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# Pneumatization of the sphenoid sinus is the major factor determining the variations of adjacent vital structures

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## Abstract

**Background** Sphenoid sinus (SS) is an important landmark for endoscopic sinus surgery (ESC) and endoscopic skull base surgery. This study examines the relation of the extent of pneumatization of the sphenoid sinus with adjacent vital structures such as the internal carotid artery, optic canal, and Vidian nerve by using paranasal sinus computed tomography (PNSCT).

**Methods** The study was designed retrospectively. PNSCT images in axial, coronal, and sagittal planes on both sides (right, R; left, L) were examined for sphenoid sinus, Vidian canal (VC), optic canal (OC), and carotid canal (CC) bilaterally.

**Results** The carotid canal did not show identification on the SS wall in females compared to males bilaterally (right,  $p=0.002$  and left,  $p=0.002$ ). The mean age was significantly higher in patients with a presellar type of sphenoid sinus ( $p=0.003$ ). The mean age was significantly lower on the right side with a VC completely within the sphenoid sinus ( $p=0.005$ ). The mean age of patients with an optic canal protrusion to the SS wall was significantly higher than patients with an optic canal indentation to the SS wall ( $p=0.007$ ). On the left side, cases with an optic canal protruding to the SS wall were older than cases with an optic canal indentation to the SS wall ( $p=0.008$ ). SS variations on the sagittal plane were significantly correlated with RVC, RCC, LVC, and LCC variations. Also, SS variations on the coronal plane were significantly related to types of LVC and RVC.

**Conclusions** Pneumatization of SS significantly affects the development of surrounding vital structures, especially with increasing age.

**Keywords** Sphenoid sinus, Vidian canal, Optic canal, Carotid canal, Sphenoid pneumatization

## Background

Sphenoid sinus is an important landmark for endoscopic sinus surgery (ESC) as well as endoscopic skull base surgery and is a compelling factor that directly affects the planning and performing of the endoscopic approaches due to the different variations in septation,

shape, dimensions, and complex relation with associated vital structures [1–3]. Sphenoid sinuses are double cavities formed within the body of the sphenoid bone, communicating with the roof of the nasal cavity through the sphenoidal recess in its anterior wall. A large sinus can show a number of ridges and depressions related to closely adjacent structures. The degree of pneumatization of the sphenoid sinus is highly variable and reaches its mature size by 14 years of age [4]. The sphenoid bone is an important structure of endoscopic approaches because it is located in the center of the skull base and has a key role such as either a door or barrier to dissection. The sphenoid sinus is the most difficult to reach

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among the paranasal sinuses. The close relationships of the air spaces in the sphenoid sinuses with important peripheral structures such as the internal carotid artery, optic nerve, maxillary nerves (in foramen rotundum) and Vidian nerves have attracted the attention of clinical studies [3]. In the case of diffuse pneumatization, adjacent structures may protrude into the sinus cavities, sometimes without bony structure [5]. In order to reduce the complications that may occur due to transsphenoidal and functional endoscopic sinus surgery, the sphenoid sinus and related regional anatomy should be known. The most useful method for this is the radiological examinations [6]. Evaluation of anatomy and variations with a paranasal sinus computed tomography (PNSCT) in the preoperative period is important in terms of preventing complications.

The extent of pneumatization is highly variable, and as it expands, it encircles the neighboring structures more. It poses a potential hazard to surrounding structures, including the optic, Vidian, oculomotor, trochlear, and abducens nerves, cavernous sinuses, and internal carotid arteries [7].

The aim of this study was to examine relation of the extent of pneumatization of the sphenoid sinus with the adjacent vital structures as internal carotid artery, optic canal, and Vidian nerve by using PNSCT.

## Methods

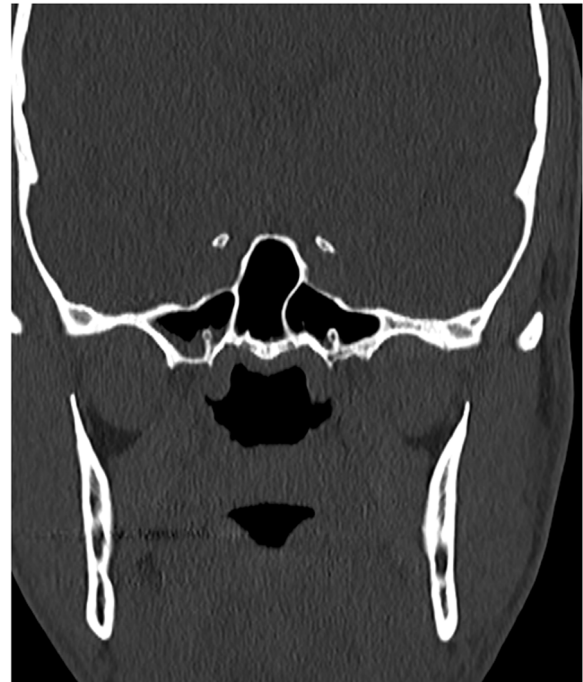
The study was designed retrospectively. PNSCT images obtained between October 2018 and June 2021 in a secondary referential state hospital were reanalyzed. High-resolution PNSCT images (Toshiba, Activion16 Multislice CT, Kyoto, Japan) in axial, coronal, and sagittal planes examined for sphenoid sinus, Vidian canal, optic canal, and carotid canal bilaterally. Participants over the age of 18 without any paranasal sinus disease were included in the study. The patients with prior sinus surgery, maxillo-facial trauma, sinonasal tumors, severe septum deviation, severe concha bullosa, midline defects, nasal polyposis, and chronic rhinosinusitis were excluded.

