

Case Report

Deep brain stimulation with a pre-existing cochlear implant: Surgical technique and outcome

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Abstract

Background: Patients with previously implanted cranial devices pose a special challenge in deep brain stimulation (DBS) surgery. We report the implantation of bilateral DBS leads in a patient with a cochlear implant. Technical nuances and long-term interdevice functionality are presented.

Case Description: A 70-year-old patient with advancing Parkinson's disease and a previously placed cochlear implant for sensorineural hearing loss was referred for placement of bilateral DBS in the subthalamic nucleus (STN). Prior to DBS, the patient underwent surgical removal of the subgaleal cochlear magnet, followed by stereotactic MRI, frame placement, stereotactic computed tomography (CT), and merging of imaging studies. This technique allowed for successful computational merging, MRI-guided targeting, and lead implantation with acceptable accuracy. Formal testing and programming of both the devices were successful without electrical interference.

Conclusion: Successful DBS implantation with high resolution MRI-guided targeting is technically feasible in patients with previously implanted cochlear implants by following proper precautions.

Key Words: Cochlear implant, deep brain stimulation, magnetic resonance imaging, Parkinson disease

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INTRODUCTION

Deep brain stimulation (DBS) has become an increasingly acceptable treatment modality for treatment of Parkinson's disease (PD),^[1-7] essential tremor (ET),^[8-11] and dystonia^[12,13] along with some psychiatric diseases.^[14,15]

Given the aging population, a neurosurgeon is likely to see DBS candidates that have other previously implanted electronic devices. Safe implantation of DBS in patients with cardiac pacemakers has been described.^[16,17] Placement of a unilateral DBS lead in a patient with a cochlear implant has also been previously described

using computed tomographic (CT)-guided targeting due to magnetic resonance imaging (MRI) artifact.^[18] More

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recently, MRI-guided bilateral DBS implantation was described in a patient with bilateral cochlear implants, albeit with the targeting being limited to the subthalamic nucleus (STN) due to significant signal artifact.^[19]

The presence of a pre-existing cochlear implant presents a number of challenges when considering DBS placement. The implant magnet is not MRI compatible, necessitating its removal surgically or alternatively using non-MRI based imaging for DBS targeting. If the magnet is removed, there is loss of hearing, and henceforth communication with the patient is diminished during DBS surgery.

We describe successful bilateral STN DBS implantation using MRI-based targeting and intraoperative CT (iCT) utilization in a patient with a pre-existing cochlear implant. Targeting accuracy and nuances leading to a safe and reliable function of both implanted devices are discussed.

CASE REPORT

Clinical background

The patient is a 70-year-old right-handed male with a 14-year history of PD. He also had a right posterior temporal cochlear implant (Advanced Bionics 90K, Valencia, CA) placed 2 years ago due to sensorineural hearing loss. After evaluation by the surgical movement disorders team, he was determined to be an appropriate candidate for bilateral STN DBS.

Surgical technique

Cochlear implant magnet removal

The surgical care was coordinated with the neurotology team. One day prior to DBS implantation, the patient was taken to the operating room by the neurotology team and placed under general anesthesia. The receiver stimulator portion of the implant was marked off by using the patient's transmitting coil as a stencil, and a half circle was drawn along the top of the receiver stimulator portion of the implant. After incision, a subgaleal pocket was developed over the cochlear implant. The soft tissue overlying the receiver implant was opened. While being careful to not damage cochlear implant, the capsule overlying the implant itself was opened in the same manner. The cochlear implant magnet was identified, removed from its pocket, and the wound was closed.

Deep brain stimulation surgery

After magnet removal, preoperative stereotactic MRI of brain was performed (T1 post-contrast volumetric, T2 axial, and SWI axial sequences) [Figure 1]. The following day, on the morning of surgery, after appropriate local anesthetic and betadine was applied to the patient's head, a Leksell Model G Stereotactic Frame (Elekta, Stockholm, Sweden) was applied in the standard fashion. Care was taken to avoid placing the occipital screw around the surgical incision. A high-resolution 1 mm slice

non-contrast CT study was then obtained [Figure 1] after frame placement and computationally merged with the preoperative MRI in the workstation. Signal artifact on CT images did not interfere with successful merge.

