Anchoring of deep brain stimulation electrodes using a microplate

Technical note

JACQUES FAVRE, M.D., JAMAL M. TAH, M.D., TIMOTHY STEEL, F.R.A.C.S., AND KIM J. BURCHIEL, M.D.

Division of Neurosurgery, Oregon Health Sciences University, Portland, Oregon

The authors report a new technique to anchor deep brain stimulation electrodes using a titanium microplate. This technique has been safely used to secure 20 quadripolar deep brain stimulation electrodes implanted for movement disorders (18 electrodes) and pain (two electrodes). Twelve electrodes were implanted in the thalamus, four in the subthalamic nucleus, and four in the pallidum. No electrode migration or rupture occurred, and all electrodes have been shown to work properly after internalization of the system.

KEY WORDS • deep brain stimulation • microplate • anchor • movement disorder • pain

Deep brain stimulation is an effective treatment for chronic pain,5,8 tremor,1,2 and other parkinsonian symptoms.9 Because the leads must remain correctly positioned for years after surgery, it is critical that they are well anchored to the skull to avoid migration or breakage. Electrode migration occurs in up to 10% of cases; it is the most important complication related to the anchoring technique, resulting in clinical failure.6

Operative Techniques

A four-hole 1.7-mm-thick titanium microplate (Leibinger, Dallas, TX) is used to secure quadripolar deep brain stimulation electrodes (model 3387; Medtronic, Minneapolis, MN) to the calvaria.

A curvilinear skin incision is made anterior to the coronal suture, 2.5 cm lateral to the midline. The plate is bent on its longitudinal axis to create a tunnel that is approximately one-half of the diameter of the electrode through which the lead passes. The plate is then placed parallel to the scalp flap and affixed to the skull medially with one 4-mm screw. The hole for the lateral screw is drilled but no screw is inserted. A 3-mm twist-drill hole is created stereotactically, 2 mm in front of the middle of the plate (Fig. 1a). The plate is then rotated anteriorly, medial to the twist-drill hole (Figs. 1b and 2 left). A guiding cannula is then inserted stereotactically through the twist-drill hole, 10 mm short of the brain target. After physiological confirmation of the target, the quadripolar electrode is inserted through the cannula toward the desired target (Fig. 1c). The cannula is gently pulled out under stereotactic guidance until the electrode is visible at the surface of the skull. The electrode is held with atraumatic forceps while the guiding cannula is removed. The electrode is bent posteriorly over the skull and the microplate is rotated over the electrode, back to its original position. A screw is placed through the lateral hole of the plate in the previously drilled hole and gently tightened (Figs. 1d and 2 right). Plate screws should be sufficiently tightened to avoid electrode movement; this is verified by gently pulling on the electrode. However, the screws should not be overtightened to avoid lead breakage.

Clinical Results

The positions of the first 10 electrodes were verified by intraoperative lateral skull x-ray films to confirm the accuracy of their placement. An initial film of the test electrode at target was performed under stereotactic conditions. A second film of the secured permanent electrode was then compared to the initial film to document that no migration had occurred. The patient’s clinical responses and postoperative skull x-ray films were used to confirm adequate placement of the last 10 implants. No displacement was demonstrated for any of the 20 electrodes at the time of patient discharge. No instances of electrode fracture related to the anchoring system were observed. Technical complications occurred in two patients: in one case the electrode was inserted too deeply; in the other, the electrode fractured during internalization of the impulse generator.
because of a stitch placed 3 cm proximal to the extension connector and 8 cm distal to the fixation plate. An adequate clinical response (such as control of tremor, induction of paresthesia, and decreased rigidity) was obtained in all patients. As of their last follow-up examination (range 1 week–2 years; median 13 months), all patients continued to experience a sustained clinical effect from stimulation. Radiological (x-ray and/or CT) follow-up studies of 15 electrodes showed no evidence of migration or lead fracture.

Discussion

Various methods have been developed to secure deep brain stimulation electrodes to the calvaria. These methods have been associated with migration rates of 2% to 10%. In 1981 Ray described the use of a silicone burr-hole ring cap, which is supplied by the electrode manufacturer (Medtronic). This method has several disadvantages: first, it requires a 14-mm burr hole, which may induce a large loss of cerebrospinal fluid, resulting in posterior displacement of the target. Second, movement of the lead can occur during insertion of the electrode into the groove of the silicone ring. If excessive traction is applied, the tip of the electrode can migrate superiorly. If insufficient traction is applied, the elasticity of the silicone can move the electrode deeper. Third, electrode manipulation and patient movement can result in lead migration after insertion of the cap secondary to insufficient rigidity of the ring-cap device.

Other methods that have been developed to secure deep brain stimulation electrodes include the use of a hollow titanium screw that fits a 2.5-mm twist-drill hole, a burr hole filled with acrylic cement, and a silastic tube secured to the skull with stitches. The former method imparts a sharp 90° angle to the electrode as it exits the screw, creating an important local constraint on the lead and increased risk of lead fracture. The last two methods are technically more complex and migration of the electrode can occur during the anchoring process.

In this report, we describe a method to secure deep brain stimulation electrodes that is simple, safe, and effective. Our method has several advantages. It can be used with any size of skull opening. It also allows a more gradual curve as the electrode exits the skull. The lip of the calvaria can be smoothed using the air drill or other instruments to improve the exit trajectory further. The price of the plate and screws (US $48.00 for the plate; $28.00 for each screw) is modest and very similar to the cost of the acrylic cement method (US $120.50 for a methylmethacrylate kit).

No electrode migration occurred with our microplate technique; however, as with all other techniques, the electrode must be handled with great care before it is anchored to prevent a change in the initial depth. This complication occurred in one patient. Intraoperative x-ray films can be useful to confirm adequate positioning of the electrode.

In our series, one electrode was fractured far away from the fixation plate. The complication was not related to the anchoring process, but to a penetrating subcutaneous stitch. This complication highlights the fragility of the electrode lead when inadequately handled. Our method allows decreased electrode manipulation, which should result in fewer episodes of migration or lead fracture at the exit site of the skull.

Conclusions

The use of a titanium microplate to anchor deep brain stimulation electrodes appears to be a reliable and easy way to prevent electrode migration. Caution must still be exercised to limit the risk of electrode breakage, and great
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care is necessary to avoid crushing the electrode under the microplate. However, this complication can be prevented by using an adequate technique that involves bending the plate before usage and gentle tightening of the second screw.

References


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Address reprint requests to: Kim J. Burchiel, M.D., Division of Neurosurgery, L-472, Oregon Health Sciences University, 3181 S.W. Sam Jackson Park Road, Portland, Oregon 97201–3098.