

# Frontal sinus reconstruction with overlapping sinus mucosa and vascularized pericranial flap Coverage after modified transbasal bifrontal craniotomy: Novel technique and clinical outcomes

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## ABSTRACT

**Background:** The modified transbasal bifrontal craniotomy is a variant of the bifrontal craniotomy with a wider surgical corridor than the standard approach. There are several methods for frontal sinus repair in bifrontal craniotomy. This study reports a novel method for frontal sinus repair in the modified transbasal interhemispheric approach by precisely overlapping the frontal sinus mucosa margin (without frontal sinus mucosa exenteration) with packing the frontal sinus with povidone-soaked gel foam and covering it with a vascularized pericranial flap.

**Methods:** In this case series, we retrospectively collected the clinical outcomes regarding cerebrospinal fluid (CSF) leakage, meningitis, and mucocele formation of patients who underwent modified transbasal bifrontal craniotomy at Vara Hospital.

**Results:** From January 2016 to December 2021, 65 patients with anterior skull-base lesions were treated with a modified transbasal interhemispheric approach with frontal sinus repair by overlapping frontal sinus mucosa with gel foam packing and vascularized pericranium flap covering. There was no case of postoperative CSF leakage, meningitis, or mucocele formation during the follow-up period of 19.2 months (min 1, max 73).

**Conclusions:** We demonstrated that the modified transbasal interhemispheric approach with frontal sinus repair using gel foam packing and pericranial flap is effective in preventing postoperative CSF leakage and meningitis.

## 1. Introduction

The bifrontal craniotomy is the standard surgical approach for treating lesions in the anterior cranial fossa, such as anterior skull-base tumors<sup>1–3</sup> and aneurysms of the anterior cerebral and anterior communicating arteries.<sup>4–8</sup> There are two types of bifrontal craniotomy, the standard bifrontal craniotomy<sup>1</sup> and the modified transbasal bifrontal craniotomy.<sup>4,5,9–11</sup> The benefit of the modified transbasal bifrontal approach is the lower basal margin of craniotomy, achieved by removing bone adjacent to the orbital bar and anterior skull base, the nasal part of the frontal bone. This provides a wider surgical corridor and reduces brain retraction. This approach is widely used in Japan.<sup>5,8,9</sup>

Although it provides a wider surgical corridor, the modified transbasal bifrontal approach requires entering the frontal sinus, resulting in

severely torn frontal sinus mucosa. Unlike the standard bifrontal approach in which entry into the frontal sinus could be avoided or, if the frontal sinus is entered, does less damage to the mucosa. Entering the frontal sinus can cause postoperative cerebrospinal fluid (CSF) leakage, and postoperative meningitis, with an incidence of between 2%–20 % and 3%–20 %, respectively.<sup>12–18</sup> Postoperative mucocele formation is a late complication of surgery involving the frontal sinus, occurring 2 months to 6 years postoperatively, with an incidence as high as 6%–13 %.<sup>19,20</sup>

Frontal sinus repair in the bifrontal approach can be performed by various methods such as mucosal exenteration, packing the frontal sinus with fatty tissue, or by covering the sinus with a pericranial flap. In Japan, the method of suturing the frontal sinus mucosa and packing the frontal sinus with abdominal fatty tissue is widely used. This prevents

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the risk of CSF leakage, meningitis, and mucocele formation by nearly 100%.<sup>17,18,21–23</sup> However, this method of frontal sinus repair takes a long time and requires an additional abdominal incision.

We report a novel method of frontal sinus repair in the modified transbasal interhemispheric approach. The frontal sinus mucosa was not exenterated. Instead of suturing the mucosa with abdominal fat packing, we repaired the mucosa by precisely overlapping the frontal sinus mucosa margin (without suturing) under high magnification of microscope, packing the frontal sinus with povidone-soaked gel foam, and covering it with a vascularized pericranial flap. We also report the clinical outcomes regarding postoperative CSF leakage, postoperative meningitis, and mucocele.

