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Olfactory Functions After Transsphenoidal Pituitary Surgery: Endoscopic Versus Microscopic Approach

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Objectives/Hypothesis: Olfactory disturbances could be observed following transsphenoidal pituitary surgeries. To our knowledge, no previous comparative studies on olfactory functions after transsphenoidal endoscopic and microscopic approaches have been performed.

Study Design: Prospective study comparing olfactory functions between endoscopic and microscopic transsphenoidal pituitary surgery.

Method: Twenty-five patients operated on with the endoscopic approach and 25 patients operated on with the microscopic transsphenoidal approach have been evaluated. The Smell Diskettes Olfaction Test was used during the preoperative period, 1 month after the operation, and 6 months after the operation. In addition, the relationship between intraoperative cerebrospinal fluid leakage from the pituitary and postoperative synechiae formation with olfaction system was evaluated. The results were analyzed using the Friedman test, Mann-Whitney test, and Chi-Square test.

Results: In the endoscopic group, there were two hyposmic patients and no anosmic patients. In the microscopic group, there were 13 hyposmic patients and five anosmic patients. The data was statistically different between both groups ($P < 0.05$). Cerebrospinal fluid leakage was observed in nine patients in the endoscopic group and in 10 patients in the microscopic group. There was no statistically significant difference between cerebrospinal fluid leakage and olfactory disturbances in both groups ($P > 0.05$). Synechia was observed in nine patients in the microscopic group and in only one patient in the endoscopic group. There was a statistically significant difference between the presence of synechia and olfactory disturbances ($P < 0.05$).

Conclusions: This is the first study to seek the difference between the endoscopic and microscopic transsphenoidal approaches on the olfactory system during pituitary surgery. The obtained results indicate that an endoscopic approach seems to be more advantageous than a microscopic approach for protecting olfactory system and function.

Key Words: Olfactory function, pituitary, microscope, endoscope, fila olfactoria.

Level of Evidence: 4.

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INTRODUCTION

The transsphenoidal approach is the most popular surgical technique for pituitary pathologies. However, there are many potential complications with this approach, such as cerebrospinal fluid (CSF) leaks; infections; and vascular, endocrinologic, and rhinological complications.[1–8] Although this approach carries considerable risks in terms of olfactory disturbance, this aspect has not been examined in detail.[7,9,10] Although many articles in the literature are concerned about a comparison between endoscopic transsphenoidal surgery (ETS) and microscopic transsphenoidal surgery (MTS) in terms of the surgical techniques, effectiveness of removal of tumors, endocrinologic relations, complication rates, and visual disturbance, there is no significant data about olfactory functions.[2,4,5,8,11–13]

In this report, we present a comprehensive analysis of olfactory functions in patients who underwent ETS or MTS for their pituitary pathologies.

MATERIALS AND METHODS

This study was based on a prospective design and approved by the Research Ethics Committee of Ankara University. Fifty patients with a diagnosis of pituitary pathology who had been approved for surgical treatment by the Department of Endocrinology were treated. All patients were operated through transsphenoidal route in Ankara University, Medical School, between November 2010 and January 2012. The evaluated two groups consisted of 25 patients who had been operated on with ETS and 25 patients who had been operated on with MTS.

In the MTS group, all operations were performed by the neurosurgery team. In this transseptal approach, patient's heads were fixed with a three-pin head holder. First, a left

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hemitransfixion incision was made, followed by the dissection between the septum and the mucoperichondrium, as well as the mucoperiosteum backward toward the level of the rostrum sphenoidale. Then a long nasal speculum was inserted through the dissection plane in the midline, which was directed to the floor of the sellae under the guidance of fluoroscopy. The speculum was opened as much as possible to gain an adequate operating corridor for the microscopic technique. At this step, the nasal septum was fractured and deviated to the right nasal cavity, lacerating the posterior septal mucosa on both sides in front of the anterior sphenoidal walls while putting pressure laterally, including on the superior nasal conchae. Afterward, the anterior walls of the sphenoid sinuses were removed, together with the intersphenoidal septum, leading to a corridor to visualize the floor of the sellae. As the last step, the floor of the sellae was also removed after checking with fluoroscopy to reach and operate on the tumor through direct vision of the operating microscope (OPMI Pentero, Zeiss, 2010, Germany; and NC4, Zeiss, 2010, Germany). At the end of the procedure, the septum was reducted to its position at the midline and the hemitransfixion incision was sutured, followed by nasal packing.

In the ETS group, the operations were performed together by neurosurgical and otolaryngological teams. In this transnasal approach, patient's heads fixation were not required because of the endoscopic vision. The otolaryngological team began the procedure using the 4-mm 0° and occasionally 30° rigid endoscopes (Karl-Storz Company, 2010, Germany). They endoscopically located and widened the natural ostium of the sphenoid sinuses between the septum and the superior nasal conchae on both sides in a mucosa-sparing atravmatic manner. Then, these two sphenoidotomies were enlarged medially and a bilateral combined midline opening at the anterior sphenoidal walls was achieved, saving the superior nasal conchae. Afterward, a posterior septectomy was performed, resecting about 1,5 cm postero-superior portion of the bony septum with its mucosa horizontally at midline, without disturbing posterior septal artery inferiorly. This facilitated a wide-angle vision to both sphenoid sinuses, enabling binostril four-handed use of endoscopes and instruments without any conflict in the transnasal transsphenoidal corridor and without the need to resect superior turbinates. Under the wide vision of endoscopes, all anatomic structures were identified in the sphenoid sinus for full orientation, including the lateral sphenoidal wall structures. Then bony intersphenoidal septum and the floor of the sellae were removed. The next step of the approach for the neurosurgical team was to remove the tumor using two instruments with two hands, while the otolaryngological team navigated them by means of the endoscopic view and occasionally assisted with an additional instrument. With this bi-nostril, two surgeons, three- or four-handed surgical technique, the tumor was removed and in all cases the necessary reconstruction was achieved followed by nasal packing.

