Accepted Manuscript online: 2025-01-06 Article published online: 2025-01-24

Added Sinonasal Morbidity of Transpterygoid Approach versus Transsphenoidal Approach: A Case-Controlled Analysis

Jasmeet Saroya[1,2] Alice E. Huang[1] Farideh Hooseinzadeh[1] Christine K. Lee[1] Juan Fernandez-Miranda[1] Peter H. Hwang[1] Zara M. Patel[1] Jayakar V. Nayak[1] Michael T. Chang[1]

[1] Department of Otolaryngology - Head and Neck Surgery, Stanford University School of Medicine, Stanford, California, United States
[2] Department of Otolaryngology - Head and Neck Surgery, University of California San Francisco School of Medicine, San Francisco, California, United States

Address for correspondence Michael Chang, MD, Stanford University, 801 Welch Rd, MC 5739, Stanford, CA 94305, United States (e-mail: Michael.t.chang@stanford.edu).

J Neurol Surg B Skull Base

Abstract

Background The transpterygoid approach is often used alongside the transsphenoidal approach in endoscopic endonasal skull base surgery to access lateral skull base regions. This study investigates the sinonasal morbidity associated with this combined approach.

Methods We conducted a retrospective analysis of 70 adult patients who underwent either transsphenoidal (TS) or transsphenoidal plus transpterygoid (TS + TP) approaches at a tertiary academic hospital from 2018 to 2023. Sinonasal quality of life was measured using the Sinonasal Outcome Test (SNOT-22) at preoperative, 2-week, 6-week, and 12-week postoperative evaluations.

Results Both cohorts exhibited a significant increase in SNOT-22 scores at 2 weeks postoperatively (TS: mean increase of 8.5, $p = 0.020$; TS + TP: mean increase of 12.3, $p < 0.001$), which normalized by 6 and 12 weeks (TS: $p = 0.587$ and $p = 0.987$, respectively; TS + TP: $p = 0.378$ and $p = 0.220$, respectively). There were no statistically significant differences in sinonasal morbidity between the TS and TS + TP cohorts at any time point. Middle turbinate (MT) sacrifice was associated with higher SNOT-22 scores ($B = 12.559$, $p = 0.035$), indicating worsened sinonasal outcomes.

Conclusion The transpterygoid approach, when added to the transsphenoidal approach, does not increase long-term sinonasal morbidity. This suggests that the combined approach is a viable option for achieving broader surgical exposure without compromising sinonasal quality of life in the long term. Further studies with extended follow-up are needed to confirm these findings and explore additional quality of life metrics.

Keywords
- transpterygoid approach
- transsphenoidal approach
- sinonasal morbidity
- endoscopic endonasal skull base surgery
- SNOT-22
- sinonasal quality of life
- skull base surgery
- middle turbinate sacrifice
- sinonasal outcomes
- retrospective analysis

received
July 19, 2024
accepted after revision
January 5, 2025
accepted manuscript online
January 6, 2025

Georg Thieme Verlag KG, Oswald-Hesse-Straße 50, 70469 Stuttgart, Germany

DOI https://doi.org/10.1055/a-2510-4619.
ISSN 2193-6331.

Introduction

In endoscopic endonasal skull base surgery, the transsphenoidal approach is utilized to treat midline pathologies of the sellar, suprasellar, and clival regions. When more lateral or inferolateral access is needed, a transpterygoid approach can be employed to augment access to regions such as the cavernous sinus, paraclival region, petrous apex, Meckel's cave, middle cranial fossa, and infratemporal fossa. When supplementing a transsphenoidal approach, the transpterygoid approach often involves additional surgery of the maxillary and ethmoid sinuses, resection of middle turbinate (MT), manipulation of the neurovascular structures within the pterygopalatine fossa (PPF), and extensive drilling of the palatine and sphenoid bone.[1,2] However, the added sinonasal morbidity of these additional maneuvers is not well studied.

