Revision of deep brain stimulator for tremor

Technical note

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The treatment of essential tremor with thalamic deep brain stimulation (DBS) is considered to be more effective and to cause less morbidity than treatment with thalamotomy. Nonetheless, implantation of an indwelling electrode, connectors, and a generator is associated with specific types of morbidity. The authors describe three patients who required revision of their DBS systems due to lead breakage. The connector between the DBS electrode and the extension wire, which connects to the subclavicular pulse generator, was originally placed subcutaneously in the cervical region to decrease the risk of erosion through the scalp and to improve cosmesis. Three patients presented with fractured DBS electrodes that were located in the cervical region near the connector, necessitating reoperation with stereotactic retargeting and placement of a new intracranial electrode. At reoperation, the connectors were placed subgaleally over the parietal region.

Management of these cases has led to modifications in the operative procedure designed to improve the durability of DBS systems. The authors recommend that surgeons avoid placing the connection between the DBS electrode and the extension wire in the cervical region because patient movement can cause microfractures in the electrode. Such microfractures require intracranial revision, which may be associated with a higher risk of morbidity than the initial operation. The authors also recommend considering prophylactic relocation of the connectors from the cervical area to the subgaleal parietal region to decrease the risk of future DBS electrode fracture, which would necessitate a more lengthy procedure to revise the intracranial electrode.

KEY WORDS • essential tremor • thalamus • deep brain stimulator • complication

Implantation of DBS electrodes has advantages over lesion-causing procedures. Thalamic stimulation for tremor is reversible and programmable, which may lead to increased long-term efficacy and reduction of side effects, compared with thalamotomy. Bilateral stimulation is associated with a decreased risk of dysarthria and cognitive impairment, compared with bilateral thalamotomy. There may also be a decreased risk of perioperative hemorrhagic stroke, although this theory remains controversial.

Nonetheless, implantation of an indwelling electrode, connectors, and generator has its own specific type of morbidity. The Activa system (Medtronic, Inc., Minneapolis, MN) consists of a DBS electrode (model 3387 lead), an in-line extension (model 7495-51), and a pulse generator (model 7424 Itrel II quadripolar implantable pulse generator). The DBS electrode is made of platinum/iridium wires and electrodes with polyurethane/polytetrafluoroethylene insulation. The lead is 50 cm long and 1.27 mm in diameter, with four stimulator contacts spaced 1.5 mm apart at the electrode tip. The in-line extension, which runs to the generator, is made of a nickel alloy, insulated with silicone rubber, and has a diameter of approximately 3 mm. We describe three cases in which the connector between the DBS electrode and the in-line extension was placed in the patient’s neck to decrease the risk of erosion through the skin and to improve cosmesis. In each case, the DBS electrode fractured in the cervical region near the connector, necessitating removal of the electrode and placement of a new one, which required stereotactic retargeting and microelectrode recording.

Clinical Material and Methods

Three patients, ranging in age from 45 to 86 years (mean 60.3 years), underwent stereotactic implantation of a DBS electrode into the left ventral intermediate thalamic nucleus for treatment of either essential or parkinsonian tremor. The electrode was tracked subcutaneously and attached to a connector in each patient’s neck. The in-line extension with the larger bore was run from the connector to the pulse generator, which lay subcutaneously on the patient’s chest wall. After this procedure all three patients experienced marked improvement in their tremors; however, all experienced recurrence of their tremors 6 to 11 months (mean 8.7 months) after their original surgeries. Plain x-ray films revealed microfractures of the DBS elec-
trode (Fig. 1) in each case. In one patient, electrical examination of the system revealed an elevated electrode impedance in conjunction with a low system current, confirming a fractured lead.

