Frontal Sinus Mucosa Bacteriological Features: Evaluation after Unintentional Opening in Neurosurgery

Hiroki Sato[1,2] Hidetoshi Ooigawa[1,2] Kaima Suzuki[1,2] Taro Yanagawa[1] Milan Lepic[2] Munehiro Otsuka[1] Goji Fushihara[1] Hiroki Kurita[2]

[1] Department of Neurosurgery, Saitama Cardiovascular and Respiratory Center, Itai, Kumagaya, Saitama, Japan
[2] Department of Cerebrovascular Surgery, International Medical Center, Saitama Medical University, Hidaka, Saitama, Japan

Address for correspondence Hidetoshi Ooigawa, MD, PhD, Department of Cerebrovascular Surgery, International Medical Center, Saitama Medical University, 1397-1 Yamane, Hidaka city, Saitama pref., 350-1298, Japan (e-mail: ho24811@5931.saitama-med.ac.jp).

J Neurol Surg B Skull Base 2024;85:119–122.

Abstract

Objectives The bacteriological features of the frontal sinus mucosa may impose significant complications in neurosurgery, when breached unintentionally. This study aimed to investigate the bacterial flora in patients undergoing frontal craniotomy for cerebrovascular substrate surgery.

Design This is a single-center prospective study.

Setting When mucosal laceration occurred, the patients underwent frontal sinus reconstruction with mucosa reconstruction, preserving the nasofrontal duct.

Participants We enrolled eight consecutive patients who underwent bifrontal craniotomy associated with frontal sinus mucosa laceration.

Main Outcome Measures A portion of the mucosa was extracted during the reconstructive procedure and was sent for microbiological analysis.

Results None of the patients presented with the bacterial flora in the mucosal cultures. No patient experienced postoperative cerebrospinal fluid leakage or meningitis. One patient with a clinical history of chronic maxillary sinusitis presented with a subcutaneous abscess around the forehead at 9 months postoperatively. The patient rapidly recovered after receiving oral administration of antibiotics.

Conclusions Our findings demonstrated that the frontal sinuses were maintained in an aseptic environment in all cases. The results may encourage the development and wider use of transfrontal sinus approaches.

Keywords
- frontal sinus
- injury
- bifrontal approach
- craniotomy
- complication

Introduction

A bifrontal craniotomy is an established common approach to the anterior skull base and frontal lobe. Craniotomy occasionally induces frontal sinus opening.[1] The complication may be avoided with the careful planning, keeping the surgical corridors >1.5 cm lateral to the supraorbital notch and/or >3 cm above the horizontal reference line.[2]

The frontal sinus communicates with the nasal cavity through the nasofrontal duct; moreover, the presence of bacterial flora in the paranasal sinuses can induce postsurgical infection. There have been several reports of focused on bacteriology of the paranasal sinuses; however, these are mostly related to the maxillary sinus.[3–7] Especially, the bacteriological characteristics of the frontal sinus remain unclear.

received
August 26, 2022
accepted after revision
January 9, 2023
accepted manuscript online
January 19, 2023
article published online
February 20, 2023

Georg Thieme Verlag KG,
Rüdigerstraße 14,
70469 Stuttgart, Germany

DOI https://doi.org/10.1055/a-2015-8371.
ISSN 2193-6331.

Mucosal laceration of the frontal sinus is a risk factor for cerebrospinal fluid (CSF) leak and infection, such as frontal sinusitis, wound infection, and intracranial abscess.[8–13] Various techniques for frontal sinus repair have been proposed.[14,15]

This study aimed to investigate the bacterial flora of the frontal sinus during neurological surgery.

Materials and Methods

This prospective study was approved by the Institutional Review Board of Saitama Cardiovascular and Respiratory Center and was conducted in accordance with the Guidelines for the Protection of Human Subjects, the ethical standards of the responsible committee on human experimentation (institutional and national), and the Helsinki Declaration of 1975, as revised in 2000.

