

# Parkinson's Disease

*Since the mid-1990s, Deep Brain Stimulation Has Been Used to Decrease Motor Symptoms*

Hong Yu, MD

Member, International Neuromodulation Society

Clinical Assistant Professor, Department of Neurosurgery, Stanford University, Stanford, California, USA

Konstantin V. Slavin, MD

Director-at-Large, International Neuromodulation Society, 2011-2014

Professor, Department of Neurosurgery, University of Illinois at Chicago, Chicago, Ill., USA

While there is no known cure for Parkinson's disease, which affects up to one of every 30 people over age 65, treatment options continue to evolve. The neurodegenerative disorder itself can take time to become gradually apparent.

In the case of "John" (whose name and minor details have been altered), the onset began with a slight tremor in his left arm. Then his family noticed that his left leg would drag when he walked. Looking back, attentive family members recalled his left arm also didn't swing much when he walked. Over the next year or so, these symptoms gradually worsened and spread. Eventually, the stiffness and slowness severely interfered with even the most mundane activities, such as dressing or walking. After consultation with a neurologist, John's Parkinson's disease was diagnosed.

## Loss of Dopamine, Movement Problems

He was far from alone; Parkinson's disease is the second most common neurodegenerative disease, affecting an estimated that 4 million people worldwide. The main signs include tremor at rest, stiffness (also known as rigidity), and slow movement (also known as bradykinesia).

Parkinson's is caused by progressive loss of dopamine-producing neurons in the brain area known as the substantia nigra. Dopamine serves as a chemical messenger linking areas of the brain in circuits that control movement. Depletion of dopamine disrupts normal function of these circuits, resulting in various motor symptoms. Dopamine replacement, in the form of a medication called levodopa, is the main medical therapy for Parkinson's.

---

Mild current from a brain 'pacemaker' offers an attractive alternative to surgical lesioning

---

Unfortunately, even with medication providing relief of initial symptoms for patients such as John, Parkinson's disease remains progressive, and there is currently no therapy that has been proven to cure or slow the progression of disease. It is estimated that 28% of Parkinson's patients suffer from debilitating motor symptoms despite optimal medical therapy. For many of these patients, surgical intervention can help restore the fluidity of movement that we all come to take for granted.

## Like a Pacemaker for the Brain

Deep brain stimulation (DBS) is a surgical treatment sometimes used in Parkinson's and other conditions. In this treatment, electrical current is applied to specific locations in the brain through implanted electrodes. These electrodes are connected by wires under the skin to a programmable internal pulse generator, similar to a heart pacemaker. The device delivers electrical impulses to specific brain areas that are involved in the motor control. High-frequency electrical stimulation at precise

locations in the brain is thought to restore the balance of the circuits that are disrupted in Parkinson's disease.

Prior to the introduction of DBS in the mid-1990s, the main surgical treatment for Parkinson's disease was lesioning, or the creation of targeted holes in specific areas of the brain. During lesioning procedures, it was observed that high-frequency stimulation at the same targets produced clinical effects similar to the lesioning itself. As the matter of fact, such stimulation was used for decades to confirm correctness of target and to predict lesioning effects. Therefore, as soon as technology advanced to allow such stimulation to be delivered continuously for a long time, surgeons did not hesitate to use it instead.

### Screening Patients for Surgical Treatment

Responsiveness to levodopa prior to operation has been shown to be the best predictor of DBS efficacy. Generally, a patient should have had symptoms for five years, to allow time to rule out the presence of atypical Parkinson syndromes, since DBS is not recommended for patients with these conditions. However, patients should not wait until their symptoms have advanced so far that they are severely debilitated all the time, even on maximum medication.

To objectively track the efficacy of DBS, most centers perform preoperative and serial postoperative clinical evaluations using motor testing scores, as well as obtaining quality of life and neuropsychological scores.

DBS is not recommended in cases of dementia, inadequately treated psychiatric illness, extensive brain atrophy, or medical conditions in which surgery is not advised. Patients should not undergo DBS implantation if they anticipate needing future MRI scans of the body (brain MRIs are usually OK). Complications of DBS surgery may include bleeding within the brain, hardware malfunction, skin erosion, and infection. Bleeding in a patient's brain has been reported to occur in less than 3% of electrode placements, and to cause permanent deficits in less than 1% of cases. Infection rates have been reported to be less than 10%, similar to other neurosurgical procedures. Infection usually requires hardware removal, as well as antibiotic therapy.