## Outcome parameters

The type of sphenoid sinus in the sagittal plane (pre-sellar, sellar, or post-sellar) and the coronal (pre-Vidian, intercanal, or post-rotundum) plane was defined. Vidian canal was classified according to the definition by Lee et al. [8]; (1) completely within the SS (Fig. 1), (2) on the floor or partially protruding into the SS, and (3) completely embedded in the sphenoid corpus (SC) (Fig. 2). The optic canal was classified according to the

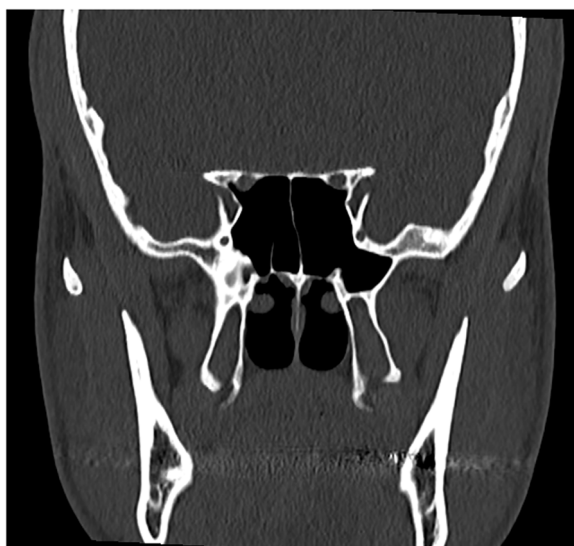


**Fig. 1** The Vidian canal is completely embedded in the sphenoid corpus on the coronal section



**Fig. 2** The bilateral Vidian canal is completely within the sphenoid sinus

relationship with the sphenoid sinus wall; (1) no indentation, (2) indentation to the SS wall, (3) protrusion to the SS wall (Fig. 3), and (4) extends laterally to the sphenoid sinus and posterior ethmoid cell (PEC) [9]. A similar classification was used for the carotid canal; (1) no indentation, (2) indentation to the SS wall (Fig. 4), and (3) protrusion to the SS wall [10]. All classifications were done bilaterally and recorded separately.



**Fig. 3** Protrusion of both optic canals to the sphenoid sinus wall



**Fig. 4** A partial indentation of the left carotid canal to the sphenoid sinus wall

### Statistical analysis

SPSS 22.0 program (IBM Corp., Armonk, NY, USA) was used for statistical analysis. The distribution of scale variables was evaluated with the Shapiro-Wilk Francia test, while the homogeneity of variance was evaluated with the Levene test. One-way ANOVA (Robust Test: Brown-Forsythe) and the Tukey HSD test for post hoc analysis were used to compare groups for age. The Pearson chi-square test was tested with the Monte Carlo simulation technique in the comparison of groups according to

gender. The possibility of co-occurrence of anatomical groups was evaluated with Spearman's correlation test. While quantitative variables were expressed as mean (standard deviation) and median (minimum-maximum) in the tables, categorical variables were shown as  $n$  (%). The variables were analyzed at a 95% confidence level, and a  $p$  value of less than 0.05 was considered significant. The study was carried out in accordance with the 1964 Helsinki Declaration and subsequent amendments. The institutional review board was approved by the ethic committee of affiliated university for the study (1118-949/27.06.2022).

