Endoscopic Endonasal Trans-sphenoidal Approach to the Sellar Region: Results of Endoscopic Dissection on 30 Cadavers

Sellar Bölgeye Endoskopik Endonazal Trans-sfenoidal Yaklaşım: 30 Kadavranın Endoskopik Diseksiyon Sonuçları

Bashar ABUZAYED[1]
Necmettin TANRIÖVER[2]
Fatma ÖZLEN[3]
Nurperi GAZİOĞLU[4]
Mustafa Onur ULU[5]
Ali Metin KAFADAR[6]
Berna ERASLAN[7]
Ziya AKAR[8]

[1,2,3,4,6,8] Istanbul University Cerrahpasa Medical Faculty, Department of Neurosurgery, İstanbul, Turkey
[5] Sakarya ToyotoSA State Hospital, Department of Neurosurgery, Sakarya, Turkey
[7] Forensic Medicine Institution, Morgue Specialization Department, İstanbul, Turkey

ABSTRACT

AIM: To recognize the endoscopic anatomy of the surgical corridor along the nasal cavity, sphenoidal sinus and the sellar area to delineate the pure endoscopic endonasal trans-sphenoidal approach (EETSA) to the region of the pituitary gland.

MATERIAL and METHODS: The endoscopic anatomy of the nasal cavity, sphenoid sinus and the sellar region was studied in 30 fresh cadavers (mean age 42.1 / range 18-66) and dissections were performed in a stepwise manner to simulate EETSA to the sellar region.

RESULTS: The sphenoid ostium, located 14.9 mm superior to the choana, was identified at the midpoint between the nasal septum and the superior turbinate in 23 specimens. The shape of the sphenoid ostium was linear (35%), fusiform (30%), oval(22%) or circular (13%). The mean width of the pituitary gland was 14.3 mm and the average minimum distance between the internal carotid arteries on both sides ranged between 13 to 22 mm. Following total hypophysectomy in 12 specimens, the width and length of diaphragma sellae was measured 10.83 and 5.83 mms respectively.

CONCLUSION: This study documents that variations are common in nasal, sphenoidal and sellar phases of the trans-sphenoidal approach. Detailed knowledge of the basic anatomical relationships through the view of the endoscope and performing endoscopic dissections in large number of specimens will facilitate the endoscopic surgical procedures and decrease the rate of surgical complications.

KEY WORDS: Endoscopic approach, Pituitary tumour, Transsphenoidal surgery, Skull-base surgery, Surgical anatomy

ÖZ

AMAÇ: Nazal kavite, sfenoidal sinüs ve sellar bölge boyunca uzanan cerrahi koridorun endoskopik anatomisini incelemek ve pituiter bez bölgesine endoskopik endonazal transfenoidal yaklaşımı (EETSY) uygulamak.

YÖNTEM ve GEREÇ: Nazal kavite, sfenoid sinüs ve sellar bölge endoskopik anatomisi 30 taze kadavrada (ortalama yaş 42.1 / aralık: 18-66) çalışıldı ve aşama aşama diseksiyon yapılarak sellar bölgeye EETSY uygulandı.

BULGULAR: Sfenoid ostiumun kohananın ortalama 14.9 mm superiorunda olduğu görüldü ve 23 spesimende nazal septum ve superior turbinatın arasında orta noktada tespit edildi.Sfenoid ostiumun şekli lineer(%35), fuziform(%30), oval(22%) veya sirküler(%13) olarak yorumlandı. Pituiter bezin ortalama genişliği 14.3 mm'di ve her iki tarafta internal karotid arterler arasındaki minimum ortalama mesafe 13 ila 22 mm arasında değişmekteydi. 12 spesimene uygulanan total hipofizektomi sonrasında diafragma sella'nın ortalama genişlik ve uzunluğu sırasıyla 10.83 ve 5.83 mm olarak ölçüldü.

SONUÇ: Bu çalışma, transnazal transsfenoidal yaklaşımın nazal, sfenoidal ve sellar aşamalarında anatomik varyasyonların sık olduğunu göstermektedir. Endoskopik bakış açısından temel anatomik ilişkilerin detaylı bir şekilde bilinmesi ve çok miktarda spesimen üzerinde endoskopik diseksiyonların uygulanması endoskopik cerrahi uygulamaları kolaylaştıracak ve cerrahi komplikasyon yüzdesini de düşürecektir.

ANAHTAR SOZCÜKLER: Endoskopik yaklaşım, Pituiter tümör, Transsfenoidal cerrahi, Kafa tabanı cerrahisi, Cerrahi anatomi

Received : 23.09.2008
Accepted : 02.02.2009

Correspondence address:
Necmettin TANRIÖVER
E-mail: nctan27@yahoo.com

INTRODUCTION

Since the seminal work of Jho and Carrau at the University of Pittsburgh Medical Center, the endoscopic endonasal trans-sphenoidal approach (EETSA) has been a major advancement in the management of numerous sellar region pathologies (16,33,34). The approach provides exceptional exposure of the extra- and intradural components of the lesions in and around the region of sella, along with neighbouring structures, providing a controlled surgical manipulation in every step of surgery due to well-documented advantages of the endoscope (8,11,12-15,17,18,20,22,23,24,26,27,30,31, 35,36,43,47,48,49,52,55). EETSA can even superimpose many traditional microscopic skull base approaches with its minimal invasiveness and superior visualization in skilled and experienced hands (1-6,9,17,18,19,23,25-28,35,36,39,42,43,51,54). However, before the surgeon embarks on EETSA with two-dimensional and somewhat distorted images, it is ideal that the surgical anatomy of the region as seen through an endoscope and its variations be clearly understood by thoroughly mastering the approach in cadaveric dissections.