Recent literature has increasingly focused on delineating and optimizing sinonasal quality of life in skull base surgery.[3,4] There is currently a paucity of literature with respect to sinonasal morbidity of a transpterygoid approach. Our study aims to determine whether there is added sinonasal morbidity of a transpterygoid approach when used in conjunction with a transsphenoidal approach for resection of skull base lesions.

Methods

This retrospective study included adult patients (age > 18 years) who underwent an endoscopic endonasal approach (EEA) to the skull base at Stanford Hospital between 2018 and 2023. Patients were included if they underwent either a transsphenoidal approach or a transsphenoidal with a transpterygoid approach, which was determined from the operative reports. Patients were included if outcome data was completed at the preoperative visit and at least one postoperative time point. We excluded patients with incomplete survey data. The primary outcome of interest was sinonasal quality of life, as measured by the Sinonasal Outcome Test (SNOT-22), which is routinely administered to patients at 2, 6, and 12 weeks following endoscopic skull base surgery. The SNOT-22 is a 22-item questionnaire where each symptom is rated on a scale of 0 to 5, for a possible total score of 120. Higher SNOT-22 scores indicate a worse quality of life, while a lower score is considered a better quality of life. We also calculated SNOT-22 subdomain scores, based on Feng et al, at each time point.[5]

Medical records were reviewed for the following variables for each case: age, sex, tumor pathology, and tumor location (anterior versus central versus posterior skull base). The tumor locations were defined as the following: anterior skull base was the region bound laterally by the orbital plates of frontal bone, medially by the crista galli of the ethmoid bone, and posteriorly by the planum sphenoidale; central skull base was the region bound within sphenoid bone, including sellar, parasellar, and suprasellar regions; posterior skull base involved the regions of the clivus to foramen magnum. Data on intraoperative variables were extracted, including status as a revision surgery, septoplasty, middle turbinate sacrifice, sphenopalatine artery sacrifice, vidian nerve sacrifice, V2 nerve sacrifice, intraoperative cerebrospinal fluid (CSF) leak, use of a nasoseptal flap, and use of a lumbar drain.

The participants were divided into two cohorts based on the surgical approach to the skull base: transsphenoidal only (TS) or transsphenoidal + transpterygoid (TP + TS). The two cohorts were matched for age, sex, pathology, and tumor location using propensity matching without replacement with a match tolerance of 0.1. To assess for any baseline differences between the two cohorts, sociodemographic and clinical characteristics were compared. Fischer's exact test was used for comparison of categorical variables and Independent Samples *t*-test was used continuous variables. Changes in SNOT-22 from preoperative to postoperative scores were then assessed for significance using the *t*-test.

To identify factors associated with change in SNOT-22 scores, multivariate linear regression models were created with change in SNOT-22 total scores and its subdomains from the baseline to the longest available time points. Surgical approach (TS vs. TS + TP) was the primary covariate of interest. Other covariates included in the model were revision, septoplasty, middle turbinate sacrifice, sphenopalatine artery sacrifice, vidian nerve sacrifice, V2 sacrifice, CSF leak, use of nasoseptal flap, and use of lumbar drain. Significance was established at a *p*-value of 0.05 or less indicating a 95% confidence interval. All statistical calculations were performed using IBM SPSS version 27.0.1.

Results

A total of 70 patients were included in the study (35 TS vs. 35 TS + TP). ►**Table 1** provides an overview of the sociodemographic and clinicopathological characteristics for the two cohorts. There was no significant difference in age, sex, or pathology between the two groups, with pituitary adenoma comprising 62.9% of all cases. Sinonasal malignancies were also noted in both groups, with 17.1% in TS + TP and 14.3% in TS. The majority of tumors were located in the central skull base (74.3%) without a difference between the cohorts. In terms of operative characteristics between the two cohorts, there was a significant difference in the rate of middle turbinate sacrifice (40.0% in TS + TP versus 11.4% in TS, $p = 0.013$) and vidian nerve sacrifice (17.1% in TS + TP, 0.0% in TS, $p = 0.025$). Notably, nasoseptal flap usage was not significantly different between the groups (70.6% in TS + TP versus 57.1% in TS, $p = 0.318$). Other variables, such as revision status, septoplasty, sphenopalatine artery sacrifice, V2 nerve sacrifice, CSF leak, and lumbar drain utilization, showed no statistically significant differences between the two groups.

