DiODe

Directional deep brain stimulation (DBS) allows steering the stimulation in an axial direction which offers greater flexibility in programming. However, accurate anatomical visualization of the lead orientation is required for interpreting the observed stimulation effects and to guide programming.

Hellerbach et al. aimed to develop and test an accurate and robust algorithm for determining the orientation of segmented electrodes based on standard postoperative CT imaging used in DBS.

Orientation angles of directional leads (CartesiaTM; Boston Scientific, Marlborough, MA, USA) were determined using CT imaging. Therefore, a sequential algorithm was developed that quantitatively compares the similarity of the observed CT artifacts with calculated artifact patterns based on the lead's orientation marker and a geometric model of the segmented electrodes. Measurements of seven ground truth phantoms and three leads with 60 different configurations of lead implantation and orientation angles were analyzed for validation.

The accuracy of the determined electrode orientation angles was -0.6 ± 1.5° (range: -5.4 to 4.2°). This accuracy proved to be sufficiently high to resolve even subtle differences between individual leads.

The presented algorithm is user-independent and provides highly accurate results for the orientation of the segmented electrodes for all angular constellations that typically occur in clinical cases [1].

Clinical records of 187 patients with directional DBS electrodes were screened for CT scans in addition to the routine postoperative CT. The orientation angle of each electrode at a specific point in time was reconstructed from CT artifacts using the DiODe algorithm implemented in Lead-DBS. The orientation angles over time were compared with the originally measured orientations from the routine postoperative CT.

Multiple CT scans were identified in 18 patients and the constancy of the orientation angle was determined for 29 leads at 48 points in time. The median time difference between the observations and the routine postoperative CT scan was 82 (range 1-811) days. The mean difference of the orientation angles compared to the initial measurement was -1.1 ± 3.9° (range -7.6 to 8.7°). Linear regression showed no relevant drift of the absolute value of the orientation angle over time (0.8°/year, adjusted R2: 0.040, p = 0.093).

The orientation of directional leads was stable and showed no clinically relevant changes either in the first weeks after implantation or over longer periods of time [2].

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1)
Hellerbach A, Dembek TA, Hoevels M, Holz JA, Gierich A, Luyken K, Barbe MT, Wirths J, Visser-Vandewalle V, Treuer H. DiODe: Directional Orientation Detection of Segmented Deep Brain Stimulation Leads: A Sequential Algorithm Based on CT Imaging. Stereotact Funct Neurosurg. 2018;96(5):335-341. doi: 10.1159/000494738. Epub 2018 Nov 27. PMID: 30481772.
2)
Dembek TA, Asendorf AL, Wirths J, Barbe MT, Visser-Vandewalle V, Treuer H. Temporal Stability of Lead Orientation in Directional Deep Brain Stimulation. Stereotact Funct Neurosurg. 2020 Oct 13:1-4.

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