Surgical treatment of Parkinson’s disease

Prof Tom Foltynie
UCL Institute of Neurology
Queen Square
London
Who can benefit from DBS?

- Parkinson’s disease
- Dystonia
- Tremor
- (Pain)
- (Epilepsy)
- Tourette’s
- OCD
- Anorexia
- HT
- Dementia
- Depression
PARKINSON’S
Major issues surrounding surgery for PD

• Brain targets
• Patient selection
• Side effects & Troubleshooting
• Alternatives to DBS
Figure 1: Thalamic clusters with corresponding cortical and cerebellar ROI masks (S1: blue - M1: red - SMA/PMC: green - dentate: yellow)
Figure 3: (A) Responders group average VTA (hot) and (B) non-responders VTAs (copper) in relation to the DRTC and the dentate-thalamic cluster
Side effects/ issues associated with VIM DBS

- Tolerance
- Dysarthria
- Poor balance
Ataxia induction vs Tremor resolution

**Figure 1** Mean values (±SD) of the lateralized tremor rating scale (Fahn-Tolosa-Marin Rating Scale, TRS) during therapeutic stimulation (STIM-ON) and item 10 of the ICARS during supratherapeutic stimulation (STIM-ST) of the four contacts of the quadripolar electrode. Contact 0 led to a significant reduction of the lateralized Fahn-Tolosa-Marin Rating Scale compared with the off stimulation condition (STIM-OFF) and the other three stimulation contacts (**P < 0.01). Supratherapeutic stimulation of contact 0 led to a significant increase of item 10 of the ICARS compared with off stimulation and stimulation of the other three contacts (##P < 0.01).

**Figure 7** Conceptual model to explain the effects of therapeutic and supratherapeutic stimulation. (A) The dentate-thalamo-cortical, the cerebello-rubro-spinal and the rubro-olivo-cerebellar system are involved in the regulation of reach-to-grasp movements. At the subthalamic stimulation site, the projection fibres of all three pathways run in close vicinity. (B) During therapeutic stimulation, propagation of essential tremor-specific pathological activity within the dentate-thalamic fibre tract is blocked which leads to reduction of ataxia and tremor. During supratherapeutic stimulation, the electrical field is enlarged and affects efferent or efferent fibres of the red nucleus leading to failure of the second cerebellar outflow system. This causes dysmetria, while tremor remains suppressed. DN = dentate nucleus; IN = interposed nucleus; IO = inferior olive; RN = red nucleus.

Physiological and anatomical decomposition of subthalamic neurostimulation effects in essential tremor

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Muscle contraction
Dysarthria
Gaze deviation

Target area

Hypomania
ICD
Rage
Dysarthria
Dizziness
Balance problems
Paresthesias

Avoiding side effects
Predictive Factors of Speech Intelligibility Following Subthalamic Nucleus Stimulation in Consecutive Patients With Parkinson’s Disease

Elina Tripoliti, PhD, MRCSLT,1* Patricia Limousin, MD, PhD,2 Tom Foltynie, MB BS, PhD, MRCP,2 Joseph Candelario, BSc,1
Idlar Aviles-Olmos, MD, PhD,1 Marwan I. Hariz, MD, PhD,1,3 and Ludovic Zrinzo, MD, PhD, FRCS1

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### TABLE 4. Multivariate regression of preoperative clinical predictive factors with left electrode contact anatomical description (medial vs. inside) as a covariate, on speech intelligibility change off- and on-medication and perceptual rating (DAB scale) change 1 year after subthalamic nucleus deep brain stimulation (N = 54)a

<table>
<thead>
<tr>
<th>Outcome and Predictive Variables</th>
<th>B-Coefficient</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in speech intelligibility AIDS pre-off to 1 y off/ON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIDS pre-on</td>
<td>−1.73</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>AIDS pre-off</td>
<td>−0.74</td>
<td>&lt; 0.398</td>
</tr>
<tr>
<td>UPDRS-III pre-on</td>
<td>−0.28</td>
<td>&lt; 0.614</td>
</tr>
<tr>
<td>UPDRS-III pre-off</td>
<td>0.00</td>
<td>&lt; 0.990</td>
</tr>
<tr>
<td>Duration of PD</td>
<td>2.35</td>
<td>&lt; 0.002</td>
</tr>
<tr>
<td>Left active contact position</td>
<td>9.25</td>
<td>&lt; 0.006</td>
</tr>
</tbody>
</table>
Minor electrode repositioning
# Subthalamic nucleus versus globus pallidus bilateral deep brain stimulation for advanced Parkinson's disease (NSTAPS study): a randomised controlled trial

