Postoperative Displacement of Deep Brain Stimulation Electrodes Related to Lead-Anchoring Technique

M. Fiorella Contarino, MD, PhD†
Maarten Bot, MD‡
Johannes D. Speelman, MD, PhD†
Rob M. A. de Bie, MD, PhD†
Marina A. Tijssen, MD, PhD†¶
Damiaan Denys, MD, PhD§
Lo J. Bour, PhD†
P. Richard Schuurman, MD, PhD‡
Pepijn van den Munckhof, MD, PhD‡

Departments of †Neurology; ‡Neurosurgery; and §Psychiatry, Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands; ¶Department of Neurology, University Medical Centre Groningen, Groningen, the Netherlands

Correspondence:
M. Fiorella Contarino, MD, PhD,
Department of Neurology,
Academic Medical Center,
Meibergdreef 9,
1105 AZ Amsterdam,
the Netherlands.
E-mail: m.f.contarino@amc.uva.nl

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WHAT IS THIS BOX?
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BACKGROUND: Displacement of deep brain stimulation (DBS) electrodes may occur after surgery, especially due to large subdural air collections, but other factors might contribute.
OBJECTIVE: To investigate factors potentially contributing to postoperative electrode displacement, in particular, different lead-anchoring techniques.
METHODS: We retrospectively analyzed 55 patients (106 electrodes) with Parkinson disease, dystonia, tremor, and obsessive-compulsive disorder in whom early postoperative and long-term follow-up computed tomography (CT) was performed. Electrodes were anchored with a titanium microplate or with a commercially available plastic cap system. Two independent examiners determined the stereotactic coordinates of the deepest DBS contact on early postoperative and long-term follow-up CT. The influence of age, surgery duration, subdural air volume, use of microrecordings, fixation method, follow-up time, and side operated on first was assessed.
RESULTS: Subdural air collections measured on average 4.3 ± 6.2 cm^3. Three-dimensional (3-D) electrode displacement and displacement in the X, Y, and Z axes significantly correlated only with the anchoring method, with larger displacement for microplate-anchored electrodes. The average 3-D displacement for microplate-anchored electrodes was 2.3 ± 2.0 mm vs 1.5 ± 0.6 mm for electrodes anchored with the plastic cap (P = .030). Fifty percent of the microplate-anchored electrodes showed 2-mm or greater (potentially relevant) 3-D displacement vs only 25% of the plastic cap–anchored electrodes ($P < .01$).
CONCLUSION: The commercially available plastic cap system is more efficient in preventing postoperative DBS electrode displacement than titanium microplates. A reliability analysis of the electrode fixation is warranted when alternative anchoring methods are used.

KEY WORDS: Deep brain stimulation, Electrode displacement, Fixation method, Image coregistration, Stereotactic surgery, Microplate, Plastic cap anchoring system

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BACKGROUND/RATIONALE

Accurate stereotactic implantation of deep brain stimulation (DBS) electrodes is essential to maximize the benefits of DBS surgery. It is assumed that anatomic structures do not move between preoperative image acquisition and stereotactic electrode implantation. However, several reports revealed erratic implantation of DBS electrodes caused by shifts of as much as 5 mm of deep brain structures due to cerebrospinal fluid (CSF) loss and subdural air invasion.[1-4] Another assumption is that implanted electrodes do not move postoperatively, whereas recently our group reported significant upward displacement of DBS leads in the months after surgery in 14 patients with Parkinson disease (PD) undergoing DBS of the subthalamic nucleus (STN).[5] This postoperative displacement significantly correlated with the amount of air invading the

ABBREVIATIONS: DBS, deep brain stimulation; **PD,** Parkinson disease; **MER,** microelectrode recording; **STN,** subthalamic nucleus

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subdural space during surgery. A similar finding was also reported by Kim et al,[6] and led us to focus more on minimizing CSF leakage during surgery.

Other explanations for postoperative DBS electrode displacement should be considered because we also observed such displacements in several patients with no or minimal subdural air.[5] For example, our technique of anchoring the DBS electrode with a titanium microplate at the border of the burr hole could in theory allow upward migration when underneath bone erosion, with subsequent loosening of the fixation and retraction of the lead, occurs in the months after surgery. In 2008, we therefore changed our anchoring technique and started using a commercially available plastic lead-anchoring device and burr-hole cover.

