Endoscopic versus microscopic approach for management of pituitary tumors

Mahmoud Farid, B. A.

Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Egypt
faridneuro@yahoo.com

Abstract: Background: Pituitary tumors are most commonly approached through the transsphenoidal approach, and tumor resection is most often performed using the operating microscope. More recently the endoscope has been introduced for use either as an adjunct to or in lieu of the microscope. Both the microscopic and endoscopic transsphenoidal approaches to pituitary tumors allow safe and effective tumor resection. This study showed the advantages and disadvantages of the pure transsphenoidal endoscopic approach compared with the standard microscopic approach. **Patients and methods**: This is a retrospective study of forty patients presented with pituitary macroadenoma including both sexes, with ranging age from 20-50 years. These patients presented to the neurosurgery department of Al-Azhar university hospitals during the period from October 2010 to October 2013.The Patients were divided into two groups: The 1st group; included 20 patients, who subjected to endoscopic endonasal transsphenoidal pituitary surgery. The 2nd group; included 20 patients, were subjected to classic microscopic sublabial transsphenoidal pituitary surgery. **Results:** This comparative study was including two groups; the first group representing twenty patients with pituitary tumors who operated using endoscopic transsphenoidal technique; and the second group showed twenty patients with pituitary tumors were operated using the microscopic sublabial transsphenoidal technique. The patients in the first group included 5 males (25%) and 15 females (75%) and in the second group included 8 males (40%) and 12 females (60%) with age ranging from (20-50) years (median: 35 years). They are presented by one or more symptoms. The commonest symptoms were headache (92.5%), followed by endocrinal symptoms (80%), then visual symptoms (75%). In the first group total removal of the lesion was achieved in 10 cases (50%), while subtotal removal was achieved in 8 cases(40%),and partial removal was achieved in 2cases (10%). While in the second group total removal was achieved in 5 cases (25%), subtotal removal was achieved in 7 cases (35%) and partial removal was achieved in 8 cases (40%). **Conclusion:** The pure endoscopic approach is a safe, effective approach to sellar region tumors that offers several advantages over the microscopic approach. It provides an excellent wide-angle and magnified view of the operative anatomy, and although it requires more anatomical exposure it remains within the group of minimally invasive approaches to the sella. High disease control rates and low rates of complications are some of the most important points related to the technique. Some of the factors related to the success of endoscopic surgery are lesion size, suprasellar/ parasellar extension, and the degree of sella floor erosion.

[Mahmoud Farid. **Endoscopic versus microscopic approach for management of pituitary tumors.** *J Am Sci* 2015;11(1):7-14]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 2

Key Words: Transsphenoidal - Pituitary surgery - Endoscopic - Microscopic

1. Introduction

Pituitary adenomas are the third most common intracranial neoplasm, accounting for 10%–25% of intracranial neoplasms with a prevalence of 16.9% in autopsy studies (8).

In March 1907, Schloffer reported the first successful removal of a pituitary tumor via a superior nasal transsphenoidal approach, which was based on Giordano's experimental work(24).The sublabial transsphenoidal route to the sella turcica, originally pioneered by Harvey Cushing (5).

In 1967, Hardy introduced the use of the operating microscope for this procedure and developed and designed his own microsurgical instrumentation, which transformed transsphenoidal surgery(9).The excellent visualization and surgical results provided by the endoscope in sinus surgery have prompted neurosurgeons to explore its potential application to transsphenoidal surgery (4).

The endonasal microscopic transsphenoidal approach has several variations, including the transseptal submucosal technique, the septal pushover, and the direct sphenoidotomy (25).

Authors reported the first use of the endoscope in pituitary surgery in 1978 (2) but its application to the sella turcica did not grow in popularity, however, until the mid-1990s, when endoscopic sinus surgery had virtually replaced conventional open techniques in use by otolaryngologists for the treatment of inflammatory sinonasal disorders

Many modifications of the transsphenoidal approach have been developed; they range from sublabial transnasal, transnasal, and pure endonasal endoscopic approaches and are used with an

increasing popularity in endoscopic over microscopic procedures (11).