Operative Procedure

Because the fractures occurred in the DBS electrode and not in the in-line extension, the patients required replacement of the intracranial DBS electrode. In each case, the pulse generator was turned off and the patient underwent MR imaging. In the first two patients, the tip of the electrode was stereotactically localized. The old electrode was removed and a new one was guided stereotactically and placed at the site of the previous electrode. A high voltage of stimulation was required to suppress these patients’ tremors, indicating that targeting was suboptimal. Because of our experiences with the first two patients, re-targeting was performed relative to the anterior and posterior commissures in the third patient. In each case, a new DBS electrode was stereotactically placed with the aid of microelectrode recording. The DBS electrode was secured with fluoroscopic guidance. The system was internalized in the patient either immediately after a computerized tomography scan confirmed no intraparenchymal hemorrhage or after 2 days of external testing and optimization of electrical settings. The in-line extensions were tracked subcutaneously to new generators, which were placed at the sites of the previous generators. The connectors lay over the left parietal area (Fig. 2).

Results

All patients experienced excellent suppression of their tremors; however, all three patients suffered significant morbidity. The first patient returned to our hospital 2 months after the revision with an infection at the pulse generator site. The in-line extension and pulse generator were removed, although the DBS electrode was left in place. The patient was treated with antibiotic agents for 4 weeks, after which a new in-line extension and pulse generator were implanted. This patient has done well with excellent tremor suppression. The second patient returned to the hospital 1 week after the revision with acute shortness of breath caused by a pulmonary embolus. This necessitated admission to the intensive care unit, placement of an inferior vena cava filter, and anticoagulation therapy. The third patient noted a new-onset right upper extremity weakness 6 hours after surgery. Magnetic resonance imaging revealed a venous infarct in the left frontal lobe around the electrode insertion site. The patient made a complete recovery, but first required outpatient physical and occupational therapy.

Discussion

Although DBS is a therapy considered safer than ablation, the procedure may be associated with morbidity specific to the implants themselves. Ondo and associates reported that two of their 33 patients suffered equipment failure 3 months after placement of the Activa system for thalamic stimulation with the connector placed behind the pinna. Benabid, et al., reported that in three of their 117 patients skin necrosis developed in front of connectors that had been placed under the scalp. These patients were noted to have extremely thin scalps. Lozano reported a 1
to 2% incidence of hardware-related complications. These early experiences resulted in technical adjustments to improve the durability of DBS systems. Neurosurgeons in our institution and elsewhere have placed the connector in the neck to avoid erosion and to improve cosmesis; however, of 12 patients in whom the connector was placed in the neck and for whom we have follow-up data, five (including the three presented in this paper) have experienced fractures of the DBS electrode. This represents a 42% lead fracture rate.

The in-line extension has a different conductor and insulator than the DBS electrode, thus making it less likely to fracture. Any breakdown in the extension can be easily repaired in a short procedure, as opposed to the lengthy and potentially morbid stereotactic intracranial procedure. Therefore, we recommend connection of the DBS electrode to the in-line extension in the parietal subgalea, where we have not experienced any case of erosion in over 75 implanted Activa systems.

Review of the case of postoperative wound infection at the site of the generator has also demonstrated another advantage of placing the connector subgaleally. In this case, the generator and extension were removed, whereas the DBS electrode was left in place. After the infection was successfully treated with antibiotic agents, general anesthesia was induced in the patient and the DBS electrode was connected to a new generator, thereby avoiding the lengthy operative time and risks associated with retargeting.

Our results show that DBS electrodes can be safely removed and confirm previous work in which it was demonstrated that these patients can safely undergo MR imaging with the stimulator turned off.12

Many authors have noted that the effects of thalamotomy may wear off over time and that repeated thalamotomy may be beneficial.10,11 This also occurs in DBS systems, but may be counteracted by increasing the stimulation parameters. Benabid, et al.,2 proposed that the decreased effect may be counteracted by increasing the stimulation parameters. Therefore, we recommend connection of the DBS electrode to the in-line extension in the parietal subgalea, where we have not experienced any case of erosion in over 75 implanted Activa systems.

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