



An Unexpectedly High Rate of Revisions for Deep Brain Stimulation Surgery in North America

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Introduction

While many studies describe outcomes and complications related to deep brain stimulation (DBS), the majority of these are from large academic centers, and results may differ from those in general neurosurgical practice.

Table 1. CPT codes for neurostimulation electrode implantation, revision, and removal.	
CPT Code	Description
61863	Twist drill, burr hole, craniotomy, or craniectomy with stereotactic implantation of neurostimulator electrode array in subcortical site (eg, thalamus, globus pallidus, subthalamic nucleus, periventricular, periaqueductal gray), without use of intraoperative microelectrode recording; first array
61864	Twist drill, burr hole, craniotomy, or craniectomy with stereotactic implantation of neurostimulator electrode array in subcortical site (eg, thalamus, globus pallidus, subthalamic nucleus, periventricular, periaqueductal gray), without use of intraoperative microelectrode recording; each additional array (List separately in addition to primary procedure)
61867	Twist drill, burr hole, craniotomy, or craniectomy with stereotactic implantation of neurostimulator electrode array in subcortical site (eg, thalamus, globus pallidus, subthalamic nucleus, periventricular, periaqueductal gray), with use of intraoperative microelectrode recording; first array
61868	Twist drill, burr hole, craniotomy, or craniectomy with stereotactic implantation of neurostimulator electrode array in subcortical site (eg, thalamus, globus pallidus, subthalamic nucleus, periventricular, periaqueductal gray), with use of intraoperative microelectrode recording; each additional array (List separately in addition to primary procedure)
61880	Revision or removal of intracranial neurostimulator electrodes

Methods

Using data from the Centers for Medicare and Medicaid Services (CMS) Part B National Summary Data File and the American College of Surgeons (ACS), we identified all DBS procedures related to primary placement, revision, or removal of intracranial electrodes. Complications and baseline demographics were abstracted, and multivariate regression was used to identify predictors of surgical revision and complications.

Table 3. Rates of DBS procedures across the Medicare Part B database, 2004-2013, and the ACS NSQIP database, 2005-2013.			
Procedure	Medicare Part B (%)	NSQIP (%)	All (%)
Stereotactic implant of subcortical electrode, without MER			
First array	3045 (10.8)	12 (6.2)	3057 (10.8)
Second array	1162 (4.1) <sup>†</sup>	3 (1.5) <sup>†</sup>	1165 (4.1) <sup>†</sup>
Stereotactic implant of subcortical electrode, with MER			
First array	20845 (74.0)	113 (58.2)	20958 (73.9)
Second array	7762 (27.5) <sup>†</sup>	37 (19.1) <sup>†</sup>	7799 (27.5) <sup>†</sup>
Revision or removal of intracranial stimulator electrodes	4289 (15.2)	66 (34.0)	4355 (15.4)
Total	28179	194	28370

<sup>†</sup>Because second array placements are not primary procedures, they are not included in the total number of procedures (i.e., one cannot bill only for a second array without a first array). Percentages are based off the total number of procedures excluding second arrays.

Results

Over 28,000 cases of DBS electrode placement, revision, and removal were identified during the years 2004-2013. Between 15.2% and 34.0% of these procedures were for electrode revision or removal (Table 3). Significant predictors of revision and removal were decreased age (odds ratio (OR) of 0.96; 95% CI: 0.94, 0.98) and higher ASA classification (OR 2.41; 95% CI: 1.22, 4.75). Up to 48.5% of revisions may have been due to improper targeting or lack of therapeutic effect. Complications occurred in 8.2% of cases, with return to surgery within 30 days being the most common adverse event (Table 6).

