Evaluation of the Relationship Between Sphenoid Sinus Morphology and Area and Volume by Computed Tomography

Mehmet Serindere
drserindere@hotmail.com

Hatay Education and Research Hospital, Department of Radiology

Ceren Aktuna Belgin
Hatay Mustafa Kemal University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology

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Abstract

Purpose

The aim of this retrospective study is to evaluate the relationship between sphenoid sinus volume and surface area measurements and its morphology by computed tomography (CT).

Methods

In this study, CT images of 150 patients were evaluated retrospectively. Sphenoid sinus pneumatization types, Onodi cell (OC) prevalence, protrusion and dehiscence of internal carotid artery (ICA) and optic nerve (ON) were evaluated. The volume and area of the sphenoid sinus were calculated using the manual segmentation module using InVesalius software program.

Results

Out of the 150 sinuses, 58 (38.66%), 47 (31.33%), 22 (33%), 4 (2.66%) and 8 (5.33%) were postsellar a, postsellarb,sellar type,conchal and presellar type, respectively. OC was found in 43 (28.7%) of 150 patients. ICA protrusion was observed in a total of 61 CTs (40.7%), 23 (15.3%) were unilateral and 38 (25.3%) were bilateral. Out of 61 CTs (40.7%) who showed ICA dehiscence, 51 (34.0%) were unilateral, and 10 (6.7%) were bilateral. ON protrusion was observed in a total of 43 CTs (28.7%), 14 (9.3%) were unilateral and 29 (19.3%) were bilateral. Out of 28 CTs (18.7%) who showed ON dehiscence, 17 (11.3%) were unilateral, and 11 (7.3%) were bilateral. The mean volume and area of sinus were 9949.4 ± 351.0 mm^3 and 4570.9 ± 1604.9 mm^2, respectively.

Conclusions

Sinus volume and area were significantly higher in patients with bilateral protrusion of ICA compared to patients without protrusion of ICA. In patients with bilateral dehiscence of ICA, sinus volume and area were found to be significantly higher than those without ICA dehiscence. Sinus volume and area were significantly higher in patients with bilateral protrusion of ON compared to patients without ON protrusion. Sinus volume and area in males were found to be significantly higher than in females.There was a negative correlation between age and sinus volume and area.Sphenoid sinuses are in different variations with the important surrounding neurovascular structures. It is important to examine these relationships in detail before the operation in order to prevent complications.

Introduction

The sphenoid sinus is considered the most variable of the paranasal sinuses [1]. The degree and type of pneumatization varies in terms of the number and location of intra and intersinus septa, and its relationship with the surrounding surgical risk factors (II, III, IV, V, VI and Vidian nerves, ICA in the cavernous sinus and pituitary gland) [2]. Therefore, blindness or heavy bleeding during surgery and even minimal damage to the surrounding structures can lead to irreversible consequences [3].

The degree of sinus pneumatization plays an important role in planning surgical procedures. The degree of sphenoid sinus pneumatization is usually determined by the position of the posterior sinus wall relative to the sella turcica [4].

Three types of pneumatization patterns have been defined in relation to sellar turcica: sellar type (90%), presellar type (9%), and conchal type (1%) [5].

There may be a close relationship between the sphenoid sinus and some neighboring vital structures such as the optic nerve (ON) and internal carotid artery (ICA) [6–8]. Accidental rupture of the intersphenoidal septum that attaches to the bony wall of the ICA or ON during endoscopic sinus surgery may cause injury to these structures, resulting in severe intraoperative bleeding or blindness [9].

Onodi cells (OCs) are located superior and lateral to the sphenoid sinus[10]. The prevalence of OC is reported to be 8-65.3% [11–13].

Identification of the OC enables surgeons to reduce the risk of injury to surrounding structures during endoscopic sinus surgery [14]. There is a close relationship between OC and ON, which requires recognition of the surrounding structures during surgery to reduce the risk of injury [14–16].Sphenoid sinus volume seems to be one of the most suitable parameters for estimating the range of motion during endoscopic surgery [17].

Computed tomography (CT) is an imaging modality used in the diagnosis of diseases and the evaluation of injuries. It also plays an important role in diagnosing anatomical variations that have relevant implications for clinical decision making during surgical interventions. CT of the paranasal sinuses reveals a wide range of findings associated with normal pneumatization processes within the sinus cavities and adjacent bone marrow spaces [18].

In this study, the relationship between sphenoid sinus volume and surface area and its morphology, which is an important anatomical structure in the practice of endoscopic surgery, was evaluated on CT images.

