Optimization of 1.5 T fMRI Imaging during Deep Brain Stimulation detects activation in motor and non-motor circuitry

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Introduction

Intraoperative fMRI is potentially a powerful technique to visualize global circuitry modulation by Deep Brain Stimulation (DBS), but human studies have been plagued by concerns over the safety of fMRI in patients with implanted devices. We describe a safe and effective methodology to perform 1.5T intraoperative fMRI during DBS in the largest series of patients reported to date. Using this methodology, we test the hypothesis that DBS to movement disorder targets (subthalamic nucleus-STN, globus pallidus interna-GPi, and ventral intermediate thalamus-VIM) leads to differential areas of blood oxygen level dependent (BOLD) signal activation.

Methods

Eight patients (n=4 STN for Parkinson's disease, n=2 VIM for Essential Tremor, and n=2 GPi for dystonia) underwent intraoperative 1.5T fMRI during block design stimulation delivered via an external pulse generator. All pulse sequences used in the study were first extensively safety-tested in an anthropomorphic phantom.

Results

DBS to VIM and GPi resulted in activation of motor circuitry, with VIM DBS activating primary motor cortex and GPi DBS activating putamen, substantia nigra, and subthalamic nucleus. In contrast, DBS to STN for PD resulted in activation of both motor and non-motor circuitry, including premotor and supplementary motor cortices, thalamus, and limbic circuitry, including cingulate and insula.

Conclusions

1.5T fMRI can safely and reproducibly detect global circuitry modulation in patients during DBS. DBS to different targets for movement disorders resulted in distinct patterns of motor and non-motor circuitry activation which may underlie the therapeutic effects and side effects.

Learning Objectives

Overall, this study describes the development of a safe and effective intraoperative fMRI setup using 1.5T MRI in patients with implanted electrodes, which has the potential to provide insight into the therapeutic outcome and/or adverse effects of DBS by various brain targets.

References