Targeting was done using the Framelink 5.1 software (Medtronic, Minneapolis, MN). Anatomic locations of anterior commissure (AC), posterior commissure (PC), and midline markers were defined to create images orthogonal to the AC-PC plane and mid-sagittal plane. Of note, both STN and globus pallidus pars interna (GPi) were successfully visualized on T2 and SWI sequences [Figure 1]. Frontal entry points were planned and trajectories were created to avoid sulci, vessels, and the ventricular wall. Bilateral STN targets were selected based on standard coordinates adjusted to fit the patient's visualized anatomy [Table 1].

The patient was positioned supine on the operating table in the "recline" position. Details of positioning using iCT for DBS have been previously described.^[20,21] Given the patient's severe sensorineural hearing loss, communication with the patient was achieved using computer-generated text displayed on an operating room monitor [Figure 2].

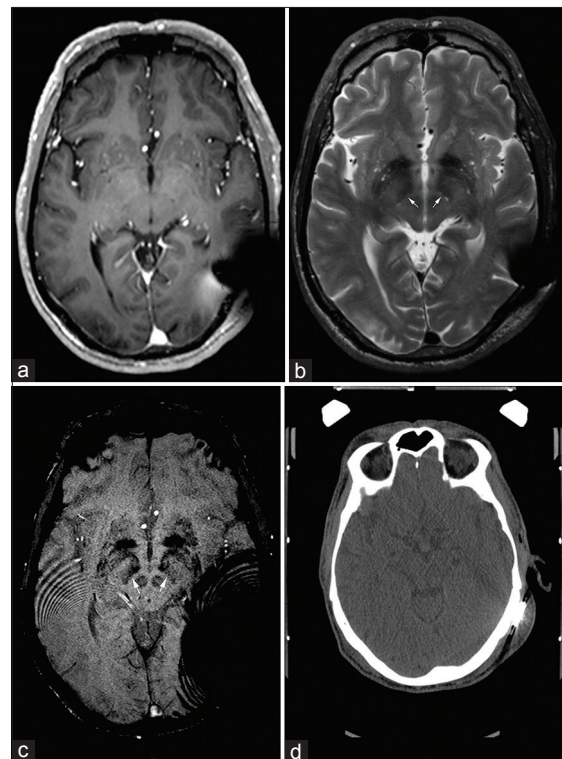


Figure 1: MRI and CT images of patient with cochlear implant after magnet removal demonstrating various degrees of signal artifact. (a) T1W axial section demonstrates artifact extending to the subcortical white matter of posterior temporal lobe. (b and c) T2W and SWI sequences, respectively, showing undistorted anatomy of subthalamic nucleus and midbrain structures. Arrows show medial STN borders. (d) Axial noncontrast CT with normal visualization of fiducial markers on the localizer

After draping, the Leksell arc and headstage were assembled. Burr holes were made. A 1.27 mm diameter

Table 1: Target, error, and final coordinates of bilateral DBS leads. All coordinates are from the mid AC-PC point

	X	Y	Z	Euclidean Error
Left STN				
Initial Target	11.05	-4.9	-3.97	
Adjustment	2mm M			
Predicted Target	9.05	-4.9	-3.97	
DBS	8.43	-4.83	-4.2	0.66
Right STN				
Initial Target	-10.8	-3.32	-3.94	
Adjustment	2mm M			
Predicted Target	-8.8	-3.32	-3.94	
DBS	-9.69	-4.6	-3.07	1.79

