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Original Article

Evaluation of Relationship Between Sphenoid Sinus Septation and Onodi Cells Using Cone-Beam Computed Tomography

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ABSTRACT

Objective: This study aimed to evaluate the sphenoid sinus septation, the presence/absence of Onodi cells, and the relationship between these structures with each other in cone-beam computed tomography.

Methods: A total of 500 cases (250 males, 250 females) between the ages of 18 and 81 were included in this study. Sphenoid sinus septations were classified as intersphenoid, multiple, and absent, and Onodi cells as present or absent. The relationship between these parameters was also assessed. Chi square test was used to determine the relationship between sphenoid sinus septation and Onodi cells.

Results: Multiple septa seen in 451 (90.2%) of the cases is the most common type of sphenoid septation. Onodi cells were present in 327 (65.4%) of the cases. A statistically significant relationship was detected between Onodi cells and mean age ($P < .05$) but no significant difference was observed between the septation and mean age ($P > .05$). There was no significant difference between the septation or Onodi cells with gender ($P > .05$). Multiple septa were observed in all cases with Onodi cell. The relationship between sphenoid sinus septation and Onodi cell was statistically significant ($P < .001$).

Conclusion: This study revealed that there was a significant relationship between sphenoid sinus septation and Onodi cells. The presence of Onodi cells was observed only with multiple septa. Cone-beam computed tomography is an effective imaging method in the evaluation of sphenoid sinus anatomy and its variations and surrounding anatomical structures.

Keywords: Cone-beam computed tomography, Onodi cell, septation, Sphenoid sinus

INTRODUCTION

Paranasal sinus anatomy can be defined according to the development degree of each sinus, the pneumatization variations (additional extensions of air-filled cells from the ethmoid complex or from the sphenoid sinuses to the enclosing bone), and variations in the bony structure.[1] The sphenoid sinuses, the most posterior of the paranasal sinuses, are situated in the center of the skull base, in the body of the sphenoid bone. They are surrounded by some important structures such as the Vidian nerve in the sinus floor, the trigeminal nerve situated in the infero-lateral wall, the carotid artery in the mid-lateral sinus wall, and the optic nerve located in the superior lateral wall.[2,3]

Since the bony canal of the optic nerve and/or of the internal carotid artery may be associated with the sphenoid septations, great care should be taken during the removal of these septations in surgical procedures.[4] The sphenoid sinus septum is generally in the anterior midline, in line with the nasal septum, but the sphenoid septum can deviate from the midline to any side, curved, displace vertically, transversely, or obliquely. Thus, the 2 sinus cavities may not be equal to each other.[4,5] The septum can be S- or C-shaped, complete or incomplete. There may also be an accessory septum in the sinus.[4]

The optic nerve can be surrounded by an air cell named the sphenoethmoid or Onodi when the most posterior ethmoid air cells in superior location extend posterolaterally and the anterior wall of the sphenoid sinus is displaced. The optic nerve in the Onodi cell can be found without a bone cover and its surface can be unprotected. The Onodi cell is a significant anatomical guide in surgical interventions to the lateral sphenoid sinus and the posterior ethmoid cells due to its relationship with the optic nerve which is vulnerable.[4]

Because the Onodi cell and the sphenoid sinus share a common bony wall, the Onodi cell can mistakenly thought to be the

