Treating Parkinson's

Deep Brain Stimulation

The surgical treatment of Parkinson's disease (PD) is the result of many decades of neurosurgical innovation, advances in brain imaging and new developments in biomedical engineering. Deep brain stimulation (DBS) surgery is the state-of-the-art neurosurgical treatment for the motor impairments of PD: stiffness, slowness, tremor, wearing-off episodes and dyskinesias. Introduced in the 1990s, DBS is now a standard treatment for advanced PD. DBS can be dramatically effective, especially for individuals who experience major tremors, uncontrollable twisting, writhing movements or disabling fluctuations in their Parkinson's symptoms throughout the day.

For individuals who are considering this elective procedure, it is important to understand not only the anticipated benefits of surgery, but also its limitations and potential risks, the technical aspects of DBS surgery and the procedures for therapy programming. Each person with PD is unique, and the goals of DBS differ for each individual.

What is Deep Brain Stimulation?

DBS consists of implanted electrodes that provide a continuous tiny electrical current to deep structures of the brain. In people with PD, as their dopamine cells degenerate, the electrical feedback loops of the deep brain structures function abnormally. Some parts have excessive activity while other parts are underactive. As a result, normal physical movement is replaced by tremor, rigidity and slowness. But by using a deep brain electrode that provides an electrical current, it is possible to jam the abnormal signaling between brain structures, and shift the electrical activity of the system towards normal function.

At the microscopic level, the precise effects of DBS remain unknown, but the electrical stimulation itself is effective, painless and safe. The electrical effects of DBS are largely and immediately reversible, and can be regulated by programming. DBS does not remove Parkinson's disease from the brain and does not repair or replace brain cells.

What are the Effects of DBS on PD Symptoms?

DBS surgery can reduce tremor, stiffness, slowness, wearing-off spells and dyskinesias. These effects can translate into gains in performing activities of daily living and improved mobility, independence, self-esteem and quality of life. Handwriting may improve, speech may become stronger and walking may be better. Some people who undergo DBS surgery may experience a significant improvement in sleep quality. Weight gain after surgery has been noted in many people with PD, sometimes attributed to the reduction in dyskinesias.

It is important to recognize that some symptoms of Parkinson's respond better to surgery than others. The effect of DBS on slowness and stiffness can generally be predicted from the response to individual doses of medication: if one or two tablets of medication can temporarily reverse an individual's symptoms of PD, it is likely that DBS will be effective.

Some people with Parkinson's have an excellent response to levodopa and other medications, with almost complete suppression of their symptoms, but they suffer from spells of wearing-off during which they become stiff, immobile and frozen. These individuals will benefit from surgery because at least some of the time, their symptoms can be improved by levodopa.

Other people with PD do not have a full response to levodopa. Even when benefiting from their best medication effect, they experience some degree of gait, balance or speech impairment. These individuals will not gain much relief from surgery. People with PD who cannot walk independently at their best on levodopa will still not be able to walk after surgery.

The guiding predictor of DBS outcome is "levodopa effect = DBS effect"… but there is one exception: severe tremor. Tremor responds well to DBS even when medications cannot suppress tremor. Therefore, a person with severe tremors that cannot be controlled by levodopa, even temporarily, often responds well to DBS.

Some people with PD who experience severe wearing-off spells also suffer from "non-motor fluctuations": episodes of anxiety, depression, bladder or bowel impairment, or painful sensations that fluctuate in parallel with their PD episodes of stiffness and slowness. It is unclear whether DBS can relieve these distressing symptoms and more research is needed to address this important area.

Age by itself does not exclude a person with Parkinson's from undergoing DBS. However, older individuals with Parkinson's are more likely to have cognitive impairment, gait freezing and falling. While advanced age does not preclude surgery, the best results are obtained in younger individuals.

DBS, Dementia and Depression

Most individuals tolerate deep brain stimulation without noticeable effects in their memory or thinking ability; in some studies, mood, behavior, mental clarity and self-esteem have improved.

There is a small group of people with PD who experience cognitive decline after surgery. These individuals are typically more elderly and have pre-existing dementia that may include word-finding difficulty, inability to carry out a sequence of tasks, problems with judging space and apathy. The presence of dementia at baseline is not an absolute disqualification to DBS if the person with Parkinson's has tremor and other symptoms that would otherwise benefit. However, if the results of pre-operative neuropsychological tests are poor, the appropriateness of DBS may be questioned.

