

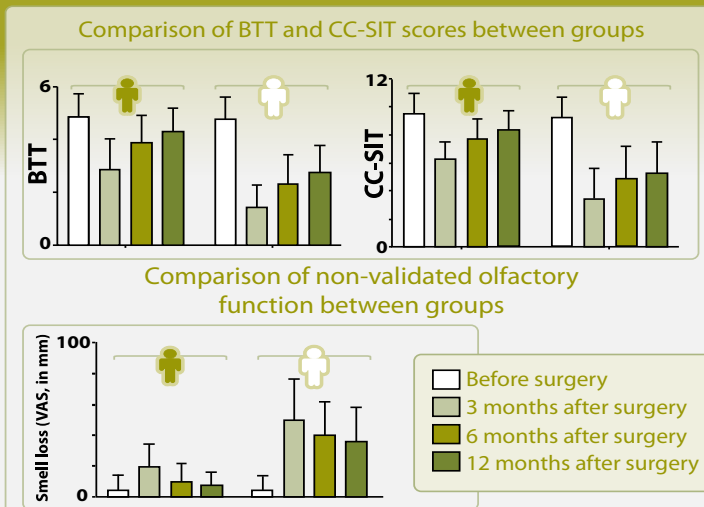
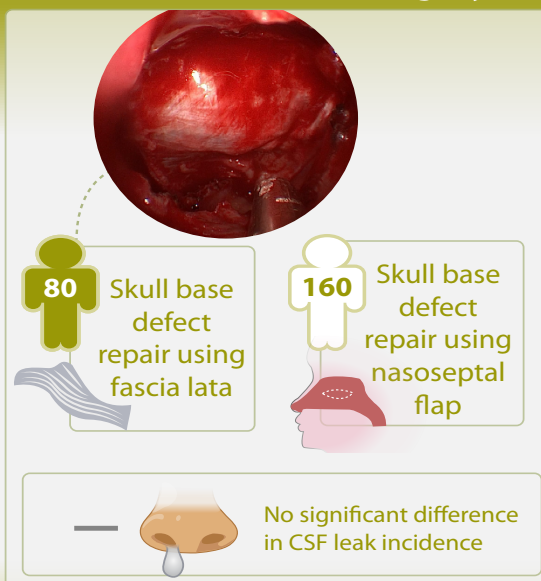
The use of fascia lata can minimize olfactory damage in endoscopic endonasal skull base surgery

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Rhinology 63: 4, 0 - 0, 2025

<https://doi.org/10.4193/Rhin24.522>

The use of fascia lata can minimize olfactory damage in endoscopic endonasal skull base surgery



•Nasoseptal flap can cause severe olfactory impairment
•Fascia lata use can be considered as an alternative to minimize damage to olfactory function

Wu Y, Xue Y, Zheng M, et al. Rhinology 2025. <https://doi.org/10.4193/Rhin24.418>

RHINOLOGY
Official Journal of the European and International Societies

Abstract

Objective: The purpose of this study was to compare the impact of using fascia lata versus a nasoseptal flap for skull base repair on olfactory function following endoscopic endonasal skull base surgery. **Methods:** Patients who underwent the endoscopic endonasal transsphenoidal approach (EETA) or the extended endoscopic endonasal transsphenoidal approach (EEETA) were included in this study. The study included 80 patients who underwent skull base defect repair using fascia lata, while the control group consisted of 160 patients who underwent skull base defect repair using a nasoseptal flap. Preoperative demographic data, skull base repair techniques, postoperative sinonasal symptoms and the incidence of cerebrospinal fluid (CSF) leakage were compared between the two groups. **Results:** Olfactory dysfunction was significantly worse at 3, 6 and 12 months after surgery than before surgery in the nasoseptal flap repair group, although olfactory function partially recovered at 12 months after surgery. Additionally, we found that non-validated visual analogue scale (VAS, 0–100 mm) and validated cross-cultural smell identification test (CC-SIT) and the butanol threshold test (BTT) olfactory impairment at 12 months after surgery were significantly worse in the nasoseptal flap repair group than in the fascia lata repair group. Furthermore, no significant difference in the incidence of CSF leakage was noted between the two groups. **Conclusions:** For endoscopic endonasal surgery, the use of a nasoseptal flap for skull base repair can cause severe olfactory impairment. The use of fascia lata for skull base repair can be considered an alternative method to minimize damage to olfactory function.