### Results

Paranasal sinus computed tomography (PNSCT) of 262 patients was evaluated bilaterally (524 sphenoid sinuses). Of the patients, 100 (38.2 %) were females and 162 (61.2%) were males. In the sagittal plane, sphenoid sinuses on the right and left sides (RSSS vs LSSS) were found to be the most postsellar type ( $n= 208$ , 79.4% vs.  $n= 210$ , 80.2%). At the coronal plane of images, the most common variation of sphenoid sinus was both on the right and left as pre-VIDIAN type (RSSC vs. LSSS) ( $n= 124$ , 47.3% vs.  $n= 116$ , 44.3%). The Vidian nerve canal on both sides (RVC vs LVC) was detected as completely embedded in the sphenoid corpus ( $n= 123$ , 46.9% vs  $n= 123$ , 46.9%). Optic canal with partial indentation to sphenoid sinus wall was found both at right and left (ROC vs. LOC) as mostly variation ( $n= 120$ , 45.8% vs.  $n= 119$ , 45.9%). No indentation or partial indentation of the right and left carotid canal (RCC and LCC) to the sphenoid sinus wall was the mostly structural formation both on the right and left side (Table 1).

The carotid canal did not show identification on the SS wall in females, both on the right (49.0% vs. 29.6%) and on the left (49.0% vs. 30.2%) side, compared to males ( $p= 0.002$  and  $0.002$ ). In accordance, the indentation of the carotid canal on the SS wall was detected significantly with a higher rate in men than in women (Table 2).

While the mean age was found to be significantly higher in patients with presellar type of sphenoid sinus compared to the sellar and postsellar type, the mean age was similar in the sellar and postsellar sphenoid sinus groups on right side (RSSS;  $p=0.003$ ,  $0.006$ , and  $0.341$ , respectively). On the right side, mean age of patients with VC completely within the sphenoid sinus was significantly lower compared to patients with VC completely embedded in the sphenoid corpus ( $p= 0.005$ ). There was a similar relationship between Vidian canal type and age on the left side (Table 3). The mean age of patients with an optic canal protrusion to SS wall was significantly higher than patients with an optic canal indentation to SS

**Table 1** Frequencies of variations of the sphenoid sinus and associated structures on right and left side

		Right		Left	
		n	%	n	%
SSS type	Pre-sellar	11	4.2	13	5.0
	Sellar	43	16.4	39	14.9
	Post-sellar	208	79.4	210	80.2
SSC type	Pre-Vidian	124	47.3	116	44.3
	Intercanal	55	21.0	62	23.7
	Post-rotundum	83	31.7	84	32.1
VC	Completely within the SS	23	8.8	27	10.3
	On the floor or partially protruding into the SS	116	44.3	112	42.7
	Completely embedded in the SC	123	46.9	123	46.9
OC type	No indentation	38	14.5	39	15.1
	Indentation to SS wall	120	45.8	119	45.9
	Protrudation to SS wall	67	25.6	67	25.9
	Laterally to the SS and PEC	37	14.1	34	13.1
CC type	No indentation	97	37.6	98	38.0
	Indentation to SS wall	98	38.0	97	37.6
	Protrudation to SS wall	63	24.4	63	24.4

SS sphenoid sinus, SSS sphenoid sinus, sagittal plane, SSC sphenoid sinus, coronal plane, VC Vidian canal, OC optic canal, CC carotid canal, SC sphenoid corpus, PEC posterior ethmoid cell

wall or laterally to the SS and PEC on right side (ROC;  $p=0.007$  and  $0.010$ ).

Left optic canal course as protruding to SS wall was detected in patients with higher average age compared to courses as indentation to SS wall or laterally to the SS and PEC ( $p=0.008$  and  $0.005$ ). The mean, standard deviation, and other statistical data of age according to subgroups for anatomical variations were given in Table 3.

SS variations on the sagittal plane were significantly correlated with RVC, RCC, LVC, and LCC variations. Also, SS variations on the coronal plane were significantly related to types of LVC and RVC (Table 4). But, when the sphenoid sinus variations were evaluated in total (no side classification), according to the sagittal and coronal planes, there were no significant correlation was detected between the sphenoid sinus variations and other VC, CC, or OC variations (Pearson correlation,  $p>0.050$ ).

## Discussion

Main results of study demonstrated that sphenoid sinuses on the right and left sides were mostly postsellar type and pre-Vidian type at the coronal plane. A completely embedded Vidian nerve canal in the sphenoid corpus, a partial indentation of the optic canal to the sphenoid sinus wall, and a structural formation of the carotid canal were the most presented variations on both sides. The carotid canal variations were significantly differentiated between gender. With increasing age, the Vidian canal tended to be embedded in the SC. The rate of optic canal

protrudation to the SS wall was significantly higher in older ages. LSSS variations were significantly correlated with RVC, RCC, LVC, and LCC variations.

Current literature supported that sphenoid sinuses show a parallel expansion in antero/posterior and lateral directions until age 10, and there may be a slight global expansion in all directions after age 14 or 15 [11–13]. The results in the presented study may indicate an expansion of the sphenoid sinus in the cranial route rather than lateral direction with advancing age.