Among the patients who underwent surgical intervention in our neurosurgical unit in a 2-year period, we enrolled consecutive patients whose frontal sinus was opened and whose mucosa was violated after bifrontal craniotomy. We obtained written informed consent from all patients preoperatively.

All patients received 1 to 2 g of cephazolin (Cefamezin α, Astellas, Chuo-ku, Tokyo, Japan) 30 minutes before the initiation of the surgery. Bifrontal craniotomy was routinely performed. When the frontal sinus was opened, and the mucosa teared, we proceeded to the reconstructive procedure (►**Fig. 1**). The mucosa was entirely dissected from the sinus wall; moreover, the posterior wall was removed from the frontal base. We confirmed the patency of the nasofrontal duct. Nasofrontal duct obstructions formed by bone dust were removed. The lacerated mucosa was partially removed and trimmed adjacent to the frontal base level to facilitate suturing. Mucosa suturing was performed using polypropylene sutures (8–0 Prolene 2775G, Ethicon, Somerville, New Jersey, United States). The sutured mucosa was covered using a gelatin sponge (Gelfoam, Baxter Healthcare Co., Denver, Colorado, United States) immersed in fibrin glue. The abdominal adipose tissue was placed on the immersed gelatin sheet to close the dead space; additionally, the fat pad was covered with a pericranial flap. The pericranial flap was fixed to the frontal base dura.

The trimmed mucosa was transferred to our microbiology laboratory and cultured on the following agar plates: blood agar (trypticase soy agar with 5% sheep blood, Becton, Dickinson, and Company, Franklin Lakes, New Jersey, United States), chocolate (Chocolate II Agar, Becton, Dickinson, and Company), BTB (BTB Agar, Kyokuto Pharmaceutical Industrial Co., Ltd., Tokyo, Japan), mannitol salt agar (mannitol salt agar with egg yolk, Eiken Chemical Co., Ltd., Tokyo, Japan), CHROMagar (CHROMagar Candida, Kanto Kagaku, Japan), Sabouraud (Sabouraud Dextrose Agar CG, Becton, Dickinson, and Company), and GAM semisolid agar (GAM Semisolid "Nissui," Nissui Pharmaceutical Co., Ltd., Tokyo, Japan). Each plate was inspected for 48 hours. In case there was no organism growth on the agar plates at 48 hours, both aerobic and anaerobic plates were cultured for an additional 5 days and inspected after 7 days. In case bacterial flora identification was required, standardized methods were used as previously described.[16]

Postoperative clinical and radiological follow-up examinations were performed. The occurrences of CSF leakage, meningitis, and other infectious events were monitored. Magnetic resonance imaging (MRI) was performed to detect latent CSF leakage or infectious disease at 1 week, 3 months, and 1 year postoperatively.

Results

During the study period, the frontal sinus was opened in 10 patients after bifrontal craniotomy. Among them, the frontal mucosa was violated in eight patients who underwent sinus reconstruction (►**Table 1**). These patients were prescribed 2 to 3 g of cephazolin (Cefamezin α, Astellas) per day for a mean of 5.1 (range, 3–8) days. We did not alter the postoperative antibiotic protocol even when the frontal sinus was opened.

All patients recovered well after surgical intervention without neurological deterioration. Samples of none of the