Vincent J J Odekerken, Teus van Laar, Michiel J Staal, Arne Mosch, Carol FE Hoffmann, Peter Mathieu WP M Lenders, M Fiorella Contarino, Marieke SJ Mink, Lo J Bour, Pepijn van den M P Richard Schuurman, Rob MA de Bie

<table>
<thead>
<tr>
<th></th>
<th>GPI deep brain stimulation (n=65)</th>
<th>STN deep brain stimulation (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>59.1 (7.8)</td>
<td>60.9 (7.6)</td>
</tr>
<tr>
<td>Age at onset of Parkinson's disease (years)</td>
<td>48.5 (7.6)</td>
<td>48.6 (9.4)</td>
</tr>
<tr>
<td>Men</td>
<td>44 (68%)</td>
<td>44 (70%)</td>
</tr>
<tr>
<td>Duration of Parkinson's disease (years)</td>
<td>10.8 (4.2)</td>
<td>12.0 (5.3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>12 months</th>
<th>Mean change at 12 months from baseline*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GPI DBS</td>
<td>STN DBS</td>
<td>GPI DBS (n=62)</td>
</tr>
<tr>
<td>Weighted ALDS (n=90)</td>
<td>73.8 (13.9)</td>
<td>68.0 (19.0)</td>
<td>76.8 (13.3)</td>
</tr>
<tr>
<td>Score for cognitive, mood, and behavioural adverse effects ≥1 (n=125)</td>
<td>--</td>
<td>--</td>
<td>36 (58%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>12 months*</th>
<th>Mean change at 12 months from baseline†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GPI DBS</td>
<td>STN DBS</td>
<td>GPI DBS (n=125)</td>
</tr>
<tr>
<td>Off phase (n=125)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPDRS motor examination (range 0-108)</td>
<td>43.8 (13.5)</td>
<td>44.4 (15.5)</td>
<td>32.4 (12.6)</td>
</tr>
<tr>
<td>Clinical dyskinesia rating scale (range 0-28)</td>
<td>0.6 (1.2)</td>
<td>1.0 (2.0)</td>
<td>0.5 (1.6)</td>
</tr>
<tr>
<td>ALDS (range 0-100)</td>
<td>53.1 (21.8)</td>
<td>48.8 (23.8)</td>
<td>64.9 (22.0)</td>
</tr>
<tr>
<td>UPDRS activities of daily living (range 0-52)</td>
<td>17.9 (6.2)</td>
<td>18.2 (6.5)</td>
<td>14.0 (6.6)</td>
</tr>
<tr>
<td>Schwab and England scale (range 0-100; median [range])</td>
<td>50 (10 to 90)</td>
<td>40 (10 to 90)</td>
<td>60 (10 to 100)</td>
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</table>
### Broad consensus about STN v GPi DBS

<table>
<thead>
<tr>
<th>STN</th>
<th>GPi</th>
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<tbody>
<tr>
<td><strong>Greater effects on</strong></td>
<td><strong>Greater effects on</strong></td>
</tr>
<tr>
<td>- Off symptoms</td>
<td>- Dyskinesias</td>
</tr>
<tr>
<td>- Drug reduction</td>
<td></td>
</tr>
<tr>
<td><strong>Higher risks for</strong></td>
<td><strong>Higher risks for</strong></td>
</tr>
<tr>
<td>- Psychiatric disturbance</td>
<td>- Exacerbation of akinesia</td>
</tr>
<tr>
<td>- Cognition</td>
<td></td>
</tr>
<tr>
<td>- Speech</td>
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</table>
DBS- Who?