CSF leakage from diaphragma sellae during tumor removal was sealed watertight when identified. In both groups we did not require a nasoseptal flap for reconstruction of CSF leaks, which could have interfered with olfaction function.[10,14] In cases of identified CSF leakage from diaphragma sellae, reconstruction was achieved by fatty tissue covered by facia lata and stabilized by Tisseel fibrin glue (Baxter, Austria) and gelfoam packing. Lumber drainage was not required in any cases. Watertight closure and healing was controlled by nasal endoscopy and objective laboratory testing.[15] No additional CSF leakage of other origin along the anterior skull base were confronted in both groups, which could accidentally be due to surgery.

Only preoperatively normosmic patients were admitted to the study. The patients were evaluated three times for smell function using a validated smell identification screening test—the Smell Diskettes Olfaction Test (Novimed, Dietikon, Switzerland)—during the preoperative period (PO); 1 month after the operation, which was considered the early postoperative period (EPO); and 6 months after the operation, which was considered the late postoperative period (LPO). According to this standardized and validated odor identification test consisting of eight items, patients assess their functions of smelling with scores between 0 and 8: "0" indicating no smelling and "8" indicating optimal smelling.[16–18] Scores between 0 and 2 were admitted as anosmia, scores between 3 and 5 were admitted as hyposmia, and scores between 6 and 8 were admitted as normosmia. The cases of CSF leakage from diaphragma sellae throughout the peroperative period during tumor removal were noted, and the relation of this complication with the tested function of olfaction was evaluated. Additionally, LPO patients were checked for synechiae with nasal endoscopy, and the presence of any relation between synechiae and function of olfaction was evaluated.

TABLE I.
Sex and Age Distribution in Both Endoscopic and Microscopic Groups and a Comparison Between Both Groups.

		ETS		MTS		
		n	%	n	%	
Sex	Female	21	84	19	76	$P > 0.05$
	Male	4	16	6	24	
Age*		40.84 ± 12.56		46.56 ± 7.75		$P > 0.05$

*Mean ± Std.Deviation.
ETS = endoscopic-transsphenoidal surgery; MTS = microscopic-transsphenoidal surgery.

The results of the olfaction test were analyzed using the Friedman test (Bonferroni corrected forms) within each group, the Mann-Whitney test (Bonferroni corrected forms), and the Chi-Square test for comparisons between the two groups. A P value of less than 0.05 was considered to be statistically significant. All statistical analyses were performed with the statistical package SPSS for Windows (Version 11.0, SPSS, Chicago, IL).

RESULTS

Of the 50 patients, 25 patients who had ETS and 25 patients who had MTS operations were included during the 21 month follow-up period. The age ranged between 19 and 68 years in the ETS group (mean 40.84 ± 12.56) and between 27 and 57 years in the MTS group (mean 46.56 ± 7.75). Forty percent of male patients were operated on with ETS, and 60% of patients were operated on with MTS. Fifty-two percents of female patients were operated on with ETS, and 47.5% of female patients were operated on with MTS. There was no statistical significance based on gender or age ($P > 0.05$) (Table I). The study included 44 cases with pituitary adenoma (38 macroadenomas and 6 microadenomas); three cases with fibrous dysplasia; and one case each of Rathke cyst, chordoma, and hypophysitis. In the adenoma series, 30 hormone-active and 14 hormone-inactive tumors were presented.

There were five anosmic and 13 hyposmic patients during the EPO and LPO periods in the MTS group. There were no anosmic patients during the EPO or LPO periods in the ETS group. There were two hyposmic patients who were improved during LPO in the ETS

TABLE II.
Distribution of Smell Diskettes Olfaction Test Scores (in Three Classes as Anosmia for 0–2; Hyposmia for 3–5; Normosmia for 6–8) in 50 Patients in Both Endoscopic and Microscopic Groups in Early and Late Postoperative Follow-Up Periods.

	Functional Classification	ETS (n)	MTS (n)	
EPO	0–2	0	5	$p < 0.05$
	3–5	2	13	
	6–8	23	7	
LPO	0–2	0	5	$p < 0.05$
	3–5	0	13	
	6–8	25	7	

EPO = early postoperative period; ETS = endoscopic-transsphenoidal surgery; LPO = late postoperative period; MTS = Microscopic-transsphenoidal surgery.

group (Table II). In the ETS group, mean PO test score was 7.64 ± 0.64, mean EPO score was 6.72 ± 1.02, and mean LPO score was 7.40 ± 0.76. In the MTS group, mean PO score was 7.48 ± 0.77, mean EPO score was 4.16 ± 2.51, and mean LPO score was 4.52 ± 2.25. In the ETS group, there was a statistical significance between PO and EPO ($P < 0.001$); and between EPO and LPO ($P < 0.01$). However, there was no statistical significance between PO and LPO ($P > 0.05$) in this group. In the MTS group, there was statistical significance between PO and EPO ($P < 0.001$) and between PO and LPO ($P < 0.001$). However, there was no statistical significance between EPO and LPO ($P > 0.05$) in this group. The scores of the olfaction test were significantly different between the two major groups (ETS and MTS) in EPO and LPO ($P < 0.05$) (Table III).

