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- **Article title:**

Subthalamic Nucleus DBS in Parkinson's disease: Valuable programming insights from anecdotal observations.

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- **Short title**

Case Report: STN-DBS programming insights

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- **Word count:**

825 words

- **Key words:**

Parkinson's disease, Subthalamic Nucleus, Deep Brain Stimulation, Programming

SUBTHALAMIC NUCLEUS DBS IN PARKINSON'S DISEASE: VALUABLE PROGRAMMING INSIGHTS FROM ANECDOTAL OBSERVATIONS

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Deep Brain stimulation of the subthalamic nucleus (STN-DBS) usually produces marked improvements in contralateral motor function in Parkinson's disease (PD) patients, which are largely immediately apparent on initiating stimulation [1–3]. This is a straightforward process in the majority of patients with standard programming algorithms [4,5]. However, it is important for the programmer to be aware of anatomical and device related anomalies that may present difficulties in some cases, and here we present such a case to share valuable clinical insights.

We discuss the case of a 56 year old patient with PD (disease duration 19 years) who had STN-DBS with a Medtronic Activa PC device 8 years ago. He had a very good response to DBS (66% improvement in UPDRS–III off medication) and reduced his levodopa equivalent medication dose from 1730mg to 690mg accompanied by the following stimulation settings: 1- 4.7V, 60 μ s, 80Hz and 10- 4.7V, 60 μ s, 80Hz. As a result of dysarthric speech, he was reprogrammed using short pulse width (30 μ s) stimulation via a Boston Scientific implantable pulse generator (IPG) which replaced his depleted Activa PC battery by connecting it to the existing cables using a Precision M8™ adaptor.

After the IPG replacement, the patient's motor symptoms did not seem to respond adequately to stimulation titrated up to 5.0 mA at each STN electrode, initially using standard 60 μ s pulse duration with the frequency unchanged. The impedance readings were

noted to be 733 Ω and 795 Ω at the respective active contacts. Subsequent conversion of his original amplitudes to current–constant settings gave equivalent values of 6.4mA and 5.9mA. The patient improved to his baseline level of function with these settings, and further improvements in mobility, balance, and speech were successfully achieved using short pulse (30 μ s) stimulation with amplitudes of 12.3 and 11.2 mA at the right and left STNs. The charge per pulse (Amplitude x Pulse width) in nanocoulombs at the 60 μ s settings were 384 and 354nC at the right and left STNs respectively, and at 30 μ s settings these were 369 and 336nC.

Lesson 1: Impedances should be taken into account when converting settings between voltage-constant and current-constant devices, as amplitudes required for an equivalent effect can vary significantly. Electrical equivalence can be calculated simply by using Ohm's law as a guide (Current= Voltage/Impedance) [6]. Despite the unconventionally high amplitudes eventually used with 30 μ s settings, the charge per pulse of stimulation is not greater than that of the original settings, and the high amplitudes in terms of current are reflective of relatively low impedances (although still within the normal range), and the short pulse duration [7]. The published data on short pulse stimulation suggest when converting from 60 μ s settings, multiplying the amplitude by a factor of 1.5 can be used to estimate the amplitude required for the same therapeutic effect at 30 μ s [8–10]. However, as illustrated in this case, some patients may require higher amplitudes at 30 μ s, and double the amplitude at 60 μ s results in an equivalent charge when using 30 μ s settings.

The patient returned four months later after a period of excellent symptom control, with a significant deterioration over the course of hours featuring severe bradykinesia on the right side of his body affecting hand dexterity, gait, and speech. Impedance recordings from the

left STN were all within normal ranges. There was an abnormally low impedance recording of 151Ω of the right STN indicating a short circuit between the active contact and a contact two levels higher. As this did not obviously explain the deterioration to this right hemibody, extensive attempts at reprogramming including using alternative left-sided contacts were made, and the IPG data log was also interrogated for any evidence of device failure, both to no avail. It was noted that the patient was known to have had an ipsilateral therapeutic response to stimulation of the right STN during his original monopolar review. The abnormal impedance on the right side was resolved by replacing the cable connecting the IPG to the right electrode.

Lesson 2: It is important to be conscious of anatomical variations and the impact these may have on stimulation effects. In this case the hypothesis was that the patient had a dominant right STN [8,9], with the short circuit resulting in deterioration of ipsilateral symptoms.

