5th Neuromodulation School for Movement Disorders
New York, New York, USA | August 13-14, 2026

International Parkinson and
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# DEEP BRAIN STIMULATION FOR PARKINSON'S DISEASE: AN OVERVIEW

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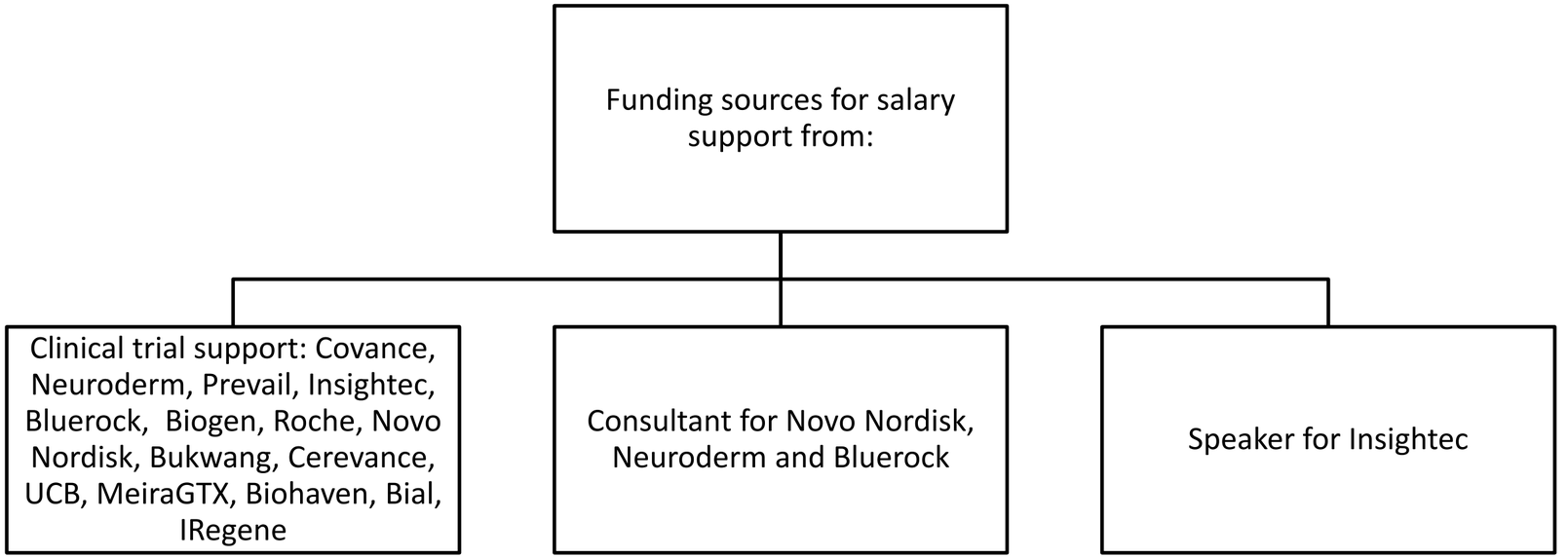
# DISCLOSURES



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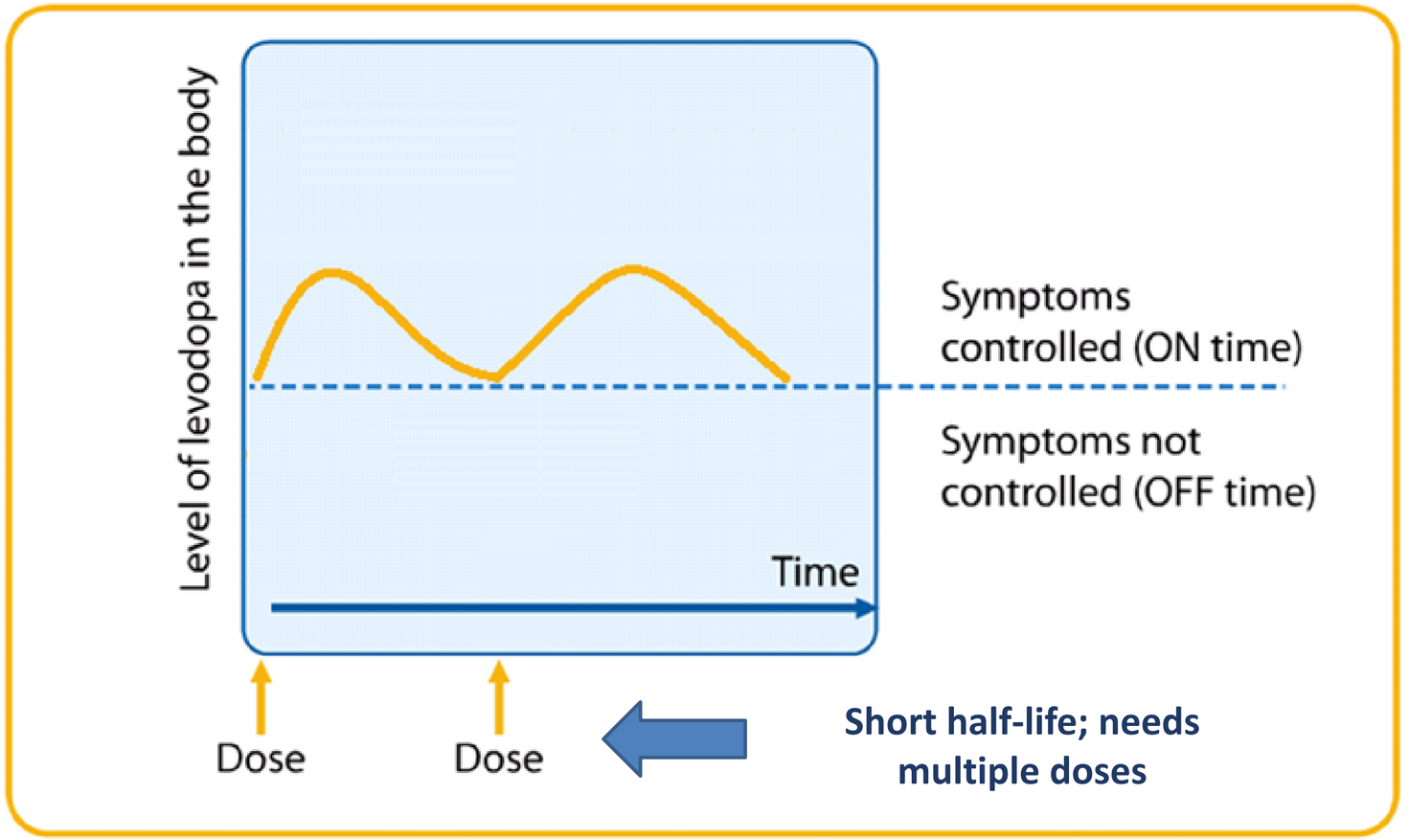
# Learning Objectives