Key words: endoscopic endonasal transsphenoidal approach, skull base lesions, olfactory function, nasoseptal flap, fascia lata

Introduction

In recent years, the endoscopic endonasal transsphenoidal approach (EETA) has become the mainstream surgical method for the removal of pituitary adenomas in the sellar region. The extended endoscopic endonasal transsphenoidal approach (EEETA) can be used to resect various skull base lesions, including invasive pituitary adenomas, craniopharyngiomas, meningiomas, chordomas, and Rathke's cysts⁽¹⁾. However, the EEETA increases the risk of intraoperative and postoperative cerebrospinal fluid leakage. To prevent cerebrospinal fluid (CSF) leakage, a broad nasoseptal flap is widely used in most patients who undergo the EEETA to reconstruct skull base defects⁽²⁾. A broad nasoseptal flap is a pedicled, vascularized mucoperichondrial flap that derives its blood supply from the posterior nasoseptal artery, a branch of the sphenopalatine artery. A nasoseptal flap may increase the risk of sinonasal symptoms and olfactory dysfunction, thereby affecting patients' quality of life. Many studies have indicated that the use of the EETA or EEETA with a nasoseptal flap causes smell impairment⁽³⁻⁶⁾. Thus, the following question arises: Is there any other alternative skull base repair method that can replace the nasoseptal flap and reduce olfactory dysfunction? Therefore, we conducted a retrospective study and selected 80 patients who underwent endoscopic endonasal surgery with fascia lata for skull base defect repair as the experimental group and matched 160 patients who used nasoseptal flap for skull base defect repair as the control group. The incidences of postoperative CSF leakage, sinonasal symptoms and olfactory dysfunction were compared between the two groups.

Materials and methods

Inclusion and exclusion criteria

Patients who underwent surgery using the EETA or EEETA at Tangdu Hospital of Air Force Medical University from March 2015 to December 2023 were included in this study. Patients aged less than 18 years and those who were diagnosed with anosmia were excluded. Patients who had sinonasal disease or a history of previous endoscopic sinus surgery or transnasal endoscopic skull base surgery were also excluded. We retrospectively selected 80 patients who met the inclusion and exclusion criteria for repairing skull base defects with fascia lata and then matched 160 patients who underwent repair of skull base defects with nasoseptal flap as the control group. Preoperative demographic information, skull base repair techniques, postoperative sinonasal symptoms and the incidence of CSF leakage were compared between the two groups. Intraoperative CSF leakage was assessed based on the classification method by Esposito et al.⁽⁷⁾. The Ethics Committee of Tangdu Hospital of Air Force Medical University approved the study, and signed informed consent was obtained from all patients.

Sinonasal symptoms and assessment of olfactory function

Patients were instructed to evaluate five sinonasal symptoms—anosmia, nasal obstruction, anterior and posterior nasal discharge, sneezing, and itching—using a visual analog scale (VAS, 0–100 mm) ranging from 0–100 mm. The cross-cultural smell identification test (CC-SIT) and the butanol threshold test (BTT) at 3 months postsurgery were administered in an outpatient setting as validated assessments of olfactory function to evaluate odor identification and odor threshold, respectively⁽⁸⁻¹⁰⁾. To assess olfactory impairment in relation to surgical intervention, we analyzed the changes in olfactory scores preoperatively and at 3 and 6 months postoperatively and compared these changes across the nasoseptal flap repair group and the fascia lata repair group.

Surgical procedure

Exposure via the EEETA was customized based on the surgical pathway, tumor size and location, and the relationship between the tumor and adjacent neurovascular structures. In most cases, we need to remove the lower 1/3 of the middle and/or superior turbinates to facilitate surgical manipulation. The posterior part of the nasal septum and the vomer were removed with a high-speed drill, and the sphenoid sinus and ethmoid sinus were also extensively removed. The boundaries of the tumor and the internal carotid were located using an intraoperative navigation system and a micro-Doppler probe.

For the nasoseptal flap repair group, after the nasal cavity was disinfected with diluted iodophor, the nasoseptal flap was designed and harvested in light of the size of the skull base defect. The superior incision begins at the opening of the sphenoid sinus, 1 cm below the olfactory sulcus, and proceeds anteriorly along the nasal septum. After surpassing the projection of the middle turbinate on the nasal septum, the incision can be extended superiorly, ultimately reaching the junction of the nasal mucosa and the skin. The inferior incision follows the nasal floor anteriorly. At the junction of the nasal floor and the lateral nasal mucosa, it can be expanded laterally; then, it continues to the junction of the nasal mucosa and skin. After the nasoseptal flap elevation was completed, it was placed in the posterior nasal aperture. The steps of skull base repair after tumor resection are as follows: 1) intrasellar fat graft; 2) intermittent suturing of the dura mater; 3) absorbable artificial dura mater covering the autologous dura mater and surrounding bone; 4) reduction of the sellar floor bone or synthetic buttress; 5) nasoseptal pedicled flap layered over the skull base defect; 6) gelatin sponge over the nasoseptal flap followed by tissue glue; and 7) nasal packing with iodoform gauze.