In all cases that a CSF leakage occurred, it was from the diaphragma sellae in the pituitary due to tumor removal during the peroperative period. No other localization or etiology for CSF leakage was observed. CSF leakage from diaphragma sellae during tumor removal occurred in nine patients in the ETS group (36%) and 10 patients in the MTS group (40%). In the ETS group, for patients with no CSF leakage mean PO test score was 7.56 ± 0.73, mean EPO score was 7.06 ± 0.85, and mean LPO score was 7.50 ± 0.81. In the ETS group, for patients with CSF leakage mean PO score was 7.78 ± 0.44, mean EPO score was 6.11 ± 1.05, and mean LPO score was 7.22 ± 0.66. In the MTS group without CSF leakage, mean PO was 7.40 ± 0.82, mean EPO was 4.07 ± 2.52, and mean LPO was 4.20 ± 2.33. In the MTS group with CSF leakage, mean PO was 7.60 ± 0.70, mean EPO was 4.30 ± 2.62, and LPO was 5.00 ± 2.16. There was no statistical significance between CSF leakage and olfactory disturbances in both groups ($P > 0.05$) (Table IV).

Postoperative synechia was observed in one patient in the ETS group (4%) and nine patients in the MTS group (36%) during the late follow-up period. The only synechia of the ETS group was observed between the anterior portion of the inferior nasal concha and the septum on the left side. On the contrary, all synechia of the MTS group were located more postero-superior at the level of posterior olfactory cleft and were between the superior nasal conchas and the septum bilaterally. In the ETS group, for patients without synechia mean score in LPO was 7.42 ± 0.77. In patients with synechia, mean score in LPO was 7.00 ± 0.00. In the MTS group with synechia, mean score in LPO was 5.25 ± 2.11. In the MTS group with synechia, mean score in LPO was 3.22 ± 1.99. There was statistically significant difference between the presence of synechia and olfactory disturbances ($P < 0.05$). The presence of synechia between the ETS and MTS groups was found to be statistical significant ($P < 0.05$) (Table V).

The clinical observations were verified by dissection of two fresh adult cadavers in the anatomy lab. The cadavers were dissected in midsagittal section. Fila olfactoria was observed (Fig. 1) and the effect of speculum on the fila olfactoria was shown (Fig. 2). In the MTS group, the blade of the speculum was pushing and continuously pressing on the superior nasal concha, applying persistent compression that could cause neural damage on the olfactory fibers but also produce mucosal lacerations on the lateral nasal surface. In clinical observation, the operation field was confined to the posterior septum and beyond to the sphenoid sinuses in the midline, being possibly far from the both superior nasal concha and fila olfactoria's sensorial territory in the ETS group (Fig. 3).

DISCUSSION

This study compares olfactory functions of patients who underwent endoscopic and microscopic transsphenoidal pituitary surgery. The patients' olfactory functions were evaluated three times using Smell Diskettes Olfaction Test during the PO, EPO, and LPO. Also, the patients who had cerebrospinal fluid leakage during the peroperative period or synechiae during the postoperative period

TABLE III.
Results of Smell Diskettes Olfaction Test in Both Endoscopic and Microscopic Groups in Three Time Periods and the Comparisons Within Each Group and Between Both Groups.

	ETS Median(Min–Max)			MTS Median(Min–Max)			
EPO	7 (4–8)		$p < 0.001$	4 (0–8)		$P < 0.001$	$p < 0.05$
PO		8 (6–8)			8 (6–8)		$p > 0.05$
LPO	$p > 0.05$		8 (6–8)	$p < 0.001$		5 (0–8)	$p < 0.05$

EPO = early postoperative period; ETS = endoscopic-transsphenoidal surgery; LPO = late postoperative period; PO: Preoperative period; MTS = Microscopic-transsphenoidal surgery.

TABLE IV.
Comparisons of the Presence of Peroperative CSF Leakage and Results of Smell Diskettes Olfaction Test in Both Endoscopic and Microscopic Groups.

		n	PO Median (Min–Max)	EPO Median (Min–Max)	LPO Median (Min–Max)	
CSF Leakage in ETS	Positive	9	8 (7–8)	6 (4–7)	7 (6–8)	$P > 0.05$
	Negative	16	8 (6–8)	7 (6–8)	8 (6–8)	
CSF Leakage in MTS	Positive	10	8 (6–8)	5 (0–7)	5 (1–8)	$P > 0.05$
	Negative	15	8 (6–8)	4 (0–8)	4 (0–8)	
		$P > 0.05$				

CSF = cerebrospinal fluid; EPO = early postoperative period; ETS = endoscopic-transsphenoidal surgery; LPO = late postoperative period; MTS = microscopic-transsphenoidal surgery; PO = Preoperative period.

were evaluated to seek any relationship between them and the olfactory functions. Based on our results, our main hypothesis was that ETS olfactory functional test results were better than those for MTS. Moreover, in the ETS group there was no statistical difference between PO and LPO ($P > 0.05$); however, in the MTS group there was a statistical difference not only between PO and EPO, but also between PO and LPO ($P < 0.001$).

