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Original Article

Olfactory Function in Elderly Patients after the Endoscopic Endonasal Approach to Remove Sellar/Parasellar/Suprasellar Tumors

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SUMMARY

Background: The endoscopic endonasal approach (EEA) is the preferred surgical option for sellar, parasellar, and suprasellar tumors. However, olfactory function in elderly patients after EEA surgery has not been well investigated.
Methods: We retrospectively collected data from 45 patients who received EEA surgery for sellar, parasellar, or suprasellar tumors between 2016 and 2018. We divided patients into the non-elderly (20–59 years; n = 29) and elderly (≥ 60 years; n = 16) groups. We analyzed preoperative and postoperative olfactory function (Taiwan Smell Identification Test [TWSIT] score) and sinonasal endoscopic appearance (Lund-Kennedy Endoscopic Score, LKES).
Results: The 1-month postoperative TWSIT score in the non-elderly group and the 1-month and 3-month postoperative TWSIT scores in the elderly group were lower than the corresponding preoperative baseline scores, albeit without statistical significance. The 2-week, 1-month, and 2-month postoperative LKES were higher than the corresponding preoperative baseline LKES in both groups. They were statistically significant in the non-elderly group but not in the elderly group. The preoperative baseline TWSIT scores were lower in the elderly group than in the non-elderly group. The postoperative TWSIT score and LKES were similar between the two groups.
Conclusion: In patients undergoing EEA surgery, there is a trend toward decreasing sense of smell at 1 month postoperatively, but it returns to the preoperative baseline level within 6 months in both non-elderly and elderly patients. This may be related to sinonasal scarring and crusting. There was no difference between the elderly and non-elderly groups in the postoperative change in smell function.

1. Introduction

Cushing et al. introduced the sublabial transseptal transsphenoidal approach to treat pituitary tumors in 1910.[1] In the 1960s, Hardy et al. used an operative microscope to perfect Cushing's approach.[2] Aided by development in endoscopic instruments, Jankowski et al. performed full endoscopic pituitary surgery in 1992.[3] With the further improvement in endoscopic instruments and techniques, the endoscopic endonasal approach (EEA) is currently the preferred surgical option to remove sellar, parasellar, and suprasellar tumors because of its safety and effectiveness.[2]

Olfactory function plays an important role in everyday life. It allows sense of smell, formation of emotion, and memory. Olfactory function also allows detection of flavors, danger signals, and toxins. Therefore, olfactory dysfunction can have a severe impact on quality of life and mental health.[4,5]

EEA surgery requires removal of healthy anatomical structures around the surgical corridor. There are some studies on olfactory function after EEA surgery, but there is still no consensus as to whether olfactory function is affected in patients undergoing EEA surgery. Some studies found that olfactory function is impaired after EEA surgery, and some determined that it improves after EEA surgery. Others discovered that olfactory function is worse initially but recovers to preoperative status after several months.[6–8]

EEA surgery is a relatively safe and effective procedure for appropriately selected elderly patients.[9,10] However, elderly patients have poorer baseline olfactory function than younger patients,[11] and olfactory function in elderly patients after EEA surgery has not been well investigated. Therefore, we examined olfactory function in younger and elderly patients after EEA surgery.

2. Patients and methods

2.1. Patients

We collected data of patients who received EEA surgery for sellar, parasellar, or suprasellar tumors at theTamsui MacKay Memorial Hospital between January 2016 and December 2018. We

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excluded patients younger than 20 years old at the time of surgery and those who were anosmic preoperatively. We divided the patients into two groups according to the age at surgery: the non-elderly group (20–59 years) and the elderly group (≥ 60 years). By reviewing medical records, we analyzed preoperative and postoperative olfactory function scores and sinonasal endoscopic scores in each group. This study was approved by the institutional review board of MacKay Memorial Hospital (number: 19MMHIS231e).