For the fascia lata repair group, the nasoseptal flap was not harvested. At the opening of the sphenoid sinus, the bilateral nasal septum mucosa was removed to expose the anterior wall

Table 1. Clinical data of patients undergoing endoscopic endonasal surgery.

Parameter	Fascia lata repair group (80)	Nasoseptal flap repair group (160)	P value
Mean age (years)	43.18±16.15	47.18±15.87	0.07
Gender (no. [%])			0.78
Male	36 (45)	75 (46.9)	
Female	44 (55)	85 (53.1)	
Smoking history			0.41
Yes	17 (21.2)	27 (16.9)	
No	63 (78.8)	133 (83.1)	
Tumor type (no. [%])			0.95
Pituitary adenoma	30 (37.5)	67 (41.9)	
Rathke's cyst	6 (7.5)	13 (8.1)	
Craniopharyngioma	21 (26.3)	41 (25.6)	
Chordoma	12 (15)	20 (12.5)	
Meningioma	11 (13.8)	19 (11.9)	
Surgical approach (no. [%])			0.67
EEEA	21 (26.3)	38 (23.8)	
EEETA	59 (73.8)	122 (76.3)	
Extent of resection (no. [%])			0.44
Gross total resection	70 (87.5)	134 (83.8)	
Subtotal resection	10 (12.5)	26 (16.3)	
Intraoperative CSF leakage (no. [%])			0.61
Grade 0-1	23 (28.8)	41 (25.6)	
Grade 2-3	57 (71.3)	119 (74.4)	

of the sphenoid sinus. After tumor resection, an approximately 5 cm incision was made on the outer side of the patient's thigh. The skin and subcutaneous space were incised layer by layer, and some fat tissue was removed for intrasellar packing. Then, a fascia lata flap was tailored according to the size of the skull base defect. In the fifth step, the fascia lata was layered over the skull base defect. The remaining steps were similar.

Statistical analysis

Continuous variables are presented as the means ± standard deviations, and categorical variables are expressed as numbers (percentages). Student's t test was used for normally distributed continuous data, the Mann–Whitney U test was used for nonnormally distributed data, and the chi-square test or Fisher's exact test was used for categorical data. All the data were analyzed via SPSS (version 25, IBM Corp), and a p value < 0.05 was considered statistically significant.

Results

Demographic data

Table 1 summarizes the clinical characteristics of the patients. In a cohort of 240 patients, 80 patients used fascia lata to repair skull base defect and the other 160 used nasoseptal flap to repair skull base defect. No significant differences in the mean age (47.18±15.87 vs. 43.18±16.15) or sex distribution were noted between the nasoseptal flap repair group and the fascia lata repair group. The proportions of different types of tumors, including pituitary adenoma, Rathke's cyst, craniopharyngioma, chordoma and meningioma, were similar between the two cohorts. The EEETA was used for 76.3% (122/160) of the patients in the nasoseptal flap repair group and 73.8% (59/80) of those in the fascia lata repair group. Gross total resection was achieved in 134 patients (83.8 %) in the nasoseptal flap repair group and 70 patients (87.5%) in the fascia lata repair group. No statistically significant differences in the extent of resection were noted between the two groups. The incidence of grade 2-3 CSF leakage was similar between the two groups.

Table 2. Sinonasal symptom scores assessed using a visual analogue scale (0-100 mm).

