Personalization of Deep Brain Stimulation Surgery Pre-Operational Planning: Integration of 7-Tesla MRI Segmentations Into 3-D Brain Visualization Platform

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Deep Brain Stimulation (DBS) Surgery is a procedure that involves implanting electrodes that send electrical impulses to target brain regions to disrupt abnormal patterns of neural activity and treats conditions such as Parkinson's disease and essential tremor. Due to the invasive nature of DBS, pre-operational planning is critical to ensure precise electrode implantation and minimize surgical implications. Planning often relies on a brain atlas, a general 3-D brain structure model; however, the atlas fails to address patient-specific structural dimensions and is seen as one of the causes of unsuccessful brain surgeries. In this study, as an alternative to the brain atlas, a personalized 3-D brain model was constructed using the patient's MRI scans and integrated into the Lead-OR, a multi-model visualization platform for DBS planning. Ultra-high-resolution MRI images scanned with a 7-Tesla MRI system were used to achieve accurate 3-D mapping of brain segmentations. Further, the variance between segmentations of patients (PD091 and PD104) and three brain atlases available on the Lead-OR platform (DISTAL, Wang, Middlebrooks) were compared. Segmentation-Atlas Variance (SAV) score was newly defined in the study to provide normalized overall deviation. Results showed that the DISTAL atlas had similar dimensions to the Middlebrooks atlas with a low SAV score of 0.082, while the Wang atlas had significantly different dimensions from Middlebrooks with a high SAV score of 0.252. PD091 and PD104 had noticeable deviations from Middlebrooks, with SAV scores of 0.148 and 0.147, respectively. These findings illustrate the benefit of using personalized brain models for pre-operational planning, potentially improving electrode placement accuracy and the success rate of DBS surgery.