Objectives

The aim of this study was to further define the role of subdural air invasion and to investigate other potential factors contributing to electrode shift, in particular different DBS lead–anchoring techniques.

PATIENTS AND METHODS

Study Design and Setting

This is a retrospective cohort study. We retrospectively analyzed data routinely obtained in all patients who underwent DBS at our center and in whom we performed both an early postoperative and long-term follow-up computed tomography (CT) scans between April 2005 and April 2010. The number of available patients with the above-mentioned characteristics determined the sample size.

Participants

Indications for surgery included PD, dystonia, obsessive-compulsive disorder, and tremor. Demographic data and clinical information were retrospectively collected from patient files. The Medical Ethical Committee of the Academic Medical Center in Amsterdam was officially consulted and waived the need for official approval of this study.

Surgical Targeting and Procedure

Target localization was based on preoperative frame-based magnetic resonance imaging (MRI) and, in most patients, microelectrode recordings (MERs) and macrostimulation.

Details of the surgical technique and MERs are described elsewhere.[7] Whenever possible, surgery was performed with the patient awake. Bilateral procedures were always performed simultaneously and were started on the most affected side or on the side contralateral to the dominant hand. For MERs, 1 to 5 parallel steel cannulae and microelectrodes, placed in a 2-mm interspace array, were inserted. All steel cannulas stayed in place throughout the surgical procedure, including during electrode implantation.

To minimize CSF loss and subdural air invasion, we applied the following operative technique: first, paths were planned with entry on top of a precoronal gyrus, at a 70° to 75° anterior angulation to the intercommissural line and a 20° to 30° lateral angulation from the midline, avoiding sulci, vascular structures, and ventricles. Second, patients were operated on while in a semisitting supine position with the head elevated at 20° to 30°. Third, we closed burr holes with fibrin glue after introduction of the microelectrodes or macrostimulation electrode. After test stimulation, a quadripolar DBS electrode (model 3389; Medtronic, Minneapolis, Minnesota) was implanted under fluoroscopic guidance. Two electrode-anchoring methods were used: until November 2008, electrodes were fixed at the border of the burr hole with a titanium microplate (MatrixNEURO, DePuy Synthes, Zuchwil, Switzerland) and plastic covering underneath (to prevent electrode damage), similar to the technique reported by Favre et al[8] (Figures 1A and 1B); from November 2008 onward, electrodes were anchored to the cranium using a commercially available plastic lead anchoring device and burr hole cover (Stimloc; Medtronic) (Figures 1C and 1D). Implantable pulse generators were implanted in a subcutaneous pocket in the infraclavicular region and connected with the electrodes with patients under general anesthesia during the same operative session.

CT Measurements of Subdural Air Collection and Electrode Location

CT (MX 8000 multislice CT system; Philips, Eindhoven, the Netherlands) with 2-mm slices (voxel size $1 \times 1 \times 2$) was performed in the early postoperative period and at long-term follow-up. Both CT scans were coregistered with preoperative stereotactic magnetic resonance imaging using Leksell Surgiplan software version 10.0 (Elekta Instruments AB, Stockholm, Sweden). The coregistration procedure implied an automatic run and successive manual fine-tuning of the coregistration performed by the examiner.

Subdural air collections were delineated on both sides of the brain independently in all patients on 3-dimensional (3-D) reconstruction of the early postoperative CT and measured volumes using BrainLAB iPlan software version 2.5 (BrainLAB, Feldkirchen, Germany).

Stereotactic coordinates of the metallic artifact of the deepest contact of the DBS electrodes were determined on the early postoperative and long-term follow-up CT scans. Because leads were implanted through burr holes that were located laterally and anteriorly from the deep brain targets, upward or downward displacement of a lead along the trajectory would also cause lateral/medial and anterior/posterior displacement. As outcome measures for electrode displacement, we used the difference in X, Y, and Z stereotactic coordinates on the long-term follow-up CT scan compared with the early postoperative CT scan, and measured absolute 3-D electrode displacement by calculating the vector derived from the square root of $\partial X^2 + \partial Y^2 + \partial Z^2$. To minimize inaccuracy due to the coregistration procedure and to the identification of electrodes tips,[9] all coregistrations and electrode markings were performed independently by 2 examiners (M.F.C. and M.B.), and average values were used for analysis.

