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TRR 295 ReTune

Long-Term Stability of Spatial Distribution and Peak Dynamics of Subthalamic Beta Power in PD Patients.

Behnke JK, Peach RL, Habets JGV, Busch JL, Kaplan J, Roediger J, Mathiopoulou V, Feldmann LK, Gerster M, Vivien J, Schneider GH, Faust K, Krause P, Kühn AA.
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This study investigated the long-term stability of subthalamic beta oscillations in Parkinson's disease (PD) patients undergoing deep brain stimulation (DBS). Local field potentials (LFPs) were recorded from 33 PD patients over multiple follow-up sessions ranging from immediately post-surgery to up to 44 months. The main objective was to assess the consistency of beta peak parameters and spatial distribution of beta power, critical for optimizing adaptive DBS (aDBS) and electrode contact selection.

Beta peak power significantly increased between the immediate postoperative session and the 3-month follow-up, likely due to the microlesional or stun effect, after which beta power stabilized. Peak frequencies exhibited substantial variability in the early postoperative period, with shifts exceeding 5 Hz in 57% of cases between 0 and 3 months. These fluctuations were notably reduced in later periods, with shifts occurring in only 27% of cases between 3 and 12 months and 29% between 12 and over 18 months. High-beta peaks (20–35 Hz) demonstrated greater long-term consistency compared to low-beta peaks (13–20 Hz), with high-beta detected in 96% of hemispheres during late follow-up, versus only 25% for low-beta.

Spatial distribution of beta power across electrode contacts remained largely stable over time. The contact with maximal beta power maintained its vertical position in 70–82% of cases, significantly more stable than chance, and its directional orientation on the horizontal plane remained consistent in 64–71% of cases. However, contacts with second highest beta power were less stable, especially in their horizontal direction, suggesting that selection of multiple directional contacts for stimulation may require longer or repeated LFP recordings.

Active contacts used for therapeutic stimulation consistently exhibited higher normalized beta power than inactive contacts across all follow-ups ($P < 0.0001$). Notably, in 58–69% of hemispheres, one of the two contacts with maximal beta power was selected for chronic stimulation. This highlights beta power as a valuable, though not exclusive, biomarker for contact selection, with additional clinical factors influencing programming choices.

Overall, the findings support the feasibility of using subthalamic beta power as a biomarker for chronic DBS programming, particularly after stabilization in the first 3 months post-implantation. They also underscore the potential for integrating chronic LFP recordings with imaging and clinical data to develop more efficient DBS programming strategies.

Dr. Jennifer K. Behnke

Jennifer K. Behnke is a neurology resident with a focus on movement disorders and DBS at Charité – Universitätsmedizin Berlin. She is a fellow of the Berlin Institute of Health Junior Clinician Scientist program and a research assistant in the lab of Prof. Kühn. Her research focuses on electrophysiological biomarkers in the basal ganglia, the effects of new stimulation patterns on Parkinson's symptoms and the optimization of DBS programming.

Prof. Andrea Kühn

Andrea Kühn is the director of the Movement Disorders and Neuromodulation Unit at Charité Berlin and the ReTune Spokesperson. Her research on basal ganglia electrophysiology has majorly contributed to the understanding of the pathophysiology of movement disorders and the mechanisms of action of DBS.

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