An Automated Targeting System for Subthalamic Nucleus Deep Brain Stimulation

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Introduction

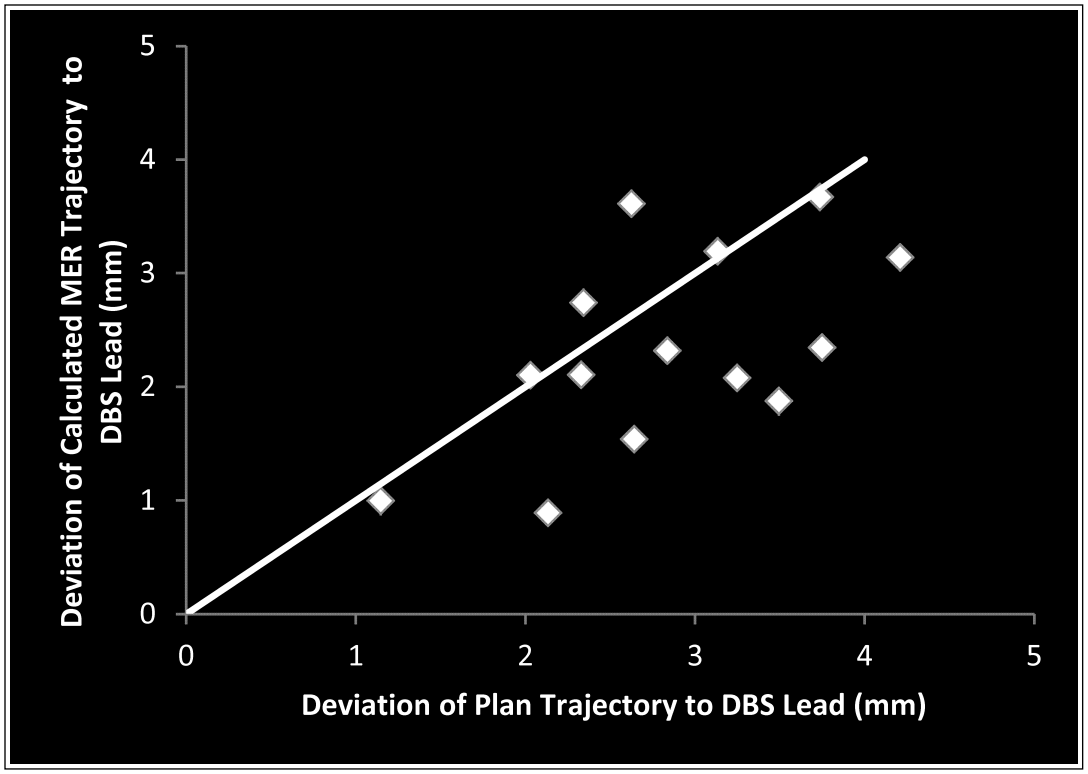
Accurate localization of the subthalamic nucleus (STN) is critical to the success of deep brain stimulation (DBS) surgery for Parkinson disease. Frame inaccuracies, imaging resolution, and target uncertainties can make STN DBS surgery a challenging procedure, even for specialty trained neurosurgeons.Our objective is to develop a novel method for automatically identifying the location of microelectrode trajectories on magnetic resonance (MR) images based on the relationship between voxel intensities and the high frequency band (HFB) signal from microelectrode recordings (MER).

Methods

We evaluated HFB power changes along 20 MER trajectories in 13 patients. We also found voxel intensity values from 3-T MRI along the preoperatively planned trajectory and the implanted DBS lead trajectory. We compared and scored over 100,000 potential voxel -based trajectories for each MER pass to identify trajectories that best matched the MER data. Top scoring voxel trajectories were averaged to produce best estimates and d
distances to actual DBS leads were compared to that of planned trajectories.

Results

Targeting certainty was improved in over 70% of evaluated trajectories. The averaged MER trajectory distance (2.33mm ± 0.2mm) was significantly closer than the planned trajectory distance (2.83mm ± 0.2mm) to the DBS electrode final position (P = 0.01, see figure). In trajectories that initially missed the STN, subsequent trajectory adjustments were predicted with 100% accuracy in the direction shifted by the attending neurosurgeon.



Conclusions

The location of DBS leads can be better estimated using this method by evaluating the position of a MER trajectory in the STN intra-operatively. This method may also reduce surgical procedure durations and errors associated with classic neurophysiological analysis by automating the analysis of both imaging and electrophysiology data.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) Describe the challenges of targeting the STN in DBS, 2) Describe how the process of intraoperative MER mapping may be automated using a computer algorithm