A very small group of individuals has become seriously depressed after surgery and several suicides have been reported. Such individuals invariably had pre-existing depression, a frequent problem in PD that requires careful attention and expert treatment. In most centers, a history of depression or dementia is a disqualifying factor for surgery.

Long-Term Results of DBS Surgery

What happens in the years after DBS surgery? According to researchers at medical centers with the longest follow-up data, people with PD continue to experience marked benefits for many years after the

Individuals Who Will Most Likely Benefit from DBS Surgery Have:

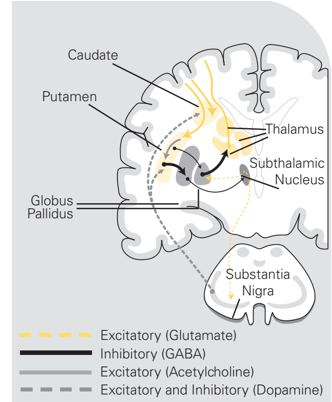
- typical "classical" PD, defined by the presence of tremor at rest, rigidity and slowness
- symptoms that still respond to individual doses of their PD medications even if the response is brief
- disabling PD symptoms in the "off" state
- uncontrollable medication-induced movements called dyskinesias
- severe tremors
- a good understanding of the potential benefits and risks of the operative procedures and evaluation, and the ability to give informed consent
- good general health
- a good emotional support network of family and friends

Individuals Who Will Likely *Not* Benefit from DBS Surgery Have:

- atypical or rare forms of parkinsonism, such as progressive supranuclear palsy (PSP), multiple system atrophy (MSA), corticobasoganglionic degeneration (CBGD) or a known acquired cause of parkinsonism such as stroke or brain trauma
- failure to experience any benefit from PD medications
- severe memory loss, confusion, hallucinations or apathy (these problems may actually get worse as a result of brain surgery)
- presence of freezing, balance problems and frequent falling
- a severe chronic psychiatric disorder such as psychosis, depression, bipolar disorder, alcoholism or a personality disorder
- inability to understand the potential benefits and risks of the operative procedures or to give informed consent
- significant medical problems that would unacceptably increase the surgical risk, such as cancer or serious heart disease
- no support network of family and friends

operation. Tremor, especially, remains well-controlled but rigidity and dyskinesias are also improved, and do not return to the baseline levels before the surgery. A person's ability to perform activities of daily living may gradually decline after the first year following surgery but remain improved even after five years or more. Many people with PD can reduce their medications after surgery and this reduction can persist.

Unfortunately, PD is a progressive condition. DBS does not prevent later complications of the disease, such as poor posture, speech impairment, gait freezing, balance problems, backwards falling or dementia.



Map of basal ganglia showing targets for surgery: globus pallidus, thalamus and subthalamic nucleus

Brain Targets for DBS

Electrodes can be placed in any brain structure. In Parkinson's, stimulation of two deep brain structures has consistently shown the broadest effects on PD motor symptoms: the subthalamic nucleus (STN) and the internal globus pallidus (GPi). The two approaches yield very similar results, and in clinical trials appear equally effective and safe.

A third brain structure — the ventrointermediate (VIM) thalamus — is the primary target for essential tremor and has also been used in Parkinson's for the rare individual whose only symptom is severe tremor that cannot be controlled by medication.

Most people with advanced PD require DBS on both sides of the brain to control symptoms on both sides of the body. DBS on one side generally helps symptoms only on the opposite body side. For people with PD who have tremor or other symptoms on only one side, one-sided stimulation may be considered. Gait problems and dyskinesias generally require stimulation on both sides of the brain. DBS can also improve parkinsonian symptoms in people with PD who have undergone previous brain surgery for Parkinson's, such as the older pallidotomy or thalamotomy procedures.

Subthalamic Nucleus Stimulation

The subthalamic nucleus (STN) is a small lens-shaped structure of about six mm in length located right beneath the much larger thalamus [see diagram on right]. The STN can be identified accurately using mapping techniques and a DBS electrode can be placed right through it, like a toothpick skewers an olive. Stimulation of the STN can improve not only tremor, but also slowness, rigidity, dyskinesias, speech, handwriting and dystonia. In carefully selected individuals, STN stimulation can reduce PD symptoms in the unmedicated state by 30 to 60 percent, as measured by standard rating scales.

Many people find that they require less PD medication after STN stimulation. Some can stop their medication altogether. As a result of the decreased need for medication, and perhaps also because of a direct stimulation effect, there may be a dramatic reduction — or even elimination — of dyskinesias.