2.2. Surgical procedure

Under general anesthesia with the patient in the supine position, the patient's head was fixed with a Mayfield head-holder. We used an intraoperative navigation system with preoperative brain CT scan with enhancement, which was performed on the day of surgery or 1 day prior to surgery. Two surgeons (a neurosurgeon and an otolaryngologist) used the binostril, four-hand technique in all patients. Both nasal cavities were decongested by inserting tampons soaked in 1:200,000 Bosmin. After the nose had been adequately decongested, we started the surgery. Three endoscopes (0-degree, 30-degree, and 45-degree; Karl Storz, Tuttlingen, German) were used during the procedure. Bilateral middle turbinates were removed or lateralized, depending on the spacing of the nostrils. We located the sphenoid sinus ostium and performed wide sphenoidotomy by microdebrider (Medtronic, Fridley, MN, USA) and Kerrison rongeur. Then, we identified the important anatomical landmarks within the sphenoid sinus, including the sellar floor, lateral optico-carotid recess, optic prominence, and carotid prominence. A diamond burr (Medtronic, Fridley, MN, USA) and Kerrison rongeur were used to drill the bone at the sella turcica in order to expose the dura underneath the bone. After dura exposure, an intraoperative navigation system and intraoperative Doppler ultrasonography were used to confirm the tumor borders and internal carotid artery course. The dura was incised in an inverted U shape using a sickle knife or scalpel. Pituitary forceps and two suction techniques were used for tumor debulking. After that, we used microdissectors, scissors, and bipolar electrocauterization to remove all of the tumor. After tumor removal, oozing was controlled by packing the cavity with neurosurgical patties, bipolar electrocauterization, and thrombin-infused gelatin matrix (FloSeal; Baxter, Deerfield, IL, USA). The skull base was then reconstructed using a dura substitute and a middle turbinate graft or vascularized nasoseptal flap if needed.[12] TISSEEL (Baxter, Deerfield, IL, USA) or DuraSeal (Integra Life Science, Plainsboro, NJ, USA) was used as necessary to strengthen the reconstruction. Finally, a Foley balloon was used to support the reconstruction if needed.[13]

2.3 Olfactory function test and sinonasal endoscopic appearance

The patients completed the Taiwan Smell Identification Test (TWSIT) on the day before the surgery to evaluate preoperative olfactory function. The TWSIT is a quick, office-based, useful odor identification tool for Taiwanese patients.[5] TWSIT scores of 46–48, 14–45, and 2–13 correspond to normosmia, hyposmia, and anosmia, respectively. We repeated the TWSIT at 1 month, 3 months, and 6 months after surgery to examine postoperative olfactory function.

Patients completed sinonasal endoscopic examinations on the day before the surgery to determine the preoperative sinonasal endoscopic appearance. The Lund-Kennedy Endoscopic Score (LKES) was used to evaluate the patients' preoperative nasal cavity condition, including polyps, edema, and discharge.[14] Both nostrils were evaluated. For polys, the scores 0, 1, and 2 indicated absence of polyps, polyps in middle meatus only, and polyps beyond middle meatus, respectively. Regarding edema, the scores 0, 1, and 2 indicated absent, mild, and severe edema. In regard to discharge, the scores 0, 1, and 2 indicated no discharge, clear and thin discharge, and thick and purulent discharge. We repeated sinonasal endoscopic examinations 2 weeks, 1 month, 2 months, 3 months, and 6 months postoperatively. The postoperative LKES evaluated not only polyps, edema, and discharge but also scarring and crusting in the nasal cavity. For scarring, the scores 0, 1, and 2 indicated absent, mild, and severe scarring. For crusting, the scores 0, 1, and 2 indicated absent, mild, and severe crusting, respectively.