The aim of this study was to demonstrate the anatomical variability in bone structures, natural openings of the sinuses, degree of aeration and septations within the sinuses and alterations in localization of neurovascular structures from an endoscopic view. Endoscopic dissections were performed in a stepwise manner to simulate the pure EETSA, so that the results obtained along the surgical path to the sellar region could be appreciated from a practical view of the endoscopic skull base surgery.

MATERIALS and METHODS

The endoscopic anatomy of the nasal cavity, sphenoid sinus and the sellar region was studied in Morgue Specialization Department of Forensic Medicine Institution, in Istanbul. Thirty fresh cadavers (mean age: 42.1 / range 18-66) with no history of head trauma or craniofacial surgery were dissected following the initial autopsy examination and approval of the forensic medicine team. EETSA to the sellar region was performed in a stepwise manner and the variations in the bone and neurovascular structures along the surgical path were recorded and surgically important anatomic measurements were documented. Total hypophysectomy was performed in 12 of the 30 specimens to delineate the endoscopic anatomy of the diaphragma sellae.

A rigid rod lens endoscope (Karl Storz and Co., Tuttlingen, Germany) with diameters of 4.0 mm (18 cm in length) and angles of 0 and 30 degrees were used. The endoscope was connected to a light source via a fiberoptic cable and to a camera, and the images were viewed on a 21-inch monitor. The scope was held by the primary surgeon in all dissections.

RESULTS

The cadavers were placed supine, with the head in neutral position and adducted approximately 10-15 degrees toward the left shoulder. With the endoscope in the left and the suction in the right hand, the endoscope was introduced to the right nostril nearly parallel to the floor of the nasal cavity. Nasal septum medially and the inferior and middle turbinates laterally were initially exposed (Figure 1A and B). By gently retracting the middle turbinate medially and introducing the endoscope to the middle meatus, the uncinate process anteriorly, ethmoid bullae posteriorly and the maxillary ostium between both structures within the hiatus semilunaris were identified (Figure 1 C and D). The choana was identified at the posteroinferior end of the nasal cavity by following the medial edge of tail of the inferior turbinate and by recognizing the medial location of the vomer at this point (Figure 1E). The endoscope was then directed superiorly approximately 15 degrees from the floor of the nasal cavity and the sphenoethmoidal recess was reached (Figure 2A). The middle and superior turbinates were lateralized by a dissector to expose the sphenoid ostium. The sphenoid ostium could be identified at an average distance of 14.9 mm superior to choana in 23 of 30 specimens and it was located in the midway between the nasal septum and superior turbinate (Figure 2B and inset). This measurement, along with all other measurements in this study has been performed via a paper ruler introduced through the nostril. The mean angle of the telescope to the hard palate was 15 degrees, when the sphenoid ostium was located at the center of the endoscopic view during the nasal phase of the dissection and this finding was confirmed by checking the position of the endoscope with fluoroscopy (Figure 2C). The shape of the sphenoid ostium was linear in shape in 8 of 23 specimens, fusiform in 7, oval in 5 and circular in 3 specimens (Figure 2D).