Parameter	Fascia lata repair group (80)					Nasoseptal flap repair group (160)				
	Baseline (Reference)	3 months after surgery	P value	6 months after surgery	P value	Baseline (Reference)	3 months after surgery	P value	6 months after surgery	P value
Nasal discharge	19.38±14.53	23.63±14.16	0.06	22.88±14.34	0.13	18.44±15.03	23.25±13.99	0.003	21.38±14.30	0.074
Nasal obstruction	20.50±13.40	24.13±12.80	0.08	23.25±12.81	0.19	20.44±15.47	23.31±14.78	0.09	22.81±15.05	0.19
Sneezing	15.13±13.50	18.95±13.12	0.07	17.95±13.19	0.18	15.81±12.16	18.31±11.61	0.06	17.94±11.77	0.11
Nasal itching	9.75±13.68	12.25±13.68	0.25	11.63±13.45	0.38	9.31±11.11	11.19±11.01	0.13	10.75±10.96	0.24

Postoperative sinonasal symptom scores

In the fascia lata repair group, the VAS scores of sinonasal symptoms at 6 months (nasal discharge, nasal obstruction, sneezing and nasal itching) were similar to the baseline VAS scores, and no significant differences were noted (Table 2). In the nasoseptal flap repair group, except for the VAS score of nasal discharge at 3 months, which was higher than the baseline VAS score, the other sinonasal symptom scores at 3 months were also similar to the baseline sinonasal symptom scores. At 6 months, the VAS score of nasal obstruction also reduced to pre-operative level. Compared with preoperative olfactory function (4.63 ± 9.24), non-validated olfactory function according to the VAS was significantly worse at 3 (50.25 ± 26.89), 6 (40.13 ± 22.13) and 12 (36.19 ± 22.15) months postoperatively in the nasoseptal flap repair group. However, despite a decline in olfactory function at 3 and 6 months after surgery, olfactory function had largely returned to normal by 12 months after surgery in the fascia lata repair group. Additionally, the olfactory function score at 12 months after surgery was significantly greater in the nasoseptal flap repair group than in the fascia lata repair group (36.19 ± 22.15 vs. 7.39 ± 8.95 mm, $p<0.001$) (Figure 1).

Comparison of validated olfactory function

The average BTT score was significantly lower at 3 months (1.45 ± 0.82), 6 months (2.34 ± 1.08) and 12 months (2.75 ± 1.02) after surgery than the preoperative BTT score (4.76 ± 0.84) in the nasoseptal flap repair group, although there was a significant increase at 6 and 12 months compared with 3 months after surgery. Furthermore, in the fascia lata repair group, despite a decrease in the average BTT scores at 3 months (2.88 ± 1.14), 6 months (3.89 ± 1.04) and 12 months (4.31 ± 0.91) after surgery compared with the preoperative BTT score (4.86 ± 0.87), the extent of the BTT score change was significantly lower in the fascia lata repair group than in the nasoseptal flap repair group (Figure 2). Similarly, in the nasoseptal flap repair group, the average CC-SIT score was significantly lower at 3 months (3.49 ± 2.17 vs. 6.29 ± 1.21 , $p<0.001$), 6 months (4.84 ± 2.34 vs. 7.75 ± 1.32 , $p<0.001$) and 12 months (5.29 ± 2.24 vs. 8.36 ± 1.37 , $p<0.001$)

than that in the fascia lata repair group (Figure 3); the extent of the CC-SIT score change was significantly worse at 3 months, 6 months and 12 months in the nasoseptal flap repair group than that in the fascia lata repair group.

Incidence of cerebrospinal fluid leakage and other complications

In the nasoseptal flap repair group, postoperative CSF leakage occurred in 6 patients. Of these, 3 were cured by continuous lumbar drainage, and the other 3 patients underwent second endoscopic endonasal surgery for skull base repair and were cured. In the fascia lata repair group, 4 patients developed CSF leakage. Of these, 2 were cured by continuous lumbar drainage, and the other 2 patients underwent reoperation to repair skull base defects and were ultimately cured. No significant difference in the incidence of CSF leakage was noted between the two groups.

In the fascia lata repair group, five patients experienced incisional pain and mild redness and swelling within two weeks postoperatively. These symptoms resolved by one month after surgery. Two patients with cicatricial diathesis developed incisional scars. The remaining patients had no significant discomfort.

Discussion

The data concerning olfactory dysfunction are heterogeneous in the study of endoscopic transnasal surgery. Some studies have indicated that endoscopic transnasal surgery for pituitary adenoma may induce long-term olfactory dysfunction^(11, 12). However, other studies have shown that endoscopic endonasal surgery for pituitary adenoma has a minimal impact on olfactory function⁽¹³⁻¹⁵⁾ and that olfactory function can be restored to the preoperative level 6–12 months after surgery⁽¹⁶⁾. The use of a nasoseptal flap in the EETA or EEETA is also an important risk factor resulting in hyposmia or anosmia^(5, 11, 17, 18). Alobid et al.⁽⁵⁾ reported that the incidence of moderate-severe smell loss associated with the transnasal transsphenoidal endoscopic approach without a nasoseptal flap was 23%, but the incidence of moderate - severe smell loss associated with the expanded

