Computerized Posturography Balance Assessment of Patients with Bilateral VIM Deep Brain Stimulation

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Abstract

Background: Bilateral VIM DBS improves tremor in both patients with ET and PD. In each condition we have noted both subjective improvement and worsening in balance. Computerized posturography (CP) is able to quantify some aspects of balance.

Methods: Fourteen patients (6 with PD and 8 with ET) with bilateral VIM DBS were recruited to undergo identical CP testing while their devices were both activated and both were deactivated. The order of testing was randomized and patients were acclimated for 30 minutes on each setting. Testing was done on the Equitest system (Neurocom International).

Results: Eleven patients completed all testing. Two PD and one ET patient withdrew secondary to anxiety and tremor exacerbation after their devices were deactivated. Sensory organization testing and perturbation latency did not change, however, compensatory motor amplitudes, which are augmented in PD, were reduced with DBS activation ($p < 0.01$). This was most robust in the PD subjects.

Conclusion: Bilateral VIM DBS activation improved some aspects of balance as measured by CP. No subject had any clear worsening of balance parameters.

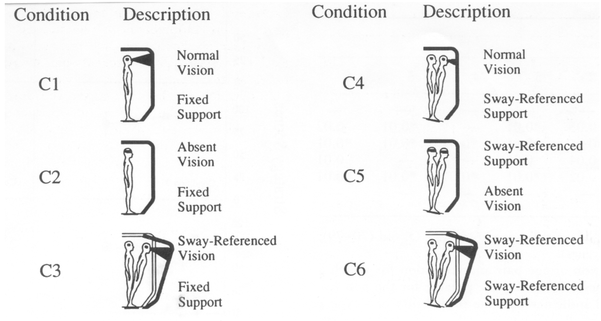
Introduction

Gait and balance difficulties, as measured by CP are seen in both PD and ET. In general, medium latency perturbations are abnormally high [1] and long latency responses are poorly adaptive [2] in PD. Sensory organization testing is often abnormal and does not improve with dopaminergic medications. [3] ET patients show modest abnormalities in CP [4] and also have impaired tandem gait. [5,6] Our population of PD and ET patients who have been implanted with bilateral VIM DBS individually report both improvement and worsening of subjective balance. [7] In both conditions bilateral VIM DBS placement more robustly altered subjective balance than unilateral placement. [8] The role of the VIM thalamus in balance control in both PD and ET is not known. Activation of a VIM DBS has been shown to reduce activity of the retroinsular (parietoinsular vestibular) cortex [9], and reduce activity in the cerebellar cortex [10], both of which could affect balance. In order to determine the clinical effects on balance of a functional lesion in the VIM thalamus, we tested patients implanted with bilateral VIM DBS to assess for any differences in static balance.

Methods

We recruited patients with ET and patients with PD from the Baylor College of Medicine Parkinson's Disease Center and Movement Disorders Clinic. All patients had staged VIM DBS procedures, with the second side placed at least 6 months prior to entry into this study. The order of testing (device on vs. device off) was randomized, and each patient acclimated to that activation status for 30 minutes prior to being tested. CP testing was performed on the Equitest (Neurocom International). Patients stood on dual force plates and faced a screen that surrounded them on three sides. Patients were harnessed to prevent falls. Sensory organization testing manipulates visual and kinesthetic information in six different paradigms: 1. eyes open and platform is still, 2. eyes closed and platform is still, 3. eyes open but the visual surround moves with postural sway. Paradigms 4, 5 and 6 repeat the first three conditions except that the platform moves in phase with the patient's sway, thus making kinaesthetic input inaccurate. [11] (Figure 1) The mean of three 20-second trials is used. The perturbation testing used small, medium, and large ampli-tude anterior and posterior translational deviations. Time to compensatory movements and amplitudes of compensatory movements were measured. The mean of both legs was used for analysis. Patients were tested while taking their normal medications. Statistical analysis included paired t-tests for the within-subject comparisons.

Figure 1. Description of Sensory Organization Testing



Results

Fourteen patients (6 with PD and 8 with ET) were recruited but two PD and one ET subject did not complete all procedures secondary to extreme anxiety, tremor exacerbation, and fatigue after their devices were deactivated. The age of the 11 completors, 7 male, was 71.1 ± 9.3 years. Sensory organization testing (SOT) did not show any differences, or trend toward differences, between activated DBS status and deactivated DBS status. (Table 1) Four patients had difficulties with conditions 5 and 6, which was seen equally during activation and deactivation. There were no significant differences in the latency to compensatory movement during perturbation testing. (Table 2) The amplitude, however, of the combined movements was relatively reduced when the DBS was activated ($p < 0.01$). This was more robust in the PD subjects and was most noted in the small and medium perturbations.

