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Treatment of dysarthria following subthalamic nucleus deep brain stimulation for Parkinson's disease

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Abstract

Deep brain stimulation of the subthalamic nucleus (STN-DBS) is an established treatment for patients with Parkinson's disease (PD). Speech impairment is a frequent side effect of the surgery. This study examined the efficacy of an intensive speech treatment (the Lee Silverman Voice Treatment, LSVT) on dysarthria after STN-DBS.

The LSVT was administered in ten patients with STN-DBS (surgical group) and ten patients without (medical group). Patients were assessed before, immediately after and six months following the speech treatment using sustained phonation, a speech intelligibility scale and monologue. Vocal loudness, speech intelligibility and perceptual ratings were the primary outcome measures.

Vocal loudness and perceptual scores improved significantly across tasks for the medical group only. Speech intelligibility did not significantly change for either group. Results in the surgical group were variable with some patients deteriorating.

Treatment of dysarthria following STN-DBS needs further investigation due to the variable response to LSVT.

Keywords

Parkinson's disease; speech; LSVT; STN-DBS

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Introduction

Speech is frequently affected in Parkinson's disease (PD) and is characterized by reduced loudness and monotone speech[1]. Medical and surgical treatments do not improve speech in the same way as they improve limb motor symptoms[2,3]. The Lee Silverman Voice Treatment (LSVT®LOUD)[4, 5] is an intensive treatment that has been developed to treat speech problems for patients with PD. LSVTLOUD aims to improve the quality of voice and speech by focusing on voice (increase amplitude of movement, increase vocal loudness)[6] There are no published data so far on the effect of LSVTLOUD on patients treated with STN-DBS.

Deep brain stimulation (DBS) is a surgical treatment for patients with PD who suffer from motor fluctuations[7]. Speech problems are a common side-effect of the stimulation in the subthalamic nucleus[2,8]. The severity, nature and perceptual characteristics of such speech difficulties can be variable and so far difficult to predict[2]. Some reports showed increase in loudness of speech following surgery with concomitant reduced intelligibility[2,9,10]. Speech problems can often limit the overall benefits of the procedure. The aim of the current study was to investigate the usefulness of the LSVTLOUD for patients following STN-DBS.

Methods

Participants

Ten patients with PD treated with bilateral STN-DBS ("surgical group" mean age 59.4±4.5 years, mean disease duration 13.6±5.3 years, mean H&Y stage when on-medication and on-stimulation 2.1±0.2) and 10 patients with medically treated PD ("medical group" mean age 63±9.7 years, mean disease duration 8.6±6.5 years, mean H&Y stage when on-medication 1.7±0.3) participated in this study. There were no changes of patients' stimulation or medication during the treatment. The mean amplitude of stimulation at the time of the treatment in the surgical group was 3.09 V (±0.28) for the left brain and 3.26 V (±0.58) for the right brain.

Treatment

The LSVTLOUD was delivered by a trained and experienced Speech and Language Therapist (ET) in the same way to all patients as instructed by the LSVT Foundation protocol[5]. The main goal of LSVTLOUD is to increase the amplitude of motor output across the speech mechanism by training increased vocal fold effort and healthy loudness while training patients to monitor vocal output. Treatment related changes are quantified (mainly using the decibel scale). It is based on the principles of motor learning such as intensity (four times per week for 16 sessions per month), complexity and saliency. Care is taken to avoid vocal strain or hyperfunction.

Speech assessment

All patients were assessed before, immediately and six months after the treatment (FU). The tasks included sustained phonation /a/ for three repetitions, the Assessment of Intelligibility for the Dysarthric Speech (AIDS)[11], and a 60-seconds monologue about a topic of the speaker's choice. The Computerized Speech lab was used for recording and analysis of all samples. Acoustic recordings were obtained using a calibrated Shure SM 48 dynamic microphone, with a 15 cm mouth-to-microphone distance at 22 KHz sampling rate in a sound treated room. For the measurement of intensity (Sound Pressure Level-SPL dB) of the sustained phonation, AIDS sentences and monologue calibration occurred at the beginning of each recording using a Quest 2100 SPL meter at 15 cm, as described previously[2,12].

