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Assessment of nasal outcomes after endoscopic removal of large midline skull base tumors with nasoseptal flap reconstruction

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Abstract

Background There have been several reconstructive methods with free flaps or vascular pedicled flaps constituting a large portion of the rebuilding of the skull base. The vascularized pedicled nasoseptal flap, however, appears to be the "gold standard" flap in the restoration of the integrity of the cranial base among all of the foregoing alternatives. This study aimed to assess the postoperative outcomes of endoscopic removal of large midline skull base tumors with nasoseptal flap reconstruction in 21 patients. Patients were assessed at 1 week postoperative using Sinonasal Outcome Test 22 (SNOT 22) to assess postoperative nasal symptoms. An endoscopic assessment of the nose was done at 1 week postoperative to assess the degree of crusting and at 4 weeks postoperative to assess the degree of nasal adhesions and the presence or absence of gangrene of the nasoseptal flap. Postoperative complications were assessed.

Results The study patients included 12 cases with pituitary macroadenoma, five cases with anterior cranial fossa meningioma, and four cases with petroclival chordoma. The skull base defect size ranged from 2.5 to 4.5 cm. The most troublesome postoperative symptoms were decreased sense of smell/taste. Postoperatively, 10 patients had mild, 7 patients had moderate, and 4 patients had severe nasal crusting. Three cases had epistaxis and two cases had postoperative cerebrospinal fluid rhinorrhea. Ten cases had no nasal adhesions, four cases had mild, four cases had moderate, and three cases had severe nasal adhesions. No cases had gangrene of the nasoseptal flap.

Conclusion The nasoseptal flap is an effective option for large skull base defect reconstruction after endoscopic resection of large skull base tumors with an acceptable postoperative patient quality of life and a low incidence of postoperative complications.

Keywords Nasal outcomes, Nasoseptal flap, Midline skull base tumors, Skull base reconstruction, Hadad-Bassagaisteguy flap

Background

The primary purpose of endonasal reconstructive procedures for skull base defects was to treat cerebrospinal fluid (CSF) rhinorrhea, which was mostly caused by traumatic (including iatrogenic) causes. New techniques like the extended endonasal approach for skull base surgery have led to the development of skull base reconstruction as a component of planned surgical treatment of lesions localized in the skull base region. In 1952, Oscar Hirsch [1] was the first to document a successful endonasal surgical closure of a CSF leak. Malte Wigand [2], however,

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was the one to conduct the first endoscopic cerebrospinal fluid rhinorrhea closure with the use of a free mucosal flap in 1981.

Up to the current date, there have been several reconstructive methods using both synthetic and autologous materials for skull base reconstruction. Surgical operations using free flaps or vascularized pedicled flaps constitute a large portion of the rebuilding of the skull base. The most frequent vascularized flaps are harvested locally from the nasal turbinates or nasal septum based on the sphenopalatine artery (SPA). When the SPA is affected by a tumor or a prior treatment (surgery or radiation), pedicled flaps raised on external head and neck arteries other than intranasal ones are used [3]. The tunneled temporoparietal fascia flap, endoscopically assisted pericranial flap, occipital flap, palatal flap, buccinator flap based on facial artery, and others can all be employed for skull base reconstruction [3]. The vascularized pedicled nasoseptal flap (NSF), however, appears to be the "gold standard" flap in the restoration of the integrity of the cranial base among all of the foregoing alternatives [4, 5]. The Hadad-Bassagasteguy flap (HBF) is another name for it, and it was initially reported by Hadad and Bassagasteguy in 2006 [4]. Only 5% of their initial series of 43 operations showed postoperative CSF leakage [4]. Kassam et al. [6] reported on a group of 75 patients, a failure rate of 10.66% in their first 25 operated patients, and 5% in their next 50 patients, thus stating NSF to be a very effective technique in skull base reconstruction. Although numerous studies have evaluated the use of nasoseptal flap in skull base reconstruction considering its efficacy and complications, few studies have investigated the sinonasal manifestations and quality of life after the flap. This study aimed to assess the postoperative outcomes of endoscopic removal of large midline skull base tumors with nasoseptal flap reconstruction.