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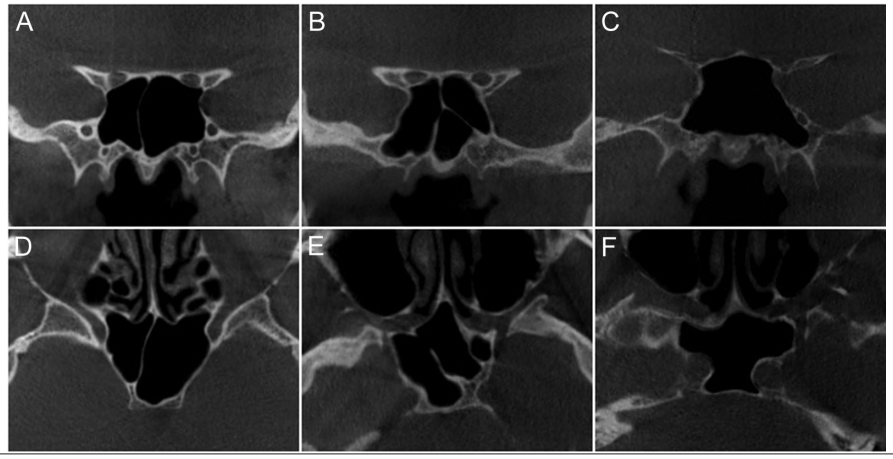
Figure 1. Sphenoid sinus septation types on coronal (A, B, C) and axial (D, E, F) CBCT sections: Intersphenoid septa (A, D), multiple septa (B, E), and absence of septa (C, F). CBCT, cone-beam computed tomography.



sphenoid sinus, but the sphenoid sinus is located inferiorly.[4] If there are unilateral or bilateral sphenoethmoidal air cells on coronal sections, there is a horizontal or cruciform septa because of air cell situated superiorly to the posterior choana (generally the sphenoid) that displaces the anterior wall of the sphenoid sinus horizontally, so that the sphenoid and the posterior ethmoid air cells can be distinguished from each other.[6] Because all sphenoid sinus septations are vertically directed, and if there are horizontally directed septa within the sphenoid sinus in sagittal sections, indeed, these septations belong to posterior ethmoid sinus.[5]

One of the methods used to provide multiplanar imaging for the maxillofacial region is cone-beam computed tomography (CBCT). Cone-beam computed tomography is a technical development in computed tomography (CT) imaging and suitable for use in situations limited with the head scanning because CBCT has relatively lower radiation dose and high isotropic spatial resolution compared to CT which is a large and expensive modality.[7,8] Cone-beam computed tomography is considered to be suitable for evaluation of paranasal sinus anatomy and surgical results and the imaging of intra- and perioperative osseous structures.[9]

Sphenoid sinus septations and Onodi cells are adjacent or associated with some neurovascular structures, and also Onodi cells are related to the walls and septations of sphenoid sinus. These structures and their relationships are important both during various sinus surgeries and in preoperative radiographic examinations. There are some investigations in the literature examining the sphenoid sinus septations and Onodi cells with CBCT or CT,[10-15] however, as far as we know, there is no study evaluating the relationship between these parameters. Therefore, the aim of this study was to assess the septation of sphenoid sinus, the presence/absence of Onodi cells, and the relationship between these structures with each other on CBCT.

Main Points

- The presence of Onodi cells was observed only with multiple septa.
- A relationship was detected between sphenoid sinus septation and Onodi cell.
- Cone-beam computed tomography is a suitable imaging method for the evaluation of sphenoid sinus.

METHODS

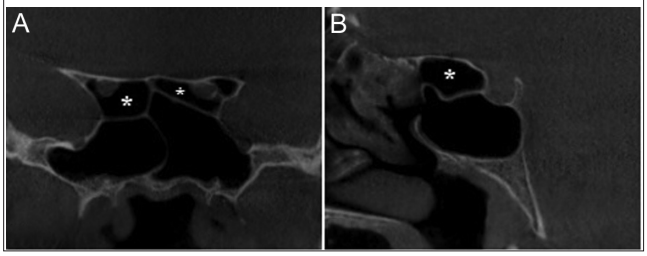
Study Design

Before the study, the ethical approval was obtained from Gaziantep University Ethics Committee (Decision No: 2020/245). The tomographical records in CBCT archive in Gaziantep University Faculty of Dentistry, Dentomaxillofacial Radiology Department were used and examined retrospectively. Images were acquired with Planmeca 3D Mid (ProMax, Helsinki, Finland) CBCT device, and Romexis software (Helsinki, Oy, Finland) was used for the analysis of the images. Multiplanar images with 16×16 and 16×9 cm field of view, a voxel resolution of 0.4 mm^3, and a slice thickness of 1 mm were used.

