Deep Brain Stimulation for Movement Disorders

U.S. DEPARTMENT OF HEALTH
AND HUMAN SERVICES
National Institutes of Health

Deep Brain Stimulation for Movement Disorders

What is Deep Brain Stimulation?

Deep brain stimulation (DBS) is a surgical procedure used to treat disabling symptoms of neurological disorders, including dystonia, epilepsy, essential tremor, and Parkinson's disease. DBS uses a surgically implanted, battery-operated medical device called an implantable pulse generator (IPG)—similar to a heart pacemaker and approximately the size of a stopwatch—to deliver electrical stimulation to specific areas in the brain that control movement, which blocks the abnormal nerve signals that cause symptoms.

The DBS system consists of three components: the lead, the extension, and the IPG. The lead (also called an electrode)—a thin, insulated wire—is inserted through a small opening made in the skull and implanted in the brain. The tip of the electrode is positioned within a specific brain area, depending on the disorder. The extension is an insulated wire that is passed under the skin of the head, neck, and shoulder, connecting the lead to the implantable pulse generator. The IPG (the "battery pack") is usually implanted under the skin near the collarbone. In some cases, it may be implanted lower in the chest or under the skin over the abdomen.

Once the system is in place, and after a period of healing post-surgery, the device is programmed to sets of parameters that work best for each person, over several visits with a neurologist. The therapy works by delivering electrical pulses from the IPG along the extension wire and the lead and into the brain. These pulses change the brain's electrical activity pattern at the target site to reduce motor symptoms.

Which parts of the brain are targeted using DBS for movement disorders?

Before the procedure, a neurosurgeon uses noninvasive diagnostic imaging—either magnetic resonance imaging (MRI) or computed tomography (CT) scanning—to identify and locate the exact target in the brain for the surgery. Most surgeons use microelectrode recording—which involves insertion of a tiny wire that monitors the activity of nerve cells—to more specifically identify the precise brain area that will be stimulated.

For treatment of Parkinson's disease, DBS targets parts of the brain that play a role in the control of movement—the thalamus (which relays and integrates sensory and motor information), subthalamic nucleus (which helps direct movement preparation), or globus pallidus (which helps regulate intended movement). DBS for dystonia specifically targets the globus pallidus interna (involved in the regulation of voluntary movement), while DBS for essential tremor targets the thalamus. Different areas of the brain may be targeted for individuals with epilepsy who don't respond well to other therapies.

How is DBS being used to treat movement disorders?

Parkinson's Disease

DBS is used to treat the most commonly debilitating motor symptoms of Parkinson's disease (PD) such as rigidity, slowed movement, stiffness, tremor, and problems walking. It is used only for individuals whose symptoms cannot be adequately controlled with medication. However, only people who improve to some degree after taking medication for Parkinson's benefit from DBS. A variety of conditions may mimic PD but do not respond to medication or DBS.

Most people with PD still need to take medicine after undergoing DBS, but many people experience considerable reduction of their motor symptoms and may be able to reduce their medications. The degree of reduction varies by individual but can lead to a significant improvement in side effects such as dyskinesia (involuntary movements caused by long-term use of levodopa). In some cases, the stimulation itself can suppress dyskinesia without a reduction in medication. DBS does not improve cognitive symptoms in PD and may worsen them. Therefore, it is not generally used if there are signs of dementia. DBS does not slow the progression of the neurodegeneration.

Dystonia

For individuals with dystonia, DBS may reduce the disorder's characteristic involuntary muscle contractions that cause such symptoms as abnormal posture, repetitive movements, or twisting. DBS has been shown to reduce both the severity of symptoms caused by dystonia and the level of disability they may cause.

People with dystonia may respond better to DBS than medication; therefore, DBS may be an appropriate option for people who have found little or no improvement of symptoms after botulinum toxin injections (often the most effective treatment for some dystonia). DBS may be quicker to reduce symptoms of dystonia that migrates from place to place in the body than dystonia that remains fixed in a single body site, although both groups are likely to see improvement.

Essential Tremor

DBS targeting the thalamus can improve the involuntary movement of the arms, hands, and head that is associated with essential tremor.

Epilepsy

Brain stimulation for focal epilepsy (seizures that originate in just one part of the brain) may reduce the number of seizures over time. It is not a single therapy but is used along with anti-epileptic drugs.

DBS has been approved as add-on therapy for adults with focal epilepsy. Another form of treatment, called neurostimulation, uses an implanted monitor in the skull and tiny wires to give small pulses of stimulation to the brain when electrical activity in the brain looks like a seizure.

Are there advantages to DBS?

DBS involves minimal permanent surgical changes to the brain. If DBS causes unwanted side effects or more promising treatments develop in the future, the IPG can be removed and the DBS procedure can be halted. Also, stimulation from the IPG is easily adjustable—without further surgery—if the person's condition changes.

Some people describe the pulse generator adjustments as "programming."

What risks are associated with DBS?

Although minimally invasive, DBS is a surgical procedure and therefore carries some associated risk. There is a low chance that placement of the stimulator may cause bleeding or infection in the brain. Complications of DBS, such as bleeding and swelling of brain tissue, may result from mechanical stress from the device but are generally reversible. Other complications may include headache, seizures, and temporary pain following surgery. Also, the hardware may erode or break down with use, requiring surgery to replace parts of the device.