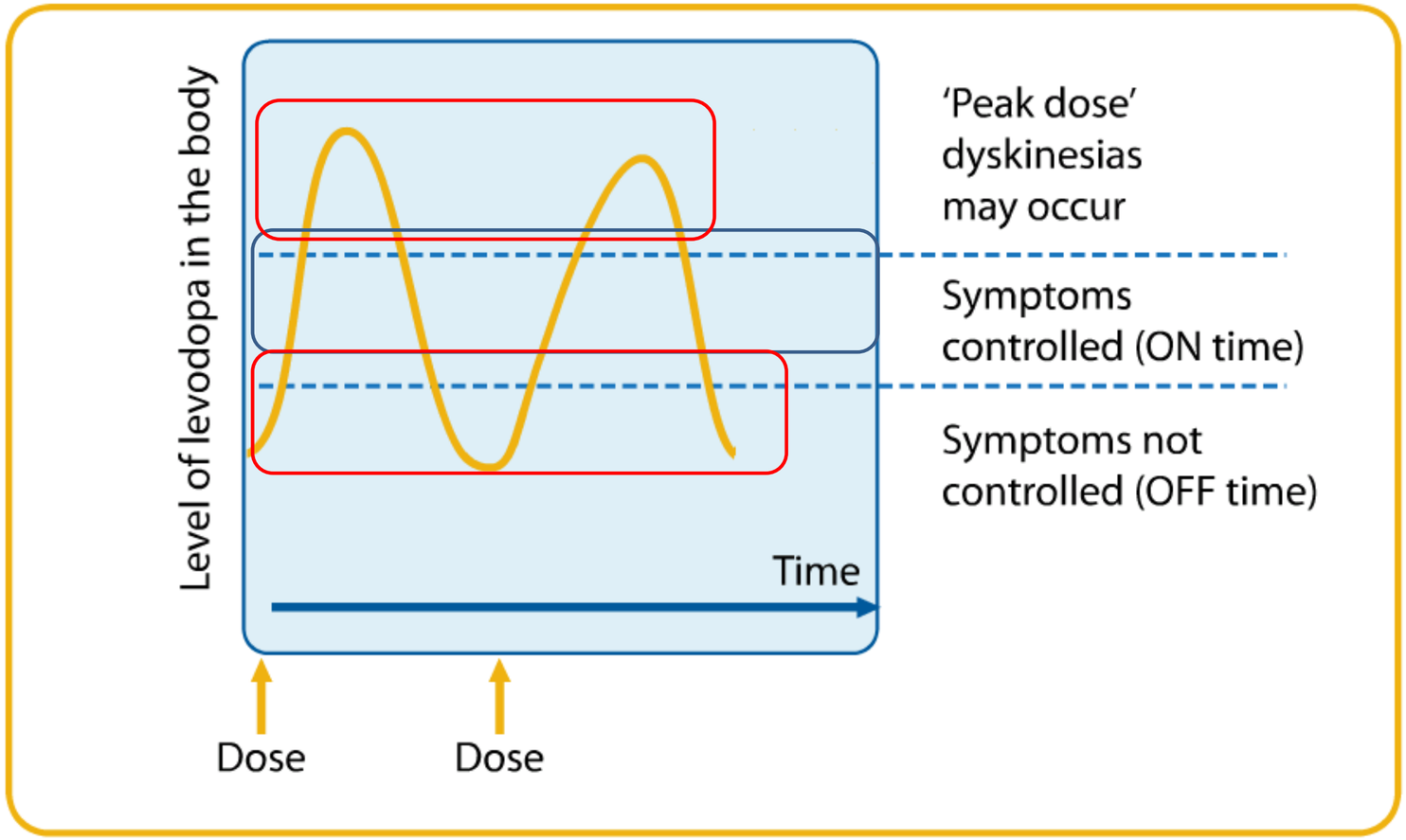
1. Identify appropriate candidacy criteria for DBS in PD
2. Understand the evidence behind treating specific symptoms
3. Recognize symptoms not typically treated by DBS
4. Describe the standard DBS patient evaluation
5. Define success and the success rate of DBS for PD