Meaningful benefit
- Disabling Tremor
- Frequent/ Unpredictable Off
- Intolerable dyskinesias
- Drug induced ICB

Risks of surgery
- Age
- Comorbidity/ brain atrophy
- Infection risk

Risks of stimulation
- Poor speech
- Weight gain
- Dopa refractory symptoms
- Psychosis
- Dementia/ poor cognition
- Unrealistic expectations
- Logistical problems
Findings
- Patients with GBA mutations require DBS earlier in their disease course
- Post surgery: no motor phenotypic difference between genetic groups
- 5 year follow-up: GBA patients have faster rate of cognitive decline
<table>
<thead>
<tr>
<th></th>
<th>GBA mutation carriers (n=17)</th>
<th>Non-carriers (n=17)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender distribution</td>
<td>10 male, 7 female</td>
<td>10 male, 7 female</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>16 white British, 1 Cambodian</td>
<td>17 white British</td>
<td></td>
</tr>
<tr>
<td>Time since onset (years)</td>
<td>21.8±6.8</td>
<td>22.2±6.0</td>
<td>0.871</td>
</tr>
<tr>
<td>Age at onset (years)</td>
<td>41.4±5.8</td>
<td>43.0±5.3</td>
<td>0.395</td>
</tr>
<tr>
<td>Age at surgery (years)</td>
<td>53.5±4.5</td>
<td>57.7±4.4</td>
<td>0.015</td>
</tr>
<tr>
<td>DBS target</td>
<td>15 STN, 2 GPi</td>
<td>17 STN</td>
<td>0.485</td>
</tr>
<tr>
<td>Alive/deceased</td>
<td>14 alive, 3 deceased</td>
<td>16 alive, 1 deceased</td>
<td>0.301</td>
</tr>
</tbody>
</table>

*Continuous values are mean ± standard deviation unless otherwise stated. Abbreviations: n = number of patients; DBS = deep brain stimulation surgery; STN = subthalamic nucleus; GPi = globus pallidus internus.*
<table>
<thead>
<tr>
<th></th>
<th>GBA mutation carriers (n=10)</th>
<th>Non-carriers (n=16)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative Total DRS-2 AMSS(^c)</td>
<td>12.5±2.3</td>
<td>13.2±2.6</td>
<td>0.506</td>
</tr>
<tr>
<td>Follow-up Total DRS-2 AMSS</td>
<td>5.8±4.6</td>
<td>11.0±3.8</td>
<td>0.006</td>
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<tr>
<td>Attention AMSS</td>
<td>9.2±2.7</td>
<td>11.5±1.9</td>
<td></td>
</tr>
<tr>
<td>Initiation/perseveration AMSS</td>
<td>5.5±3.6</td>
<td>8.4±3.0</td>
<td></td>
</tr>
<tr>
<td>Construction AMSS</td>
<td>6.3±3.7</td>
<td>9.4±1.9</td>
<td></td>
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<tr>
<td>Conceptualisation AMSS</td>
<td>8.1±3.1</td>
<td>11.3±1.6</td>
<td></td>
</tr>
<tr>
<td>Memory AMSS</td>
<td>7.8±4.6</td>
<td>10.3±2.5</td>
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\(^a\) Values are mean ± standard deviation unless otherwise stated.

\(^b\) All scores are on a scale of 2 to 18. Higher scores denote better cognitive performance.

\(^c\) Data available for 10 GBA carriers and 6 non-carriers.

Abbreviations: n = number of patients; DRS-2 = Mattis Dementia Rating Scale; AMSS = Age-corrected Mayo’s Older Americans Normative Studies (MOANS) Scaled Score.
Combating negative effects of stimulation

Published trials supportive of efficacy for each
STN-DBS frequency effects on freezing of gait in advanced Parkinson disease

ABSTRACT

Background: Severe gait disturbances and freezing episodes (frequently resistant to optimal dopaminergic treatment) often appear in advanced Parkinson disease (PD). Even several years after initiation, high-frequency subthalamic nucleus deep brain stimulation (STN-DBS) is still very effective for controlling segmental symptoms. However, there are no long-term data on the management of gait disorders and freezing in STN-DBS.

Objectives: To compare the effects of various STN-DBS parameters on freezing of gait and to determine whether such effects are more related to stimulation energy (usual voltages vs high voltages at 130 Hz) or frequency (130 Hz vs approximately half this frequency: 60 Hz).

