Deep Brain Stimulation for Movement Disorders

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Division of Movement Disorders
OSU Department of Neurology

History of DBS

- 1987 - First DBS implant

- 1997 – FDA approval for tremor
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- 2002 – FDA approval for Parkinson’s Disease
- 2003 – FDA provide HDE* for dystonia
- 2010 – Over 80,000 DBS implants worldwide
  - > 23 years of safety
  - >2,000 published articles on DBS

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• With proper patient selection, improvement occurs with:
  ▪ Standard scales/measures of disease
  ▪ Quality of life measures
  ▪ Medication intake
  ▪ Chronic care costs
  ▪ Medicare and Insurance reimbursed for FDA approved indications

• Surgically implanted medical device into deep brain structures, and connected to an implantable programming device placed commonly in the upper chest wall. Much like a pacemaker, they can deliver electrical stimulation to a specific brain target.

Offers hope to severely impaired patients when symptoms are intractable despite optimal medication and other available therapies.

Video

Surgically implanted medical device into deep brain structures, and connected to a implantable programming device placed commonly in the upper chest wall. Much like a pacemaker, they can deliver electrical stimulation to a specific brain target.

Stimulation of the specified target can re-modulate abnormal activity within brain circuitry that is causing the symptoms

Video with the permission from Medtronics:
Simple PD Circuitry

Motor Cortex

Putamen receptors

D2

D1

GABA/Substance P

VA/VL

Thalamus

GABA

Dopamine

GABA

Glutamate

STN

SNc

GPi

Excitatory

Inhibitory

Simple PD Circuitry
**Targets for Movement Disorders**

**VIM Thalamus:**
- Essential Tremor

**Subthalamic Nucleus:**
- Parkinson's disease

**Globus Pallidus:**
- Parkinson's disease and Dystonia

Images with the permission of Medtronic:
http://professional.medtronic.com/wcm/groups/mdtcom_sg/@mdt/@neuro/documents/images

Targets for Movement Disorders

VIM Thalamus: Essential Tremor

Subthalamic Nucleus: Parkinson’s disease

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Components of Successful DBS Therapy
### Components of Successful DBS Therapy

- Appropriate candidate selection
- Proper patient education and support
- Accurate surgical DBS lead placement
- Optimal DBS programming
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- Appropriate candidate selection
- Proper patient education and support
- Accurate surgical DBS lead placement
- Optimal DBS programming
- Medication management in concert with DBS

Consider DBS if refractory to medications:

- Propranolol
- Primidone
- Gabapentin
- Carbamazepine
- Mirtazapine
- Clozapine

Video with the permission from Medtronic:
**Tremor**

- Consider DBS if refractory to medications:
  - Propranolol, Primidone, Gabapentin, Benzodiazepines
  - PD medications: Carbamazepine, Mirtazapine, Clozapine

- **Expectations:**
  - Improve quality of life by reducing disabling tremor
    - Rest > Postural > Intent
    - UE > LE > Head

Video with the permission from Medtronics:

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**American Academy of Neurology**

*Tremor Guidelines – released June 2005*

- Unilateral thalamic VIM DBS resulted in a significant (60 to 90%) reduction of contralateral limb tremor


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**Tremor**

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- **Target area of stimulation:** VIM Thalamus

Video with the permission from Medtronics:

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**Tremor – DBS Off vs On**

Video

Video with the permission from Medtronics:
Parkinson’s Disease

Motor
• Bradykinesia

Parkinson’s Disease

Motor

Motor
• Bradykinesia
• Rigidity
**Motor**
- Bradykinesia
- Rigidity
- Tremor

**Non-Motor**
- Constipation
- Loss of smell
- Excessive drooling
- Gastro-esophageal Reflux
- Depression/ Anxiety
- Memory /Cognitive changes
- Sleep disturbance
- Skin changes
- Bladder/urinary problems
- Sweating spells
- Low blood pressure
- Sexual dysfunction

Levodopa generally provides smooth and stable benefits for 5-7 years, but after this we start seeing increasing motor fluctuations and dyskinesia.

These motor fluctuations can considerably decrease Quality of Life for People with Parkinson’s Disease.
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**Candidates for DBS in PD**

- Clear diagnosis of *idiopathic Parkinson's disease*
  - Atypical Parkinson's or Parkinson's like syndromes do not improve with surgery
- Issues include one or more of the following
  - 1) Significant *motor fluctuations* and/or disabling *dyskinesia*
    - "On" time characterized by disabling dyskinesia
    - "Off" time characterized by disabling tremor, rigidity, or akinesia/bradykinesia
    - "On"/"off" motor fluctuations
  - 2) *Disabling tremor* despite optimal medication treatment:
### Candidates for DBS in PD

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- Issues include one or more of the following
  - 1) Significant motor fluctuations and/or disabling dyskinesia
     - “On” time characterized by disabling dyskinesia (or other non-motor side effects)
     - “Off” time characterized by disabling tremor, rigidity, or akinesia/bradykinesia
     - “On”/“off” motor fluctuations
  - 2) Disabling tremor despite optimal medication treatment:
    - Levodopa
    - Ropinirole/Pramipexole
    - Selegiline/Rasagiline
    - Benzodiazepines
    - Amantadine
    - Anticholinergic
  - 3) Medication intolerance

### Evaluation of PD for DBS Consideration

- Review history of disease and treatment
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- Assess for whether there is a good response to levodopa with levodopa challenge:
  - At least 33-40% improved UPDRS motor score
  - Stable cognition (absence of significant dementia)
  - No co-morbid psychiatric/behavioral problem
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- Stable cognition (absence of significant dementia)
- No co-morbid psychiatric/behavioral problem
- Realistic expectations and good social support

PD – DBS Treatment Window

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<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<td>Parkinson’s Disease Progression</td>
<td>Medication Treatment</td>
<td>Motor Fluctuations</td>
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DBS Consideration

Efficacy: Benefits of Activa Therapy Impact on Mobility

- Dyskinesia
- Before
- “On” Time
- After
- “Off” Time

This graph is only for illustrative purposes and does not represent actual “on” and “off” time.

