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Original Article

Infections in deep brain stimulation: Shaving versus not shaving

Felix S. Gubler[1], Linda Ackermans[1], Pieter L. Kubben[1], Aysun Damci[1], Mark L. Kuijf[2], Mayke Oosterloo[2], R. Jeroen Vermeulen[2], Sarah Hescham[3], Ersoy Kocabicak[3,4], Erkan Kurt[5], Yasin Temel[1,5]

Departments of [1]Neurosurgery, [2]Neurology, [3]Neuroscience, Maastricht University Medical Center +, Maastricht, The Netherlands, [4]Department of Neurosurgery, Ondokuz Mayis University Hospital, Atakum-Samsun 55139, Samsun, Turkey, [5]Department of Neurosurgery, Radboud University Medical Center, Geert Grooteplein Zuid 10, 6525 GA Nijmegen, The Netherlands

E-mail: *Felix S. Gubler - felix.gubler@mumc.nl; Linda Ackermans - linda.ackermans@mumc.nl; Pieter L. Kubben - p.kubben@mumc.nl; Aysun Damci - a.damci@student.maastrichtuniversity.nl; Mark L. Kuijf - mark.kuijf@mumc.nl; Mayke Oosterloo - mayke.oosterloo@mumc.nl; R. Jeroen Vermeulen - jeroen.vermeulen@mumc.nl; Sarah Hescham - sarah.hescham@maastrichtuniversity.nl; Ersoy Kocabicak - ersoy.kocabicak@omu.edu.tr; Erkan Kurt - kurt@tip.nl; Yasin Temel - y.temel@maastrichtuniversity.nl

*Corresponding author

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Abstract

Background: To report our experience of infections in deep brain stimulation (DBS) surgeries comparing shaving versus no shaving of cranial hair. Nonshaving is strongly preferred by patients due to aesthetic and psychological factors.

Methods: This study is a prospective follow-up of the infection rate in 43 nonshaven DBS cases between April 2014 and December 2015 compared to our former infection rate with shaving in our center. Minimum follow-up was 6 months. All patients, except 7 epilepsy patients, received implantation of the electrodes together with the extension cables and internal pulse generator in one session.

Results: In 43 nonshaven patients, a total of 81 electrodes were implanted or revised with a mean follow-up of 16 months. One patient (2.32%) developed an infection of the implanted DBS-hardware and was treated with antibiotics.

Conclusion: In our experience nonshaving of cranial hair in DBS surgery does not lead to more infections when compared to shaving. We have changed our protocol to nonshaving based on these findings.

Key Words: Complication, deep brain stimulation, infection, shaving

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INTRODUCTION

Shaving of hair in cranial neurosurgery is still a common practice to reduce the risk of infections. However, there is more and more evidence that shaving does not decrease the risk of wound infection.[2,3,13,14,18] There are even studies postulating that shaving may increase the risk of infection.[14,20] The question arises how to act in surgeries involving implants such as deep brain stimulation (DBS). Infections are a feared complication in DBS surgeries,[19] although infection rates in DBS surgeries are generally low around 4% with a variation between 0.4 and 22.2%.[6,19]

Our philosophy in DBS surgeries was to entirely shave the hair of the patient to minimize the risk of infection. This has been the case from 1999 until 2014. However,

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with increasing application of DBS in younger patients with dystonia, epilepsy, and early stage Parkinson's disease (PD), patients indicated a strong preference towards nonshaving if possible. The latest dataset on shaving or not shaving in DBS was published 15 year ago and suggested that unshaved patients had no increased infection risk.[12]

In this study, we have prospectively investigated the infection rate of DBS surgeries in unshaved patients compared to our historical data of the infection rate of shaved patients.

MATERIALS AND METHODS

Study design

This study is a prospective observational study for the occurrence of postoperative infection of the DBS hardware. All patients receiving DBS at our center were monitored from the moment we stopped shaving in April 2014.

Data collection and follow-up

Between April 2014 and December 2015 all patients undergoing DBS were followed from the moment of operation. Indications included movement disorders, psychiatric disorders and epilepsy. Patient data including age, sex, diagnosis, DBS indications, and targets were reviewed [Table 1]. All postoperative infections related to the DBS hardware were recorded. Data collected on the infections included type, localization, microbiology, treatment, and outcome. In all patients, a minimum follow-up of 6 months was obtained.

