

Limbic system surgery for treatment-refractory obsessive-compulsive disorder: a prospective long-term follow-up of 64 patients

Clinical article

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Object. Obsessive-compulsive disorder (OCD) is a common and disabling psychiatric illness, and in a significant proportion of patients with OCD the disease is refractory to conventional pharmacotherapy and psychotherapy. For more than half a century, patients with severe, treatment-resistant OCD have been treated with stereotactic limbic system lesions, including dorsal anterior cingulotomy. The authors present their results describing the efficacy and durability of limbic system surgery for OCD, characterizing a large cohort of patients treated at a single institution with a mean follow-up of more than 5 years.

Methods. The authors identified 64 consecutive patients undergoing cingulotomy for refractory OCD at the Massachusetts General Hospital between 1989 and 2009. Changes in OCD and major depressive disorder symptom severity were assessed at both the initial and most recent postoperative follow-up by using the Yale-Brown Obsessive Compulsive Scale and the Beck Depression Inventory, respectively. Full and partial OCD symptom responses were defined as Yale-Brown Obsessive Compulsive Scale score reductions of $\geq 35\%$ and 25%–34%, respectively.

Results. Regarding OCD symptom improvement, at the first postoperative follow-up (mean 10.7 months), 35% of patients demonstrated a full response and 7% were partial responders. Thirty patients had a subsequent procedure (repeat cingulotomy or subcaudate tractotomy). By the most recent follow-up (mean 63.8 months), rates climbed to 47% and 22% for full and partial responses, respectively. Of the 24 patients with at least a partial response at initial follow-up, 20 (83%) retained at least a partial response at final follow-up. Comorbid major depressive disorder severity decreased by 17% at the most recent follow-up.

Conclusions. Limbic system surgery based on initial cingulotomy offers a durable and effective treatment option for appropriately selected patients with severe OCD who have not responded to conventional pharmacotherapy or psychotherapy.

(<http://thejns.org/doi/abs/10.3171/2012.11.JNS12389>)

KEY WORDS • cingulotomy • obsessive-compulsive disorder • psychiatric neurosurgery • depression • functional neurosurgery

OBSESSIVE-COMPULSIVE disorder is a psychiatric illness characterized by intrusive, recurrent thoughts (obsessions) coupled with repetitive behaviors that are performed in an attempt to reduce anxiety (com-

Abbreviations used in this paper: BDI = Beck Depression Inventory; CBTC = corticobasal ganglia-thalamocortical; DBS = deep brain stimulation; DSM-III, -III-R, -IV = Diagnostic and Statistical Manual of Mental Disorders, 3rd edition, 3rd edition-revised, 4th edition; MDD = major depressive disorder; OCD = obsessive-compulsive disorder; SRI = serotonin reuptake inhibitor; Y-BOCS = Yale-Brown Obsessive Compulsive Scale.

pulsions). These obsessions and compulsions can cause severe emotional distress, financial hardship, and social isolation. With a lifetime prevalence of approximately 2%–3%,²² OCD is among the most common mental illnesses in the US, and of patients in whom OCD is diagnosed, one-half experience severe symptoms.¹⁵ Obsessive-compulsive disorder is also associated with high rates of comorbid MDD and suicidal ideations.²¹

Standard treatment for patients with OCD includes a combination of psychotherapy and pharmacotherapy; however, 40%–60% of patients do not respond satisfac-

torily.²¹ In patients with severe OCD, various neurosurgical interventions may be considered when exhaustive trials of conventional treatments have proven unsuccessful. Dorsal anterior cingulotomy, developed at the Massachusetts General Hospital in the 1960s,⁴ has for decades been successfully used for patients with severe, treatment-refractory OCD. Other effective stereotactic ablative procedures within the limbic system include anterior capsulotomy,^{17,25} subcaudate tractotomy,¹⁶ and limbic leukotomy,^{13,14} which is a combination of cingulotomy and subcaudate tractotomy.