Technological advances in the areas of endoscope-assisted microneurosurgery, frameless stereotaxy and three-dimensional computer-assisted neuronavigation, color Doppler ultrasonography, and real-time intraoperative magnetic resonance imaging have been applied to the classic transsphenoidal operation.

2. Methods

Between October 2010 and October 2013 retrospective study of 40 patients who presented with pituitary macroadenomas and underwent pituitary surgery using endoscopic and microscopic transsphenoidal approaches. The study included patients of both sexes, with age ranging from (20-50) years.

These patients were divided into two groups: The first group; included 20 patients, who are subjected to endoscopic endonasal transsphenoidal pituitary surgery. The second group; included 20 patients, who are subjected to classic microscopic sublabial transsphenoidal pituitary surgery. Both groups were evaluated through Full history, general and neurological examination, visual field examination, laboratory (hormonal) and radiological examination pre and postoperative.

All the patients who underwent surgery were given intravenous hydrocortisone in ‘‘stress’’ doses 100mg IV every 6 hours, 24 hours before operation that was tapered rapidly over 2 to 3 days postoperative to allow physiologic replacement.

The first group was operated upon using the endoscopic endonasal techniques. The commonly used endoscope is a rigid scope 4 mm in diameter, with 0-degree, 30-degree, and 45-degree lenses, according to the different steps of the surgical operation with digital video camera, and high-resolution monitor.

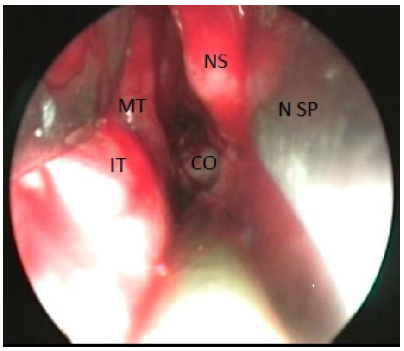

Fig1: Shows the endoscopic picture of nasal cavity showing the NS on LT side and middle and inferior turbinate on RT side and 2 blades of opened nasal speculum on both sides

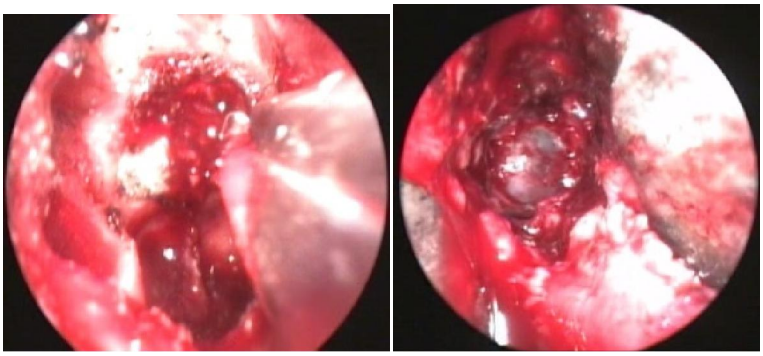

Fig.2: Removal of bone with Kerrison bone nibbling forceps to expose the dura of the sellar floor

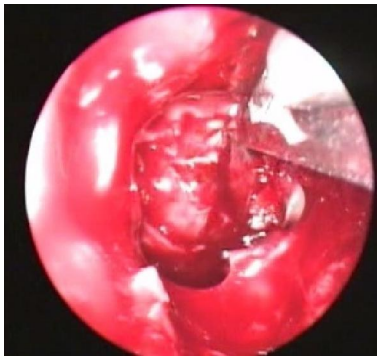

Fig.3: Opening of the dura of the sellar floor with scalpel N11 making cruciate incision.

