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Effects of Different Deep Brain Stimulation Frequencies on Lower Limb Movement in Patients with Parkinson's Disease

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***Abstract*—The effects of different deep brain stimulation (DBS) frequencies on lower limb movement in patients with Parkinson's disease are not clear. In this study, we analyzed the clinical evaluation scores and biomechanical paraments in lower limb motor examinations under different DBS frequency settings. Both high-frequency and variable-frequency stimulations showed obvious improvements in motor symptoms. Considering the effectiveness in controlling axial symptoms, variable-frequency stimulation might be a potential stimulation setting in practice.**

***Clinical Relevance*—This study explores the effects of different DBS frequency settings on lower limb movement in patients with Parkinson's Disease.**

I. Introduction

Deep brain stimulation (DBS) is an effective treatment for Parkinson's Disease (PD) [1]. However, the principle of achieving the optimal DBS settings is still not clear. High-frequency stimulation (HFS) is considered effective in controlling motor symptoms including tremor. Some studies showed that low-frequency stimulation (LFS) could produce better movement improvements, such as gait [2]. A study reported that variable-frequency stimulation (VFS) could effectively alleviate axial symptoms such as speech and freezing of gait (FOG) [3].

In this study, based on clinical evaluations and accelerometer sensors, we compared the effects of different DBS stimulation frequencies on lower limb movement.

II. Methods

We recruited eight male and five female PD patients (aged 56.0±6.7 years) whose major symptoms were rigidity and bradykinesia. At the one-month, three-month, and six-month clinical visits after DBS implantation surgery, they performed the Unified Parkinson's Disease Rating Scale-III (UPDRS-III) test under DBS Off, HFS (130Hz), LFS (60Hz), and VFS (130-60 Hz alternation) settings with medication OFF. Their performances were evaluated by the same experienced neurologist. Seven wearable kinematic sensors (Noraxon, Myomotion-7) were attached to shanks, thighs, feet, and pelvis of each participant.

Based on these kinematic signals, we extracted 10 biomechanical parameters for gait task, including the walking time, cadence, amplitude, double support phase ratio, the area under the power spectra curve between 0 and 10 Hz of thigh and shank signals, and motion intensity. We also acquired the amplitude, frequency, and rhythm for toe tapping and leg agility tasks.

To investigate the effects of different stimulation frequencies on lower limb motor symptoms, we analyzed the afore mentioned biomechanical paraments, UPDRS-III total score and partial scores for bradykinesia, rigidity and postural instability and gait disorder (PIGD) with linear mixed-effects models. We considered patient gender, age and post-surgery time as fixed effects and repeated measurements as random effects.

III. Results

Compared to the DBS OFF setting, all DBS ON settings alleviated lower limb motor symptoms, with significantly reduced bradykinesia, rigidity and PIGD subscores ($p < 0.05$). In gait task, DBS increased the step length and reduced the proportion of double support phase under all frequencies. Both HFS and VFS shortened the walking time. HFS also increased the motion intensity ($p < 0.05$). Regarding the rigidity task, both HFS and VFS increased the amplitude and frequency with statistical significance.

IV. Discussion & Conclusion

We used both clinical scales and biokinematical sensing to evaluate the improvements of lower limb movement under different DBS frequency settings. HFS and VFS showed to be more effective stimulation modes compared to LFS. Since this patient cohort did not have axial symptoms such as FOG, the effectiveness of VFS is not comprehensively measured. We observed that VFS induced greater reduction in speech subscore. Taking into account the factors such as mitigating axial symptoms and saving battery power, VFS might be a potential stimulation setting in clinical practice.

References

[1] A. Benabid *et al.*, "Acute and long-term effects of subthalamic nucleus stimulation in Parkinson's disease," *Stereotact Funct. Neurosurg.,* vol. 62, no. 1-4, pp. 76-84, 1994.

[2] D. Su *et al*,. "Su, Dongning, et al. "Frequency-dependent effects of subthalamic deep brain stimulation on motor symptoms in Parkinson's disease: a meta-analysis of controlled trials," *Scientific reports,* vol. 8, pp. 1-9, 2018.

[3] F. Jia *et al.*, "Variable frequency stimulation of subthalamic nucleus in Parkinson's disease: rationale and hypothesis," *Parkinsonism & related disorders,* vol. 39, pp. 27-30, Dec. 2017.

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