2.4. Statistics

We used MedCalc Statistical Software version 19.1.5 (MedCalc Software bv, Ostend, Belgium) for statistical analysis. All data are expressed as the mean ± SD. In each group, we compared preoperative and postoperative TWSIT scores and LKES by Wilcoxon signed-rank test. We compared the number of patients with normosmia, hyposmia, and anosmia in the entire cohort, the non-elderly group, and the elderly group using Chi-square test. The Mann-Whitney U test was used to compare the preoperative TWSIT score and LKES and the postoperative TWSIT score and LKES differences (postoperative score minus preoperative baseline score) between the two groups. A p-value < 0.05 was considered statistically significant.

3. Results

A total of 45 patients were enrolled in this study. We excluded 5 patients, 3 because they were younger than 20 years old on the day of surgery and 2 because they were anosmic preoperatively. There were 29 patients in the non-elderly group (20–59 years), with a mean age of 45.7 years (SD = 10.6 years, range 22 to 59 years). In this group, 10 patients (34.5%) were men, and 19 patients (65.5%) were women. The histologic diagnoses included 21 pituitary adenomas, 1 tuberculum sella meningioma, 1 astrocytoma, and 6 Rathke's cleft cysts. There were 16 patients in elderly group (≥ 60 years), with a mean patient age of 70.1 years (SD = 7.8 years, range 60 to 86 years). In this group, 7 patients (43.8%) were men, and 9 patients (56.2%) were women. The histologic diagnoses were all pituitary adenoma (Table 1).

The mean preoperative baseline TWSIT score in the non-elderly group was 42.3 ± 6.3. The 1-month postoperative TWSIT score was 38.5 ± 11.6, which was lower than the preoperative baseline score, although it was not statistically significant (p = 0.077). The 3-month and 6-month postoperative TWSIT scores were 41.7 ± 6.6 and 42.6 ± 6.0, respectively (p = 0.738 and p = 0.596, respectively, compared to baseline). In the elderly group, the mean preoperative baseline TWSIT score was 37.1 ± 6.9. The 1-month and 3-month postoperative TWSIT scores (29.3 ± 12.5 and 30.0 ± 12.0, respectively) were lower than the preoperative baseline score, with marginal significance (p = 0.054 and p = 0.074, respectively). The 6-month postoperative TWSIT score was 35.6 ± 12.8 (p > 0.99 compared to baseline) (Table 2).

Regarding olfactory status, we divided the patients into three categories according to TWSIT score: normosmia (46–48), hyposmia (14–45), and anosmia (2–13). Preoperatively, 45 patients completed the TWSIT (29 patients in the non-elderly group and 16 patients in the elderly group). One month postoperatively, 36 patients completed the TWSIT (25 patients in the non-elderly group and 11 patients in the elderly group). Three months and 6 months postoperatively, 33 patients completed the TWSIT (22 patients in the non-elderly group and 11

Table 1
Demographic characteristics of each group (non-elderly group: 20–59 years; elderly group: ≥ 60 years).

	Non-elderly group	Elderly group
Total patient number (%)	29	16
Male	10 (34.5%)	7 (43.8%)
Female	19 (65.5%)	9 (56.2%)
Mean age at surgery, years (median ± SD, range)	45.7 ± 10.6 (22–59)	70.1 ± 7.8 (60–86)
Histological diagnosis, n, (%)		
Adenoma	21 (72.4%)	16 (100%)
Meningioma	1 (3.4%)	0
Astrocytoma	1 (3.4%)	0
Rathke's cleft cyst	6 (29.8%)	0

SD: standard deviation.

patients in the elderly group). The preoperative and postoperative olfactory status in all patients, in the non-elderly group, and in the elderly group are found in Table 3. There was no significant difference in the numbers of patients in the three categories pre- and postoperatively in the entire cohort ($p = 0.260$), the non-elderly group ($p = 0.610$), or the elderly group ($p = 0.133$).