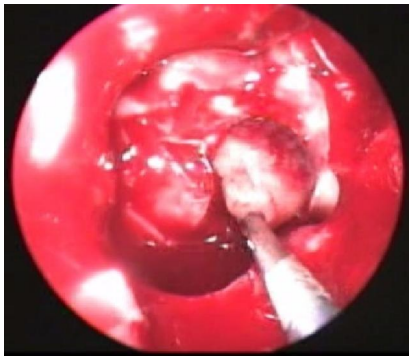

Fig.4: Tumor removal with a ring curette from the lateral wall of the sella.

The second group was operated upon using the microscopic transsphenoidal approach. The patient position was supine with the operative site above the level of the heart. The head was supported by a Mayfield horseshoe headrest, with extended neck. The nasal mucosa and gingival mucosa are infiltrated with 0.5% lidocaine containing epinephrine at a ratio of 1:200,000, and the nasal cavity was packed with cottonoid sponges soaked with the same solution to enhance hemostasis and shrink the turbinate.

The upper lip was everted with lip retractors, and a sublabial incision was made. Subperiosteal dissection was carried out superiorly to expose the piriform aperture (anterior nares) and the rostrum of the maxilla. Once the floor of the nasal cavity was identified, the mucosa was dissected from the floor along the medial aspect and was carried posteriorly and superiorly to free the mucosa from one side of the nasal septum.

Speculum inserted, and operating microscope is employed at this time, then anterior wall of the sphenoid sinus is opened, mucosa of the sphenoid sinus is removed from the posterior wall, anteroinferior wall of the pituitary fossa is opened, the dura is opened, tumor is removed with a variety of instruments (e.g. pituitary rongeurs)

All patients postoperative were kept in an intensive care unit for the 24 hours, and onwards according to case clinical response. Close observation of vital signs, conscious level, features of increased intracranial tension and fluid balance were specifically noted. Serum electrolytes, hemoglobin and hematocrit, urine output and osmolality and renal functions were checked in the early post-operative period for all patients.

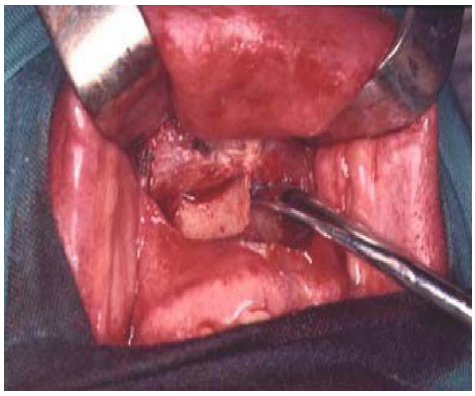

Fig.5: Sublabial incision with Subperiosteal dissection of the mucosa to expose the rostrum of the maxilla.

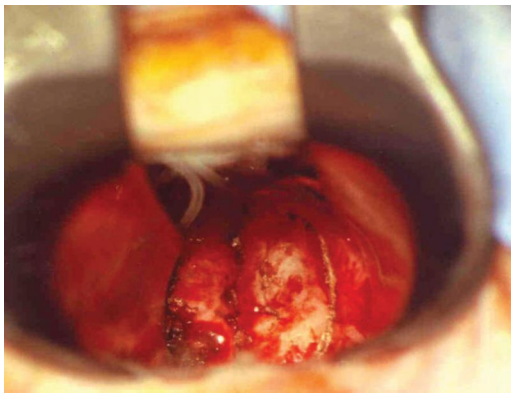

Fig.6: Microscopic view after placing the sphenoid speculum exposing the sphenoid rostrum.

3. Results

Endoscopic endonasal transsphenoidal surgery has gained increasing acceptance by neurosurgeons in many centers throughout the world, and this technique is now routinely used for the same indications as the conventional microsurgical technique.

This comparative study was done between October 2010and October 2013, including two groups; the first group showed 20 patients with pituitary tumors operated using endoscopic endonasal technique, and the second group, showed 20 patients with pituitary tumors who operated using the microscopic sublabial transsphenoidal technique. Our patients in the first group included 5 males (25%) and 15 females (75%) and in the second group included 8 males (40%) and 12 females(60%) with age ranging from (20-50) years (median: 35 years).