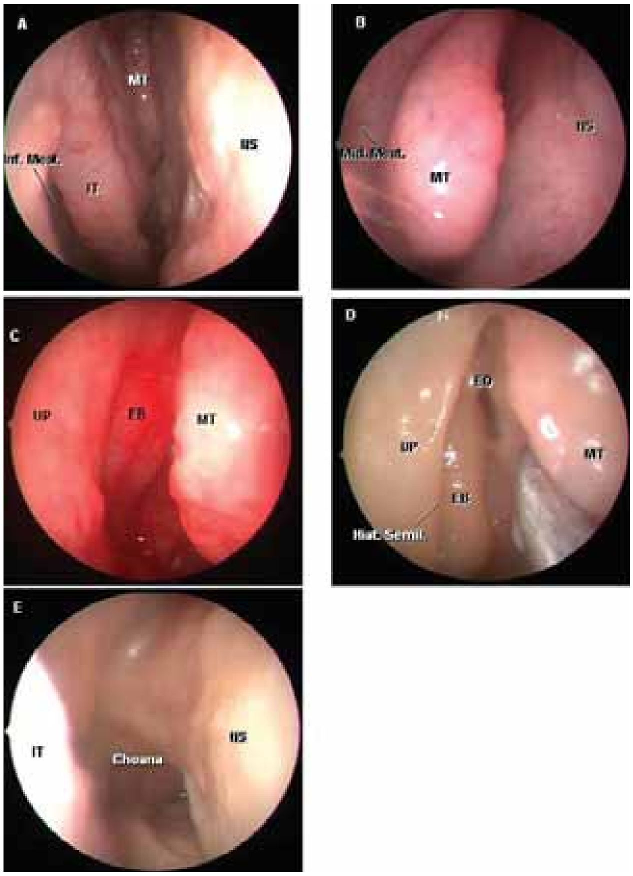

Figure 1: ***A*** *and* ***B****. Endoscopic view of a cadaveric dissection into the right nostril. The inferior and middle turbinates have been exposed along the surgical route.* ***C*** *and* ***D****. The endoscope has been introduced to the middle meatus, lateral to the middle turbinate, and the turbinate has been retracted medially (in 1D) to expose, from anterior to posterior, the uncinate process, hiatus semilunaris, ethmoid bullae and the ostium of the ethmoidal sinus.* ***E****. The choana has been exposed by following the medial edge of the tail of the inferior turbinate.* EB*: ethmoid bullae,* EO*: ostium of the ethmoidal sinus,* ET*: table for endoscopic instruments,* EU*: endoscopic unit,* Hiat.*: hiatus, Inf: inferior,* IT*: inferior turbinate,* Meat.*: meatus,* Mid.*: middle,* MT*: middle turbinate,* ***NS****: nasal septum,* P*: cadaver,* UP*: uncinate process,* S*: surgeon,* Semil.*: semilunaris.*

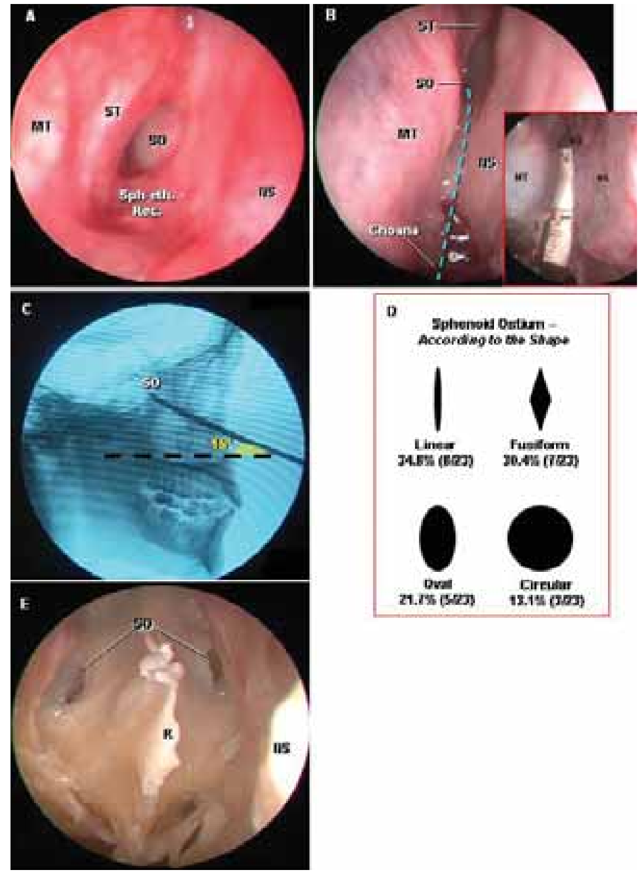

Figure 2: ***A****. The sphenoid ostium has been identified in the right spheno-ethmoidal recess. The configuration of the sphenoid ostium in this case is oval.* ***B****. The mean distance between the sphenoid ostium and the choana (*blue interrupted line*) is approximately 15 mm.* ***C.*** *The mean angle of the telescope to the hard palate was 15 degrees, when the sphenoid ostium was centered at the endoscopic view during the nasal phase of the dissection.* ***D****. The shape of the sphenoid ostium was appreciated as linear (35%), fusiform (30%), oval (22%) or circular (13%) in this study.* ***E.*** *The fractured nasal septum and the mucosa has been dissected lateraly to the left side exposing the anterior wall of the sphenoid sinus and the sphenoid ostia on both sides.* MT*: middle turbinate,* NS*: nasal septum,* R*: rostrum,* SO*: superior turbinate,* ST*: superior turbinate*

A vertical incision 1 cm long was performed along the nasal septum medial to the sphenoid ostium using an endoscopic knife. The posterior part of the nasal septum was pushed to the left side separating it from the rostrum and septal mucosa of the left nasal cavity was then visualized. The dissector was passed between the rostrum and the fractured nasal septum and the mucosa is dissected laterally and medially on both sides exposing the anterior wall of the sphenoid sinus and both ostiae (Figure 2E). The anterior wall of the sphenoid sinus was resected either with high-speed drill or an angled Kerrison rongeur. According to the degree of aeration, the sphenoid sinus was considered as sellar in 24 specimens (80%) and presellar in 6 (20%). The variations in orientation and location of the septae in the sphenoidal sinus were recorded at this stage of the dissection. The average number of septae within the sphenoid sinus was 2 (range 1 to 5), and most of them were vertically oriented. The septae within the sphenoid sinus and sinus mucosa were removed, exposing the sellar floor and other anatomic landmarks in the sinus (Figure 3A and B). At the center of the exposure, sellar floor was identified, along with carotid and optic protuberances on both sides. The opticocarotid recesses, which represent the optic strut and the anterior clinoids, were located between the optic and carotid protuberance (Figure 3C). The intrasphenoidal septae were extending towards the opticocarotid recesses in 9 specimens (30%).