According to our results, the CSF leakage from the diaphragma sellae, an important possible complication of transsphenoidal pituitary surgeries, occurred in an approximately similar number of patients in both groups. However, there was no statistical significance between CSF leakage and olfactory disturbances in both groups ($P > 0.05$).

Synechia, another important complication that in particular was observed during the late follow-up period in transsphenoidal pituitary surgeries, was observed more in the MTS group. There was a statistically significant difference between the presence of synechia and olfactory disturbances ($P < 0.05$). In the ETS group there was only one patient having synechia between the anterior portion of the inferior nasal concha and the septum on the left side. This was probably due to surgical trauma on both surfaces from introducing the instruments and endoscope endonasally. On the other hand, as reported in the results there were nine patients having postoperative synechia in the MTS group. All of those synechia were located more postero-superior at the level of posterior olfactory cleft and were between superior nasal concha and the septum.

TABLE V.
Comparisons of the Presence of Synechiae and Results of Smell Diskettes Olfaction Test in Both Endoscopic and Microscopic Groups.

		n	LPO Median (Min–Max)	
Synechiae in ETS	Positive	1	7 (7–7)	$P > 0.05$
	Negative	24	8 (6–8)	
Synechiae in MTS	Positive	9	4 (0–5)	$P > 0.05$
	Negative	16	5 (0–8)	
		$P < 0.05$		

ETS = endoscopic-transsphenoidal surgery; LPO = late postoperative period; MTS = microscopic-transsphenoidal surgery; PO = preoperative period.

Understandably, the microscopic technique gives the impression that it is more mucosa-saving, and thus seems more function-saving due to submucosal retraction with the speculum; and the endoscopic technique seems more destructive and nonfunctional due to posterior septectomy done at the level of anterior walls of sphenoid sinuses. Nevertheless, the findings of this study are contradictory. In the MTS group, although careful submucosal dissection were performed in all cases, when the speculum was introduced and forcefully opened at the level of anterior walls of sphenoid sinuses it almost always applies an unbalanced force at the posterior olfactory groove, cracking and displacing the bony septum laterally to the contralateral side of the dissection, almost always lacerating the submucosal layers generally on both sides at this level without observable control. The surgeon only sees and controls the medial sides of the speculum blades. Moreover, these blades bilaterally push and continuously press on the superior nasal conchae, also causing mucosal lacerations on the lateral nasal surface. This mucosal damage on both surfaces prepares the optimal conditions for synechia formation at this already narrow groove between the septum and the superior nasal conchae.

These factors are most probably the cause of synechia and subsequent function loss in the MTS group in the postoperative period due to excessive healing, which is not under the control of the surgeon either intraoperatively or postoperatively. On the other hand, although endoscopic technique seems more destructive, between 1- to 2-cm wide posterior septectomy was always performed with sharp cutting instruments, possibly causing less extra-mucosal damage to the rest of the mucosal surfaces. This also facilitates less mucosal bleeding during the surgery, which also could be a negative issue for an endoscopic view. Additionally in this technique, the superior nasal conchae are minimally and delicately lateralized; if possible and if necessary with extra care not to cause mucosal damage. If the median wideness after posterior septectomy lets the surgical team perform endoscopic surgery from the midline trajectory, the superior nasal conchae were left untouched. In the postoperative period, the reason why no synechia was observed in this area could be explained by the fact that at that localization the septum was removed and the area between the both superior nasal conchae was wide enough.

Fig. 1. Dissected fila olfactoria in a cadaver (midsagittal plane). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Sense of smell is very important for humans and a loss of this sense may be a serious cause of emotional changes, social problems, and depression.[19] In any situation such as an injury to the olfactory system, diagnostic imaging of olfactory pathways and recovery of olfaction is very difficult, which is why olfactory system must be carefully preserved during surgical interventions.[20,21] In the literature there are a lot of anatomical studies seeking the causes of hyposmia/anosmia in transsphenoidal surgeries.[22–28] In their microscopic anatomical study in which they classified the superior and supreme turbinates into three types, Orhan et al. described how the type of turbinate may change or effect the frequency of hyposmia/anosmia after related interventions.[28] In their endoscopic anatomical studies, Unlu et al.[23] and Aydin et al.[22] emphasized the superiority of endoscopy to provide a straight approach to the sellar region, where it offers a multi-angled and close-up view of relevant anatomical structures, especially internal carotid artery and optic nerves. In their anatomical and clinical studies, Comert et al.[26] and Aydin et al.[29] explained the importance of the elevation of the frontal lobe and its effect on the olfactory system, which may explain the olfactory disturbance. Er et al. advised a sublabial transseptal approach to pituitary adenomas in order to abstain from rhinological complications.[30]

Olfactory disturbances may be seen after transsphenoidal pituitary surgery.[3,4,6,10,31–33] On the other hand, olfactory improvement was described in acromegalic patients after transnasal transsphenoidal surgery.[9] Dusick et al.[33] declared that decreased olfaction was seen more frequently in patients with endonasal pituitary surgical complications, which had similar results for our patients who developed synechiae, but contrasted to our patients who developed peroperative CSF leakage.