Perioperative procedure

All patients undergoing DBS received the same treatment with the exception of shaving cranial hair. The evening before the operation hair was washed with povidon-iodine shampoo. On the morning of the surgery, before the stereotactic frame (Leksell, Elekta, Stockholm, Sweden) was mounted with local anesthesia, the head and hair of the patient was disinfected with colorless chlorhexidine solution (chlorhexidine digluconate 0.5% in alcohol 70%). Then, stereotactic computed tomography (CT) scan was performed to be fused with the previously performed magnetic resonance imaging (MRI), on which the anatomical planning was already done (Framelink, Medtronic, Minneapolis, USA). After positioning the patient on the operation table, again the head, hair, and frame were disinfected with chlorhexidine solution. Shortly after the chlorhexidine was dried, we placed both side pieces on the frame and the head was covered in a sterile manner with sterile surgical drapes and a large adhesive sterile transparent drape (Molnlycke Healthcare, Goteborg, Sweden). Small holes were cut in the transparent drape on both sides of the frame to expose the side pieces for mounting the arc on the frame. Both sides were sealed tightly with a povidon-iodine soaked gauze [Figure 1]. The skin incision was marked on the transparent drape using the stereotactic coordinates and a rectangular shape was cut out of the drape. Most of the hair was already fixed away underneath the adhesive transparent drape. If necessary, the remaining hair just around the planned incision was cut short using a scalpel. In this step, it was crucial to avoid touching the skin if possible. We fixed the transparent drape in all four directions exposing the incision and keeping possible hair out of the way using Steri-Strips. Prophylactic antibiotic (Cefazolin, 2 g) was administered intravenously at least 30 minutes before incision of the skin, repeated intraoperatively after 4 hours (1 g), and continued postoperatively for a total of 24 hours (1 g). For other surgical details including microelectrode recording, intraoperative testing, final electrode position, and anchoring of the final electrode, we refer to previous publications.[8,17] It is important to mention is that we anchored the final electrode with a combination of acryl-based antibiotic-containing cementation and a fixation screw.[17]

Table 1: Patient characteristics

Indication	Target	*N* (patients)	Age (SD)	M/F ratio	Age range
PD	STN	21	-	16/5	41-80
Tremor	VIM/PSA	11	-	8/3	39-78
Epilepsy	ANT	7	-	5/2	22-55
Other	GPi/VC-VS	4	-	1/3	12-50
Total		43	55 (16.9)	30/13	12-80

STN: subthalamic nucleus, VIM: Ventral intermediate nucleus of the thalamus, PSA: Posterior subthalamic area, ANT: Anterior nucleus of the thalams, GPi: Globus pallidus interna, VS-VC: Ventral Capsule and Ventral Striatum. Mean age with standard deviation (SD) and age range in years, M/F: Male to female ratio. PD: Parkinson's disease, Tremor: essential tremor, tremor dominant Parkinson's, Multiple sclerosis with tremor, other: dystonia and obsessive compulsive disorder

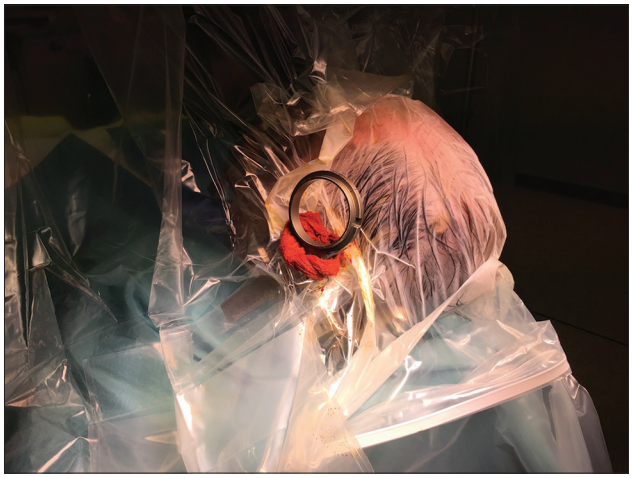

Figure 1: Our DBS surgical preparation including the sterile transparent drape (Molnlycke Healthcare, Goteborg, Sweden) (printed with permission of the patient)

After the leads were placed, the distal ends were positioned in a subcutaneous pocket with a silicon protection (Medtronic, Minneapolis, USA). The wound was closed with a subcutaneous Vicryl suture and the skin was closed with one continuous Ethilon suture.