Data analysis

For the acoustical analysis of intensity of sustained phonation, reading and monologue we calculated the mean vocal sound pressure level (SPL dB) measures from the speech recording of each condition. The AIDS sentences were rated blindly by an independent speech and language therapist (LS), blinded to the patients' treatment and the timing of the assessment. The percentage of words correctly identified was derived from the AIDS sentences according to the instructions of the manual. To explore the impact of the LSVTLOUD on perceptual characteristics of speech we used the 35 speech dimensions listed by Darley, Aronson and Brown [13] grouped under six speech clusters[14] (Table 2). Each speech cluster was assessed on a seven-point interval scale, from seven (normal speech) to one (greatest deviation from normal). Mean speech ratings were calculated for each of the speech-sign clusters across the groups in the three time points with a maximum total of 42 representing a near-normal speech according to the instructions in Plowman-Prine et al (2008)[43].

Statistical analysis

The primary outcome was the change in mean SPL dB across the three tasks. Secondary outcomes were the change in speech intelligibility and the change in the total perceptual rating of monologue between baseline and follow-up in the medical and surgical groups. A two-way ANOVA with factor 1 time (pre-post and FU) and factor 2 group (medical vs. surgical) was used to compare the effect of the LSVTLOUD in the two groups of patients across time points. Bonferroni post tests were used to explore the change between baseline and follow-up within groups.

Results

Patients in the two groups did not differ significantly at baseline in any of the measures. Mean vocal loudness increased significantly across all tasks between baseline and FU for the medical group only (Table 1). Speech intelligibility did not significantly change in the two groups between baseline and follow-up (surgical group 88.5±23.4% at baseline and 83.1±21.7% at FU and medical group 95.1±7.9% and 98.2±2.9% respectively) but this could be due to a ceiling effect for the medical group. Results from the perceptual rating of the monologue showed significant main effect for group in the subsections of articulation ($F(1,36) = 10.1$, $p=0.0051$) respiration, ($F(1,36)=8.4$, $p=0.009$), phonation ($F(1,36)=4.9$, $p=0.038$), and the total score ($F(1,36)=8.1$, $p=0.01$), with only the medical group showing a significant improvement. There was also a significant main effect for time for the respiration ($F(2,36)=4.5$, $p=0.01$) prosody, ($F(2,36)=7.1$, $p=0.002$), and the total score ($F(2,36)=6.1$, $p=0.004$) showing that over time the medical group improved. There was an interaction effect for respiration ($F(2,36)=5.07$, $p=0.01$), phonation ($F(2,36)=5.77$, $p=0.006$) and the total score ($F(2,36)=6.3$, $p=0.004$). Post hoc Bonferroni tests showed that these measures improved in the medical group both immediately post LSVTLOUD and at 6 months FU whereas respiration deteriorated in the DBS group (Table 2). A more detailed analysis of the perceptual ratings showed that four out of ten patients in the DBS group deteriorated following LSVTLOUD, three remained the same and three had a transient improvement only. The speech of the patients who deteriorated was characterized by a strained-hoarse voice quality, an excess loudness variations, monoloudness, monopitch, reduced stress, imprecise consonants, distorted vowels and insufficient breath support leading to short phrases. These features worsened with effort for increased loudness.

Discussion

In this study LSVTLOUD had a significant effect on vocal loudness and perceptual ratings of speech in patients with PD treated medically but not in patients following STN-DBS. Patients with STN-DBS presented with a variable response to LSVTLOUD treatment, with no sustained improvement and some patients showing worsening of their perceptual ratings at FU.

The rationale for the treatment goals and tasks of the LSVTLOUD is based on the motor (hypokinesia) and sensory (lack of immediate feedback) aspects of PD speech[15,16,17]. LSVTLOUD also targets motor learning, by using treatment strategies that incorporate cueing and repetition. Overlearning a new motor task through intensive practice and repetition can improve task automaticity and create a stronger memory (habit) for the motor behavior [17]. This intensive, high effort work on vocal loudness can bring significant improvement, as reported in clinical studies so far[4,5,6,15] and observed in our medical group.

