Endoscopic Sphenoid Sinus Anatomic Considerations: A Study on 60 Cadavers
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Abstract
Introduction:
Sphenoid sinus can be considered a key element in advanced sinus and skull base surgery. Due to its importance, many researchers tried to document its characteristics and evaluate possible differences among different races and populations.

Materials and Methods:
This study was conducted between March 2017 and December 2018 on 60 fresh adult cadavers in Tehran Forensic Medicine Center, Tehran, Iran. The evaluated variables were distances between nasal spines, posterior wall of the sphenoid, pituitary gland, and the distance between the anterior and posterior ethmoid artery and optic nerve, which were calculated using a flexible ruler through the direct length in millimeter. Another important variable was dehiscence, which was evaluated in optic and carotid artery canals.

Results:
After dissecting 120 sphenoid sinuses, the carotid artery was dehiscent in 24 (20%) cases, and optic nerve dehiscence was observed in 15 (12.5%) cadavers. The mean distance between the anterior wall of the sphenoid sinus and the anterior nasal spine was determined at 73.3±1.3 mm (rang: 58.3-87 mm), and the mean distance between the anterior part of the middle of the pituitary gland and the anterior nasal spine was estimated at 81.1±1.6 mm.

Conclusion:
According to our finding, the dehiscence of the key structural organs may be more prevalent in the Persian sphenoid sinus, which should be considered carefully in the management of related pathologies.

Keywords:
Endoscopic endonasal approach, Sphenoid sinus, Pituitary gland, Skull base surgery.

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Introduction

The sphenoid sinus is an important region in sinus and skull base surgery. Proximity to the carotid artery, optic nerve, pituitary gland, and brain in adjacent areas have made working in this field a tough task. Extended usage of endoscopy in approaching skull base lesions requires the re-evaluation of the precise anatomy of the sphenoid sinus (1-10). Hemorrhagic complications, cerebrospinal fluid leakage, and blindness are possible complications, and surgery through the sphenoid sinus can lead to long-lasting disabilities (1). A better understanding of the anatomical variations of adjacent neurovascular organs may help to avoid the aforementioned complications (1). Endoscopic skull base surgery has brought us several benefits, such as clear access to surgical landmarks. These advantages have revolutionized many surgical approaches to skull base pathologies, such as pituitary tumors (2-7). Many authors have tried to define the characteristics of the sphenoid sinus (1,2, 8-15); however, some have given definitions that are not endoscopic (10), and the small sample sizes of some others have made the interpretation of the results difficult. Moreover, the variance among races requires this study to be conducted on different populations. Therefore, this study was performed to define the endoscopic anatomy of the sphenoid sinus and the adjacent structures.

Materials and Methods

Study subjects

In total, 60 Iranian fresh adult cadaveric heads that had not suffered from severe trauma of the head and neck, did not have sinus or central nervous system diseases, and were older than 25 years of age were included in this study. The mean age of the cadavers was estimated at 46.7±13.3 years, and the majority of them (n=39; 65%) were male. This study was performed between March 2017 and December 2018 in Tehran Forensic Medicine Center, Tehran, Iran.

Ethical approval

The study protocol was approved by the Institutional Review Board of Tehran University of Medical Sciences, Tehran, Iran. Detailed information about the study was given to the family of the deceased and written informed consent was obtained from them. All parts of this study were conducted according to the Declaration of Helsinki.

Method of dissection

All cadavers were laid in the surgical position with heads being slightly extended and rotated 30° to the surgeon's site. Dissection began using a 0° and 30° rigid endoscope (Karl Störz) with a diameter of 4 mm and a length of 18 cm to find the superior turbinate and consequently the natural ostium of the sphenoid sinus. Subsequently, the ostium of the sphenoid sinus was extended to the largest up to the level of the planum sphenoidal to expose the widest surgical field under anterior endoscopic view. Furthermore, the optic nerve, intracavernous carotid artery, and adjacent structures were defined and examined. All procedures were recorded using a DVD recorder. Afterward, according to the Wigand techniques, posterior ethmoidectomy was performed to find Onodi cells, as well as anterior and posterior ethmoid arteries. All septets of the sphenoid sinus were removed. In the next step, the same procedures were performed in the opposite site and then intersphenoid septa were removed, and the pituitary gland was exposed. The internal carotid artery on both sides was dissected using a microdrill and cutting punch.