Our group's initial retrospective review of the efficacy of cingulotomy for OCD included 33 patients who underwent at least one cingulotomy procedure.¹² By conservative estimate, at least 25%–30% of patients experienced a significant improvement in OCD symptoms (a decrease of $\geq 35\%$) as measured on the Y-BOCS. A subsequent prospective study assessed the long-term outcomes of 18 patients, and confirmed the 25%–30% response rate, with a mean follow-up period of nearly 27 months.³ More recently, we updated the outcomes of those 18 patients and an additional 26, with a 32-month mean follow-up.⁶ In this group of 44 patients, 45% experienced at least a partial response to cingulotomy. Some of them had undergone a second or third cingulotomy procedure. In both of these prospective studies, patients also experienced an improvement in anxiety and depression symptoms.

Currently, we report the long-term results of the 44 patients from our last study, and include 20 additional patients who have since undergone cingulotomy for OCD. Some of these patients also underwent subsequent limbic system surgical procedures (repeat cingulotomy or subcaudate tractotomy). We sought to assess the long-term efficacy and durability of limbic system surgery predicated on initial cingulotomy in this group of 64 patients, with a mean follow-up of more than 5 years.

Methods

Patient Selection

This study was approved by the Massachusetts General Hospital Institutional Review Board. Patients referred to our institution between 1989 and 2009 for evaluation of their candidacy for limbic system surgery for OCD were thoroughly evaluated by a multidisciplinary team consisting of psychiatrists, neurologists, and neurosurgeons. Surgical candidates were required to have met DSM-III, DSM-III-R, or DSM-IV criteria for OCD, to have demonstrated severe functional impairment due to symptoms related to OCD, and to have failed to benefit from conventional psychopharmacological and behavior treatments. Medication trials must have included a minimum of 3 SRIs. One of these SRIs must have included clomipramine hydrochloride. Also required were 2 trials with augmentation agents, such as clonazepam, lithium carbonate, buspirone hydrochloride, and typical or atypical antipsychotic drugs. For a trial to be considered adequate, the maximum tolerated dose must have been taken for at least 10 weeks. In addition, a minimum of 20 hours of behavior therapy, including exposure and response prevention, must also have been completed.

Patients considered appropriate by these criteria were offered cingulotomy, and they signed informed consent for enrollment in the study after a careful discussion of the risks and benefits of surgery. Some patients who did not derive clinical benefit from cingulotomy after several months underwent a second and sometimes a third procedure. Subsequent procedures were either a repeat cingulotomy or a subcaudate tractotomy (thereby completing a limbic leukotomy).

Operative Technique

Procedures were performed using standard MRI-guided frame-based stereotactic techniques under local anesthesia. Bilateral bur holes were placed 1.5 cm lateral to the midline and 9.5 cm posterior to the nasion. In some patients (prior to approximately the year 2000) a single pair of lesions was made, termed a single anterior cingulotomy. The target was 2 cm posterior to the most anterior point of the frontal horn of the lateral ventricle, 0.7 cm lateral to midline, and 0.5 cm superior to the corpus callosum. Lesions were produced using a thermoelectric ablation electrode (Cosman Medical) with a 10-mm exposed tip, heated to 85°C for 60 seconds. In other patients (after approximately the year 2000) a triple anterior cingulotomy was performed. The aforementioned target corresponded to the most posterior pair of lesions. Two more pairs of lesions were then created, each 7 mm anterior and 2 mm inferior to the previous lesion. A postoperative MRI scan was obtained to verify the location of the lesions (Fig. 1).

Data Collection and Rating Scales

The patients' electronic and paper medical records as well as telephone interviews were reviewed to determine patient demographics, surgery characteristics, and assessment scores.