The floor of the sella was fractured by a sharp dissector and widened with an angled 2-mm Kerrison rongeur to expose the sellar dura (Figure 3D). We used a high-speed drill to open the sellar floor in all 6 specimens with a presellar type sphenoid sinus. After opening the dura, the pituitary gland was visualized and gentle elevation of the gland exposed the posterior lobe of the gland (Figure 3E). The width of the pituitary gland and the minimum distance between both internal carotid arteries were measured and documented at this stage of the dissection (Figure 3F). The medial wall of cavernous sinus and inferior hypophyseal artery, arising from the posterior bend of the cavernous segment of the ICA could be exposed by retracting the pituitary gland medially (Figure 4A and B). Total hypophysectomy was performed in 12 of the 30 specimens in order to expose the diaphragma sella and measure its dimensions. The width of diaphragma sellae was measured as 10.83 mm (range 5-16 mm) and its length ranged between 4 to 10 mm (mean 5.83) (Figure 4C). Table I summarizes the results of this study in 30 endoscopic dissections.

DISCUSSION

The trans-sphenoidal midline route is the shortest surgical pathway to the sellar region, provides sufficient exposure with the least amount of brain retraction and offers low mortality and morbidity rates (7,10,21,22,29,32,38-42,44-47,52-55). Introduction of the endoscope for the sellar region, following functional endoscopic sinus surgery, has been a major advancement not only for pituitary surgery but also for skull base surgery (16,32-34, 37). Indeed, performing and mastering EETSA to sellar region has been the first revolutionary step in introducing the extended endoscopic skull base approaches (8,15,51). Although there has been a significant number of studies on surgical anatomy of the endoscopic endonasal approach to the sellar and parasellar region, the number of specimens in these studies were limited (1,2,18,19,20,50,52). Due to problems and expense involved in obtaining specimens for research in surgical anatomy, there

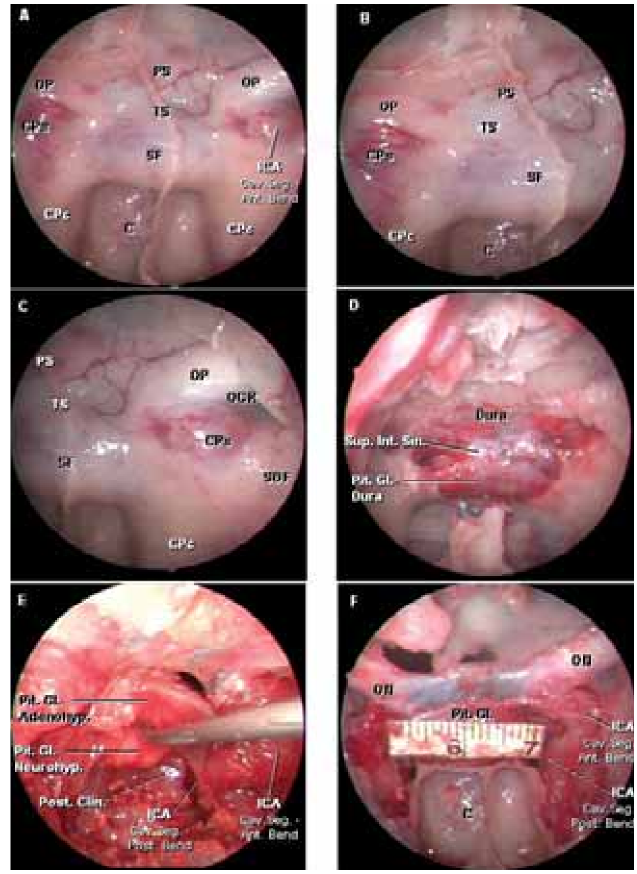

Figure 3: ***A****. Endoscopic view of sphenoid sinus. The septae within the sphenoid sinus and sinus mucosa have been removed exposing the sellar floor and other anatomic landmarks in the sinus, including the optic and carotid protuberances.* ***B****. Enlarged view of right side of sella. The optic protuberance, sellar and clival carotid protuberances have been exposed on the right side. The sellar floor, tuberculum sellae between the optic protuberances, and the planum sphenoidale have been exposed. The anterior bend of the cavernous segment of the ICA could be seen through the extremely thin transparent bone.* ***C****. Optico-carotid recess on the left side, located between the optic and carotid protuberances, corresponds to optic strut and the anterior clinoid more posteriorly. The superior orbital fissure has been identified anterolateral to the anterior bend of the cavernous ICA.* ***D****. The bone on the sellar floor, tuberculum sellae and part of the planum have been removed to expose the dura over the pituitary gland and the superior intercavernous sinus.* ***E****. The dura has been opened and the anterior lobe of the pituitary gland has been elevated with a dissector to show the posterior lobe. The posterior clinoids have been exposed just medial to the posterior bend of the ICA within the cavernous sinus.* ***F****. The safe surgical zone between the two ICAs, where the pituitary gland is located, was approximately 18 mm in this study. However, the minimum intercarotid distance may be as short as 13 mm. The nearest point between both ICA at the sellar region is the posterior bend of the cavernous segment of the ICA in almost all cases.* Adenohyp.: *adenohypophysis,* Ant.: *anterior,* C: *clivus,* Cav.: *cavernous,* Clin.: *clinoid,* CPc: *carotid protuberance (clival part),* CPs: *carotid protuberance (sellar part),* Gl.: *gland,* ICA: *internal carotid artery,* Int.: *intercavernous,* Neurohyp.: *neurohypophysis,* OCR: *Optico-carotid recess,* ON: *optic nerve,* OP: *optic protuberance,* Pit.: *pituitary,* PS: *planum sphenoidale,* TS: *tuberculum sellae,* Post.: *posterior,* Seg.: *segment,* SF: *sellar floor,* Sin.: *sinus,* SOF: *superior orbital fissure,* Sup.: *superior.*