Sphenoid sinus septation and Onodi cells were examined according to mean age and gender in 500 cases (250 males, 250 females) between the ages of 18 and 81, and the relationship between these parameters with each other was also investigated. Images with fracture line due to trauma in the maxillofacial area or any maxillofacial lesion, sphenoid sinus disease, intracranial tumors, and craniofacial anomalies were not included in the study.

Sphenoid sinus septations were examined in coronal and axial sections, and they were classified as intersphenoid, multiple, or absent (Figure 1). If there was a single septa extending vertically from the superior to the inferior, located at or near the midline and dividing the sinus into 2 equal/unequal cavities, it was noted as the intersphenoid septa. If there was one or more complete or incomplete accessory septa in addition to the main septum, it was evaluated as multiple septa, and sinuses without septa were recorded as "absent."

Figure 2. Onodi cells on CBCT sections: coronal (A; asterisks) and sagittal (B; asterisk). CBCT, cone-beam computed tomography.



The presence or absence of Onodi cells was investigated in the coronal and sagittal planes (Figure 2). Sinuses with at least 1 Onodi cell were classified as "present" in these images, and sinuses without any Onodi cells were classified as "absent."

All CBCT images were assessed by the same maxillofacial radiologist. In order to determine the intra-observer calibration, the evaluations made by the observer were repeated in 100 randomly selected CBCT images (20% of all images), 2 weeks after the initial assessment, and intra-observer calibration was examined.

Statistical Analysis

Intraclass correlation coefficient was used to calculate intraobserver agreement. The conformity of the data to normal distribution was evaluated by Shapiro Wilk test. Chi square test was used to determine the relationship between sphenoid sinus septation and Onodi cells. As descriptive statistics, mean ± standard deviation for numerical variables and number and % values for categorical variables were given. Statistical Package for the Social Sciences software (version 24.0) (Armonk, NY, IBM SPSS Corp.) was used for statistical analysis, and *P* value < .05 was considered statistically significant.

RESULTS

Of the total 500 CBCT images between the ages of 18 and 81 (mean 46.11 ± 15.90), 250 were male (50%), 250 were female (50%), and the mean age was 47.02 ± 15.78 and 45.19 ± 16.01, respectively. The intraobserver reliability coefficient for all evaluations was found to be almost perfect (0.91).

When the distribution of sphenoid sinus septation was investigated, 44 (8.8%) cases had intersphenoid septation, 451 (90.2%) had multiple septa (Table 1). The sphenoid septum was absent in 5 (1%) cases. The relationship between the mean age and septation was also assessed. The mean age was 46.36 ± 17.65 for intersphenoid septa, 46.14 ± 15.75 for multiple septa, and 40.60 ± 15.66 for absent. No significant difference was determined between the septation and mean age ($P > 0.05$).

When the relationship of Onodi cells with mean age was examined, the mean age of 327 (65.4%) cases with Onodi cells was found to be 47.34 ± 15.32, and the mean age of 173 (34.6%) cases without Onodi was 43.77 ± 16.76 (Table 1). A statistically significant relationship was detected between Onodi cells and mean age ($P < .05$).

Table 1. Distribution of Sphenoid Sinus Septation and Onodi Cell According to Mean Age

		N (%)	Age (Mean ± SD)	*P*
Sphenoid sinus septation	Intersphenoid	44 (8.8)	46.36 ± 17.65	.751
	Multiple	451 (90.2)	46.14 ± 15.75	
	Absent	5 (1.0)	40.60 ± 15.66	
Onodi cell	Present	327 (65.4)	47.34 ± 15.32	.033*
	Absent	173 (34.6)	43.77 ± 16.76	

SD, Standard Deviation.
*$P < .05$.