Variables and measurements

In addition to demographic characteristics, the distance between nasal spines, the posterior wall of the sphenoid, pituitary gland, and the distance between the anterior and posterior ethmoid artery and optic nerve were calculated using a flexible ruler through the direct length in millimeter. Dehiscence in the carotid artery and optic nerve was recorded via direct touching of them by the tip of the suction. The rest of the variables were measured using digital videos provided by recording dissections. The angles and distances were calculated with adobe Photoshop 7 measure tools which corrected the value comparing with the plastic ruler which was placed in the field of the surgery. The shape and size of the sphenoid sinus ostium, the distance between the natural ostium, as well as the choana and the superior turbinate were calculated in this study (Figure 1).
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Fig 1: Measurement between natural ostium and the choana

This study also measured the opticocarotid angle, the distance between the pituitary gland and the lower wall of the sphenoid sinus, the distance between medial margins of the cavernous carotid artery and the inferior margin of the pituitary gland, and two carotid arteries at the longest axis.

Statistical method

The data were analyzed in SPSS software (version 15.0) using descriptive statistical methods (mean±SD). The sample size was calculated considering α=0.05, d=4%, and P=0.05. A p-value less than 0.05 was considered statistically significant.

Results

Out of 60 dissected cadavers (120 sphenoid sinuses), the carotid artery was dehiscent in 24 (20%) sphenoid sinuses.

Table 1: Findings in the cadaveric study

| Findings in the cadaveric study | Number (% ) |
|---------------------------------|-------------|
| Optic nerve was dehiscent       | 15 (12.5%)  |
| Mean distance of optic nerve with the posterior ethmoid | 8.336±2.27 mm |
| Mean distance of optic nerve with the anterior ethmoid | 14.34±2.74 mm |
| Mean distance of the sphenoid sinus and the anterior nasal spine | 73.3±1.3 mm |
| Mean distance of the anterior wall of the sphenoid sinus and the anterior nasal spine | 73.3±1.3 mm |

The dehiscences were unilateral and bilateral in 6 (5%) and 9 (15%) sphenoid sinuses and cadavers, respectively. The optic nerve was dehiscent in 15 (12.5%) cadavers which were unilateral in 7 (5.83%) sphenoid sinuses and bilateral in 4 (6.66%) cadavers. The mean distances between the optic nerve, as well as the posterior and the anterior ethmoid artery, were 8.336±2.27 and 14.34±2.74 mm, respectively. The shapes of the sphenoid sinus ostium were circular and elliptical in 48 (40%) and 72 (60%) cadavers, respectively. Furthermore, the mean values of the longer and the shorter axis were 3.28±1.5 and 2.76±1.45 mm, respectively, with an overall mean of 3.02±1.47 mm. The shortest ostium was estimated at 1.5×1.5 mm, and the longest one was obtained at 5.5×5.5 mm (Figure 2).

Fig 2: Ostium of the sphenoid sinus

The mean distance between the anterior wall of the sphenoid sinus and the anterior nasal spine was estimated at 73.3±1.3 mm (distance range: 58.3-87 mm), and the mean distance between the anterior part of the middle of the pituitary gland and the anterior nasal spine was determined at 81.1±1.6 mm (distance range: 68-100 mm) (Figure 3).

Fig 3: Pituitary gland

The vertical distance between the inferior part of the pituitary gland and the lower wall of the sphenoid sinus was calculated at 5.89±1.38 mm (distance range: 6.5-13 mm), and the mean distance between the carotid artery and the pituitary gland was determined at 5.89±1.38 mm (distance range: 3.7-8.2 mm) (Figure 4).
The mean inter-carotid distance was estimated at 13.2±2.75 mm (distance range: 7.1-17.6 mm). Furthermore, the mean distance between the natural ostium and the posterior choana was obtained at 15.34±1.83 mm (distance range: 12.3-19.8 mm). In addition, the distance between the superior turbinate and the natural ostium was calculated at 15.33±1.82 (distance range: 12.1-19.7 mm), which showed no significant relationship in this regard (t-test; P=0.98). It should be mentioned that no significant difference was observed between gender and the evaluated items. The mean opticocarotid angle was estimated at 67.96±6.04º (range: 58º-78º). In addition, the mean distances between the optic nerve, as well as the anterior and posterior ethmoid artery were determined at 14.3±2.78 and 8.38±2.78 mm, respectively. It is worth mentioning that the Onodi cells were found in 11 (18.3%) cadavers.