The beneficial effects of STN stimulation generally parallel those of levodopa, but do not surpass the best result of medication. Its main advantage is improvement in wearing-off spells and dyskinesias.

Globus Pallidus Stimulation

The globus pallidus is a dense wedge of nerve tissue that occupies the center of the basal ganglia region. The deepest portion of the globus pallidus, named the posteroventral medial globus pallidus interna (GPi), is the site of the now-abandoned pallidotomy operation, and represents the main outflow connection from the globus pallidus to the thalamus. The globus pallidus is a larger and more complex structure than the STN, with a complicated internal circuitry. Like STN stimulation, globus pallidus stimulation has broad beneficial anti-PD effects.

Globus pallidus stimulation has effectiveness similar to that of STN stimulation. The operation is performed less frequently, perhaps due to neurosurgeons' preference or training. But in randomized comparisons, the result of bilateral globus pallidus stimulation is the same as that for STN stimulation: a 30 to 60 percent improvement in PD symptoms in the unmedicated state. Globus pallidus stimulation can also bring about substantial reductions in dyskinesias and dystonia.

It has been noted that people with Parkinson's who undergo DBS at the subthalamic nucleus can often reduce their medications by a greater amount than those who undergo stimulation of the globus pallidus. Based on this observation, it has been argued that the reduction in dyskinesias following globus pallidus stimulation is a direct effect of the procedure, whereas with STN stimulation, the improvement in dyskinesias results from decreased medication requirement. If medication reduction is a goal of DBS surgery, the STN target is preferred.

Getting Ready for DBS Surgery

The decision to undergo DBS surgery requires careful discussions with the individual, spouse, children and family, as well as the treating neurologist and neurosurgeon. If the decision is made to proceed with DBS, the person with Parkinson's must undergo pre-operative screening tests. The tests include a general medical examination, blood tests, an electrocardiogram, a chest x-ray, a brain imaging study, neuropsychological testing and any other data collection required by the institution's protocol. If everything turns out right, and the individual agrees to proceed, surgery can be scheduled.

The Brain Operation in Stages

DBS surgery involves the placement of an electronic device in stages. Each piece of the apparatus must be fitted into the person with PD and the procedures can be done in any order.

By far the most complicated and time-consuming part of the operation is placement of the DBS lead, which requires careful brain mapping. People with symptoms on both sides of the body require bilateral operations. Sometimes the two DBS leads are implanted in the same operation; at other times, they are staged over two operations that are weeks or months apart. Similarly, some surgeons place the entire apparatus — DBS lead, connector and implantable pulse generator (IPG) — in a single, marathon procedure. Others first perform only the DBS lead insertion and delay the rest of the work to a second, outpatient procedure the following week.

The Day of Surgery

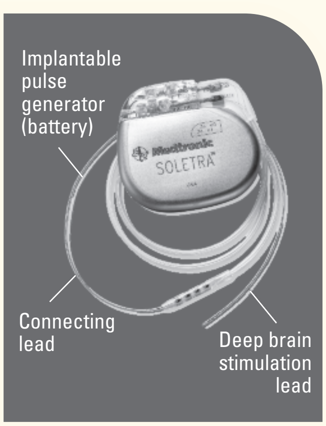
Procedures vary from hospital to hospital but the operations generally take three to six hours and are usually performed while individuals are awake, without medication and experiencing PD symptoms. It may sound frightening but it usually proceeds smoothly and without incident or discomfort.

The first step of the brain operation is placement of the stereotactic head frame — a large, open casing made of metal bars that is screwed into the individual's skull at four points. The attachment of the frame is critical to a successful result because the head must be maintained in a fixed position throughout the operation. The head frame is mounted under local anesthesia and is not painful, though some people complain of headache afterwards. The scars are tiny and heal completely.

Different techniques can be used for the head frame attachment but all are variations on the basic method. The frame is usually placed on the person's head on the day of the operation but it can be also done on the days before the operation. Sometimes, the anchoring screws are placed in advance of the op-

Technical Details of DBS

A deep brain stimulator consists of three parts: (1) DBS lead, or electrode, (2) connecting lead, or wire, and (3) IPG.