The distribution of sphenoid sinus septation and Onodi cell according to gender was shown in Table 2. In males, 27 of the cases (10.8%) had intersphenoid, 220 (88.0%) had multiple septa, while 3 (1.2%) had no septa. In females, intersphenoid septa were in 17 (6.8%) cases, multiple septa in 231 (92.4%), and 2 (0.8%) had no septa. The frequency of Onodi cells in males and females was 156 (62.4%) and 171 (68.4%), respectively, and the absence of Onodi cells in genders was 94 (37.6%) and 79 (31.6%), respectively. There was no significant difference between the septation or Onodi cells with gender ($P > 0.05$).

The presence of Onodi cells was observed only with multiple septa (Table 3). The cases without Onodi were found together with multiple septa in 24.8% and with intersphenoid septa in 8.8%. The rate of cases with the absence of both Onodi cells and septa together was 1%. When the sphenoid sinus septation and Onodi cell were compared, a statistically significant relationship was observed ($P < .001$).

DISCUSSION

In this study, sphenoid sinus septation and Onodi cells were investigated according to mean age and gender on CBCT images and the relationship between these parameters was evaluated. In the literature, few studies have been found investigating sphenoid sinus septation and Onodi cells in CBCT,[13-15] but to the best of our knowledge, there is no published study assessing the relationship between these parameters. In this study, a statistically significant relationship was found between sphenoid sinus septation and Onodi cells. Multiple septa were observed in all

Table 2. Distribution of Sphenoid Sinus Septation and Onodi Cell According to Gender

		Male N (%)	Female N (%)	*P*
Sphenoid sinus septation	Intersphenoid	27 (10.8)	17 (6.8)	.254
	Multiple	220 (88.0)	231 (92.4)	
	Absent	3 (1.2)	2 (0.8)	
Onodi cell	Present	156 (62.4)	171 (68.4)	.158
	Absent	94 (37.6)	79 (31.6)	

Table 3. Relationship Between Sphenoid Sinus Septation and Onodi Cell

		Sphenoid Sinus Septation				
		Intersphenoid N (%)	Multiple N (%)	Absent N (%)	Total N (%)	*P*
Onodi cell	Present	0 (0)	327 (65.4)	0 (0)	327 (65.4)	.000*
	Absent	44 (8.8)	124 (24.8)	5 (1.0)	173 (34.6)	
Total N (%)		44 (8.8)	451 (90.2)	5 (1.0)	500 (100)	

*$P < .05$.

cases with Onodi cells. The most common sphenoid septation type was multiple (90.2%). Onodi cells were present in 65.4% of the cases.

When the sphenoid sinuses are well developed, structures such as the vidian (pterygoid) canal, foramen rotundum (maxillary nerve), optic nerve, and internal carotid artery can be defined by their indentations in the sinus cavity. These anatomical associations can be a potential surgical risk factor because fracture or removal of any sphenoid septa or indentations can cause injuries to surrounding nerves or vessels. The location and number of the sphenoid sinus septations are highly changeable and they usually attach to the osseous canal of the internal carotid artery and/or optic nerve, which extends into the posterolateral sphenoid sinus.[4,5]

The sphenoid and posterior ethmoid cells are also interrelated. The posterior ethmoid cells invading the sphenoid in the posterior and superior direction will cause contact of these cells with the optic nerve.[5] Also, this posterior ethmoid cell, called the Onodi cell, shares a bony wall with the sphenoid sinus.[4] Therefore, it should not be passed to more posterior part of the sphenoid sinus which has become an important landmark in ethmoidectomies.[5]