Materials And Methods

This study was approved by Ethical Committee of the Hatay Mustafa Kemal University (decision date: 06.10.2022 number: 08) and was in accordance with the principles of the Helsinki Declaration. Paranasal sinus CT images of patients who applied to Hatay Education and Research Hospital for any reason were selected from the database. No examination was requested for the study, and CT images requested for any reason within the indication and already available in the system were included in the study. Sphenoid sinus pathology, history of maxillofacial trauma or previous endoscopic surgery, presence of sinusitis, images of patients younger than 18 years of age and low-quality images were excluded from the study. CT images of 150 patients (58 female, 92 male) aged between 18–81 years (mean: 35.4 ± 15.4 years) who met the inclusion criteria were evaluated.

Philips Brilliance 64-slice CT machine (Philips Healthcare, Cleveland, OH, USA) was used for all the CT procedures taken with following parameters; 120 Kv, 250 mAs, and 0.625 mm slice thickness. CT images were analyzed using a 64-bit RadiAnt DICOM viewer software, version 2020.2.3 (Medixant, Poznan- Poland).

Pneumatization types were examined in 4 categories [4–6] (Fig. 1):

Type I (Conchal): Incomplete or minimal extension of the sinus.

Type II (Presellar): The posterior border of the sphenoid sinus is in front of the anterior wall of the sell turcica.

Type III (Sellar): The sinus is located between the anterior and posterior wall of the sella.

Type IV (Postsellar): The posterior wall of the sinus has passed the posterior border of the sella.

Type IV (a): Pneumatization does not pass through the posterior clinoid process.

Type IV (b): The posterior clinoid process is also included in the pneumatized region.

OC prevalence, ICA and ON protrusion and dehiscence were evaluated (Fig. 2–4). ICA and OS were classified according to their relationship with the sphenoid sinus wall [19]. The protrusion of the neurovascular structure was defined as protrusion when it was more than 50% of its circumference [20, 21]. Any disintegration of the bone structure between the canals and the sinus cavity was also considered as dehiscence [6].

Based on the studies of Szabo et al. [22], the sphenoid sinus was separated from the airway using the manual segmentation module presented by the program on the image. Then, the volume and area of the sphenoid sinus were calculated using the program. InVesalius software (CTI, Campinas, São Paulo, Brazil) was used for volume and surface area measurements (Fig. 5).

Measurements were performed by two observers who had 7 years (M.S and C.A.B) clinical experience in general and dentomaxillofacial radiology. The observers also performed the study twice with an interval of 2 weeks to detect inter-observer reliability. All evaluations and measurements were performed on a 15.6-inch full HD notebook monitor with resolution of 1920 × 1080 pixels.To ensure standardization of all evaluations and to rule out differences in image resolution, two observers used the same laptop.

Statistical Analysis

Intraclass correlation coefficient (ICC) values were calculated for interobserver reliability. ICC less than 0.40 is considered weak agreement, a value between 0.40 and 0.75 is considered fair, and a value greater than 0.75 is considered excellent [23]. P values < 0.05 were considered to indicate statistical significance.In the descriptive statistics of the data, mean, standard deviation, median minimum, maximum, frequency and ratio values were used. The distribution of variables was measured with the Kolmogorov-Smirnov test. ANOVA (Tukey test), Independent sample t test, Kruskal-Wallis, Mann-Whitney U test were used in the analysis of quantitative independent data. Chi-square test was used in the analysis of qualitative independent data, and Fischer test was used when the Chi-square test conditions were not met. Spearman correlation analysis was used in the correlation analysis. SPSS 28.0 program was used in the analysis.

Results

The inter-observer reliability was estimated by Intraclass Correlations (ICC). ICC indicated excellent reliability for all observations (ICC > 0.85).

Pneumatization Types of Sphenoid Sinus

Out of the 150 sinuses, 58(38.66%), 47 (31.33%) and 22 (33%) were postsellar a, b and sellar type, respectively. Conchal and presellar types were found in only 4 (2.66%) and 8 (5.33%) sinuses.The sphenoid sinus with postsellar b type had the highest volume while conchal type had the least volume. Similarly, for all types, males showed higher volume and area than females in this study.