We compared SNOT-22 total and subdomain scores to baseline scores within each cohort. In the TS cohort, there was a significant increase in total SNOT-22 scores at 2 weeks compared with baseline ($p = 0.020$), with subsequent normalization at 6 weeks ($p = 0.587$) and 12 weeks ($p = 0.987$). There was a significant elevation in the nasal subdomain ($p < 0.001$) at 2 weeks. By 6 and 12 weeks, total scores and nasal subdomain returned to baseline levels ($p = 0.587$ and

Table 1 Comparison of sociodemographic, clinicopathological, and operative characteristics of the study cohorts

		Transsphenoidal only		Transsphenoidal + Transpterygoid		*P*-value
Age, mean (SD)		49.3	(16.2)	53.7	(13.9)	0.226
Sex, *n* (%)	Female	20	(57.1)	21	(60.0)	1.000
	Male	15	(42.9)	14	(40.0)	
Race	White	17	(48.6)	21	(60.0)	0.463
	Black	2	(5.7)	2	(5.7)	
	Asian	10	(28.6)	4	(11.4)	
	Hispanic/Latino	2	(5.7)	2	(5.7)	
	Other	4	(11.4)	6	(17.1)	
Pathology	Craniopharyngioma	1	(2.9)	0	(0.0)	1.000
	Fibro-osseous lesion	2	(5.7)	1	(2.9)	
	Hemangioma	1	(2.9)	0	(0.0)	
	Meningioma	0	(0.0)	1	(2.9)	
	Meningocele	1	(2.9)	1	(2.9)	
	Petroclival neoplasm	3	(8.6)	4	(11.4)	
	Pituitary adenoma	22	(62.9)	22	(62.9)	
	Sinonasal malignancy	5	(14.3)	6	(17.1)	
Tumor location	Anterior skull base	7	(20.0)	5	(14.3)	0.840
	Central skull base	26	(74.3)	27	(77.1)	
	Posterior skull base	2	(5.7)	3	(8.6)	
Intradural dissection		18	(51.4)	10	(28.6)	0.087
Extradural dissection		17	(48.6)	25	(71.4)	
Revision surgery		7	(21.2)	9	(25.7)	0.778
Concurrent septoplasty		7	(20.0)	7	(20.6)	1.000
Middle turbinate sacrifice		4	(11.4)	14	(40.0)	0.013*
Sphenopalatine artery sacrifice		3	(8.8)	5	(14.3)	0.710
Vidian nerve sacrifice		0	(0.0)	6	(17.1)	0.025*
V2 sacrifice		0	(0.0)	1	(2.9)	1.000
CSF leak		18	(51.4)	16	(45.7)	0.811
Nasoseptal flap		20	(57.1)	24	(70.6)	0.318
Lumbar drain		4	(11.4)	7	(21.9)	0.329

Abbreviation: CSF, cerebrospinal fluid.
Note: $^{*}p < 0.05$.

$p = 0.987$, respectively). Ear/facial, sleep, and psychological symptoms remained stable across the time points without significant changes. In the TS + TP cohort, there was a similar significant increase in total SNOT-22 scores at 2 weeks postoperatively compared with baseline ($p < 0.001$), with significant increases in both the nasal ($p < 0.001$) and ear/facial subdomains ($p = 0.023$). At 6 and 12 weeks, the total scores, nasal, and ear/facial subdomains did not demonstrate a significant difference compared with baseline ($p > 0.05$ for all). Sleep and psychological subdomains showed no significant changes across the time points. These findings suggest a transient worsening of sinonasal symptoms at 2 weeks postoperatively, with subsequent resolution or normalization by 6 and 12 weeks within both surgical approach cohorts. ►**Table 2** compares SNOT-22 scores between TS and TS + TP cohorts. There were no statistically significant differences between the two cohorts in SNOT-22 total scores at baseline, 2 weeks, 6 weeks, and 12 weeks postoperatively ($p > 0.05$ for all). Similarly, none of the SNOT-22 subdomain scores demonstrated a significant difference between the two cohorts at any time point.

