Follow-up Programming and Troubleshooting

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Disclosure

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Routine follow-up patients

- Checking the system
  - Impedance
  - Battery and charging
  - Usage of programs
- Identify problems with history-taking and examination
  - Adjusting medication vs. DBS parameters
  - For DBS parameters: amplitude, frequency, pulse width, contact
  - Always consider the adverse effect of DBS

Device issues

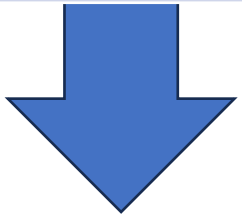
- Impedance: abrupt worsening of parkinsonian symptoms which could be unilateral or bilateral
- Battery: especially to refer to the surgeon at the right time for the battery replacement
- Charging: to confirm whether the patients charged well without any problem
- Usage of programs: to figure out which stimulation parameter is better

Routine follow-up patients

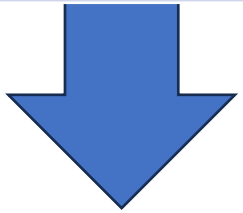
- Checking the system
  - Impedance
  - Battery and charging
  - Usage of programs
- Identify problems with history-taking and examination
  - Adjusting medication vs. DBS parameters
  - For DBS parameters: amplitude, frequency, pulse width, contact
  - Always consider the adverse effect of DBS

Identify problem

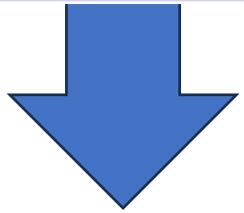
Doctor's	Patient's	Care-giver's
1. Wearing Off 2. Off freezing 3. MCI 4. Dyskinesia	1. Off pain 2. Depression 3. Constipation 4. Wearing off	1. ICD 2. Depression 3. MCI 4. Dyskinesia



Great response from DBS



Good response from DBS



Minimal response from DBS

Identify problem

- Motor symptoms
  - Appendicular sign, asymmetry
  - Axial symptoms and gait disorders
  - Fluctuations and dyskinesia
- Non-motor symptoms
  - Hypomania
  - Impulse control disorders and DDS
  - Cognitions

→ Parkinsonian symptoms (levodopa-responsive or not) vs. stimulation-induced side effects vs. unrelated symptoms

Response to Levodopa

- If the patient's problem is responsive to levodopa, increasing stimulation (usually amplitude) can be beneficial
- Also, fluctuating symptoms with medication can be better with stimulation
- Although tremor did not respond to levodopa, tremor can be better with stimulation. Especially high frequency stimulation at the dorsal contact could be helpful

