A Semi-automated Software for Estimating Subthalamic Nucleus Boundaries and Assisting Optimal Target Selection for Deep Brain Stimulation Implantation Surgery

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INTRODUCTION

Deep brain stimulation (DBS) of the subthalamic nucleus (STN) has become standard of care for the treatment of Parkinson's disease. Reliable interpretation of microelectrode recording (MER) data, used to guide DBS implantation surgery, requires expert electrophysiological evaluation. We have developed a software package, implemented on an electrophysiological recording system, to provide online objective estimates for entry into, and exit from, STN. In addition, the electrode track selected for DBS implantation into STN can be determined through this software's ability to detect changes in beta-spectrum activity.

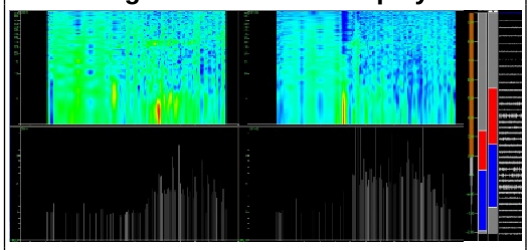
METHODS

We retrospectively collected data from 15 MER-guided STN-DBS surgeries (4 experienced neurosurgeons; 3 sites); estimates for entry into and exit from STN, and DBS track selection, were compared between those determined by the software, and those by the implanting neurosurgeon.

HaGuide Tool

A real time process to accurately detect the STN during surgery based on microelectrode recording (RMS and Beta Oscillation) and Hidden Markov Model (HMM). Root mean square (RMS) and power spectrum density (PSD) of the MERs were used to train and test the HMM in identifying the dorsolateral oscillatory region (DLOR) ventro-medial non-oscillatory region (VMNR) within the STN.

Figure 1: HaGuide display

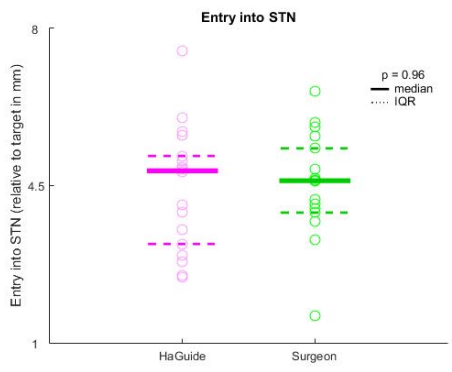


Power spectrum densities and RMS graphs

RESULTS

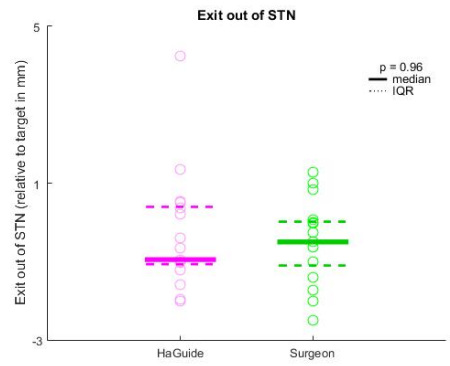
Comparison of the absolute difference between software and neurosurgeon differed by 0.76 mm (median; IQR = 1.10) for STN entry, and 0.86 mm (median; IQR = 1.20) for STN exit. Agreement between software and neurosurgeon for implanted track was 93% (14 of 15 surgeries).

Figure 2: Comparison of estimations for entry into STN



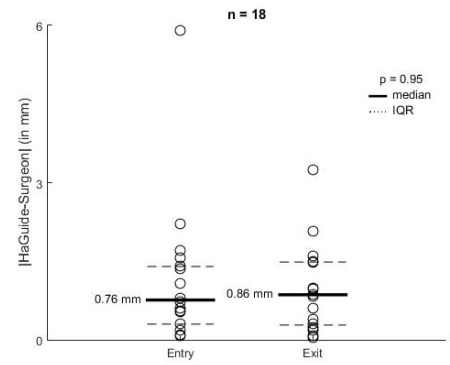
Across 18 microelectrode recordings, HaGuide estimation of entry into STN was not statistically different from surgeon estimation (p = 0.96).

Figure 3: Comparison of estimations for exit out of STN



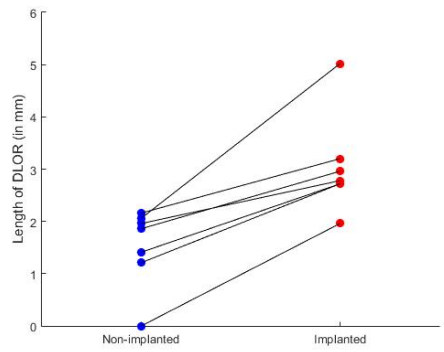
Across 18 microelectrode recordings, HaGuide estimation of exit from STN was not statistically different from surgeon estimation (Wilcoxon rank-sum; p = 0.96).

Figure 4: Absolute difference in estimation (entry and exit)



The absolute difference was computed for both entry and exit into STN. In both cases, the difference was less than 1mm (mean entry difference = 0.76mm; mean exit difference = 0.86 mm). Estimated accuracy was not statistically different between the entry and exit (Wilcoxon rank-sum; p = 0.95)

Figure 5: DLOR length predicts implanted track



HaGuide-estimated extent of DLOR region within STN predicted the track ultimately selected for DBS implant (paired t-test; p = 0.0015; data from 6/15 cases).

Conclusions

These data demonstrate that the software can reliably and accurately estimate entry into and exit from STN, and select the track corresponding to ultimate DBS implantation.

References

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