Table 1: Age &sex distribution in each group:

Sex	**Group 1 (n=20)**	**Group 2 (n=20)**	**Total(n=40)**
Males	5 (25%)	8 (40%)	13(32.5%)
Females	15(75%)	12 (60%)	27(67.5%)
Age	20-45ys.	25-50ys.	20-50ys.

Patients presented to the outpatient clinic by one or more symptoms, the most common is headache (92.5%), followed by endocrinal symptoms (80%) commonly hyperprolactinemia then visual symptoms (75%).The most common is visual field defect bitemporal hemianopia.

Table 2: Shows summary of the frequency of different symptoms in both groups

Symptoms:	1st group (n=20)	2nd group (n=20)	Total (n=40)
Headache	19	18	37 (92.5%)
Endocrinal	17	15	32 (80%)
Visual	14	16	30 (75%)

According to the hormonal assay In both groups, it was found that 12 patients (30%) had nonfunctioning adenomas, while 28 (70%) had functioning tumors, of which 17patients (45%) had hyperprolactinemia, 5 patients (12.5) had mixed Prolactinomas & GH adenomas, 4 (7.5%) had increased growth hormone and 2 patients (5%) had TSH hypersecretion.

CT scan and MRI brain were done for all patients pre and postoperative. Thin sliced axial and coronal CT scans were useful to assess the bony walls of the sella and sphenoid sinuses, symmetry and aeration of the sphenoid sinus and to delineate the relationship of the sphenoid sinus septum to the sella turcica floor and carotid canals. However, MRI was better to visualize the tumor, its soft tissue delineation and extension and exact relation to the cavernous sinus, carotid artery, optic pathway and the cisterns. This allowed optimal planning for surgery.

Table 3: Tumor extension based on CT scan & MRI in both groups

Tumors extension	1st group	2ndgroup	Total No.
Sellar extension	6 (30%)	4 (20%)	10(25%)
Suprasellar extension only	9 (45%)	10(50%)	19(47.5%)
Suprasellar with parasellar extension	5(25%)	6(30%)	11(27.5%)

Based on the imaging finding, the first group showed5 patients (25 %) with tumors confined to the sella, while 15 patients (75%) the tumors were extended suprasellar and parasellar. In second groupthereare5 patients (25 %) with tumors confined to the sella, while 15 patients (75 %), the tumors were extended suprasellar.

Tumor removal in the first group was achieved in 10 cases (50%) as evidenced by follow up CT & MRI, while subtotal removal was achieved in 8 cases (40%), and partial removal was achieved in 2 cases (10%). While in the second group out of 20 cases, the total removal was achieved in 5 cases (25%), while subtotal removal was achieved in 7 cases (35%) and partial removal was achieved in 8 cases (40%) because of their suprasellar and parasellar extensions.

Table 4: Represents the extent of tumor removal among 2 groups

Extent of resection	1st group N=20	2nd group N=20	Total N=40
Total resection	10 (50%)	5 (25%)	15(37.5%)
Subtotal resection	8(40%)	7(35%)	15 (37.5%)
Partial resection	2(10%)	8(40%)	10(25%)

The overall clinical improvement between the two groups is demonstrated in table 13. Persistence of the preoperative symptoms was related to partial removal of the tumors.

Table 5: Represents clinical improvement between the two groups:

Degree of improvement	1st group	2nd group	Total No. 40
Totally cured	12 (60%)	7(35%)	19(47.5%)
Improved with residual symptoms	6(30%)	8(40%)	14(35%)
Persistence of the preop. symptoms	2(10 %)	5(25%)	7 (17.5%)

The hospital stay was shorter in the first group than second group. The average length of hospital stay in the endoscopic group was 2.4 days with median of 2 days, while the average length of hospital stay in the microscopic group was 4.2 days with median of 4 days. And The mean operative time in the first group (endoscopic group) is shorter than in second group (microscopic group). The mean operative time was 1.30 hours .in endoscopic group endoscopic group while in microscopic group was 3 hours.