A better understanding of the anatomy of this region may improve surgical techniques and also help to avoid surgical complications during and after surgery.

The normal distance between cavernous internal carotid arteries is a critical landmark since the detection of the boundaries of dissection in skull base surgery is a vital step to avoid complications; however, it should be considered that this distance is variable in the skull base pathologies (1).

Despite all these difficulties, little anatomical research has been conducted concerning the anatomy of the sphenoid sinus. In our series, the rates of carotid artery dehiscence and optic nerve dehiscence were 24% and 12.4%, respectively, which were higher than those in the other studies with a reported rate of about 8% for both (16). This variation can be observed in so many reports due to the methods of assessment and the ethnic groups.

Anusha et al. showed that in the majority of the large studies, the carotid artery could be dehiscent in about 22% of cadavers, which was consistent with our series. However, there were other reports of low rates of dehiscence in 4% of the cases; moreover, 41% and 67% of dehiscences were noted in Libyan and Asian populations in cadaveric studies, respectively (26). The Onodi cells could be found in 11 (13.8%) cadavers which was similar to those in other reports (16, 27). The mean distance between the sphenoid sinus natural ostium and the nasal spine was 73.3±1.3 mm which was relatively longer than that in some other reports, and since this distance is shorter in Asian cadavers, it is more similar to the Caucasian skulls (25).

In the presellar area, the mean inter-carotid distance was similar to that in the other reports (28). Therefore, the trans-sphenoid approach to skull base lesions can be safe and feasible; however, the awareness of the surgical anatomy and angles, as well as the ratios of this organ are mandatory.
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Conclusion
Our findings showed that the dehiscences of the vital structures were more common in Iranian cadavers. Accordingly, this should be considered in the surgical treatment of these pathologies.

