

Individualized targeting of subthalamic nucleus deep brain stimulation for gait disturbances in Parkinson disease

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Introduction

- Subthalamic nucleus (STN) deep brain stimulation (DBS) alleviates the motor symptoms of Parkinson disease (PD) [1]
- However, a generalized targeting approach may lead to suboptimal outcomes for patients with diverse symptoms
- Volume of tissue activation (VTA) modeling can be used to compute the spatial extent of stimulation relative to specific neural structures to assess clinical outcomes [2]
- Better outcomes for gait disturbances may be obtained by stimulating regions within or around the STN [3, 4]

Objective. Determine the optimal stimulation region within or around the STN for PD patients impacted by gait disturbances

Methods

- Retrospectively analyzed 40 PD patients with bilateral STN DBS
- Calculated the therapeutic VTA for 72 implants to quantify STN and non-STN activation in different regions
- Evaluated associations between stimulation location and improvement in gait symptoms (MDS-Unified Parkinson's Disease Rating Scale Part III, items 3.10-3.12) using stepwise regression
- Compared implants grouped by stimulation location based on symptom improvement using Kruskal-Wallis tests
- Examined electrode position (relative to the STN) for comparison

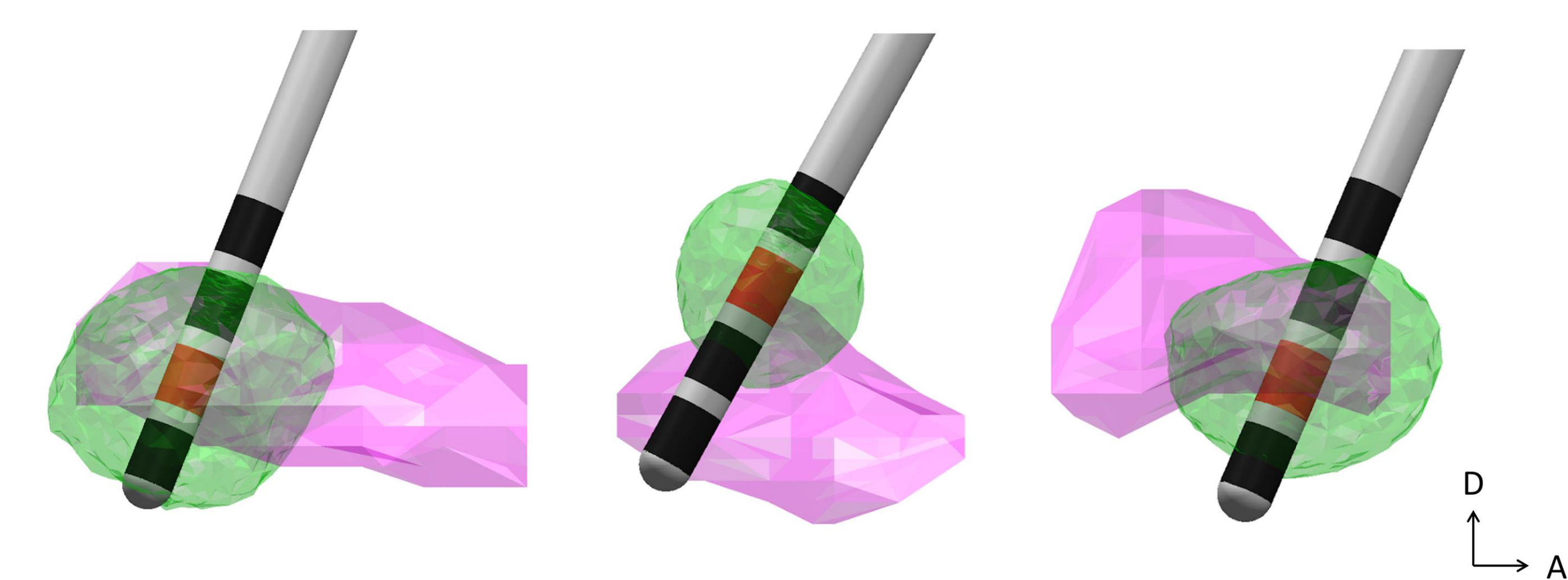


Fig. 1. Patient-specific VTA models. Sagittal view of the VTA (green) and STN (pink) boundary overlap for three implants across three patients. Variability in VTA location is highlighted by showing a majority posterior (left), majority central (center), and majority anterior VTA (right). The DBS lead is shown in gray, with the active contact in red and inactive contacts in black. VTA: volume of tissue activation; STN: subthalamic nucleus; DBS: deep brain stimulation; A: anterior; D: dorsal.

- Posterior STN points within VTA
- Anterior STN points within VTA
- Posterior STN points outside VTA
- Anterior STN points outside VTA