Among the microscopic resection group, intraoperative CSF leaks occurred in 6 patients (24%), whereas intraoperative CSF leaks occurred in 7 individuals (28%) undergoing endoscopic resection. Postoperative CSF leaks occurred in only 1 patient (4%) in the microscopic resection group compared with 3 patients (12%) in the endoscopic group. The most common complication in the microscopic group was DI, which occurred in 4 patients (16%) postoperatively. One patient in endoscopic group resection experienced DI.

The postoperative follow up and further treatment in the endoscopic group, 14 patients (70%) did not need any further treatment, while 5 patients (25%) referred to radiosurgery, and only 1 patient (5%) needed to redo surgery because of the large residual tumor. In the microscopic group, 10 patients (50%) did not need any further treatment. 3 patients (15%) referred to the radiosurgery and 7 patients (35%) to redo the surgery because of the large residual tumor .

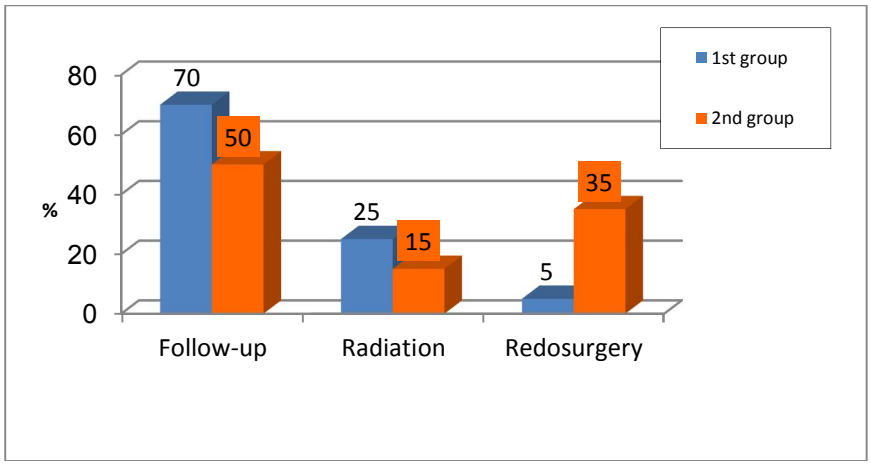

Chart 1: The postoperative follow up and further treatment elicited in both groups:

4. Discussion

Since the initial transsphenoidal approach performed by Schloffer, the transsphenoidal approach has become the preferred surgical approach to most pituitary tumors. Transitional steps are taking place among neurosurgeons from traditional microscopic transsphenoidal surgery to endoscopic endonasal pituitary surgery (18).

The introduction of endoscopes in the 1980s not only allow a panoramic view but also allow the advancement of this view into the surgical field. Jankowski *et al.* were the first to bring their application to access of the pituitary in 1992. Then (13) have reported a series of 50 patients who underwent endoscopic endonasal transsphenoidal surgery with encouraging results. Purely endoscopic approaches to pituitary adenomas have been described as a safe and effective alternative to the traditional microscopic procedure (7)

Transsphenoidal surgery remains the main approach for resecting pituitary tumors and other lesions of the sellar and parasellar regions (19).

This study compare the microscopic and the endoscopic transsphenoidal pituitary surgery regarding to the degree of exposure of hidden areas, operative time, postoperative hospital stay, occurrence of complications, postoperative tumor residue and resection capabilities. The study included 40 patient divided into two groups each included 20 patients with pituitary adenomas. The study was done from October 2010to October 2013. Although the patients of both groups were randomly chosen, there was no significant difference between them regarding age, sex distribution, visual field defects, or preoperative imaging assessment of tumor size or extensions.

Regarding the age and sex of the patients, the age of the whole population ranged from 20 to 50 years with a mean of 35 years old. This is coincided with some series (11) where they had age mean of 35.85 years in their study. However others (25) had slightly higher mean of age (around 45 years old). Our study included 13 males and 27 females with a male : female ratio 1:2(female predominance). This agrees the data recorded by a series (25)which had male to female ratio of 3:4 and 2:3 respectively.