Sphenoid sinuses usually have an intersphenoid septum.[12] In most of the studies evaluating septa, the incidence of single/main intersphenoid septum was found to be quite high. Idowu et al[16] found this rate as 95%, Hamid et al[12] 71.6%, ELKammash et al[17] 70%, Rahmati et al[18] 69.8%, Anusha et al[19] 53.7%, and Kayalioglu et al[20] detected it as 46% in their study with bony specimens. Although this rate was seen as 38%,[21] 29.6%,[22] 28.1%,[23] and 20%[24] in some studies, the incidence in our study was 8.8% and it was much lower than in others. When the intersphenoid sinus septation was evaluated according to gender, Kapur et al[25] found that this parameter was 68% and 77.9% in males and females, respectively, and Akgül et al[26] detected this rate as 48.1% and 43.7%, respectively. In the present study, intersphenoid sinus septa were found as 10.8% in males and 6.8% in females.

The prevalence of multiple sphenoid sinus septa has been observed at around 50% in some studies,[19,22,27] and in some[12,17,28] at lower rates. This prevalence has been reported by Sareen et al[24] as 80% in their research on cadavers, Jaworek-Troć et al[29] as 78.04%, Seddighi et al[23] as 71.9%. In our research, this value was found to be 90.2%, consistent with other studies. When multiple septa were evaluated according to gender, Kapur et al[25] found this as 32% and 22.1% in males and females, respectively, and Akgül et al[26] found it as 51.9% and 56.3%, respectively. In this study, higher rates were detected to be 88.0% and 92.4%, respectively, compared to other studies.

Considering the studies with the absence of septa, the frequency in the control group in Yalçın's[22] study was 14.8%, 10.8% in the study of Hamid et al,[12] 7.5% in the study of Ngubane et al[28] 4% in the study of Wiebracht and Zimmer.[30] In the CT study of Sirikci et al,[31] in the anatomical and endoscopic study of Tan and Ong[3] on cadavers, and in the research of Seddighi et al[23] on pituitary adenomas on CT, there was no case without septa. Similarly, in the current study, the absence of septa was observed in only 1% of the cases.

In investigations with CT, the incidence of Onodi cells was reported by Wada et al[32] as 50.8% in the study group with a mean age of 55.6, Chmielik and Chmielik[33] as 39.8% in their study between the ages of 8 and 18, Hwang et al[34] as 32% in the study among persons aged 19-76 years, Ozturan et al[35] reported it as 16.6% in their study between the ages of 13 and 91. In the present study, the mean age was 47.34 ± 15.32 years and its incidence was higher (65.4%) than the others, and a significant relationship was detected between the mean age and Onodi cells. It was observed that the mean age of the patients with Onodi cells was higher than those without Onodi cells.

When the Onodi cells were assessed according to gender, Tomovic et al[36] on CT found this parameter as 62.2% and 63.5% in males and females, respectively, and Thanaviratananich et al[37] in the endoscopic study on cadavers detected this rate as 58.7% and 63.2%, respectively. Özdemir et al[38] on CT observed this parameter as 24.5% and 17.6% in males and females, respectively, and Avsever et al[15] on CBCT found this rate as 4.3% and 5.1%, respectively. In our study, Onodi cells were observed as 62.4% in males and 68.4% in females.

In the study of Driben et al[10] with CT and subsequent endoscopic dissection on adult human cadavers, the prevalence of Onodi cells detected was 7% and 39%, respectively, and significant difference was found between analyses. Weinberger et al[11] observed Onodi cells with a frequency of 8% in CT analysis and 14% in cadaver samples. In the CT study on different ethnicity of Hindi et al,[39] the relationship between the racial group and the incidence of Onodi cells was significant and they reported the incidence in the Chinese group higher than the others. Özdemir

et al[38] found the prevalence of Onodi cells on CT as 21.2% in the Turkish population. Tomovic et al,[36] in the study with different ethnic groups, found no statistically significant difference between the groups, and they detected Onodi cells in 57.0% of the African American population, in 62.7% of the Hispanic population, and in 73.1% of the White population. In the current study, consistent with these data, the incidence of Onodi cells was observed to be 65.4%.

