidity, akinesia, and balance disturbances.[2–4] Another typical symptom of PD is the speech impairment known as hypokinetic dysarthria, which may affect as many as 70–90% of patients with PD and worsen in the later stages of the disease.[4] The most common features of hypokinetic dysarthria associated with PD include monopitch and monoloudness, reduced stress, variable rate, short rushes of speech, inappropriate silences, breathy and harsh voice, and imprecise articulation.[5] These speech-related symptoms are associated with loss of dopamine and/or the degeneration of nondopamingeric systems that are affected by PD.[4,5] Harel et al[2] suggested that it is the dysregulation of the basal ganglia loop because of dopaminergic depletion which is responsible for the changes in speech motor control abilities observed in patients with PD.

Treatment for the symptoms of PD has mainly focused on pharmaceutical therapy and surgical techniques. Levodopa (L-dopa), the main medicine for treatment of PD motor symptoms, is a dopamine precursor. Brain enzymes modify the drug to create dopamine. L-Dopa is the oldest and most effective treatment for PD. At the beginning of treatment, most patients have a favorable response. It reduces tremors, slowness, and stiffness of muscles. However, L-dopa becomes less effective as the disease progresses. "Wearing-off" is a frustrating aspect of drug therapy in PD, and patients experience "on" times and "off" times.[6] Motor fluctuations appear with an alternate state of severe Parkinsonian disability, which means "off" period, and a state of improved mobility, which means "on" period. These fluctuations are known as the "on-off" effect and have been confirmed to make a contribution in the aggravation of dysarthria.[4,7–10]

The main surgical treatment for PD motor symptoms is deep brain stimulation (DBS). There are three main surgical targets: the ventral intermediate nucleus, internal globus pallidus, and subthalamic nucleus (STN). Currently, the STN is generally considered to be the most effective target for PD motor symptoms, including Parkinsonian dysarthria.[11] Stimulation of the ventral intermediate nucleus and internal globus pallidus has not shown to produce improvement in dysarthria.[4,12] STN-DBS may improve speech impairment, such as phonation[13–15] and articulation.[16] However, in general, the results of these studies have been controversial.[15,17–19]

It should be emphasized that these controversial results were based on the subjective assessment of item 18 (speech) of the Unified Parkinson's Disease Rating Scale (UPDRS). Only a few studies used instrumental analysis to analyze voice and

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articulation parameters of speech. Moreover, there have been only a very limited number of studies with instrumental analysis that specifically focused on speech alteration after STN-DBS.

Normal male and female individuals have different speech characteristics,[20] and there is a difference in gender distribution among patients with PD who have received surgical treatment.[21] Because more male patients with PD received surgical treatment, most existing data about the effects of DBS come from male patients.[5,18] We suggest that the influence of gender should be considered in a study of the effects of DBS for dysarthria in patients with PD. To date, reports about the influence of gender on DBS treatment for dysarthria are rare. The aim of this study was to perform an objective instrumental evaluation of speech alteration in patients with PD after STN-DBS and examine the influence of gender.

METHODS

Patients

Eleven patients (five men and six women; age range, 43–69 years; average age, 58.2 ± 9.2 years) diagnosed with idiopathic PD participated in this study. The duration of PD ranged from 3 to 13 years. All the patients underwent bilateral STN-DBS at the Beijing Institute of Functional Neurosurgery, Capital Medical University. The inclusion criteria were as follows: (1) idiopathic PD, without other neurological deficits; (2) motor fluctuations with good response to L-dopa ("on-off" effect); (3) absence of previous psychiatric problems or cognitive decline; and (4) no morphological abnormalities of the larynx and vocal tract. No patients had undergone voice therapy. All the patients gave valid, informed consent to participate in the study. The specific characteristics of the patients are summarized in Table 1. As a control, another 10 normal volunteers (four men and six women), with average age of 53.1 ± 13.5 years (range, 41–70 years), who were matched for age and gender, also participated in this study. The acoustic characteristics of the control group are shown in Table 2.

Procedures

The motor disabilities and speech tasks were evaluated and recorded under six different conditions. Based on the medication and stimulation states, the six conditions were as follows:

1. Presurgery, medication-on state (pre-on);
2. Presurgery, medication-off state (pre-off);
3. Postsurgery, medication-on state, stimulation is off (Med ON-Stim OFF);
4. Postsurgery, medication-off state, stimulation is off (Med OFF-Stim OFF);
5. Postsurgery, medication-on state, stimulation is on (Med ON-Stim ON);
6. Postsurgery, medication-off state, stimulation is on (Med OFF-Stim ON).

The on-off effect is generally related to medication cycles, and STN-DBS is considered the most effective treatment for

TABLE 1.
The Patients' Characteristics, Including Gender, Age, Assessments of Global Motor State and Speech by Means of the UPDRS

			Presurgery				Postsurgery							
			Pre-on		Pre-off		Med ON-Stim OFF		Med OFF-Stim OFF		Med ON-Stim ON		Med OFF-Stim ON	
Patient	Age (yr)	PD Duration (yr)	UPDRS	Speech	UPDRS	Speech	UPDRS	Speech	UPDRS	Speech	UPDRS	Speech	UPDRS	Speech
PD1/F	51	8	39.5	1	72.5	1	15	0	53	1	14	0	23	1
PD2/M	47	6	47.5	1	80	2	37	1	69	1	32	1	51	0
PD3/M	59	5	49.5	1	87	1	27	1	68	1	27	1	51	2
PD4/F	53	6	18	0	61	1	15	0	53.5	1	14	0	56	0
PD5/F	68	10	46	2	88	3	48.5	2	76	3	43	2	67	3
PD6/M	63	7	30.5	1	74	1	30.5	1	59.5	1	20	1	26	1
PD7/F	69	12	22	1	72	1	23	1	56	1	21	1	38	1
PD8/M	42	3	16	2	98	3	25	3	45	3	23.5	2.5	34	3
PD9/F	67	9	59	0	82.5	1	49	0	70.5	1	36	1	61.5	1
PD10/F	53	5	27	0	72.5	1	24	1	39	1	19.5	0	27	1
PD11/M	67	13	36.5	1	97.5	2	40	1	59.5	1	39	1	50	1

Abbreviations: F, female; M, male.
UPDRS III scores range from 0 (no impairment on any tasks) to 108 (severe impairment on all tasks). Speech item 18 of UPDRS III, range from 0 (normal) to 4 (unintelligible).