Comparison of Balance Control While Walking in Patients with Advanced Parkinson's Disease Pre- and Post-DBS Surgery

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Summary

Patients with advanced Parkinson's disease change their strategies for controlling walking balance after deep brain stimulation surgery. After surgery, during the double limb stance, the horizontal distance between the centre of mass and the centre of pressure increased, and the distance and velocity of the centre of mass shift increased. Medial and lateral body sway were reduced during double limb and single limb in the frontal plane, but angular velocity was increased.

Introduction

Patients with Parkinson's disease (PD) develop resistance to drugs in the middle and late stages of the disease. Once the effectiveness of the drug has diminished, it has a minimal effect on controlling involuntary movements. The patient's ability to control movement and balance is reduced, increasing the risk of falls. At this time, deep brain stimulation (DBS) surgery is currently an effective method for patients with mid to late-stage PD. Previous studies have shown that DBS combined with sustained drug control can effectively control movement. Can effective control movements also be reflected in maintaining dynamic balance while walking? Understanding balance alterations in patients with PD is crucial for fall prevention. Therefore, this study aimed to compare dynamic balance control during walking in patients with Parkinson's disease before and after surgery.

Methods

Eight patients with advanced PD, H & Y stage II-III) walked at their preferred speeds. All patients underwent bilateral DBS and were tested preoperatively (Pre-DBS) and 3 months postoperatively (Post-DBS). An 8-camera motion capture system (Vicon) at 120 Hz was used to track their centre of mass (COM). Two force plates (AMTI) measured the ground reaction forces and the centre of pressure (COP) at 1200 Hz. The spatiotemporal gait parameters (gait velocity, stride length) were measured. The differences between the maximum and minimum values of tilt angle (TA) and angular velocity (AV) were used to evaluate the level of body sway during walking. The TA was calculated using the vector pointing from the COP to the COM in both the sagittal and frontal planes [1, 2]. The single limb support (SLS) and double limb support (DLS) of the stance phase of the gait cycle were selected for data analysis. Each variable was tested for normality using the Mann-Whine test. A significance level of $\alpha = 0.05$ was set for all tests. SPSS version 20 (SPSS Inc.) was used for all statistical analyses.

Results and Discussion

The walking velocity and step length of the post-DBS were statistically significantly greater than those of the pre-DBS. In the sagittal plane during DLS, the TA and AV of post-DBS were statistically significantly greater than those of pre-DBS. The TA decreased, and the AV was more significant for the post-DBS than the pre-DBS in the frontal plane during DLS and SLS.

Table 1: Mean (SD) of TA and AV at DLS and SLS during walking

N=8	Pre-DBS	Post-DBS	*P*
Sagittal Plane			
TA (degree)			
DLS	12.9 (2.5)	15.3 (1.9)	0.05*
SLS	16.2 (5.7)	18.7 (2.8)	0.29
AV (degree/ angle)			
DLS	209.6 (111.6)	389.5 (172.8)	0.06*
SLS	201.6 (207.7)	293.4 (205.4)	0.18
Frontal Plane			
TA (degree)			
DLS	6.2 (2.2)	3.2 (1.4)	0.02*
SLS	1.7 (0.3)	1.2 (0.7)	0.03*
AV (degree/ angle)			
DLS	63.8 (24.2)	67.4 (31.6)	0.05*
SLS	55.6 (54.3)	63.1 (43.7)	0.02*

Conclusions

Parkinson's disease patients change their strategies for controlling walking balance after DBS surgery. They walk significantly faster after DBS surgery. During DLS in the sagittal plane, the centre of gravity moves from the back to the front. Postoperatively, the TA and AV increase, indicating that the horizontal distance between the COM and COP also increases. Weight shifts can be performed at faster speeds, and balance can be maintained. During DLS and SLS in the frontal plane, medial and lateral body sway were reduced, but angular velocity was increased. DBS therapy effectively allows patients with PD to maintain the ability to control balance during walking.

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References

[1] Pai YC et al. J Biomech 30, 347-354, 1997.
[2] Lu TW et al. Gait Posture 26: 553-9, 2007.
[3] Chen, SC *et al*. Gait Posture 33: 695- 700,2011.