Sweet spot

The sweet spot is a place where a combination of factors results in a maximum response for a given amount of effort.

While deep brain stimulation (DBS) of the subthalamic nucleus (STN) has been extensively used for more than 20 years in Parkinson's disease (PD), the optimal area of stimulation to relieve motor symptoms remains elusive.

Objective: We aimed at localizing the sweet spot within the subthalamic region by performing a systematic review of the literature.

Method: PubMed database was searched for published studies exploring optimal stimulation location for STN DBS in PD, published between 2000 and 2019. A standardized assessment procedure based on methodological features was applied to select high-quality publications. Studies conducted more than 3 months after the DBS procedure, employing lateralized scores and/or stimulation condition, and reporting the volume of tissue activated or the position of the stimulating contact within the subthalamic region were considered in the final analysis.

Results: Out of 439 references, 24 were finally retained, including 21 studies based on contact location and 3 studies based on volume of tissue activated (VTA). Most studies (all VTA-based studies and 13 of the 21 contact-based studies) suggest the superior-lateral STN and the adjacent white matter as the optimal sites for stimulation. Remaining contact-based studies were either inconclusive (5/21), favoured the caudal zona incerta (1/21), or suggested a better outcome of STN stimulation than adjacent white matter stimulation (2/21).

Conclusion: Using a standardized methodological approach, our review supports the presence of a sweet spot located within the supero-lateral STN and extending to the adjacent white matter [1)].

The results of a study of Zolal et al. suggested the possibility that atlas-based clustering, as well as diffusion tractography-based parcellation, can be useful in estimating the stimulation target (“sweet spot”) for Subthalamic deep brain stimulation for Parkinson's disease. Atlas-based as well as diffusion-based clustering might become a useful tool in DBS trajectory planning [2)].

Stimulation effects of 449 DBS settings in 21 PD patients were clinically and quantitatively assessed through standardized monopolar reviews and mapped into standard space. A sweet spot for best motor outcome was determined using voxelwise and nonparametric permutation statistics. Two independent cohorts were used to investigate whether stimulation overlap with the sweet spot could predict acute motor outcome (10 patients, 163 settings) and long-term overall Unified Parkinson's Disease Rating Scale Part III (UPDRS-III) improvement (63 patients).

Results: Significant clusters for suppression of rigidity and akinesia, as well as for overall motor improvement, resided around the dorsolateral border of the STN. Overlap of the volume of tissue activated with the sweet spot for overall motor improvement explained R2 = 37% of the variance in acute motor improvement, more than triple what was explained by overlap with the STN (R2 = 9%)

and its sensorimotor subpart (R2 = 10%). In the second independent cohort, sweet spot overlap explained R2 = 20% of the variance in long-term UPDRS-III improvement, which was equivalent to the variance explained by overlap with the STN (R2 = 21%) and sensorimotor STN (R2 = 19%).

Interpretation: This study is the first to predict clinical improvement of parkinsonian motor symptoms across cohorts based on local DBS effects only. The new approach revealed a distinct sweet spot for STN DBS in PD. Stimulation overlap with the sweet spot can predict short- and long-term motor outcome and may be used to guide DBS programming [3].

Based on local field potential data acquired from 54 patients undergoing STN-DBS, power values within alpha, beta, low beta, and high beta bands were calculated. Values were projected into common stereotactic space after DBS lead localization. Recorded beta power values were significantly higher at posterior and dorsal lead positions, as well as in active compared with inactive pairs. The peak of activity in the beta band was situated within the sensorimotor functional zone of the nucleus. In contrast, higher alpha activity was found in a more ventromedial region, potentially corresponding to associative or premotor functional zones of the STN. Beta- and alpha-power peaks were then used as seeds in a fiber tracking experiment. Here, the beta-site received more input from primary motor cortex whereas the alpha-site was more strongly connected to premotor and prefrontal areas. The results summarize predominant spatial locations of frequency signatures recorded in STN-DBS patients in a probabilistic fashion. The site of predominant beta-activity may serve as an electrophysiologically determined target for optimal outcome in STN-DBS for PD in the future [4].

References

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