In recent years, pituitary surgery has drifted from open transcranial techniques to a microscopic and then fully endoscopic approach[2,5,8,13,34,35] and/or combined forms.[36] Furthermore, from the neurosurgical point of view, the endoscope has become not only a part of pituitary surgeries but also a part of the surgery of various cranial pathologies in pediatric and adult populations.[37–41] On the other hand, microscopic transsphenoidal surgery may still be the preferred approach as it is accepted to be the gold standard for the endocrine results of Cushing tumors, as well as turning back to the microscope might be required in cases of severe hemorrhage. So it could be suggested that there is no need for special expensive endoscopic equipments, and that all necessary equipments for pituitary surgery are basic ones that are found in every neurosurgical unit.[42,43] From the otolaryngological point of view, however, endoscopic equipment is one of the mainstream surgical tools, widely available and routinely used for inflammatory rhinologic diseases. Thus there is a high level of expertise for its utility in the sinonasal cavity and even beyond. And in a multidisciplinary fashion the endoscopic skills could be acquired and further developed through the endonasal expanded approaches to address various pathologies, which could benefit from the best of both disciplines in favor of the patients.[44]

We and others believe that nowadays, endoscopic approach for pituitary surgery is combining the advantages of two disciplines, which makes it the most popular approach. The endoscopic approach provides less morbidity, shorter hospital stay, shorter operation time, well comfort just after surgery, lower estimated blood lose, less lumbar drain use, less pain, low complication rates and better endocrine outcomes in pediatric and adult populations. Additionally, when compared with the unparalled traditional conical view of the microscope, the endoscopic technique provides the panoramic view that leads potentially more complete tumor resections.[1,11,12,45–51] In a comparison of endoscopic versus traditional microscopic resection, O'Malley et al. described as a primary concern that tumor extirpation was equal in both approaches with similar rates of CSF leaks, complications, and reoperation rates.[12]

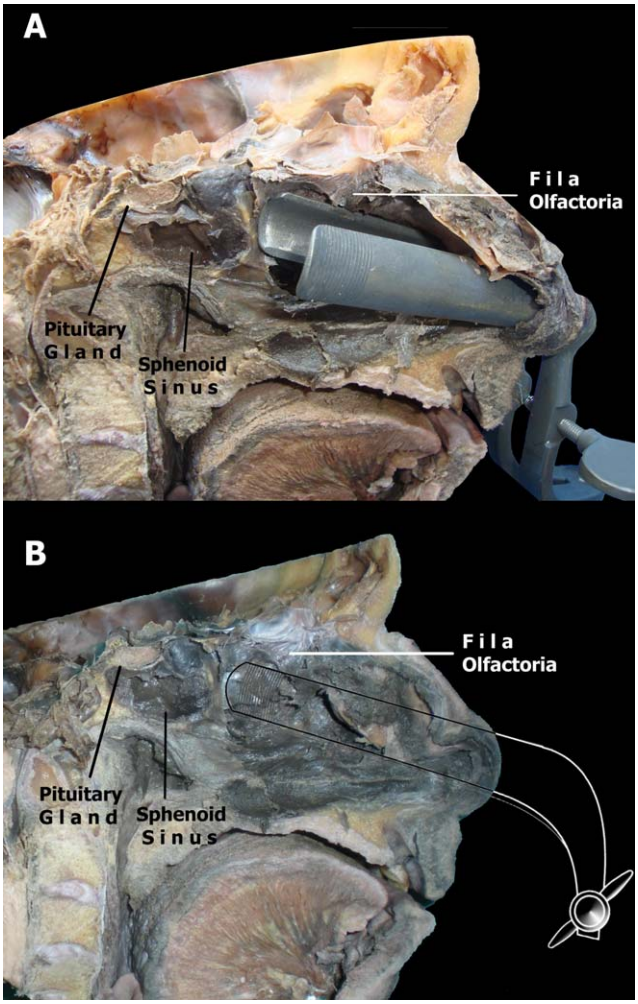

Fig. 2. Effect and route of the speculum in a cadaver in microscopic-transsphenoidal surgery (A). Image of a speculum and its regional relation with fila olfactoria in a cadaver in microscopic-transsphenoidal surgery (B) (midsagittal plane). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Karabatsou et al. explained that endoscopic pituitary surgery had a minimal impact on the quality of life of the patients.[52] Also, early and high rate of sense of visual recovery was emphasized after endoscopic pituitary surgery.[53] In spite of many comparable studies and many data between endoscopic and microscopic approaches in pituitary surgery, sense of olfaction has been ignored.[1,2,7,11,12,45,46,48] Rotenberg et al.[2] explained that usage of Hadad Flap may result in olfactory impairment after endoscopic transsphenoidal surgery, which we had not used in our ETS series.