The preoperative baseline LKES was 0.17 ± 0.49 in the non-elderly group. The 2-week, 1-month, and 2-month LKES were significantly higher than the preoperative baseline score (2-week: 2.08 ± 1.36, $p < 0.001$; 1-month: 1.95 ± 1.20, $p < 0.001$; and 2-month: 1.11 ± 1.36, $p = 0.016$). The 3-month and 6-month postoperative LKES were 0.40 ± 0.75 and 0.18 ± 0.37, respectively, which were not statistically different than the baseline LKES ($p = 0.188$ and $p = 0.938$, respectively). In the elderly group, the preoperative baseline LKES was 0.31 ± 1.11. The 2-week, 1-month, and 2-month postoperative LKES were higher than preoperative baseline score but without statistical significance (2-week: 1.60 ± 1.14, $p = 0.125$; 1-month: 1.79 ± 0.86, $p = 0.156$; and 2-month: 1.00 ± 0.96, $p = 0.313$). The 3-month and 6-month postoperative LKES were 0.41 ± 0.63 ($p = 0.625$) and 0.22 ± 0.36 ($p = 0.616$), respectively (Table 4).

We also compared the preoperative and postoperative TWSIT scores and LKES between the non-elderly group and elderly groups. The preoperative baseline TWSIT scores in the non-elderly group and the elderly group were 42.3 ± 6.3 and 37.1 ± 6.9, respectively ($p = 0.011$). However, when comparing the changes relative to baseline (postoperative score minus preoperative baseline score), there was no difference in the 1-month, 3-month, and 6-month postoperative

Table 2
Taiwan Smell Identification Test (TWSIT) scores in the non-elderly group (20–59 years) and the elderly group (≥ 60 years).

	Mean TWSIT score	*p*-value
Non-elderly group (n = 29)		
Pre-op baseline	42.3 ± 6.3	
Post-op 1 month	38.5 ± 11.6	0.077
Post-op 3 months	41.7 ± 6.6	0.738
Post-op 6 months	42.6 ± 6.0	0.596
Elderly group (n = 16)		
Pre-op baseline	37.1 ± 6.9	
Post-op 1 month	29.3 ± 12.5	0.054
Post-op 3 months	30.0 ± 12.0	0.074
Post-op 6 months	35.6 ± 12.8	> 0.99

p-value: compare post-operative mean TWSIT score with pre-operative baseline.

Table 4
Lund-Kennedy Endoscopic Score (LKES) in the non-elderly group (20–59 years) and the elderly group (≥ 60 years).

	Mean LKES	*p*-value
Non-elderly group (n = 29)		
Pre-op baseline	0.17 ± 0.49	
2 weeks post-op	2.08 ± 1.36	< 0.001*
1 month post-op	1.95 ± 1.20	< 0.001*
2 months post-op	1.11 ± 1.36	0.016*
3 months post-op	0.40 ± 0.75	0.188
6 months post-op	0.18 ± 0.37	0.938
Elderly group (n = 16)		
Pre-op baseline	0.31 ± 1.11	
2 weeks post-op	1.60 ± 1.14	0.125
1 month post-op	1.79 ± 0.86	0.156
2 months post-op	1.00 ± 0.96	0.313
3 months post-op	0.41 ± 0.63	0.625
6 months post-op	0.22 ± 0.36	0.616

p-value: compare post-operative mean LKES with pre-operative baseline.
* $p < 0.05$.

Table 3
Olfactory status of the non-elderly group (20–59 years old group) and the elderly group (≥ 60 years old group).