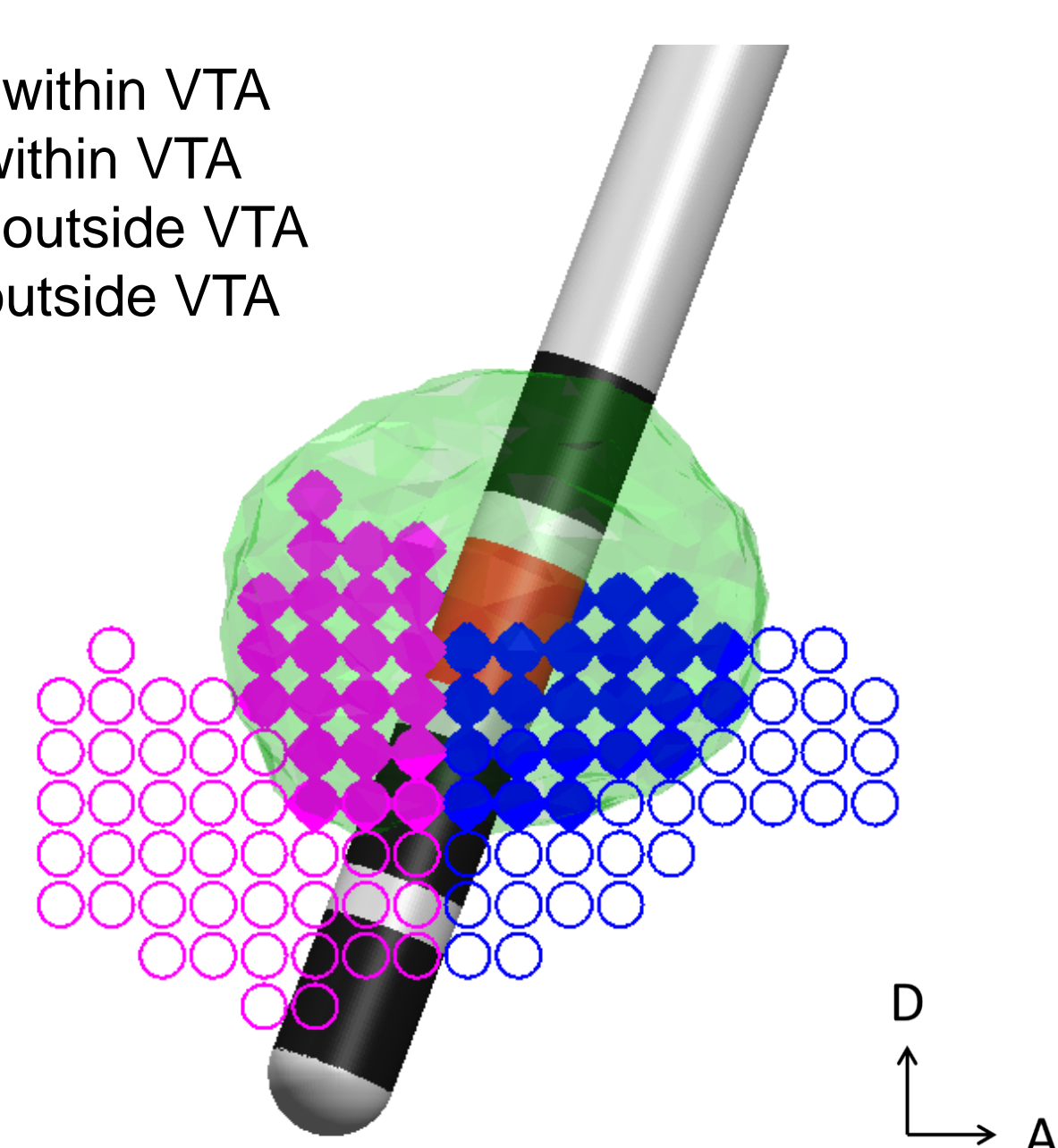


Fig. 2. VTA-STN overlap (anterior-posterior direction). Sagittal view of the VTA (green) and STN (pink and blue) overlap for one implant. Anterior and posterior STN points are shown in blue and pink, respectively. STN points within and outside the VTA are filled and open, respectively. STN activation corresponds to the overlapping green and pink/blue regions, while external activation corresponds to the non-overlapping green region. The DBS lead is shown in gray, with the active contact in red and inactive contacts in black. VTA: volume of tissue activation; STN: subthalamic nucleus; A: anterior; D: dorsal.