Methods

The present study was a case series study including 21 patients enrolled in the study to assess the sinonasal outcomes after endoscopic excision of large midline skull base masses with nasoseptal flap reconstruction. Patients with other intranasal pathologies, patients with surgical unfitness, and patients requiring open approaches were excluded from the study. The study was conducted after approval of the institutional review board, and informed written consent was taken from every patient before participation in the study.

Preoperative assessment

All patients of the study were assessed by a history taking and a comprehensive otorhinolaryngology examination including an endoscopic assessment of the nose to define the intranasal tumor and its site of origin. Imaging of the patients was done using computed tomography and magnetic resonance imaging of the nose, paranasal sinuses, and skull base.

Preoperative considerations

The cases were managed by an otorhinolaryngology-neurosurgery team. The size of the anticipated post-surgical defect was assessed. When the tumor affects the septal tissue or the sphenoid rostrum, the nasoseptal flap may not be an effective alternative for reconstructing very anterior cranial fossa defects. Children younger than 10 years might not be a good candidate for this flap because the size of the flap might not be sufficient to cover the defect in the skull base in this population.

Operative technique

The Hadad-Bassagasteguy flap, a pedicled flap supported by blood flow from the nasoseptal artery, a branch of the posterior septal artery, and a branch of the sphenopalatine artery, was employed. The surgical procedures were performed under general anesthesia with an endotracheal intubation. Nasal pledgets soaked in 4% oxymetazoline were placed in both nasal cavities to help decongestion of the nasal passages. Intranasal injection of 1% lidocaine and 1:100,000 epinephrine was performed at the sublabial plane, the posterior septum, the posterior section of the middle turbinate, and the anterior aspect of the sphenoid sinus to decongest the sphenopalatine artery. On the surgical side, 1% lidocaine and 1:100,000 epinephrine were injected into the nasal septal anterior region. Injections at the sublabial region and anterior septum were done just in case a septal cartilage graft was needed if the flap was not effective in closing the defect.

The posterior incision was first made with an electrical cautery set to 10. The sphenoid ostium was identified followed by making the superior incision just underneath this ostium. The epithelium of the olfactory cleft was avoided as this incision was prolonged anteriorly, 1–2 cm below, and parallel to the septum's most superior part, reaching the inferior turbinate's anterior edge. The incision was now prolonged inferiorly and vertically to the desired inferior boundary of the flap. Next, a cut was made in the inferior posterior part above the choana. The incision was then prolonged into the septum inferiorly, slightly above the maxillary crest, and directed anteriorly to meet the vertical limb of the incision (this incision may also be carried onto the nasal floor to generate a bigger flap).

The flap was subsequently moved back to the anterior face of the sphenoid sinus between the posterior superior and inferior incisions using a Cottle elevator, while maintaining the pedicle, in a subperichondrial and

subperiosteal plane. The flap was pushed into the nasopharynx after being fully elevated. The nasoseptal flap was then guided out of the nasopharynx and restored to its normal orientation along the septum after the neurosurgery component of the procedure, which involved filling the defect with fat graft, to make sure it was not rotated or twisted. The flap was then placed over the skull base, mostly concealing the fat and the defect in the skull base. The flap should not be bent to make sure that it covers the bony margins of the defect and that the mucosal surface faces the nasal cavity and not the intracranial defect. The flap was then secured with a number of pieces of Gelfoam. The nasal packing made of Merocel was utilized to secure the septal flap.

Postoperative care

The patients were instructed not to blow their noses. In order to lessen crusting at the flap donor site, humidified air was employed. The patient was prevented from raising the intracranial pressure by not straining, hunching over, or carrying heavy things. Stool softeners and open-mouth sneezing were suggested to patients. To prevent cerebral infections, the patients received perioperative third-generation cephalosporin prescriptions. Three days after surgery, the nasal packing was removed. Depending on the risk factors for CSF leak and the current clinical picture, nasal saline spray can be begun. Office nasal debridement was performed beginning 2 weeks postoperatively and then every 1 to 2 weeks afterwards until no more crusting was seen. Debriding over the flap was done carefully to prevent damaging it and allowing CSF to leak. Follow-up was done for 6–8 weeks till complete healing of the donor site which is the main source of crusting after this surgery.