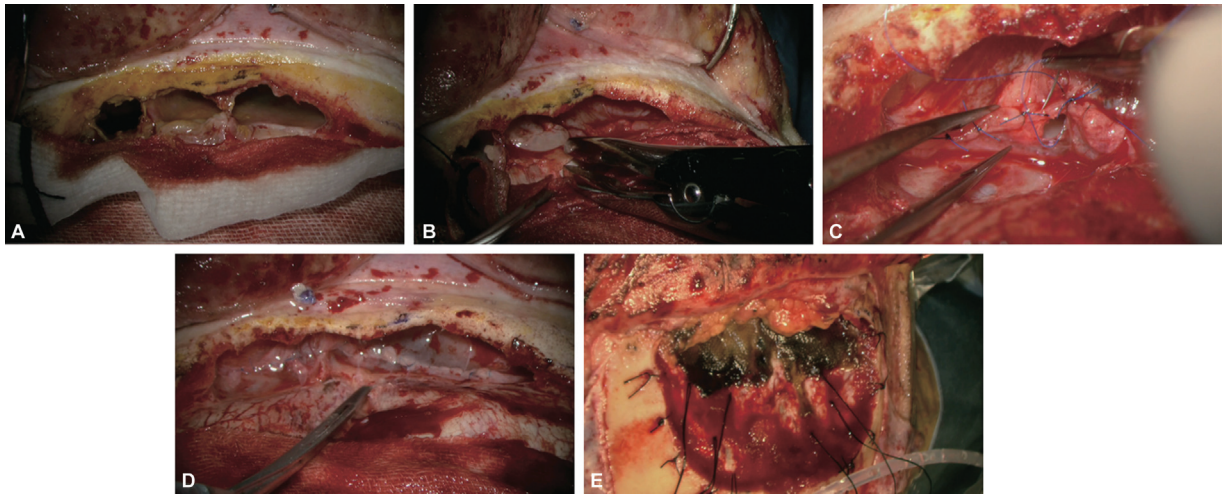

Fig. 1 Frontal sinus reconstruction after the opening of the frontal sinus. **(A)** Bilaterally violated mucosa of the frontal sinus. **(B)** Removal of the posterior wall to the frontal base. **(C)** Mucosal closure is performed by suturing. **(D)** A watertight closure of the mucosa is obtained. **(E)** Abdominal fat is placed on the sutured mucosa and covered using a pericranial flap and SURGICEL.

Table 1 Summary of patients

No.	Age (y)	Sex	Disease	Incubated flora	Remarks
1	60	M	ACoA aneurysm	None	Chronic maxillary sinusitis
2	65	F	R-ACoA aneurysm; SAH	None	
3	68	M	ACoA aneurysm	None	
4	73	F	ACoA aneurysm	None	
5	70	F	ACoA aneurysm	None	
6	68	F	R-ACoA aneurysm; SAH	None	
7	29	M	AVM	None	
8	75	M	ACoA aneurysm	None	

Abbreviations: ACoA, anterior communicating artery; AVM, arteriovenous malformation; F, female; M, male; R, ruptured; SAH, subarachnoid hemorrhage.

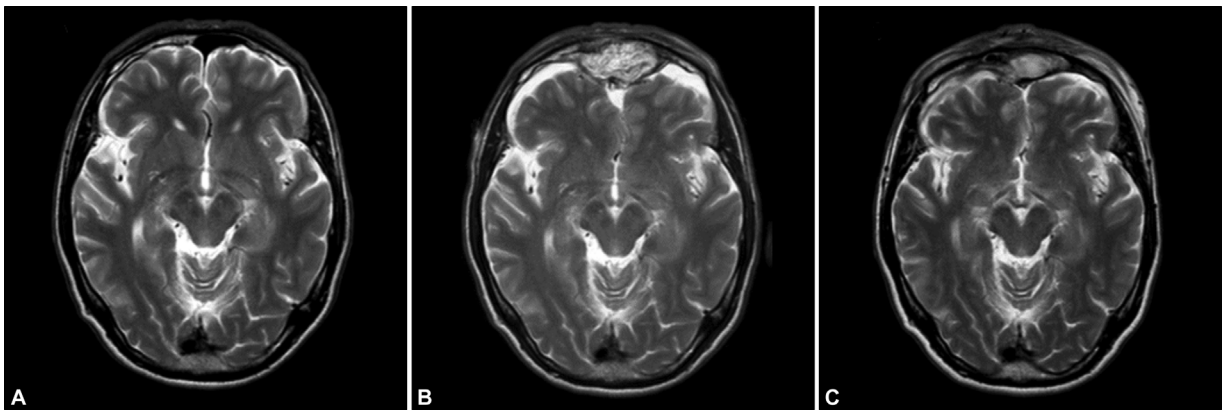

Fig. 2 MRI findings in the patient with a postoperative subcutaneous abscess. **(A)** Preoperatively. **(B)** 1 week postoperatively. **(C)** 9 months postoperatively.

