Sweet spot for subthalamic deep brain stimulation

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.

de Roquemaurel et al. from the Unit of Functional Neurosurgery, Department of Clinical and Movement Neurosciences, UCL Queen Square Institute of Neurology and the National Hospital for Neurology and Neurosurgery, London, Neurology department, Strasbourg University Hospital, aimed at localizing the sweet spot within the subthalamic region by performing a systematic review of the literature.

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.

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).

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)].

Reliable interpretation of microelectrode recording (MER) data, used to guide DBS implantation surgery, requires expert electrophysiological evaluation. Recent efforts have endeavored to use electrophysiological signals for automatic detection of relevant brain structures and optimal implant target location.

Individual motor improvement after deep brain stimulation (DBS) of the subthalamic nucleus (STN) for Parkinson's disease (PD) varies considerably. Stereotactic targeting of the sensorimotor subthalamic nucleus (dorsolateral sensorimotor part of the STN) is considered paramount for maximising effectiveness, but studies employing the midcommissural point (MCP) as anatomical reference failed to show correlation between DBS location and motor improvement. The medial border of the STN as reference may provide better insight in the relationship between DBS location and clinical outcome.

Motor improvement after 12 months of 65 STN DBS electrodes was categorised into non-responding, responding and optimally responding body-sides. Stereotactic coordinates of optimal electrode contacts relative to both medial STN border and MCP served to define theoretic DBS 'hotspots'. RESULTS:

Using the medial STN border as reference, significant negative correlation (Pearson's correlation -0.52, P<0.01) was found between the Euclidean distance from the centre of stimulation to this DBS hotspot and motor improvement. This hotspot was located at 2.8 mm lateral, 1.7 mm anterior and 2.5 mm superior relative to the medial STN border. Using MCP as reference, no correlation was found. CONCLUSION:

The medial STN border proved superior compared with MCP as anatomical reference for correlation of DBS location and motor improvement, and enabled defining an optimal DBS location within the nucleus. We therefore propose the medial STN border as a better individual reference point than the currently used MCP on preoperative stereotactic imaging, in order to obtain optimal and thus less variable motor improvement for individual patients with PD following STN DBS [2)].

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 STN-DBS in PD patients. Atlas-based as well as diffusion-based clustering might become a useful tool in DBS trajectory planning [3)].

1)
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2)
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