For clinical ratings of OCD and depression symptoms, we evaluated patient data at 3 different time points: 1) preoperatively, at baseline; 2) at the first postoperative follow-up; and 3) at the most recent postoperative follow-up. The first postoperative clinical assessment visit was usually scheduled to occur 9–12 months after surgery because the effect of the lesion evolves over months. In the interim, the patients were seen for surgical follow-up visits and closely followed by their referring psychiatrist. Included among the assessments were the structured clinical interview for DSM-IV preoperatively, and the Y-BOCS and BDI scores

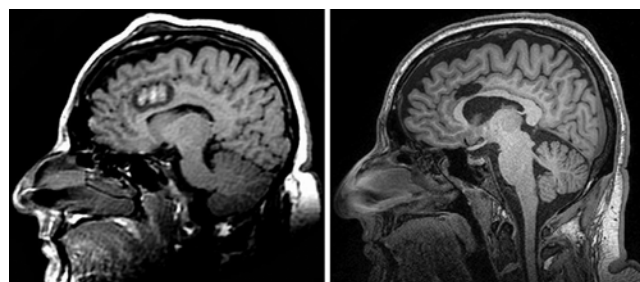


FIG. 1. Sagittal T1-weighted MR images of the left hemisphere depicting lesions created by the triple dorsal anterior cingulotomy on postoperative Day 1 (left), and 78 months later (right) in a representative patient.

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both pre- and postoperatively. The Y-BOCS and BDI assessments are considered to be valid and reliable measurements of obsessive-compulsive and depressive symptoms, respectively.^{5,8}

Analysis of Data

To classify patient response we used the change in Y-BOCS score as the primary outcome measure. Full responders were classified as patients demonstrating a decrease of $\geq 35\%$ in Y-BOCS score, indicating significant improvement of OCD symptoms. Partial responders were classified as patients who demonstrated a Y-BOCS score decrease of 25%–34%; hence a lesser, yet worthwhile improvement in their OCD symptoms. Nonresponders were classified as patients who had little to no improvement in OCD symptoms as evidenced by a decrease in Y-BOCS score of $< 25\%$. Pharmacology trials have traditionally used thresholds of 25% and 35% to define response; hence we used these categorical thresholds to define partial and full response, respectively. In addition, previous surgical studies have defined response identically. For descriptive statistics, the mean was used as a measure of central tendency, and the SEM as a measure of dispersion.

Results

Patient Demographic Data

Sixty-four patients (42 male and 22 female patients) were included in this study. The mean age at the time of surgery was 34.7 ± 1.4 years (range 16–69 years). The mean follow-up duration for the first postoperative visit was 10.7 ± 1.3 months, and for the most recent visit it was 63.8 ± 7.7 months. Thirty-six patients underwent cingulotomy with a single pair of lesions, and 28 received a triple pair of lesions. Patients who failed to improve after the procedure were considered for a second and sometimes a third procedure. Thirty-four patients underwent a single cingulotomy procedure, and 30 underwent one or more subsequent procedures (second procedure in 30, and third procedure in 5). Of the 64 total patients, complete follow-up data were available in 57. In an additional 2 patients, initial follow-up scores were not available, but most recent follow-up scores were. Thus, percentages were calculated based on a denominator of 57 at initial follow-up and 59 at most recent follow-up.

Prior to consideration for cingulotomy, several attempts at standard nonsurgical management, including medical and behavioral therapy, must have been tried and have failed. In patients in this cohort, 9.2 ± 0.5 monotherapy trials (at least 3 of which must have been SRIs) had failed, as had 2.2 ± 0.1 augmentation trials with benzodiazepines, mood stabilizers or anticonvulsants, or typical or atypical antipsychotics. In addition, these patients had participated in a minimum of 60 hours of behavioral therapy, with many patients having undergone behavioral therapy for several years.

Outcome for All Patients

Table 1 details the patient clinical rating scores and treatment responses at preoperative baseline and at the first and most recent postoperative follow-up. Prior to sur-

gery, the mean Y-BOCS score for the cohort was 31.3, placing them in the severe disease category. At the first follow-up (mean 10.7 months), 20 patients (35%) met the criterion for a full response, whereas 4 (7%) were classified as partial responders. These numbers had increased by the most recent mean follow-up of 63.8 months, at which time 28 patients (47%) met the criteria for full responders and 13 patients (22%) for partial. Thus, 41 patients (69%) achieved at least partial responder status at most recent follow-up.