Disappointingly, there was no initial improvement in the patient's right sided symptoms despite resolution of the ipsilateral impedance issue for 4 days, although his gait and mobility did improve slightly. However, on day 5, he noticed a significant improvement in right hand bradykinesia and speech, and over the subsequent day he returned to his previous optimal level without any changes to medications and stimulation settings.

Lesson 3: While therapeutic motor effects of STN stimulation are usually time-locked to changes and almost immediately evident for the most part, some patients may have a significantly delayed clinical response which may lag by several days. Apart from contact location and stimulation parameters, this possibility should be a consideration in cases of an initial suboptimal response.

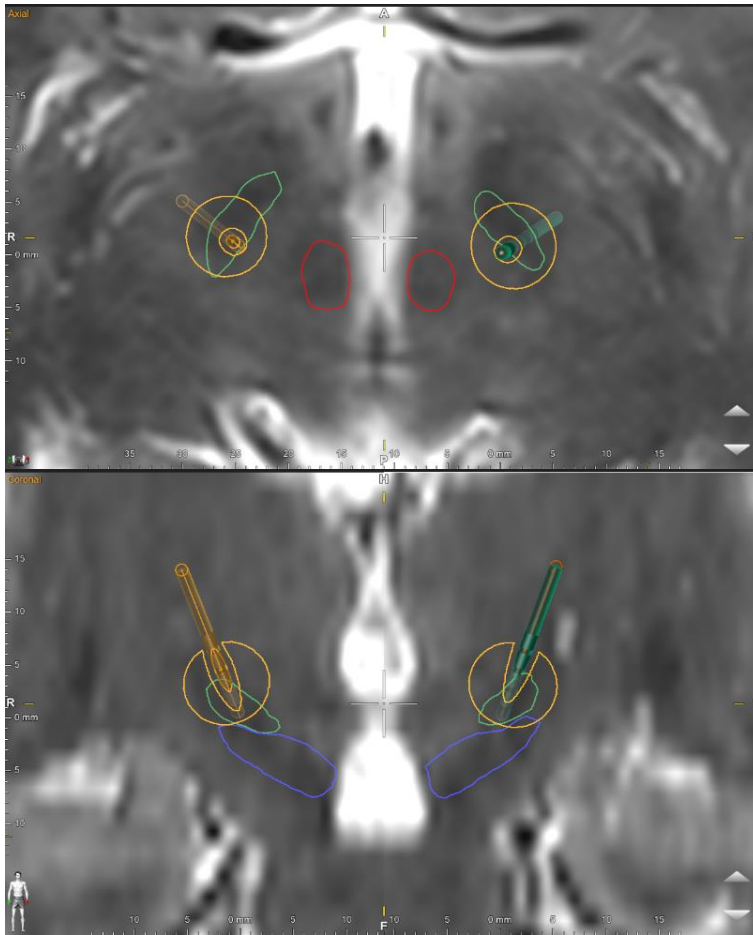


Figure 1

Intraoperative stereotactic axial (top) and coronal (bottom) T2-weighted MR images of the patient showing electrode placement in the subthalamic nuclei (green). The red nuclei are segmented in red in the axial view, and the substantia nigra in indigo in the coronal view. The volume of tissue activated (VTA) on each side using the patient's final settings are modelled in yellow using Boston Scientific Guide™ XT software.

Acknowledgements

We would like to thank the patient involved in this case report.

Statement of Ethics

All procedures described in this case report were carried out under the institution's usual standard of clinical care, and no experimentation was performed. The patient provided written informed consent for use of clinical information and images for publication.

No funding was received for this work.

Disclosures:

TF has received grant support from NIHR, John Black Charitable Foundation, Rosetrees Trust, Michael J Fox Foundation, and Cure Parkinson's Trust. He has honoraria for speaking at meetings supported by Boston Scientific, BIAL and Profile Pharma. He serves on advisory boards for BIAL, Oxford Biomedica and Peptron. VD has received honoraria and travel expenses from Boston Scientific. HA has received honoraria and travel expenses from Boston Scientific and BrainLab. PL and LZ have received honoraria and travel expenses from Medtronic and Boston Scientific for speaking at meetings.

Author contributions

VD: Writing of the first draft, HA: Images and VTA modelling; LZ, PL, TF: critical review and revisions of manuscript; All authors: clinical care.

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