	Pre-op	1 month post-op	3 months post-op	6 months post-op
Total (n = 45)				
Normosmia	14	7	7	14
Hyposmia	31	27	25	18
Anosmia	0	2	1	1
		Chi-square test: $p = 0.260$, contingency coefficient = 0.223		
Non-elderly (n = 29)				
Normosmia	11	7	7	10
Hyposmia	18	17	15	12
Anosmia	0	1	0	0
		Chi-square test: $p = 0.610$, contingency coefficient = 0.209		
Elderly (n = 16)				
Normosmia	3	0	0	4
Hyposmia	13	10	10	6
Anosmia	0	1	1	1
		Chi-square test: $p = 0.133$, contingency coefficient = 0.408		

TWSIT score differences between the two groups. There were no significant differences in the LKES between the two groups at baseline or in the LKES differences (postoperative score minus preoperative baseline score) at 2 weeks, 1 month, 2 months, 3 months, or 6 months postoperatively (Table 5).

Table 5
Comparison of Taiwan Smell Identification Test (TWSIT) score and Lund-Kennedy Endoscopic Score (LKES) differences in the non-elderly group (20–59 years) and the elderly group (≥ 60 years).

	Non-elderly group	Elderly group	*p*-value
TWSIT score			
Pre-op baseline	42.3 ± 6.3	37.1 ± 6.9	0.011*
1-month post-op diff.	-4.6 ± 11.4	-7.4 ± 9.9	0.318
3-month post-op diff.	-0.6 ± 4.2	-5.5 ± 9.6	0.112
6-month post-op diff.	0.6 ± 5.1	-1.5 ± 8.7	0.659
LKES			
Pre-op baseline	0.17 ± 0.49	0.31 ± 1.11	0.695
2-week post-op diff.	1.88 ± 1.39	1.60 ± 1.14	0.704
1-month post-op diff.	1.77 ± 1.32	1.21 ± 1.65	0.638
2-month post-op diff.	1.04 ± 1.42	0.50 ± 1.71	0.833
3-month post-op diff.	0.25 ± 0.72	0.05 ± 1.33	0.654
6-month post-op diff.	-0.03 ± 0.70	-0.22 ± 1.28	0.911

diff.: difference (postoperative score minus preoperative baseline score).
* $p < 0.05$.

4. Discussion

EEA surgery is the mainstay of treatments for sellar/parasellar/suprasellar tumors. The olfactory mucosa is located in the superior portion of the nasal septum, cribriform plate, and medial portion of the superior turbinate and middle turbinate.[6,7]

In this study, we found that elderly patients tended to have poorer postoperative olfactory function longer than non-elderly patients. However, even in elderly patients, postoperative olfactory function and sinonasal cavity conditions had returned to preoperative status within 6 months postoperatively. The possible causes of postoperative olfactory dysfunction were sinonasal scarring and crusting. Further, elderly patients have worse baseline olfactory function than non-elderly patients. However, the differences between preoperative baseline and postoperative TWSIT scores and LKES (postoperative score minus preoperative baseline score) were similar between the elderly group and the non-elderly group. Overall, there was a trend toward decreasing sense of smell at 1 month postoperatively, but olfactory function returned to preoperative baseline levels within 6 months postoperatively in both groups (Table 2). There was no significant difference between the elderly and non-elderly groups in the postoperative change in smell functions (Table 5).

Several studies have examined changes in olfactory function after EEA surgery. Kim et al. demonstrated that endoscopic endonasal trans-sphenoidal approaches might contribute to olfactory dysfunction in patients older than 30 years in a retrospective study of 226 patients.[6] Rioja et al. published a prospective study of 55 patients, of whom 38 received transnasal trans-sphenoidal endoscopic approaches to the sella turcica and 17 received expanded endonasal approaches to the skull base. They concluded that minor but long-term loss of smell can occur after skull base surgery.[15] Kuwata et al. retrospectively studied 21 patients with primary pituitary tumors and 5 with recurrent pituitary tumors who underwent endoscopic endonasal trans-sphenoidal approaches. They reported that endoscopic endonasal trans-sphenoidal surgeries improved or maintained olfactory function in 88% of patients.[7] Hart et al. conducted a case series of 57 patients and found that there was a difference in olfactory function between baseline and 1 month after endoscopic pituitary tumor resection, but no clinically significant difference was noted 3 months after surgery. This meant that there was no clinically significant lasting effect on olfactory function after endoscopic pituitary tumor resection.[8] Netuka et al. published a prospective study of 143 patients who received endoscopic endonasal surgery for pituitary adenoma. They found that the risk of olfactory deterioration after endoscopic endonasal approach is low but not completely negligible.[16]