The most common presenting symptom was headache in (92.5%) of patients followed by endocrinal disturbance (80%) then finally visual symptoms (75%) like blurring of vision, decreased visual acuity or visual field affection, The most common visual field defect was bitemporal hemianopia. (14**)** Stated that the presenting symptoms of pituitary adenomas are endocrinal symptoms,

headache or symptoms due to compression of the nearby structures like optic chiasm causing visual symptoms or cavernous sinus which rarely causes cranial nerve palsies.

The hormonal profile of our study was, 30% had nonfunctioning adenomas, while 70 % had functioning tumors, 45 % had Prolactinomas, 12.5% had mixed Prolactinomas & GH adenomas,7.5% had GH adenomas, and 2patients (5%) had TSH hypersecretion. This hormonal distribution is very variable in different studies. Most of them agree with our study in that the most common functioning adenomas are prolactinomas.

Based on imaging findings, it was found in our study that 25% of the patients had sellar tumors, 47.5% had tumors with suprasellar extension, and 27.5% had suprasellar and parasellar extension.

According to the extent of tumor removal this study showed more tumor resection in the endoscopic group than the microscopic group. In the endoscopic group, gross total resection has been achieved in 50 % of the cases as evidenced by the follow up MRI, while 40 % showed a subtotal resection, all of them were having suprasellar extension. Only in 2 patients (10 %) the resection was partial because the tumor was tough, vascular with parasellar extension.

On the other hand, the microscopic group, total removal has been achieved in only 25%, subtotal resection in 35 % and the resection was partial in 40% because of the supra and parasellar extension and that part of the tumors was not accessible.

All the above results are comparable to the results shown in different series. In a study of almost 40 patients who had undergone microscopic resection of tumor, when the sella was subsequently evaluated using an angled endoscope, 40% of patients had residual tumor(10).

Other study also found that more than 40% of patients undergoing a transsphenoidal resection using the microscopic approach had residual tumor that was identified only by the endoscope(12).

Other authors using the endoscopic assisted technique in which the microscope is used in the approach but the endoscope is then used to evaluate the sella and ensure the complete tumor resection have agreed the superiority of the endoscopic view(1).

In our study, 12 patients (60 %) in the endoscopic group were totally cured with improvement of all preoperative symptoms, 6 patients (30%) were improved with some residual symptoms remained and 2 patients (10 %) did not improve and their symptoms persisted as preoperative.

In the microscopic group 7 patients (35 %) were totally cured, 8 patients (40 %) improved with residual symptoms and 5 patients (25 %) did not improved.

Our results are compared to the results of other Authors, (7) were evaluated 120 patients with functioning adenomas, and the remission rate of hypersecretion was significantly better in the endoscopic group than in the microsurgical group (63 versus 50%).This is comparable to the large series by other group(6), which achieved 71% biochemical cure in growth hormone (GH) secreting adenomas, and 81 and 88% remission rates in Cushing's disease and prolactinomas, respectively(7). Additionally, others reported on 300 patients undergoing endoscopic resection with a similar cure rate of 87% in GH secreting adenomas, 86% in Cushing's disease, and 80% in Prolactinomas(15).

Regarding to the visual field assessment, among14 patients with preoperative visual symptoms in the endoscopic group, 12 (85.8%) showed varying degrees of visual improvement after surgery and only 2 patients (14.2%) did not improve. In the microscopic group among the 16 patients, 10 of them (62.5%) showed visual improvement, while the other 6 (47.5%) showed no improvement. Non improvement was either related to partial removal of the tumor or the rapid onset of visual deterioration as in case of apoplexy. Some series reported complete normalization of preoperative visual defects in 50% of endoscopically approached tumors with an additional 39% having improvement in patients with preoperative loss of visual field or acuity(6).

In a large microscopic series of almost 300 patients with preoperative visual deficits reported complete recovery of vision in 40%, and improvement in 50%(16).

