Functional Neurosurgical Therapies for Movement Disorders and Epilepsy

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“Functional Neurosurgery”
The use of ultra-precise neurosurgical techniques to surgically modulate abnormal physiologic processes in the nervous system

Movement disorders

Epilepsy

Pain disorders

Psychiatric disorders
“Functional Neurosurgery”

The use of ultra-precise neurosurgical techniques to surgically modulate abnormal physiologic processes in the nervous system

Movement disorders

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Psychiatric disorders

*Therapy is tailored to each individual patient
Deep brain stimulation (DBS)

• DBS is a surgical procedure used to treat many of the debilitating symptoms of Parkinson’s disease and other movement disorders
• DBS is non-ablative: it is reversible and adjustable
• It is currently indicated for movement disorders that are refractory to medical therapy
Parkinson’s Disease

• A complex, progressive degenerative neurologic disorder that causes loss of control over body movements

• Primary motor symptoms:
  Tremor
  Rigidity
  Akinesia/bradykinesia
  Postural instability
Parkinson’s Disease

- Motor symptoms arise when the substantia nigra degenerates and DA neurons die
- Medical treatment: replace dopamine—very effective
- BUT, there are limitations...
  - Increasing dosages
  - Increasing side effects
    - Dyskinesia
    - Hallucinations
    - Wearing off
    - Unpredictability
Parkinson’s Disease

Diagram showing the therapeutic window over time from the 1st year to the 9th year, with periods of 'ON' and 'OFF' time, and 'ON with dyskinesia' phases.
DBS Therapy Provides an Additional 5.1 Hours of On Time to Smooth Out Motor Function*

*Activa Therapy Clinical Summary, 2009.
For patients <75 with severe motor complications of Parkinson's disease, neurostimulation was more effective than medical management alone at 6 mo
https://www.youtube.com/watch?v=CS1_XFtaLEo
The DBS system consists of three components:
The **lead** is a thin electrode inserted into the brain
An **extension** cable, connecting the lead and neurostimulator
The **neurostimulator** is a battery and pulse generator that is implanted under the skin, usually near the collarbone.
There are three brain targets that have been FDA approved for use in Parkinson’s disease.

- The most commonly utilized brain targets include the subthalamic nucleus (STN) and also the globus pallidus interna (Gpi)
- Target choice is tailored to a patient’s individual needs
- The preoperative evaluation helps determine choice of brain target
DBS surgical procedure

Preoperative MRI is used to create a plan to precisely target the area of interest.
DBS surgical procedure

A small incision is made in the scalp and a hole drilled through the skull to expose the brain.
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

Frame-based
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

Frame-based

Frameless
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

Awake surgery
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

Microelectrode recording
DBS surgical procedure

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Microelectrode recording
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

Image guided “asleep” surgery
DBS surgical procedure

There are several strategies to precisely place the DBS lead in the target:

“Directional” DBS leads
DBS surgical procedure

The extension and neurostimulator are placed under general anesthesia: as a second step or stage.
DBS surgical procedure

Typical DBS incisions
DBS for other movement disorders

Commonly seen by PCPs! Responds very well to DBS...

Essential Tremor—Thalamus (Vim)

Dystonia—Globus Pallidus (GPi)
Surgery for medically refractory epilepsy

Goal: identify an area in the brain that causes seizures and determine whether this area can be removed safely

Noninvasive workup +/- invasive recording → craniotomy for resection vs. minimally invasive ablation

Other options are available when:
• a specific area of seizure onset is not identified
• multiple areas of seizure onset are identified
• resection/ablation is not possible without causing new neurologic problems

(responsive neurostimulation, vagus nerve stimulation)
Surgical evaluation for medically refractory epilepsy

*Subdural grid placement*: improved spatial resolution of the brain surface compared to scalp EEG
Surgical evaluation for medically refractory epilepsy

**Stereo EEG**: multiple depth electrodes placed to monitor superficial and deep structures
Resective surgery for medically refractory epilepsy: The best chance for a surgical cure for seizures
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Wiebe et al., 2001 NEJM
Surgery for medically refractory epilepsy
Stereotactic laser ablation: minimally invasive epilepsy surgery
Surgery for medically refractory epilepsy

*Stereotactic laser ablation*

MRI-guided ablation
Surgery for medically refractory epilepsy

*Stereotactic laser ablation*

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*Responsive neurostimulation:* detects epileptiform discharges and delivers therapeutic stimulation
Surgery for medically refractory epilepsy

*Responsive neurostimulation:* detects epileptiform discharges and delivers therapeutic stimulation

![Diagram showing brain activity and seizure reduction](image)

**Median Seizure Reduction**

- Year 1: 44% (n=181)
- Year 2: 53% (n=174)
- Year 3: 60% (n=214)
- Year 4: 63% (n=204)
- Year 5: 65% (n=172)
- Year 6: 66% (n=115)
- Year 7: 72% (n=185)

*Normal Brain Activity* → *Unusual Activity* → *Treatment* → *Brainwaves Normalize*
Thank you
What are the risks?

DBS is *elective* brain surgery...

- The most common complications are **device- or wound-related**: infection, skin erosion, or interruption in therapy because of mechanical or electrical problems

- **Stimulation-related side effects**: numbness, tingling, worsening of tremor, mood problems, speech/language impairments. Typically, these side effects can be resolved by adjusting the device

- **Serious complications** are rare, but include stroke, hemorrhage, seizures and brain abscess
There is a “window of opportunity” for PD when DBS therapy may be most effective in order to obtain maximum benefit

When the patient is experiencing troubling motor symptoms not effectively controlled by medications, characterized by:
• “On” time with disabling dyskinesias (or other nonmotor side effects)
OR
• “Off” time with disabling tremor, rigidity, or akinesia/bradykinesia
OR
• Frequent and/or unpredictable “on/off” motor fluctuations

* Medication-resistant tremor