1. The DBS lead is an insulated wire with four contacts at its end. The lead is inserted deep into the brain so that its tip directly stimulates the chosen target site. Its other end, near the surface of the brain, is anchored to the inside of the skull.
2. The connecting wire runs under the skin from the DBS lead at the scalp site, behind the ear and down the neck into the chest or abdomen where it connects to the battery pack, or implantable pulse generator (IPG).
3. The IPG resides like a pacemaker beneath the skin of the chest wall under the collar bone, or can be implanted in the abdomen. The IPG is a metal disc about two-to-three inches in diameter and one-half inch thick. It contains a small battery and a computer chip. The IPG sends electrical impulses through the connecting wire to the DBS electrode implanted in the brain.

eration so that the head frame may be more efficiently attached on the day of surgery. And sometimes, the head frame is fastened to the operating table to serve as a scaffold for all mapping and surgical procedures, while other neurosurgeons use a "frameless" approach, in which the frame is not fixed to the operating table. In all approaches, patient comfort is optimized, and the most important consideration is the accuracy of targeting.

The goals of the operation are (i) to place electrodes deep inside the brain with millimeter accuracy, and (ii) to avoid damaging other sensitive structures, such as blood vessels. The successful outcome and the risks of the procedure depend critically upon accurate targeting. After the head frame is attached, the person with PD undergoes a brain imaging scan while wearing the apparatus. The calibrations on the head frame are merged with the brain image to form a computerized map of the brain. This map becomes the blueprint for planning and measuring the trajectories of the electrodes into brain.

Because of the need to communicate with the operative team, a person with PD usually undergoes surgery while awake. Light anesthesia is given to ease any discomfort or anxiety; and virtually no patient has any recollection of the operation afterwards. After providing local anesthesia to the scalp, the surgeon next creates an operative field by drilling a small opening into the top of skull, called a burr hole. The burr hole is the passageway for the insertion of the stimulating electrode into the brain. Since the brain is completely devoid of sensation, the rest of the operation is painless. During the procedure, the neurosurgeon and operating room staff converse with the patient to find out what symptoms he or she may be experiencing.

As an additional means to ensure the accuracy of the surgical probe, some hospital centers perform electrical brain mapping during surgery. This technique uses tiny electrodes that can record electrical activity directly from individual brain cells in the deep brain regions. The microelectrodes are much smaller and more delicate than the electrodes that provide the deep brain stimulation. They are used to identify cells within the thalamus, globus pallidus, subthalamic nucleus and adjacent brain structures, and the information they provide helps steer the main probe towards the desired surgical target.

For individuals who have PD symptoms on both sides of their body, electrode insertions need to be performed on both sides of the brain. After the first DBS electrode has been placed, the procedure is repeated on the opposite side. Another burr hole is made, the brain mapping is done all over again and the second-side insertion of the deep brain electrode is accomplished — all within the same operation.

Step-By-Step Plan of Operation for Deep Brain Stimulation Surgery

1. Head frame is attached to skull
2. Magnetic resonance imaging (MRI) is done for brain mapping
3. Burr hole is drilled in scalp under local anesthesia
4. Electrophysiological brain mapping using microelectrode is done
5. Deep brain stimulator electrode is inserted in brain
6. Implantable pulse generator (IPG) is placed in chest wall or abdomen
7. Connecting wire is attached to IPG in the chest, and tunneled under skin of neck to deep brain electrode at the scalp site

After the Brain Operation

The hospitalization required for a deep brain stimulator implantation is usually two or three days. Sometimes symptoms are dramatically improved after the DBS electrode is in position, even though the battery has not been attached and the system has not yet been activated. This effect is usually attributed to brain swelling at the tip of the electrode. After the operation, many individuals find themselves exhausted, and perhaps slightly confused. Some complain of mild headache. These symptoms usually resolve within 24 hours. Most individuals should remain on their pre-operative medication after the operation, although some centers begin a medication reduction protocol at this point. Typically, people return home with scalp staples or stitches in place, to be removed one week later in the surgeon's office once the scalp heals.

Implanting the Battery

The DBS electrode requires a power source. Once the deep brain electrode has been inserted, the remaining surgical task is implanting the extension wire and the battery, or implantable pulse generator (IPG). This may be done at the same time as the brain implant, or may be deferred to a later date — often, one week after the brain operation. The operation is relatively simple: the surgeon creates a subcutaneous muscular pocket, whether under the collarbone or in the abdomen, and inserts the IPG. The IPG is attached to the connecting wire, which is tunneled up into the neck, behind the ear and to the scalp site, where the external end of the DBS electrode was implanted previously. The connecting lead is attached to the DBS lead. At this point, the entire apparatus is in place under the skin. The incisions are closed using stitches or staples. The battery produces a visible bump on the chest, especially in people who are lean.

