

## Technical Note

# Dual floor burr hole technique in deep brain stimulation: A retrospective study on 209 patients

Domenico Servello, Christian Saleh, Alberto R. Bona, Marina Minichiello, Edvin Zekaj

Department of Neurosurgery and Neurology, IRCCS Galeazzi Hospital, Milan, Italy

E-mail: Domenico Servello - [servello@libero.it](mailto:servello@libero.it); Christian Saleh - [chs12us75010@yahoo.com](mailto:chs12us75010@yahoo.com); Alberto R. Bona - [alberto.bona@hotmail.com](mailto:alberto.bona@hotmail.com);Marina Minichiello - [marina.minichiello@unimi.it](mailto:marina.minichiello@unimi.it); \*Edvin Zekaj - [ezekaj@yahoo.com](mailto:ezekaj@yahoo.com)

\*Corresponding author

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## Abstract

**Background:** Skin erosion/infections due to deep brain stimulation hardware are highly worrisome complications. They can lead to the removal of the entire deep brain stimulation device, and consequently hold the whole treatment in otherwise pharmacologically refractory patients. Several techniques have been used such as C-shape skin incision and dual floor burr hole or single passage of connecting cables to reduce the incidence of skin complications.

**Methods:** In this paper, we describe our experience in 209 patients using a dual-floor burr hole technique to reduce skin adverse effects.

**Conclusion:** The dual floor burr hole technique is a safe technique with a low incidence of skin erosions and complications.

**Key Words:** Complications, deep brain stimulation, dual floor burr hole, surgical technique

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## INTRODUCTION

Over the last three decades since the renaissance of deep brain stimulation (DBS) for pharmacological refractory motor diseases, its indications have rapidly expanded to other conditions such as psychiatric disorders and Alzheimer's disease. To date there have been approximately 100,000 patients treated with DBS. Surgical objectives are to improve clinical symptoms and reduce surgical side effects and complications. Regarding other surgeries where permanent hardware implants are used hardware-related (HWR) complications constitute in DBS surgery a worrisome chapter. In DBS HWR, complications can be broadly divided into hardware malfunctioning and complications caused by the permanent hardware presence such as skin erosions/infections or even poor aesthetical results.

In DBS hardware, complications have been reported up to 26%.<sup>[8]</sup> In these patients, an additional surgery with

revision, exchange, or removal of system components or removal of the total system is frequent.<sup>[7,9]</sup> In a series of 85 consecutive Parkinson's disease (PD) patients who underwent DBS, 24.7% had skin complications of which 37% of skin complications were at the level of the burr hole cap.<sup>[8]</sup> Servello *et al.* reported an incidence of 18% of skin erosions/infections in Tourette's syndrome (TS) patients.<sup>[5]</sup> In a recent study by Servello *et al.* in 8 out of 48 TS patients (16%), the entire DBS system was

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removed due to skin erosions or infections.<sup>[6]</sup> Taking into account that DBS is “theoretically” a permanent system, skin erosions or infection are important clues when assessing risk and benefits of this surgery. To reduce the incidence of skin erosions, surgeons have applied several precautions such as C-shape skin incision and dual floor burr hole or single passage of connecting cables to avoid additional retroauricular skin incision.<sup>[3,4]</sup> In this paper, we present our experience in 209 patients using a dual-floor burr hole technique on fixing the burr hole cap.

## MATERIALS AND METHODS

We conducted a retrospective study on skin erosions in all patients undergoing DBS at our department from January 2010 to December 2015. We divided and allocated patients based on the sites of the skin erosions in five groups – frontal, parietal, retro-mastoid, lateral-cervical, and internal pulse generator (IPG) pouch level. The frontal group included erosions at the level of the burr hole cap area, the parietal group included erosions at the connecting cables level, the retromastoid group included erosions at the connectors level, the lateral-cervical group included erosions at the level of the connecting cables in the lateral cervical area, and IPG pouch for erosions at the IPG level. Clinical data were collected by the surgical registry of the senior neurosurgeon (D.S.) and by all computerized patient medical records. Patients with skin erosions were carefully evaluated to find any risk factor that might be correlated with skin erosion. All the DBS surgical procedures were performed by the senior neurosurgeon (D.S.). A total of 209 DBS procedures were performed with bilateral lead positioning in all cases (418 dual burr hole procedures). There were 131 males and 78 females, aged between 21 to 77 years (mean 57 years). One hundred and seventy-one patients were treated for PD, 8 patients had dystonia, 3 patients had essential tremor, 15 patients were treated for TS, 5 patients had obsessive compulsive disorder (OCD), 1 patients had major depressive disorder, 5 patients had parkinsonism (3 patients with progressive supranuclear palsy, 1 with post-anoxic parkinsonism, and 1 with multiple system atrophy), and one patient had Huntington Chorea [Table 1]. In all patients, we performed a dual floor burr hole to allocate the burr hole cap lock by using a linear incision.