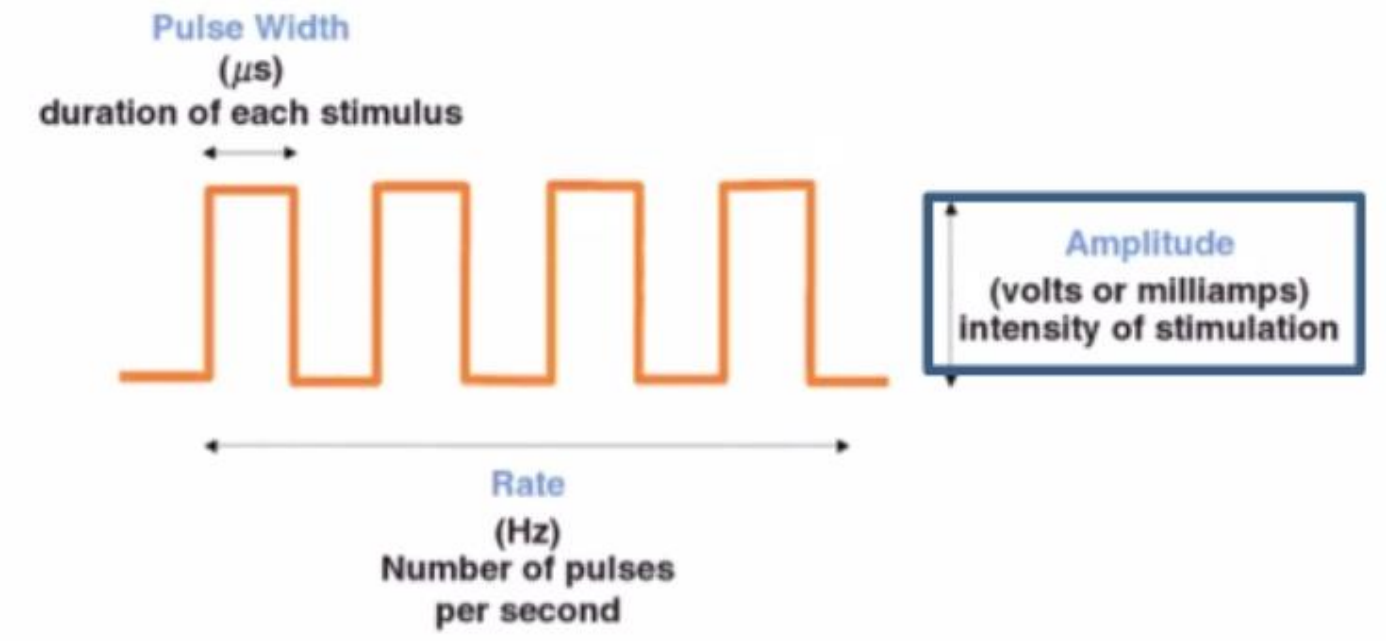
Identify problem

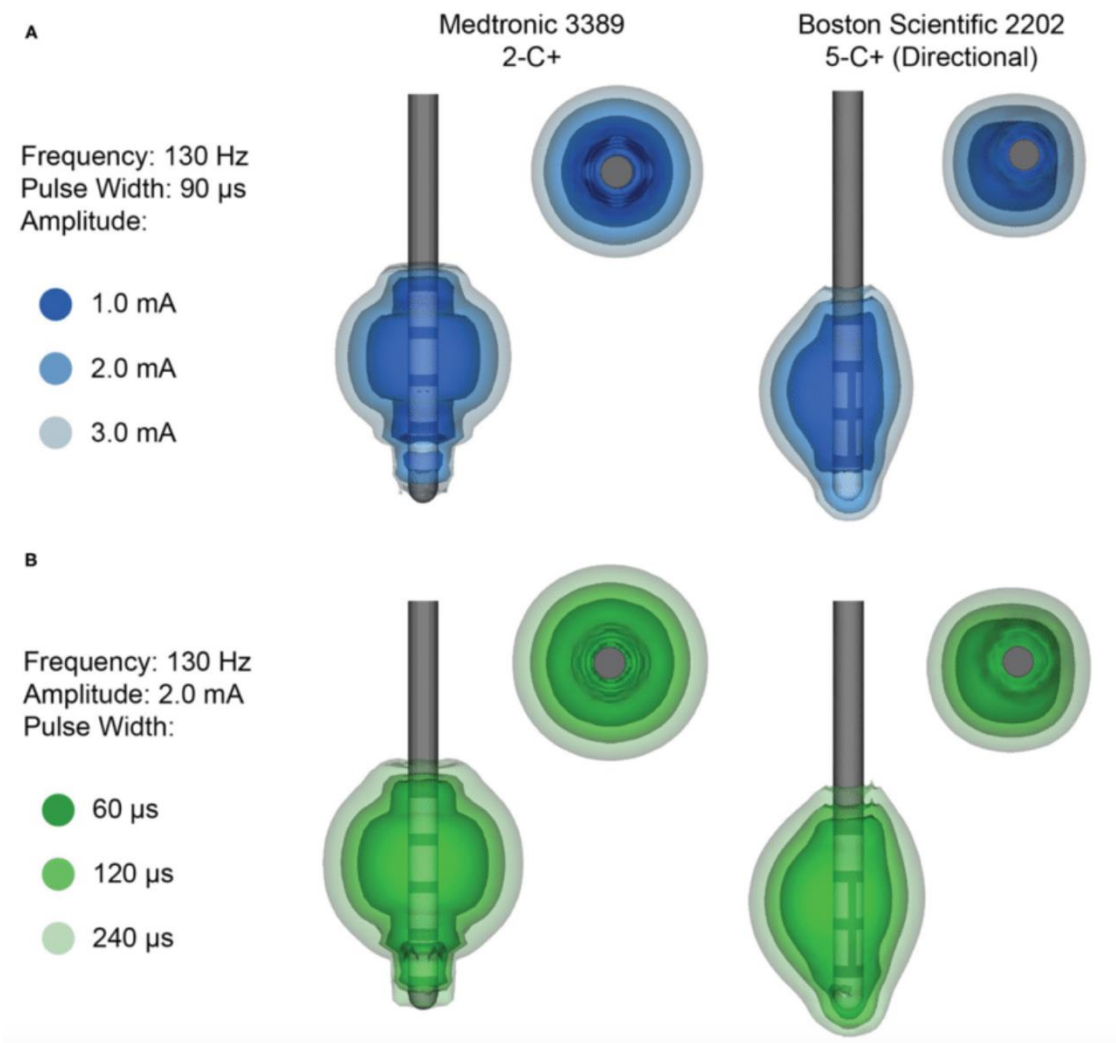
Doctor's	Patient's	Care-giver's
1. Wearing Off 2. Off freezing 3. MCI 4. Dyskinesia	1. Off pain 2. Depression 3. Constipation 4. Wearing off	1. ICD 2. Depression 3. MCI 4. Dyskinesia
Adjust DBS or medication	Adjust DBS or medication Antidepressant, laxatives	Decrease DA or other dopaminergic medication

Increasing medication vs. stimulation

- There is no absolute rule to decide increasing medication or stimulation
- For tremor, increasing stimulation can be a better option
- For fluctuation, increasing stimulation with/without decreasing medication can be better than medication adjustment
- For asymmetry, adjusting stimulation is preferred
- Decisions should be made based on age, side effects, battery consumption, ADL and QoL
- Also, the target for the stimulation amplitude or LEDD can vary depending on the patients