Statistical Analysis

Multiple linear regression analysis was used to assess the influence of several factors on directional postoperative DBS electrodes displacement along the X, Y, and Z axes and on the absolute 3-D displacement. Factors included in the analysis were age at surgery, duration of surgery, volume of postoperative subdural air collections, use of MER, electrode fixation method, follow-up time (time between early postoperative CT scan and follow-up CT scan), and whether the side was operated on first or second. Pearson correlation analysis was conducted to assess the correlations among the variables. Missing data were handled by listwise deletion. A paired-samples *t* test and χ^2 test were used to compare groups where appropriate. Statistical analysis was performed using PASW Statistics version 18 (SPSS Inc, Quarry Bay, Hong Kong). A *P* value $<.05$ was considered significant. Mean values are presented ± standard deviation.

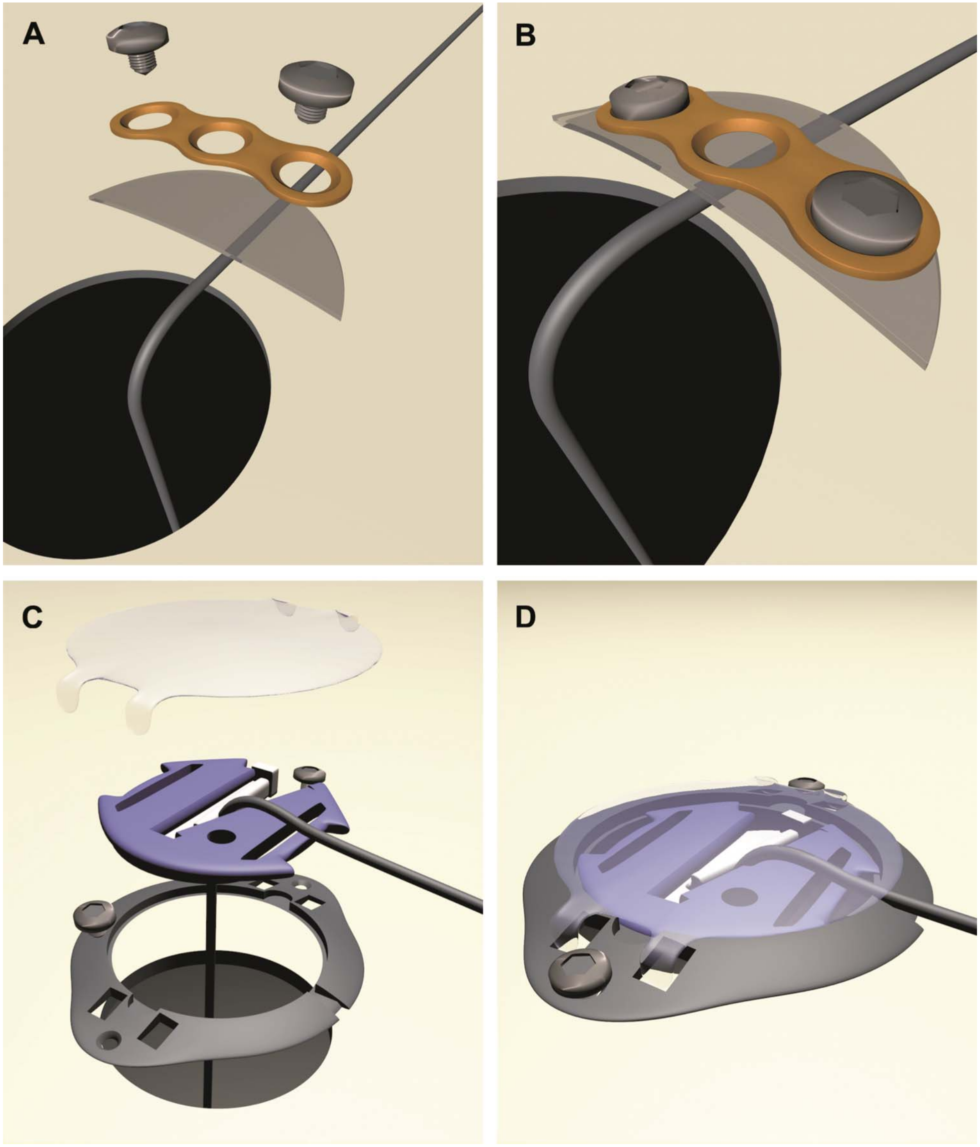

FIGURE 1. *Electrode fixation methods used in this series.* **A**, **B**, *microplate fixation system based on a custom-made, slightly concave titanium microplate, which is fixed to the cranium with 2 screws. Between the plate and the electrode, a small silicone plate is inserted to prevent electrode damage.* **C**, **D**, *commercially available fixation system (Medtronic Stimloc) made of a plastic ring filling the burr hole, a plastic inlay with a lead clip, and a cap/burr hole cover. The electrode is fixed by a clamp in the inner inlay.*