Results from multivariate linear regression analyses are shown in ►**Table 3**. For SNOT-22 total scores, choice of surgical approach did not significantly impact score changes (B = −1.262, Beta = −0.036, $p = 0.796$). Middle turbinate sacrifice was associated with significantly increased SNOT-22

Table 2 Comparison of SNOT-22 scores between transsphenoidal versus transsphenoidal + transpterygoid approach

		TS only	TS + TP	*P*-value
Baseline	SNOT-22 total (mean, SD)	20.4 (18.2)	18.0 (21.7)	0.617
	Nasal	6.0 (6.7)	5.2 (6.9)	0.625
	Ear/Facial	2.2 (3.5)	2.3 (4.0)	0.924
	Sleep	11.3 (10.6)	9.8 (12.1)	0.566
	Psych	0.9 (1.6)	0.8 (1.4)	0.809
2 weeks	SNOT-22 total	27.9 (20.8)	30.8 (25.2)	0.612
	Nasal	11.9 (7.7)	13.7 (9.2)	0.400
	Ear/Facial	3.0 (3.1)	3.7 (3.8)	0.387
	Sleep	12.8 (12.0)	12.3 (12.5)	0.882
	Psych	0.9 (2.0)	1.1 (2.5)	0.750
6 weeks	SNOT-22 total	18.8 (14.3)	14.3 (20.9)	0.414
	Nasal	6.6 (5.0)	5.9 (7.7)	0.740
	Ear/Facial	1.8 (2.3)	2.5 (3.5)	0.500
	Sleep	9.7 (8.9)	8.6 (11.4)	0.766
	Psych	0.7 (1.2)	0.4 (1.5)	0.463
12 weeks	SNOT-22 total	21.9 (26.3)	24.4 (30.7)	0.854
	Nasal	7.5 (8.6)	12.3 (9.3)	0.287
	Ear/Facial	2.7 (3.4)	3.4 (6.2)	0.777
	Sleep	10.2 (12.7)	11.1 (15.1)	0.894
	Psych	1.5 (3.0)	1.0 (2.2)	0.704

Abbreviations: SD, standard deviation; SNOT-22, Sinonasal Outcome Test; TS, transsphenoidal; TS + TP, transsphenoidal + transpterygoid.

Table 3 Linear multivariate regression analysis of surgical factors and association with change in total SNOT-22 from baseline

	Unstandardized coefficients		Standardized coefficients	t	*P*-value
	B	Std. error	Beta		
Total SNOT-22					
Surgical approach	−1.262	4.847	−0.036	−0.26	0.796
Revision surgery	−10.094	5.415	−0.24	−1.864	0.068
Septoplasty concurrently	−0.454	5.852	−0.01	−0.078	0.938
Middle turbinate sacrifice	12.559	5.81	0.313	2.162	0.035*
Sphenopalatine artery sacrifice	10.164	8.248	0.183	1.232	0.223
Vidian nerve sacrifice	9.163	8.441	0.154	1.086	0.283
V2 sacrifice	−33.42	20.011	−0.239	−1.67	0.101
CSF leak	10.14	5.213	0.29	1.945	0.057
Nasoseptal flap	−3.428	5.775	−0.094	−0.594	0.555
Lumbar drain	−4.735	6.22	−0.099	−0.761	0.45
Nasal SNOT-22					
Surgical approach	−1.252	2.136	−0.083	−0.586	0.56
Revision surgery	−2.883	2.386	−0.158	−1.208	0.232
Septoplasty concurrently	−2.913	2.578	−0.151	−1.13	0.264
Middle turbinate sacrifice	7.013	2.56	0.404	2.739	0.008*

Table 3 (*Continued*)