OC Prevalence

While OC was found in 43 (28.7%) of 150 CTs, OC was not be detected in 107 (71.3%) CTs. OC ratio did not differ significantly between the genders and age (p > 0.05) (Table 1,2). The volume and area of sphenoid sinüs did not differ significantly between groups with and without OC (p > 0.05) (Table 3,4)

Table 1
Distribution of parameters by gender

		Female				Male				p	
		Mean ± SD /n-%			Median	Mean ± SD /n-%			Median		
Age		39.1	±	16.1	37.5	33.2	±	14.6	29.5	0.019*	m
Volume		8896.5	±	3058.3	8768.6	10613.2	±	4155.9	10343.5	0.004*	t
Area		4123.4	±	1230.7	4149.1	4853.0	±	1749.4	4591.5	0.003*	t
Onodi Cell	Absent	43		74.1%		64		69.6%		0.546	X²
	Present	15		25.9%		28		30.4%			
ICA Protrusion	Absent	35		60.3%		54		58.7%		0.965	X²
	Unilateral	9		15.5%		14		15.2%			
	Bilateral	14		24.1%		24		26.1%			
ICA Dehisence	Absent	35		60.3%		54		58.7%		0.445	X²
	Unilateral	21		36.2%		30		32.6%			
	Bilateral	2		3.4%		8		8.7%			
ON Protrusion	Absent	47		81.0%		60		65.2%		0.105	X²
	Unilateral	3		5.2%		11		12.0%			
	Bilateral	8		13.8%		21		22.8%			
ON Dehisence	Absent	49		84.5%		73		79.3%		0.686	X²
	Unilateral	5		8.6%		12		13.0%			
	Bilateral	4		6.9%		7		7.6%			

[t] Independent sample t test / [m] Mann-Whitney U test / [X² C]hi-square test

Min: Minimum, Max: Maximum, SD: Standard deviation

Table 2
Distribution of parameters by age

		Age				p	
		Min-Max	Median	Mean ± SD			
Onodi Cell	Absent	18.0 - 81.0	31.0	34.6 ± 15.3		0.277	m
	Present	18.0 - 70.0	36.0	37.5 ± 15.6			
ICA Protrusion	Absent	18.0 - 74.0	34.0	35.9 ± 14.8		0.287	K
	Unilateral	18.0 - 63.0	27.0	31.3 ± 14.2			
	Bilateral	18.0 - 81.0	33.0	36.9 ± 17.3			
ICA Dehisence	Absent	18.0 - 74.0	34.0	35.9 ± 14.8		0.678	K
	Unilateral	18.0 - 81.0	31.0	35.1 ± 16.3			
	Bilateral	18.0 - 70.0	28.0	33.4 ± 17.3			
ON Protrusion	Absent	18.0 - 81.0	34.0	37.3 ± 16.0		0.103	K
	Unilateral	18.0 - 60.0	33.0	32.0 ± 11.4			
	Bilateral	18.0 - 69.0	25.0	30.4 ± 13.5			
ON Dehisence	Absent	18.0 - 81.0	33.0	36.1 ± 15.9		0.644	K
	Unilateral	18.0 - 53.0	32.0	31.0 ± 9.9			
	Bilateral	19.0 - 69.0	25.0	35.0 ± 17.0			

[K] Kruskal-wallis (Mann-whitney u test), Min: Minimum, Max: Maximum, SD: Standard deviation

Table 3
Distribution of parameters by sinus volume

		Volume (mm^3)							p	
		Min-Max			Median	Mean ± SD				
Onodi Cell	Absent	2815.7	-	22364.5	9947.3	10272.2	±	3898.9	0.106	t
	Present	851.3	-	22419.3	8957.7	9146.2	±	3649.8		
ICA Protrusion	Absent	2815.7	-	20624.7	8828.3	9157.5	±	3484.7	0.002*	A
	Unilateral	851.3	-	16097.9	9838.0	10049.2	±	3699.6		
	Bilateral	4479.0	-	22419.3	11328.3	11743.8	±	4228.5		
ICA Dehisence	Absent	2815.7	-	20624.7	8828.3	9157.5	±	3484.7	0.000*	A
	Unilateral	851.3	-	22419.3	9838.0	10564.6	±	3993.6		
	Bilateral	6634.9	-	18256.9	13700.2	13859.9	±	3583.9		
ON Protrusion	Absent	2815.7	-	22419.3	8828.3	9277.8	±	3559.6	0.001*	A
	Unilateral	851.3	-	18765.6	9901.5	10202.0	±	4355.6		
	Bilateral	5943.0	-	20624.7	12324.5	12305.3	±	3825.9		
ON Dehisence	Absent	2815.7	-	22419.3	9359.3	9726.1	±	3772.7	0.267	A
	Unilateral	851.3	-	18765.6	11339.1	11317.6	±	4478.1		
	Bilateral	5943.0	-	16034.5	9963.5	10311.4	±	3567.4		

