DEEP BRAIN STIMULATION SURGERY FOR PARKINSON'S DISEASE

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Parkinson's disease (PD) is a relatively common degenerative disorder of the nervous system, affecting approximately 1% of the population older than 50 years of age. The four major signs of PD are: (1) *tremor*; (2) *rigidity* (resistance to passive movements); (3) *bradykinesia* (slowness in movements and gait); and (4) *postural instability* (trouble with balance and posture). Each patient differs in the severity of each component of PD, and the pace of clinical progression of the disease.

For patients with early PD, levodopa (Sinemet) and other antiparkinsonian medications are usually effective for maintaining a good quality of life. As the disorder progresses, however, medications can produce disabling side effects. Many patients on long-term levodopa therapy can develop troublesome *dyskinesias*, abnormal involuntary movements that often cause the limbs and body to writhe or jump. In addition, their dose of levodopa no longer lasts as long as it once did. This may lead to "*on-off fluctuations*," a condition in which the ability to control movement changes unpredictably between a mobile ("on") state and an immobile ("off") state. When patients no longer have an acceptable quality of life due to these shortcomings of medical therapy, surgical treatment should be considered.

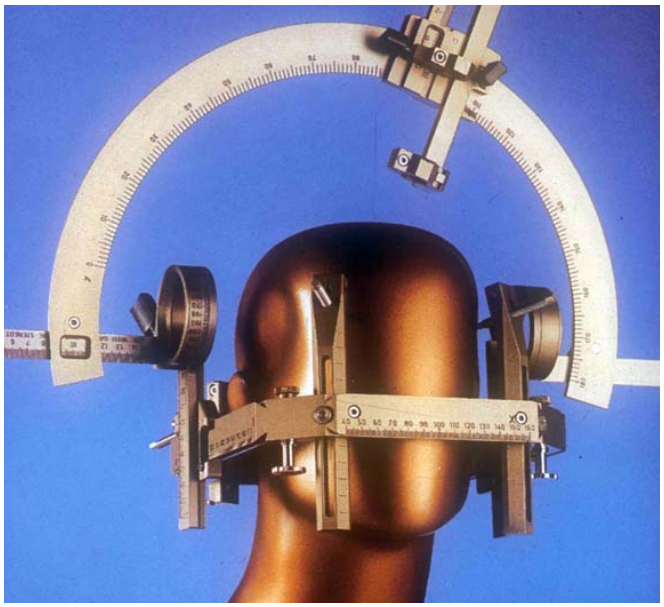

Figure 1. Stereotactic frame (Leksell model) for targeting deep brain structures

The most common type of modern surgery for PD is deep brain stimulation (DBS) surgery. This involves placing a thin metal electrode into one of several possible brain targets. This electrode is then attached to a computerized pulse generator, which is implanted under the skin in the chest (much like a heart pacemaker). All parts of the DBS system are internal; there are no wires coming out through the skin. To achieve best results, stimulation is adjusted during a routine office visit by a physician or nurse using a programming computer held next to the skin over the pulse generator. DBS reversibly alters the abnormal function of the brain tissue in the region of the stimulating electrode.

There are now three possible target sites in the brain for PD: the globus pallidus internus (GPi), the subthalamic nucleus (STN), and the ventral intermediate nucleus (Vim) of the thalamus. These structures are small

clusters of nerve cells that are important for control of movement. Thalamic (Vim) stimulation is only effective for tremor, not for the other signs of PD. Stimulation of the GPi or STN, in contrast, may benefit not only tremor but also rigidity and bradykinesia. All three targets are now approved by the U.S. Food and Drug Administration.

DBS surgery is performed in two stages. *Implantation* of the DBS electrode is performed with the patient awake, under local anesthesia and sedation. *Stereotaxis* is used, which is a method for precisely targeting deep structures in the brain through a small skull opening. A rigid stereotactic frame (Figure 1) is attached to the patient's head before surgery, and a brain imaging study is obtained with the frame in place. This is then used to calculate the exact trajectory to the desired brain target (Figure 2). To increase the precision of surgery, we employ brain mapping with *microelectrode recording*. Using this method, the neurosurgeon and neurophysiologist record and analyze brain cell activity near the target. The DBS electrode is then placed into the final target location and tested for potential side effects of stimulation. After electrode placement, the patient stays overnight for observation and then goes home the next day.

The second operation, done approximately one week later, involves internalization of the pulse generator. This procedure is done with the patient completely asleep (under general anesthesia). The pulse generator (battery) is placed in the upper chest and connected to the wire coming from the brain electrode (Figure 3). The patient goes home the same day, and later returns to clinic for intensive and individualized programming to control their symptoms.

The major benefit of DBS surgery for PD is that it can improve movement and reduce drug side effects. DBS "smoothes out" the on-off fluctuations between too much and too little movement and provides better function during more of the day. DBS may also allow reduction in antiparkinsonian medications. The primary risks of DBS surgery are bleeding and infection. The most serious potential risk is bleeding in the brain, producing a stroke. This risk is approximately 3%, with about 1% of patients having a permanent disability. Infection occurs in about 4% of patients. Infection is usually not life-threatening but may require removal of the DBS system.

In summary, there are more surgical treatment options for PD than ever before. Most importantly, class 1 evidence indicates that DBS improves outcome and quality of life for patients with Parkinson's disease. In considering patients for DBS, good candidates should have definitive diagnosis of PD, intact intellectual function and memory, history of benefit from taking levodopa (Sinemet), freedom from other severe medical diseases, the ability to remain calm and cooperative during an awake neurosurgical procedure, and sufficient motivation to participate in this form of therapy.

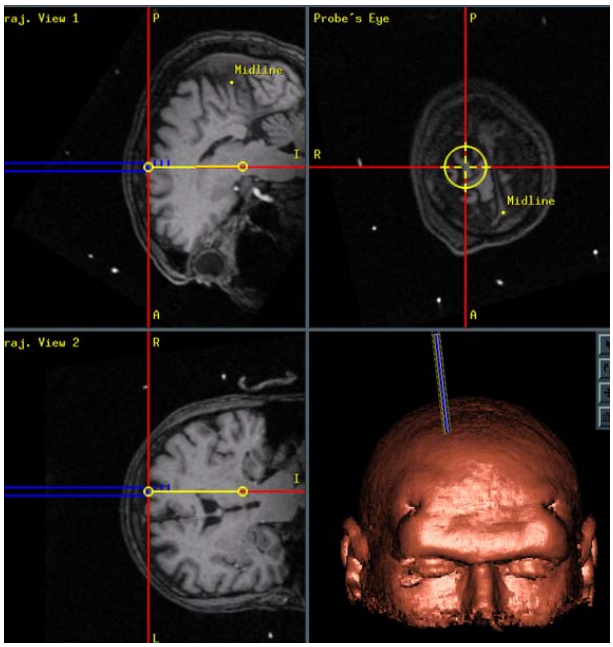

Figure 2. Intraoperative neuronavigation workstation allows precise trajectory planning to deep brain targets.

Figure 3. Deep brain stimulation (DBS) system with DBS electrode connected to pulse generator implanted in left upper chest.