# Usual Response to Levodopa in Early PD




*Source: mypdinfo.com*

# Motor Fluctuations from Long-Term Levodopa Use

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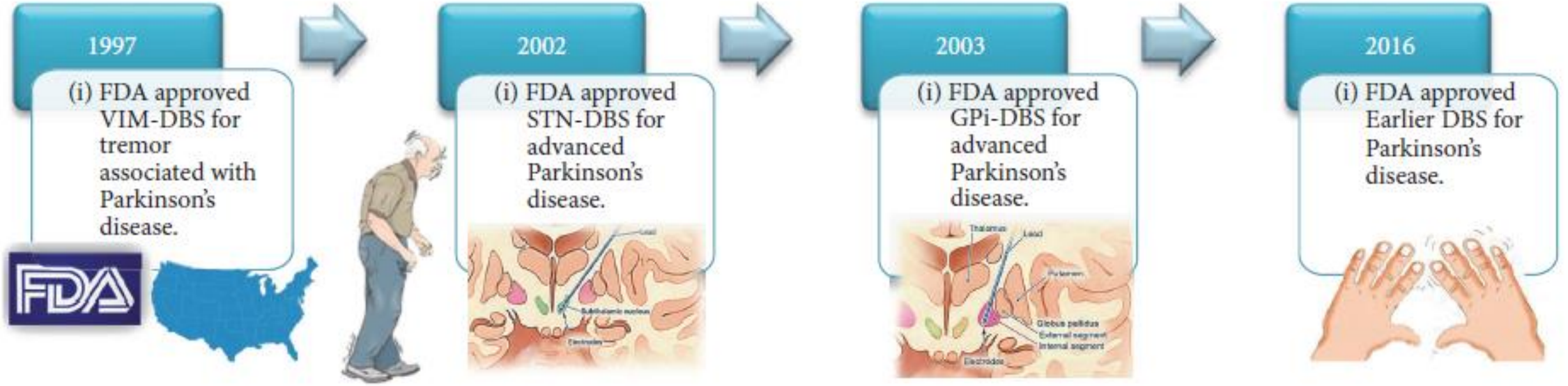


FIGURE 1: DBS FDA approval timeline.

Suarez-Cedeno et al, Parkinson's Disease 2017

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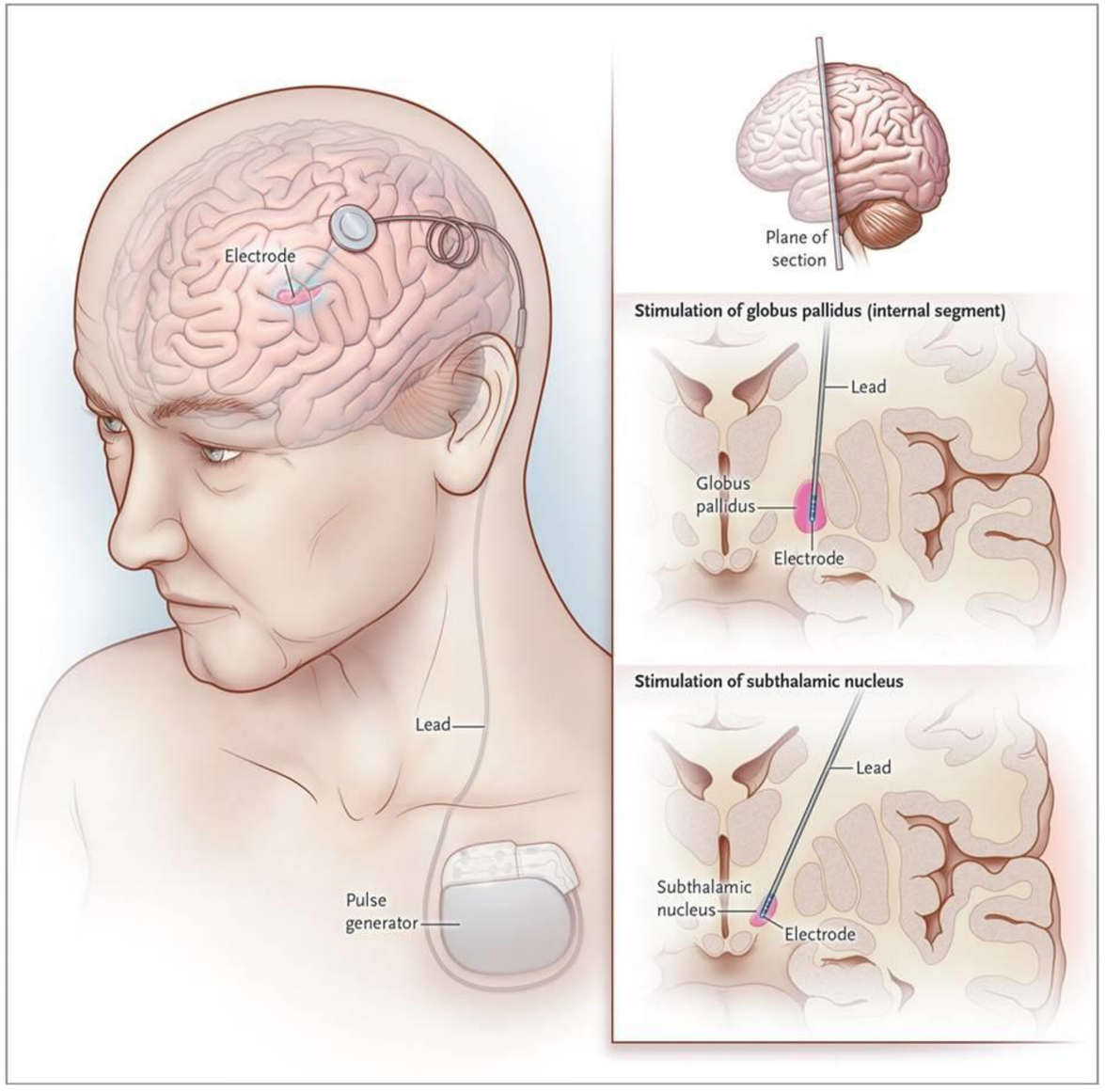