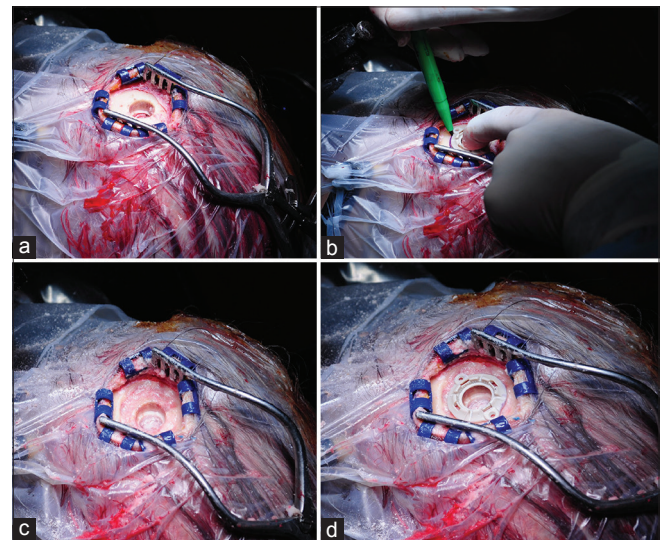
### Surgical procedure

The patient was positioned in a supine position with the head fixed to the operating table by the head frame. We

performed an accurate hair washing or scalp brushing with povidone iodine solution and betadine (hair cutting was not performed). The O-Arm was positioned to acquire the intraoperative radiological examinations. A sterile drape was fixed to the patient’s head and to the O-Arm. Under local anesthesia, a 5–6 cm linear skin incision was performed centered at the trajectory of the electrodes. With a high speed drill a 14-mm burr hole was performed [Figure 1a]. The burr hole cap shape was designed on the skull with a sterile pencil [Figure 1b]. A 4-mm cutting using a 4-mm diamond high speed drill was used to drill out the external teca bone and to create the allocation for the burr hole cap [Figure 1c]. The optimal depth for the burr hole cap was determined by the tactile sensation of the first surgeon. The depth of the double burr hole was aimed such that the upper surface of the burr hole cap was at the same level of the cranial vault. The next step was the burr hole cap fixation to the vault with two screws [Figure 1d]. The final intraoperative result is presented in Figure 1d, and a postsurgical example of aesthetic result with and without double burr hole in Figures 2 and 3, respectively.

## RESULTS

Sixteen patients (7.6%) had skin erosions. Five patients exhibited multiple skin erosions in sequential time. The



**Figure 1:** (a) The first burr hole done with standard perforator of 12 mm. (b) The surgeon designs the contours of the electrode holding system (c) The double burr hole is performed with high speed drill (d) The electrode holding system is fixed to the skull with screws

**Table 1:** In the table are shown all the DBS procedures with the corresponding pathologies

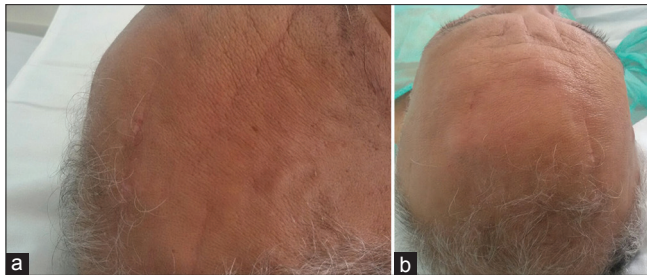
DBS procedures	Male	Female	Parkinsons Disease	Dystonia	Essential Tremor	Tourette Syndrome	OCD and MDD	Parkinsonism	Huntington Corea
209	171	38	171	8	3	15	5	5	1