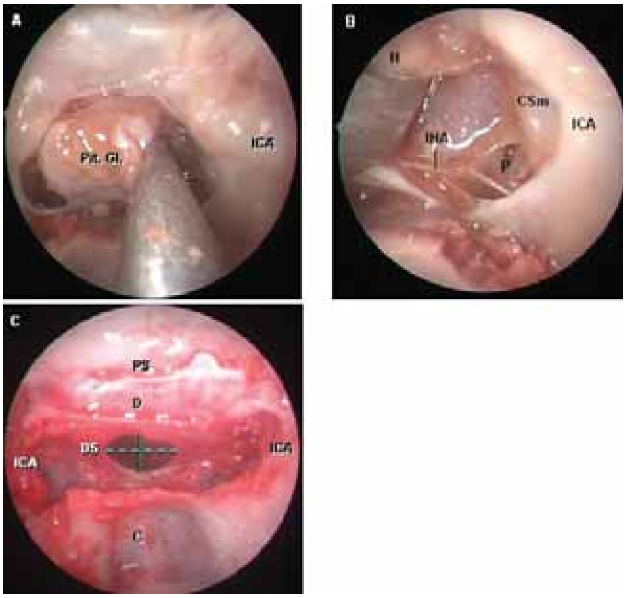

Figure 4: ***A***. *The pituitary gland has been retracted medially to expose the medial wall of the cavernous sinus and the cavernous segment of the left ICA.* ***B***. *The endoscope has been further advanced anteriorly to expose the inferior hypophyseal artery, arising from the posterior bend of the cavernous ICA and passing to the posterior part of the pituitary gland.* ***C***. *The pituitary gland has been removed via the endoscopic endonasal approach to expose the opening of the diaphragma sellae. The average width of diaphragma sellae (*blue interrupted line*) was 11 mm and its length (*green interrupted line*) ranged between 4 to 10 mm (mean 5.83) in our study.* C*: clivus,* CSm*: medial wall of cavernous sinus,* D*: dura,* DS*: diaphragma sellae,* Gl.*: gland,* H*: pituitary gland,* ICA*: internal carotid artery,* IHA*: inferior hypophyseal artery,* Pit.*: pituitary* PS*: planum sphenoidale.*

has been a tendency to dissect a limited number of specimens during research on skull base endoscopy. However, the limited number of specimens may cause significant differences between the results of similar studies. Close collaboration with Forensic Medicine may be a partial solution to this problem, especially if minimally invasive techniques are being used in the study. Our study presents the largest endoscopic skull base dissection series to date, which may overcome some of the limitations of the previous studies.

This study, similar to the previous reports, documents that the standard EETSA without removing any turbinates creates a sufficient corridor with full exposure to the sellar region. The surgeon should be aware of the variations of different anatomical structures along the surgical corridor and the target region from the endoscopic view to perform a standard EETSA to the sellar region. One

Table I: The summary of the results in 30 cadaveric dissections.

	age	sex	ostium	C-O	SW	HW	ICD	septae	ST	DS	O-P	P-A	O	S
1	64	m	+	16	34	18	21	2	sellar					
2	30	m	+	16	36	14	18	1	sellar					
3	26	f	+	15	38	19	22	1	sellar					
4	32	m	+	14	36	17	22	3	presellar					
5	40	m	+	15	37	13	16	1	sellar					
6	27	m	+	13	35	15	19	2	sellar					
7	62	m	-	13	32	11	17	1	sellar					
8	23	m	+	16	36	16	19	5	sellar					
9	32	m	+	13	39	15	20	5	presellar					
10	44	m	+	14	34	13	19	1	sellar					
11	28	f	+	16	33	13	19	2	sellar					
12	64	m	+	15	30	11	17	1	sellar					
13	39	m	+	14	30	12	18	2	sellar					
14	66	m	-	16	31	12	17	1	presellar					
15	21	m	+	14	36	15	19	1	sellar					
16	37	m	-	17	34	18	20	1	sellar					
17	18	m	+	16	31	13	18	2	presellar					
18	53	f	-	13	38	15	18	3	sellar					
19	26	m	+	16	35	16	18	3	presellar	8x5	14	15		
20	62	m	-	14	36	15	16	2	sellar	16x7	16	17		
21	42	f	+	17	34	16	18	1	sellar	12x6	13	14		
22	31	m	-	15	32	15	18	2	sellar	14x10	9	10		
23	42	f	+	14	36	17	20	1	sellar	7x4	9	10		
24	53	m	+	17	37	11	17	2	sellae	16x6	13	15		
25	43	f	+	15	33	11	13	4	sellar	9x4	10	13		
26	29	m	+	16	32	13	16	1	presellar	8x7	10	11		
27	65	m	+	13	37	14	16	3	sellar	10x4	10	12		
28	63	m	-	14	36	12	14	1	sellar	5x4	8	10		
29	46	m	+	16	38	15	18	1	sellar	15x8	11	16		
30	55	f	_	15	35	15	17	1	sellar	10x5	10	13		