Postoperative assessment and outcomes

Patients were assessed at 1 week postoperative using SNOT 22 to assess postoperative nasal symptoms. An endoscopic assessment of the nose was done at 1 week postoperative to assess the degree of crusting whether mild, moderate, or severe, and at 4 weeks postoperative to assess the degree of nasal adhesions and the presence or absence of gangrene of the nasoseptal flap. Postoperative complications including bleeding and CSF leak were assessed.

Statistical analysis

The study data were analyzed using the Statistical Package for Social Sciences (SPSS), version 23.0 (IBM Corp., Armonk, NY, USA). Mean and standard deviation (SD) were used to express quantitative data. Frequency and percentage were used to express qualitative data.

Results

The current study included 21 patients distributed as 13 (61.9%) males and 8 (38.1%) females with an age range from 41 to 62 years and a mean of 46.7 ± 6.83 years. The 21 cases included 12 cases (57.1%) with a diagnosis of pituitary macroadenoma (Fig. 1) and were operated by transnasal transsellar hypophysectomy. Five cases (23.8%) had a diagnosis of anterior cranial fossa meningioma (Fig. 2) and were operated by endoscopic transplanum excision, and four cases (19.1%) had a diagnosis of petroclival chordoma (Fig. 3) and were operated by endoscopic transclival excision. The skull base defect size ranged from 2.5 to 4.5 cm with a mean of 3.64 cm ± 0.57 SD (Table 1).

The postoperative evaluation of sinonasal outcomes 1 week after the operation using the SNOT 22 questionnaire revealed that the most troublesome symptoms for the patients were decreased sense of smell/taste with a mean score of 3.95 ± 0.74 SD, irritability with a mean score of 3.24 ± 0.44 SD, nasal blockage with a mean score of 3.14 ± 0.73 SD, and need to blow the nose with a mean of 3.14 ± 0.57 SD. However, the least troublesome symptoms for the patients were sneezing with a mean score of 0.29 ± 0.46 SD, ear fullness with a mean score of 0.33 ± 0.48 SD, ear pain with a mean score of 0.43 ± 0.51 SD, and reduced productivity with a mean score of 0.43 ± 0.51SD (Table 2).

During the postoperative period, 10 patients (47.6%) had mild nasal crusting, 7 patients (33.35%) had moderate nasal crusting, and 4 patients (19.05%) had severe nasal crusting. Three cases (14.3%) had epistaxis and were managed by endoscopic cautery of the bleeding vessel. Two cases (9.5%) had postoperative CSF rhinorrhea which were managed by an endoscopic repair. Ten cases (47.6%) had no nasal adhesions, 4 cases (19.05%) had mild nasal adhesions, 4 cases (19.05%) had moderate nasal adhesions, and 3 cases (14.3%) had severe nasal adhesions. No cases had gangrene of the nasoseptal flap (Table 3).

Discussion

Prior to the adaptation of the nasoseptal flap for endonasal skull base reconstruction, large defects of the anterior cranial base were repaired with multiple layers of non-vascularized tissues, including fat, fascia (autologous and cadaveric), bone, cartilage, or alloplastic materials. These materials were supplemented with nasal packing, balloon catheters for external support, and postoperative spinal drains to lower CSF pressure. Endonasal skull base surgery was effectively held back by the abnormally high rate of postoperative CSF leaks (20–30%) and high flow intraoperative leakage. With the addition of the