The mean Y-BOCS score change (for which a decrease from preoperative baseline represents an improvement in OCD symptoms) was a decrease of 26% at the first follow-up and 36% at the most recent follow-up. Correspondingly, an improvement of comorbid depressive symptoms was indicated by mean BDI score decreases of 24% and 17% at the first and at most recent follow-up, respectively.

By univariate regression analysis, we found that neither age before surgery ($p = 0.23$), nor sex ($p = 0.92$), nor types of obsessions and compulsions (sorted into 4 broad categories: symmetry [$p = 0.61$], forbidden thoughts [$p = 0.59$], cleaning/contamination [$p = 0.75$], and hoarding [$p = 0.91$]) was predictive of the change in Y-BOCS score.

Of the 20 patients who had achieved full responder status at the time of the first follow-up, 14 remained full responders by the time of the most recent follow-up. Two dropped to partial responder status in that interval, and 4 became nonresponders. During the same interval, 11 patients who were nonresponders at initial follow-up became full responders, and 1 moved from partial to full responder, for a total of 28 full responders at the most recent follow-up. An additional 8 initial nonresponders gained partial response status. Thus of the 24 patients with at least a partial response at initial follow-up, 20 (83%) retained at least a partial response at most recent follow-up.

Outcome After Single Procedure

Of 34 patients (30 with initial and 32 with most recent follow-up data available) who underwent a cingulotomy with no other subsequent procedure, 15 patients (50%) achieved a full response and 3 patients (10%) achieved a partial response at the first follow-up. The average Y-BOCS change in this group was a decrease of 36%. At the most recent follow-up, 12 patients (38%) were full responders, and an additional 8 (25%) were partial responders, for a total of 20 patients (63%) with at least partial response. The mean Y-BOCS change at that time was a decrease of 28%.

Outcome After Multiple Procedures

Thirty patients (27 with available follow-up data) underwent a second procedure following the initial cingulotomy (either repeat cingulotomy or subcaudate tractotomy). The mean interval between the first and second procedure was 17.3 ± 3.2 months. Five patients underwent a third procedure (subcaudate tractotomy in all cases). The mean interval between the second and third procedure was 24.3 ± 5.1 months.

TABLE 1: Clinical response following limbic system surgery for OCD*

Procedure & Outcome	Findings		
	Preop	First FU†	Most Recent FU‡
all patients; n = 64			
responder		20 (35)	28 (47)
partial responder		4 (7)	13 (22)
nonresponder		33 (58)	18 (31)
Y-BOCS	31.3 ± 0.8	22.7 ± 1.3	19.6 ± 1.1
Y-BOCS change (%)		−26 ± 4	−36 ± 4
BDI	26.7 ± 1.4	18.8 ± 1.6	19.1 ± 1.9
BDI change (%)		−24 ± 7	−17 ± 11
FU (mos)		10.7 ± 1.3	63.8 ± 7.7
cingulotomy alone; n = 34			
responder		15 (50)	12 (38)
partial responder		3 (10)	8 (25)
nonresponder		12 (40)	12 (38)
Y-BOCS	30.9 ± 1.3	19.5 ± 1.9	21.3 ± 1.5
Y-BOCS change (%)		−36 ± 6	−28 ± 5
BDI	24.3 ± 1.8	15.7 ± 2.2	21.3 ± 2.6
BDI change (%)		−27 ± 11	2 ± 18
FU (mos)		12.7 ± 2.0	58.5 ± 10.7
cingulotomy + subsequent lesion; n = 30			
responder		5 (19)	16 (59)
partial responder		1 (4)	5 (19)
nonresponder		21 (78)	6 (22)
Y-BOCS	31.7 ± 1.0	25.4 ± 1.6	17.9 ± 1.7
Y-BOCS change (%)		−15 ± 4	−45 ± 5
BDI	29.7 ± 2.2	20.8 ± 2.1	17.4 ± 2.7
BDI change (%)		−22 ± 7	−41 ± 8
FU (mos)		10.2 ± 1.7	65.2 ± 10.5

* Data are presented as either the number (%) or the mean ± SEM. Abbreviation: FU = follow-up.