All patients underwent internalization in the same surgical session except for 7 epilepsy patients. These patients received implantation 5 days later due to electrophysiological recordings from the externalized leads.

Before implantation of the rest of the hardware, we removed the stereotactic frame and repositioned the patient. After marking the incisions on the cranial, infraclavicular, and abdominal site, we disinfected with povidon-iodine and covered with sterile surgical drapes to perform the rest of the operation with re-opening the cranial incision to connect the leads to the rest of the hardware. All incisions were closed with subcutaneous Vicryl sutures. Head incisions were closed with transcutaneous Ethilon sutures. The clavicular and abdominal incisions were closed with intracutaneous Monocryl sutures. PD and tremor patients recieved the electrode implantation awake with local anesthesia and were put under general anesthesia for the internalization part of the operation. Epilepsy, dystonia/dyskinetic cerebral palsy, and obsessive-compulsive disorder patients were under general anesthesia during the entire operation.

(Historical) analysis

The results of the postoperative wound infections without shaving related to the DBS hardware were prospectively followed-up and retrospectively analysed at our center. In addition, we compared the results to our historical infection rates with shaving.[19] We calculated the odds ratio, 95% confidence interval, and performed a test of significance in which a *P* value smaller than 0.05 was considered significant.

RESULTS

Table 2 shows the results of our implantations in this period of 20 months. The follow-up duration of all 43 patients ranged from 6 to 26 months with a mean of 16 months ±14.4 months.

Infections

We observed one (2.32%) postoperative infection and compared it to our historical infection rate [Table 3]. The infection concerned an 18-year-old male with severe bilateral dyskinetic cerebral palsy due to perinatal asphyxia. His right side was more affected and dyskinesia was progressive over the years resulting in self-injury. In addition to refractory upper airway infections and painful bowel problems, the patient received enteral feeding via a percutaneous endoscopic gastrostomy (PEG) tube in 2007. Entering into adolescence, resulting in more muscle power, led to an increase in injuries. However, the severity of dyskinesia could not be well explained and extensive screening revealed no causes. Extensive treatment, including intrathecal baclofen, did not succeed. After an elaborative screening, he was indicated for bilateral DBS of the internal globus pallidus.

The operation on 11 February 2015 proceeded without complications, and 1 day later DBS was activated. On the fourth postoperative day, the patient developed a cough as well as fever (38.3°C), elevated infection parameters in the blood: C-reactive protein 41, white blood cell count 36, and sedimentation 12. Wound inspection and urine screening showed no abnormalities. Despite a negative chest X-ray, antibiotic therapy (ciprofloxacin orally twice daily 2750 mg) was started on suspicion of a hospital-acquired pneumonia, most likely based on patient's medical history. On the following days, infection parameters and fever worsened with dehiscence and puss from the retroauricular wound and a hematoma around the iPG. The wound was revised and the hematoma aspirated. Wound culture showed *Staphylococcus aureus* growth, for which flucloxacillin (6 times daily 1000 mg i.v.) was added. The infection subsided and infection parameters normalized. We decided on a multidisciplinary approach to treat the patient with ciprofloxacin and rifampicin because explanting the hardware was not an option in this case due to the severity of symptoms.[19] DBS had reduced the dyskinetic movement disorder based on our observations and report of the parents. Due to the disease course, we were not able to do formal scoring of the symptoms. The reason for the antibiotic switch was the possibility to administer ciprofloxacin as a suspension via the PEG. An intravenous line was no longer an option. Rifampicin was added for the bacterial biofilm on the hardware. The first of March 2015 the patient was discharged from our hospital.