Results

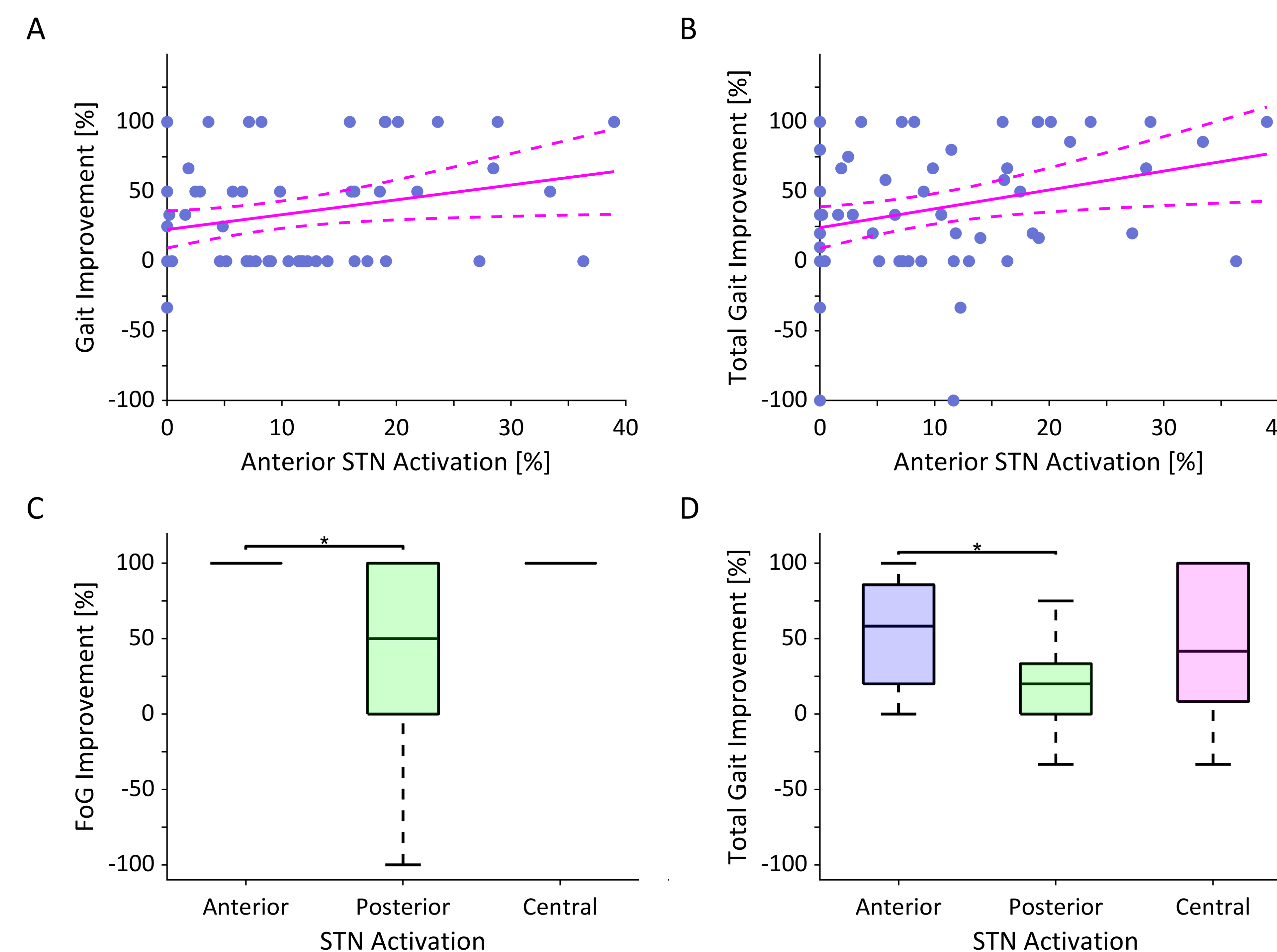


Fig. 3. STN activation. (A) Relationship between anterior STN activation and gait (item 3.10) improvement. The data ($n = 67$) are shown as points and the linear fit and 95% confidence intervals are shown as solid and dashed lines, respectively. (B) Relationship between anterior STN activation and total gait (sum of items 3.10-3.12) improvement. Data ($n = 65$). (C) Comparison of majority anterior STN activation ($n = 7$) and majority posterior STN activation ($n = 8$) groups with respect to FoG (item 3.11) improvement. The central STN activation group ($n = 4$) is also shown (not considered for statistical analysis). The median and lower and upper quartiles are equal in the anterior and central groups. * $p < 0.05$. (D) Comparison of majority anterior STN activation ($n = 22$) and majority posterior STN activation ($n = 19$) groups with respect to total gait improvement. Central STN activation group ($n = 12$). STN: subthalamic nucleus; FoG: freezing of gait.

