

17T MRI in DBS: Using High Resolution Tractography to Validate 3T MRI Atlas Guided Targeting

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Introduction

Pre-operative planning for DBS electrode implantation varies widely. We obtain a T1 inverted sequence on a 3T MR scanner to define and target STN, GPi, or VIM. A deformable atlas is applied to demarcate the target structures. We imaged post-mortem brains with DBS leads using a 17T MRI to validate that the structures on our transformed 3T atlas were those we perceived them to be. Furthermore, we performed tractography at 17T to elucidate the volume of tissue activation with micron resolution.

Methods

Post-mortem brain specimens from patients who had been implanted with DBS for PD were obtained. The specimens underwent formalin fixation within 24 hours after subject expiration. 3T MR sequences were obtained and an anatomic atlas was applied per our standard planning technique. The brains were sectioned and the area of interest around the DBS electrode track was imaged with a T1 sequence using 17T MR Microscopy. 17T tractography was performed and a computational model was applied to determine the volume of tissue activation during clinical stimulation.

Results

Five patients with bilateral STN DBS for PD underwent post-mortem imaging. Fusion of the 3T sequences with the anatomic atlas overlay to the 17T sequence confirmed that basal ganglia structures demarcated on the atlas corresponded with those visualized on the 17T MR microscopy. 17T tractography demonstrated tissue activation within and in some cases around the surrounding target structure.

Conclusions

We developed a novel method of targeting utilizing an inverted T1 3T MRI. We obtained post-mortem 17T MR confirming DBS lead placement within structures delineated on our 3T atlas. High resolution tractography confirms volume of tissue activation within and surrounding the targeted structure. This work supports our use of 3T imaging and an atlas matching technique to define the STN, GPi and VIM and achieve precise and accurate placement of the DBS lead.



3T and 17T representative axial image demonstrating subthalamus, internal capsule, red nucleus and DBS lead.



17T sagittal image demonstrating regions of interest (green – zona incerta; orange – STN; purple – SNR; red – red nucleus; blue – internal capsule; yellow – optic tract)



Volume of tissue activation

Top: Thalamus and its projections (left: sagittal, right: coronal) with superimposed DBS lead and region of activation (orange sphere)

Bottom: Subthalamic nucleus and its projections (left: sagittal, right: coronal) with superimposed DBS lead and region of activation (orange sphere). A (anterior), P (posterior), S (superior), I (inferior), M (medial), L (lateral)