[A] ANOVA / [t] t test, Min: Minimum, Max: Maximum, SD: Standard deviation

Table 4
Distribution of parameters by sinus area

		Area (mm²)							p	
		Min-Max			Median	Mean ± SD				
Onodi Cell	Absent	1637.7	-	8941.2	4588.1	4698.2	±	1621.8	0.126	t
	Present	1547.3	-	9825.2	4073.7	4254.1	±	1534.5		
ICA Protrusion	Absent	1637.7	-	8743.0	4172.9	4291.8	±	1501.8	0.005*	A
	Unilateral	3058.3	-	7212.5	4028.6	4466.0	±	1291.3		
	Bilateral	1547.3	-	9825.2	5271.5	5288.0	±	1815.1		
ICA Dehisence	Absent	1637.7	-	8743.0	4172.9	4291.8	±	1501.8	0.003*	A
	Unilateral	1547.3	-	9825.2	4245.7	4781.5	±	1706.5		
	Bilateral	4669.6	-	8286.5	5882.3	5980.7	±	1087.2		
ON Protrusion	Absent	1637.7	-	9825.2	4167.5	4337.0	±	1522.6	0.003*	A
	Unilateral	2248.2	-	7078.6	4088.5	4517.1	±	1448.6		
	Bilateral	1547.3	-	8648.9	5341.8	5459.7	±	1710.6		
ON Dehisence	Absent	1637.7	-	9825.2	4206.5	4492.2	±	1613.0	0.383	A
	Unilateral	3058.3	-	8648.9	4596.1	5060.2	±	1494.6		
	Bilateral	1547.3	-	7212.5	5004.6	4687.4	±	1680.4		

[A] ANOVA / [t] t test, Min: Minimum, Max: Maximum, SD: Standard deviation

Protrusion and Dehiscence of ICA

In 89 (59.3%) of 150 CTs, neither protrusion nor dehiscence was observed in the ICA. ICA protrusion was observed in a total of 61 CTs (40.7%), 23 (15.3%) were unilateral ICA protrusion and 38 (25.3%) were bilateral ICA protrusion. Out of 61 CTs (40.7%) who showed ICA dehiscence, 51 (34.0%) were unilateral ICA dehiscence, and 10 (6.7%) were bilateral ICA dehiscence. Both the rates of protrusion and dehiscence of ICA did not differ significantly between the gender ($p > 0.05$) (Table 1). However, there was no significant difference between age and the rates of protrusion and dehiscence of ICA ($p > 0.05$) (Table 2). When the effect of ICA on sinus volume and area was investigated, it was observed that sinus volume and area were statistically significantly higher in patients with bilateral protrusion of ICA compared to patients without protrusion of ICA ($p < 0.05$). Similarly, in patients with bilateral dehiscence of ICA, sinus volume and area were found to be statistically significantly higher than those without ICA dehiscence ($p < 0.05$)

(Table 3,4). On the other hand, unilateral ICA protrusion or dehiscence did not show a statistically significant relationship with other parameters ($p > 0.05$).

Protrusion and Dehiscence of ON

ON protrusion was observed in a total of 43 CTs (28.7%), 14 (9.3%) were unilateral ON protrusion and 29 (19.3%) were bilateral ON protrusion. ON protrusion was not observed in 107 CTs (71.3%). Out of 28 CTs (18.7%) who showed ON dehiscence, 17 (11.3%) were unilateral ON dehiscence, and 11 (7.3%) were bilateral ON dehiscence. ON dehiscence was not detected in 122 CTs (81.3%).It was found that there was no significant relationship between the protrusion or dehiscence rate of ON with both gender and age ($p > 0.05$) (Table 1,2). When the effect of ON on sinus volume and area was evaluated, sinus volume and area were statistically significantly higher in patients with bilateral protrusion of ON compared to patients without ON protrusion ($p < 0.05$), on the other hand, it was determined that there was no statistically significant relationship between unilateral ON protrusion and other parameters ($p > 0.05$) (Table 3,4). It was observed that whether ON showed dehiscence or not did not affect the sinus volume and area statistically ($p > 0.05$).