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References
1. Yilmazlar S, H Kocaeli, Eyigor O, Hakyemzey B. Clinical importance of the basal cavernous sinuses and cavernous carotid arteries relative to the pituitary gland and macroadenomas: quantitative analysis of the complete anatomy. Surgical neurology, 2008; 70(2): p. 165-174.
2. Unlu, C Meco, HC Ugur, A Comert, Endoscopic anatomy of sphenoid sinus for pituitary surgery. Clinical Anatomy, 2008; 21(7): p. 627-632.
3. Unal B, Bademci G, Bilgili YK, Batay F, Avci E. Risky anatomic variations of sphenoid sinus for surgery. Surgical and Radiologic Anatomy. 2006 May 1; 28(2):195-201.
4. De Divitiis O, Conti A, Angileri FF, Cardali S, La Torre D, Tschabitscher M. Endoscopic transoral-transclival approach to the brainstem and surrounding cisternal space: anatomic study. Neurosurgery. 2004 Jan 1; 54(1):125-30.
5. Alfieri A, Jho HD. Endoscopic endonasal approaches to the cavernous sinus: surgical approaches. Neurosurgery. 2001 Aug 1;49(2):354-62.
6. Cavallo LM, Cappabianca P, Messi A, Esposito F, Stella L, de Divitiis E, Tschabitscher M. The extended endoscopic endonasal approach to the clivus and cranio-vertebral junction: anatomical study. Child's Nervous System. 2007 Jun 1; 23(6): 665-71.
7. Ramakrishnan VR, Suh JD, Lee JY, O'Malley BW, Grady MS, Palmer JN. Sphenoid sinus anatomy and suprasellar extension of pituitary tumors. Journal of neurosurgery. 2013 Sep 1; 119(3): 669-74.
8. Aratijo Filho BC, Neto CP, Weber R, Voegels RL. Sphenoid sinus symmetry and differences between sexes. Rhinology. 2008 Sep 1; 46(3):195-9.
9. Gong J, Mohr G, Vézina JL. Endoscopic pituitary surgery with and without image guidance: an experimental comparison. Surgical neurology. 2007 Jun 1; 67(6):572-8.
10. 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. Operative Neurosurgery. 2005 Apr 1; 56(suppl_4): ONS-379.
11. Aydin S, Cavallo LM, Messi A, Dal Fabbro M, Cappabianca P, Barlas O, De Divitiis E, Calbucci F. The endoscopic endonasal trans-sphenoidal approach to the sellar and suprasellar area: Anatomic study/Comment. Journal of neurosurgical sciences. 2007 Sep 1; 51(3):129.
12. Herzallah IR, Casiano RR. Endoscopic endonasal study of the internal carotid artery course and variations. American journal of rhinology. 2007 May; 21(3):262-70.
13. Bassim MK, Senior BA. Endoscopic anatomy of the parasellar region. American journal of rhinology. 2007 Jan; 21(1):27-31.
14. de Notaris M, Esposito I, Cavallo LM, Burgaya AC, Galino AP, Esposito F, Poblete JM, Ferrer E, Cappabianca P. Endoscopic endonasal approach to the ethmoidal planum: anatomic study. Neurosurgical review. 2008 Jul; 31(3):309-17.
15. Tan HK, Ong YK. Sphenoid sinus: an anatomic and endoscopic study in Asian cadavers. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists. 2007 Oct; 20(7): 745-50.
16. Cavallo LM, de Divitiis O, Aydin S, Messi A, Esposito F, Iaconetta G, Talat K, Cappabianca P, Tschabitscher M. Extended endoscopic endonasal transsphenoidal approach to the suprasellar area: anatomic considerations—part 1. Operative Neurosurgery. 2007 Sep 1; 61(suppl_3): ONS-24.
17. Stoković N, Trkulja V, Đumić-Čule I, Čuković-Bagić I, Lauc T, Vukičević S, Grgurević L. Sphenoid sinus types, dimensions and relationship with surrounding structures. Annals of Anatomy-Anatomischer Anzeiger, 2016 Jan 1; 203:69-76.
18. El-Banawy OA, El-Dien AE, Zolfakar AS, Halaka AN, Ayad H. Endoscopic endonasal partial middle turbinectomy approach: adaptability of the procedure in a cadaveric study and in surgery for different sphenoid sinus and skull base lesions. Skull Base. 2006 Nov; 16(01):001-13.
19. Magro F, Solari D, Cavallo LM, Samii A, Cappabianca P, Paternò V, Lüdemann WO, Divitiis ED, Samii M. The endoscopic endonasal approach to the lateral recess of the sphenoid sinus via the pterygopatine fossa: comparison of endoscopic and radiological landmarks. Operative Neurosurgery. 2006 Jan; 59 (suppl_4): ONS-237.
20. Casler JD, Doolittle AM, Mair EA. Endoscopic surgery of the anterior skull base. The Laryngoscope. 2005 Jan; 115(1):16-24.
21. Batay F, Vural E, Karasu A, Al-Mefty O. Comparison of the exposure obtained by endoscope and microscope in the extended trans-sphenoidal approach. Skull Base. 2002; 12(03):119-24.
22. Jho HD, Ha HG. Endoscopic endonasal skull base surgery: Part 2-The cavernous sinus. Minimally Invasive Neurosurgery. 2004 Feb; 47(01): 9-15.

23. Jho HD, Ha HG. Endoscopic endonasal skull base surgery: Part 3-The clivus and posterior fossa. Minimally Invasive Neurosurgery. 2004 Feb; 47(01): 16-23.

24. Kim HU, Kim SS, Kang SS, Chung IH, Lee JG, Yoon JH. Surgical anatomy of the natural ostium of the sphenoid sinus. The Laryngoscope. 2001 Sep; 111(9): 1599-602.

25. Anusha B, Baharudin A, Philip R, Harvinder S, Shaffie BM. Anatomical variations of the sphenoid sinus and its adjacent structures: a review of existing literature. Surgical and Radiologic Anatomy. 2014 Jul 1; 36(5):419-27.

26. Budu V, Mogoanta CA, Fanuta B, Bulescu I. The anatomical relations of the sphenoid sinus and their implications in sphenoid endoscopic surgery. Rom J Morphol Embryol. 2013 Jan 1; 54(1):13-6.

27. Fujii K, Chambers SM, Rhoton AL. Neurovascular relationships of the sphenoid sinus: a microsurgical study. Journal of neurosurgery. 1979 Jan 1; 50(1):31-9.