Adverse effects produced by stimulation are generally reversible once the stimulation has been turned off. In addition, the stimulation parameters can be adjusted, allowing greater flexibility in treatment.

The specific symptoms treated by DBS depend on the location of the implant. Although the exact mechanism by which DBS works is still unknown, it is believed that electrical stimulation at critical locations restores balance to the circuitry that is malfunctioning in Parkinson's disease. Each location that serves as a target for stimulation therapy is a critical station along the complex circuitry necessary for control of movement.

### Preparing for a Surgical Implant

Due to variations in individual anatomy, the surgeon will often modify the target choice based on the directly visualized brain region on the MRI. Unfortunately, most structures targeted in DBS have an indistinct boundary on currently available MRI; therefore this initial target choice is only an approximation. After selecting the target point, an entry point is chosen such that the trajectory path avoids vessels, thereby reducing the incidence of bleeding complications.

Mapping the target coordinates to the surgical field is traditionally performed using a rigid metal frame (stereotactic frame) to hold the patient's head still. More recently, there have been developments of frameless and miniframe systems, with equivalent accuracy and improved patient comfort.

Given the limitations of the current image-guided target localization methods, physiologic target confirmation plays a critical role in DBS implantation. Physiologic target confirmation is performed in the operating room, and consists of microelectrode recordings, test stimulations, or both. Unlike most surgical procedures, this part of the DBS implantation process is done with the patient awake so the surgical team can evaluate effects of stimulation on patient's symptoms and check for any side effects.

### Implanting the Neurostimulator

After John underwent preoperative testing, his physicians informed him he would be a good candidate for DBS. He had already weighed its risks and benefits.

On the day of the intraoperative mapping, he was brought into the operating room and given sedatives while his surgeon created two holes in his skull (one on each side) at the pre-planned entry sites and mounted an apparatus that would guide the test electrodes along the pre-planned trajectories. Then he was allowed to wake up fully before the microelectrodes were slowly advanced to the planned target in his brain.

The brain cell activity was amplified and translated into a chirping sound, which his surgical team listened to for characteristic nerve-firing patterns from various parts of his brain along the trajectory. Identification of areas where neuronal signals correlate to movements in specific areas of the body helped to refine the stimulation target further. Test stimulation provided the final confirmation of the optimal location. Clinical efficacy and side effects were noted for each test stimulation area. After the desired target was determined, the actual DBS electrode was inserted.

The electrode was then connected to an extension wire, which was tunneled under the skin down the neck and connected to the internal pulse generator implanted over the chest wall, much like a cardiac pacemaker. (Many centers do this part of surgery on a different day.) Altogether, implantation takes several hours.

### Finding Maximum Relief from Symptoms

A few weeks after his DBS system was implanted, John underwent his initial session to turn it on and test different settings to maximize relief of his symptoms.

While DBS is not a cure, it can significantly improve patients' quality of life, and has become an important part of the treatment of Parkinson's disease to improve patients' movement control. DBS has become the standard of surgical care for appropriately chosen patients like John, extending the time they can experience relief from disease symptoms.

As the use of DBS becomes more widespread, physicians are gaining a better understanding of the efficacy and limitations. Newer targets are being investigated to capture the symptoms still inadequately controlled by current methods.

**Please note:** *This information should not be used as a substitute for medical treatment and advice. Always consult a medical professional about any health-related questions or concerns.*

### Further reading

1. Lang AE. When and how should treatment be started in Parkinson disease? *Neurology* . 2009;72(7 Suppl):S39-43.
2. Weaver FM, Follett K, Stern M, et al. Bilateral deep brain stimulation vs best medical therapy for patients with advanced Parkinson disease: a randomized controlled trial. *JAMA* . 2009;301(1):63-73.
3. Zesiewicz TA, Sullivan KL, Arnulf I, Chaudhuri KR, Morgan JC, Gronseth GS, et al. Practice Parameter: treatment of nonmotor symptoms of Parkinson disease: report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* . 2010 Mar 16;74(11):924-31.

### Resources

National Institute of Neurological Disorders and Stroke

[http://www.ninds.nih.gov/disorders/parkinsons\\_disease/parkinsons\\_disease.htm](http://www.ninds.nih.gov/disorders/parkinsons_disease/parkinsons_disease.htm)

National Parkinson Foundation

[www.parkinson.org](http://www.parkinson.org)

Parkinsons Disease Foundation

[www.pdf.org](http://www.pdf.org)

The Michael J. Fox Foundation for

Parkinson's Research

[www.michaeljfox.org](http://www.michaeljfox.org)