The Volume and Area of Sphenoid Sinus

The mean volume and area of sinus were 9949.4 ± 351.0 mm^3 and4570.9 ± 1604.9 mm^2, respectively. The sinus volume and area in females were calculated as 8896.5 ± 3058.3 mm^3 and 4123.4 ± 1230.7 mm^2, respectively, and the sinus volume and area in males as 10613.2 ± 4155.9 mm^3 and 4853.0 ± 1749.4 mm^2, respectively (Table 3,4). Sinus volume and area in males were found to be significantly higher than in females ($p < 0.05$).There was a negative correlation between age and sinus volume and area (r= -0.443 for volume; r= -0.380 for area; p = 0.000).

Discussion

Pneumatization Types of Sphenoid Sinus

Even less is known about genetic and environmental factors that may influence the pneumatization process: some authors suggest that nasal airflow and positive air pressure in the nasopharynx can alter the pneumatization of the paranasal sinuses as well as the morphology of the nasal opening. Other theories consider opportunistic expansion of the epithelium versus the structural configuration of the bone: finally, genetic and pathological factors are taken into account, although their weight in determining pneumatization still needs to be determined [24].

In some studies, it was observed that three types of sphenoid sinus pneumatization were defined as sellar, presellar and conchal type. Sellar type pneumatization was classified as the type reaching posterior to the tuberculum sella[5]. In these reviewed studies [9, 25–28], the most common type was reported to be the sellar type, with a prevalence ranging from 58.7–93%.

Degaga et al.[29] reported the conchal, presellar, sellar and postsellar type prevalence as 2%, 25.5%, 50% and 22.5%, respectively. In the study of Battal et al.[30], conchal, presellar, sellar and postsellar type prevalence was reported as 1%, 18.2%, 12.7% and 68.2%, respectively. Tomovic et al.[31] reported that conchal, presellar, sellar, and postsellar type percentage were 1.8%, 7.3%, 47.6%, and 43.3%, respectively.Movahhedian et al.[4] reported the percentages of the conchal, presellar, sellar, postsellar (a), and postsellar (b) types as 1%, 11.5%, 35.5%, 38.9%, and 13.1%, respectively. Our results with a higher prevalence of postsellar type were generally compatible with the literature.

OC Prevalence

In the reviewed studies, the prevalence of OC was reported to be 8-65.3% [4,11–13,16,25, 27,28,32).

In this study, the prevalence of OC was found as 28.7% The difference between these rates is due to the fact that OCs are better detected in studies in which axial sections are examined, whereas OCs can be considered as posterior ethmoid cells in coronal section examinations [28].

Protrusion and Dehiscence of ICA

Movahhedian et al. [4] reported the prevalence of ICA dehiscence as 42.8%. Hewaidi etal.[21]reported that protrusion of ICA was observed in 41% of cases, of whom 22.7% were bilateral, 11.3% were right sided, and 7% were left sided. Dehiscence of ICA was observed in 30% of cases, of whom 10.3% were bilateral, 14.3% were on the right, and 5.3% were on the left. Erdoğan et al.[28] reported that the prevalence of ICA protrusion and dehiscence were 45.8% and 2.5%, respectively. Li et al.[33] reported the unilateral and bilateral protrusion as 8.68% and 20.57%, respectively. In the study of Turna et al.[34], protrusion and dehiscence of ICA were observed in 3% and 24 0.5% of the subjects, respectively. Parvathy et al.[35] reported that protrusion of ICA was found in 23.3% of cases (19M; 16F), of whom 42.9% were bilateral, 34.3% were right sided and 22.9% were left sided. Dehiscence of ICA was seen in 4% of cases (2M; 4F) of whom 50% were bilateral, 16.7% were on the right and 33.3% were on the left. In the study of Anusha et al.[26], the rates of ICA dehiscence and protrusion were 3.0 and 10.0%, respectively. Fadda et al.[9] reported the protrusion and dehiscence of ICA as 26.3% and 0.4%. In 1.1% of the cases, the ICA was dehiscent and protruded simultaneously. In the study of Singh et al.[36], protrusion and dehiscence of ICA was observed in 28% (16% M; 12% F) and 9% (3% M; 6% F) of cases. Dündar et al.[37] reported the prevalence of ICA protrusion as 27.9%. Davoodi et al.[38] reported that the protrusion and dehiscence of ICA in 48.5% and 39% of males, 34.3% and 44.9% of females, respectively. In this study, the prevalence of ICA protrusion and dehiscence was found as 40.7% and 40.7%, respectively.