*Image: NEJM (nejm.org)*

# Ideal candidates for DBS

## DBS replicates what levodopa does

- Exception: medication resistant tremor which responds better to DBS

## Ideal Candidates:

- **Definite diagnosis of PD**
- ROBUST Carbidopa/Levodopa (Sinemet) responders
- Generally healthy
- No significantly cognitive impairment
- Stable mood
- Good support

**Best-case DBS efficacy ≈ your best levodopa response — minus the fluctuations**

# Original CAPSIT Criteria

- Consider DBS after at least 5 years of disease
- At least 33% response to levodopa from OFF to ON state
- No standard application to consider axial or non-motor symptoms
- Patients would complete at home diaries one week per month for 3 months

# Other Factors to Consider Besides Taking 5 + doses of C/L per day, 2+ hours of fluctuations, and 1+ hours of bothersome dyskinesia:

- Impact on functional status and quality of life
- Intolerable side effects in objective levodopa responders
- Medication resistant painful dystonia
- Deteriorating functionality limiting employment prospects

# Other factors to consider: Age, genetics, PD subtype

- Consider biological not chronological age of the patient
  - Large retrospective study demonstrated:
    - No significant difference in 30-day and 90-day post-operative complication risk between those younger than 75 and older than 75
    - No difference between the age groups when assessing individual complications such as hemorrhage, infections, PE or PNA

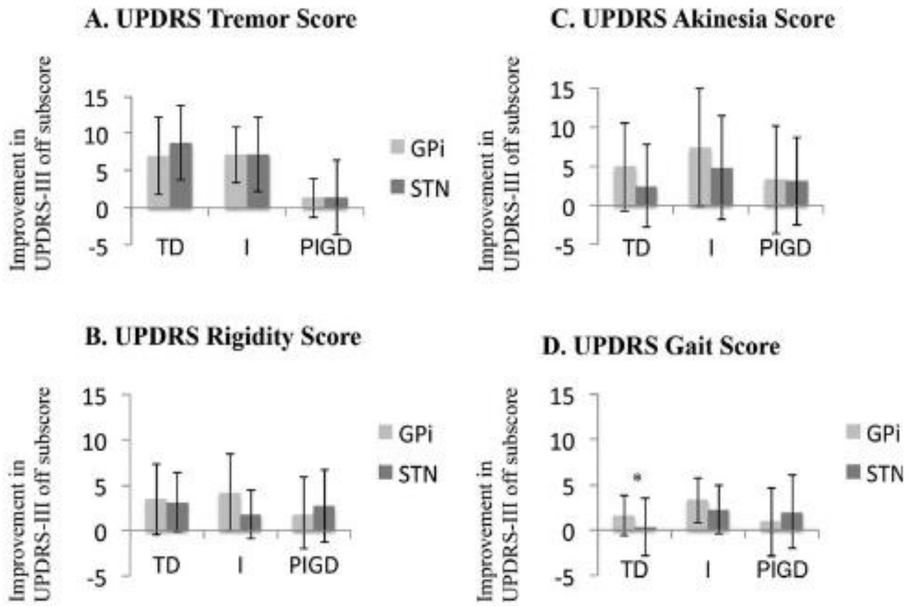
*Complication data: JAMA Neurology, 2014*

## Impact of genetics is mixed — but useful for counseling on long-term progression

| Gene / mutation | DBS response |
|---|---|
| **LRRK2 G2019S** | Good STN-DBS response (more tremor, strong dopaminergic response) |
| **LRRK2 R1441G** | Less robust response (more postural instability) |
| **GBA** | Variable — depends on mutation severity (p.L444P vs p.N370S) and target (STN vs GPi) |
| **PRKN** | Good early STN response (<2 yr); long-term data limited; few GPi cases |

**Genetic test results are NOT an absolute contraindication to DBS**

- Veterans Affairs Cooperative Study (24 months) assessed response of DBS depending on PD subtype:
  - PIGD had worse response to DBS regardless of target compared to TD or Intermediate subtype
  - No difference in response to target when looking at motor subscores except tremor better with GPi in part due to response to gait
  - Both targets improved motor symptoms overall regardless of the subtype




Annals of Neurology 2015

- Axial symptoms (gait, posture) are not always levodopa-responsive — but they are not exclusionary for DBS
  - DBS can improve leg hypokinesia, arm/leg swing, posture, stride velocity
  - Levodopa-responsive FOG and refractory camptocormia can respond to DBS
- Late falls/postural instability risk: older age, more ON-med axial symptoms, frontal dysfunction, longer disease duration, akinetic-rigid type
- Speech effects are mixed — counsel on possible worsening; consider pre-op PT / OT / ST

- Preoperative non-motor symptom burden matters:
  - Verbal fluency, mood, cognition may worsen (lower dopaminergic meds + disease progression)
  - ICDs from high dopaminergic tone may improve after DBS
  - NMS from non-motor fluctuations (psychiatric, autonomic, cognitive) can improve
- QOL gains peak ~6 months, diminish by 36; sustained in younger patients with higher baseline NMS burden

# In summary when considering patient selection, both motor and non-motor symptoms need to be considered for patient selection

**CONSIDER DBS**

- Good levodopa response (except for disabling tremor)
- Good cognition
- Disabling fluctuations/dyskinesia

**CAUTION — LESS LIKELY**

- The presence of severe dysarthria
- Non-transitory psychosis
- Moderate to severe dementia
- Repeated falls
- Poorly controlled depression