RESULTS

A total of 178 patients underwent bilateral or unilateral DBS at our center in 2005 to 2010. In 55 patients both an early postoperative CT scan (within 3 days) and a long-term follow-up CT scan were performed. Forty patients (73%) received both scans as part of a clinical trial ("NSTAPS" trial, randomly comparing STN DBS and GPi DBS for Parkinson's disease,[10] or a trial assessing the efficacy of nucleus accumbens DBS for OCD[11]). The remaining 15 patients (27%) received the early postoperative scan as part of our routine procedure, and the long-term follow-up scan to check the electrode position for optimization of stimulation parameters. Their clinical and demographical characteristics are presented in Table 1. Fifty-two patients underwent bilateral DBS and 3 unilateral DBS. One patient with bilateral implantation had 1 electrode explanted early after implantation due to infection. Thus, a total of 106 electrodes were used for analysis.

TABLE 1. Clinical Characteristics of the Patients Included in the Study[a]

Sex, female/male	22/33
Age at surgery, y (range)	55.1 ± 11.6 (26-72)
Diagnosis, no. of electrodes/no. of patients)	
Parkinson disease	63/32
Dystonia	15/8
OCD	24/12
Tremor	4/3
Total	106/55
Surgical target	
STN	33
GPi	44
Accumbens	24
Thalamus	5
Surgery duration, min (range)	208.7 ± 70.4 (80-357)
No. microelectrodes per side (range)	2.8 ± 1.8 (0-5)
No. (%) of sides with MER	83 (78.3)
No. (%) of sides with fixation method = plate	50 (47.2)
Early CT time (days after surgery) (range)	1.2 ± 0.7 (0-3)
Follow-up CT time, mo (range)	12.3 ± 6.3 (2-35)
Volume of subdural air, cm^3 (range)	4.3 ± 6.2 (0-32.8)

[a]OCD, obsessive-compulsive disorder; STN, subthalamic nucleus; GPi, globus pallidus pars interna; MER, microelectrode recordings; CT, computed tomography. Data are presented as average ± standard deviation.

Subdural Air Volume

Measurement of postoperative subdural air collections revealed air volumes between 0 and 32.8 cm^3, with a mean of 4.3 ± 6.2 cm^3. The amount of air did not correlate with the age, length of surgery, use of MER, or electrode fixation method. In bilateral cases, the amount of subdural air on the side operated first (mean, 4.4 ± 6.1 cm^3) and second (mean, 4.0 ± 6.2 cm^3) was comparable (paired-samples *t* test, $P = .51$). On all follow-up CT scans, air collections had resolved.

Postoperative DBS Electrode Displacement

None of the electrodes penetrated the lateral ventricle. Absolute electrode displacement along the electrode trajectory (3-D) was, on average, 1.9 ± 1.5 mm (range, 0.5-14.7 mm). The displacement in stereotactic X coordinate of the metallic artifact of the deepest contact of DBS leads from early postoperative (on average, 1 day after implantation) to follow-up CT scan (on average, 1 year) varied between 0.7 more medial and 3.3 mm more lateral (mean absolute displacement of 0.8 ± 0.6 mm). The displacement in stereotactic Y coordinate varied between 1.3 more posterior and 3.3 mm more anterior (mean absolute displacement, 0.8 ± 0.7 mm). The displacement in the stereotactic Z coordinate varied between 14.3 mm more dorsal and 2.2 mm more ventral (mean absolute displacement, 1.2 ± 1.5 mm). The direction of displacement was dorsally for 82 DBS electrodes (77%) and ventrally for 24 electrodes (see **Figure**, **Supplemental Digital Content 1**, http://links.lww.com/NEU/A568).