	Unstandardized coefficients		Standardized coefficients	t	*P*-value
	B	Std. error	Beta		
Sphenopalatine artery sacrifice	4.405	3.634	0.183	1.212	0.231
Vidian nerve sacrifice	0.689	3.719	0.027	0.185	0.854
V2 sacrifice	−7.006	8.817	−0.116	−0.795	0.43
CSF leak	0.959	2.297	0.063	0.418	0.678
Nasoseptal flap	−2.179	2.545	−0.139	−0.856	0.396
Lumbar drain	−3.15	2.74	−0.152	−1.15	0.256
Ear/Facial SNOT-22					
Surgical approach	−0.977	0.949	−0.147	−1.029	0.308
Revision surgery	−0.218	1.061	−0.027	−0.206	0.838
Septoplasty concurrently	0.82	1.146	0.097	0.716	0.477
Middle turbinate sacrifice	−0.636	1.138	−0.084	−0.559	0.578
Sphenopalatine artery sacrifice	1.369	1.615	0.13	0.848	0.401
Vidian nerve sacrifice	1.545	1.653	0.137	0.935	0.354
V2 sacrifice	−1.11	3.919	−0.042	−0.283	0.778
CSF leak	3.043	1.021	0.458	2.981	0.004*
Nasoseptal flap	−1.48	1.131	−0.215	−1.308	0.197
Lumbar drain	−0.885	1.218	−0.097	−0.726	0.471
Sleep SNOT-22					
Surgical approach	−3.761	2.391	−0.205	−1.573	0.122
Revision surgery	−8.918	2.672	−0.405	−3.337	0.002*
Septoplasty concurrently	1.091	2.887	0.047	0.378	0.707
Middle turbinate sacrifice	3.093	2.867	0.147	1.079	0.286
Sphenopalatine artery sacrifice	4.673	4.07	0.16	1.148	0.256
Vidian nerve sacrifice	3.881	4.165	0.124	0.932	0.356
V2 sacrifice	−8.489	9.874	−0.116	−0.86	0.394
CSF leak	7.269	2.572	0.397	2.826	0.007*
Nasoseptal flap	−2.098	2.85	−0.11	−0.736	0.465
Lumbar drain	−1.61	3.069	−0.064	−0.524	0.602
Psych SNOT-22					
Surgical approach	0.448	0.412	0.157	1.088	0.281
Revision surgery	0.322	0.46	0.094	0.7	0.487
Septoplasty concurrently	−0.293	0.497	−0.081	−0.589	0.559
Middle turbinate sacrifice	0.877	0.494	0.268	1.776	0.082
Sphenopalatine artery sacrifice	0.525	0.701	0.116	0.749	0.457
Vidian nerve sacrifice	0.945	0.717	0.195	1.317	0.194
V2 sacrifice	−2.441	1.701	−0.214	−1.435	0.157
CSF leak	0.089	0.443	0.031	0.201	0.842
Nasoseptal flap	0.435	0.491	0.147	0.886	0.38
Lumbar drain	−0.692	0.529	−0.178	−1.31	0.196

Abbreviations: CSF, cerebrospinal fluid; SNOT-22, Sinonasal Outcome Test.
* symbolizes a p-value of less than 0.05.

total scores (B = 12.559, Beta = 0.313, $p = 0.035$). Other variables, including revision surgery, septoplasty, sphenopalatine artery sacrifice, vidian sacrifice, V2 sacrifice, CSF leak, nasoseptal flap, and lumbar drain, did not exhibit significant associations with SNOT-22 total score changes ($p > 0.05$).

Within the SNOT-22 nasal subdomain, middle turbinate sacrifice was significantly associated with increased scores (B = 7.013, Beta = 0.404, $p = 0.008$). Surgical approach did not significantly impact score changes (B = −1.252, Beta = −0.083, $p = 0.560$). All other variables did not exhibit significant associations with nasal subdomain score changes ($p > 0.05$). In analysis of other SNOT-22 subdomains, surgical approach was not associated with significant change. Notable findings include the presence of CSF leaks and association with a significant increase in ear/facial subdomain scores (B = 3.043, Beta = 0.458, $p = 0.004$) and sleep subdomain scores. Sleep SNOT-22 scores suggested worsened sleep quality (B = 7.269, Beta = 0.397, $p = 0.007$). Revision surgeries were associated with a significant decrease in Sleep SNOT-22 scores (B = −8.918, Beta = −0.405, $p = 0.002$). No variables were associated with changes in the psychiatric subdomain SNOT-22 scores ($p > 0.05$).

