

Deep Brain Stimulation: Indications, Techniques, and Practice Parameters

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Deep brain stimulation is a surgical procedure involving implantation of electrodes into deep nuclei of the brain. The procedure is used to treat several medical conditions, including Parkinson's disease. Currently, three possible sites may be selected as targets for DBS treatment of Parkinson's disease and other movement disorders: the ventralis intermediate nucleus of the thalamus (Vim), the globus pallidus pars interna (GPi), and the subthalamic nucleus (STN). The electrodes are placed under local anesthetic, using stereotactic or computer-assisted guidance techniques. Intraoperative microelectrode recording of single neurons is often performed to verify the correct physiological target location, and test stimulation is used to confirm therapeutic benefit and to evaluate side effects. Several electrode passes may be required to refine the target location. Once correct physiological targeting has been confirmed, the electrodes are permanently anchored in place. Electrodes may be placed unilaterally or bilaterally, depending on the disease being treated and the individual patient's symptomatology. The electrodes are then connected to a computerized pulse generator that is implanted subcutaneously, in a manner similar to that used for a pacemaker. Pulse generator implantation is performed either contemporaneously with electrode placement, or as a staged procedure at a later date. Stimulation parameters are adjusted to maximize therapeutic effects. Subthalamic nucleus stimulation has been shown to reverse or improve rigidity, bradykinesia, balance deficits and tremor of Parkinson's disease. Vim thalamic stimulation can successfully treat both Parkinsonian tremor and other severe forms of tremor. Stimulation of the globus pallidus is useful in the treatment of dystonias and Parkinson's disease.

In December 1997, the Blue Cross and Blue Shield Association (BCBSA) Medical Advisory Panel (MAP) found that unilateral DBS of the thalamus for patients with disabling, medically unresponsive tremor due to essential tremor or Parkinson's disease met the Technology Evaluation Center (TEC) criteria, defined as:

1. The technology must have final approval from the appropriate governmental regulatory bodies
2. The scientific evidence must permit conclusions concerning the effect of the technology on health outcomes
3. The technology must improve the net health outcome
4. The technology must be as beneficial as any established alternatives
5. The improvement must be attainable outside the investigational settings

More recent evidence suggests that bilateral DBS of the GPi or the STN may alleviate the entire constellation of parkinsonian symptoms (tremor, rigidity, and bradykinesia). Thus, attention has shifted to studies of these targets as more appropriate sites than the thalamus for DBS in advanced Parkinson's disease. Unless contraindicated, DBS of either the STN or GPi requires a bilateral procedure.

The BCBSA Technology Assessment of bilateral DBS of the STN or Gpi for Parkinson's disease published in January 2002 provided an overview of the current literature on DBS for Parkinson's disease. Important points from that Assessment include:

1. In the studies examined in the Assessment, improvement in motor function with bilateral DBS of either the STN or the GPi is consistently demonstrated in each study. The published studies demonstrate statistically significant improvement in treated patients, as measured by standardized rating scales of neurologic function.
2. The results for bilateral DBS for advanced Parkinson's disease that are reported in the literature have been achieved at other experienced centers. Bilateral DBS meets the criterion of effectiveness outside of investigational centers when performed at centers that can demonstrate comparably low procedure-related morbidity and mortality.
3. The literature analyzed in the Technology Assessment suggests that bilateral DBS of the STN may provide a more consistent and more positive improvement than bilateral DBS of the GPi. However, results from a more recent publication (2) suggest that good therapeutic benefit can be obtained from GPi DBS, with perhaps less potential risk of cognitive side effects. While STN DBS allows decrease in medication dosage, GPi DBS patients do not show a change in medication requirements. Definitive determination of which stimulation target, the STN or GPi, provides the best combination of safety and efficacy may be provided by a recently approved trial, involving 6 Parkinson's disease centers with a total expected patient enrollment of 300 patients.
4. In August 1997, the U.S. Food and Drug Administration (FDA) approved the premarket application (PMA) for the Activa® Tremor Control System (Medtronic, Inc., Minneapolis, MN) for use in patients with essential tremor or tremor caused by Parkinson's disease. In March 2000, the FDA's Neurological Devices Panel Advisory Committee unanimously recommended for final FDA approval the bilateral use of the Medtronic device via supplemental PMA for the treatment of advanced Parkinson's disease (U.S. Food and Drug Administration 2000). The supplemental PMA for the Activa® Parkinson's Control Therapy system received final FDA approval on January 14, 2002.

Based on these points and others, the Assessment concluded that the TEC criteria were met for bilateral DBS of the STN or GPi.