## 2. Materials and methods

This study was approved by the institutional review board of the Faculty of Medicine Vara Hospital, Navamindradhiraj University (IRB number COA021/2566). We retrospectively collected the medical record data of patients, who were diagnosed with an anterior skull-base tumor, or anterior cerebral, or anterior communicating artery aneurysm, at Vara Hospital from January 2016 to December 2021. Patients treated with a modified transbasal interhemispheric approach with frontal sinus repair by gel foam packing and vascularized pericranial flap were included in the study. We excluded patients who underwent redo bifrontal craniotomy due to inadequate vascularized pericranial flap. We collected data on demographics and clinical outcomes, including age, sex, underlying diseases, indications for surgery, operative time, intra-operative blood loss, postoperative CSF leakage, and postoperative meningitis.

### 2.1. Surgical technique for bifrontal craniotomy

The patient was placed in a supine position with the head slightly higher than the level of the heart. A modified bicoronal scalp incision was made just behind the hairline (Fig. 1A). The scalp flap was elevated from the pericranial tissue. After the pericranium tissue was elevated from the skull (preserving the vascularized pedicle and the supraorbital nerves), 3 burr holes were made in the frontal region. The bifrontal craniotomy was performed as low as possible, with the lower margin just above the orbital bar. The nasal part of the frontal bone was also removed (Fig. 1B).

### 2.2. Surgical technique for frontal sinus repair

After entering the frontal sinus, the mucosa was carefully dissected from the frontal sinus wall (Fig. 2A). The posterior wall of the frontal

sinus was removed (Fig. 2B). The nasofrontal duct was irrigated with normal saline to remove bone dust and blood clot. This maintains its patency which prevents future mucocele formation. The frontal sinus mucosa was not exenterated. The margin of the frontal sinus mucosa was precisely overlapped without suturing, under high magnification of microscope (Fig. 2C). The frontal sinus cavity was packed with povidone-soaked gel foam. After finishing the operation, the frontal sinus cavity was covered with a vascularized pericranial flap (Fig. 2D). Fig. 3 demonstrates the steps of the surgical technique for frontal sinus repair.

### 2.3. Postoperative care

In the postoperative period, fosfomycin was administered intravenously (4 g every 12 h for 48 h). This is standard postoperative practice in our institution. Sutures were removed on postoperative day 7.

### 2.4. Postoperative outcome assessment

We retrospectively reviewed the medical records to identify the occurrence of CSF leakage, meningitis, and postoperative mucocele. Postoperative CSF leakage was defined as persistent glucose-positive nasal fluid discharge. Postoperative meningitis was diagnosed when there was a persistent fever with signs of meningeal irritation, and a positive lumbar puncture.<sup>24</sup> Frontal sinus mucocele was defined as clinical enlargement of the frontal sinus with confirmation by computed tomography or magnetic resonance imaging.<sup>19</sup>

## 3. Results

From January 2016 to December 2021, there were 65 patients diagnosed with anterior skull-base lesions which was treated by modified transbasal interhemispheric approach and frontal sinus repair by overlapping frontal sinus mucosa with gel foam packing and vascularized pericranium flap. Their baseline characteristics are presented in Table 1. When classified these patients according to the diseases, there were 13 anterior skull base tumors, 16 anterior cerebral aneurysms, and 36 anterior communicating artery aneurysms (Table 2). There was no postoperative CSF leakage, meningitis, or mucocele during the follow-up period of 19.2 months (min 1, max 73). The rate of postoperative CSF leakage is 0/person-months. The rate of postoperative meningitis is 0/person-months. The rate of postoperative mucocele is 0/person-months.