Discussion

In endoscopic skull base surgery, the goal of the approach is not only to provide adequate surgical exposure for disease management, but also to preserve sinonasal function and quality of life. This study evaluates the sinonasal morbidity associated with the addition of the transpterygoid approach to the transsphenoidal approach in a case-controlled manner. The results indicate that incorporating the TP approach does not lead to additional sinonasal morbidity compared with the TS approach alone, as evidenced by the lack of significant differences in postoperative SNOT-22 total scores between the TS + TP and TS groups. This study also demonstrates that beyond the acute postoperative period of 2 weeks, a return to baseline sinonasal quality of life can be achieved in patients undergoing both TS and TS + TP approaches, which is consistent with other data in transsphenoidal surgery.[6,7]

Recent studies have highlighted the importance of sinonasal quality of life following endoscopic skull base surgery, reflecting an evolving understanding of postoperative outcomes beyond survival rates.[4] Several advances in EEA techniques have been made with a focus on preserving sinonasal quality of life, such as turbinate preservation and local rotational grafts to limit crusting of the nasoseptal donor site. However, with respect to the transpterygoid approach, there is currently little understanding regarding its impact on quality of life. To date there exists one study of morbidity in 37 patients undergoing a TP approach, which found that SNOT-22 scores did not significantly differ from baseline at 3 and 6 months postoperatively.[8] Our study's findings are in accordance with these conclusions, and also further specifies our understanding of quality of life through a case-controlled comparison to transsphenoidal approaches as well as an analysis of SNOT-22 subdomains.

An interesting finding from this study's multivariate regression analysis is the suggestion that middle turbinate resection is independently associated with worse short-term SNOT-22 total and nasal subdomain scores. Although there were significantly higher rates of MT resection in the TS + TP cohort, MT resection was still performed in some TS cases as well, which may explain the discrepancy between MT resection being associated with worse SNOT-22 scores but not with the TP approach. The current literature suggests a lack of consensus on whether MT must be removed in endoscopic endonasal skull base surgery, with the only clear indication for removal if it is involved directly in a disease process.[9] Many studies have looked into various aspects of MT preservation versus resection. A prospective, observational study of 160 endoscopic transsphenoidal surgeries in which the MT was preserved reported adequate skull base exposure, and no cases of post-obstructive sinusitis postoperatively.[10] Other studies in which the MT was resected have shown that there is no impact of MT resection on olfaction or other quality of life outcomes.[10–13] In our study, we had a higher rate of MT sacrifice in the transpterygoid approach compared with the transsphenoidal approach, which likely represents a necessity of MT resection to achieve wider exposure of the skull base. However, in light of our study's findings, it may be worth considering performing a transpterygoid approach in an MT-sparing manner, as described here, if it is appropriate for the pathology.[13,14] It is also important to note that our study, like many others, is limited to relatively short-term outcome data, making it difficult to assess the implications of MT resection versus preservation on long-term sinonasal function. This gap underscores the need for future research with longer follow-up periods to comprehensively understand the impact of MT management in skull base surgery.

This study has several limitations. As a retrospective analysis, it is subject to the inherent biases and limitations of such a study design. Although the SNOT-22 scores represent prospectively collected data at relatively regular intervals, the retrospective nature still introduced heterogeneity in length of follow-up and data completion. No objective measures of sinonasal morbidity were collected, such as postoperative endoscopic exams, imaging, or return of the patient to the operating room. Furthermore, the SNOT-22 does not address other potential symptoms that may be relevant to a transpterygoid approach, such as dry eye, facial numbness, and palate numbness, which may profoundly impact quality of life. These may be important quality of life metrics to track in future investigations, as one study reported that dry eye occurred in 38.5% of those with vidian nerve resection, and facial numbness in 66.7% of those with a V2 resection.[8] This also highlights the need for a more comprehensive approach to quality of life tracking in future studies.