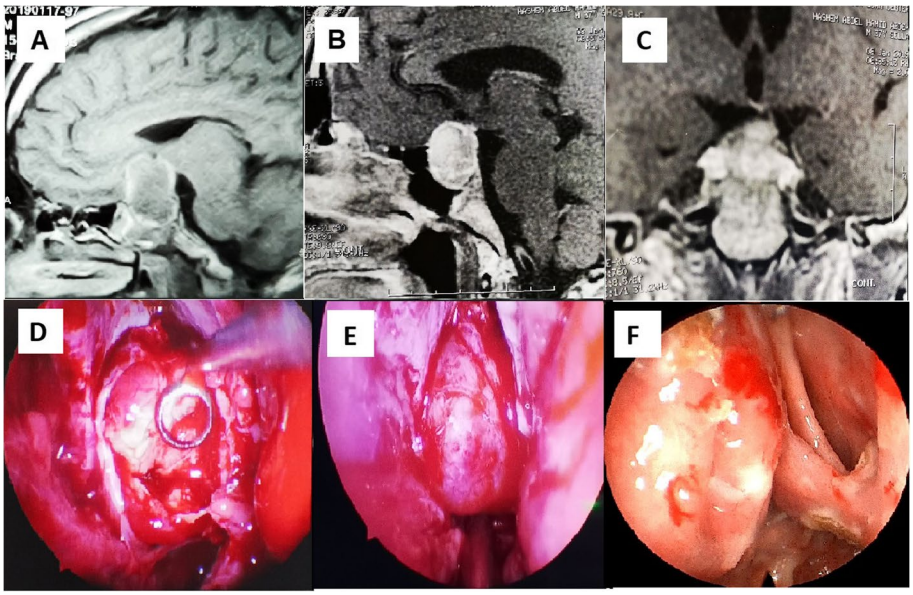

Fig. 1 A 24-year-old male patient with a pituitary macroadenoma: **A** sagittal T1 pre-contrast MRI image, **B** sagittal T1 post-contrast MRI image, and **C** coronal T1 post-contrast MRI image showing an intensely enhanced pituitary macroadenoma with a suprasellar extension. **D** Intraoperative endoscopic view revealing the exposed pituitary adenoma after opening the sellar floor. **E** An intraoperative endoscopic view showing the covered skull base defect with a nasoseptal flap. **F** A 1-month postoperative endoscopic view showing the healed nasoseptal flap with minimal crusting

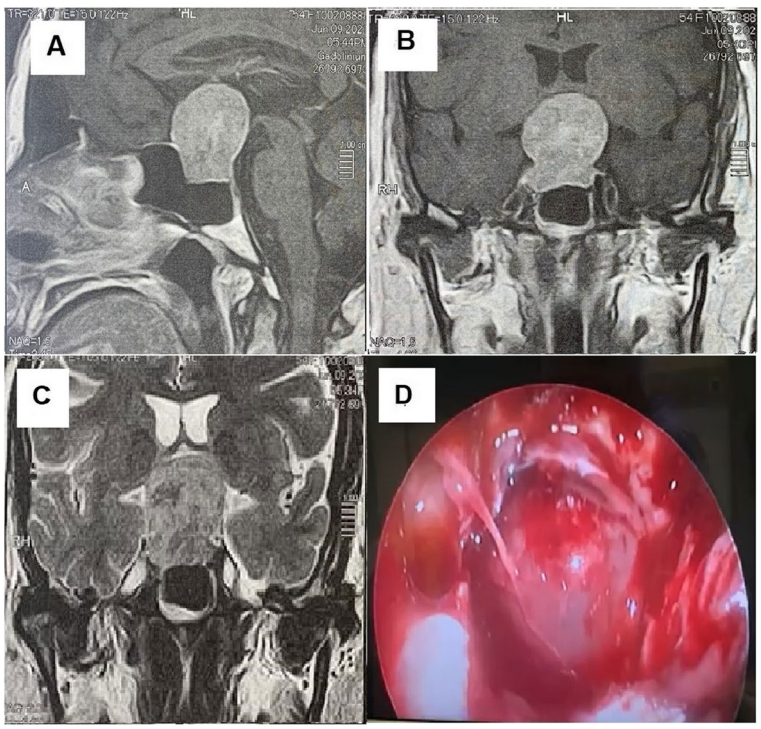

Fig. 2 A 30-year-old male patient with an anterior cranial fossa meningioma: **A** sagittal T1 post-contrast MRI image, **B** coronal T1 post-contrast MRI image, and **C** coronal T2 MRI image showing a large sellar lesion with suprasellar extension, an intense enhancement, and hyperintense in T2. **D** Intraoperative endoscopic view revealing the exposed dura after opening the sellar floor

