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Learning from the Past: Probabilistic Deep Brain Stimulation Atlas Based on Intra-Operative Data

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The study describes a method to set up disease specific deep brain stimulation (DBS) atlases based on intra-operative stimulation test data exemplified with data from 6 essential tremor (ET) patients implanted in the ventrointermediate nucleus of the thalamus (Vim).

I. INTRODUCTION DBS consists in delivering electric stimulation to the brain structures responsible for movement regulation using multi-contact electrodes in order to control symptoms of movement disorders. To ensure proper placement of the electrode during surgery, awake intra-operative testing of symptoms is common. Normative analysis methods have been applied by other groups [1] to study the mechanisms of action of DBS, but focus on stimulation settings and longterm symptoms and rarely study ET. In comparison, intra-operative tests during awake surgery produce a large amount of exploration data. We present in this paper the group analysis of intra-operative stimulation test data in patients who received DBS for ET.

II. METHOD A group specific anatomical template was created based on WAIR (white matter attenuated inversion recovery) and T1 MR (magnetic resonance) images from 19 bilaterally implanted DBS patients (PD:13, ET:6). Deep brain structures manually delineated by the neurosurgeon were projected to and summarized in the template. The distribution of the electric field (EF) was resolved for the ET patients for each position and amplitude evaluated during surgery. In each voxel, tremor improvement and EF norm were used to discriminate voxels with scores significantly above or below average using one-sampled two-sided t-test.

III. RESULTS The stimulation atlas describes the efficacy of DBS by combining the probabilistic anatomical template, outlines of deep brain structures and improvement scores. IVoxels associated for improvement above average concentrate in the Posterior subthalamic area (infero-posterior to Vim) extending in the direction of Zi and along the posterior limit of Vim. Voxels significant for improvement below average concentrate in the anterior and posterior limits of the region of interest.

IV. DISCUSSION This study underlines the potential of the high quality data collected during surgery for the analysis of the mechanisms of action of DBS in tremor using state-of-the art group-analysis approaches. The low number of patients is compensated by the high number of tests in each patient, allowing to identify significant improvement regions. The next steps are the integration of more patients and investigation in different statistics approaches to capture and quantify reliability of the results.

Keywords: Deep Brain Stimulation; Probabilistic Stimulation Atlas; Essential Tremor; Intra-operative Stimulation; Vim

Topics: Multimodal imaging and analysis