Abbreviations: C-O: *choana-ostium distance,* ***SW***: *width of the sellar floor,* ***HW***: *width of the pituitary gland,* ***ICD***: *intercarotid distance,* ***ST***: *the aeration of sphenoid sinus,* ***DS***: *diaphragma sella opening - dimensions,* ***O-P***: *optic canal - posterior ethmoidal artery distance,* ***P-A***: *posterior ethmoidal- anterior ethmoidal artery distance,* ***O***: *shape of the sphenoid ostium,* ***S***: *orientation of septae within the shenoid sinus.*

of the critical surgical maneuvers during the initial phase of the EETSA is to accurately identify the sphenoid ostium. The surgeon will identify the sphenoid ostium about 15 mm superior to the posterior nasal aperture, the choana in approximately 77% of the cases. In the remaining 10-15%, most often a well-pneumatized sphenoid sinus, with a relatively narrow sphenoethmoidal recess and/or a prominent superior turbinate can be expected. It should be noted that the mean angle of the telescope to the hard palate is about 15 degrees, when the sphenoid ostium is targeted at the center of the endoscopic view and this can easily be confirmed by checking the position of the endoscope with fluoroscopy. One of four types of the shape of sphenoid ostium can be appreciated during endoscopic surgery and the most common type is a linear configuration, which has the smallest opening among others. The circular ostium is larger than the other three types and only occurs in approximately 13% of the cases. In our study, one out of five cadavers had a presellar type of sphenoid sinus and contrary to surgery, all were discovered during the endoscopic dissection. We were able to identify the sphenoid ostium in all presellar sphenoid sinuses, but one.

During endoscopic dissection within the sphenoid sinus, the surgeon may expect 1 to 5 sphenoid septae, most of which would be oriented vertically. In our study, we found a tendency of the septae to extend into both opticocarotid recesses. All septal variations within the sphenoid sinus should be carefully evaluated prior to endoscopic surgery in order to prevent surgical complications. An average safe area of 18 mm exists between the two internal carotis arteries (ICA) to open the sellar floor and expose the pituitary gland. However, this distance may be as short as 13 mm and the posterior bend of the cavernous segment of the ICA represents the nearest point between both ICA in most cases. The diaphragma sellae, a fold of dura with a central defect, forms an incomplete roof above the pituitary gland and can be endoscopically visualized following total hypophysectomy or removal of macroadenomas. The width of the diaphragma sellae is approximately 11 mm and its antero-posterior length is 6 mm. We were able to locate the diaphragma sellae in all 12 specimens following total hypophysectomy and the diaphragm separated the anterior lobe of the pituitary gland from the overlying optic chiasm in all of these dissections.

Inability to recognize important anatomical structures, such as the optic and carotid prominences, along the surgical path due to arterial or venous blood obscuring the surgical field may disturb the endoscopic manipulations and extend the time of surgery. This difficulty can be overcome by precise knowledge of the surgical anatomy related to the endoscopic surgical corridor and, also, with careful preoperative planning to determine neurovascular structures that would be encountered during each step of the endoscopic procedure. We believe that both of these factors play major role for the success of any endoscopic skull base surgery, especially if performed without image guidance.

The standard EETSA to the sellar region, the most widely used endoscopic surgical pathway to the skull base, is similar to the microsurgical trans-sylvian approach to the basal cisterns in several ways. Both of these approaches are the best gateways to a wide target area, provide a sufficient surgical corridor in order to access a broad range of intra- and extracranial lesions and may be extended in multiple directions. However, we believe that the neurosurgeon should not underestimate the importance of training in surgical anatomy for either of these well-described, surgical corridors. Skull base endoscopy training through cadaveric dissections may be an important step to overcome some of the difficulties encountered during EETSA, such as handling profound bleeding with endoscopic manipulations. The dissections in the training laboratory offer increased familiarity with the instruments and manipulations through a narrow corridor, thereby facilitating performing an accurate and safe surgery. Furthermore, the research on surgical anatomy of the endoscopic approaches to the skull base will lead to; 1) more popularized use of the endoscope in neurosurgery, 2) definition of novel endoscopic approaches and modifications, 3) extension of indications for the endoscopic approaches and 4) more developed endoscopic tools.

CONCLUSIONS

This study documents that variations are common in nasal, sphenoidal and sellar phases of the EETSA to the sellar region. A detailed knowledge of the basic anatomical relationships through the view of the endoscope and performing endoscopic dissections in a large and cumulative number of specimens will facilitate endoscopic surgical procedures and decrease the rate of surgical complications.

ACKNOWLEDGEMENTS

All of this work has been approved and supported by the Council of Forensic Medicine, The Republic of Turkey Ministry of Justice. The authors are grateful to Keramettin Kurt, M.D., President of the Council of Forensic Medicine, The Republic of Turkey Ministry of Justice and Gursel Cetin, M.D., Head of the Morgue Specialization Department, Forensic Medicine Institution in Istanbul.