Table 4. Principal diagnoses of primary and revision surgeries in NSQIP database (based on ICD-9 codes).			
Principal Diagnosis	Primary (n = 128)	Revision or Removal (n = 66)	All (n = 194)
<b>Movement Disorders</b>	<b>121 (94.5)</b>	<b>24 (36.4)</b>	<b>145 (74.7)</b>
Parkinson's	81 (63.3)	16 (24.2)	97 (50.0)
Essential Tremor	31 (24.2)	2 (3.0)	33 (17.0)
Dystonia	7 (5.5)	2 (3.0)	9 (4.6)
Abnormal involuntary movements	2 (1.6)	3 (4.5)	5 (2.6)
Undefined movement disorder		1 (1.5)	1 (0.5)
<b>Other Neurologic/Psychiatric Disorders</b>	<b>5 (3.9)</b>	<b>3 (4.5)</b>	<b>8 (4.1)</b>
Depression	2 (1.6)		2 (1.0)
Atypical Facial Pain	1 (0.8)	1 (1.5)	2 (1.0)
Trigeminal Neuralgia		1 (1.5)	1 (0.5)
Complex Regional Pain		1 (1.5)	1 (0.5)
Tourette's	1 (0.8)		1 (0.5)
Multiple Sclerosis	1 (0.8)		1 (0.5)
<b>Device Complication</b>	<b>0</b>	<b>15 (22.7)</b>	<b>15 (7.7)</b>
Malfunction of device		12 (18.2)	12 (6.2)
Other device complication		3 (4.5)	3 (1.5)
<b>Infection or Wound Complication</b>	<b>0</b>	<b>16 (24.2)</b>	<b>16 (8.2)</b>
Infection of device		13 (19.7)	13 (6.7)
Open Scalp Wound		1 (1.5)	1 (0.5)
Wound dehiscence		1 (1.5)	1 (0.5)
Other postoperative infection		1 (1.5)	1 (0.5)
<b>Other</b>	<b>1 (0.8)</b>	<b>8 (12.1)</b>	<b>9 (4.6)</b>
Adjustment of brain "neuropacemaker"		3 (4.5)	3 (1.5)
Brain tumor		2 (3.0)	2 (1.0)
Blindness		1 (1.5)	1 (0.5)
Cranial nerve injury		1 (1.5)	1 (0.5)
Breast cancer		1 (1.5)	1 (0.5)
Meningitis/arachnoiditis	1 (0.8)		1 (0.5)

Table 6. Surgical characteristics for primary and revision surgeries in NSQIP database.			
Surgical Characteristic	Primary Placement Number (%)	Revision/Removal Number (%)	All Number (%)
Unilateral vs. Bilateral Placement			
Unilateral	88 (68.8)	†	88 (45.4) <sup>†</sup>
Bilateral	40 (31.3)		40 (20.6) <sup>†</sup>
Microelectrode recording used			
No	11 (8.6)	†	11 (5.7) <sup>†</sup>
Yes	117 (91.4)		117 (60.3) <sup>†</sup>
Battery placement/replacement/removal in same surgery <sup>‡</sup>			
No	2 (1.6)	43 (65.2)	45 (23.2)
Placement or Revision (CPT 61885 or 61886)	124 (96.9)	8 (12.1)	132 (68.0)
Removal or Revision (CPT 61888)	0	13 (19.7)	13 (6.7)
Dual coded*	2 (1.6)	2 (3.0)	4 (2.1)
Any complication			
No	118 (92.2)	59 (89.4)	177 (91.2)
Yes	10 (7.8)	7 (10.6)	17 (8.8)

<sup>†</sup>There is no explicit code for unilateral vs. bilateral revision/removal of electrodes, nor for the utilization of microelectrode recording for revision. Therefore, none of the cases marked as revisions/removals could be categorized.  
<sup>\*</sup>There is one CPT code for revision/removal of pulse generators (61888) and two for primary placement or revision (61885 and 61886).  
<sup>‡</sup>These cases listed both the 61888 CPT code for revision/removal and either 61885 or 61886 for placement/revision.

Conclusions

Data from the multiple databases suggest that DBS has a higher rate of revision and removal than previously reported, between 15.2 and 34.0%. There is a clear need to better track and understand the true prevalence and nature of such failures as they occur in the wider surgical community.

Table 7. Complications from brain stimulation placement and revision surgeries in the NSQIP database.			
Complication	Primary Placement Number (%)	Revision/Removal Number (%)	All Number (%)
Death (secondary to MI)	1 (0.6)	0	1 (0.5)
Return to OR within 30 days	4 (3.1)	5 (7.6)	9 (4.6)
DVT requiring therapy	2 (1.6)	1 (1.5)	3 (1.5)
Urinary tract infection	2 (1.6)	1 (1.5)	3 (1.5)
Superficial SSI	1 (0.8)	1 (1.5)	2 (1.0)
Stroke	1 (0.8)	1 (1.5)	2 (1.0)
Myocardial infarction	1 (0.8)	0	1 (0.5)
Pulmonary embolism	1 (0.8)	0	1 (0.5)
Ventilator dependent >48 hours post-op	0	1 (1.5)	1 (0.5)
Sepsis	0	1 (1.5)	1 (0.5)
Bleeding requiring transfusion	0	1 (1.5)	1 (0.5)
Unplanned reintubation	0	1 (1.5)	1 (0.5)