*(Antonini et al. Current Medical Research and Opinion. 2018)*

# What symptoms improve and do not improve after DBS?

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# DBS greatly improves the following:

- **Tremor**
- **Rigidity**
- **Bradykinesia**
- **Fluctuations**
- **Dyskinesia**
- **Quality of life**

*Gait and axial symptoms that are levodopa responsive and associated with bothersome motor fluctuations may improve with appropriately targeted and individualized DBS approaches.*

Non-motor symptoms do not consistently respond to DBS due to:

- Underlying pathways
  - Ventromedial STN stimulation can lead to cognitive/psychiatric effects
  - PPM stimulation may help with some sleep features
  - Some thalamic stimulation can lead to reduction in ANS symptoms
- Subtypes of NMS:
  - Central vs dystonic pain
  - Different types of apathy
- Degree of mesolimbic degeneration
  - Resulting in de novo ICD's

- What non-motor features have shown improvement from DBS?
  - Non-motor fluctuations that respond to levodopa
    - Open label studies suggest role of improving cognitive, pain, psychiatric and autonomic fluctuations with DBS (role of reducing medications with STN or more consistent treatment with stimulation)
  - ICD's that are result of hyperdopaminergic state can improve with DBS and medication reduction
    - Patients with severe mesolimbic degeneration may develop de novo ICDs after stimulation
  - Sleep—Improved continuous sleep time, arousal index, overall sleep quality
    - No obvious improvement in excessive daytime sleepiness

- Not improved by DBS
  - Cognition — consistent decrease in verbal fluency; mild decline in working memory, abstract reasoning, executive function
    - Risk: premorbid burden, poor attention, axial symptoms, frontal/caudate trajectories, post-op programming & med changes
- Mixed results — not consistent across studies:
  - Apathy (varies by subtype)
  - Pain — dystonic responds better than central
  - Urinary symptoms, constipation, dysphagia
  - Orthostasis and hyperhidrosis
  - Weight
  - Depression / anxiety

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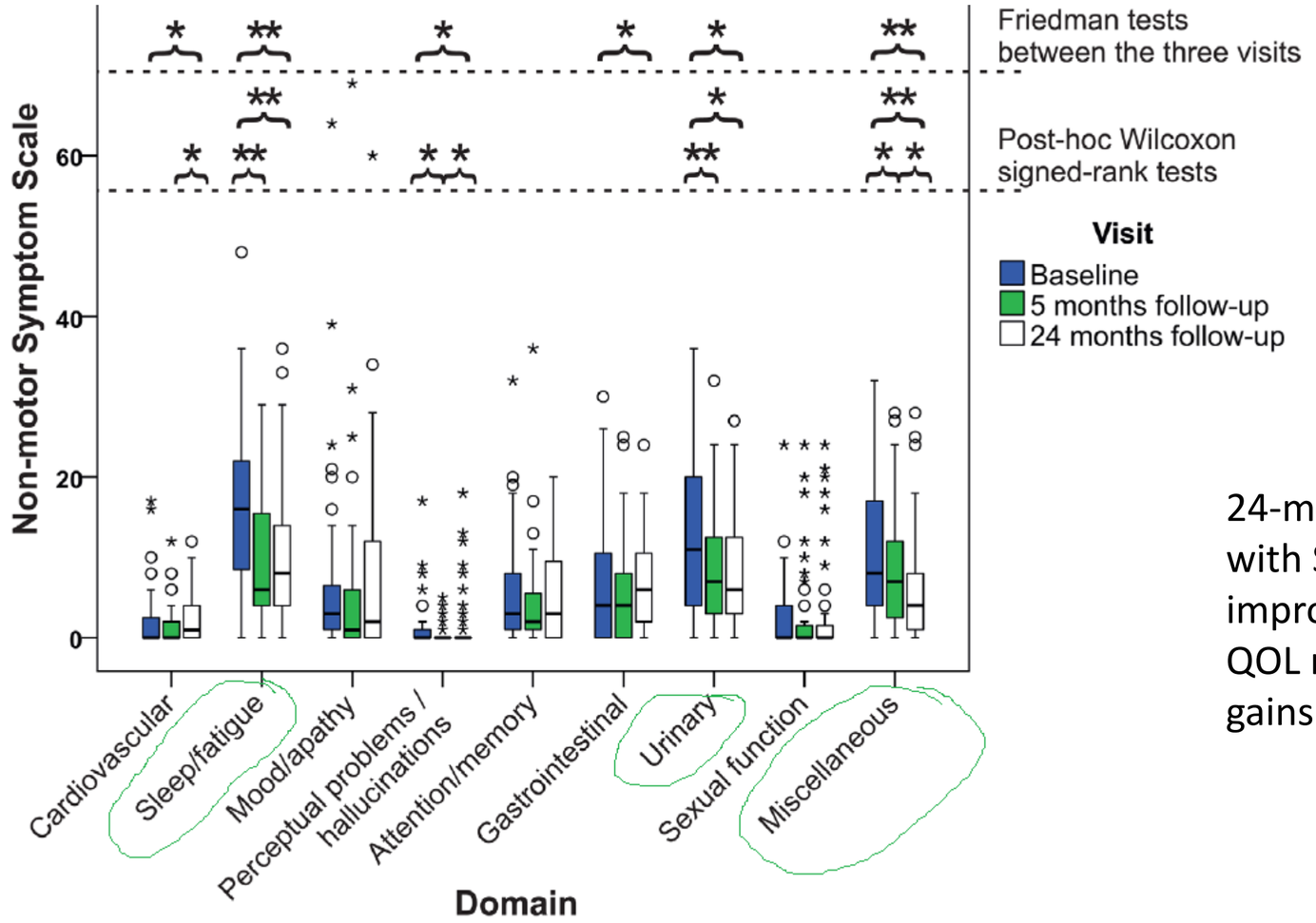


24-month study of 67 patients with STN DBS, total NMSS improved at 5 months along with QOL measures with diminishing gains at 24 months.