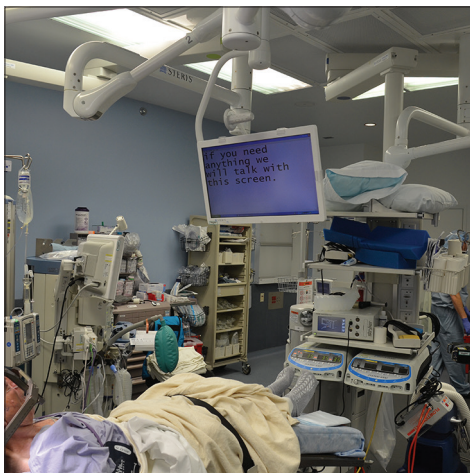


Figure 2: Intraoperative photograph demonstrating the use of a computer monitor to communicate with the patient that has sensorineural hearing loss during DBS surgery

and 25 mm length sterile guide tube (Alpha Omega, Nazareth, Israel) was inserted to a depth of 15 mm above target. Microelectrode recording ensued at this time. The leads (model 3389, Medtronic, Inc., Minneapolis, Minnesota) were subsequently assembled and advanced to target. iCT images were obtained and computationally merged with the preoperative CT [Figure 3]. Target accuracy was measured by recording the x, y, and z coordinates at the center of the lead's most distal contact. The Euclidean distance from the intended target was calculated using the formula $\sqrt{|\Delta x|^2 + |\Delta y|^2 + |\Delta z|^2}$ [Table 1]. The distal ends of the DBS leads were coiled and tunneled to a pocket created contralateral (left side) to the cochlear implant.

Cochlear implant magnet replacement

Immediately following DBS implantation, the patient was placed under conscious sedation. The postauricular area was prepped and draped. The incision that was made for cochlear implant removal 24 hours earlier was opened, the receiver stimulator portion of the cochlear implant was identified, and a new cochlear implant magnet was placed. The wound was closed in layers. The patient recovered uneventfully and was discharged home the following day.

One week later, he presented for placement of the pulse generator in the left chest and connection to the DBS leads.

Postoperative course

There were no surgical or postoperative complications. The incision for cochlear implant magnet removal was allowed to heal for 2 weeks, at which point the sutures were removed. The patient was asked not to use the cochlear implant for an additional 2 weeks to avoid infection of this wound and potential contamination of the cochlear implant. The patient's hearing and

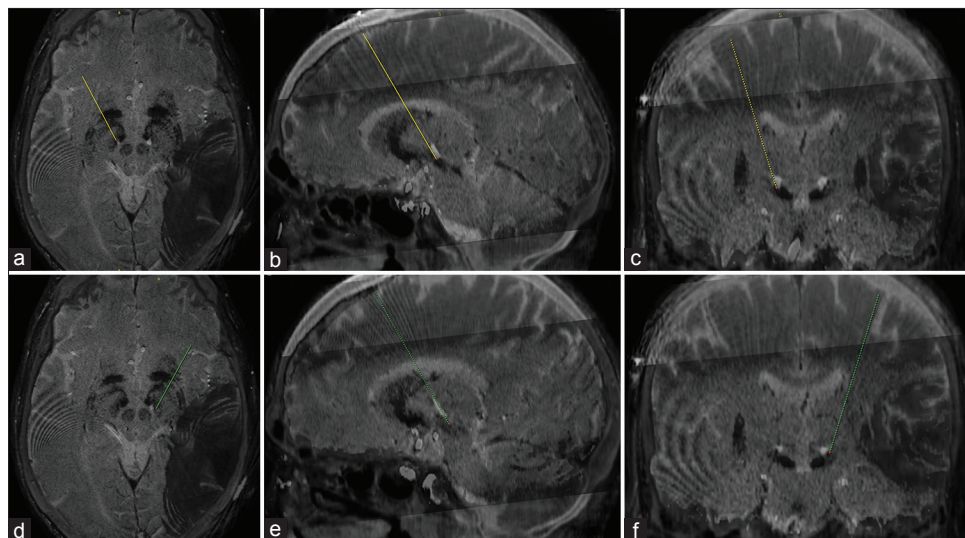


Figure 3: Merged iCT images with preoperative MRI. (a-c) Left SWI sequences in the axial, sagittal, and coronal planes showing final DBS distal contact location in relation to the original target (yellow). (d-f) Right SWI sequences demonstrating final DBS location compared to the target (green)

Table 2: Hearing and speech perception results before and one year after DBS implantation

	Preop	One-Year Postop
HINT-Q (%)	76	74
CNC words (%)	44	40

CNC words: consonant-vowel nucleus-consonant words; HINT-Q: Hearing in Noise Test sentences presented in quiet

speech perception remained stable at 1 year after DBS implantation [Table 2]. No changes were made in the cochlear implant settings.