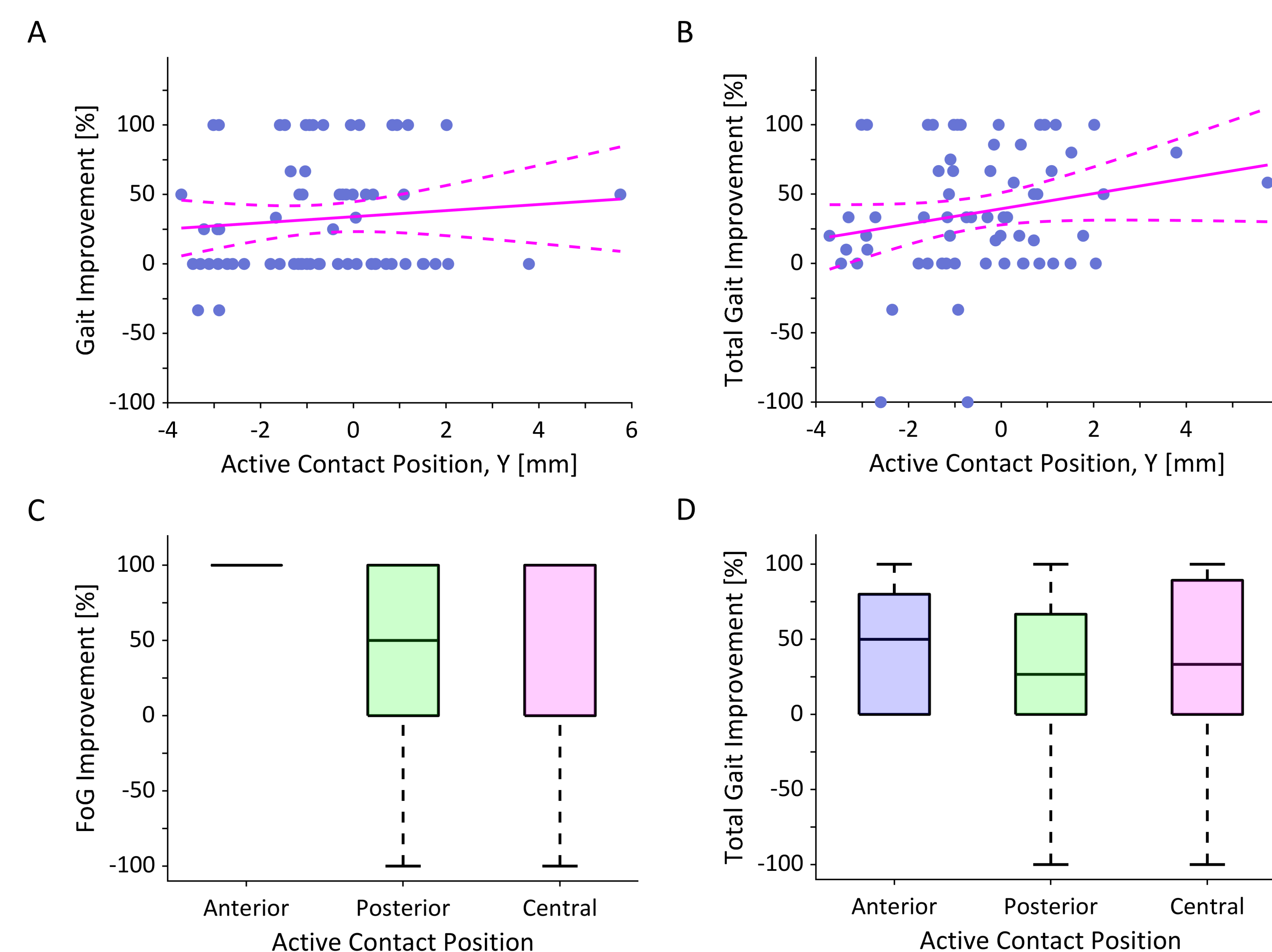


Fig. 4. Active contact position. (A) Relationship between active contact position in the y- (anterior-posterior) direction and gait (item 3.10) improvement. The data ($n = 67$) are shown as points and the linear fit and 95% confidence intervals are shown as solid and dashed lines, respectively. (B) Relationship between active contact position in the y-direction and total gait (sum of items 3.10-3.12) improvement. Data ($n = 65$). (C) Comparison of anterior active contact ($n = 8$) and posterior active contact ($n = 9$) groups with respect to FoG (item 3.11) improvement. The central active contact group ($n = 4$) is also shown (not considered for statistical analysis). The median and lower and upper quartiles are equal in the anterior group; median and upper quartile in central group. (D) Comparison of anterior active contact ($n = 25$) and posterior active contact ($n = 26$) groups with respect to total gait improvement. Central active contact group ($n = 13$). FoG: freezing of gait.

Conclusion

- Significant positive associations between anterior STN activation and gait ($p = 0.03$) and total gait improvement ($p = 0.01$)
- Significant differences in freezing of gait (FoG) ($p = 0.03$) and total gait ($p = 0.02$) when comparing majority anterior and majority posterior STN activation
- For non-STN activation, a significant positive association between anterior external activation and FoG ($p = 0.02$)
- No significant relationship between electrode position and gait symptoms
- This study demonstrates the utility of VTA modeling and highlights the importance of patient- and symptom-specific targeting

More anterior STN DBS may be preferable for patients whose primary symptoms include gait disturbances