Protrusion and Dehiscence of ON

In the study of Fadda et al.[9], the protrusion and dehiscence rate of ON were 13% and 1.5%, respectively. Hewaidi et al.[21] reported the prevalence of ON protrusion as 35.7%. Protrusion was seen as bilateral (20.3%), right sided (7%), and left sided (8.3%) of cases, respectively. Dehiscence of ON was noticed in 30.7% of patients, of whom 10% were bilateral, 12.3% were right sided, and 8.3% were left sided. Parvathy et al.[35] reported the prevalence of ON protrusion as 27.3% (24M; 17F), of whom 78%, 14.6% and 7.3% were bilateral, right sided and left sided, respectively. Dehiscence of ON was seen in 4% of cases (5M; 1F) of whom 50%, 33.3% and 16.7% were bilateral, right sided and left sided, respectively.Lupascu et al.[25], Anusha et al. [26], Li et al. [33] and Dündar et al.[37] reported the prevalence of ON protrusion as 65%, 2.3%, 16% and 17.8%, respectively.Movahhedian et al.[4] and Anusha et al.[26] reported the prevalence of ON dehiscence as 64.5% and 7%, respectively. Singh et al.[36] reported the rate of ON dehiscence as 29% (18% M; 11%F). Bilateral dehiscence of ON was more common than unilateral. In this study, the prevalence of ON protrusion and dehiscence was found as 28.7% and 81.3%, respectively.

Davoodi et al.[38] reported that the protrusion and dehiscence of ON in 38% and 28.5% of males, 34.9% and 46% of females, respectively.

The Volume and Surface Area of Sphenoid Sinus and Its Relation to Other Parameters

Singh et al.[36] reported that the average volume and diameterwas 6576.92mm^{3}and 30.48 mm, respectively. The sinus volume was larger in males than in females. Sinus volume was significantly associated with gender and sinus condition. In the study of Sentürk et al.[32], total sinus volume was found to be 15.07 cm^3 in cases without OC. They stated that total sinus volume was significantly lower in the cases with bilateral OC than without OC. In unilateral OC cases, a significant reduction in sinus volume was seen only for the side with OC. Similarly, Nomura et al.[39] reported that presence of OC reduces the volume. Li et al.[33] reported that the volume depended upon the protrusion degree in sinus and showed statistical differences. The volume of11.16, 14.2 and 25.03 cm^3 was measured in cases without ICA protrusion, with the unilateral protrusion, and the bilateral protrusion, respectively. Gibelli et al.[40] reported that the total sinus volume was 10.005 cm^3 and 7.920 cm^3 in males and females, respectively. Presellar type showed the least sinus volume while the retrosellar type had the highest volumes.In this study, the sphenoid sinus with postsellar b type had the highest volume while conchal type had the least volume. Similarly, for all types, males showed higher volumes than females in this study.

In the study of Orhan et al.[41], the median sinus volumes were 4.40 cm^3 on the right and 4.20 cm^3 on the left. This study stated the mean volume and area of sinus were 9949.4 ± 351.0 mm^3 and 4570.9 ± 1604.9 mm^2, respectively.

Cohen et al.[42] stated that that the volume of sphenoid sinuses decreases with age.Oliveira et al.[43] suggests possible application for gender diagnosis based on the dimorphism of the sphenoid sinuses, although there was no statistically significant differences between males and females in their study. However, Cohen et al.[42] stated sexual dimorphism in sphenoid sinus size. Similarly, in our study, it was observed that there was a decrease in sinus volume and area with increasing age.

Along with the evaluation of sinus wall thickness and protrusion of surrounding noble structures, one of the most relevant information in surgery is the volume of the sphenoid sinuses [44]. However, volume is also one of the most difficult parameters to calculate [40].In recent years, the introduction of automatic and manual segmentation in CT scans has enhanced research in this area, allowing operators to easily obtain 3D models of anatomical structures and calculate volumes and areas[45]. Although semi-automatic segmentation is faster, manual segmentation is widely used in endoscopic surgery for computer and robotic assistance [45, 46].Due to its widespread use, we preferred to use the manual segmentation module in this study.

Conclusion

To the best of our knowledge, no study on the sphenoid sinus area and its relationship with morphological parameters could be found in the literature. Although there are studies reporting the relationship between volume and some morphological parameters, no study has been found on the relationship between such a large number of parameters. In the literature, it is seen that different results of the morphological and volumetric parameters have been reported. These different results may be due to differences in ethnic characteristics, devices and methods used. Therefore, there is a need for detailed and future studies in different populations investigating the relationship between sphenoid sinus morphological parameters and its volume. We think that this study will be a guide for future studies.