In our study, we observed no statistically significant difference in preoperative and postoperative TWSIT scores in both the non-elderly group and the elderly group. However, the 1-month score was lower than the preoperative baseline score in the non-elderly group, and the 1-month and 3-month postoperative scores were lower than the preoperative baseline score in the elderly group. Therefore, there was a trend toward decreasing sense of smell during the early postoperative period in both groups. This also implied that elderly patients tend to have poorer postoperative olfactory function longer than non-elderlypatients. However, over time the olfactory function returned to the preoperative baseline level in both groups. Additionally, there were no significant differences in the preoperative and postoperative numbers of patients with normosmia, hyposmia, and anosmia in the entire cohort, the non-elderly group, orthe elderly group.

Regarding sinonasal endoscopic appearance, the 2-week, 1-month, and 2-month postoperative LKES were significantly higher than the preoperative baseline LKES in the non-elderly group. This meant that there was more edema, discharge, scarring, and crusting in the nasal cavity within 2 months after EEA surgery in the non-elderly group. In the elderly group, there was no statistically significant difference between the preoperative baseline and postoperative LKES. In both the non-elderly group and the elderly group, the sinonasal endoscopic appearance returned to the preoperative conditions within 3 months postoperatively.

When examining the results of both the TWSIT score and the LKES, we noticed that the duration of postoperative olfactory dysfunction (decreased TWSIT score) was compatible with the duration of postoperative sinonasal scarring and crusting (increased LKES). As the sinonasal conditions recovered, the olfactory function improved.

We also compared olfactory function and sinonasal endoscopic appearance between the non-elderly group and the elderly group. The preoperative baseline TWSIT score of the elderly group was significantly lower than that of the non-elderly group, indicating that elderly patients had worse initial olfactory function. Zhang et al. determined using a meta-analysis that age-related decline in odor identification starts in the fifth decade of life.[11] Attems et al. conducted a mini-review about olfaction and aging. They concluded that multiple factors contribute to age-related olfactory dysfunction, including structural and functional abnormalities of the olfactory functional regions, environmental insults, sensory loss of receptor cells, and changes in neurotransmitter and neuromodulator systems.[17] Seiberling et al. reported several reasons for smell and taste dysfunction in elderly patients, including nervous diseases, nutritional diseases, endocrine diseases, local factors, viral infections, medications, and traumas.[18] We also found that olfactory function is worse in elderly patients, which is compatible with these previous results. Regarding the 1-month, 3-month, and 6-month postoperative TWSIT score differences (postoperative score minus preoperative baseline score), there were no significant differences between the non-elderly group and the elderly group. We also observed that postoperative olfactory dysfunction was not more severe in the el-

derly group than in the non-elderly group. Additionally, there was no significant difference in LKES differences (postoperative score minus preoperative baseline score) between the non-elderly group and the elderly group. Therefore, postoperative nasal cavity recovery was not poorer in the elderly group.

Our study has several limitations. First, the number of patients in our study was relatively small, especially in the elderly group. Therefore, even though we observed some differences, we could not demonstrate statistical significance. Second, not all of our patients completed the postoperative tests. This might have affected our data. Third, this is a retrospective study. Therefore, we are planning a prospective study with more detailed data collection. We will try to analyze more factors between these two groups in the future.