eight patients, including those with chronic maxillary sinusitis, showed bacterial organisms on the agar plates. During the follow-up period (mean, 1.8 years; range, 1 month to 2 years), clinical and radiological examinations were carried out to screen for CSF leak or meningitis. There were no patients with mucoceles postoperatively. One patient, with a history of chronic sinusitis, presented with a subcutaneous abscess around the forehead at 9 months postoperatively, with comorbid deteriorating left maxillary sinusitis (►**Fig. 2**). Percutaneous needle aspiration revealed *Streptococcus constellatus* as the pathogen involved in the abscess. The patient with postoperative subcutaneous abscess was prescribed clarithromycin (400 mg/day, Clarith tablets 200, Taisho Pharmaceutical Co., Ltd., Toshima-ku, Tokyo, Japan) and cefaclor (750 mg/day, Kefral, Kyowa Pharmaceutical Industry Co., Ltd., Kita-ku, Osaka, Japan) for 30 days. The patient rapidly recovered after antibiotic administration.

Discussion

In our study, examination of directly resected mucosa did not reveal bacterial flora in any patient. Although the effect of antibiotics should be considered, it is unlikely that a single preoperative antibiotic dose is sufficient to achieve complete sterility.

There has been only one study on frontal sinus sterility. Albu and Florian[17] investigated the bacteriology of the frontal sinuses using lavage specimens. Among 84 sinuses (42 patients), 72 (85.72%) sinuses were sterile, 10 (11.9%) harbored one organism, and 2 (2.38%) harbored two organisms. Although our study and this previous study applied different specimen collection methods, including mucosa itself or lavage, they both suggest that most frontal sinuses are maintained in an aseptic environment.

Several studies have described the bacteriology of the paranasal sinus. Among them, some have described most of the paranasal sinuses as sterile,[3,5,7] given their inherent defense mechanisms.[18] Contrastingly, others have reported the existence of some bacterial flora in the paranasal sinus.[4,6] However, most of these studies addressed the maxillary sinus, with limited bacteriological knowledge of the frontal sinus.

In our study, none of the patients experienced postoperative CSF leakage or meningitis. However, one patient with a history of chronic maxillary sinusitis showed a subcutaneous abscess at 9 months postoperatively. MRI findings showed deterioration of the maxillary sinusitis accompanied by a forehead subcutaneous abscess. Nasofrontal duct obstruction may trigger this purulent condition.[19] Although sinus reconstruction with mucosal suturing is effective to some extent, it might not guarantee long-term protection from infections caused by surrounding parasinusitis.

We routinely apply oxidized regenerated cellulose (SURGICEL, Johnson & Johnson, Somerville, New Jersey, United States) over the dura for the cessation of bleeding from the dura (►**Fig. 1E**). SURGICEL is thought to be useful for hemostasis and be bacteriostatic because of its acidic condition.[20] Spangler et al[21] reported that the low pH of this material affects a broad spectrum of bacteria, including antibiotic-resistant microorganisms. In our study, this antibacterial material might have supported our technique in the aseptic environment and provided favorable results.

This study has some limitations. First, this was a small-scale single-center prospective study, which could not yield definitive conclusions. Second, all patients were administered with cephazolin preoperatively; therefore, we could not completely exclude the effectiveness of the treatment for the frontal sinus. Third, we partially removed the mucosa from the lacerated edge (approximately 1 cm^2). This procedure might lead to missing the target given the uneven distribution of the bacterial flora.

Conclusion

Our findings suggest that the majority of cases with unintended frontal sinus opening in the course of neurosurgical procedures are maintained in a sterile state. Our findings may encourage the development and wider use of transfrontal sinus approaches.

Funding
The second author, Hidetoshi Ooigawa, received financial support for the conduct of the research from the research fund of the Saitama Cardiovascular and Respiratory Center. The funding source was not involved in this study design.

Conflict of Interest
None declared.

Acknowledgments
We sincerely appreciate the skillful work of the staff of the Clinical Microbiology Laboratory at our institution.