Adjusting stimulation





Frey J et al. 2022

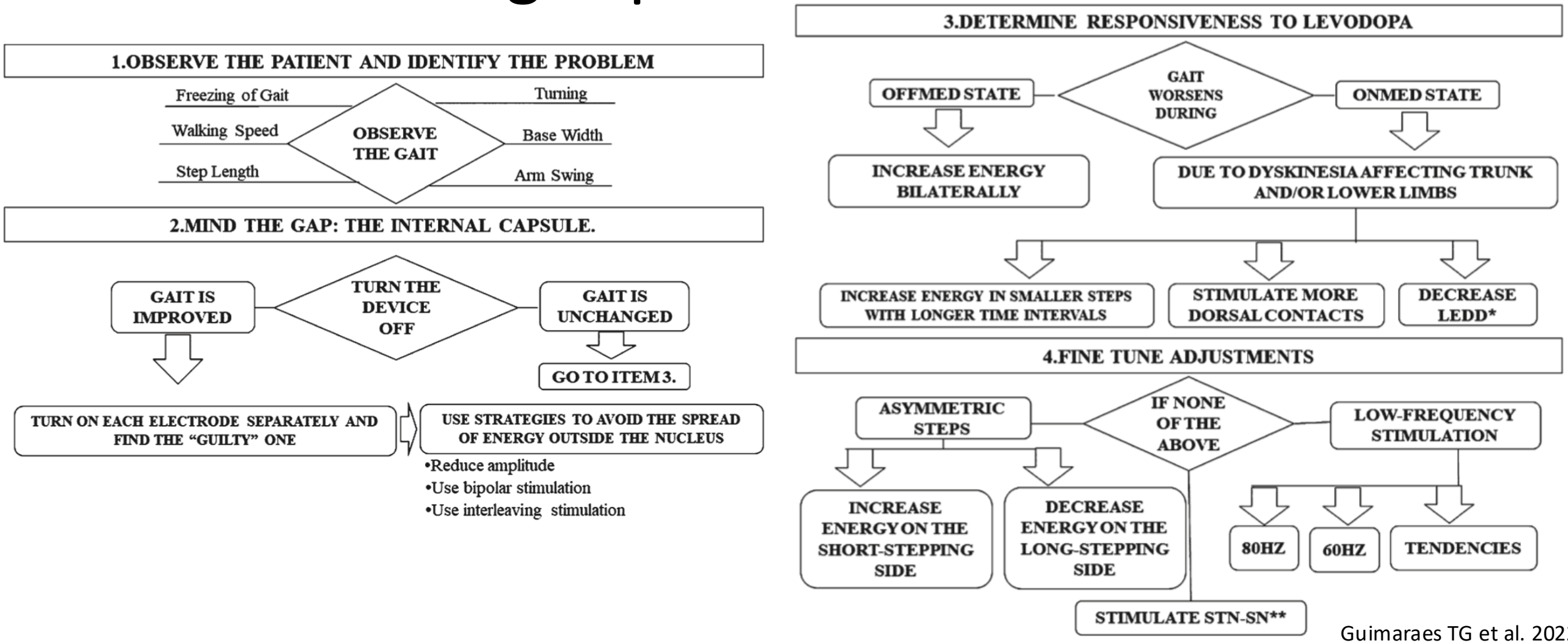
Take Home Message (follow-up patients)

- Check the device always, but especially in patients with aggravated parkinsonism
- Patient's complaints could be different from the problems from the physician's point of view
- Definite patient's complaints or problems based on motor or non-motor symptoms responsive or non-responsive to levodopa, stimulation-induced side effects and non-related symptoms to PD
- Adjust parameters amplitude > frequency > pulse width > contacts in outpatients clinic, but you can review the best contact based on image-guided program or local field potential nowadays

Troubleshooting

- Almost the same algorithm with managing follow-up patients, but more focused on dealing with chief complaints related to parkinsonian symptoms or stimulation-induced adverse effects

Lessons from gait problem after DBS



Guimaraes TG et al. 2022

Functional dystonia referred to DBS clinic

TABLE 1 *Demographics and clinical classification of FMD patients who were referred for functional neurosurgery (DBS and ablative procedures)*

Phenomenology	Functional dystonia	Functional tremor	Functional myoclonus	Functional tourettism	All phenomenologies
No. (% of referrals with similar phenomenology)	6 (9)	3 (1.8)	1 (50)	1 (17)	11 (4.7)
Total DBS referrals for similar phenomenology	67	161	2	6	236[a]
Age (y ± SD)	44 ± 16.7	61 ± 2.2	65	23	48.8 ± 17.3
Sex (F:M)	4:2	1:2	1:0	1:0	7:3
Disease duration (y ± SD)	7.8 ± 12.2	9.3 ± 7.6	2	13	8.4 ± 10.3
Diagnostic classification[b] % (n)					
• Clinically definite	50% (3)			100% (1)	36% (4)
• Clinically established plus other features	33% (2)	33% (1)			27% (3)
• Laboratory supported definite[c]	17% (1)	67% (2)	100% (1)		36% (4)

Gorodetsky C et al. 2022

Step 3. Review where we are stimulating

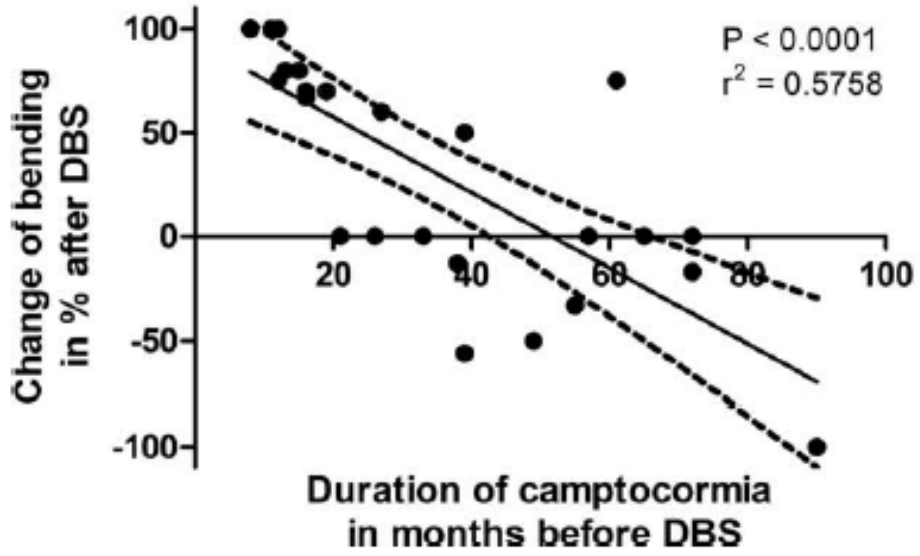
- To offer optimal spots for the stimulation, it is important to know where we are stimulating
- Directional stimulation could be useful to avoid sour spot and stimulate sweet spot