Side effects of the stimulation may include numbness or tingling sensations, behavioral changes, as well as balance or speech problems.

What research is being done?

The mission of the National Institute of Neurological Disorders and Stroke (NINDS) is to seek fundamental knowledge of the brain and nervous system and to use that knowledge to reduce the burden of neurological disease. NINDS is a component of the National Institutes of Health, the leading supporter of biomedical research in the world.

NINDS supports research on DBS to determine its safety, reliability, and effectiveness as a treatment for neurological disorders. NINDS-supported research on brain circuitry was critical to the development of DBS. Researchers are continuing to study DBS and to develop ways of improving it.

In one NINDS clinical study, researchers are monitoring the progress of participants over a two-year period who receive DBS for either Parkinson's disease, dystonia, or essential tremor. Participants will return periodically and will be examined and answer questions, their DBS placement will be evaluated with MRI, and their neurostimulator will be programmed. The monitoring will include tests of movements, thinking, and memory.

Other NINDS researchers are collecting data on the physiology and effectiveness of DBS therapy and motor and cognitive function in people with either Parkinson's disease, dystonia, or essential tremor who don't respond to other treatment. Data will include the change in motor symptoms measured before and three months after treatment. Intra-operative electrode recordings will investigate the neurophysiological mechanisms of DBS and explore the neural circuits essential for motor and cognitive processing in the basal ganglia.

For more information about current NINDS clinical studies on brain stimulation, see www.clinicaltrials.gov and search for "deep brain stimulation AND NINDS."

NINDS-supported researchers are developing and testing improved implantable pulse generators and new devices, and conducting studies to better understand and optimize the therapeutic effect of neurostimulation on neural circuitry and brain regions affected in neurological disease. Several research directions combine other tools, such as complex imaging of the brain, with DBS.

The Brain Research through Advancing Innovative Neurotechnologies (BRAIN®) Initiative spurs research to unlock the mysteries of the brain and accelerate the development of research and technologies to treat neurological disorders such as Parkinson's disease, essential tremor, and dystonia. For example, in one project aimed at treating essential tremor, researchers are using DBS devices that are capable of recording and stimulating simultaneously, to continuously monitor brain activity and deliver stimulation only when necessary to control tremor. This work may provide proof-of-concept for a first of its kind DBS system to treat essential tremor. For more information about the BRAIN Initiative, see www.braininitiative.nih.gov.

More information about DBS research for movement disorders funded by NINDS and other NIH Institutes and Centers can be found using NIH RePORTER (http://projectreporter.nih.gov), a searchable database of current and past research projects supported by NIH and other federal agencies. It includes links to publications and resources from these projects.

Where can I get more information?

For more information on neurological disorders and research programs funded by the National Institute of Neurological Disorders and Stroke, contact the Institute's Brain Resources and Information Network (BRAIN) at:

BRAIN
P.O. Box 5801
Bethesda, MD 20824
800-352-9424
www.ninds.nih.gov

More information is available from the following organizations:

Parkinson's Disease

American Parkinson Disease Association
135 Parkinson Avenue
Staten Island, NY 10305-1425
718-981-8001
800-223-2732
www.apdaparkinson.org

Davis Phinney Foundation
4730 Table Mesa Drive, Suite J-200
Boulder CO 80305
303-733-3340
866-358-0285
www.davisphinneyfoundation.org

Michael J. Fox Foundation for Parkinson's Research
Grand Central Station
P.O. Box 4777
New York, NY 10163
800-708-7644
www.michaeljfox.org

Parkinson's Foundation
200 SE 1st Street, Suite 800
Miami, FL 33131
800-473-4636
www.parkinson.org

Parkinson Alliance
P.O. Box 308
Kingston, NJ 08528-0308
609-688-0870
800-579-8440
www.parkinsonalliance.org

Parkinson's Resource Organization
74-090 El Paseo, Suite 104
Palm Desert, CA 92260-4112
760-773-5628
877-775-4111
www.parkinsonrecource.org

Dystonia

The Bachmann-Strauss Dystonia & Parkinson Foundation
P.O. Box 38016
Albany, NY 12203
212-509-0995
www.dystonia-parkinson.org

Dystonia Medical Research Foundation
1 East Wacker Drive, Suite 1730
Chicago, IL 60601-1980
312-755-0198
800-377-3978
www.dystonia-foundation.org

Essential Tremor

International Essential Tremor Foundation
P.O. Box 14005
Lenexa, KS 66285-4005
913.341.3880
888-387-3667
www.essentialtremor.org

HopeNet
14425 Coachway Drive
Centreville, VA 20120
703-543-8131
www.thehopenet.org

Tremor Action Network
P.O. Box 5013
Pleasanton, CA 94566
510-681-6565
www.tremoraction.org

National Institute of
Neurological Disorders
and Stroke

NIH . . . Turning Discovery Into Health

Prepared by:
Office of Communications and Public Liaison
National Institute of Neurological
Disorders and Stroke
National Institutes of Health
Department of Health and Human Services
Bethesda, Maryland 20892-2540

NIH Publication No. 18-NS-5648 July 2018