OCD: Obsessive compulsive disorder, MDD: Major Depressive Disorder

**Table 2: In the table are shown all erosions divided in groups and pathologies**

	Total number of patients	Frontal	Parietal	Retromastoid area	Lateral Cervical Area	IPG pouch	Total DBS removed	Infections
	16	6	2	7	5	6	11	3
Parkinson Disease	10	6	0	5	3	2	7	3
Dystonia	2	0	1	0	2	0	2	0
Essential Tremor	0	0	0	0	0	0	0	0
Tourette Syndrome	1	0	1	0	0	1	1	0
OCD an MDD	2 (OCD)	0	0	1	0	2	1	0
Parkinsonins	1 (MSA)	0	0	1	0	1	0	0
Huntington Corea	0	0	0	0	0	0	0	0

OCD: Obsessive compulsive disorder, MDD: Major Depressive Disorder



**Figure 2: (a and b) Photograph shows the aesthetic results of double burr hole surgery. As noted no external protrusion is noticed**

frontal region at the burr hole cap level skin erosions occurred in 6 patients, retromastoid area in 7 patients, subclavicular region at the IPG level in 6 cases, lateral cervical region in 5 patients, and parietal area in 2 patients. In all patients, we performed a surgical revision surgery, but in 11 patients we had to remove the entire DBS system [Table 2]. The mean age of patients with skin erosion was 53.3 years (SD: 13.2). Skin erosions were seen in 10 patients with PD (5.8%), in 2 dystonia patients (25%), 2 patients with OCD (40%), 1 patient with TS (6.6%), and 1 patient with PD (20%). In 8 patients, we noted a peripheral skin groove around the borders of the stim lock without skin erosions [Figure 4].

## DISCUSSION

Hardware-related complication can be divided in hardware malfunctioning and tissue complications related to the permanent presence of the hardware. The most frequent tissue complications are skin erosions and infections, and are one of the main concerns for functional neurosurgeon as they can result in surgical revision or even removal of the entire system. The etiology is multifactorial, and in our opinion the most important factors may be summarized as three principal causes: factors related to characteristics of the device, to patients features, and to the surgical procedure.

1. Device features: Thicker and sharper devices increase the risk of skin erosions. The three main companies in DBS market (Medtronic, Boston Scientific, and Saint



**Figure 3: Photograph shows the aesthetic results of single burr hole surgery. As noted the electrode holding system determines an evident cutaneous protrusion**

Jude Medical) have invested in improving devices. The latest burr hole cap and IPG are thinner than the older ones. Other companies such as Neuropace for epilepsy have developed a cranial IPG to reduce complication rates related to the internalization of the DBS electrode

2. Patients features: It is well known that diabetic patients have more difficulties in wound healing, hence a higher incidence of skin problems in these patients is expected. Notoriously, PD patients may have important skin atrophy, which also increases risk of skin erosions. Another category of patients with higher risk in skin lesions are OCD patients or TS patients with OCD/OCB components. In these cases, the higher incidence of skin erosions and infection maybe due to the tendency of these patients to scratch the wounds. Warning and education of the patients on the risk of skin erosion due to repetitive touching and scratching of the wounds maybe sufficient for most patients. In rare cases, unorthodox solutions might be needed. For example, in one of the first patients with TS who underwent DBS at our department and presented with skin erosions due to repetitive scratching of the surgical wounds, we were forced to plaster the upper limbs of the patient for 2 months. With this medieval-like solution, the patient did well on wound healing and on response to DBS treatment
3. Surgical procedure: Sites of skin complications are at the cranial cap, in the-retro mastoid area, the