Dafsari et al, Movement Disorders. 2018

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# PATIENT EVALUATION FOR DBS

# Motor evaluations for DBS

- OFF/ON testing ≥ 12 h after last carbidopa/levodopa dose
  - ≥ 30% response confirms levodopa responsiveness (some use ≥ 50%) — not a sole criterion
  - Interpret with OFF MDS-UPDRS score and Hoehn & Yahr stage
- Levodopa-refractory tremor at adequate dosing (carb/levo 600–900 mg/day) is a valid indication
- In OH / psychiatric / GI-intolerant patients: a robust med response supports DBS; a poor response → evaluate for atypical parkinsonism

# Cognitive Evaluations for DBS

- Neurocognitive assessments (3-6 months prior to surgery) should evaluate for mild cognitive impairment and include at least 2 domains (attention, language, visuospatial functioning, memory, executive functioning)
  - **NO formal cutoff**
- Global index of cognition (MMSE, MOCA, Mattis-DRS-2) can be good summaries but CANNOT replace formal neuropsychiatric testing.
- Important to assess degree of cognitive impairment that may limit functional improvement, affect surgical consenting and goals of therapy discussion, and place individual at risk for further cognitive decline

- Evaluates effect of medications, mood disorders, and wearing off motor and non-motor symptoms on cognition
- Depression/anxiety by themselves are not contraindications but if severe should be treated prior to surgery to reduce postoperative delirium risk and poor QOL
- Additionally assesses for:
  - substance abuse
  - other psychiatric disorders (OCD, personality disorders)
  - suicidal ideation
  - social circumstances
  - risk of longer postoperative confusion

- Pre-op MRI is used to:
  - Visualize DBS targets, find structural pathology, map venous anatomy for a safe trajectory
  - Cortical atrophy → subdural-hematoma risk; ventricular enlargement → harder STN targeting
- In 135 patients: microvascular disease, atrophy, lacunes frequently present— only atrophic/degenerative change affected subjective DBS response
- MRI features linked to post-DBS cognitive decline: subcortical iron deposition, frontal cortical thinning, white-matter disease load

# Assessing for Comorbidities

- Cardiovascular disease and cardiac risk factors can increase postoperative readmission rates
- For gait, consider evaluating for orthopedic or neuropathic components which do not improve with DBS

# TIMING OF DBS

# EARLYSTIM TRIAL: Stim + BMT vs BMT

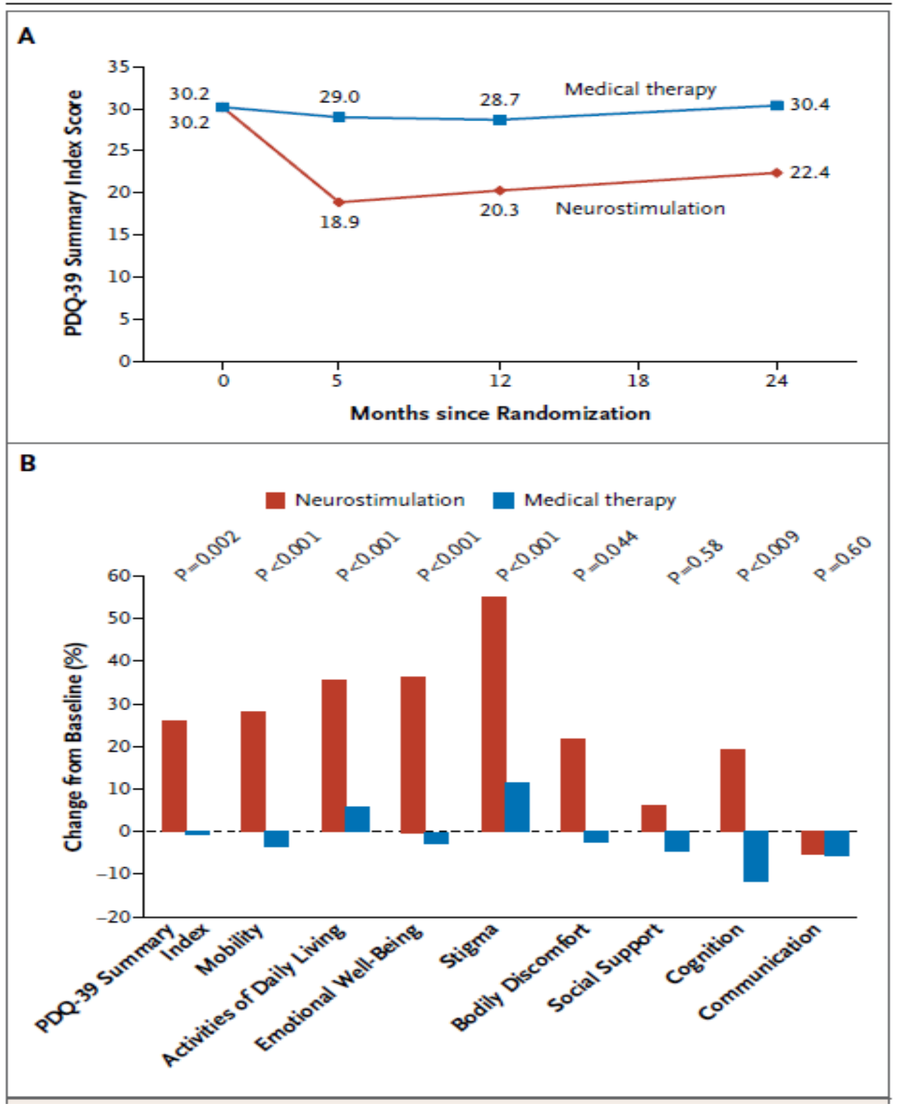
- **Inclusion:**
  - **18-60 years**
  - **Disease duration 4 or more years**
  - **ON H/Y <3**
  - **50% improvement from OFF to ON**
  - **Dyskinesia or fluctuations for 3 years or less**
  - **At least a score of 6 on MDS UPDRS II**
  - **Mild to moderate impairment in social or occupational functioning**

