Surgical Treatments

When should surgical treatment be considered?

For most people with Parkinson disease, levodopa and other medications are effective for maintaining a good quality of life. As the disorder progresses, however, some patients develop variability in their response to treatment, called “motor fluctuations.” During an “on” period, a person can move with relative ease, often with reduced tremor and stiffness. “Off” periods describe those times when a person is having more difficulty with movement. A common time for a person with Parkinson disease to experience an “off” period is just prior to taking the next dose of levodopa, and this experience is called “wearing off.” Another form of motor fluctuation is uncontrolled writhing movement (choreiform movement) of the body or a limb, which is called “dyskinesia.” For most people with Parkinson disease, wearing off and dyskinesias can be managed with changes in medications (see the “Medications for Parkinson disease" section above). However, when medication adjustments do not improve mobility or when medications cause significant side effects, surgical treatment may be considered.

Overview of Neurosurgical Procedures for Parkinson’s Disease.

Deep Brain Stimulation Procedures

Thalamic (thalamus) stimulation
(Vim DBS)
Reduces tremor but not the other signs of PD; approved by U.S. Food & Drug Administration (FDA) in 1997

Pallidal (globus pallidus) stimulation
(GPi DBS)
Reduces tremor, rigidity, bradykinesia, and gait disorder; approved by FDA in 2002

Subthalamic nucleus (STN DBS)
Reduces tremor, rigidity, bradykinesia, and gait disorder; approved by FDA in 2002

Many surgical teams now offer an alternative treatment called deep brain stimulation (DBS). DBS surgery involves placing a thin metal electrode (about the diameter of a piece of spaghetti) into one of several possible brain targets and attaching it to a computerized pulse generator, which is implanted under the skin in the chest (much like a heart pacemaker). All parts of the stimulator system are internal; there are no wires coming out through the skin. To improve control of symptoms, the stimulator can be adjusted during a routine office visit by a physician or nurse using a programming computer held next to the skin over the pulse generator. Unlike lesioning, DBS does not destroy brain tissue. Instead, it reversibly alters the abnormal function of the brain tissue in the region of the stimulating electrode. Although deep brain stimulation is a major new advance, it is a more complicated therapy that may demand considerable time and patience before its effects are optimized.

What are the possible brain targets for DBS?

There are now three possible target sites in the brain that may be selected for placement of stimulating electrodes: the globus pallidus (GPi), the subthalamic nucleus (STN), and the thalamus (the specific region of thalamus is called "Vim" (ventro-intermediate nucleus). These structures are small clusters of nerve cells that play critical roles in the control of movement. The effects of stimulating these brain regions are indicated in Table 1. Thalamic (Vim) stimulation is only effective for tremor, not for the other symptoms of PD. Stimulation of the globus pallidus or subthalamic nucleus, in contrast, may benefit not only tremor but also other parkinsonian disturbances such as rigidity (muscle stiffness), bradykinesia (slow movement), and gait problems. For most patients with PD, DBS of the globus pallidus or subthalamic nucleus are more appropriate choices than thalamic DBS because stimulation at these targets affects a broader range of symptoms.

How does DBS work?

The theoretical basis for DBS of the GPi or STN in PD was worked out in the late 1980s and early 1990s. In PD, loss of dopamine-producing cells leads to excessive and abnormally patterned activity in both the GPi and the STN. "Pacing" of these nuclei with a constant, steady-frequency electrical pulse corrects this excessive and abnormal activity. DBS does not act directly on dopamine-producing cells and does not affect brain dopamine levels. Instead, it compensates for one of the major secondary effects of dopamine loss, the excessive and abnormally patterned electrical discharge in the GPi or the STN. The mechanism by which the constant-frequency stimulation pulse affects nearby brain cells has not been determined.

How is the surgery performed?

The procedure for performing lesion surgery or implanting a brain electrode varies somewhat from one medical center to another. Typically these operations are performed with the patient awake, using only local anesthetic and occasional sedation. The basic surgical method is called stereotaxis, a method useful for approaching deep brain targets though a small skull opening. For stereotactic surgery, a rigid frame is attached to the patient's head just before surgery, after the skin is anesthetized with local anesthetic. A brain imaging study (usually MRI) is obtained with the frame in place. The images of the brain and frame are used to calculate the position of the desired brain target and guide instruments to that target with minimal injury to the brain.

After frame placement, MRI, and calculation of the target coordinates on a computer, the patient is taken to the operating room. At that point sedative medication is given and a patch of hair on top of the head is shaved. After administration of local anesthetic to the scalp to make it completely numb, an incision is made on top of the head behind the hairline and a small opening (1.5 centimeters, about the size of a nickel) is made in the skull. At this point, all intravenous sedatives are turned off so that the patient becomes fully awake.