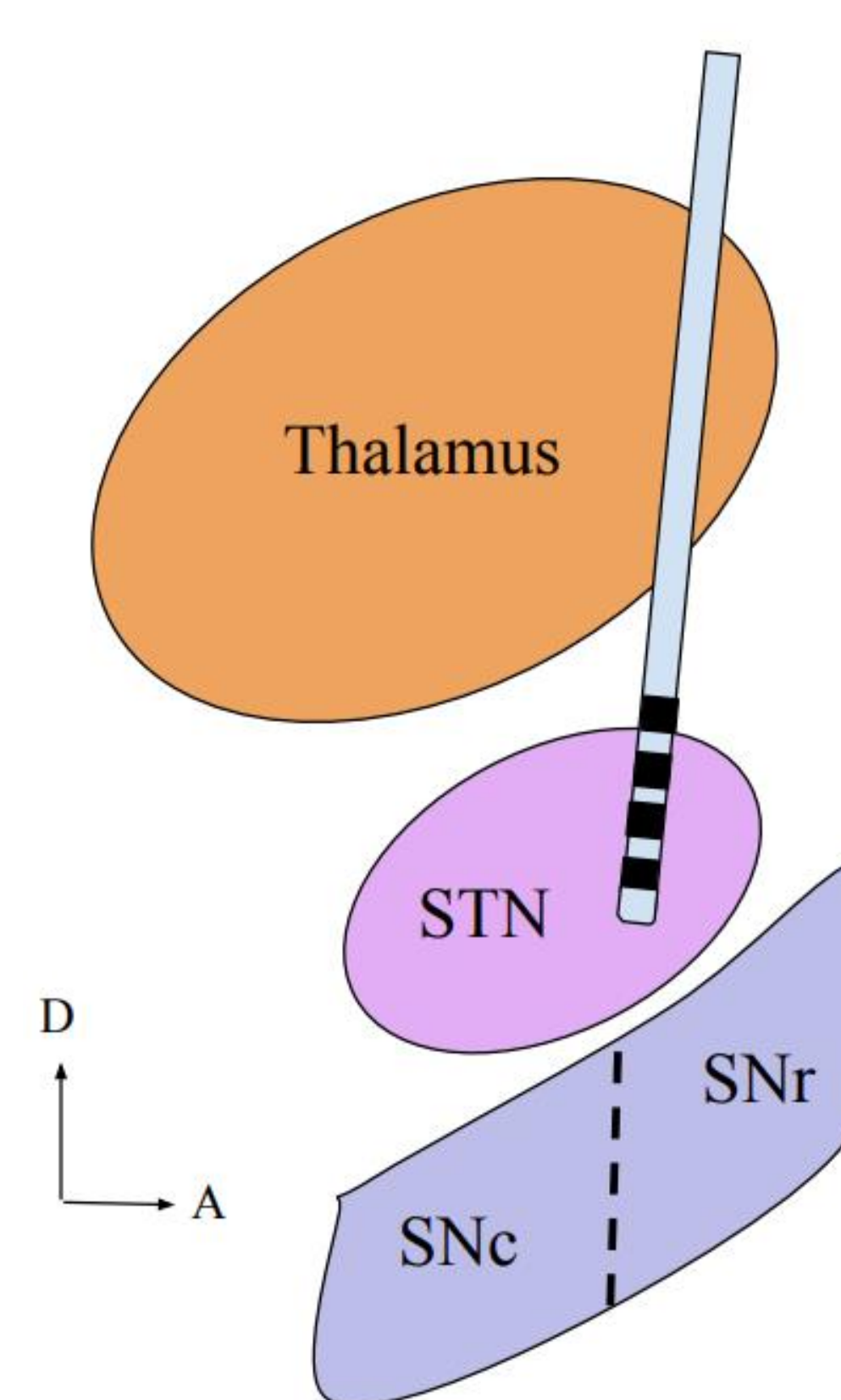


Fig. 5. STN and surrounding structures. The substantia nigra pars reticulata (SNr) may be a superior stimulation target specifically for FoG due to its proximity to the STN.

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