REFERENCES

1. Alfieri A, Jho H: Endoscopic endonasal cavernous sinus surgery: an anatomic study. Neurosurgery 48:827-837, 2001
2. Alfieri A, Jho HD: Endoscopic endonasal approaches to the cavernous sinus: Surgical approaches. Neurosurgery 49:354-362, 2001
3. Al-Nashar IS, Carrau RL, Herrera A, Synderman CH: Endoscopic transnasal transpterygopalatine fossa approach to the lateral recess of the sphenoid sinus. Laryngoscope 114:528-532, 2004

4. Aust MR, McCaffrey TV, Atkinson J: Transnasal endoscopic approach to the sella turcica. Am J Rhinol 12:283-287, 1998
5. Badie B, Nguyen P, Preston JK: Endoscopic-guided direct endonasal approach for pituitary surgery. Surg Neurol 53:168-173, 2000
6. Bolger WE: Endoscopic transpterygoid approach to the lateral sphenoid recess: Surgical approach and clinical experience. Otolaryngology-Head and Neck Surgery 133:20-26, 2005
7. Cappabianca P, Alfieri A, Colao A, Cavallo LM, Fusco M, Peca C, Lombardi G, de Divitiis E: Endoscopic endonasal transsphenoidal surgery in recurrent and residual pituitary adenomas: technical note. Minim Invasive Neurosurg 43: 38-43, 2000
8. Cappabianca P, Alfieri A, de Divitiis E: Endoscopic endonasal transsphenoidal approach to the sella: Towards functional endoscopic pituitary surgery (FEPS). Minim Invasive Neurosurg 41: 66-73, 1998
9. Cappabianca P, Alfieri A, Thermes S, Buonamassa S, de Divitiis E: Instruments for endoscopic endonasal transsphenoidal surgery. Neurosurgery 45: 392-396, 1999
10. Cappabianca P, Cavallo LM, Colao A, de Divitiis E: Surgical complications associated with the endoscopic endonasal transsphenoidal approach for pituitary adenomas. J Neurosurg 97: 293-298, 2002
11. Cappabianca P, Cavallo LM, Colao A, Del Basso De Caro M, Esposito F, Cirillo S, Lombardi G, de Divitiis E: Endoscopic endonasal transsphenoidal approach: Outcome analysis of 100 consecutive procedures. Minim Invasive Neurosurg 45: 193-200, 2002
12. Cappabianca P, Cavallo LM, de Divitiis E: Endoscopic endonasal transsphenoidal surgery. Neurosurgery 55: 933-941, 2004
13. Cappabianca P, Cavallo LM, Esposito F, de Divitiis E: Endoscopic endonasal transsphenoidal surgery: Procedure, endoscopic equipment and instrumentation. Childs Nerv Syst 20: 796-801, 2004
14. Cappabianca P, Cavallo LM, Valente V, Romano I, D'Enza AI, Esposito F, de Divitiis E: Sellar repair with fibrin sealant and collagen fleece after endoscopic endonasal transsphenoidal surgery. Surg Neurol 62: 227-233, 2004
15. Cappabianca P, de Divitiis E: Endoscopy and transsphenoidal surgery. Neurosurgery 54: 1043-1050, 2004
16. Carrau RL, Jho HD, Ko Y: Transnasal trans-sphenoidal endoscopic surgery of the pituitary gland. Laryngoscope 106: 914-918, 1996
17. Carrau RL, Snyderman CH, Curtin HB, Janecka IP, Stechison M, Weissman JL: Computer-assisted intraoperative navigation during skull base surgery. Am J Otolaryngol 17: 95-101, 1996
18. Catapano D, Sloffer CA, Frank G, Pasquini E, D'Angelo VA, Lanzino G: Comparison between the microscope and endoscope in the direct endonasal extended transsphenoidal approach: anatomical study. J Neurosurg 104: 419-425, 2006
19. Cavallo LM, Cappabianca P, Galzio R, Iaconetta G, de Divitiis E, Tschabitscher M: Endoscopic transnasal approach to the cavernous sinus versus transcranial route: anatomic study. Neurosurgery 56 (2 Suppl): 379-389, 2005
20. Cavallo LM, Messina A, Cappabianca P, Esposito F, de Divitiis E, Gardner P, Tschabitscher M: Endoscopic endonasal surgery of the midline skull base: Anatomical study and clinical considerations. Neurosurg Focus 19(1): E2, 2005
21. Cavallo, LM, Briganti F, Cappabianca P, Maiuri F, Valente V, Tortora F, Volpe A, Messina A, Elefante A, de Divitiis E: Hemorrhagic vascular complications of endoscopic transsphenoidal surgery. Minim Invasive Neurosurg 47: 145-150, 2004
22. Charalampaki P, Reisch R, Ayad A, Conrad J, Welschehold S, Perneczky A, Wüster C: Endoscopic endonasal pituitary surgery: Surgical and outcome analysis of 50 cases. Journal of Clinical Neuroscience 14: 410-415, 2007
23. de Divitiis E, Cappabianca P, Cavallo LM: Endoscopic transsphenoidal approach: Adaptability of the procedure to different sellar lesions. Neurosurgery 51: 699-707, 2002
24. de Divitiis E, Cappabianca P: Microscopic and endoscopic transsphenoidal surgery. Neurosurgery 51: 1527-1530, 2002
25. Dusick JR, Esposito F, Kelly DF, Cohan P, DeSalles A, Becker DP, Martin NA: The extended direct endonasal transsphenoidal approach for nonadenomatous suprasellar tumors. J Neurosurg 102: 832-841, 2005
26. Frank G, Pasquini E, Doglietto F, Mazzatenta D, Sciarretta V, Farneti G, Calbucci F: The endoscopic extended transsphenoidal approach for craniopharyngiomas. Neurosurgery 59[Suppl1]:ONS75–83, 2006
27. Frank G, Pasquini E, Mazzatenta D: Extended transsphenoidal approach. J Neurosurg 95: 917-918, 2001
28. Frank G, Pasquini E: Endoscopic endonasal approaches to the cavernous sinus: Surgical approaches. Neurosurgery 50: 675, 2002
29. Fujii K, Chambers SM, Rhoton AL JR: Neurovascular relationships of the sphenoid sinus: a microsurgical study. J Neurosurg 50: 31-39, 1979
30. Gamea A, Fathi M, El-Guindy A: The use of rigid endoscope in trans-sphenoidal pituitary surgery. J Laryngol Otol 108: 19-22, 1994
31. 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
32. Jankowski R, Auque J, Simon C, Marchal JC, Hepner H, Wayoff M (1992) Endoscopic pituitary tumor surgery. Laryngoscope 102: 198-202
33. Jho HD, Carrau RL, Ko Y, Daly MA: Endoscopic pituitary surgery: an early experience. Surg Neurol 47: 213-223, 1997
34. Jho HD, Carrau RL: Endoscopic endonasal trans-sphenoidal surgery: experience with 50 patients. Neurosurg Focus 1:1-6, 1996
35. Jho HD, Ha HG: Endoscopic endonasal skull base surgery: Part 1-the midline anterior fossa skull base. Minim Invasive Neurosurg 47: 1–8, 2004
36. Jho HD, Ha HG: Endoscopic endonasal skull base surgery: Part 2-the cavernous sinus. Minim Invasive Neurosurg 47: 9-15, 2004
37. Kennedy DW: Functional endoscopic sinus surgery: Technique. Arch Otolaryngol 111: 643-649, 1985
38. Lang J: Clinical anatomy of the nose, nasal cavity and the paranasal sinuses. Thieme, New York, 1989
39. Laws ER, Kanter AS, Jane JA Jr, Dumont AS: Extended transsphenoidal approach. J Neurosurg 102:825-828, 2005
40. Moreland DB, Diaz-Ordaz E, Czajka GA: Endoscopic endonasal hemisphenoidotomy for resection of pituitary lesions confined to the sella: Report of 3 cases and technical note. Minim Invasive Neurosurg 43: 57-61, 2000