† Based on 57 patients with initial follow-up data in the “all patients” group; 30 in the “cingulotomy alone” group; and 27 in the “cingulotomy + subsequent lesion” group.

‡ Based on 59 patients with most recent follow-up data in the “all patients” group; 32 in the “cingulotomy alone” group; and 27 in the “cingulotomy + subsequent lesion” group.

Within this group, there were only 5 full responders (19%) and 1 partial responder (4%) at the initial follow-up. The mean change in Y-BOCS score was a decrease of 15%. At the most recent follow-up after the last procedure, however, the response rate increased to 16 (59%) full and 5 (19%) partial, with a mean Y-BOCS decrease of 45%. Thus, 21 patients (78%) experienced at least a partial long-term response following their last procedure.

A 2 × 3 chi-square analysis (single vs multiple procedure × full vs partial vs nonresponse) demonstrated no difference in responder status at the most recent follow-up between those who underwent a single procedure compared with those who underwent multiple procedures ($\chi^2 = 2.86$, $df = 2$, $p = 0.24$).

Single Versus Triple Anterior Cingulotomy

Thirty-six patients underwent an initial cingulotomy consisting of a single pair of lesions, and 28 underwent

an initial cingulotomy with a triple pair of lesions. A 2 × 3 chi-square analysis (single pair vs triple pair initial cingulotomy × full vs partial vs nonresponse) demonstrated no difference in long-term response status attributable to whether the initial cingulotomy was a single or triple lesion pair ($\chi^2 = 1.33$, $df = 2$, $p = 0.51$).

Postoperative Complications

There were 19 adverse events. There were no intracranial hemorrhages. Five patients had temporary postoperative memory difficulty that resolved days to months later. Two patients had urinary retention that improved after a few days, and 1 patient with preexisting urinary incontinence reported a slight worsening of incontinence postoperatively. Four patients had noticeable postoperative abulia, 1 after the initial cingulotomy, and 3 others after the later limbic leukotomy. In 1 of these patients, a CT scan showed slightly larger ventricles, and a frontal

ventriculostomy was placed in the operating room to rule out hydrocephalus as a contributing factor to his neurological change. Intracranial pressures were in the single digits, and the ventriculostomy was removed without incident after 4 days. The abulia improved over the next few days. Abulia in the other 3 patients who were observed conservatively also spontaneously improved in the ensuing days.

Three patients experienced intraoperative generalized seizures that resolved spontaneously within less than 1 minute. Two of these patients did not experience further seizures, but 1 patient developed a seizure disorder that required antiepileptic treatment for control. One additional patient had a single postoperative seizure.

One patient developed an infection that progressed into a subdural empyema. He underwent craniotomy for evacuation of the empyema, with no further complication. One patient had a pulmonary embolus while on a long airplane trip home.

Two patients committed suicide. One had a history of comorbid MDD (preoperative BDI 41, indicating severe depression) with months of suicidal ideation and one previous suicide attempt. At the first and only follow-up (7 months postoperatively) for this patient, her Y-BOCS score was essentially unchanged (a decrease of 4%) but her BDI had decreased by 27%. She committed suicide 3 months later. The second patient had a history of bipolar disorder and was depressed (BDI 39, severe depression) at the time of surgery. He was discharged from the hospital in stable neurological condition on postoperative Day 2. He committed suicide 8 days later.