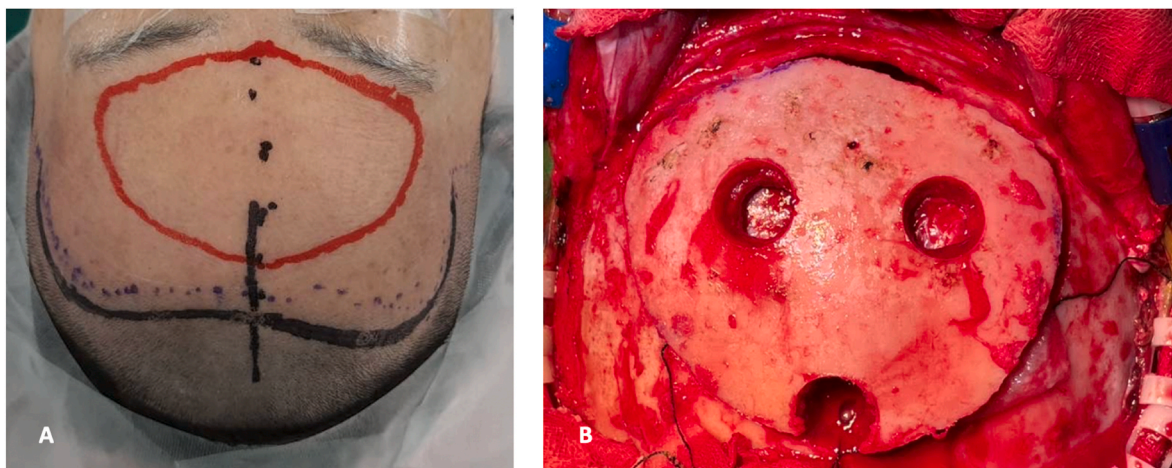
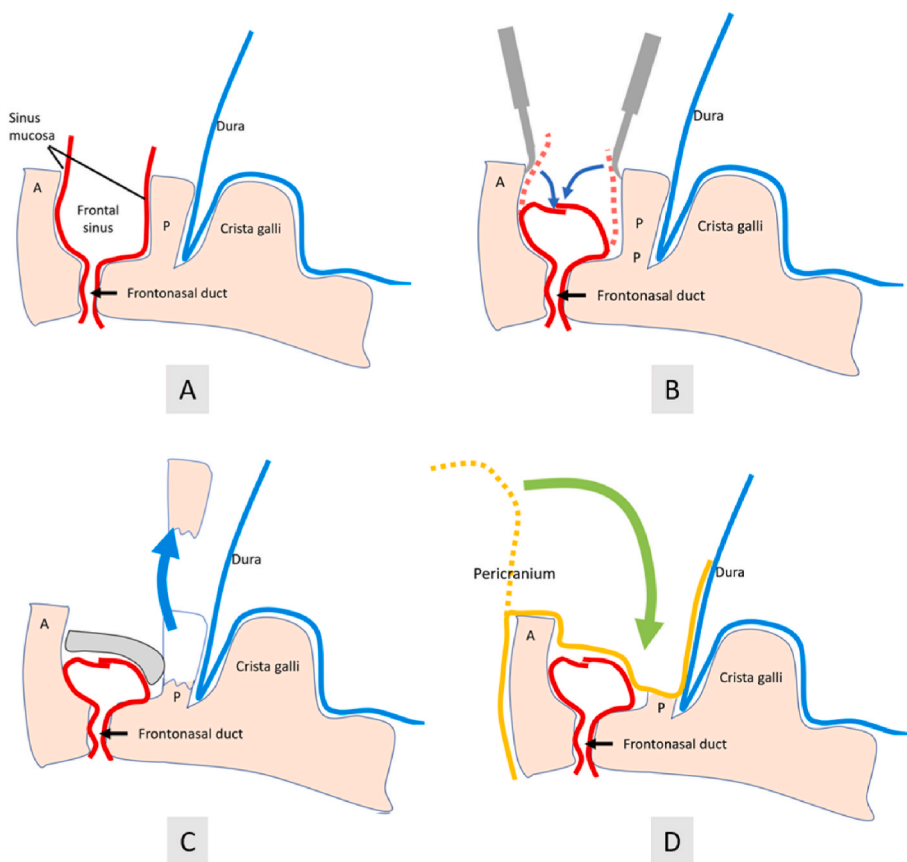
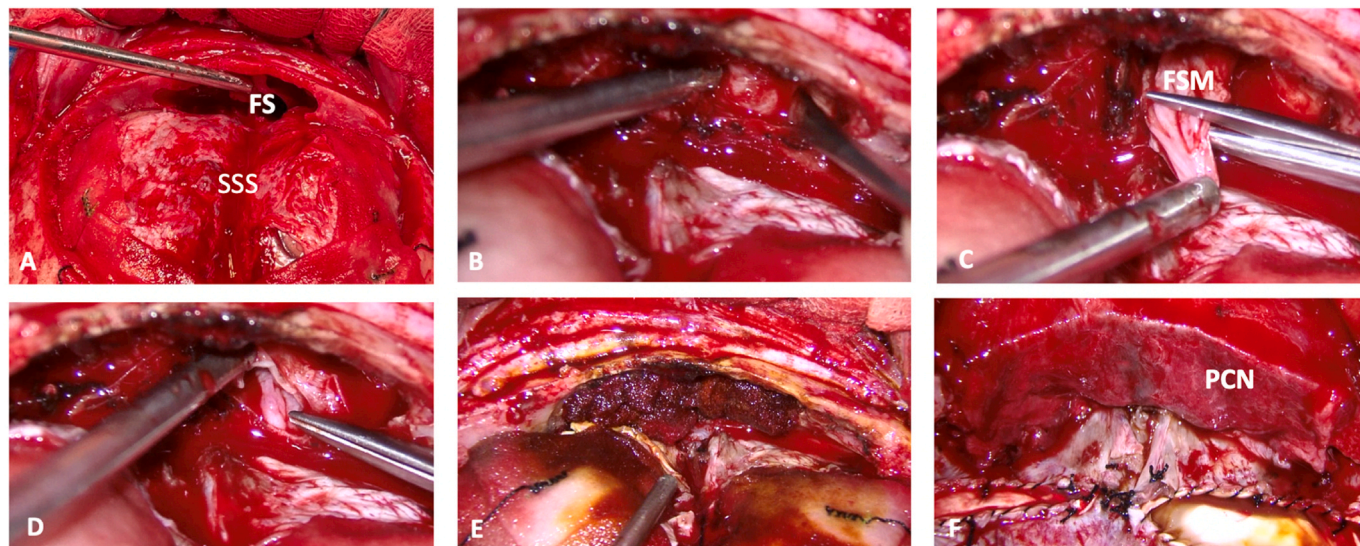