Methods: We blindly assessed STN-DBS parameters in 13 PD patients reporting severe gait disorders. We compared the effects on gait of two different voltages (the patient’s usual voltage [median 3 volts] and a high voltage [median 3.7 volts]) and two different frequencies (60 and 130 Hz, while maintaining the same total energy delivered) vs “off-stimulation” conditions.

Results: The number of freezing episodes was significantly lower at the 60-Hz “high voltage/equivalent energy” and higher at the 130-Hz/high voltage than for “off stimulation.” The slight improvement in the Unified Parkinson’s Disease Rating Scale motor score observed (at 130 Hz) did not achieve statistical significance.

Conclusions: Our results prompt consideration of a new strategy for two-stage subthalamic nucleus deep brain stimulation (STN-DBS) frequency optimization, with stimulation at 130 Hz and the usual voltage during the initial years of STN-DBS and then at 60 Hz at a high voltage in Parkinson disease patients who develop severe gait disorders. Neurology® 2008;71:80-84
<table>
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<tbody>
<tr>
<td>SWS: completion time, s</td>
<td>50* [30-75]</td>
<td>41* [26-54]</td>
<td>30* [23-52]</td>
<td>90* [27-120]</td>
<td>24* [20-38]</td>
</tr>
<tr>
<td>SWS: number of steps</td>
<td>48* [37-80]</td>
<td>41* [31-67]</td>
<td>32* [26-48]</td>
<td>60* [34-90]</td>
<td>25* [21-40]</td>
</tr>
<tr>
<td>SWS: number of freezing episodes</td>
<td>3* [2.5-3.5]</td>
<td>2* [1-2.5]</td>
<td>0.75* [0-1.25]</td>
<td>4* [3.5-10]</td>
<td>0* [0-0]</td>
</tr>
<tr>
<td>UPDRS subscore: gait (/4)</td>
<td>2.5 [2-3]*</td>
<td>1 [1-2]*</td>
<td>—</td>
<td>—</td>
<td>1 [1-2]*</td>
</tr>
<tr>
<td>UPDRS subscore: rest tremor (/20)</td>
<td>2 [2-3]*</td>
<td>1 [0-2]*</td>
<td>—</td>
<td>—</td>
<td>1 [1-2]*</td>
</tr>
<tr>
<td>UPDRS subscore: rigidity (/20)</td>
<td>8 [6-9]*</td>
<td>5 [3-6]*</td>
<td>—</td>
<td>—</td>
<td>6 [3-9]*</td>
</tr>
<tr>
<td>UPDRS subscore: akinesia (/32)</td>
<td>16 [14.5-16]*</td>
<td>16 [14.5-16]*</td>
<td>—</td>
<td>—</td>
<td>11 [9-11]*</td>
</tr>
</tbody>
</table>
In our study, we identified several predictive factors correlated with a response to LFS for patients with severe gait disorders after 3 to 5 years of stimulation: an elevated age, an axial phenotype, a lower dopasensitivity before stimulation and a loss of dopasensitivity one year after stimulation.
Short Pulse Width in Subthalamic Stimulation in Parkinson’s Disease: a Randomized, Double-Blind Study

Walid Bouthour, MD,1,2 Jennifer Wegryzky, PhD,1 Shahan Momjian, MD,3 Julie Peron, PhD,1 Vanessa Fleury, MD,1 Emilie Tomkova Chauoi,1 Judit Horvath, MD,1 Colotte Boex, PhD,3,1 Christian Lüscher, MD,1,2 Pierre R. Burkhard, MD,1 Paul Krack, MD, PhD,1 and Andre Zacharia, MD1,4

Results: The therapeutic window widened when the pulse width shortened ($r = -0.45; P < 0.001$), and charge per pulse was reduced ($P < 0.05$).