**Figure 4: Shows a complication of peripheral skin groove around the borders of the electrode holding system**

location of the connectors, and at the IPG pouch. There are few reports on how to lower the risk of skin erosions and infections. A recent and interesting study by Falowski *et al.*<sup>[1]</sup> reviewed the evolution of the surgical procedure of DBS from 1996 to 2010. Following advise was given: Covering the burr hole cap with pericranium and placing the leads and connectors below the temporal muscle fascia. The authors also rightfully emphasized the importance of accurate skin preparation and pre- and postsurgical antibiotic coverage. At the cranial cap, other authors have reported a reduction of skin erosions using a double C-shaped skin incision and a double floor burr hole.<sup>[4]</sup> At the retroauricular area, some authors have created a bone groove to place the connector to reduce pressure to the skin.<sup>[2]</sup> At the IPG pouch level, to reduce skin erosions, the pouch should be large enough and the IPG should be placed on or underneath the well-vascularized pectoralis fascia rather than into the subcutaneous fat.

In our experience with the double floor burr hole we had 6 cases (0.9%) of skin erosions at the cranial cap level; all patients had PD. In all patients, we tried a surgical revision, which consisted of wound borders removal and deeper positioning of the distal end of the DBS electrodes; in 1 patient, a cutaneous flap was tried. In all patients, the DBS system was removed due to several skin erosions.

A poor aesthetic outcome was the result of skin groove formation in 8 patients, where the double burr hole was too deep. In none of these patients skin erosions were noted.

### Tips and tricks

The dual floor burr hole does not require particular surgical skills but some precautions need to be kept in mind. In some patients, the cranial vault bone was so friable that during drilling with the cutting drill an

excessive bone drilling was done which led to a deeper dual floor burr hole. In these cases, the burr hole cap was located deeper than the cranial vault favoring the formation of skin groove around the burr hole cap similar to the case reported in Figure 4. In patients with thin cranial vault, care must be taken on the amount of bone drilling as we had in cases where it was difficult to fix the burr hole cap with the screw as the remaining bone was too thin. In these cases, the surgeon might be satisfied even if the burr hole cap has a small protrusion over the cranial vault.

## CONCLUSION

The aim of our paper was to describe our technique on positioning the new burr hole cap generation for DBS surgery. These techniques aim on one side to improve the aesthetic result and on the other hand aim to reduce skin erosions at the stim lock level. From January 2010 to December 2015, 209 patients were treated with bilateral DBS. We had 6 cases of skin erosions at the cranial burr hole cap, which is 1.8% of the treated patients and only 0.9% considering the overall bilateral procedures. Another complication is the formation of peripheral skin groove which did not lead to skin erosions. The dual floor burr hole technique is a safe technique with a low incidence of skin erosions and complications.

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### Conflicts of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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## DEEP BRAIN ELECTRODE DEVICE COMPLICATIONS

The authors touch on several important points to avoid complications of DBS devices installation. Incisions well planned, avoiding devices that are under the line of suture is a very important technical feature, mostly avoiding straight incision over the cap. It is indeed very unfortunate that the incidence of erosion is so high, not only for these authors, but also for all functional neurosurgeons implanting old fashion devices. Better burr-hole cap is overdue in the market. Actually the head implanted generators may indeed decrease the incidence of these unfortunate complications at least in the chest. Better devices are already in the market with low-profile hardware. Many surgeons practicing the installation of DBS no longer use the cap provided by the manufacturer, as it is prone to erosions, poor aesthetics, and high incidence of infections, as shown by the authors. Fortunately, the authors candidly present their complications and described them in detail; this paper may entice manufacturers to offer us better devices. We definitely hope so now that we have more competition in the market. The lowering profile of caps, use of smaller burr-holes (4–6 mm), and holding electrodes with plates

and screws avoid all the cap complications that the authors mentioned, without the need of the double-burr hole they suggest. As one of the developers of the cap, we have already abandoned its use.<sup>[1]</sup> We hope that this work helps our colleagues rethink the way of holding their electrodes in place, better-planned incisions to avoid poor aesthetics and loss of surgeries, mostly in the elderly with frail skin, as is the case of Parkinson's disease patients, where the majority of the erosions occurred in this article. Another important factor we saw in the authors' data is the higher incidence of erosion in the few patients they operated on for obsessive compulsive disorder.

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Antonio De Salles, M.D., Ph.D.

Editor, SNI: Stereotactic

São Paulo, Brazil

E-mail: [a.desalles@yahoo.com](mailto:a.desalles@yahoo.com)