The absolute 3-D displacement and the directional DBS electrodes displacement in the X, Y, and Z axes significantly correlated only with electrode fixation method ($P = .030$ for 3-D displacement, $P = .026$ for X coordinate, $P = .009$ for Y coordinate, $P < .001$ for Z coordinate). The average 3-D displacement for the electrodes anchored with the titanium microplate was 2.3 ± 2.0 mm, whereas for the electrodes anchored with the plastic cap, it was 1.5 ± 0.6 mm (Table 2, Figure 2). The percentage of electrodes that moved dorsally was higher among the electrodes anchored with microplates (45 electrodes moved dorsally, 90%; 5 electrodes moved ventrally, 10%) than among those anchored with the plastic cap (37 electrodes moved dorsally, 66%; 19 electrodes moved ventrally, 34%; $P = .005$). No correlation was observed with any of the other factors (age at surgery, duration of surgery, volume of postoperative subdural air collections, use of MER, follow-up time [time between early postoperative CT scan and follow-up CT scan], and whether the side was operated on first or second). There were no differences in electrode displacement between the patients participating in the trials and the other patients.

Being the voxels of CT 1 × 1 × 2 mm, the minimum 3-D measurement error of the method used would be approximately ±1.5 mm. Considering also the coregistration technique, displacements of 2 mm or less fall under the maximal limit of accuracy. In the current series, a total of 39 electrodes showed a total 3-D displacement of 2 mm or greater (37%). It occurred significantly more often in microplate- (25 electrodes with 3-D-displacement ≥2 mm, 50%) than in plastic cap–anchored electrodes (14 electrodes with 3-D displacement of 2 mm or greater, 25%, $P < .01$) (Figure 2).

Only 1 microplate-anchored electrode of this series (0.9%) was repositioned due to clinical consequences of displacement (14.7 mm upward 3-D displacement). This occurred in a patient with cervical dystonia, presenting with lack of effect. Data from a sensitivity analysis performed after removing this lead showed comparable results (correlation of electrode displacement with electrode fixation method: $P = .002$ for 3-D displacement, $P = .028$ for X coordinate, $P = .003$ for Y coordinate, and $P < .001$ for Z coordinate). Dystonia is known to be associated with higher rate of complications.[12] Cervical dystonia, in particular, might place greater strain on the tunneled wires. For this reason, we also performed a sensitivity analysis after excluding all patients with dystonia, which led to comparable results (correlation of electrode displacement with electrode fixation method: $P = .007$ for 3-D displacement, $P = .008$ for X coordinate, $P = .011$ for Y coordinate, and $P < .001$ for Z coordinate).

DISCUSSION

Postoperative DBS Electrode Displacement

We demonstrated that DBS leads can show displacement after surgery even after minimization of CSF loss. The only factor

TABLE 2. Range of Displacement in the Stereotactic Space and Mean Absolute Displacement[a]

	Mean Absolute 3D Displacement	Range Absolute 3D Displacement	Mean Absolute Displacement X	Range X Coordinate		Mean Absolute Displacement Y	Range Y Coordinate		Mean Absolute Displacement Z	Range Z Coordinate	
				Medial	Lateral		Posterior	Anterior		Upward	Downward
Microplate	2.3 ± 2.0	0.5-14.7	0.9 ± 0.7	−0.7	3.3	0.8 ± 0.7	−1.2	3.3	1.6 ± 2.0	−14.3	0.6
Plastic cap	1.5 ± 0.6	0.5-2.9	0.6 ± 0.4	−0.5	2.0	0.8 ± 0.7	−1.3	2.8	0.8 ± 0.5	−1.8	2.2

[a]All values are given in millimeters. 3-D, 3-dimensional.

correlating with postoperative displacement was the method of anchoring DBS electrodes: displacement was greater for DBS leads anchored with a titanium microplate than for DBS leads anchored with a plastic cap.

This study of 106 DBS electrodes in 55 patients, implanted for various diseases at various deep brain targets, confirms that DBS leads have often not reached their final position on early postoperative imaging, as previously reported in our analysis of 26 leads in 14 PD patients undergoing STN DBS (not included in this series).[5] In this previous study, postoperative displacement was significantly correlated with the amount of air invading the subdural space and the subsequent posterior shift of the frontal cortex during surgery. In the patients operated thereafter, we therefore changed our operative technique in order to minimize CSF loss during surgery. These changes involved planning the burr holes on top of a gyrus, performing surgery with patients in a semisitting position and, in particular, effective sealing of the burr hole with fibrin glue immediately after introduction of the microelectrodes and macrostimulation electrode. For the patients presented here, this resulted in much smaller postoperative subdural air volumes than in our previous series (on average, 4.3 ± 6.2 cm^3 vs 17 ± 24 cm^3).[5] Similarly small postoperative intracranial air volumes were also reported by others who used special operative techniques to minimize CSF loss.[13] As a consequence of the smaller subdural air volumes, postoperative displacement along the electrode trajectory of the currently analyzed DBS leads was much less than in our previous study (3-D displacement, 1.9 ± 1.5 mm vs 3.3 ± 2.5 mm[5]). The minimization of CSF leakage is also reflected by the fact that the amount of air in this series did not statistically influence the amount of displacement. None of the other explored factors (age at surgery, length of surgery, use of MER, follow-up time, or whether it was the side operated on first or second) significantly correlated with displacement either.