This agrees with the study(25), reported incidence of 43% visual field defects with 77% improvement after surgery and with other study(11), who reported 50% preoperative diminution of vision. All their patients had improved vision postoperatively.

The operative time and postoperative hospital stay in this study, the mean operative time in endoscopic group shorter than microscopic group. It was 1.30 hours in endoscopic group while in microscopic group was 3 hours. However most authors have the opinion that endoscopes decrease the need for nasal packing and allow for shorter operative times and hospital stays (12) and (21).

Complications in transsphenoidal pituitary surgery are typically related to blind dissection, inability to differentiate normal gland from tumor, injury to the optic tracts and chiasm, or aggressive tumor dissection near the lateral and posterior aspects of the sella turcica (20).

Among the microscopic resection group, intraoperative CSF leaks occurred in 6 patients (24%), whereas intraoperative CSF leaks occurred in 7 individuals (28%) undergoing endoscopic resection. Postoperative CSF leaks occurred in only 1 patient (4%) in the microscopic resection group compared with 3 patients (12%) in the endoscopic group. The most common complication in the microscopic group was DI, which occurred in 4 patients (16%) postoperatively. One patient in endoscopic group resection experienced DI. On series (3) reported an intraoperative CSF leak in 37% of their patients who underwent endonasal endoscopic pituitary surgery. In some studies (22) 9% of their patients developed intraoperative CSF leak. They repaired the defect with intrasellar placement of abdominal fat and fibrin glue and lumbar drainage for 5 days postoperatively. A study reported on 50 patients, half undergoing microscopic approaches and half undergoing endoscopic approaches, showing comparable complication rates between the two groups for both CSF leak and incidence of diabetes insipidis, with a trend toward less diabetes insipidis in the endoscopic group (17).

Our postoperative follow up and further treatment in this study was based on either total removal of the tumor or evidence of residual or recurrence in the postoperative MRI. Among the 20 patients of the endoscopic group, 14 of them (70%) did not need any further treatment and referred only to regular follow up, while 5 patients (25%) referred to radiosurgery for the residual part of the tumor. Only 1 patient (5%) needed repeated transsphenoidal surgery because of large residual tumor left. For the 20 patient in microscopic group, 10 of them (50%) did not need any further treatment and only referred to follow up. 3 patients (15%) referred to radiosurgery and 7 patients (35%) repeated the surgery because of the large residual tumor.

Conclusion

The pure endoscopic approach is a safe, effective approach to sellar region tumors that offers several advantages over the microscopic approach. It provides an excellent wide-angle and magnified view of the operative anatomy, and although it requires more anatomical exposure it remains within the group of minimally invasive approaches to the sella. High disease control rates and low rates of complications are some of the most important points related to the technique. Some of the factors related to the success of endoscopic surgery are lesion size, suprasellar/ parasellar extension, and the degree of sella floor erosion