Discussion

In this group of 64 patients undergoing limbic system surgery for treatment-refractory OCD, we observed a full response rate of 47%, and a partial response rate of 22% with a mean follow-up of more than 5 years, for a total of 69% achieving at least partial response. Considering the fact that these patients had previously failed to benefit from all conventional treatment modalities and had been severely disabled by their illness for years or decades, these responses represent significant improvements in quality of life.

Our management strategy for surgical candidates is based on initial cingulotomy. Slightly more than half the patients underwent cingulotomy alone, with an initial full responder rate of 50%. More than three-fourths of the remainder were nonresponders to initial cingulotomy at the initial follow-up and underwent subsequent procedures. The dramatic increase in full responder rate between initial and final follow-up (from 19% to 59%) in the multiple surgery group matched the success of the single surgery group, with no significant difference between the groups at final follow-up. Thus the graduated approach consisting of initial cingulotomy followed by subsequent procedures in nonresponders appears to be an effective strategy.

Compared with our previous study from 2002,⁶ our current results further establish the efficacy and durability of limbic system surgery. In that study, a full response was defined as a Y-BOCS score decrease $\geq 35\%$ and a clinical

global improvement score ≤ 2 . Achievement of one but not both criteria was classified as a partial response. Because clinical global improvement values were not available for a sufficient number of patients at the most recent follow-up in the current study, we used Y-BOCS decrease $\geq 35\%$ as the sole criterion for a full response. Thus full-responder status in the current study is similar in criteria terms to partial-responder status in our previous study. Given this correspondence in response criteria, the 47% full response rate in the current study with a mean 64-month follow-up is very similar to the 45% full or partial response rate with 32-month follow-up in our previous study. This stability in response rate over a follow-up interval twice as long, along with the observed 83% maintenance of response status between initial and most recent follow-up, support the durability of the improvements in OCD symptoms following stereotactic ablative procedures.

Nineteen patients who were nonresponders at initial follow-up gained at least partial responder status by last follow-up. This number accounts for almost half of the 41 total patients with at least a partial response. This pace of improvement suggests that the anatomical and physiological changes set in motion by the lesions occur on the time scale of months to years. Given this experience, our current practice for patients with a suboptimal early response is to observe for at least 9–12 months before considering a subsequent procedure. Anticipation of this timeline should also be an important component of the preoperative discussion with patients and referring psychiatrists.

The overall improvement in BDI scores of 17% at 5 years in the current study is less than the 27% improvement at 2.5 years observed in our previous study.⁶ At initial follow-up, however, the current cohort's 24% decrease was similar to the previous study's 29% decrease. It is therefore possible that whereas the initial improvement in depressive symptoms is substantial, it is less durable than the improvement in OCD symptoms, especially given the fact that these patients' eligibility for surgery was based primarily on OCD rather than depressive symptoms. Indeed, the mean preoperative BDI for patients at our institution, whose primary indication for cingulotomy was MDD, was 39,²³ compared with the mean preoperative BDI of 27 in the current cohort. Correspondingly, the BDI at last follow-up for the MDD group in that earlier study was 21, a final end point very similar to the BDI of 19 for the current OCD group.

Most of the adverse effects in this series were self-limited, but a few were significant. There were no intracranial hemorrhages, and there was 1 infection. The possibility of postoperative abulia should be recognized, as should the observation that it is more common following limbic leukotomy than cingulotomy, and that it typically improves without intervention. The BDI scores of the 2 patients who committed suicide were 39 and 41, indicating severe depression. The BDI score of one of the patients had actually improved before she committed suicide, but the other suicide occurred soon after surgery.

Although the pathophysiology of OCD is not completely understood, dysfunction in CBTC circuits appears to play a central role. Whereas other CBTC circuits are re-

sponsible for the control of limb movement, eye movement, and working memory, the CBTC components implicated in OCD are those involved in behavioral or affective control.^{1,2} These include the ventromedial, orbitofrontal, and cingulate cortex; the ventromedial caudate and ventral striatum; and the mediodorsal thalamus.