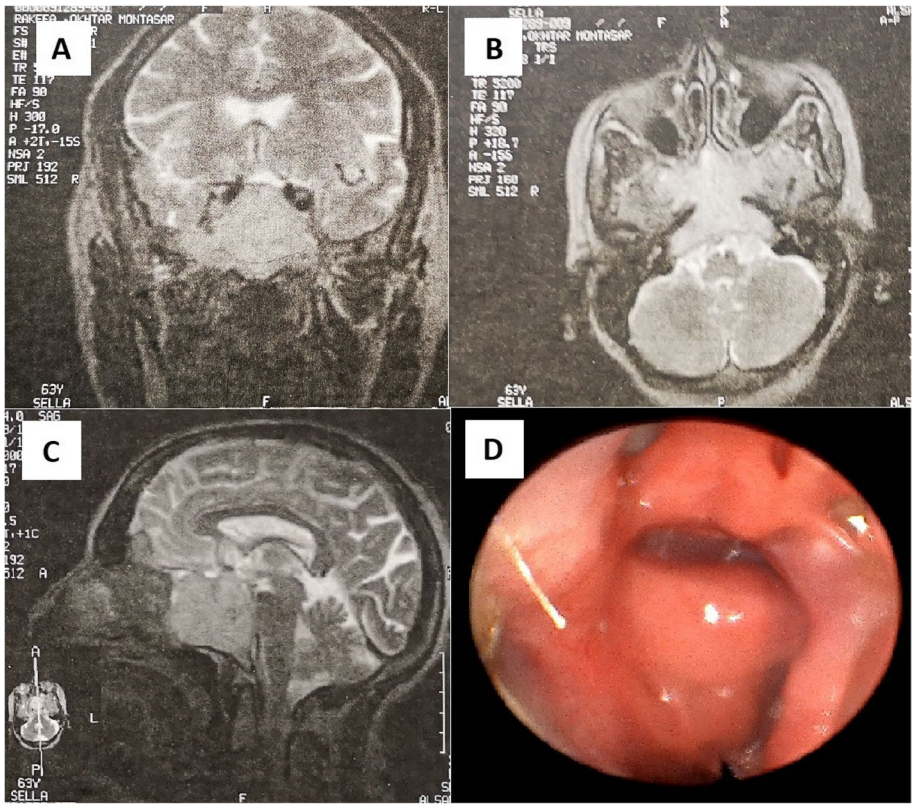

Fig. 3 A 63-year-old female patient with a petroclival chordoma: **A** coronal T2 MRI image, **B** axial T2 MRI image, and **C** sagittal T2 MRI image showing a large clival lesion intermediate to hyperintense signal with invasion of the sella with right parasellar extension and extension to sphenoidal sinus and both pterygoid plates and prepontine cistern posteriorly. **D** A 3-month postoperative endoscopic view showing the healed nasoseptal flap covering the skull base defect

Table 1 Demographic and clinical criteria of study patients

Item		Mean	Percentage
Age		46.7	6.83
		No	%
Gender	**Male**	13	61.9%
	Female	8	38.1%
Operation	**Transnasal transsellar hypophysectomy**	12	57.1%
	Transplanum Excision	5	23.8%
	Transclival excision	4	19.1%
Diagnosis	**Pituitary macroadenoma**	12	57.1%
	Meningioma	5	23.8%
	Chordoma	4	19.1%

vascularized mucosal nasoseptal flap, the postoperative CSF leak rate was decreased to around 5% [4, 7, 8]. Hadad Bassagaisteguy flap is a pedicled nasoseptal flap based on the posterior nasoseptal artery, a branch of the posterior nasal artery, and is made up of the mucoperiosteum and mucoperichondrium of the nasal septum. The significant defects of the anterior, middle, clival, and parasellar skull bases can be repaired with this adaptable flap [9]. Due to the huge size and broad arc of rotation of the nasoseptal flap, defects from the frontal sinus to the lower clivus can be reached by this flap [10]. Infrasellar or suprasellar defects can be repaired with this flap, but not both at once. It is angled vertically when utilized for a suprasellar defect and may repair a defect that spans the sella to the frontal sinus and between the two orbits. If used for an intrasellar defect, it is horizontally oriented and can cover a defect from the sellar floor to the foramen magnum [11].