References

1. Baussart B, Aghakhani N, Portier F: Endoscopic and surgical treatment of pituitary macroadenomas and invasive suprasellar tumors. A retrospective series of 13 consecutive patients. Neurochirurgie 51:455–463,2005.
2. Bushe KA, Halves E: Modifizierte Technik bei transnasaler Operation der Hypophysengeschwulste. ActaNeurochir, 41:163–175, 1978
3. Cappabianca P., Cavallo L.M., Valente V., :Sellar repair with fibrin sealant and collagen fleece after endoscopic endonasal transsphenoidal surgery. Surg Neurol., 62:227–233, 2004.
4. Carrau RL, Jho HD, Ko Y: Transnasal-transsphenoidal endoscopic surgery of the pituitary gland. Laryngoscope, 106: 914–918, 1996
5. Cushing H: The Weir Mitchell Lecture: Surgical experiences with pituitary disorders. J Am Med Assoc., 63:1515–1525, 1914
6. 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, 62:1006–1015, 2008.
7. D'Haens J, Van Rompaey K, Stadnik T, Haentjens P, Poppe K, Velkeniers B: Fully endoscopic transsphenoidal surgery for functioning pituitary adenomas: a retrospective comparison with traditional transsphenoidal microsurgery in the same institution. SurgNeurol., 72:336–340, 2009
8. Ezzat S, Asa SL, Couldwell WT, Barr CE, Dodge WE,VanceML, *et al.*: The prevalence of pituitary adenomas: a systematicreview. Cancer 101:613–619, 2004
9. Hardy J: [Surgery of the pituitary gland, using the trans-sphenoidal approach. Comparative study of 2 technical methods.] Union Med Canada, 96:702–712, 1967
10. Helal M.Z.: Combined micro-endoscopic trans-sphenoid excisions of pituitary macroadenomas. Eur Arch Otorhinolaryngol., 252:186–189, 1995.
11. Jane JA Jr, Han J, Prevedello DM, Jagannathan J, Dumont AS, Laws ER Jr: Perspectives on endoscopic transsphenoidal surgery. Neurosurg Focus, 19(6):E2, 2005
12. Jarrahy R, Berci G, Shahinian HK.: Assessment of the efficacy of endoscopy in pituitary adenoma resection. Arch Otolaryngol Head Neck Surg 126: 1487–1490, 2000.

13. Jho HD, Carrau RL: Endoscopic endonasal transsphenoidal surgery: Experience with 50 patients. J Neurosurg, 87:44–51, 1997.
14. Johnson A.P: Pituitary tumors: medical and surgical management. In: Scott Brown's Otorhinolaryngology, Head and Neck Surgery, 7th edition. Gleason M. (ed). Publisher: Edward Arnold., 4098-4118, 2008.
15. Kabil MS, Eby JB, Shahinian HK. : Fully endoscopic transnasal versus transseptal transphenoidal pituitary surgery. Neurosurg., 15:190–196, 2005.
16. Mortini P, Losa M, Barzaghi R, *et al*.: Results of transsphenoidal surgery in a large series of patients with pituitary adenoma. Neurosurgery, 56:1222–1233, 2005.
17. O'Malley BW Jr, Grady MS, Gabel BC, *et al.*: Comparison of endoscopic and microscopic removal of pituitary adenomas: single-surgeon experience and the learning curve. Neurosurg Focus, 25:E10,2008.
18. Powell MP, Lightman Sl, Perneczky A: The management of pituitary tumors: a handbook. Churchill Livingstone, London, 12: 263-264,1997.
19. Rosen MR, Saigal K, Evans J, Keane WM: A review of the endoscopic approach to the pituitary through the sphenoid sinus. Curr Opin Otolaryngol Head Neck Surg., 14:6–13, 2006
20. Schaberg. Madeleine R., Anand Vijay K., Schwartz Theodore H. and Cobb William: Microscopic versus endoscopic transnasal pituitary surgery. Current Opinion in Otolaryngology & Head and Neck Surgery, 18:8–14, 2010.
21. Sethi DS, Pillay PK: Endoscopic management of lesions of the sellaturcica. J LaryngolOtol., 109:956–962, 1995.
22. Sethi D.S. and Leong J.L.,: Endoscopic Pituitary Surgery. Otolaryngologic Clinics of North America. 39: 563–583, 2006.
23. Shin JL, Asa SL, Woodhouse LJ, Smyth HS, Ezzat S:Cystic lesions of the pituitary:Clinicopathological features distinguishing craniopharyngioma, Rathke's cleft cyst, and arachnoid cyst. J ClinEndocrinolMetab., 84:3972 – 3982,1999.
24. Schloffer H: Erfolgreiche Operation eines Hypophysentumors auf nasalem Wege. Wien KlinWchnschr, 20:621–624, 1907
25. Zada G, Kelly DF, Cohan P, *et al.*: Endonasal transsphenoidal approach for pituitary adenomas and other sellar lesions: an assessment of efficacy, safety, and patient impressions. J Neurosurg., 98:350–358, 2003

12/18/2014