Anchoring by means of a titanium microplate proved to be less efficacious than the commercially available plastic cap system in keeping electrodes in place during long-term follow-up. Different types of custom-made fixation methods (similar to the one that we used before) are still preferred at some centers due to the lower costs.[3,14,15] Metal plates can be used as an alternative anchoring method because the plastic cap does not fit in smaller craniostomies (eg, when a twist drill is used[16]) or even as a rescue method if intraoperative malfunctions of a plastic cap fixation system should occur.[17] Moreover, lower profile fixation techniques might be preferred because the higher profile of a plastic cap might in the longer term be associated with a higher degree of scalp erosion.

We hypothesize that anchoring DBS electrodes directly on the bone of the cranium might allow for upward migration when bone erosion underneath and subsequent loosening of the anchoring occur (Figure 3). These phenomena were in fact observed in several other patients who underwent stereotactic repositioning of their displaced leads (personal observations by P.v.d.M. and P.R.S.).

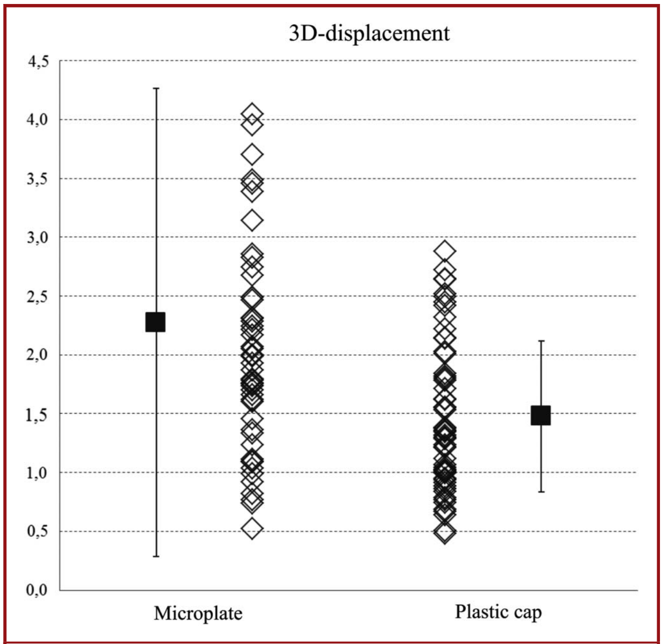

FIGURE 2. *Scatterplot representing absolute 3-dimensional (3-D) electrode displacements for the microplate-anchored electrodes and the plastic cap–anchored electrodes. One electrode with 14.7-mm displacement is not shown for graphical reasons.*

Postoperative displacement seems to be greatly alleviated by the use of a plastic cap system in which the anchoring does not rely on direct contact between the DBS electrode and the bone of the cranium.

Our results suggest that the anchoring method with the plastic cap provides reliable fixation of the electrode in the majority of cases. This could be considered a valid reason to face the relatively high costs of this device (~600 € for a bilateral procedure at our center compared with ~200 € for the titanium microplate and screws).

Impact of Postoperative DBS Electrode Displacement on Treatment Success of DBS

The average absolute DBS electrode displacement in this series was 2.3 ± 2.0 mm for the electrodes anchored with the titanium microplate, whereas for the electrodes anchored with the plastic cap, it was 1.5 ± 0.6 mm. It is important to consider that CT imaging acquisition was performed with voxels of 1 × 1 × 2 mm and that the coregistration technique implies some inaccuracy,[9] which may be also partly due to artifacts from the DBS leads or titanium microplate on the cranium, although in this study, we tried to reduce it to a minimum by using the average scores of 2 independent raters. Moreover, the currently used quadripolar DBS lead (model 3389; Medtronic) has four 1.5-mm contacts with three 0.5-mm interspaces, with the centers of adjacent contacts being separated by 2 mm. In daily clinical practice, patients may therefore benefit from switching DBS to a lower or higher contact when 2 mm or greater postoperative displacement occurs after initial programming of the stimulation parameters. For these reasons, we only consider electrode displacement of 2 mm or greater as potentially clinically meaningful. In this series, 3-D displacement of 2 mm or greater was observed in 39 electrodes (37% of the total), the majority of these being anchored with the microplate.