Declarations

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Author Contribution

M. S.: Protocol development, Data collection, Data analysis

C. A. B.: Data analysis, Manuscript writing

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Availability of data and materials

All data used in this work are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

Conflict of interest

The authors declare that they have no confict of interest

Ethics approval

Ethical approval was taken from the Ethical Committee of our university (Decision date: 06/10/2022, Number: 08). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate

Since the article does not contain any identifying information about the participants, informed consent is not required for its publication.

Consent for publication

Not applicable.

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Figures

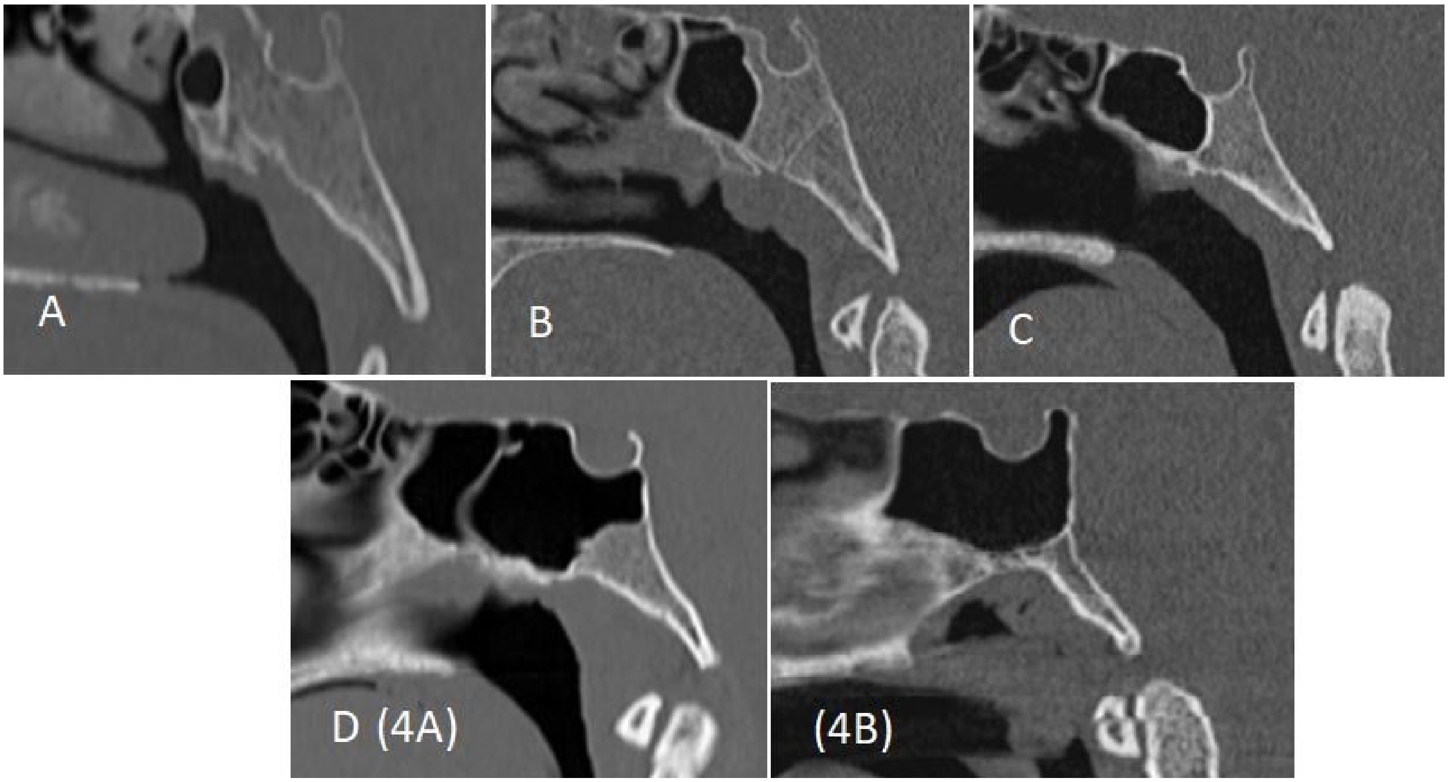

Figure 1

Types of sphenoid sinus pneumatization. A. Conchal (Type I), B. Presellar (Type II), C. Sellar (Type III), D. Postsellar without (type IVa) and with (type IVb) air cells in posterior clinoid process