References

1 Siedlecki Z, Sabramowicz M, Woźniak J, et al. Extent of the frontal sinuses in the aspect of neurosurgical craniotomy approaches. Folia Morphol (Warsz) 2022;81(04):1047–1053
2 Flanigan P, Kshettry VR, Mullin JP, Jahangiri A, Recinos PF. Frontal sinus morphometry in relation to surgically relevant landmarks in the United States population. World Neurosurg 2016;91:12–15
3 Abou-Hamad W, Matar N, Elias M, et al. Bacterial flora in normal adult maxillary sinuses. Am J Rhinol Allergy 2009;23(03):261–263
4 Brook I. Aerobic and anaerobic bacterial flora of normal maxillary sinuses. Laryngoscope 1981;91(03):372–376
5 Cook HE, Haber J. Bacteriology of the maxillary sinus. J Oral Maxillofac Surg 1987;45(12):1011–1014
6 Jiang RS, Liang KL, Jang JW, Hsu CY. Bacteriology of endoscopically normal maxillary sinuses. J Laryngol Otol 1999;113(09):825–828
7 Sobin J, Engquist S, Nord CE. Bacteriology of the maxillary sinus in healthy volunteers. Scand J Infect Dis 1992;24(05):633–635
8 Meetze K, Palmer JN, Schlosser RJ. Frontal sinus complications after frontal craniotomy. Laryngoscope 2004;114(05):945–948
9 Murai Y, Mizunari T, Kobayashi S, Teramoto A. Surgical technique for the prevention of cerebrospinal fluid leakage after bifrontal craniotomy. World Neurosurg 2014;81(02):344–347
10 Schramm VL Jr, Maroon JC. Sinus complications of frontal craniotomy. Laryngoscope 1979;89(9 Pt 1):1436–1445
11 Takeuchi S, Tanikawa R, Katsuno M, et al. An effective method of frontal sinus reconstruction after bifrontal craniotomy: experience with 103 patients. World Neurosurg 2015;83(06):907–911
12 Yasui N, Nathal E, Fujiwara H, Suzuki A. The basal interhemispheric approach for acute anterior communicating aneurysms. Acta Neurochir (Wien) 1992;118(3–4):91–97
13 Farmer J. The Paranasal Sinuses: Neurosurgical Considerations. 2nd ed. vol 1. Neurosurgery. McGraw-Hill Health Professions Division; 1996:588–590
14 Ciporen J, Lucke-Wold B, Gillham H, Cua D, Kim J, Akins P. Paramedian forehead flap for repair of refractory high-flow anterior skull base CSF leak. Turk Neurosurg 2017 (e-pub ahead of print). Doi: 10.5137/1019-5149.JTN.20662-17.1
15 Miller C, Weisbrod L, Beahm D, Chamoun R. Compartmentalization: an open technique for frontal sinus repair and preservation-description of technique and early case series. J Neurol Surg B Skull Base 2021;82(02):189–195
16 Takayanagi N, Kagiyama N, Ishiguro T, Tokunaga D, Sugita Y. Etiology and outcome of community-acquired lung abscess. Respiration 2010;80(02):98–105
17 Albu S, Florian IS. Bacteriology of normal frontal sinuses. Am J Otolaryngol 2013;34(04):327–330
18 Winther B, Gwaltney J. Microbiology of chronic frontal sinusitis. In: Kountakis SE, Senior BA, Draf W, eds. The Frontal Sinus. Springer-Verlag; 2005:53–57
19 Daniels DL, Mafee MF, Smith MM, et al. The frontal sinus drainage pathway and related structures. AJNR Am J Neuroradiol 2003;24 (08):1618–1627
20 Dineen P. The effect of oxidized regenerated cellulose on experimental infected splenotomies. J Surg Res 1977;23(02):114–125
21 Spangler D, Rothenburger S, Nguyen K, Jampani H, Weiss S, Bhende S. In vitro antimicrobial activity of oxidized regenerated cellulose against antibiotic-resistant microorganisms. Surg Infect (Larchmt) 2003;4(03):255–262