Discussion

Implantation of VIM DBS effectively improves tremor in both PD and ET. [12,13] Although patients frequently report subjective balance problems, especially with bilateral placement, we did not find worsening of any balance parameter, compared to when the DBS were deactivated for 30 minutes. In fact, perturbation amplitudes, which are abnormally large in PD patients, tended to normalize with bilateral VIM DBS activation.

Several other studies have measured different aspects of balance in PD patients with unilateral VIM DBS. Burleigh et al. were the first to report altered EMG compensatory movement to forced perturbation in a single PD patient with a unilateral VIM DBS. [14] Pinter et al. reported decreased postural sway, which is a similar paradigm to SOT condition 1 and 2, in 7 PD patients with unilateral DBS when the device was activated. [15] Locomotion parameters, however, were not affected. Likewise, Defebvre et al. did not find any differences in gait kinematic parameters using the Vicon optoelectric system in seven PD patients with unilateral VIM DBS. [16]

Potential weaknesses of this study include the fact that subjects underwent testing at different times relative to their implantation dates. The role of acclimation or permanent physiological changes caused by chronic VIM DBS is not known, and 30 minutes of deactivation may not represent a true "de novo" physiological state. Finally three patients could not tolerate deactivation. Nevertheless, we did not find any physiological bases for subjective worsening of balance, and do feel that some aspects of balance may actually improve with bilateral VIM DBS.

Table 1. Sensory Organization Testing

Fixed Support						Sway-Referenced Support					
Normal Vision		Absent Vision		Sway-Referenced Vision		Normal Vision		Absent Vision		Sway-Referenced Vision	
OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
86.6 ± 2.1	89.1 ± 1.3	82.5 ± 3.0	80.0 ± 6.5	81.0 ± 4.5	77.0 ± 9.7	65.1 ± 13.2	76.6 ± 8.6	53.8 ± 21.9	33.6 ± 28.8	32.9 ± 24.2	34.7 ± 29.8
87.8 ± 1.0	87.8 ± 2.8	82.5 ± 3.0	80.0 ± 6.5	81.0 ± 4.5	80.0 ± 3.5	74.3 ± 4.4	69.8 ± 10.8	43.8 ± 21.9	41.8 ± 22.3	50.5 ± 11.5	50.8 ± 14.3
87.0 ± 2.4	88.6 ± 2.5	78.3 ± 12.4	75.6 ± 19.0	80.0 ± 5.6	78.1 ± 9.4	68.5 ± 16.9	74.1 ± 12.1	35.8 ± 30.1	36.5 ± 30.1	39.3 ± 24.7	40.5 ± 28.7

Table 2. Perturbation Testing

Backward						Forward					
Short		Medium		Large		Short		Medium		Large	
OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
191 ± 23	190 ± 13	170 ± 13	166 ± 21	161 ± 12	156 ± 19	184 ± 8	170 ± 27	153 ± 11	152 ± 11	152 ± 16	149 ± 16
193 ± 10	190 ± 15	156 ± 4	159 ± 9	150 ± 8	155 ± 5	173 ± 13	168 ± 24	146 ± 13	154 ± 6	151 ± 9	154 ± 6
192 ± 26	190 ± 18	165 ± 15	163 ± 22	159 ± 15	156 ± 19	180 ± 14	169 ± 32	150 ± 17	153 ± 14	152 ± 20	151 ± 18
110 ± 11	91 ± 19	107 ± 6	92 ± 25	103 ± 16	91 ± 19	97 ± 20	90 ± 27	84 ± 15	92 ± 22	88 ± 16	91 ± 21
121 ± 21	85 ± 9	97 ± 13	95 ± 17	98 ± 7	94 ± 15	115 ± 26	93 ± 9	103 ± 4	96 ± 8	97 ± 5	97 ± 9
114 ± 19	89 ± 21	103 ± 11	93 ± 26	101 ± 17	92 ± 24	103 ± 28	91 ± 33	91 ± 18	93 ± 26	91 ± 17	93 ± 27

Key References

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