The success of surgical procedures derives from their ability to modulate these regions and the white matter connections between them. The first application of stereotactic procedures in neurosurgery, performed by Spiegel and colleagues,²⁴ consisted of lesioning the medial nucleus of the thalamus to reduce "emotional reactivity." The anterior capsulotomy, developed by Talairach et al.²⁵ and Leksell,¹⁷ targeted connections between the orbitofrontal cortex and thalamus in the anterior limb of the internal capsule, and motivated later DBS studies in that target.^{19,20} Knight¹⁶ developed the subcaudate tractotomy to disrupt connections between prefrontal cortical regions, the cingulate, and deep limbic structures including the amygdala. Shortly thereafter, in the mid-1960s, Ballantine and colleagues⁴ targeted the cingulate cortex itself, along with connecting fibers in the cingulum bundle, with the dorsal anterior cingulotomy. The combination of the latter two, the limbic leukotomy, was later used by Kelly and colleagues.^{13,14}

Recently DBS, motivated by the success of lesioning procedures,^{9,11,18} has emerged as a promising treatment for OCD. The encouraging initial results of DBS for OCD led to the approval of this procedure under a humanitarian device exemption from the FDA. Potentially appealing characteristics of DBS include its reversibility and programmability. Furthermore, information obtained from DBS studies may help elucidate the neuroanatomical basis for OCD and inform the development of further therapies. In addition, DBS procedures are easily amenable to double blinding and sham treatment as a control, and previous^{7,9,10} and ongoing trials have incorporated such a design. The lack of these features is an important limitation of the current study. Given the refractory nature of the disease in patients who qualify for consideration for cingulotomy as well as the rigorous candidacy vetting process, a sham-treated control group would be ethically difficult to justify.

Results from a multicenter trial of DBS for OCD in the ventral capsule/ventral striatum target are similar to those in this study.⁹ The mean preoperative Y-BOCS for the 26 patients in that study was 34.0, similar to the value of 31.3 for the 64 patients in our cohort. The full responder rate (also defined as $\geq 35\%$) at 12 months was 48%, and at last follow-up (mean 31.4 months) it was 61.5%. The fraction of patients who achieved at least partial responder status (also $\geq 25\%$) at last follow-up was 73% in the DBS study, compared with our value of 69%. Thus the efficacy of ventral capsule/ventral striatum DBS for OCD seems approximately similar to that for stereotactic ablative procedures, although it should be noted that the follow-up duration in the DBS study was less than half that of the current study.

However, DBS is expensive, both in terms of cost of the equipment and the time required for adjustment of stimulation parameters. Furthermore, DBS but not lesion

studies typically involve long-term follow-up by committed, expert, and dedicated OCD specialists. The potentially beneficial effect of this additional surveillance should not be underestimated and has not been closely studied. It will be interesting to compare long-term outcomes of DBS to those of ablative procedures.

Conclusions

Limbic system surgery based on initial cingulotomy for severe, treatment-refractory OCD remains a viable and durable option for appropriate patients when conventional treatments have failed. As new therapies including DBS are developed and tested, it will be important to keep these results in mind, as they continue to stand the test of time.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Sheth, Cosgrove, Eskandar, Dougherty. Acquisition of data: Neal, Tangherlini, Gentil, Dougherty. Analysis and interpretation of data: Sheth, Neal, Tangherlini, Mian. Drafting the article: Sheth, Neal. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Sheth. Statistical analysis: Sheth. Study supervision: Cosgrove, Eskandar, Dougherty.

Acknowledgments

The authors thank Valerie Giorgione and Amanda Duffy for their help with data collection.

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Manuscript submitted February 16, 2012.

Accepted November 8, 2012.

Portions of this work were submitted in abstract form for the American Association of Neurological Surgeons' annual meeting, which was held in Miami, Florida, on April 14–18, 2012.

Please include this information when citing this paper: published online December 14, 2012; DOI: 10.3171/2012.11.JNS12389.

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