The effect of the observed lead displacements on clinical symptoms of this group of patients cannot be determined retrospectively. However, it is of note that only 1 of 106 electrodes (0.9%) in 55 patients needed to be repositioned due to unsatisfactory clinical effect (upward 3-D displacement of

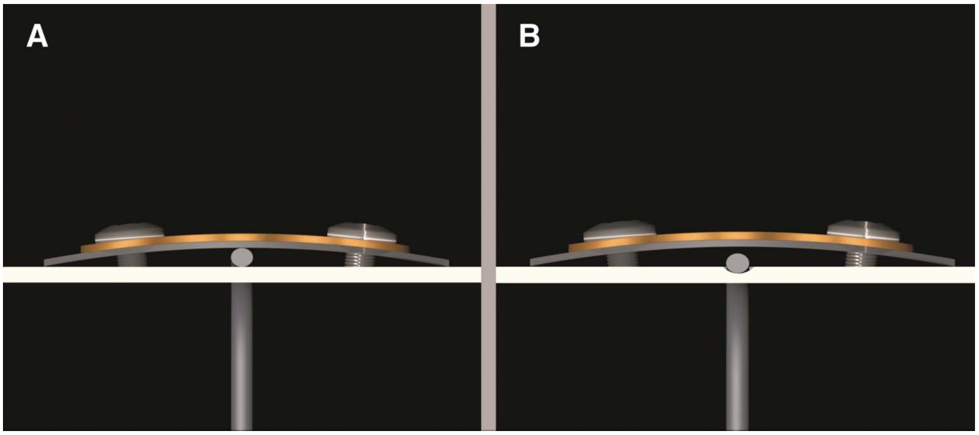

FIGURE 3. *Illustrative drawing of the possible cause of electrode displacement in patients in whom the microplate system was used.* **A**, *transskeletal cut showing the situation just after fixation with the microplate.* **B**, *transskeletal cut showing bone erosion underneath with subsequent loosening of the fixation.*

14.7 mm). It is reasonable to believe that effects deriving from minor electrode displacement could be corrected for by adaptation of the stimulation parameters used for chronic stimulation.

Impact of Postoperative DBS Electrode Displacement on Assessing the Anatomic Localization of Active DBS Contacts

The outcome of DBS is believed to depend on accurate targeting of specific deep brain substructures. For example, the outcome of STN DBS is believed by many authors to critically depend on accurate targeting of the sensorimotor part of the STN,[3,18] whereas others point to the more dorsally located zona incerta.[19-21] This controversy stresses the importance of accurate documentation of electrode localization to determine the precise relationship between the position of active contacts and clinical outcome. Although several reports have assessed this relationship,[22-26] postoperative imaging was usually performed on the day of surgery or on the first postoperative day when, according to our data, DBS leads might not have reached their final positions but are still prone to upward migration. In addition to subdural air,[5] we now show that anchoring techniques also influence long-term accuracy of DBS targeting. For scientific purposes, we strongly advocate repeated postoperative imaging after long-term follow-up to accurately determine the location of lead contacts.

CONCLUSION

DBS electrodes are subject to postoperative displacement, which can be clinically relevant in some cases. The most important factors determining postoperative electrode displacement are likely related to CSF loss and subdural air invasion. Once these factors are minimized, a potentially relevant factor is the electrode-anchoring method. Although custom-made metallic microplates are less expensive and widely used for a number of reasons, the commercially available plastic cap system proved to be more efficient than microplates in preventing postoperative electrode displacement. Our data are collected in an unselected population of patients with different conditions and of different age and sex; surgical techniques described in this paper are used worldwide. Based on our data, we suggest that an analysis of reliability of the electrode anchoring should be performed in all cases in which alternative anchoring methods are used.