The BCBSA Assessment also stated that “Because it is associated with a higher incidence of speech, swallowing, and cognitive dysfunction, bilateral DBS of the Vim is seldom performed.” We disagree with this statement, as many centers perform bilateral Vim DBS for patients with bilateral tremor (1, 3). Although between 30-50% of patients will initially have side effects from stimulation, the adjustability and reversibility of the therapy allow virtually all patients to achieve some measure of tremor control with minimal or controllable side effects. If unacceptable side effects persist, the DBS system can be deactivated. DBS therefore represents the only option for patients with severe bilateral tremor. However, most investigators now agree that the results from STN stimulation are superior for Parkinson’s disease, and the side effect profile less. Thalamic DBS should thus usually be reserved for Essential Tremor or other non-Parkinsonian tremor disorders, although it may still have a role in rare Parkinsonian patients whose sole disabling symptom is tremor.

DBS has thus been shown to be a safe and effective procedure for medically intractable Parkinson’s disease and other movement disorders, when performed in appropriate centers.

General Indications:

1. The procedure may only be performed with FDA-approved devices, systems, and equipment.
2. The patient and caregiver have understanding and willingness to comply with anticipated post surgical evaluations and adjustments of medications and stimulator settings.
3. There should be significant deterioration in the quality of life and functionality of the patient’s life.

Specific indications by target site:

Subthalamic nucleus:

1. Moderate to severe medically intractable Idiopathic Parkinson’s disease as diagnosed by a neurologist with experience in movement disorders. The patient should have had the disease for at least three years and have two or more of the four cardinal features (tremor, rigidity, bradykinesia, and postural instability).
2. Motor response complications or medication side effects of levodopa therapy (including motor fluctuations and dyskinesias) despite all reasonable medical therapies and medication adjustments
3. Bilateral implantation needed to avoid additive effects of stimulation and medication which lead to disabling dyskinesia stimulated side (if medicated)

appropriately for non-stimulated side) or akinesia on non-stimulated side (if under-medicated for stimulated side).

VIM thalamus: (uni- or bilateral dependent on uni- vs. bilateral disease):

1. Moderate to severe medically intractable Essential Tremor, Parkinsonian tremor, or idiopathic postural or intention tremors

Globus pallidus interna:

1. Moderate to severe medically intractable Idiopathic Parkinson's disease as diagnosed by a neurologist with experience in movement disorders. Specific patient selection criteria are the same as for "Subthalamic nucleus" above.
2. Moderate to severe medically intractable primary dystonia (i.e. DYT-1, Torticollis, writers cramp)
3. Tardive dystonias from psychotropic medications

General contraindications for DBS (all targets):

1. Parkinson's plus syndromes: e.g. Olivo-ponto-cerebellar degeneration, Corticobasal degeneration, Shy-Drager syndrome, Multi-system atrophy, Lewy Body Parkinsonism, and others
2. Patients with demand cardiac pacemakers.
3. Patients with cognitive deterioration/dementia (defined clinically by criteria in DSM IV, with a mini-mental Status examination score of less than 22, or by standard neuropsychological tests with score less than 1.5 standard deviations below normal. (i.e. Mathis dementia rating scores of less than 124, FSIQ of less than 70).

Relative contraindications:

1. Structural lesions of the CNS as the etiology of the movement disorder.
2. Psychiatric conditions (Axis –II or III DSM-IV diagnosis).
3. Moderate to severe radiographic atrophy of the cerebral cortex, brainstem, or cerebellum.

DBS electrode insertion should be performed using stereotactic or image-guided techniques. Numerous different systems, both framed and frameless, are available for stereotactic targeting. DBS procedures should only be performed by neurosurgeons skilled in the techniques of stereotactic and functional surgery, who have been trained in the performance of DBS procedures and who have been credentialed by their institutions as competent to perform these procedures. Controversy exists regarding the ideal method of performing DBS, but it is generally acknowledged that physiological confirmation of the target site, either by microelectrode recording or by macroelectrode stimulation, is necessary to achieve optimal outcomes. In cases where microelectrode recording is performed, the assistance of a neurologist or neurophysiologist may help to facilitate decisions on a final target and optimize outcomes. However, an appropriately trained neurosurgeon who is skilled in the performance and interpretation of microelectrode recording may not require intraoperative assistance in this area. Interpretation of intraoperative neurophysiological data can thus be performed either by a qualified neurologist or neurosurgeon.

It has been recommended that centers performing DBS should be equipped for functional stereotactic procedures, with the availability of high-resolution scanners, navigational equipment, and electrophysiological monitoring equipment. Optimal outcomes can be achieved by physicians well experienced in the pathology and treatment of movement disorders, stereotactic neurosurgery, and electrophysiology.

References:

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