“ON” Time Without Dyskinesias Improves from 27% to 74% of a Patient’s Waking Day

Before Surgery (n=96)
- 49% on
- 27% off
- 23% dyskinesia

6 Months After Surgery Bilateral STN Activa® Implant (n=91)
- 74% on
- 19% off
- 7% dyskinesia


Slide with the permission from Medtronic:
**Parkinson's Disease Off and On DBS**

- Video
  - Right video with the permission from Medronics: http://professional.medtronic.com/pthneuro/pt dbs-md/edu/presentations-downloads/index.htm

**Dystonia**

- Definition: sustained muscle contractions causing posturing, twisting, or repetitive movements
- Can be primary or secondary
- Dystonia is commonly described based on involved areas:
  - Focal: one area (torticollis, blepharospasms, writer’s cramp, or other occupational dystonia)
  - Segmental: two or more contiguous areas
  - Hemidystonia: either left or right side of the body
  - Generalized: crural or other parts

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**American Academy of Neurology PD Guidelines – Released in April 2006**

- 10 - 20% of people with Parkinson disease may be eligible for surgical intervention and treatment

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**DBS: PD**

Symptom Improvement after 5 years*

- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

- Rigidity
- Tremor
- Akinetic
- Dyskinesia


Slide with the permission from Medronics:
Consider DBS for Primary Dystonia after other treatments fail

- Currently approved under Humanitarian Device Exemption (HDE)
- Candidates
  - Primary Dystonia (i.e. DYT1 positive), including generalized and segmental dystonia, hemidystonia and cervical dystonia (torticollis)
  - Disabling symptoms that are inadequately treated by medications or other treatments
  - Approved for pediatrics (age 7 and older)

DBS Evaluation

- Movement Disorder Neurology
  - Evaluate medications and disease
  - Discuss realistic goals of therapy
  - Levodopa ON-OFF assessment in Parkinson's disease
- Neurosurgery
  - Discuss surgery, implantable devices, risks
- Brain Imaging
- Neuropsychological testing

Poor Candidates for DBS

- Significant dementia or cognitive impairment
  - Neuropsychological compromise
- Untreated depression, anxiety, psychosis, or other psychiatric illness
- Unable to cooperate during surgical procedure
- Unable to cooperate during programming visits
- Unrealistic expectations of outcomes
- Co-existing medical problems that significantly increase risks of surgery
  - Uncontrolled heart disease, lung disease, hypertension, or diabetes.
- Significant structural abnormalities detected by brain imaging that would pose higher risk of brain surgery


- Double blind, class I study
- 40 pts with GPi DBS randomized to Stimulation or Sham for 3 months
- At 3 months, all patients received open label active stimulation until the 6-month outcome measure
  - Stim ON: 15.8±14.1 points
  - Sham: 1.4±3.8 points (P<0.001)
- BFMDRS score reduction
Targeting

Anatomical Atlas Morphing and Targeting

Surgery

Intra-operative Testing

Video

Video with the permission from Medtronic:

Images with the permission from Medtronic:

Courtesy of Dr. Ali Rezai
Potential Complications/Risks

- Stroke
- Hemorrhage or Infarction (inherent in any stereotactic procedure): May be silent or symptomatic
- Confusion or cognitive changes (may be transient)
- Infection (typically occurs at neurostimulator site in chest when it does occur)
- Device related (hardware failure)

DBS Neurostimulators

Images with the permission from Medtronic: http://professional.medtronic.com/pt/neuro/dbs-md/edu/presentations-downloads/index.htm

DBS Post-Implant Programming

- First programming 4-6 weeks after surgery
- Adjustments in first 3-6 months
- Neurostimulator is replaced when battery needs replacing (outpatient procedure)

Images with the permission from Medtronic: http://professional.medtronic.com/pt/neuro/dbs-md/edu/presentations-downloads/index.htm
Individualized Therapy

- Adjustable parameters maximizes the therapeutic effect:
  - Electrode(s)
  - Polarity
  - Amplitude
  - Pulse width
  - Rate

- Stimulation related side effects reversible with adjustments

Images with the permission from Medtronics:

Patient Access Review Devices

Images with the permission from Medtronics:

Long Term Precautions/Restrictions

Images with the permission from Medtronics:
### Long Term Precautions/Restrictions

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| Diathermy Contraindicated | - Electrical or radiofrequency therapeutic devices  
- Surgery – electrocautery  
- Lithotripsy |
| No MRI with body coil (heating effect). Can have MRI head with use of specific restrictions if no open or short circuits. | |
| Caution around electro-magnetic fields | - Metal/theft detectors  
- Store refrigerators, industrial microwave ovens  
- Arc welding equipment, high voltage power lines |
| Caution with other medical devices | (external defibrillation, cardiac pacemakers) |
Summary

- Overall, DBS has potential for being life altering for those suffering from essential tremor, Parkinson's disease and also primary dystonia.
- With proper patient selection we have excellent outcomes.
- Though some restrictions, continued DBS therapy does not have many limitations.