The limited gains on speech of patients with STN-DBS observed in our study can be due to differences in the pathophysiology of dysarthria, the sensory processing or the ability for motor learning. Speech following STN-DBS can be perceptually different from the hypokinetic dysarthria initially described by Darley and colleagues[2, 13]. Voice can occasionally sound strained, strangled and breathless, resulting in scanning, “one-word-at-a-time” speech. Speech can be affected by voltage amplitude and contact location[12] as well as clinical pre-operative factors. The effects of STN-DBS on sensory processing of speech and motor learning have not been examined systematically so far. Alberts et al (2008) [18] and Frankemolle et al (2010)[19] have used a dual task cognitive-motor task to show that DBS can compromise performance, mainly due to the spread of current in the non-motor regions of the subthalamic nucleus. Speech can be described as a complex cognitive-motor task and the LSVTLOUD heavily relies on training both. Thus the limited effect of LSVTLOUD on surgical patients might be partially due to the stimulation effect on motor learning and ability for dual processing.

The small number of patients in the two groups limits the generalisation of the results. As the LSVTLOUD is based on principles of motor learning [20,21] it would be interesting to investigate any impairment in motor learning. Perceptual ratings from the Ramig group have concentrated on use of a Visual Analogue Scale for a pair of read sentences [17], “better-worse” judgment of the “Rainbow Passage” [22, 23], and perceptual rating of vowels [24]. Further investigations are needed into the efficacy of tailoring therapy to the particular speech problems post STN-DBS or of providing therapy before STN-DBS in order to maximize the benefits of the procedure.

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Table 1

Means (SD) of Sound Pressure Level (SPL dB) at 15cm mouth-to-microphone distance for phonation, reading and monologue in the surgical (DBS) and medical (MED) groups across time points.

LOUDNESS	PRE LSVT	POST LSVT	FU LSVT
Phonation			
DBS	77.2 (7.3)	81.7 (8.7)	79.9 (7.2)ns
MED	76.6 (11.1)	84.1 (8.5)*	86.5 (3.5)**
Reading			
DBS	76.4(5.8)	80.9(5.7)	79.5(6.2)ns
MED	74.5(6.6)	81.3(8.1)*	85.3(2.9)**
Monologue			
DBS	77.4 (4.1)	76.1 (6.5)	79.3 (5.7)ns
MED	75.2 (7.0)	78.9 (6.3)	81.9 (3.5)*

* $p<.05$,

** $p<.001$ for time

Table 2

Means (SD) of perceptual rating for the monologue task in the medical (MED) and surgical (DBS) groups across time points. Mean ratings are calculated for each cluster (scale of 1 to 7). Total of 42 is the maximum and denotes near normal speech.

PERCEPTUAL SCALE	PRE LSVT	POST LSVT	FU LSVT
Resonance (/7)			
DBS	5.4 (1.1)	5.7 (1.1)	5.8 (1.4)
MED	5.9 (0.5)	6.2 (0.4)	6.2 (0.4)
Prosody (/7)			
DBS	5.2 (1.0)	5.5 (1.5)	5.4 (1.6)
MED	5.6 (1.0)	6.7 (0.6)***	6.4 (0.8)*
Articulation (/7)			
DBS	4.5 (2.1)	4.5 (1.6)	3.6 (1.8)
MED	5.9 (1.6)	6.2 (0.7)	6.3 (0.6)
Rate (/7)			
DBS	4.8 (1.9)	5.0 (1.4)	4.4 (1.9)
MED	5.5 (1.2)	6.3 (0.9)	6.1 (0.8)
Phonation (/7)			
DBS	5.0 (1.3)	4.8 (1.5)	4.4 (1.1)
MED	5.1 (0.9)	6.1 (0.7)**	5.9 (0.7)*
Respiration (/7)			
DBS	4.5 (1.3)	4.8 (1.3)	4.0 (1.5)*
MED	5.1 (1.2)	6.2 (0.6)**	6.1 (0.5)**
Total (/42)			
DBS	29.4 (7.0)	30.4 (6.9)	27.9 (7.5)
MED	33.0 (4.6)	37.8 (3.2)***	37.3 (2.9)**

* p<.05,

** p<.01,

*** p<.001