5. Conclusion

In conclusion, elderly patients tended to have poor olfactory function longer than non-elderly patients. However, even in elderly patients, postoperative olfactory function and sinonasal cavity conditions had returned to preoperative status within 6 months postoperatively. The possible causes of postoperative olfactory dysfunction are sinonasal scarring and crusting. The negative impact of EEA surgery for sellar/parasellar/suprasellar tumors on the olfactory function of elderly patients is very small. However, elderly patients and their families should be informed about short-term (less than 6 months) postoperative olfactory dysfunction as a consequence of EEA surgery.

Declaration of any financial and non-financial conflicts of interest

None.

References

1. Pascual JM, Prieto R. Harvey Cushing and pituitary Case Number 3 (Mary D.): the origin of this most baffling problem in neurosurgery. *Neurosurg Focus.* 2016;41:E6.
2. Gao Y, Zhong C, Wang Y, et al. Endoscopic versus microscopic transsphenoidal pituitary adenoma surgery: a meta-analysis. *World J Surg Oncol.* 2014;12:94.
3. Jankowski R, Auque J, Simon C, et al. Endoscopic pituitary tumor surgery. *Laryngoscope.* 1992;102:198–202.
4. Yin LX, Low CM, Puccinelli CL, et al. Olfactory outcomes after endoscopic skull base surgery: a systematic review and meta-analysis. *Laryngoscope.* 2019;129:1998–2007.
5. Hsu NI, Lai JT, Shen PH. Development of Taiwan Smell Identification Test: a quick office-based smell screening test for Taiwanese. *Am J Rhinol Allergy.* 2015;29:e50–e54.
6. Kim BY, Kang SG, Kim SW, et al. Olfactory changes after endoscopic endonasal transsphenoidal approach for skull base tumors. *Laryngoscope.* 2014;124:2470–2475.
7. Kuwata F, Kikuchi M, Ishikawa M, et al. Long-term olfactory function outcomes after pituitary surgery by endoscopic endonasal transsphenoidal approach. *Auris Nasus Larynx.* 2019;pii: S0385-8146(19)30266-4.
8. Hart CK, Theodosopoulos PV, Zimmer LA. Olfactory changes after endoscopic pituitary tumor resection. *Otolaryngol Head Neck Surg.* 2010; 142:95–97.
9. Gondim JA, Almeida JP, de Albuquerque LA, et al. Endoscopic endonasal transsphenoidal surgery in elderly patients with pituitary adenomas. *J Neurosurg.* 2015;123:31–38.
10. Chen SH, Sprau A, Chieng L, et al. Transsphenoidal approach for pituitary adenomas in elderly patients. *World Neurosurg.* 2019;121:e670–e674.
11. Zhang C, Wang X. Initiation of the age-related decline of odor identification in humans: a meta-analysis. *Ageing Res Rev.* 2017;40:45–50.
12. Hadad G, Bassagasteguy L, Carrau RL, et al. A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. *Laryngoscope.* 2006;116:1882–1886.
13. Snyderman CH, Gardner PA. *Master Techniques in Otolaryngology - Head and Neck Surgery: Skull Base Surgery*. Pittsburgh, PA: Lippincott Williams & Wilkins; 2015.
14. Lund VJ, Kennedy DW. Quantification for staging sinusitis. The Staging and Therapy Group. *Ann Otol Rhinol Laryngol Suppl.* 1995:167:17–21.
15. Rioja E, Bernal-Sprekelsen M, Enriquez K, et al. Long-term outcomes of endoscopic endonasal approach for skull base surgery: a prospective study. *Eur Arch Otorhinolaryngol.* 2016;273:1809–1817.
16. Netuka D, Masopust V, Fundová P, et al. Olfactory results of endoscopic endonasal surgery for pituitary adenoma: a prospective study of 143 patients. *World Neurosurg.* 2019;129:e907–e914.
17. Attems J, Walker L, Jellinger KA. Olfaction and aging: a mini-review. *Gerontology.* 2015;61:485–490.
18. Seiberling KA, Conley DB. Aging and olfactory and taste function. *Otolaryngol Clin North Am.* 2004;37:1209–1228, vii.