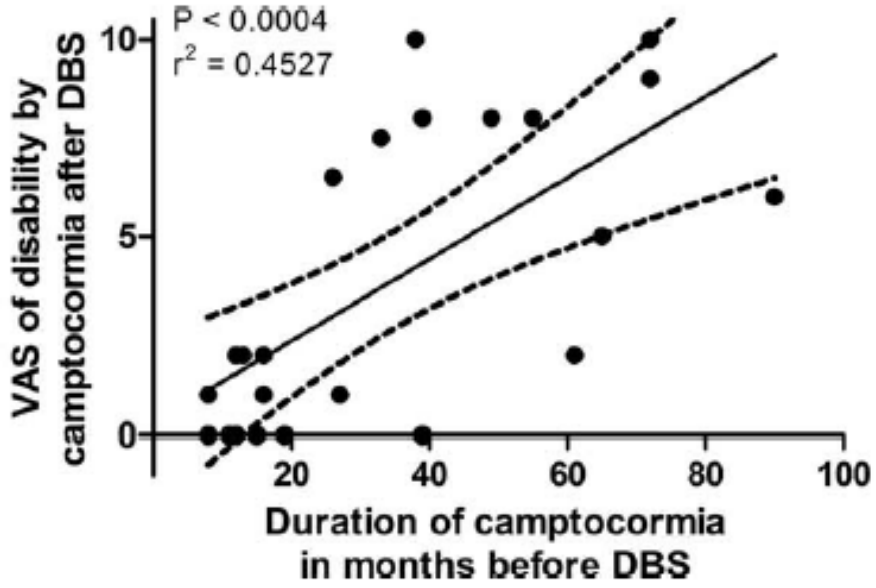
Step 4. Check response to levodopa

- When the problem responds to levodopa, there's more chance to improve with stimulation adjustment
- Also, reviewing where we stimulate is important and Image-guided programming or review of local field potential could be helpful to find the sweet spot

Response to Levodopa

- Axial symptoms, which may not respond to levodopa, usually do not improve with increasing stimulation, even with some studies reporting some benefit





Schulz-Schaeffer WJ et al. 2015

Step 5. Apply Advanced Stimulation

- When the problem responds to levodopa, there's more chance to improve with stimulation adjustment
- Also, reviewing where we stimulate is important and Image-guided programming or review of local field potential could be helpful to find the sweet spot

Low frequency stimulation

Low frequency stimulation

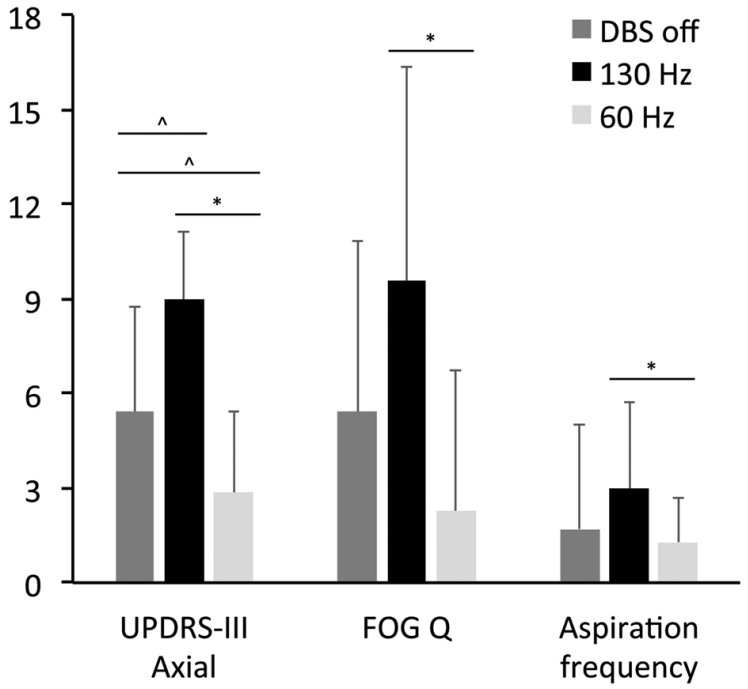
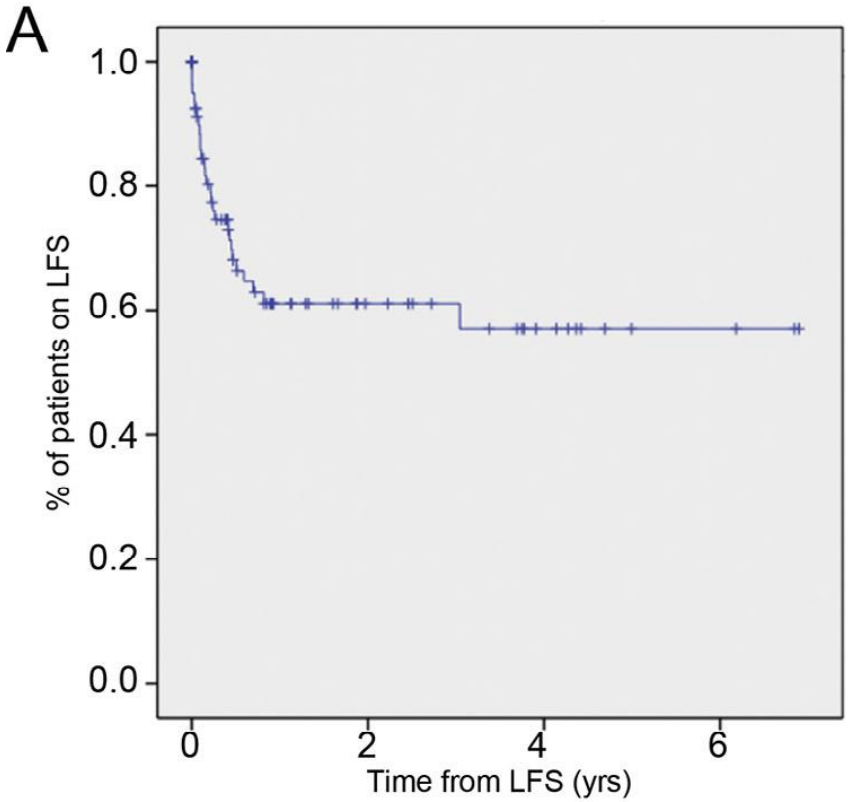