Three days later, the patient was re-admitted to a local hospital with fever. Infection screening in blood, urine, sputum, cerebrospinal fluid, and gastrointestinal tract showed no abnormalities. Inspection of the iPG abdominal implantation site, retroauricular, and

Table 2: Results of all DBS procedures between April 2014 and December 2015 at our center. Mean follow-up and standard deviation (SD) in months. Infections in number of patients and the percentage of the total

Procedure	*N* (Patients)	*N* (Electrodes)	Bilateral	Unilateral	Follow-up (SD)	No. of infections (%)
Implantation	39	77	38	1	-	1 (2.32%)
Revision	4	4	0	4	-	0
Total	43	81	38	5	16 (14.4)	1 (2.32%)

Table 3: Comparison of the infection rate in DBS without shaving (2014-2015) to our historical infection rate (1996-2002) with shaving

	Shaven (1996-2002)	Unshaven (2014-2015)
N (patients)	106	43
No. of infections (%)	4 (3,80%)	1 (2.32%)
Odds Ratio (95% CI)		0.61 (0.066-5.59)
P-value		0.66

CI: Confidence interval

clavicular scars showed no signs of infection at that time. Nevertheless, the abdominal scar started to leak later for which the patient was admitted to our hospital on 14th April 2015. Sadly, the next morning he was found dead in his bed due to autoasphyxiation. No autopsy was performed on the request of the family.

DISCUSSION

Our results show that not shaving does not lead to more infections in DBS surgeries but might even lead to a lower risk. These results are in accordance with the current literature concerning cranial neurosurgery.[2,3,13,14,18,20] The same applies for shunt implant procedures in neurosurgery. Multiple studies have shown the same or a lower infection rate when comparing shaving to nonshaving and vary respectively between 1.2 and 11% and between 0.95 and 3.3%.[2,3,7,16,20]

In addition, a lower infection rate of 1.6% versus 0.5%, when not shaving, was found in a retrospective analysis concerning DBS surgeries.[12] Independently, the recently published guidelines of the World Health Organisation and the guidelines of the Center of Disease Control and prevention instruct to avoid hair removal at any operative site. If absolutely necessary, it is advised to clip the hair to one side or use a clipper. Shaving is strongly discouraged because of a higher risk on surgical side infections.[1,10,11]

Our theory concerning the explanation of increased infections due to the shaving of hair comes down on a two-sided mechanism: the mechanical disruption of the skin's natural barrier and the disruption of the skin on a microenvironmental level. The introduction of traumatic skin lesions due to shaving leads to disruption of the skin's mechanical barrier. These shaving-induced lesions, visible or not, make the introduction of bacteria in the wound area more likely.[15,18] One study reported there was no significant difference in infection rate after shaving with or without visible skin lesions (5.3% versus 5.7%).[15] The same study also showed an effect of the timing of shaving on the postoperative wound infection. The infection rates with shaving direct preoperatively were 3.1% compared to 7.1% and 20% respectively within 24 hours prior to surgery and more than 24 hours.

This time interval related risk infection supports the mechanical skin barrier disruption theory. The longer before a surgery a patient is shaved, and thus the likelihood of introducing bacteria, the more time these bacteria will have to grow and proliferate to manifest in a possible wound infection.

On the other hand, we also think that shaving alters the skin's normal microenvironment which contains several microbiota including bacteria (*Actinobacteria* and *Staphylococcaceae*) and phyla. The skin flora in the normal patient is nonpathogenic, mostly commensal and in some cases mutualistic. Beneficial effects of skin bacteria are the prevention of colonizing of other transient pathogenic microorganism by competing for nutrients, secreting chemicals against them, or simulating the skin's immune response.[4] Another possibility is that endogenous skin bacteria and other microorganism could cause skin or wound infections and in some cases enter the bloodstream. These considerations point out that the skin flora is a very complex system with a delicate balance which could easily be disrupted.

A final note is that nonshaving is clearly preferred by neurosurgical patients due to psychological and aesthetic factors.[5,9]

Limitations

Limitations of this study are the small sample size and old historical compare group. Clinical significant equivalence or non-inferiority of not shaving cannot be shown by this small cohort of patients as reflected in the confidence interval and *P* value. The current historical comparison is the best available in our center.

CONCLUSION

In our experience not shaving in DBS surgery does not lead to more infections when compared to shaving of cranial hair. Not shaving is also highly preferred by patients.

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Conflicts of interest

There are no conflicts of interest.

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