Knowing the anatomical relationships of the sphenoid sinus is important because it can help explain the unusual symptoms caused by sphenoid sinus disease, as well as avoid surgical complications.[5] Cone beam computed tomography scanning of the paranasal sinuses provides useful information in evaluating the extent of the Onodi cell and detailed anatomy before the endoscopic sinus surgery.[40] Cone-beam computed tomography is an imaging method suitable for use in evaluating the bone structure of the head region and paranasal sinus anatomy and is relatively low-dose compared to CT.[7-9] Therefore, in our study, CBCT was used in the evaluation of sphenoid sinuses.

It has been reported that a horizontal septum crossing the sphenoid sinus lumen in coronal or sagittal plane images indicates the presence of Onodi cells.[5,6] This means that there is at least 1 septum in the sphenoid sinuses where Onodi cells are detected. In the present study, a statistically significant relationship was found between sphenoid sinus septation and Onodi cells. The fact that only multiple septations were found in cases that detected Onodi cells showed there was also another septa in addition to the horizontal septum. In accordance with the existing literature, in our study, if the sphenoid sinus septa were absent, Onodi cells were also absent. It can be thought that this relationship is due to the anatomical proximity of septa and Onodi cells and the variations during the development of these structures.

The difference between these results we obtained and the results of other studies may be due to reasons such as ethnicity, the study group consisting of living individuals/cadavers/dry bones, different sample numbers, or age groups. It may also be due to differences between study groups and imaging methods and using different classifications in the evaluation of sphenoid sinus septation.

The limitation of this study was that the medical history or systemic diseases of the cases were not known as the study was retrospective. Therefore, studies that are prospective or involve a particular pathological condition affecting the paranasal sinuses may be planned in the future. In addition, by increasing the number of samples, studies can be conducted in different populations and according to age groups.

CONCLUSION

In this study, the distribution of sphenoid sinus septation and Onodi cells according to mean age and gender was investigated, and a significant relationship was found between these parameters. Onodi cell was observed only with multiple septa. It is important to know these structures and their relationship with each other to define the variations in the surrounding neurovascular structures, planning and performing various sinus surgeries correctly, and avoid complications. Cone-beam computed tomography is an effective imaging method in the evaluation of sphenoid sinus anatomy and its variations and surrounding anatomical structures.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Research Ethics Committee of Gaziantep University (Decision No: 2020/245).

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REFERENCES

1. Eggesbø HB, Søvik S, Dølvik S, Eiklid K, Kolmannskog F. CT characterization of developmental variations of the paranasal sinuses in cystic fibrosis. *Acta Radiol*. 2001;42(5):482-493. [CrossRef]
2. Kamburoğlu K, Melo SLS, Li Z, et al. Anatomy of the nose and paranasal sinuses. In: Scarfe W, Angelopoulos C, eds. *Maxillofacial Cone Beam Computed Tomography*. Springer: Cham; 2018:365-397.
3. Tan HK, Ong YK. Sphenoid sinus: an anatomic and endoscopic study in Asian cadavers. *Clin Anat*. 2007;20(7):745-750. [CrossRef]
4. Levine H, Clemente MP, eds. *Sinus Surgery: Endoscopic and Microscopic Approaches*. Stuttgart: Thieme; 2005.
5. Som P, Lawson W, Fatterpekar G, Zinreich S. Embryology, anatomy, physiology, and imaging of the sinonasal cavities. In: Som PM, Curtin HD, eds. *Head and Neck Imaging*. St Louis: Mosby; 2011:116-117.
6. Beale TJ, Madani G, Morley SJ. Imaging of the paranasal sinuses and nasal cavity: normal anatomy and clinically relevant anatomical variants. *Semin Ultrasound CT MR*. 2009;30(1):2-16. [CrossRef]
7. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. *J Can Dent Assoc*. 2006;72(1):75-80.
8. Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 1: physical principles. *AJNR Am J Neuroradiol*. 2009;30(6):1088-1095. [CrossRef]
9. Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 2: clinical applications. *AJNR Am J Neuroradiol*. 2009;30(7):1285-1292. [CrossRef]
10. Driben JS, Bolger WE, Robles HA, Cable B, Zinreich SJ. The reliability of computerized tomographic detection of the Onodi (sphenoethmoid) cell. *Am J Rhinol*. 1998;12(2):105-111. [CrossRef]
11. Weinberger DG, Anand VK, Al-Rawi M, Cheng HJ, Messina AV. Surgical anatomy and variations of the Onodi cell. *Am J Rhinol*. 1996;10(6):365-372. [CrossRef]
12. Hamid O, El Fiky L, Hassan O, Kotb A, El Fiky S. Anatomic variations of the sphenoid sinus and their impact on trans-sphenoid pituitary surgery. *Skull Base*. 2008;18(1):9-15. [CrossRef]