FIG. 1. Data from Xie et al.[22] presented as mean and standard deviation during DBS off, HFS (130 Hz) and LFS (60 Hz). Abbreviations: *= $p<0.05$; ^= $p<0.05$ (Bonferroni correction); FOG Q freezing of gait

Watch out appendicular sign



Biase L, Fasano A. 2016, Zibetti M et al. 2016

Combined with Nigral Stimulation

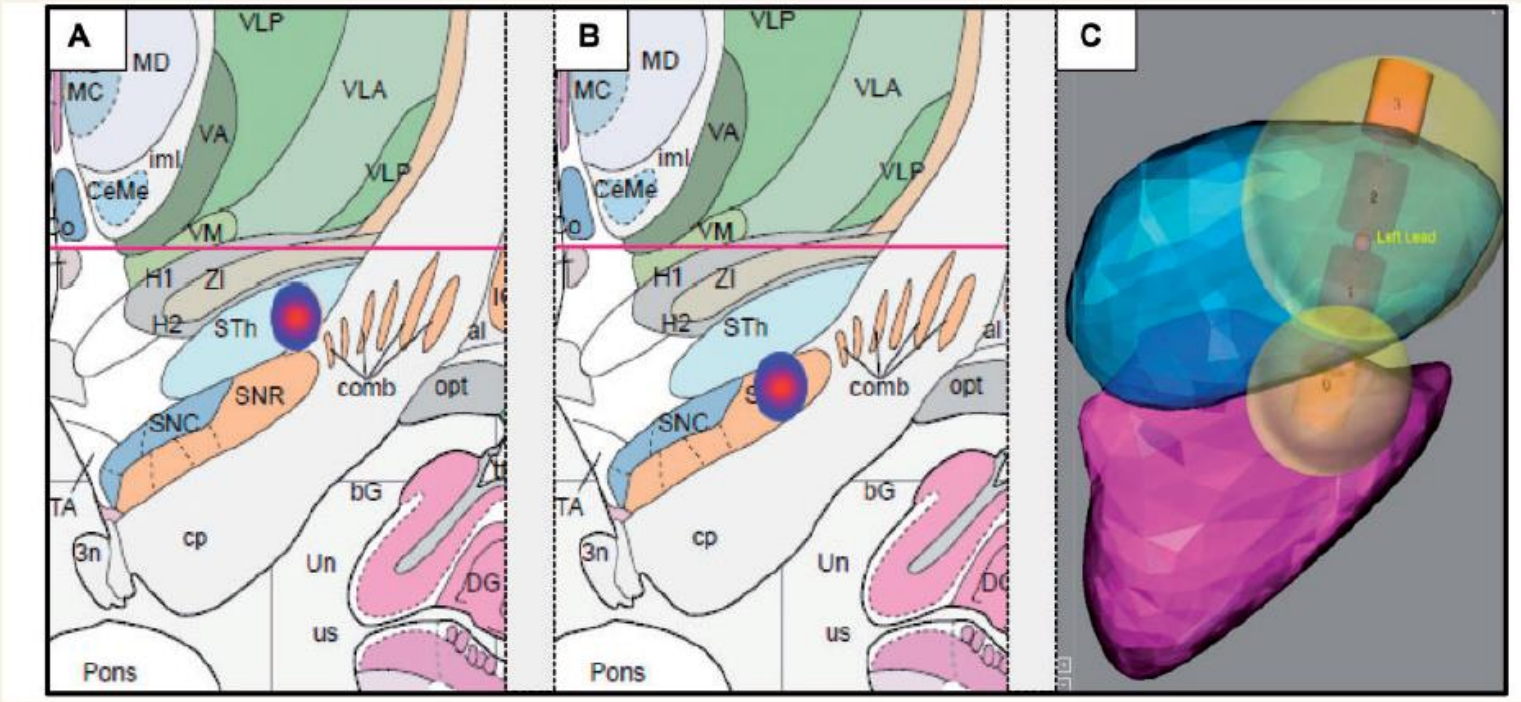


Figure 2 Localization of active electrode contacts of (A) dorsolateral STN and (B) dorsolateral SNr. Coordinates relative to the mid-commisural point (MCP) were: left STN -11.4 ± 0.8, -0.9 ± 2.0, -3.0 ± 1.7; right STN 13.5 ± 1.1, -0.5 ± 1.7, -2.2 ± 1.5; left SNr -10.0 ± 0.9, -3.4 ± 2.1, -6.4 ± 1.8; right SNr 12.1 ± 1.3, -3.3 ± 1.7, -5.8 ± 1.5 (x, y, z; x = medio-lateral, y = anterio-posterior, z = rostro-caudal). Electrode coordinates (mean ± standard deviation in x- and y-direction) are visualized in coronal view on the Atlas of the Human Brain with permission (Mai *et al*., 2007). (C) An additional illustrative image of electrode localization including a simulation on volume of tissue activated was kindly provided by Medtronic based on work by Yelnik *et al*. (2007) (atlas) and D'Haese *et al*. (2012) (atlas and algorithms).

