Deep Brain Stimulation of the Dentato-Rubro-Thalamic tract: Outcomes of Direct Targeting for Tremor

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Introduction

New targets for Deep Brain Stimulation (DBS) for tremor control have recently gained popularity. Modulation of the cerebello-thalamo-cortical circuit via the dentato-rubro-thalamic tract (DRTt) has been recognized as effective for tremor suppression (3,4). Our prospective observational study analyzed outcomes after using direct targeting of the DRTt.

Methods

20 consecutively enrolled intention tremor patients obtained pre-operative 3T MRI with diffusion tensor (dTi) sequences. The DRTt was drawn for each individual patient on StealthViz dTi software (Medtronic) using the dentate nucleus as the seed region and the ipsilateral pre-central gyrus as the end region (3), which was then directly targeted during DBS surgery. Intraoperative testing confirmed successful tremor control. Post-operative analysis of electrode contact position as seen on CT relative to the DRTt was performed and Euclidean distance calculated from the therapeutic contact.

Table 1: Electrode Contact Parmeters and Position

	N	Mean frequency (Hz) (SD, range)	Mean Voltage L cathode (SD, range)	Mean L contact Pulse Width (µs) (SD, range)	Mean distance L active contact (mm) to DRTt (SD)	Mean Voltage R cathode (SD, range)	Mean R contact Pulse Width (µs) (SD, range)	Mean distance R active contact (mm) to DRTt (SD)
Patients	20	158 (24, 135-200	3.4 (1.3, 1.7-7.0)	88 (36.5, 60-180)	0.9 (1.1, 0-2.5)	2.6 (1.4, 0.5-6.9)	80 (25, 60-150)	0.8 (0.8, 0-2.5)

The volume of tissue activated (VTA) was estimated using therapeutic parameters and an isotropic model (2).

Results

The mean age of patients was 65.3 years; mean duration of tremor was 12.6 years. Most patients (95%) had distal upper extremity tremor; 1 patient (5%) had proximal bilateral upper extremity tremor. Head tremor was seen in 7/20 (35%). Mean voltage for the L electrode = 3.35 V; R = 2.6 V. Mean distance from the center of the active EC to the DRTt was 0.90 mm on the L, and 0.82 mm on the R. 38 of 38 (100%) depicted and targeted DRTts lay within the estimated VTA for each individual therapeutic contact. Overall, there was 90% tremor control. All patients self-reported improved quality of life.

Table 2: Comparison between Coordinates from Direct and Indirect targeting

Number of Patients (N)	Mean ACPC length (mm) (SD, range)	Mean 3V width (mm) (SD, range)	Mean (X,Y,Z)* (SD) target coordinates (directly targeting DRTt)		Mean (X,Y,Z)* (SD) coordinates of therapeutic contact (SD)		Mean (X,Y,Z)** (SD) coordinates, calculated using formula from Benabid et al.[1]: X: 11.5 mm from 3V Y: ACPC/12 x 2.5 mm ant. to PC Z: 0 mm from MCP	Mean (X,Y,Z)** (SD) coordinates, calculated using formula from Pell & Thomas (Framelink, Medtronic)[7]: X: ACPC x 0.55 mm from midline Y: ACPC/4 mm post. to MCP Z: 0 mm from MCP	Mean (X,Y,Z)** (SD) coordinates, calculated using Papavassiliou et al.[6]: X: 10 mm from 3V Y: 6 mm ant. to PC Z: 0 mm from MCP
			Left	Right	Left	Right			
20	25.0 (1.6, 22.3-28.0)	6.4 (2.5, 2.0-11.5)	X: 12.7 (1.5)	X: 12.7 (1.6)	X: 13.5 (1.8)	X: 13.5 (1.8)	X: 14.7 (1.3) ***	X: 13.8 (0.9)	X: 13.2 (1.3)
			Y: -8.2 (1.3)	Y: -7.4 (1.6)	Y: -6.3 (1.6)	Y: -5.8 (1.6)	Y: -7.3 (0.5) ***	Y: -6.3 (0.4)	Y: -6.5 (0.8)
			Z: -0.9 (0.5)	Z: -1.2 (0.5)	Z: 2.9 (2.7)	Z: 1.7 (2.5)	Z: 0 (0.0)	Z: 0 (0.0)	Z: 0 (0.0)

* relative to ACPC midpoint and mid-commisural plane (MCP); ** adapted coordinates relative to ACPC midpoint; *** statistically significantly different to mean coordinates of therapeutic contact ($p<0.05$, t-test); 3V = 3rd ventricle; ACPC = anterior commissure-posterior commissure distance; PC = posterior commissure

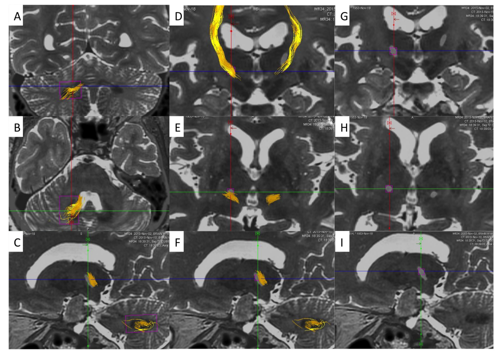

Figure 1: (A,B,C): Depiction of the seed ROI in the cerebellar deep nuclei used to construct the left DRTt (purple box) using StealthViz software, in three planes, with end ROI in the precentral gyrus (3). (D,E,F): Bilateral depiction of the DRTt. (G,H,I): Depiction of estimated VTA (2) from the left active electrode contact (crosshairs) using therapeutic parameters, drawn as a 2-D area.

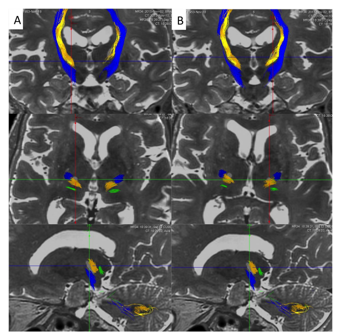

Figure 2: Illustration of the DRTt (yellow) relative to the corticospinal tract (blue), medial lemniscus (green) and implanted DBS electrodes and therapeutic contacts (crosshairs).

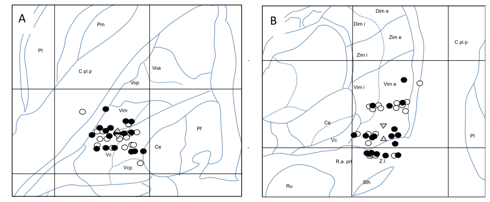

Figure 3: Location of the left (white) and right (black) active cathodal contact in the 20 patients series transposed onto a brain atlas (8). Mean positions of left (triangle apex down) and right (apex up) contacts shown. Axial (A) adapted from plate LXXVIII, h.d. 1.5; coronal (B) adapted from plate LXVIII, f.p. 7.0.

Conclusions

Direct targeting of the DRTt is effective in tremor suppression. Accounting for both model and software limitations, electrode placement directly affecting these fiber tracts reproducibly resulted in tremor control, and is our preferred targeting strategy.

References

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