Figure 2

Onodi cell (asterisk)

Figure 3

Protrusion and dehiscence of internal carotid artery. A. No protrusion and dehiscence B. Protrusion of internal carotid artery C. Dehiscence of internal carotid artery (asterisk)

Figure 4

Protrusion and dehiscence of optic nerve A. No protrusion and dehiscence B. Protrusion of optic nerve C. Dehiscence of optic nerve (asterisk)

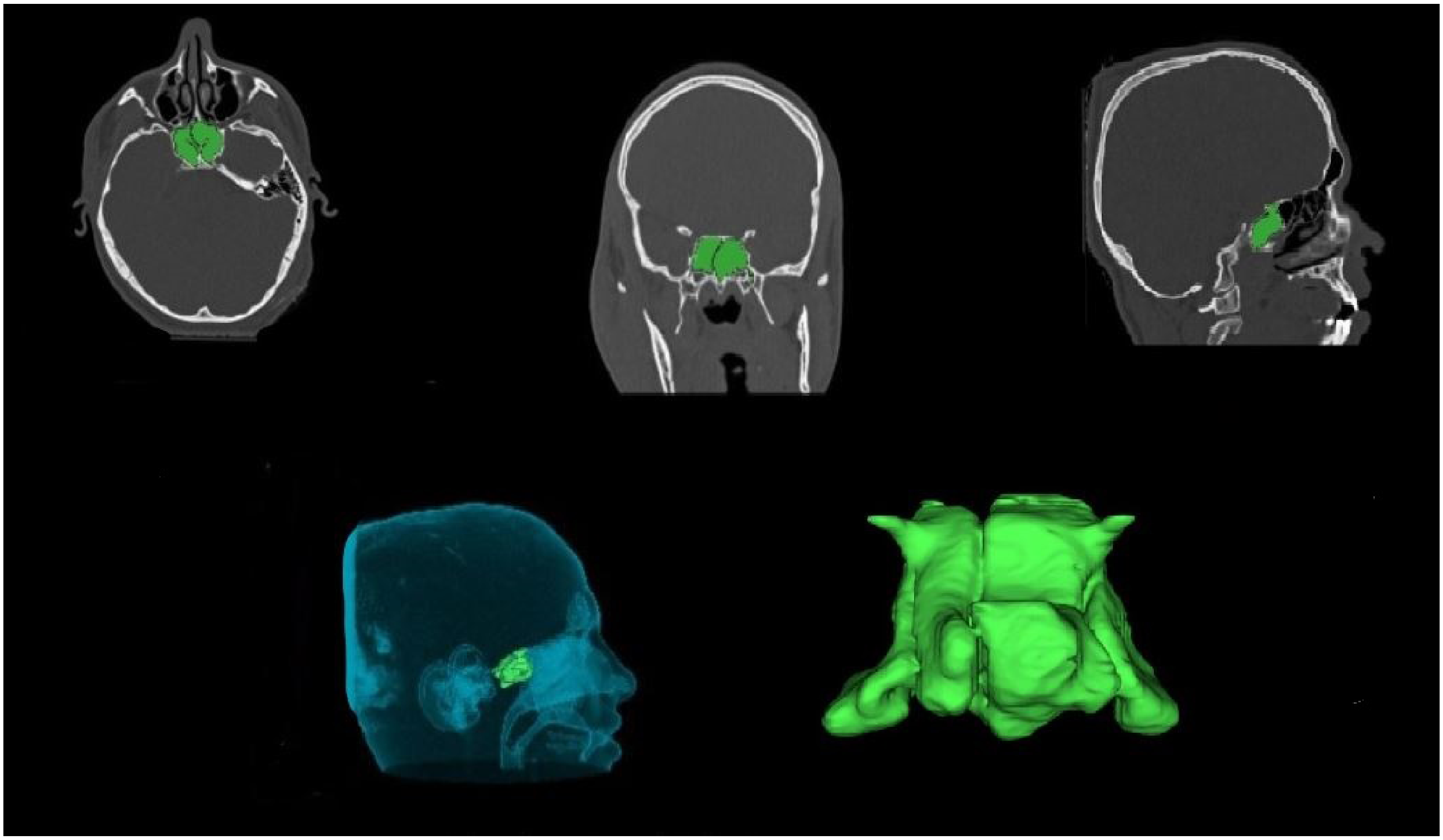

Figure 5

Volumetric measurement and 3D reconstruction of sphenoid sinus with using InVesalius software