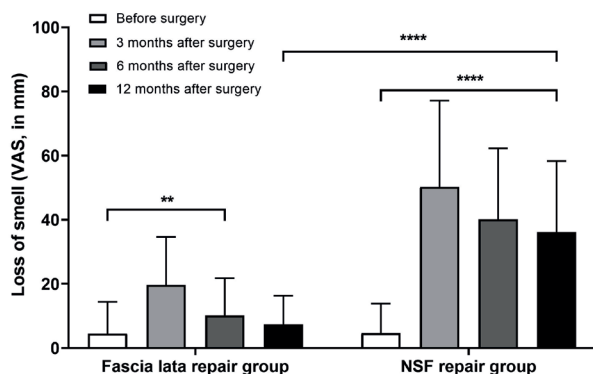


Figure 1. The effects of different skull base repair techniques on the loss of smell were evaluated using the visual analog scale (VAS). The effect of the nasoseptal flap in comparison with the fascial lata in the repair of skull base defects.

endonasal approach using a nasoseptal flap was 50%. Seo et al.⁽¹⁷⁾ demonstrated that utilization of a nasoseptal flap was a significant risk factor for olfactory dysfunction in a retrospective study of 928 patients and noted that olfactory function was significantly worse in the extended endoscopic endonasal approach group compared with the endoscopic trans-sellar approach group. A systematic review of olfactory function in endonasal surgery revealed that the utilization of septal flaps is a detrimental factor for olfactory recovery⁽¹⁸⁾, and Majovsky et al.⁽¹⁹⁾ reported that an endoscopic approach without harvesting the nasoseptal flap can result in better preservation of olfactory function. However, some studies have shown that olfactory function in patients who use a nasoseptal flap to reconstruct skull base defects can recover at 6 months after surgery⁽²⁰⁻²²⁾. Research supporting the use of a nasoseptal flap that does not affect olfactory function has focused on patients who underwent the EETA rather than those who underwent the EEETA. In addition, only a small number of individuals who underwent the EEETA have been included in these studies. The study subjects were mainly patients with pituitary adenomas. In our study, the vast majority (over 70%) of patients underwent surgery using the EEETA, and relatively large nasoseptal flaps were used. In addition, the study subjects included patients with pituitary adenomas, craniopharyngiomas, chordomas and meningiomas. Our results revealed that at 12 months postsurgery, there was still a significant decline in olfactory function in the nasoseptal flap repair group compared with that before surgery, and the degree of decline in olfactory function in the nasoseptal flap repair group was significantly greater than that in the fascia lata repair group. These findings indicate that the use of a nasoseptal flap is an important risk factor for olfactory dysfunction in patients who undergo the EEETA for tumor resection. However, for the fascia lata repair group, nonvalidated VAS scores and validated measurements of olfactory function revealed that

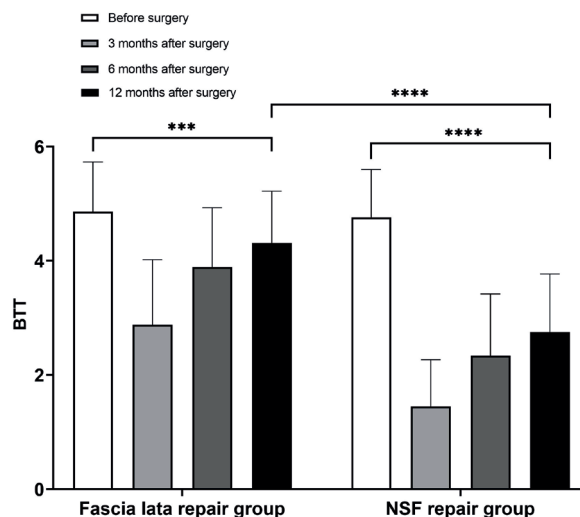


Figure 2. The effects of different skull base repair techniques on the loss of smell using the butanol threshold test (BTT). Effect of the nasoseptal flap in comparison with the fascial lata in the repair of skull base defects.