In the current study, the most troublesome manifestation for the patient based on SNOT 22 questionnaire was the decreased sense of smell/taste. This can be explained by the encroachment of flap harvest on the epithelium of the olfactory cleft. Upadhyay et al. [12] assessed the results of the University of Pennsylvania Smell Identification Test (UPSIT) in 10 patients who had free mucosal graft restoration and 35 patients who underwent reconstruction of a skull base defect using NSF. Following surgery, the UPSIT scores

Table 2 Mean scores of items of SNOT 22 questionnaire two weeks postoperative

Item	Mean	SD
1. Need to blow nose	3.14	0.57
2. Nasal Blockage	3.14	0.73
3. Sneezing	0.29	0.46
4. Runny nose	2	0.63
5. Cough	3.1	0.54
6. Post-nasal discharge	1.95	0.67
7. Thick nasal discharge	2.05	0.67
8. Ear fullness	0.33	0.48
9. Dizziness	0.57	0.51
10. Ear pain	0.43	0.51
11. Facial pain/pressure	2.05	0.67
12. Decreased sense of smell/taste	3.95	0.74
13. Difficulty falling asleep	1.95	0.67
14. Wake up at night	2.29	0.46
15. Lack of a good night's sleep	2.14	0.57
16. Wake up tired	2	0.63
17. Fatigue	0.48	0.51
18. Reduced productivity	0.43	0.51
19. Reduced concentration	1.48	0.51
20. Frustrated/restless/irritable	3.24	0.44
21. Sad	0.57	0.51
22. Embarrassed	1.86	0.57

Table 3 Postoperative endoscopic assessment and complications of the study patients

Parameter		Number	Percentage
Degree of crusting	**Mild**	**10**	**47.6%**
	Moderate	**7**	**33.35%**
	Severe	**4**	**19.05%**
Flap gangrene		**0**	**0%**
Epistaxis		**3**	**14.3%**
CSF rhinorrhea		**2**	**9.5%**
Nasal Adhesion	**None**	**10**	**47.6%**
	Mild	**4**	**19.05%**
	Moderate	**4**	**19.05%**
	Severe	**3**	**14.3%**

were compared at baseline, 6 weeks, 3 months, and 6 months. When compared to baseline, the authors reported a statistically significant decline in UPSIT scores in the NSF group after 6 weeks. The scores were returned to preoperative levels at the 3- and 6-month follow-ups. However, there was no appreciable drop in UPSIT scores in the free mucosal graft group postoperatively. Similar results with full olfactory recovery after 6 months were obtained in other series that described comparable olfactory strip preservation strategies [13–15]. Kim et al. [16] compared electrocautery to cold knife dissection of the NSF and discovered higher epithelial damage in the former, but no statistical difference in olfaction.

The second most troublesome symptom for the patients was irritability which reflects the degree of stress encountered by the patients based on their diagnosis of having skull base tumors along with the associated postoperative nasal discomfort. Nasal blockage with a need to blow the nose constituted the next significant postoperative symptoms which can be explained by the commonly encountered postoperative crusting caused by the exposed bone and cartilage following harvesting the nasoseptal flap.

In the current study, during the postoperative period, 10 patients (47.6%) had mild nasal crusting, 7 patients (33.35%) had moderate nasal crusting, and 4 patients (19.05%) had severe crusting. Septal cartilage and bone are exposed to the nasal cavity following nasoseptal flap harvest. Re-epithelialization of the exposed bone and cartilage is thought to cause the healing process to take a longer time [17]. De Almeida et al. [18] compared individuals with and without NSFs to examine how long it took for nasal crusting to resolve. Those with an NSF did not recover more slowly than patients without an NSF. They found no independent variables linked to persistent crusting in their investigation (age, sex, radiation therapy, chemotherapy, surgical complexity, and use of fat graft). Similar to this, Pant et al. [19] discovered no variation in the time spent crusting between groups. Obstruction, post-nasal discharge, and thick nasal discharge from the Sino-Nasal Outcome test—22 items (SNOT-22) were employed as indices for nasal crusting by Jalessi et al. [20]. They discovered no differences at 3, 6, or 12 months, but a substantially higher score in the NSF group at 1 month.