13. Yilmaz N, Kose E, Dedeoglu N, Colak C, Ozbag D, Durak MA. Detailed anatomical analysis of the sphenoid sinus and sphenoid sinus ostium by cone-beam computed tomography. *J Craniofac Surg*. 2016;27(6):e549-e552. [CrossRef]
14. Štoković N, Trkulja V, Dumić-Čule I, et al. Sphenoid sinus types, dimensions and relationship with surrounding structures. *Ann Anat*. 2016;203:69-76. [CrossRef]
15. Avsever H, Gunduz K, Karakoç O, Akyol M, Orhan K. Incidental findings on cone-beam computed tomographic images: paranasal sinus findings and nasal septum variations. *Oral Radiol*. 2018;34(1): 40-48. [CrossRef]
16. Idowu OE, Balogun BO, Okoli CA. Dimensions, septation, and pattern of pneumatization of the sphenoidal sinus. *Folia Morphol (Warsz)*. 2009;68(4):228-232.
17. ELKammash TH, Enaba MM, Awadalla AM. Variability in sphenoid sinus pneumatization and its impact upon reduction of complications following sellar region surgeries. *Egypt J Radiol Nucl Med*. 2014;45(3):705-714. [CrossRef]
18. Rahmati A, Ghafari R, AnjomShoa M. Normal variations of sphenoid sinus and the adjacent structures detected in cone beam computed tomography. *J Dent (Shiraz)*. 2016;17(1):32-37.
19. Anusha B, Baharudin A, Philip R, Harvinder S, Shaffie BM, Ramiza RR. Anatomical variants of surgically important landmarks in the sphenoid sinus: a radiologic study in Southeast Asian patients. *Surg Radiol Anat*. 2015;37(10):1183-1190. [CrossRef]
20. Kayalioglu G, Erturk M, Varol T. Variations in sphenoid sinus anatomy with special emphasis on pneumatization and endoscopic anatomic distances. *Neurosciences (Riyadh)*. 2005;10(1):79-84.
21. Lupascu M, Comsa GI, Zainea V. Anatomical variations of the sphenoid sinus-a study of 200 cases. *ARS Med Tomitana*. 2014;20(2):57-62. [CrossRef]
22. Yalcin ED. Assessment of sphenoid sinus types in patients with cleft lip and palate on cone-beam CT. *Eur Arch Otorhinolaryngol*. 2020;277(4):1101-1108. [CrossRef]
23. Seddighi A, Seddighi A, Mellati O, Ghorbani J, Raad N, Soleimani MM. Sphenoid sinus: anatomic variations and their importance in trans-sphenoid surgery. *Int Clin Neur;J* 2014(1):31-34.
24. Sareen D, Agarwal AK, Kaul JM, Sethi A. Study of sphenoid sinus anatomy in relation to endoscopic surgery. *Int J Morphol*. 2005;23(3):261-266. [CrossRef]
25. Kapur E, Kapidi A, Kulenovi A, Sarajli L, Šahinović A, Šahinović M. Septation of the sphenoid sinus and its clinical significance. *Int J Collab Res Intern Med Public Heal*. 2012;4:1793-1802.
26. Akgül MH, Muluk NB, Burulday V, Kaya A. Is there a relationship between sphenoid sinus types, septation and symmetry; and septal deviation? *Eur Arch Otorhinolaryngol*. 2016;273(12):4321-4328. [CrossRef]