Nonetheless, our study provides new insights into the sinonasal morbidity associated with the transperygoid approach in ESBS, demonstrating that it does not result in significant additional sinonasal morbidity when used in addition to the transsphenoidal approach.

Previous Presentation

Accepted for poster presentation at American Rhinologic Society 2024 COSM on May 17, 2024 in Chicago, Illinois.

Conflict of Interest

None declared.

Acknowledgments

The authors have no acknowledgments to declare. All contributors to this study are listed as authors.

References

1 Hofstetter CP, Singh A, Anand VK, Kacker A, Schwartz TH. The endoscopic, endonasal, transmaxillary transpterygoid approach to the pterygopalatine fossa, infratemporal fossa, petrous apex, and the Meckel cave. J Neurosurg 2010;113(05):967–974

2 Finger G, Gun R, Wu KC, Carrau RL, Prevedello DM. Endoscopic endonasal transpterygoid approach: technical lessons. Oper Neurosurg (Hagerstown) 2023;25(05):e272

3 Bokhari AR, Davies MA, Diamond T. Endoscopic transsphenoidal pituitary surgery: a single surgeon experience and the learning curve. Br J Neurosurg 2013;27(01):44–49

4 Pinheiro-Neto C, Rowan NR, Celda MP, Mukherjee D, Gompel JJV, Choby G. Optimizing quality of life and minimizing morbidity through nasal preservation in endoscopic skull base surgery: a contemporary review. J Neurol Surg B Skull Base 2022;83(06):602–610

5 Feng AL, Wesely NC, Hoehle LP, et al. A validated model for the 22-item Sino-Nasal Outcome Test subdomain structure in chronic rhinosinusitis. Int Forum Allergy Rhinol 2017;7(12):1140–1148

6 McCoul ED, Bedrosian JC, Akselrod O, Anand VK, Schwartz TH. Preservation of multidimensional quality of life after endoscopic pituitary adenoma resection. J Neurosurg 2015;123(03):813–820

7 Balaker AE, Bergsneider M, Martin NA, Wang MB. Evolution of sinonasal symptoms following endoscopic anterior skull base surgery. Skull Base 2010;20(04):245–251

8 Choi JE, Noh YS, Lee KE, et al. Morbidities associated with the endoscopic transnasal transpterygoid approach: focusing on postoperative sequelae. World Neurosurg 2020;137:e43–e51

9 Kennedy DW. Middle turbinate resection: evaluating the issues—should we resect normal middle turbinates? Arch Otolaryngol Head Neck Surg 1998;124(01):107

10 Nyquist GG, Anand VK, Brown S, Singh A, Tabaee A, Schwartz TH. Middle turbinate preservation in endoscopic transsphenoidal surgery of the anterior skull base. Skull Base 2010;20(05): 343–347

11 Shah J, Tang D, Grafmiller K, Cappello ZJ, Roxbury C, Sindwani R. Using the middle turbinate to protect the skull base in endoscopic transsphenoidal surgery: a cadaver study. Am J Rhinol Allergy 2021;35(01):59–63

12 Maza G, Li C, Krebs JP, et al. Computational fluid dynamics after endoscopic endonasal skull base surgery-possible empty nose syndrome in the context of middle turbinate resection. Int Forum Allergy Rhinol 2019;9(02):204–211

13 Barham HP, Gould EA, Ramakrishnan VR. Swing technique for middle turbinate preservation in expanded endonasal skull base approaches. Int Forum Allergy Rhinol 2014;4(07):583–586

14 Renteria A, Levi L, Silva B, et al. Outcomes of the middle turbinate swing technique during the expanded endonasal approach (EEA): a tertiary center experience. J Neurol Surg B Skull Base 2024;85; (S 01):S031