In the present study, two cases (9.5%) had postoperative CSF rhinorrhea which were managed by endoscopic repair. In a study involving twenty-five patients who had expanded endonasal approach (EEA) surgeries with the use of NSF, Wardas et al. [21] reported a non-anticipated postoperative CSF leakage in 2 cases. Singh et al. [22] assessed 53 patients who received Hadad-Bassagasteguy flap (HBF) to restore anterior skull base lesions among patients with high-flow on-table CSF leak and found that only 2 of the total patients (2/53; 3.8%) experienced a post-operative CSF fluid leak. They concluded that patients with high-flow intraoperative CSF leak can benefit significantly from the use of HB posterior nasal septal flap for rebuilding of anterior skull base. For the correction of defects in the skull base, Eloy et al. [23] evaluated the effectiveness of the

pedicled nasoseptal flap without CSF diversion in 59 patients. No participants in this research experienced a postoperative CSF leak.

In the present study, ten cases (47.6%) had no nasal adhesions, 4 cases (19.05%) had mild nasal adhesions, 4 cases (19.05%) had moderate nasal adhesions, and 3 cases (14.3%) had severe nasal adhesions. In a study by Dolci et al. [24] to investigate the postoperative complications in 41 patients subjected to transnasal endoscopic surgery to access the skull base utilizing the nasoseptal flap technique, eight patients (19.5%) exhibited nasal fossa synechia. Nasoseptal flap for skull base reconstruction in 12 children was evaluated by Ben-Ari et al. [25] who reported that 2 patients (16.7%) had synechia.

In the current study, three cases (14.3%) had epistaxis which was managed by endoscopic cautery of the bleeding vessel. In the cohort of 330 consecutive patients studied by Thompson et al. [26], 3% developed postoperative epistaxis, including 3 who had several episodes (14 events). Packing in the emergency room was used to control the majority of the patients (8/14 incidents). Five patients needed operating room control, while one patient needed chemical cautery. Abstinence from alcohol was the only patient trait to approach significance (p value = 0.04). The likelihood of a patient having epistaxis was higher if they were a man, older, and hypertensive. The limitations of our study included the lack of a control group which may be attributed to the relative scarcity of these cases in our center. Another limitation is the lack of thorough assessment of preoperative and postoperative olfactory status using a smell assessment tool like The University of Pennsylvania Smell Identification test. This will be considered in future studies focusing on the effect of the nasoseptal flap on the olfactory function.

Conclusion

Nasoseptal flap is an effective option for the reconstruction of large skull base defects after endoscopic resection of large skull base tumors with acceptable postoperative patient's quality of life as expressed by SNOT 22 questionnaire, postoperative clinical findings of the nasal cavity. The procedure had a low incidence of postoperative complications including epistaxis and CSF rhinorrhea.

Abbreviations

CSF	Cerebrospinal fluid
EEA	Extended endonasal approach
HBF	Hadad-Bassagaisteguy flap
NSF	Nasoseptal flap
SNOT 22	Sinonasal Outcome Test 22
UPSIT	University of Pennsylvania Smell Identification Test

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Authors' contributions

AI provided the concept and design with the definition of intellectual content and conducted clinical studies, data collection, and manuscript editing. HN conducted clinical studies, data collection, data analysis, and manuscript editing. AH conducted literature research, clinical studies, data collection, data analysis, and manuscript preparation. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board of Menoufia Faculty of Medicine with approval number 6/2022-ENT-11. The participants of the study provided written consent before participation in the study or publication of their data.

Consent for publication

The participants of the study provided written consent before publication of their data.

Competing interests

The authors declare that they have no competing interests.

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