One month after the surgery the patient returned to the Movement Disorder clinic for initial DBS programming. Interrogation of the device revealed normal function without interference from the cochlear implant when tested at both monopolar and bipolar settings. Impedances were normal. Optimal clinical improvement was noted with bipolar settings (1-2+ left; 9-10+ right) at a voltage of 3.0 V, pulse width of 60 μ s, and frequency of 130 Hz bilaterally. At these settings, the patient had significant tremor suppression with no adverse effects. At the latest follow-up 8 months after DBS implantation, the left side voltage was increased to 3.2 with maintained efficacy.

DISCUSSION

The presented case suggests that direct targeting of the basal ganglia and thalamic nuclei is feasible and safe using MRI in a patient with a cochlear implant. Safe implantation of DBS in patients with cardiac pacemakers^[16,17] has been previously reported. Furthermore, subsequent implantation of a cochlear hearing device in patients with prior DBS have been reported.^[22,24] De Los Reyes *et al.*^[18] have described CT-guided DBS implantation of the ViM subnucleus in a patient with essential tremor and unilateral cochlear implant. The authors described the MRI artifact causing a shift in one of the fiducial markers on the stereotactic frame localizer, thus necessitating a CT-guided approach. While this approach is reasonable for indirect targeting, it does not provide the resolution needed for direct targeting often used in STN or GPi surgery. In a more recent report by Buell *et al.*,^[19] the authors successfully implanted bilateral STN DBS leads using MRI targeting by decoupling the MRI study (obtained before frame placement) from the CT study and merging the studies. They did, however, report significant signal artifact in the GPi which limited targeting to the STN.

In the presented report, we were able to circumvent the abovementioned issues by close temporal interval removal of the cochlear magnet, obtaining the MRI study before frame placement, with next day frame placement, and CT image merging for targeting. The accuracy of MRI-CT merging has been previously described and validated.^[25-27]

Minimal artifact is generated by the cochlear implant on the preoperative MRI, primarily affecting the cortical and subcortical regions; however, this artifact did not disturb the anatomical location of the deep nuclei of the brain. Similarly, CT artifact from the implant did not have any effect on the fiducial markers on the stereotactic frame localizer. Moreover, iCT images were readily merged with the preoperative CT and target error calculations were within the acceptable range. One suggested alternative solution to the MRI artifact problem in the previous study^[18] would be to mathematically calculate the correct location of the shifted fiducial. While this could prove to be feasible, our method takes any approximation out of an already complex algorithm.

While the presented technique offers better anatomical resolution for planning, it has the drawback of requiring the orchestration of multiple procedures in close proximity, along with the associated potential increased risks such as infection.

Functionality of the DBS device and clinical efficacy of either device do not appear to be affected by a pre-existing cochlear implant given the clinical results and normal impedances at the latest follow-up. This is consistent with previous case reports.^[18,19,22,24] Caution is warranted, however, if consideration is being given to a rechargeable DBS generator as there is no prior data on the interference between the charging unit and the cochlear implant.

The cochlear implant functionality appears to remain intact with no change in hearing function after DBS surgery, as shown here. This is likely due to the low level of stimulation and spatial separation of the devices. Another important issue of consideration is patient communication after magnet removal, especially during DBS surgery. Buell *et al.*^[19] surgically replaced the cochlear magnet immediately after the preoperative MRI but before DBS surgery to allow the patient hearing function. Unfortunately, activation of the device resulted in significant electrical artifact during microelectrode recording. Furthermore, repeated manipulations around the cochlear implant surgical wound may increase the risk of infection. An alternative approach, as described here, would be to withhold magnet replacement until DBS surgery is completed. Communication with the patient can readily be done via a computer screen coupled to a keyless keyboard. This method also allows the intraoperative examiner and additional subjective parameter of measuring motor dexterity.

CONCLUSION

Implantation of a nonrechargeable open loop DBS system in patients with pre-existing cochlear implants appears to be safe.

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Conflicts of interest

There are no conflicts of interest.

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