Fig. 1. Surgical technique for bifrontal craniotomy A. Modified bicoronal incision behind the hairline B. Modified bifrontal craniotomy.



**Fig. 2.** Diagram illustrating frontal sinus repair (sagittal view). A: Bifrontal craniotomy with preserved vascularized pericranial flap (red = frontal sinus mucosa, blue = dura). B: Frontal sinus mucosa dissected from the frontal sinus wall, margin of the frontal sinus mucosa was precisely overlapped. C: Frontal sinus cavity packed with gel foam (gray). D: Frontal sinus cavity covered with a vascularized pericranial flap (yellow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



FS: Frontal sinus, SSS: Superior sagittal sinus, FSM: Frontal sinus mucosa, PCN: Pericranium

**Fig. 3.** Surgical technique for frontal sinus repair A. The posterior wall of the frontal sinus was removed. B. The frontal sinus mucosa was dissected from the frontal sinus wall. C. The redundant part of the mucosal wall was cut. D. The margin of the frontal sinus mucosa was precisely overlapped without suturing under a microscope. E. The cavity of the frontal sinus was packed with povidone-soaked gel foam. F. The frontal sinus was covered with a vascularized pericranial flap.

**4. Discussion**

We report a novel method for frontal sinus repair after modified

transbasal interhemispheric approach surgery in patients with anterior cranial fossa lesions. In our experience, this approach is less time-consuming and is effective in preventing postoperative complications,

**Table 1**  
Demographic data and baseline characteristics of patients.

Characteristics	Patients (n = 66)
Age, years, mean (SD)	54 (12)
Female N (%)	39 (59.1 %)
Diabetes mellitus	12 (18.2 %)
Operative time, minutes, mean (SD)	270 (95)
Blood loss, milliliter, mean (SD)	470 (350)

including CSF leakage, meningitis, and mucocele formation.

Postoperative CSF leakage is a complication of the bifrontal interhemispheric approach that can lead to meningitis, which is a serious postoperative complication. CSF leakage is usually treated with CSF drainage via a lumbar drain. Some patients may need surgical repair of the leakage site. These procedures increase the patients' length of stay.<sup>1,2,25,26</sup>

Postoperative mucocele formation is another complication of surgery involving the frontal sinus. A frontal sinus mucocele can lead to cosmetic deformity and postoperative infection. Mucoceles usually require surgical drainage and antibiotic treatment.<sup>19,20</sup> Frontal sinus repair after the standard bifrontal interhemispheric approach can be performed by several methods such as frontal sinus mucosal exenteration, packing the frontal sinus cavity with fatty tissue, or covering the frontal sinus with a vascularized pericranial flap.<sup>10,14,17,18,21–23,25–27</sup> However, in the modified transbasal interhemispheric approach, the craniotomy margin is much lower than the standard bifrontal interhemispheric approach. This leads to a widely opened frontal sinus with severely damaged mucosa.<sup>9,11,17,18</sup>

