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Learning more about the optimal anatomical position for deep brain stimulation in essential tremor patients: 3d visualisation of intraoperative stimulation test results

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Abstract:

Introduction: The outcome of deep brain stimulation (DBS) depends heavily on the position of the implanted lead. After a preoperative anatomical planning, most groups collect numerous intraoperative data such as therapeutic effects induced by stimulation tests. To choose the final implant position, physicians “mentally” visualise all available data. The aim of the present work was to develop a method visualising intraoperative stimulation test results, patient’s images, electric field (EF) simulations for the patient-specific stimulation conditions and the corresponding therapeutic effects quantitatively evaluated by accelerometry. The application to five essential tremor (ET) patients should give a first idea about the optimal target position.

Methods: In Clermont-Ferrand University Hospital the anatomic target structure and the neighbouring structures were manually outlined, a target and a trajectory defined and two parallel trajectories per hemisphere intraoperatively evaluated. Stimulation tests were performed at 7 to 8 positions per trajectory and several stimulation current amplitudes. The therapeutic effect was evaluated using a previously published method based on accelerometry. Finite element models and simulations were performed for up to three stimulation amplitudes per position and EF isosurfaces (0.2V/mm) were extracted. For the 3D visualization of the numerous overlapping isosurfaces, we generated “improvement maps” by assigning to each voxel within the isosurfaces the highest tremor improvement. Those maps were visualized together with anatomical images, delineated structures and trajectories (Paraview, Kitware Inc). The method was applied to 5 ET patients implanted in the ventro-intermediate nucleus of the thalamus (VIM). Results were analysed by the neurosurgeon regarding the optimal implant position. Results: The clinical teams were able to identify the optimal implant position for all patients with more ease and in less time compared to the routine discussion using pen and paper. Additionally, for 7 of the 9 improvement maps, the highest improvement region was found to be in the posterior subthalamic area, inferior and posterior to the VIM.

Conclusion: Improvement maps assist the clinicians in determining the optimal implant location of the chronic DBS lead. Results support findings of other studies that the fibre tracts in the posterior subthalamic area like prelemniscal radiations may be responsible for alleviating tremor in ET patients.