27. Aksoy F, Yenigun A, Goktas SS, Ozturan O. Association of accessory sphenoid septa with variations in neighbouring structures. *J Laryngol Otol*. 2017;131(1):51-55. [CrossRef]
28. Ngubane NP, Lazarus L, Rennie CO, Satyapal KS. The septation of the sphenoidal air sinus. A cadaveric study. *Int J Morphol*. 2018;36(4):1413-1422. [CrossRef]
29. Jaworek-Troć J, Zarzecki M, Mróz I, et al. The total number of septa and antra in the sphenoid sinuses: evaluation before the FESS. *Folia Med Cracov*. 2018;58(3):67-81. [CrossRef]
30. Wiebracht ND, Zimmer LA. Complex anatomy of the sphenoid sinus: a radiographic study and literature review. *J Neurol Surg B Skull Base*. 2014;75(6):378-382. [CrossRef]
31. Sirikci A, Bayazıt YA, Bayram M, Mumbuç S, Güngör K, Kanlikama M. Variations of sphenoid and related structures. *Eur Radiol*. 2000;10(5):844-848. [CrossRef]
32. Wada K, Moriyama H, Edamatsu H, et al. Identification of Onodi cell and new classification of sphenoid sinus for endoscopic sinus surgery. *Int Forum Allergy Rhinol*. 2015;5(11):1068-1076. [CrossRef]
33. Chmielik LP, Chmielik A. The prevalence of the Onodi cell–most suitable method of CT evaluation in its detection. *Int J Pediatr Otorhinolaryngol*. 2017;97:202-205. [CrossRef]
34. Hwang SH, Joo YH, Seo JH, Cho JH, Kang JM. Analysis of sphenoid sinus in the operative plane of endoscopic transsphenoidal surgery using computed tomography. *Eur Arch Otorhinolaryngol*. 2014;271(8):2219-2225. [CrossRef]
35. Ozturan O, Yenigun A, Degirmenci N, Aksoy F, Veyseller B. Coexistence of the Onodi cell with the variation of perisphenoidal structures. *Eur Arch Otorhinolaryngol*. 2013;270(7):2057-2063. [CrossRef]
36. Tomovic S, Esmaeili A, Chan NJ, et al. High-resolution computed tomography analysis of the prevalence of onodi cells. *Laryngoscope*. 2012;122(7):1470-1473. [CrossRef]
37. Thanaviratananich S, Chaisiwamongkol K, Kraitrakul S, Tangsawad W. The prevalence of an Onodi cell in adult Thai cadavers. *Ear Nose Throat J*. 2003;82(3):200-204. [CrossRef]
38. Özdemir A, Bayar Muluk NB, Asal N, Şahan MH, Inal M. Is there a relationship between Onodi cell and optic canal? *Eur Arch Otorhinolaryngol*. 2019;276(4):1057-1064. [CrossRef]
39. Hindi K, Alazzawi S, Raman R, Prepageran N, Rahmat K. Pneumatization of mastoid air cells, temporal bone, ethmoid and sphenoid sinuses. Any correlation? *Indian J Otolaryngol Head Neck Surg*. 2014;66(4):429-436. [CrossRef]
40. Orhan K, Aksoy S, Avsever IH, Gunduz K. Incidental findings in TMJ imaging. In: Rozylo-Kalinowska I, Orhan K, eds. *Imaging of the Temporomandibular Joint*. Springer: Cham; 2019:205-246.