Conclusions: This randomized, double-blind study showed that shorter pulse widths widen the therapeutic window of STN-DBS in PD without increasing the electrical charge required to obtain the same acute clinical benefit. © 2017 International Parkinson and Movement Disorder Society

Key Words: deep brain stimulation; subthalamic nucleus; Parkinson’s disease; pulse width; rigidity

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Pulse Duration Settings in Subthalamic Stimulation for Parkinson’s Disease

Frank Steigerwald, MD,1 Lars Timmermann, MD,2 Andrea Kühn, MD,3 Alfonso Schnitzler, MD,4 Martin M. Reich, MD,1 Anna Dalal Kirsch, MD,1 Michael Thomas Barbe, MD,2 Veerle Visser-Vandewalle, MD,2 Julius Hübl, MD,3 Christoph van Riesen, MD,3 Stefan Jun Groiss, MD,4 Alexis-Sabine Moldovan, MD,4 Sherry Lin, PhD,5 Stephen Carciari, PhD,5 Ljubomir Manola, PhD,6 and Jens Volkman, MD1*

Results: The therapeutic window was the difference between patients’ efficacy and side effect thresholds.

Interpretation: Subthalamic neurostimulation at 30 μs versus 60 μs pulse width is equally effective on PD motor signs, is more energy efficient, and has less likelihood of stimulation-related side effects. © 2017 The Authors. Movement Disorders published by Wiley Periodicals, Inc. on behalf of International Parkinson and Movement Disorder Society

Key Words: Deep brain stimulation; Parkinson’s disease; pulse width; stimulation parameters; subthalamic
Choosing between manufacturers

- Long term reliability
- Commercial support
  - MRI compatibility
- PC & rechargeable systems
  - IPG size & longevity
- Programming options
  - Directional leads
- Research compatibility
Adaptive Deep Brain Stimulation in Advanced Parkinson Disease

Simon Little, MA, MBBS,1 Alex Pogosyan, PhD,1 Spencer Neal, BEng (Hons),2 Baltazar Zavala, BA,1 Ludvic Zrinzo, PhD,2 Marwan Hariz, PhD,2 Thomas Foltynie, PhD,2 Patricia Limousin, PhD,2 Keyoumars Ashkan, MD,3 James FitzGerald, PhD,1 Alexander L. Green, PhD,1 Tipu Z. Aziz, PhD,1 and Peter Brown, MA, MBBS, MD1
Negative effects of implanting hardware ~1%
Alternatives to DBS
Stereotactic Thalamotomy
Non Invasive “surgery”
MR guided Focused Ultrasound (MR-gFUS)

Fig. 2. Patient positioned at the MR table with stereotactic frame mounted onto the focused ultrasound transducer. The frame is used for head fixation only, since the procedure is entirely MR image-guided. A flexible membrane around the patient’s head seals the circulating and cooling degassed water.
A Randomized Trial of Focused Ultrasound Thalamotomy for Essential Tremor

W. Jeffrey Elias, M.D., Nir Lipsman, M.D., Ph.D., William G. Ondo, M.D., Pejman Ghanouni, M.D., Ph.D., Young G. Kim, M.D., Ph.D., Wonhee Lee, M.D., Ph.D., Michael Schwartz, M.D., Kullervo Hynynen, Ph.D., Andres M. Lozano, M.D., Binit B. Shah, M.D., Diane Huss, D.P.T., N.C.S., Robert F. Dallapiazza, M.D., Ph.D., Ryder Gwinn, M.D., Jennifer Witt, M.D., Susie Ro, M.D., Howard M. Eisenberg, M.D., Ph.D., Paul S. Fishman, M.D., Ph.D., Dheeraj Gandhi, M.D., M.B., B.S., Casey H. Halpern, M.D., Rosalind Chuang, M.D., Kim Butts Pauly, Ph.D., Travis S. Tierney, M.D., Ph.D., Michael T. Hayes, M.D., G. Rees Cosgrove, M.D., Toshio Yamaguchi, M.D., Ph.D., Keiichi Abe, M.D., Takaomi Taira, M.D., Ph.D., and Jin W. Chang, M.D., Ph.D.
First experience with MR-guided focused ultrasound in the treatment of Parkinson's disease

Anouk Magara1, Robert Bühler2, David Mose2, Milk Kowalski4, Payam Pourtehran2 and Daniel Jeanmonod3

