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The Impact of Deep Brain Stimulation on Speech and Swallowing in Patients with Parkinson's Disease

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Abstract

Each year, according to parkinson.org, approximately 60,000 people in the US are diagnosed with Parkinson's Disease (PD). PD is a neurodegenerative disorder that affects dopamine-producing neurons in the portion of the brain called the Substantia Nigra. Symptoms of PD include resting tremors, muscle rigidity, and speech difficulties regarding articulation and vocal quality. There is no cure for PD, however, pharmaceutical, behavioral, and surgical interventions such as deep brain stimulation (DBS) can be used to treat symptoms of PD. Although there is a significant amount of research regarding the effects of DBS in patients with PD, there is little evidence describing how DBS specifically affects speech and swallowing for individual patients with PD. This project is intended to analyze the impact of DBS on speech and swallowing in two patients with PD at follow up evaluations post-DBS implementation.

Background: Key Terms/Definitions

DBS: A surgical intervention involving the implantation of electrodes in the brain, and an impulse generator battery beneath the collarbone or abdomen.

Formants: Amplified harmonics. Concentrations of acoustic energy

Speech Intelligibility: How well a person's speech is understood by others.

DDK: Measurement of how quickly someone can rapidly produce alternating sounds.

Clinical Significance: Impact on clinical practice.

HINT: Hearing in noise test.

Methods

This project uses previously collected data from two participants (DBS 01 and DBS 02) who underwent DBS implantation. The original data were obtained pre-DBS implantation, post-surgery, and at 3-month intervals following the post-surgical evaluation. The independent variables include: (1) First and second formants of the vowels /a/, /i/, and /u/ during sentence reading to determine vowel space area. (2) Vocal intensity during paragraph reading from the "Farm passage." (3) Vocal intensity during picture description. The participants were given a picture and asked to describe the picture in detail for one-minute. (4) Percent speech intelligibility during a word reading task. Participants read words and sentences randomly selected from the Speech Intelligibility Test, and five listeners transcribed what they heard from audio recordings of this task. (5) Vocal intensity during a monologue. Participants discussed a topic of interest for one minute. (6) Perceptual data from questionnaires addressing communication and swallowing function. Participants completed self-assessments (EAT-10, VAS) rating quality of life related to speech, swallowing, eating, and socializing. (7) Oral motor examination to assess facial symmetry, lip, jaw, and tongue movement, dentition, hard palate integrity, soft palate elevation/symmetry, ability to follow motor commands, volitional cough, dry swallow, diadochokinetic rates (DDK) and word/sentence repetition. (8) Vocal intensity and duration of vowel prolongation. Participants sustained the vowel "ah" six times for as long as possible. (9) Rate and volume of swallowing during a timed swallow test, where participants drank 150ml of water as quickly as possible, swallowed three presentations of liquid (pureed applesauce), and ate several small cookies. (10) kPa of pressure generated by the tongue and lips was measured using the Iowa Oral Performance Instrument model (IOPI). The IOPI used a pressure transducer to determine right, left, and center lip pressures, as well as pressure between the alveolar ridge and anterior tongue. (11) Pressure generated during maximum inspiration pressure (MIP) and maximum expiration pressure (MEP). These were measured using an RPM01 respiratory pressure meter. A mouthpiece was placed between the lips and tongue and secured with a bite block to measure MIP and MEP.

DBS 01 Results

DBS 01 had statistically significant improvements from pre-post for the monologue on various topics (p value .011) and sustained "ah" phonation (p value .001). DBS 01 from pre-FU only had statistically significant improvements for the monologue (t value .039). DBS 01 effect size pre-post was small for sentence reading (.21), picture description (.34), monologue on various topics (.42), and sustained "ah" phonation (.23). DBS 01 effect size from pre-FU decreased for all tasks except for HINT sentences, where there was an increase from trivial to small effect size (increase from .18 to .21). All other effect sizes decreased from pre-FU, with small effect sizes remaining for picture description (.25), and monologue on various topics (.25). Overall, DBS 01's baseline loudness for all tasks was significantly below average for his age and gender.