Hyposmia/anosmia may be caused by undue superior nasal septum dissection and trauma to fila olfactoria with transsphenoidal speculum in microscopic approach.[28,32] Forceful opening of the speculum in order to get the widest possible opening for better access to the pituitary in a narrow bony corridor not only creates unintentional large septal mucosal lacerations at the posterior olfactory groove in most instances, but also compresses the superior nasal conchae, laterally applying evident pressure on the distribution area of fila olfactoria all along the tumor removal and reconstruction time. Additionally, as our results reveal, uncontrolled mucosal lacerations at that area heal with synechias that most probably contribute to the poorer olfaction scores in the MTS group. Endoscopic technique is less traumatic to nasal mucosa and the superior nasal conchae with the elimination of transsphenoidal retractor, which may explain why olfactory disturbances are seen less in the endoscopic group when compared to the microscopic group, as demonstrated in our results.[4] This issue may be very important and applicable when any new equipment is being developed for both microscopic and endoscopic pituitary surgeries.[54] Apart from this, endoscopic endonasal surgery aims to create the most minimal mucosal damage. Otherwise it would simply cause more unnecessary bleeding during the surgery, which would inversely affect the procedure by impairing the endoscopic view, subsequently causing a lack of orientation. Ideally, endoscopic technique uses the nasal corridor only to reach the pathology, without disturbing any mucosal surface more than adequate for the exposure. In our practice, the mucosal surface of the posterior septum and the anterior walls of the sphenoid sinuses are usually involved.

As a result of our findings, we believe that endoscopic surgery creates fewer traumas and better healing of the mucosal surfaces especially responsible for olfaction. Furthermore, some endoscopic surgical approaches in pituitary surgery may reduce the olfactory disturbances, performing a unilateral transnasal transethmosphenoidal approach without the resection of the posterior portion of the nasal septum or using a transglabellar approach to the pituitary pathologies.[35,55] Nevertheless,

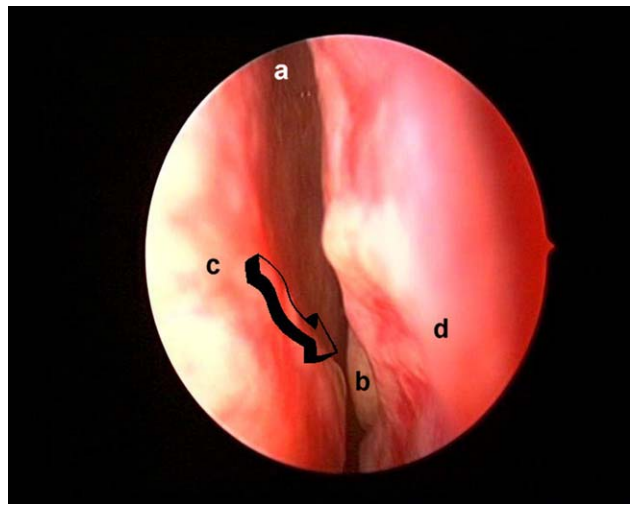

Fig. 3. A left nostril view from a case of our ETS series in which fewer trauma to nasal mucosa with elimination of the speculum and a distant operating region from fila olfactoria attract attention. (a = fila olfactoria's territory, b = middle turbinate, c = nasal septum, d = medial wall of maxilla, arrow = surgical corridor for ETS). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

as shown in our results, using the bi-nostril four-handed technique with posterior septectomy while being atraumatic to the olfactory regions yield less risk (4%) to olfactory function as compared to otolaryngological nasal surgeries such as septal surgery or sinus surgery, 7% and 9%, respectively.[56]

CONCLUSION

In this study, comprehensive analysis of olfactory functions in patients who underwent endoscopic or microscopic transsphenoidal surgery for pituitary pathologies was done. The olfactory functions were better preserved in the endoscopic approach. Peroperative CSF leakage from the diaphragma sellae was found not to affect the olfactory functions in both groups. However, synechiae seems to develop more in microscopic approach, especially at the posterior olfactory groove, and a high number of olfactory disturbances were observed in this group. Further studies are needed, with more patients and longer follow-up periods to better assess olfactory function preservation and relations of complication frequencies, as well as the surgical approaches.

