

Coronal Flair Magnetic Resonance Imaging for Delineation of the Subthalamic Nucleus: Validation with Intraoperative Microelectrode Recordings

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Abstract

Introduction: Accurate delineation of the dorsal and ventral borders of the subthalamic nucleus (STN) is critical for optimal deep brain stimulation (DBS) electrode placement in Parkinson's disease. Although magnetic resonance imaging (MRI)-based targeting is widely employed, correlation of STN borders identified on coronal FLAIR MRI with intraoperative microelectrode recordings (MER) has not been previously validated. The objective is to determine whether the dorsal and ventral borders of the STN identified on coronal FLAIR MRI correspond spatially with electrophysiological boundaries defined by MER.

Method: We retrospectively analyzed 30 STN trajectories from 15 patients undergoing bilateral STN-DBS. Coronal FLAIR MRI was used to identify the dorsal and ventral borders of the hypointense STN, distinguished from the substantia nigra (SN) by a characteristic hypointense reentrant signal. These anatomical landmarks were compared with the onset and offset of neuronal activity determined intraoperatively by MER. Statistical analysis included descriptive measures (mean $\pm$ SD), Shapiro–Wilk test for normality, and Pearson correlation coefficients. Statistical significance was set at $p < 0.05$.

Results: There was strong anatomical concordance between the dorsal FLAIR-defined border and MER onset, as well as between the ventral hypointense reentrant separating the STN from the SN and MER termination. The mean FLAIR-defined STN length was 5.92 ± 0.98 mm, compared to 5.42 ± 1.04 mm defined by MER. A significant positive correlation was found between FLAIR- and MER-defined lengths ($r = 0.435$, $p = 0.016$). The mean dorsal delta was 0.22 ± 1.13 mm and the ventral delta was -0.29 ± 0.85 mm. Table 1 summarizes the statistical results. Figure 1 illustrates the multimodal integration of FLAIR-based landmarks, MER, stereotactic planning, and postoperative reconstruction.

Discussion: The use of FLAIR (Fluid-Attenuated Inversion Recovery) sequences has emerged as a critical advancement in DBS targeting, particularly for subthalamic nucleus vi-

FLAIR signal length	5.92 ± 0.98	5.56 - 6.28	-
MER length	5.42 ± 1.04	5.03 - 5.81	-
FLAIR-MER correlation	$r = 0.435$	0.08 - 0.69	0.016*
Delta dorsal	0.22 ± 1.13	-0.20 - 0.64	293
Delta ventral	-0.29 ± 0.85	-0.61 - 0.03	76

Table 1. Summary of statistical results.

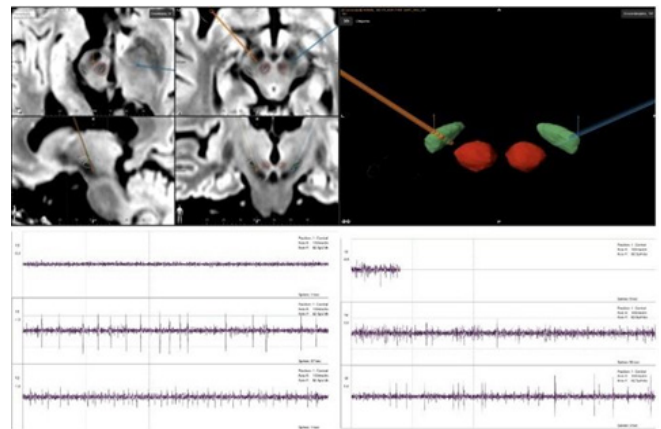


Figure 1. Illustrates the multimodal integration of FLAIR-based landmarks, MER, stereotactic planning, and postoperative reconstruction.

ualization. FLAIR sequences offer superior contrast and reduced artifacts compared to conventional T2-weighted imaging. Three-dimensional SPACE FLAIR at 3T represents a significant advancement in STN visualization. This technique demonstrated superior clinical outcomes with 62.2% improvement in UPDRS scores compared to 43.6% with conventional T2-weighted Imaging. This method demonstrated 93% agreement with microelectrode recordings in contact location, according to some studies, and the correlation between imaging findings and electrophysiological recordings

provides robust validation of targeting accuracy.

Conclusions: The hypointense signal of the STN on coronal FLAIR MRI enables reliable identification of its dorsal and ventral borders. These MRI-defined boundaries show strong correlation with electrophysiological limits determined by MER, supporting the incorporation of FLAIR MRI into DBS surgical planning.

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