In recent years, DBS battery technology has improved, with batteries that last longer, provide more programming features, and can even be recharged. There are many battery options: one battery versus two, a standard battery versus a rechargeable battery, etc. For these decisions, individuals undergoing DBS can be advised by their neurologist and neurosurgeon. For individuals who already have an implanted cardiac pacemaker, the DBS battery can be implanted on the opposite chest or in the abdomen.

The battery implants are performed under general anesthesia. The procedure can be performed as an outpatient procedure. When individuals wake up after the procedure, they may experience chest or neck discomfort and require mild painkillers. Once the batteries and wires are connected, the deep brain stimulation system can be activated. Sometimes, the initial programming is done immediately after the batteries are implanted, but often, this step is postponed until the first post-operative visit. After the batteries are implanted, people with PD are discharged from the hospital, returning to the office the following week to have the stitches or staples removed. After the incisions heal, most individuals report that they do not feel the battery or the wires.

Medication Adjustment After DBS Surgery

Immediately after surgery, most individuals resume their pre-operative medication at their usual doses. However, after the stimulators are turned on and programmed, many people can reduce their medications, a process that must be carefully supervised by the treating neurologist. In some cases, eliminating medications that may be causing side effects is an explicit goal of surgery. Drugs that are associated with dyskinesias, such as entacapone or long acting carbidopa/levodopa, can sometimes be removed. Dopamine agonists that may cause hallucinations, excessive drowsiness or abnormal behaviors can also be reduced. For individuals taking levodopa, an optimal combination of medication and electrical stimulation can usually be determined during the first three months of stimulator adjustments.

Programming the Stimulator

After the operation, individuals must now begin a period of stimulator adjustments, performed over the course of several outpatient visits. Physicians and nurses who program the stimulator work with several variables at once: the way the electrode contacts are turned on, the frequency, pulse width and the voltage. The stimulator adjustments and settings are different for every person with PD. Some undergo surgery believing they will be immediately much better after the stimulator devices are activated. In practice, this improvement may take several weeks, even months, while the stimulator settings are being improved and the medications adjusted to an appropriate level.

In the first months following implantation, people with PD may require frequent stimulation adjustments. After this period, the electrical settings usually stabilize.

People with PD may check their deep brain stimulators using a hand-held device that resembles a television remote controller. Provided by the stimulator manufacturer, this lightweight plastic handheld device allows individuals to determine whether their stimulators are in the "on" or "off" position. If the stimulator has inadvertently been turned off, pressing a button on the remote will turn it back on. In addition, the handheld device can allow individuals to choose between different pre-set programs of stimulation, designated "A" or "B." The handheld device does not permit individuals to adjust their stimulator parameters themselves or perform any troubleshooting, although future versions may allow this. Any problems with the stimulator require a phone call or perhaps a visit to the medical center to have the device checked.

The life expectancy of the stimulator battery varies with output settings but is estimated at three to five years. As the energy in the battery becomes depleted, the efficacy of the stimulation starts to decline and PD symptoms increase. Individuals can check the battery status using the handheld device or the neurologist can do this in the office. In order to avoid an interruption in DBS therapy, it is important to replace the battery before it completely depletes.

The battery replacement is performed under light general anesthesia in an ambulatory surgical procedure that takes about one hour. The old IPG is removed from the chest or abdomen site by re-opening the incision. The device is disconnected from the connecting lead, the new IPG is inserted and hooked up, and the incision is again closed with stitches or staples. Externally rechargeable batteries eliminate the need for battery replacement but for most individuals, the need for frequent recharging is too cumbersome.

Risks of Deep Brain Stimulation

The risks of DBS can be separated into two categories: the risks of the surgical procedures and the risks of stimulation. The most serious potential risks are associated with the implantation of the brain electrodes. Like all types of surgery, operator experience is the most important determinant of risk. The lowest complication rates are at major centers that perform this type of highly specialized surgery on a weekly basis.

Risks of Surgery

Potential complications of DBS range from mild headache or drowsiness to more serious or irreversible effects, such as stroke or hemorrhage. Some people with PD, especially those who are already suffering from mild cognitive problems, may experience post-operative sleepiness, disorientation, confusion, slowness of mental processing, hallucinations, poor motivation or depression. These events typically resolve within 24 or 48 hours but may last longer. After bilateral subthalamic nucleus stimulation, some individuals have experienced difficulty opening their eyes. At medical centers that have the most experience with DBS, the risk of stroke or bleeding is less than five percent per stimulator placement.