Weiss D et al. 2013

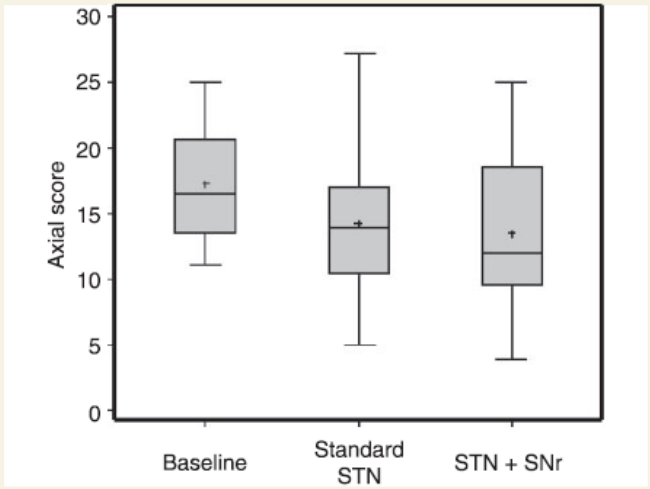


Figure 3 Primary endpoint at '3-week follow-up'. Results are given as box plots. *x*-axis: therapeutic condition; *y*-axis: axial score. [STN + SNr] = combined STN + SNr stimulation.

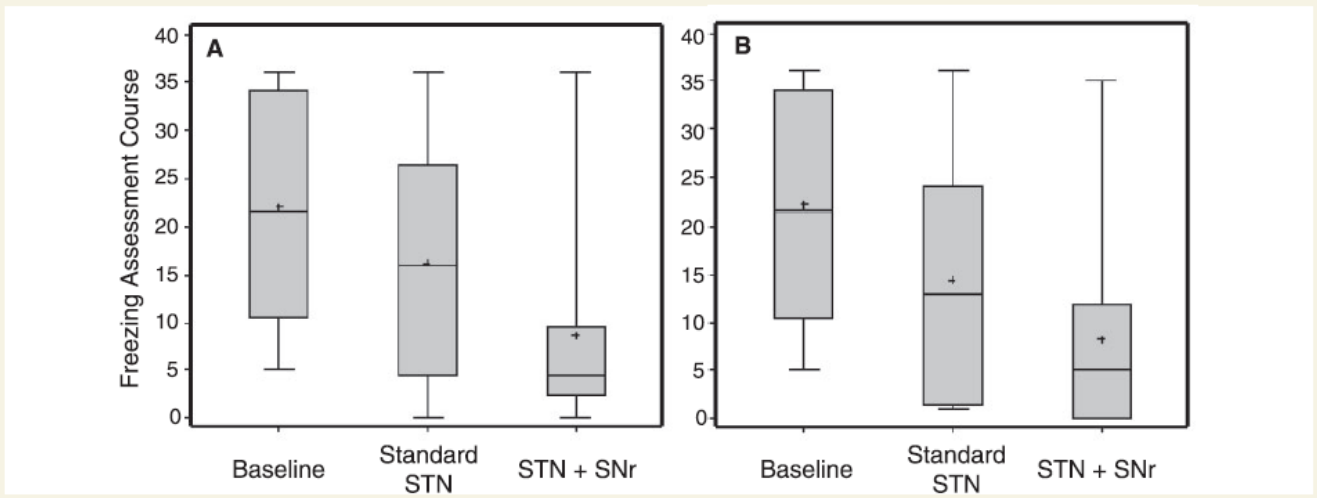


Figure 4 Secondary endpoint: results at (**A**) 'immediate testing' and at (**B**) '3-week follow-up' are given for the Freezing of Gait Assessment Course. Results are given as box plots. *x*-axis: therapeutic condition; *y*-axis: score of the Freezing of Gait Assessment Course. [STN + SNr] = combined STN + SNr stimulation.

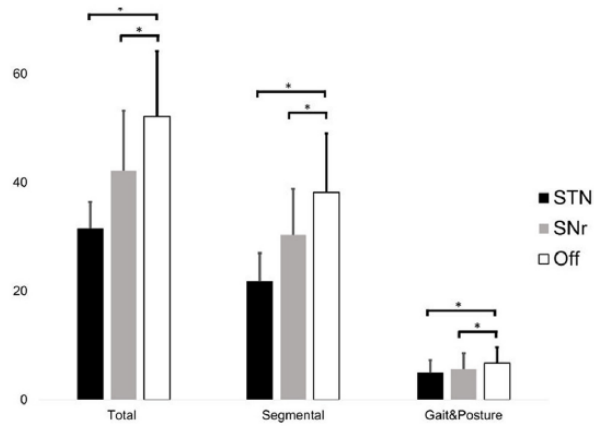


FIGURE 1 | Score of the total UPDRS III (left), segmental score (sum of items 20–26 + 31, only upper and lower limbs), and gait and posture subscore (sum of items 27–30) during subthalamic nucleus (STN), substantia nigra pars reticulate (SNr), and Off stimulation. Significant differences ($p < 0.05$) are denoted by horizontal square brackets. Both STN and SNr stimulations could significantly improve the segmental and gait and posture subscore.