### Graphs

**A**
- Pre-FUS: Green bars
- 3 months Post-FUS: Pink bars
- Patient Number: x-axis
- UPDRS Score: y-axis

**B**
- Group 1: Mean = 7.6 [%]
- Group 2: Mean = 60.9 [%]
- Patient Number: x-axis
- UPDRS Score Reduction [%]: y-axis

**C**
- Group 1: Mean = 22.5 [%]
- Group 2: Mean = 96.7 [%]
- Patient Number: x-axis
- Global Symptom Relief [%]: y-axis
Experimental surgical options

- Gene therapy
- Cell therapy
Long-term safety and tolerability of ProSavin, a lentiviral vector-based gene therapy for Parkinson’s disease: a dose escalation, open-label, phase 1/2 trial

Stéphane Poźni, Jean Marc Gourbage, C Scott Ralph, Helene Lapet et, Sonia Lavisse, Philip C Butcher, Colin Watts, James Minkin, Michelle Kellereit, Sarah Dray, Nikkiezu Inammers, Jean-Pascal Lefebvre, Claire Thirion, Gilles Feneux, Cherri Lucas, Pierre Brugliera, Ioanna Gabriel, Kou Almog, Xavier Chatz, Nnaka Tare, Aurélie Kros, Alain Ghebre, Philippe Le Corre, Patrick Delhez, David P Irene, Sarah Mason, Natalie Valerie Guzman, Nicholas D Mazoroski, Pierre A Radcliffe, Richard Morgan, Susan Williams, Olivier Rascot, Stuart Naylor, Roger A Baner, Philippe Henvry, Philippe Remy, Pierre Crozes, Kyriacos A Mitropoulos

Summary

Background Parkinson’s disease is typically treated with oral dopamine replacement therapies; however, long-term treatment leads to motor complications and, occasionally, impulse control disorders caused by intermittent stimulation of dopamine receptors and off-target effects, respectively. We aimed to assess the safety, tolerability, and efficacy of bilateral, intratratal delivery of ProSavin, a lentiviral vector-based gene therapy aimed at restoring local and continuous dopamine production in patients with advanced Parkinson’s disease.

Two-dimensional FLAIR MRI sequences

\[ ^{12}C\text{-raclopride PET} \]

Baseline  | 6 months
---|---
Caudate nucleus | (23.4%) | (43.1%)
PostCom putamen | (30.3%) | (61.7%)

Mean change in UPDRS part III motor score

All patients | Cohort 1 (n=3) | Cohort 2a (n=3) | Cohort 2b (n=3) | Cohort 3 (n=6)
---|---|---|---|---
-13  | -11  | -12  | -14  | -13
Long-term Clinical Outcome of Fetal Cell Transplantation for Parkinson Disease
Two Case Reports

Zinovia Kefalopoulou, MD, PhD; Marios Politis, MD, PhD; Paola Piccini, MD, PhD, FRCP; Niccolo Mencacci, MD; Kailash Bhatia, MD, PhD; Marjan Jahanshahi, PhD; Håkan Widner, MD, PhD; Stig Rehncrona, MD, PhD; Patrik Brundin, MD, PhD; Anders Björklund, PhD; Olle Lindvall, MD, PhD; Patricia Limousin, MD, PhD; Niall Quinn, MD; Thomas Foltynie, MRCP, PhD

Motor scores on the Unified Parkinson’s Disease Rating Scale (UPDRS) during “off” phases for patients 7 (A) and 15 (B) pretransplantation (point 0) and at different follow-up times posttransplantation: “practically defined off”: morning motor evaluations after 12-hour withdrawal of Parkinson disease medication and worst “off.” Motor evaluations to reflect severity of motor disability documented at other points during an inpatient admission.5
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- Dilan Athauda
- Dejan Georgiev
- Philipp Mahlknecht
- Patricia Limousin
- Andrew Lees
- Ludvic Zrinzo
- Marwan Hariz
- Marjan Jahanshahi
- Tom Warner
- Kailash Bhatia
- Eileen Joyce
- Mark Edwards
- Huw Morris
- Niall Quinn
- John Hardy
- Nicholas Wood
- Anthony Schapira
- John Thornton
- Peter Brown
- Roger Barker
- David Burn