- **Exclusion:**
  - **Dementia (Mattis DRS score of <130)**
  - **Major depression with SI (BDI >25)**
  - **Acute psychosis**
  - **Any medical or psychiatric comorbidity that would interfere with the study**
  - **Disease duration of <4 years due to possible atypical PDism**

**Table 1.** Baseline Characteristics of the Study Population.*

| Characteristic | Neurostimulation (N=124) | Medical Therapy (N=127) |
|---|---|---|
| Age — yr | 52.9±6.6 | 52.2±6.1 |
| Sex — no. (%) | | |
| Male | 94 (75.8) | 85 (66.9) |
| Female | 30 (24.2) | 42 (33.1) |
| Duration of Parkinson's disease — yr | 7.3±3.1 | 7.7±2.7 |
| Dyskinesia† | | |
| No. of patients | 84 | 94 |
| Duration — yr | 1.4±0.8 | 1.5±0.8 |
| Motor fluctuations† | | |
| No. of patients | 121 | 124 |
| Duration — yr | 1.6±0.8 | 1.8±0.8 |
| Treatment with levodopa | | |
| No. of patients | 111 | 115 |
| Duration — yr | 4.8±3.3 | 5.0±3.3 |
| Treatment with dopamine agonist | | |
| No. of patients | 118 | 115 |
| Duration — yr | 5.9±3.0 | 6.1±3.0 |
| Levodopa-equivalent daily dose — mg | 918.8±412.5 | 966.9±416.5 |

Primary Outcome



# Key Secondary Outcomes and AE's

- OFF MDS UPDRS III scores improved by 53% in the neurostimulation group with at 16.4 point greater reduction at 2 years compared to BMT
- Part IV scores improved by 61% in the neurostimulation group
- Part II scores reduced by 6 points in the neurostimulation group
- LEDD was reduced by 39% in the neurostimulation group but increased by 21% in the BMT group
- No significant differences in cognition in both groups
- AE's mostly mild to moderate

# Clinical Implications and Considerations from EARLYSTIM

- Prior to EARLYSTIM, patients referred to DBS after 10 years of disease
- Paradigm shift in offering DBS earlier in disease course to reduce motor, social and psychological disability and improve QOL
- FDA extended indication to PD patients of at least 4 years duration with recent onset of motor complications or motor complications of longer duration that are not adequately controlled
- However, earlier DBS may include those with atypical parkinsonisms who do not respond to DBS, those with more aggressive genetic forms that may have inconsistent DBS results,  or those with a slow disease trajectory who may not need surgical intervention

# When to have conversations about DBS?

- Discuss DBS early — it reduces stigma
- Why patients avoid DBS (surveys):
  - Fear of brain surgery or complications
  - Perceived poor risk–benefit, or that DBS is ineffective
  - Feel adequately managed, or haven't exhausted medications
- Early conversations ease fears and show DBS is not a last resort — enabling informed decisions

# HOW EFFECTIVE HAS DBS BEEN?

Several large studies have demonstrated tremendous efficacy of DBS in improving motor symptoms and quality of life

**Table 1 | Randomized Control Trials for DBS in PD**

| Authors & Year | Location | Groups | *n* | Primary Outcome Blinded? | Primary Outcomes | Length | Results |
|---|---|---|---|---|---|---|---|
| Deuschl et al.[7] | Germany & Austria | active: STN DBS<br>control: best medical | 156 total<br>78 active<br>78 control | No | PDQ-39 &<br>UPDRS-III scores | 6 mos | DBS improved PDQ-39 by 25%, UPDRS-III scores by 40% |
| Weaver et al.[8]<br>VA trial | USA | active: STN or GPi DBS<br>control: best medical | 255 total<br>121 active<br>134 control | Yes | good quality on time (hours/day) | 6 mos | DBS improved good quality on time (> 4.6 h/day), > 56% motor improvements |
| Follett et al.[9]<br>VA trial | USA | STN vs. GPi DBS | 299 total<br>147 STN<br>152 GPi | Yes | UPDRS-III score (on stimulation, off medication) | 2 yrs | STN DBS reduced medication doses but worsened depression and visuomotor processing speed |
| Williams et al. [10]<br>PD SURG trial | UK | active: STN or GPi DBS<br>control: best medical | 315 total<br>162 active<br>153 control | No | PDQ-39 scores | 1 yr | PDQ-39 summary index (94% improved), mobility, ADL, & bodily discomfort scores. |
| Okun et al.[11]<br>St Jude trial | USA | active: STN<br>sham: STN | 168 total<br>101 active<br>35 control | No | good quality on time (hours/day) | 3 mos | 4 h good quality on time, >40% UPDRS improvement |
| Odekerken et al.[12]<br>NSTAPS study | Netherlands | STN vs. GPi DBS | 128 total<br>63 STN<br>65 GPi | Yes | weighted ALDS; composite cognitive, mood, behavioral score | 1 yr | Primary outcomes regarding disability equivalent; Secondary UPDRS motor outcomes: STN better |
| Schuepbach et al.[13]<br>EARLYSTIM trial | Germany & France | active: STN DBS<br>control: best medical | 251 total<br>124 active<br>127 control | No | PDQ-39 scores | 2 yrs | DBS improved PDQ-39 summary index, UPDRS parts II-IV, & good quality on time |
| Vitek et al.[14]<br>INTREPID trial | USA | active: therapeutic STN<br>control: subtherapeutic STN DBS | 160 total<br>121 active<br>39 control | Yes | good quality on time (hours/day) | 3 mos | UPDRS II scores (off meds), PDQ-39 summary index, & Schwab & England scores |