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BIBLIOGRAPHY

1. Gondim JA, Schops M, de Almeida JP, et al. Endoscopic endonasal transsphenoidal surgery: surgical results of 228 pituitary adenomas treated in pituitary center. *Pituitary* 2010;13:68–77.
2. Rotenberg B, Tam S, Ryu WH, Duggal N. Microscopic versus endoscopic pituitary surgery: a systematic review. *Laryngoscope* 2010;120: 1292–1297.
3. Cappabianca P, Cavallo LM, Colao A, de Divitiis E. Surgical complications associated with the endoscopic endonasal transsphenoidal approach for pituitary adenomas. *J Neurosurg* 2002;97:293–298.
4. Schaberg MR, Anand VK, Schwartz TH, Cobb W. Microscopic versus endoscopic transnasal pituitary surgery. *Curr Opin Otolaryngol Head Neck Surg* 2010;18:8–14.
5. Duz B, Harman F, Secer HI, Bolu E, Gonul E. Transsphenoidal approaches to the pituitary: a progression in experience in a single centre. *Acta Neurochir (Wien)* 2008;150:1133–1139.
6. Berker M, Hazer DB, Yucel T, et al.Complications of endoscopic surgery of the pituitary adenomas: analysis of 570 patients and review of the literature. *Pituitary* 2012;15:288–300.
7. Gondim JA, Almeida JP, Albuquerque LA, et al. Endoscopic endonasal approach for pituitary adenoma: surgical complications in 301 patients. *Pituitary* 2011;14:174–183.
8. Goudakos JK, Makou KD, Georgalas C. Endoscopic versus microscopic trans-sphenoidal pituitary surgery: a systematic review and meta-analysis. *Clin Otolaryngol* 2011;36:212–220.
9. Actor B, Sarnthein J, Prömmel P, Holzmann D, Bernays RL. Olfactory improvement in acromegaly after transnasal transsphenoidal surgery. *Neurosurg Focus* 2010;29:E10.
10. Rotenberg BW, Saunders S, Duggal N. Olfactory outcomes after endoscopic transsphenoidal pituitary surgery. *Laryngoscope* 2011;121:1611–1613.
11. Frank G, Pasquini E, Farneti G, et al. The endoscopic versus the traditional approach in pituitary surgery. *Neuroendocrinology* 2006;83: 240–248.
12. O'Malley BW, Grady MS, Gabel BC, et al. Comparison of endoscopic and microscopic removal of pituitary adenomas: single-surgeon experience and learning curve. *Neurosurg Focus* 2008;25:E10.
13. Dehdashti AR, Ganna A, Karabatsou K, Gentili F. Pure endoscopic endonasal approach for pituitary adenomas: early surgical results in 200 patients and comparison with previous microsurgical series. *Neurosurgery* 2008;62:1006–1017.
14. 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.
15. Meco C, Arrer E, Oberascher G. Efficacy of cerebrospinal fluid fistula repair: sensitive quality control using the beta-trace protein test. *Am J Rhinol* 2007;21:729–36.
16. Briner H.R., Simmen D. Smell diskettes as screening test of olfaction. *Rhinology* 1999;37:145–148.
17. Simmen D, Briner HR. Olfaction in rhinology–methods of assessing the sense of smell. *Rhinology* 2006;44:98–101.
18. Scadding G, Hellings P, Alobid I, et al. Diagnostic tools in rhinology EAACI position paper. *Clin Transl Allergy* 2011;1:2.
19. Smeets MA, Veldhuizen MG, Galle S, et al. Sense of smell disorder and health-related quality of life. *Rehabil Psychol* 2009;54:404–412.
20. Wise JB, Moonis G, Mirza N. Magnetic resonance imaging findings in the evaluation of traumatic anosmia. *Ann Otol Rhinol Laryngol* 2006;115: 124–127.
21. Mueller CA, Hummel T. Recovery of olfactory function after nine years of post-traumatic anosmia: a case report. *J Med Case Rep* 2009;3:9283.
22. Aydın S, Cavallo LM, Messina A, et al. The endoscopic endonasal transsphenoidal approach to the sellar and suprasellar area: anatomic study. *J Neurosurg Sci* 2007;51:129–138.
23. Unlu A, Meco C, Ugur HC, Comert A, Ozdemir M, Elhan A. Endoscopic anatomy of sphenoid sinus for pituitary surgery. *Clin Anat* 2008;21: 627–632.
24. Abuzayed B, Tanriover N, Akar Z, Eraslan BS, Gazioglu N. Extended endoscopic endonasal approach to the suprasellar parachiasmatic cisterns: anatomic study. *Childs Nerv Syst* 2010;26:1161–1170.
25. Abuzayed B, Tanriover N, Gazioglu N, et al. Endoscopic endonasal anatomy and approaches to the anterior skull base: a neurosurgeon's viewpoint. *J Craniofac Surg* 2010;21:529–537.
26. Comert A, Ugur HC, Kahilogullari G, Comert E, Elhan A, Tekdemir I. Microsurgical anatomy for intraoperative preservation of the olfactory bulb and tract. *J Craniofac Surg* 2011;22:1080–1082.
27. Van Lindert EJ, Ingels K, Mylanus E, Grotenhuis JA. Variations of endonasal anatomy: relevance for the endoscopic endonasal transsphenoidal approach. *Acta Neurochir* 2010;152:1015–1020.
28. Orhan M, Govsa F, Saylam C. A surgical view of the superior nasal turbinate. *Eur Arch Otorhinolaryngol* 2010;267:909–916.
29. Aydin IH, Onder A, Kadioglu HH, Tahmazoglu I, Kayaoglu GR. Postoperative anosmia after removal of pituitary gland adenomas using the pterional approach. *Acta Neurochir (Wien)* 1992;119:101–103.
30. Er U, Gurses L, Saka C, et al. Sublabial transseptal approach to pituitary adenomas with special emphasis on rhinological complications. *Turk Neurosurg* 2008;18:425–430.
31. Dusick JR, Esposito F, Kelly DF, et al. The extended direct endonasal transsphenoidal approach for nonadenomatous suprasellar tumors. *J Neurosurg* 2005;102:832–841.
32. Kennedy DW, Cohn ES, Papel ID, Holliday MJ. Transsphenoidal approach to the sella: the Johns Hopkins experience. *Laryngoscope* 1984;94:1066–1074.
33. Dusick JR, Esposito F, Mattozo CA, Chaloner C, McArthur DL, Kelly DF. Endonasal transsphenoidal surgery: the patient's perspective-survey results from 259 patients. *Surg Neurol* 2006;65:332–342.
34. Yang I, Wang MB, Bergsneider M. Making the transition from microsurgery to endoscopic transsphenoidal pituitary neurosurgery. *Neurosurg Clin N Am* 2010;21:643–651.
35. Kabil MS, Jarrahy R, Shahinian HK. The application of craniofacial techniques and intracranial endoscopy to pituitary surgery. *J Craniofac Surg* 2005;16:812–818.
36. Frazier JL, Chaichana K, Jallo GI, Ouinones-Hinojosa A. Combined endoscopic and microscopic management of pediatric pituitary region tumors through one nostril: technical note with case illustrations. *Childs Nerv Syst* 2008;24:1469–1478.
37. Belli E, Longo B, Marini FB, Matteini C. Could transcranial endoscopy represent an alternative to craniotomy in skull base surgery? *J Craniofac Surg* 2005;16:155–158.
38. Turhan T, Ersahin Y, Akinturk N, Mutluer S. Fenestration methods for Sylvian arachnoid cysts-endoscopy or microsurgery. *Childs Nerv Syst* 2012;28:229–235.
39. Kassam A, Horowitz M, Welch W, et al. The role of endoscopic assisted microneurosurgery (image fusion technology) in the performance of neurosurgical procedures. *Minim Invas Neurosurg* 2005;48:191–196.
40. Di Rocco F, Juca CE, Arnaud E, Renier D, Sainte-Rose C. The role of endoscopic third ventriculostomy in the treatment of hydrocephalus associated with faciocraniosynostosis. *J Neurosurg Pediatrics* 2010;6:17–22.
41. Di Rocco C, Massimi L, Tamburrini G. Shunt vs. endoscopic third ventriculostomy in infants: are there different types and/or rates of complications? *A review. Childs Nerv Syst* 2006;22:1573–1589.
42. Tarapore PE, Sughrue ME, Blevins L, Auguste KI, Gupta N, Kunwar S. Microscopic endonasal transsphenoidal pituitary adenomectomy in the pediatric population. *J Neurosurg Pediatr* 2011;7:501–509.
43. Powell M. Microscope transsphenoidal surgery. *Acta Neurochir (Wien)* 2012;154:913–917.
44. Snyderman C, Kassam A, Carrau R, Mintz A, Gardner P, Prevedello DM. Acquisition of surgical skills for endonasal skull base surgery: a training program. *Laryngoscope* 2007;117:699–705.
45. Neal JG, Patel SJ, Kulbersh JS, Osguthorpe JD, Schlosser RJ. Comparison of techniques for transsphenoidal pituitary surgery. *Am J Rhinol* 2007;21:203–206.
46. Higgins TS, Courtemanche C, Karakla D, et al. Analysis of transnasal endoscopic versus transseptal microscopic approach for excision of pituitary tumors. *Am J Rhinol* 2008;22:649–652.