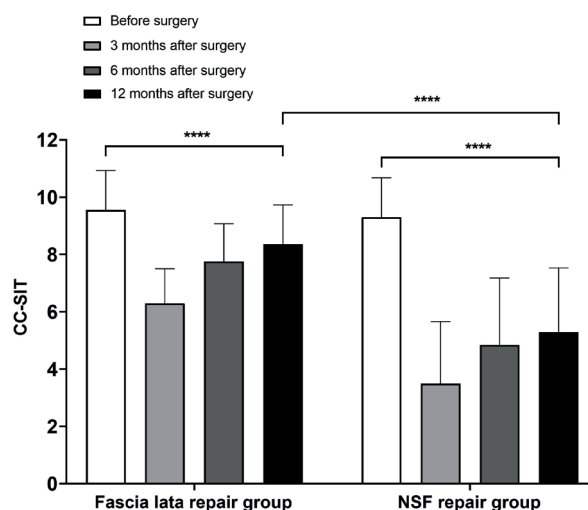


Figure 3. The effects of different skull base repair techniques on the loss of smell using the cross-cultural smell identification test (CC-SIT). Effect of the nasoseptal flap in comparison with the fascial lata in the repair of skull base defects.

olfactory function can recover to a relatively good level by 12 months postsurgery; however, there was still a certain degree of decline compared with the preoperative values. This decline in olfactory function may be attributed to the application of the EEETA; some authors believe that the use of the EEETA for tuberculum sellae meningiomas may increase injury to the olfactory neuroepithelium⁽¹⁷⁾. Further study revealed that, compared with nasoseptal flap repair, fascia lata repair did not increase the incidence of CSF leakage; thus, the use of fascia lata to repair skull base defects can serve as an alternative method. There are numerous skull base repair techniques that can be used in the

context of high-flow CSF leaks, and we employ a combination of the dural suture technique along with the repositioning and fixation of autologous bone flaps or artificial bone grafts. We subsequently use either a nasoseptal flap or fascia lata to repair skull base defects, which can effectively prevent high-flow CSF leakage. In most cases, it is not necessary to use both fascia lata and nasoseptal flaps to repair the defect simultaneously. For studies on other nasal symptoms following use of the EETA or EEETA, 6 months after surgery, the VAS scores for nasal discharge, nasal obstruction, nasal itching, and sneezing in both groups of patients returned to preoperative levels. Only in the nasoseptal flap repair group was the VAS score for nasal discharge at 3 months significantly higher than that before surgery, but at 6 months it recovered to preoperative level. Therefore, the impact of both skull base repair methods on other nasal symptoms in patients is relatively minimal. This finding is consistent with the results reported in previous studies^(5,6).

The fascia lata has good tissue compatibility, certain toughness, and thickness, which can effectively repair skull base defects and reduce the risk of CSF leakage. However, harvesting fascia lata from the lateral thigh may lead to donor site pain, hematoma, infection, or scar formation. In some patients, partial absorption or atrophy of the fascia lata may occur in the long term, resulting in a weakened repair site and increased risk of delayed CSF leak. Moreover, the fascia lata needs to be laid in multiple layers and securely fixed. If the intraoperative apposition is not tight or the fixation is improper, it may affect the repair outcome.

Conclusion

Olfactory function, as measured using the VAS score and CC-SIT and BTT, was significantly worse at 12 months after surgery than before surgery in the nasoseptal flap repair group. Although there was a certain degree of decline in olfactory function

in the fascia lata repair group, the degree of the decline was significantly lower than that in the nasoseptal flap repair group. Furthermore, the incidence of postoperative CSF leakage was similar between the two groups. Therefore, the use of fascia lata to repair the skull base in the EEETA has a lesser impact on olfaction function compared with the use of a nasoseptal flap and can be considered an alternative method.

Ethics statement

This study was approved by the Ethics Committee of Tangdu Hospital of Air Force Medical University, and informed consent was given by all participants.

Authorship contribution

ZTZ and CQ: supervision, writing - review and editing. WYX and XYF: writing - original draft preparation. ZM: data collection and analysis. WHY and ZYZ: investigation and data collection All authors contributed to the article and approved the submitted version.

Conflict of interest

EETA=endoscopic endonasal transsphenoidal approach; EEETA=extended endoscopic endonasal transsphenoidal approach; CSF=cerebrospinal fluid; VAS=visual analog scale; CC-SIT=cross-cultural smell identification test; BTT= butanol threshold test.

Conflict of interest

The authors declare that there are no conflicts of interest.

Funding

None.

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Rhinology 63: 4, 0 - 0, 2025
<https://doi.org/10.4193/Rhin25.061>

Received for publication:
 February 1, 2025
Accepted: April 14, 2025

Associate Editor:
 Ahmad Sedaghat