Wagle Shukla et al. NPJ: Parkinson's disease 2025

- These large clinical trials demonstrated:
  - Reduction in OFF time range from 1.8 to 4.2 hours
  - Improved ON time without troublesome dyskinesia from 1.9 to 4.9 hours
  - Reduction in LEDD from 24 to 66%
  - Mean improvement in PDQ-39 of 24%

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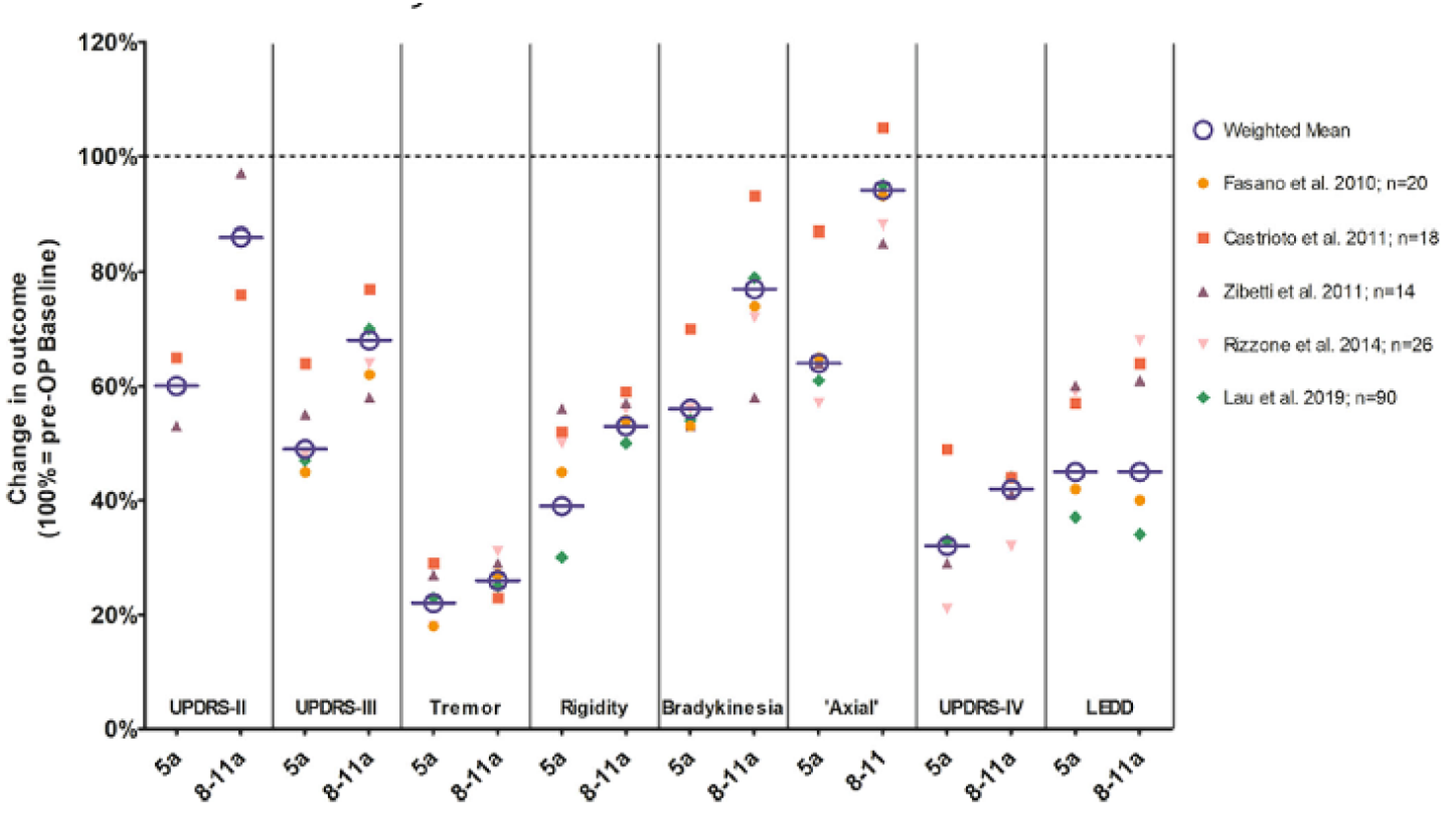
## Long-term effects of DBS on PD

Continued benefits in ADLs

UPDRS III and subscores (tremor, rigidity, bradykinesia)

Part IV scores and LEDD

Sustained at 8–11 years vs baseline




No evidence for disease modification
No evidence of significant benefit with implantation prior to development of levodopa induced complications
Trends towards reduction in nursing home placement and death

Mahlknecht et al. Movement Disorders. 2022

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# In Summary

1. DBS remains a highly effective advanced treatment for the motor symptoms of PD
2. Patient selection weighs levodopa response, neuropsychiatric status, imaging, comorbidities and social support
3. DBS has variable effects on non-motor symptoms
4. Discussing DBS earlier may reduce stigma and improve overall quality of life