Task	Pre Avg (SD)	Post Avg (SD)	Pre-Post t-test	Effect Size	FU Avg (SD)	Pre-FU t-test	Effect Size
Sentence Reading	61.61 (9.51)	58.53 (3.64)	0.084	0.21	58.77 (3.49)	0.062	0.19
Paragraph Reading	60.36 (5.39)	59.50 (3.59)	0.214	0.09	59.64 (5.67)	0.375	0.06
Picture Description	62.22 (12.22)	56.00 (0.63)	0.195	0.34	57.65 (2.45)	0.112	0.25
Word List Reading	57.07 (2.91)	58.11 (2.94)	0.080	0.18	57.68 (2.04)	0.325	0.12
HINT Sentences	56.56 (3.67)	57.76 (2.66)	0.094	0.18	58.00 (3.01)	0.144	0.21
Monologue Various Topics	55.84 (7.74)	63.00 (7.84)	0.011	0.42	58.96 (3.36)	0.039	0.25
Sustained Ah	65.38 (6.26)	67.75 (3.41)	0.001	0.23	65.76 (5.08)	0.466	0.03

DBS 02 Results

DBS 02 had statistically significant improvements from pre-post for sentence reading (t value .020), word list reading (p value .042), monologue on various topics (t value.001) and sustained “ah” phonation (t value 0.00). DBS 02 pre-post effect size was small for paragraph reading (.28), word list reading (.26) and monologue on various topics (.38). DBS 02 pre-post effect size was moderate for sentence reading (.51), and large for sustained "ah" phonation. DBS 02 pre-post effect size was trivial for picture description (.05) and HINT sentences (.04). DBS 02 pre-FU effect size was large for sustained “ah” phonation (.82), moderate for sentence reading (.51), and small for paragraph reading (.28), word list reading (.26) and monologue on various topics (.38). DBS 02 had statistically significant improvement pre-FU for all tasks, and each task had a large effect size except for word list reading (.47).

Task	Pre Avg (SD)	Post Avg (SD)	Pre-Post t-test	Effect Size	FU12 Avg (SD)	Pre-FU12 t-test	Effect Size
Sentence Reading	50.89 (6.85)	56.70 (0.82)	0.020	0.51	68.80 (0.86)	0.000	0.88
Paragraph Reading	56.32 (4.09)	59.50 (6.44)	0.059	0.28	67.79 (2.52)	0.000	0.86
Picture Description	56.91 (6.19)	57.38 (2.84)	0.432	0.05	63.72 (2.44)	0.000	0.59
Word List Reading	56.69 (3.74)	58.76 (3.87)	0.042	0.26	62.37 (6.64)	0.000	0.47
HINT Sentences	57.14 (4.04)	59.08 (3.53)	0.057	0.04	65.37 (2.28)	0.000	0.78
Monologue Various Topics	57.82 (4.03)	60.95 (3.54)	0.001	0.38	64.81 (2.46)	0.000	0.72
Sustained Ah	63.88 (2.11)	71.65 (3.07)	0.000	0.82	76.65 (1.23)	0.000	0.97

Discussion

T-tests and effect sizes were calculated for each patient from pre-post, and from post-FU to determine statistical and clinical significance. Overall, DBS 01's baseline loudness for all tasks was significantly below average for his age and gender. DBS 01 showed statistically significant improvements from pre-post for monologue on various topics and sustained "ah" phonation, but from pre-FU, there were only statistically significant improvements for the monologue. DBS 01 showed clinical significance for picture description and monologue on various topics from pre-post, as these tasks had a small effect size. DBS 01 also showed clinical significance from pre-FU for HINT sentences, where the effect size increased from trivial to small, despite effect sizes decreasing for all other tasks. DBS 02 showed statistically and clinically significant improvement for all tasks. DBS 02's p-values from pre-FU were 0.00 for all speech tasks. DBS 02 had effect sizes from pre-post ranging from trivial to moderate. DBS 02's effect sizes from pre-FU increased to be large for all speech tasks except word list reading, as the effect size grew from small to moderate. These data show that DBS 02 had statistically and clinically significant improvements following DBS implementation for all speech tasks.

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