Disclosure

The DBS team of the AMC received an unrestricted fellowship grant from Medtronic. Drs van den Munckhof, Contarino, and de Bie have received travel grants from Medtronic. Dr Speelman has acted as independent advisor for Medtronic. Dr Bour has acted as independent consultant for Philips and Sapiens. Dr Schuurman has received travel grants from Medtronic and acts as independent advisor for Medtronic on educational matters. Dr Denys acts on irregular basis as independent advisor for Medtronic. The other authors have no financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

The authors of this paper describe a large institutional deep brain stimulation (DBS) series that compares 2 commonly used lead-anchoring techniques. Not surprisingly, they found that dedicated anchors (burr hole–based locking devices) are better than simple titanium miniplates when it comes to prevention of electrode migrations.

There are many reasons for this, and for one, the idea of using miniplates was introduced for use with the twist-drill approach and not for the currently commonly used burr-hole approach that is required when one uses multipass targeting.

Moreover, the reader must keep in mind that leads do not migrate in vertical, horizontal, or anteroposterior direction, they only move "in" or "out" along the preset trajectory. Therefore, the issue of on average less than 2 mm (1.9 ± 1.5 mm) displacement may be, at least theoretically, solved by having more redundant contacts along the same electrode lead, similar to what we use in spinal cord and peripheral nerve stimulation procedures where such displacements are very common.

Also, the issue of choosing burr hole–based anchors vs miniplates may solve itself if these anchors would become a standard accessory for each DBS lead that is included in each lead kit (as already happens in the United States); the surgeons have a tendency to use prepackaged devices assuming their accepted superiority, particularly if this means saving time and money.

Many years ago, I witnessed DBS lead anchoring with cement and at that time was not sure if such "permanent" solution is needed. Based on these study results, I wonder how that age-old technique would have fared compared with the current expensive contraptions.

Konstantin V. Slavin
Chicago, Illinois

The authors present an analysis of DBS lead displacement with 2 different techniques to anchor the lead to the cranium. DBS leads can only be displaced along their axis (ie, being pulled out or pushed in). As the axis of the DBS lead is angled in space with respect to the defined anterior commissure–posterior commissure (AC-PC) coordinate system, a 1-dimensional displacement (along the axis) becomes unnecessarily described as a 3-dimensional displacement in the AC-PC coordinate system. Displacement in directions other than along the long axis of the DBS lead is likely a measurement or coregistration error. The authors conclude that the microplate is a less secure method to fixate the DBS lead. Although frustrating at times, the plastic cap may be a superior anchor. The plastic cap grasps the lead twice: at the shutter door (the clip) and in the groove at the lateral margin of the ring, secured by the cap. This double-grasp may be the critical difference.

Adam O. Hebb
Englewood, Colorado

In this report, the authors expand on their prior analysis of DBS lead displacement, which demonstrated that the volume of sub-dural air on the early post-operative CT was correlated with the degree of lead displacement observed on the long-term follow-up CT. Here, the authors again examined a variety of factors that may affect lead displacement, having now significantly reduced the volume of post-operative subdural air by limiting CSF losses with fibrin glue. They find that the method of anchoring the DBS lead was the only significant variable affecting the degree of lead displacement long-term; specifically that using the plastic burr hole cap sold by the device manufacturer significantly reduces the degree of lead displacement as compared to anchoring the lead with a titanium miniplate. Not surprisingly, the greatest effect was seen along the Z-axis (depth), as ventral/dorsal shifts in lead position along the implantation trajectory are most common.

In reality, the degree of displacement was small in both groups and the clinical significance of the difference is debatable, particularly since only one patient in the series required surgery to reposition a displaced lead that was clinically impotent. This lead, which was anchored with the miniplate technique, was a significant outlier, with a 14 mm dorsal displacement. Moreover, the patient suffered with cervical dystonia, a diagnosis that is associated with increased hardware difficulties. Based on these results, one must conclude that while the plastic anchoring device is statistically superior from the standpoint of minimizing lead displacement, it is still acceptable to employ either anchoring method, except perhaps in patients with cervical or generalized dystonia or Tourette Syndrome; patients whose excessive movements are more likely to place undue strain on the implanted wires and therefore the anchoring system. The two factors driving the use of mini-plates are the cost and the relatively high profile of the plastic burr hole cap. What we still need to know is whether use of the miniplate technique reduces the risk of scalp erosion resulting in device removal to a significant degree.

This is particularly important in balding males whose atrophic scalps predispose to this complication.

Ron L. Alterman
Boston, Massachusetts