MER vs. MRI guidance in placement of DBS electrodes for Parkinson's disease

Joohi Jimenez-Shahed, MD[1], Michele York, PhD[2], Erica M Smith-Gloyd, MA[1], Joseph Jankovic, MD[1] and Ashwin Viswanathan, MD[3]

[1]Parkinson's Disease Center and Movement Disorders Clinic, Department of Neurology; [2]Division of Neuropsychology; [3]Department of Neurosurgery

Baylor College of Medicine, Houston, Texas

BACKGROUND

- Variables determining outcomes in deep brain stimulation (DBS) for Parkinson's idseas (PD) include patient selection, electrode placement, and device programming (Bronstein 2011)
- Methods for optimizing electrode placement
  - Microelectrode recording (MER)
  - Macrostimulation
  - Anatomic lead placement with magneatic resonance imaging (MRI) or other image guidance
- No Class I evidence exists to support that use of MER improves patient outcomes compared to other approaches
- Potential risks of MER
  - Major vascular injury: 1.7-3.4% (Hariz 2002, Gorgulho 2005, Sansur 2007, Zrinzo et al 2012)
  - 1.6% of these hemorrhages are symptomatic (Kenney 2007, Baizabal Carvallo 2012)
  - Likely due to the use of multiple parallel trajectories to map the target nucleus
  - Requires an awake and prolonged procedure for the patient
- Although neurophysiological mapping is lacking with MRI-guided approach, this technique has been shown to be effective and safe with accurate electrode placement (Liu 2001, Starr 2010, Foltynie 2011)
- Potential benefits of image guidance
  - Single planned surgical trajectory
  - May be performed under general anesthesia
  - Ability to account for brain shift through intra-operative imaging
  - Early detection of intraoperative hemorrhage
- The relative safety and efficacy of image guided electrode placement compared to traditional MER-guidance has not been studied.

- **OBJECTIVE:** To obtain pilot data comparing the safety and efficacy of DBS electrode implantation using MRI guidance to MER guidance in patients with Parkinson's disease (PD).

METHODS

- Patients with PD considered by consensus opinion to be candidates for DBS placement in the subthalamic nucleus (STN) or pallidum (GPi) were randomized to MER- vs MRI-guided procedures.
- *Inclusion Criteria:*
  - Age 30-79
  - Diagnosis of idiopathic PD
  - Determined to be candidates for STN or GPi DBS by consensus recommendation of a multidisciplinary team as evidenced by:
    1. Ability to provide informed consent as determined by preoperative neuropsychological assessment
    2. Optimized medically by a movement disorders neurologist.
    3. Persistent motor symptoms which are not effectively controlled with optimal medical management. These symptoms may include levodopa-induced dyskinesias, tremor, or fluctuations in the effectiveness of levodopa throughout the day.
- *Exclusion Criteria:*
  - Dementia as determined by pre-operative neuropsychological assessment
  - Previous intracranial surgery
  - Intracranial tumor
  - Lack of ability to provide informed consent as determined by preoperative neuropsychological assessment
  - Medical co-morbidities that would make the patient a poor surgical candidate
- Pre-operative motor score off medications was compared to post-operative on DBS/off medication score at >6months.
- Pre- and post-operative neuropsychological assessments, number of MER tracts or stylet passes, incidence of radiologically-apparent hemorrhage, and surgical complications were also compared.
- Radial error of electrode placement based on post-op high-res CT
- Post-operative neurology and neuropsychology raters were blinded to treatment assignment.

RESULTS

Figure 1: Subject characteristics and follow-up

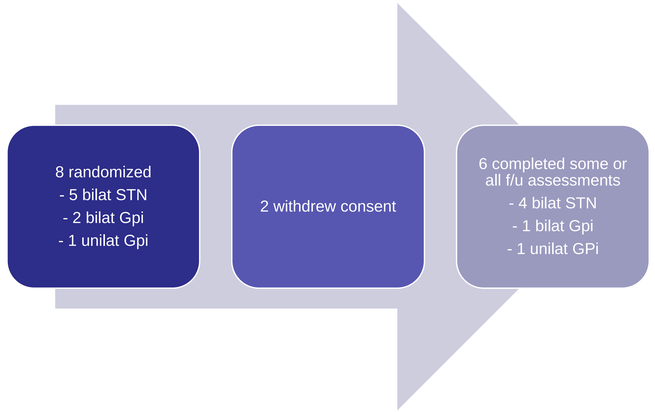

Table 1: Surgical outcomes

	MRI	MER
N	3	5
Electrodes	5	10
Mean# stylet passes or MER tract per electrode	1	2.3 (range 2-4)
Microlesion effect	1 (33%)	4 (80%)
Mean radial error	0.6mm +/- 0.3mm	1.1 +/- 0.3mm
Adverse events		
Hemorrhage	0	0
Surgical	0	0
Post-operative	0.33 per patient* (1 in 3 pts)	1.4 per patient† (7 in 5 pts)

