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Device-Assisted and Lesioning Procedures in the Management of Parkinson's Disease: A Therapeutic Evolution

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Abstract

Parkinson's Disease (PD) is a progressive neurodegenerative disorder characterized by motor symptoms including bradykinesia, resting tremor, rigidity, and postural instability. While dopaminergic pharmacotherapy remains the cornerstone of symptom management, long-term use often results in complications such as motor fluctuations and dyskinesias. In this context, device-assisted and lesioning procedures have emerged as viable adjuncts or alternatives to pharmacological interventions.

Introduction

Parkinson's Disease affects millions globally, with increasing prevalence among aging populations. Standard treatments primarily involve levodopa and dopamine agonists, which initially provide significant relief. However, their diminishing effectiveness over time and side effects underscore the need for more sustainable interventions. Surgical and non-invasive neuromodulation techniques have therefore gained traction in recent years.

Deep Brain Stimulation (DBS)

DBS is one of the most established device-assisted treatments for advanced PD. It involves the implantation of electrodes in specific brain regions such as the subthalamic nucleus (STN) or the globus pallidus internus (GPi). This technique provides adjustable, reversible modulation of abnormal neuronal circuits, leading to substantial improvements in motor function and reduced dependence on medications. Innovations in adaptive (closed-loop) DBS, which adjusts stimulation in real time based on neural feedback, are currently being explored to enhance therapeutic outcomes and minimize side effects (Lozano et al., 2013).

Lesioning Techniques

Lesioning procedures, such as MRI-guided focused ultrasound (MRgFUS) thalamotomy and pallidotomy, have seen a resurgence with advancements in precision targeting. These minimally invasive approaches offer effective symptom control, particularly for unilateral tremor-dominant PD, and are suitable for patients contraindicated for DBS. MRgFUS thalamotomy, for instance, has demonstrated promising results with minimal adverse effects (Elias et al., 2016).

Future Directions

Emerging research is focused on enhancing patient selection criteria and procedural accuracy through integration of neuroimaging, biomarkers, and AI-driven targeting algorithms. Moreover, hybrid therapies that combine gene therapy with device-based neuromodulation are under active investigation, aiming to deliver personalized, precision medicine in PD treatment (Lozano et al., 2012).

Conclusion

Device-assisted and lesioning procedures are at the forefront of a paradigm shift in the management of Parkinson's Disease. With continual technological advancements, these interventions hold great promise for providing individualized care, particularly for patients with medication-refractory symptoms.

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