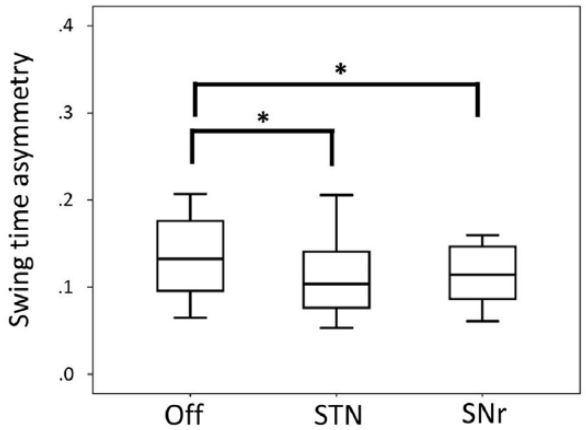
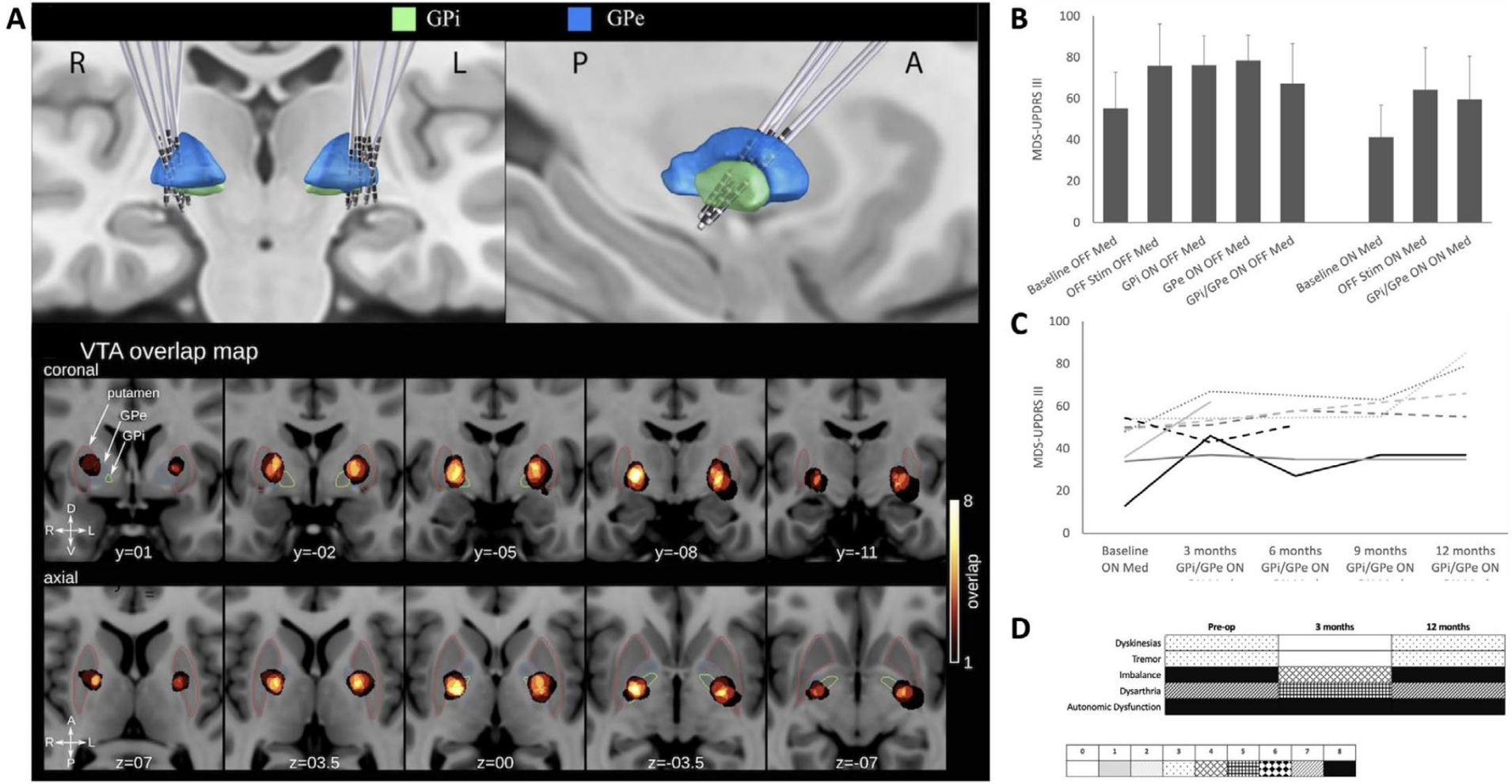


FIGURE 2 | Boxplot representing median values, 25–75% range (box) and min–max range (bars) of swing time asymmetry. Differences were computed with the Wilcoxon signed rank test and are denoted by horizontal square brackets. Abbreviations: STN, subthalamic nucleus deep brain stimulation; SNr, substantia nigra deep brain stimulation; ll, leg length; CV, coefficient of variation.

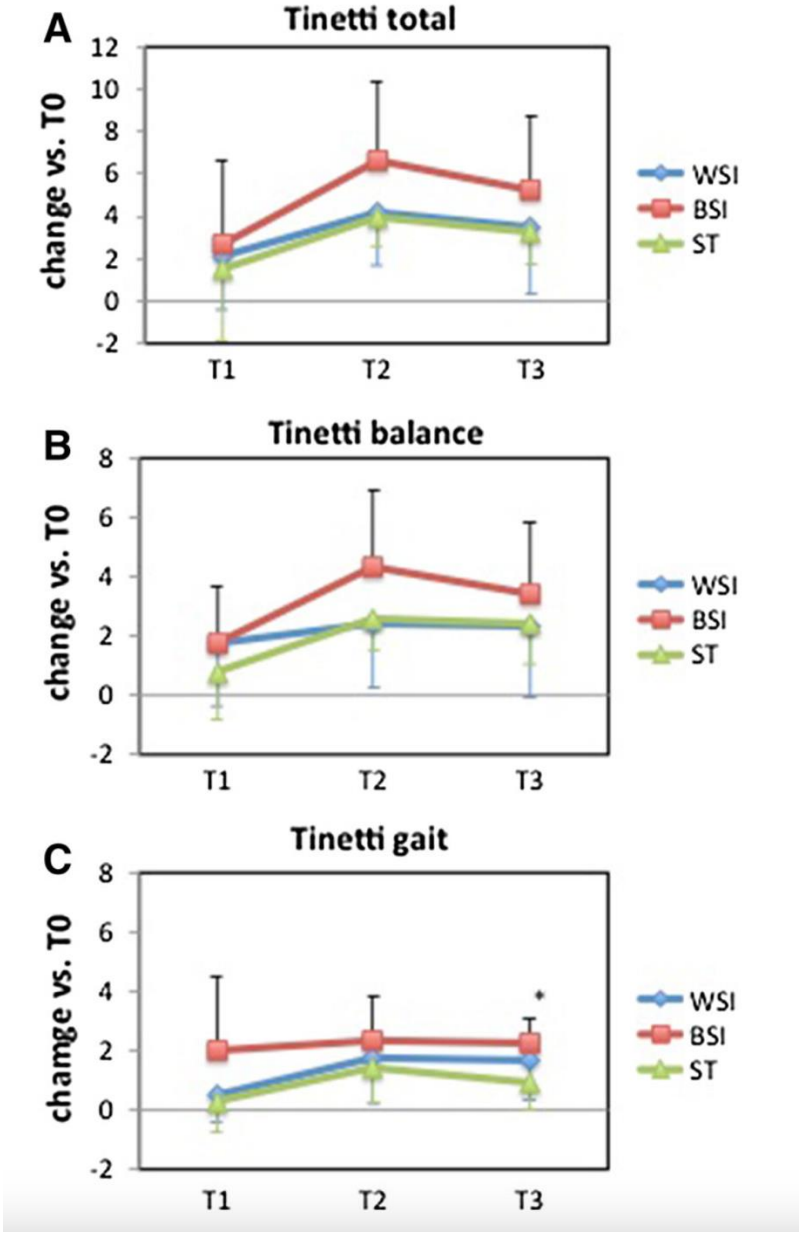
Weiss D et al. 2013, Scholten N et al. 2017

