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Response to Deep Brain Stimulation is Associated with Increased Resting State Connectivity in the Associative Basal Ganglia Circuit

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Introduction

Deep brain stimulation (DBS) of the subthalamic nucleus (STN) or globus pallidus pars interna (GPi) is indicated in patients with refractory Parkinson's disease (PD) with significant motor fluctuations. While clinical characteristics facilitate patient selection, no objective tool to predict response to DBS exists. We examined resting state functional magnetic resonance imaging (rsfMRI) to determine the feasibility of this modality to serve as such a predictive tool.

Methods

Eight patients (3 female) with advanced PD underwent a preoperative MRI under anesthesia in preparation for DBS surgery. Motor scores (UPDRS-III) were collected before and after DBS (mean follow-up of 5.9 months). Scans were performed in a 3T Achieva Philips MR scanner, including rsfMRI (TR=2000ms, TE=25ms, FOV=68×68mm, flip angle=90o, spatial resolution=1.87×1.87×3.5mm, matrix size=128×128). Images were preprocessed to correct for spatial and temporal artifacts. Regions of interest (ROIs) were defined using the Harvard-Oxford atlas and the ATAG-MNI04 basal ganglia atlas. Functional connectivity (FC) was calculated using the MatLab-based CONN toolbox via two-tailed bivariate correlations. Significant FC differences between patients who had improved UPDRS-III scores following DBS versus those who had worse UPDRS-III scores following DBS were evaluated with both a ROI-to-voxel and ROI-to-ROI analysis (FDR-corrected $p<0.05$).

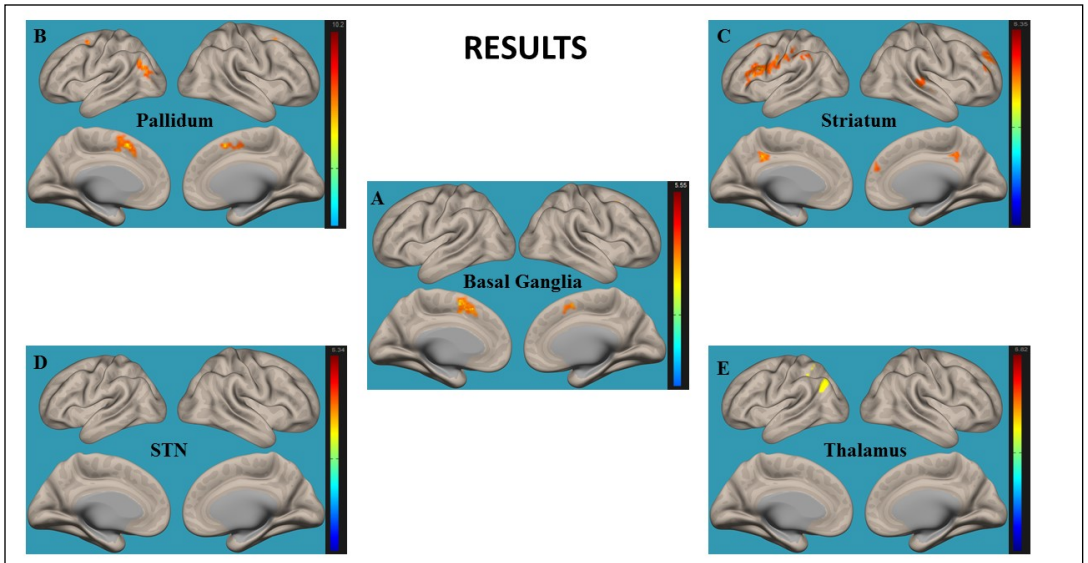
Results

Patients were 66.5±8.9 years old with disease duration of 7.3±1.8 years. Preoperative UPDRS-III was 29.3±10.6 and postoperative UPDRS -III was 21.9±9.0. Patients who responded more favorably to DBS had increased resting state connectivity within the basal ganglia (STN, pallidum, thalamus, striatum) and increased connectivity between the striatum and the frontal operculum ($p=0.001$).

Conclusions

Three major basal ganglia networks consisting of motor, associative, and limbic circuits have been described. While much focus has been on motor circuits in PD, our findings suggest that the associative circuit may play a role in DBS response and show promise in the ability for rsfMRI to provide better pre-surgical consultation to patients regarding prognosis from DBS.

RESULTS



Functional connectivity changes in basal ganglia (A) and its components of the pallidum (B), striatum (C), STN (D), and thalamus (E) in relation to DBS responsiveness using a seed-to-voxel analysis.

Implications

Patients with greater fcMRI in the motor and associative basal ganglia circuits exhibited preferential response to DBS
In the future, these connectivity patterns obtained on pre-surgical scans can help identify patients who are less likely to benefit from DBS and potentially eliminate unsuccessful surgeries

Learning Objectives

By the conclusion of this session, participants should be able to:
1.Describe indications for deep brain stimulation
2.Understand the role of resting state functional magnetic resonance imaging in Parkinson’s disease
3.Identify the three major basal ganglia networks involved in Parkinson’s disease