* hardware discomfort; † headaches, tremors worse, confusion, falls leg cramps, hardware discomfort

Table 2: Neurologic Outcomes

	MRI	MER
Mean baseline UPDRS	39.0±14.0	38.3±13.3
% improvement UPDRS*	43.7±32.3% (n=2)	33.7±0.49% (n=2)
% Δ LEDD	69.7±27.4	23.2±43.7
Mean time (d) after surgery	229±67	191±10

* on stim/off meds compared to off meds baseline
UPDRS = Unified Parkinson's Disease Rating Scale
LEDD = levodopa equivalent daily dosing

RESULTS – CONT.

Table 3: Neuropsychological Outcomes

Pre-operative	Post-operative
Premorbid intellectual functioning was not significantly different between the groups.	
MMSE scores were intact and not significantly different between the groups (MRI: 29 vs MER: 26).	MMSE remained intact for both groups.
Total DRS total scores were significantly different between the groups, but both are considered intact (MRI: 143 vs MER: 140).	• DRS Total scores were not significantly different between the groups and did not significantly change following surgery. • A trend for slower processing speed for the MER group after surgery (Trail Making Part A, Symbol Digit written). • Significant difference between the groups on a problem solving/reasoning task (WCST categories and total errors) with an improvement noted in the MRI group.
No significant differences in depression or anxiety scores.	Depression scores were significantly higher for the MER group versus the MRI group (MRI: 4 and MER: 10), but both are considered minimal levels.
No other significant differences between the groups.	

CONCLUSIONS

- MER allows for electrophysiological mapping of the brain target in DBS procedures (either STN or GPi), but is not the only effective methodology for accurate electrode placement.
- This pilot study suggests that, compared to MER guidance for DBS electrode placement, MRI-guided procedures in patients with PD may be associated with:
  - Fewer electrode passes
  - Fewer post-operative side effects
  - Less chance of microlesion effect
  - Less radial error in electrode placement
- UPDRS and LEDD should be interpreted with caution due to variance in follow-up interval
- Neuropsychological measures should be interpreted with caution due to small sample size

- Further study is warranted to verify these findings in a larger cohort of patients.

REFERENCES

1. Baizabal Carvallo JB, Simpson R, Jankovic J. Diagnosis and treatment of complications related to deep brain stimulation hardware. Mov Disord 2011;26:1398-1406.
2. Bronstein JM, Tagliati M, Alterman RL, et al. Deep brain stimulation for Parkinson disease: an expert consensus and review of key issues. Arch Neurol. 2011 Feb;68(2):165-171.
3. Foltynie T, Zrinzo L, Martinez-Torres I, Tripoliti E, Petersen E, Holl E, et al: MRI-guided STN DBS in Parkinson's disease without microelectrode recording: efficacy and safety. J Neurol Neurosurg Psychiatry 2011, 82:358-363.
4. Gorgulho A, De SAlles AA, Frighetto L, Behnke E: Incidence of hemorrhage associated with electrophysiological studies performed using macroelectrodes and microelectrodes functional neurosurgery. J Neurosurg 2005, 102:888–896.
5. Hariz MI: Safety and risk of microelectrode recording in surgery for movement disorders. Stereotactic Funct Neurosurg 2002, 78:146-15.
6. Kenney C, Simpson R, Hunter C, Ondo W, Almaguer M, Davidson A, Jankovic J. Short-term and long-term safety of deep brain stimulation in the treatment of movement disorders. J Neurosurg 2007;106:621-625.
7. Liu X, Rowe J, Nandi D, Hayward G, Parkin S, Stein J, Aziz T: Localisation of the subthalamic nucleus using Radionics Image Fusion and Stereoplan combined with field potential recording. Stereotact Funct Neurosurg 2001, 76:63-73.
8. Sansur CA, Frysinger RC, Pouratian N: Incidence of symptomatic hemorrhage after stereotactic electrode placement. J Neurosurg 2007, 107:998-1003.
9. Starr PA, Martin AJ, Ostrem JL, Talke P, Levesque N, Larson PS: Subthalamic nucleus deep brain stimulator placement using high-field interventional magnetic resonance imaging and a skull-mounted aiming device: technique and application accuracy. J Neurosurg 2010, 112:479-490.