47. Kuroki A, Kayama T. Endoscopic approach to the pituitary lesions: contemporary method and review of the literature. *Biomed Pharmacother* 2002;1:158–164.
48. Strychowsky J, Nayan S, Reddy K, Farrokhyar F, Sommer D. Purely endoscopic transsphenoidal surgery versus traditional microsurgery for resection of pituitary adenomas: systematic review. *J Otolaryngol Head Neck Surg* 2011;40:175–185.
49. Choe JH, Lee KS, Jeun SS, Cho JH, Hong YK. Endocrine outcome of endoscopic endonasal transsphenoidal surgery in functioning pituitary adenomas. *J Korean Neurosurg Soc* 2008;44:151–155.
50. Rigante M, Massimi L, Parrilla C, Galli J, Caldaralli M, Di Rocco C, Paludetti G. Endoscopic transsphenoidal approach versus microscopic approach in children. *Int J Pediatr Otorhinolaryngol* 2011;75: 1132–1136.
51. Locatelli D, Massimi L, Rigante M, et al. Endoscopic endonasal transsphenoidal surgery for sellar tumors in children. *Int J Pediatr Otorhinolaryngol* 2010;74:1298–1302.
52. Karabatsou K, O'Kelly C, Ganna A, Dehdashti AR, Gentili F. Outcomes and quality of life assessment in patients undergoing endoscopic surgery for pituitary adenomas. *Brit J Neurosurg* 2008;22:630–635.
53. Anik I, Anik Y, Koc K, et al. Evaluation of early visual recovery in pituitary macroadenomas after endoscopic endonasal transsphenoidal surgery: quantitative assessment with diffusion tensor imaging (DTI). *Acta Neurochir (Wien)* 2011;153:831–842.
54. Chole RA, Lim C, Dunham B, Chicoine MR, Dacey RG. A novel transnasal transsphenoidal speculum: a design for both microscopic and endoscopic transsphenoidal pituitary surgery. *J Neurosurg* 2011;114: 1380–1385.
55. Haruna S, Otori N, Moriyama H, Kamio M. Endoscopic transnasal transethmoidal approach for pituitary tumors: assessment of technique and postoperative findings of nasal and paranasal cavities. *Auris Nasus Larynx* 2006;34:57–63.
56. Pade J, Hummel T. Olfactory function following nasal surgery. *Laryngoscope* 2008;118:1260–64.