To maximize the precision of the surgery, some surgical teams employ a "brain mapping" procedure in which fine microelectrodes are used to record brain cell activity in the region of the intended target to confirm that it is correct, or to make very fine adjustments of 1 or 2 mm in the intended brain target if the initial target is not exactly correct. The brain mapping produces no sensation but patients must be calm, cooperative, and silent during the mapping or else the procedure must be stopped. The brain's electrical signals are played on an audio monitor so that the surgical team can hear the signals and assess their pattern. Since each person's brain is different, the time it takes for the mapping varies from about 30 minutes to up to 2 hours for each side of the brain. The neurological status of the patient (such as strength, vision, and improvement of motor function) is monitored frequently during the operation by the surgeon or neurologist.

The procedures for lesion surgery and DBS differ once the target site has been confirmed by microelectrode recording. In the case of lesion surgery, a computer-controlled probe is used to create the desired lesion. This may take several minutes and some of the benefits may be observed immediately. Once the desired lesion has been made, the probe is removed and the skull and scalp are closed surgically.

If a person undergoes DBS implantation, once the target site has been confirmed by microelectrode recording, the permanent DBS electrode is inserted. After the DBS electrode is inserted and tested, intravenous sedation is resumed to make the patient sleepy. The electrode is anchored to the skull with a plastic cap, and the scalp is closed with sutures. The patient then receives a general anesthetic and is completely asleep for the placement of the pulse generator in the chest and positioning of a connecting wire between the brain electrode and the pulse generator unit. This part of the procedure takes about 40 minutes.

Would both sides of the brain be done at once, or only one side?

DBS on one side of the brain mainly affects symptoms on the opposite side of the body. Many patients have symptoms on both sides of the body. DBS leads can be placed on one side or both sides on the same operating day. The decision to place one or two stimulators in one operating day is made according to a patient's symptoms and general health. For elderly patients, or patients concerned about a longer operation, it may be best to stage the procedures a few weeks or months apart.

What are the benefits of surgery?

The major benefit of surgery for PD is that it makes movement in the off-medication state more like movement in the on-medication state. In addition, it may reduce levodopa-induced dyskinesias. The procedure is most beneficial for PD patients who cycle between states of immobility ("off" state) and states of better mobility ("on" state). Surgical treatments "smooth out" these fluctuations so that there is better function during the day. Symptoms that improve with levodopa (slowness, stiffness, tremor, gait disorder) may also improve with DBS. Symptoms that do not respond at all to levodopa usually do not improve significantly with DBS. Following DBS, there may be a reduction in need for, but not elimination, of antiparkinsonian medications. At present, it is believed that DBS only suppresses symptoms and does not alter the underlying progression of PD.

What are the risks of DBS surgery?

The most serious potential risk of the surgical procedures is bleeding in the brain, producing a stroke. This risk varies from patient to patient, depending on the overall medical condition and on the surgeon, but the average risk is about 2%. If stroke occurs, it usually does so during or within a few hours of surgery. The effects of stroke can range from mild weakness that recovers in a few weeks or months to severe, permanent weakness, intellectual impairment, or death.

The second most serious risk is infection, which occurs in about 4% of patients. If an infection occurs, it is usually not life-threatening, but it may require removal of the entire

DBS system. In most cases, a new DBS system can be re-implanted when the infection is eradicated. Finally, hardware may break or erode through the skin with normal usage, requiring it to be replaced. In the first few days after surgery, it is normal to have some temporary swelling of the brain tissue around the electrode. This may produce no symptoms, but it can produce mild disorientation, sleepiness, or personality change that lasts for up to 1-2 weeks.

What makes a patient a good candidate surgical treatment for Parkinson disease?

Deciding whether a person is a good candidate for surgical treatment is best determined by an evaluation by a neurologist or neurosurgeon familiar with the surgical treatment of Parkinson disease. In reviewing the outcome of many people who have undergone surgical treatment for Parkinson disease, the patients who derive the most benefit have good general health, normal intellectual and memory function for their age, and continue to experience benefit (however short) from levodopa.

Can patients control the DBS device themselves?

Following surgery, the patient is given the Medtronic Access Review unit, a hand-held battery-operated unit that can be used to determine whether the device is on or off, to turn it on or off, and to check battery life. The device does not at this time allow the patient to alter the intensity of stimulation. This is done in the physician's office. Normally, in DBS for Parkinson disease, the device is left on all the time. The next generation of DBS devices may allow some patient control over the intensity of stimulation

Is DBS surgery covered by health insurance?

Medicare now covers DBS for Parkinson disease. Insurance approval should be sought prior to hospital admission. There may be variation on private insurance coverage.