It was believed that covering the frontal sinus with only a vascularized pericranial flap was not enough to prevent postoperative CSF leakage in this approach. Murai et al and Takeuchi et al described frontal sinus mucosa suturing to prevent CSF leakage after the modified transbasal interhemispheric approach.<sup>9,17,18</sup>

This had excellent results (~100 %) in preventing postoperative CSF leakage and mucocele formation.<sup>17,18</sup> However, this procedure is lengthy and creates additional abdominal scars. In developing countries, long operative time is an obstacle to resource allocation.<sup>28,29</sup> Therefore, suturing the frontal sinus mucosa is less feasible in such settings.

Our method of frontal sinus repair is similar to that described by Takeuchi, except that we overlap the margin of the frontal sinus mucosa without suturing. Precise overlapping of the frontal sinus mucosa under high magnification of microscope promotes its healing, thus preventing CSF leakage and meningitis. Further, nonsuturing techniques reduce the operative time, which is also beneficial in developing countries with

**Table 2**  
Outcome of the patients classified by disease.

Disease	N	Operation	Operative time ± SD (min)	Blood loss ± SD (ml)	CSF leakage	Meningitis	Mucocele	FU period (min/max) (month)
Anterior skull base tumor	Total 13 Planum sphenoidale meningioma 5 Olfactory groove meningioma 6 Esthesioneuroblastoma 1 Pituitary adenoma 1	Craniotomy remove tumor	340 ± 90	860 ± 760	0	0	0	32 (1,70)
Ruptured Anterior communicating artery aneurysm	33	Craniotomy clipping aneurysm	250 ± 50	360 ± 170	0	0	0	21.5 (1,73)
Unruptured Anterior communicating artery aneurysm	3	Craniotomy clipping aneurysm	190 ± 15	210 ± 70	0	0	0	13 (1,23)
Ruptured anterior cerebral artery aneurysm (A2-3 aneurysm)	16	Craniotomy clipping aneurysm (n = 13) Trapping aneurysm with ACA bypass (n = 3)	260 ± 150 340 ± 140	340 ± 140 700 ± 300	0 0	0 0	0 0	7.2 (1,27) 4 (1,11)

limited resources. Liu et al described a similar modified transbasal bifrontal craniotomy with removal of the posterior wall of the frontal sinus. However, the sinus mucosa was exenterated in their method.<sup>10</sup> We believe that mucosal exenteration may disrupt the normal physiological drainage of the frontal sinus, which may lead to mucocele formation. Therefore, we do not exenterate the frontal sinus mucosa.

To our knowledge, this is the first study to report frontal sinus repair in the modified transbasal bifrontal craniotomy by precisely overlapping the frontal sinus mucosa without suturing, and packing the frontal sinus with gel foam and a vascularized pericranial flap covering. Postoperative complications related to CSF leakage and meningitis were comparable to the frontal mucosa suturing technique.<sup>17,18</sup> In our series, there was no postoperative CSF leakage, meningitis, or mucocele formation. We demonstrated that this technique is safe and effective in preventing these complications, and may be especially useful in developing countries which have limited resources.

This study had some limitations. First, it was retrospective. A prospective study should be conducted to confirm the effectiveness of this surgical procedure. Second, the follow-up period among some patients was relatively short. As patients from all over the country are referred to our hospital, those from rural areas were less likely to attend follow-up at our center. Third, there is no control group in our study. Finally, the nature of the diseases of our population in this study are heterogeneous including vascular lesion and varieties of tumors.

## 5. Conclusion

Frontal sinus repair using the modified transbasal interhemispheric approach by precisely overlapping the frontal sinus mucosa margin under a microscope with gel foam packing together with vascularized pericranial flap covering is safe and effective in preventing CSF leakage and meningitis in developing countries.

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## Data availability statement

The data for this study are available from the corresponding author upon reasonable request.

### CRedit authorship contribution statement

**Chanon Ariyaprakai:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Nasaeng Akharathammachote:** Supervision. **Areeporn Chonhenchob:** Supervision. **Kitiporn Sriamornrattanukul:** Visualization, Supervision, Project administration.

### Declaration of competing interest

None.

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### Abbreviations list

CSF: cerebrospinal fluid  
 Max: maximum  
 Min: minimum  
 SD: standard deviation