Additional GPe stimulation

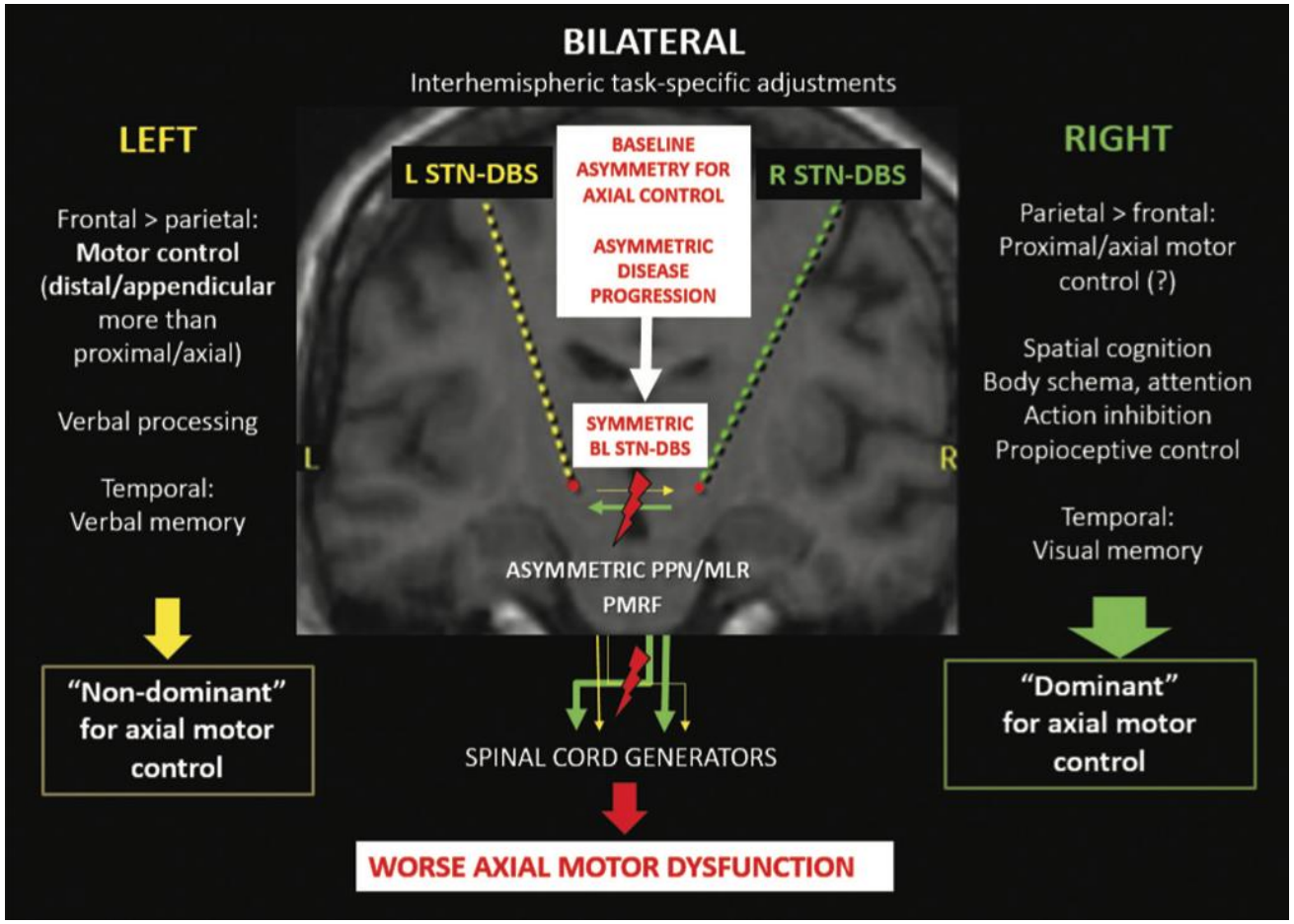


Di Luca D et al. 2023

Asymmetry



Right side stimulation



Ricciardi L et al. 2015, Lizzaraga et al. 2017

Take Home Message (Troubleshooting)

- Identify the problem, first
- Always consider capsular side effects
- Response to more stimulation and levodopa is important
  - Some symptoms can be seen with peak-dose (ON FOG, uncontrolled dyskinesia)
- Changing contacts based on the review of stimulation site
  - Image-guided programming or the review of local field potentials can be helpful and maximize the benefit of directional stimulation
- Low frequency stimulaiton could be helpful for the axial symptoms
  - There is a risk for worsening appendicular sign
- For gait issues, asymmetry or focusing on right hemisphere can be also considered