Because DBS involves implanted hardware, there is a risk of infection. Despite every precaution, a skin infection can sometimes occur at the battery site in the chest wall or abdomen, or along the wiring in the neck or at the scalp. If the skin breaks down and an infection tracks into the device or its wiring, antibiotics may be required. In some cases, the entire apparatus must be removed and replaced.

Risks of Stimulation

Programming the deep brain stimulator can be a slow and tedious task. Individuals are often asked to withhold their medication for several hours before a programming session so that the DBS center personnel can determine the best device settings. Sometimes during a programming session, individuals may experience temporary tingling or shocking sensations, or uncomfortable muscle spasms.

Additional stimulator-induced problems may include balance impairment, dizziness, speech difficulties or a general vague sensation of "not feeling right." There are rare reports of stimulation-induced feelings of depression, despair or impulsive behavior. Deep brain stimulation can also induce dyskinesias that resemble the dyskinesias caused by levodopa.

All stimulator-induced effects are temporary and reverse promptly with a change in the DBS settings. After a programming session, it is a good idea for individuals to wait at the center for an hour or so before returning home just to make sure that the new stimulator settings are well-tolerated.

People with PD with implanted deep brain stimulators are generally allowed to participate in any physical activity they choose. However, it is important not to engage in activities that could subject the device or wires to a direct physical blow or acceleration stress, such as contact sports or chiropractic neck manipulation. Sometimes, with repeated trauma, the connecting lead or the battery erodes through the skin, requiring replacement.

Deep brain stimulators may switch off by accident if an individual walks through a magnetic field, such as a security device or theft detector. This carries no permanent risk to the person with PD or stimulator device. When the stimulator switches off, however, PD symptoms can immediately return. If this happens, the person may re-activate the stimulator using the handheld device.

There is an important warning that people with PD with implanted brain electrodes should not undergo ultrasound diathermy, a treatment that involves applying a heating coil to the skin.

It is also recommended that individuals with implanted brain stimulators check with their neurologist before undergoing magnetic resonance imaging (MRI) scans, a technique that exposes individuals to a powerful magnetic field. A brain MRI can be safely obtained on people with implanted DBS electrodes, as long as the devices are set to zero voltage output and turned off. But MRI scans should not be performed on other parts of the body (back, hip, knee, etc.) in patients with DBS because a full body MRI scan requires a more powerful magnetic field. In case of questions about the stimulator, individuals should always contact their treating neurologist, who may recommend a return visit to the medical center for a device check. Future generations of DBS electrodes will be entirely-MRI compatible.

Some have argued that surgery should be performed on people with mild PD in order to delay the progression of the disease or forestall complications of medication usage. This notion is not justified because there is no evidence that earlier surgery can slow disease progression or protect brain cells. Current surgical techniques, along with medications, provide benefit only by suppressing the symptoms of PD. There is no evidence that DBS is neuroprotective. The risks and inconveniences of surgery underscore its role as a treatment of last resort, after medication options have been thoroughly tried.

Insurance and Deep Brain Stimulation Surgery

Most private insurers, as well as Medicaid and Medicare, will cover the expenses of deep brain stimulation surgery, including the operation, anesthesia, neuroimaging, hospital care, physician's fees, and the stimulator devices. Medicare covers 80 percent of the cost of the surgical procedures; for most individuals, the remaining 20 percent is provided by a secondary insurance carrier. Individuals with no secondary medical coverage are advised to speak with the administrator at their surgery center. It is important to note that DBS is considered standard therapy that should be covered by all medical insurance carriers.

Should I Have DBS Surgery?

The decision to undergo DBS is a very individual choice. Tens of thousands of people with Parkinson's worldwide have undergone this procedure and experienced long-lasting relief from unwanted symptoms. But the prospect of brain surgery and implanted hardware is not easy for some to accept. The potential complication risk is acceptably low to justify the procedure but adverse effects may still rarely happen. DBS is always an elective procedure, and the decision to have the surgery is usually driven by quality of life issues. Because DBS surgery and subsequent programming involve complex procedures, it is important to choose a surgical center that is well-established, has an excellent safety record, and possesses the resources and personnel dedicated to providing comprehensive care for DBS patients.

Is Deep Brain Stimulation a Cure?

No DBS is not a cure. A cure for PD would be a treatment that can stop the disease from progressing, and even reverse it.

For people with Parkinson's and their families, the progress is always too slow. But there are reasons to be optimistic. DBS has revolutionized the treatment of PD and has improved the quality of life for thousands of people with PD. It is anticipated that in coming years, many more scientific advances will be translated into benefits for people with Parkinson's and so the hope for a cure is linked with true promise and great optimism.

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