41. Perneczky A, Fries G: Endoscope-assisted brain surgery: part 1- evolution, basic concept, and current technique. Neurosurgery 42: 219-225, 1998
42. Pirris SM, Pollack IF, Snyderman CH, Carrau RL, Spiro RM, Tyler-Kabara E, Kassam AB: Corridor surgery: the current paradigm for skull base surgery. Childs Nerv System 23: 377-384, 2007
43. Prevedello DM, Doglietto F, Jane JA Jr, Jagannathan J, Han J, Laws ER Jr: History of endoscopic skull base surgery: its evolution and current reality. J Neurosurg 107: 206-213, 2007
44. Rhoton AL Jr, Hardy DG, Chambers SM: Microsurgical anatomy and dissection of the sphenoid bone, cavernous sinus and sellar region. Surg Neurol 12: 63-104, 1979
45. Rhoton AL Jr, Natori Y: Orbit and Sellar region: Microvascular anatomy and operative approaches. New York: Thieme Medical Publishers, Inc., 1996
46. Rhoton AL Jr: The supratentorial cranial space: Microsurgical anatomy and surgical approaches. Neurosurgery 51(Suppl 1): 335-374, 2002
47. Rodziewicz GS, Kelley RT, Kellman RM, Smith MV: Transnasal endoscopic surgery of the pituitary gland: Technical note. Neurosurgery 39: 189-193, 1996
48. Sethi DS, Pillay PK: Endoscopic management of lesions of the sella turcica. J Laryngol Otol 109: 956-962, 1995
49. Sethi DS, Pillay PK: Endoscopic pituitary surgery: a minimally invasive technique. Am J Rhinol 10: 141-147, 1996
50. Sethi DS, Stanley RE, Pillay PK: Endoscopic anatomy of the sphenoid sinus and sella turcica. J Laryngol Otol 109: 951-955, 1995
51. 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 117: 699-705, 2007
52. Spencer WR, Das K, Nwagu C, Wenk E, Schaefer SD, Moscatello A, Couldwell WT: Approaches to the sellar and parasellar region: Anatomic comparison of the microscope versus endoscope. Laryngoscope 109: 791-794, 1999
53. Unal B, Bademci G, Bilgili YK, Batay F, Avci E: Risky anatomic variations of sphenoid sinus for surgery. Surg Radiol Anat 28(2):195-201, 2006
54. Van Alyea OE: Sphenoid sinus: anatomic study with consideration of the clinical significance of the structural characteristics of the sphenoid sinus. Arch Otolaryngol 34: 225-253, 1941
55. Wurster CF, Smith DE: The endoscopic approach to the pituitary gland. Arch Otolaryngol Head Neck Surg 120: 674, 1994