SS are complex structures due to their deep anatomical localization and high variability in shape and size depending on the degree of pneumatization. It was stated that size and shape of SS show a high variability with a range of 200% or more in both directions [12]. Embryologically, the carotid artery, optic nerve, and Vidian nerve develop before sphenoid sinus development, and sinus enlargement gives these structures their final anatomical design as irregularities in the sinus wall [12]. The anatomical relationships of the various neurovascular structures vary according to the degree of pneumatization of the sphenoid sinus [14]. Hammer and Radberg showed that sellar type being the commonest variation [15]. The incidence of this study was reported as 86%. In similar studies, it has been shown that sellar pneumatization is higher at a rate of 55–77.3% [14]. El Sayed et al. found a higher rate of presellar pneumatization in their population [16]. Abdalla [17] reported postsellar pneumatization at a rate of 74.8% in his study on the Iraqi population. In our

**Table 2** Frequencies of variations of the sphenoid sinus and associated structures according to the gender on the right and left side

		Right				p	Left				p	
		Gender					Gender					
		Female	Male				Female	Male				
		n	%	n	%		n	%	n	%		
Sphenoid sinus sagittal plane	Pre-sellar	No	99	99.0	152	93.8	0.056	98	98.0	151	93.2	0.140
		Yes	1	1.0	10	6.2		2	2.0	11	6.8	
	Sellar	No	81	81.0	138	85.2	0.374	83	83.0	140	86.4	0.450
		Yes	19	19.0	24	14.8		17	17.0	22	13.6	
	Post-sellar	No	20	20.0	34	21.0	0.848	19	19.0	33	20.4	0.874
		Yes	80	80.0	128	79.0		81	81.0	129	79.6	
Sphenoid sinus coronal plane	Pre-Vidian	No	54	54.0	84	51.9	0.735	56	56.0	90	55.6	0.944
		Yes	46	46.0	78	48.1		44	44.0	72	44.4	
	Intercanal	No	73	73.0	134	82.7	0.061	72	72.0	128	79.0	0.195
		Yes	27	27.0	28	17.3		28	28.0	34	21.0	
	Post-rotundum	No	73	73.0	106	65.4	0.201	72	72.0	106	65.4	0.268
		Yes	27	27.0	56	34.6		28	28.0	56	34.6	
Vidian canal	Completely within the SS	No	90	90.0	149	92.0	0.583	88	88.0	146	90.1	0.589
		Yes	10	10.0	13	8.0		12	12.0	16	9.9	
	On the floor or partially protruding into the SS	No	54	54.0	92	56.8	0.659	56	56.0	94	58.0	0.748
		Yes	46	46.0	70	43.2		44	44.0	68	42.0	
	Completely embedded in the SC	No	56	56.0	83	51.2	0.453	56	56.0	83	51.2	0.453
		Yes	44	44.0	79	48.8		44	44.0	79	48.8	
Optic canal	No indentation	No	86	86.0	138	85.2	0.856	84	84.0	139	85.8	0.690
		Yes	14	14.0	24	14.8		16	16.0	23	14.2	
	Indentation to SS wall	No	49	49.0	93	57.4	0.185	52	52.0	91	56.2	0.510
		Yes	51	51.0	69	42.6		48	48.0	71	43.8	
	Protrudation to SS wall	No	77	77.0	118	72.8	0.453	77	77.0	118	72.8	0.543
		Yes	23	23.0	44	27.2		23	23.0	44	27.2	
Laterally to the SS and PEC	No	88	88.0	137	84.6	0.438	88	88.0	140	86.4	0.712	
	Yes	12	12.0	25	15.4		12	12.0	22	13.6		
Carotid canal	No indentation	No	51	51.0	114	70.4	0.002	51	51.0	113	69.8	0.002
		Yes	49	49.0	48	29.6		49	49.0	49	30.2	
	Indentation to SS wall	No	71	71.0	93	57.4	0.027	71	71.0	94	58.0	0.035
		Yes	29	29.0	69	42.6		29	29.0	68	42.0	
	Protrudation to SS wall	No	78	78.0	121	74.7	0.543	78	78.0	121	74.7	0.543
		Yes	22	22.0	41	25.3		22	22.0	41	25.3	

SS sphenoid sinus, SC sphenoid corpus, PEC posterior ethmoid cell

study, we found that postsellar pneumatization was at a highest rate. We think that finding similar results with Abdalla is due to the close neighborhood of the Iraqi and Turkish populations and the fact that people of similar ethnic origin (Arabic and Kurdish) live in both regions. Also at the coronal plane, the most common variation of SS was both on the right and left as the pre-Vidian type, and SS variations on the coronal plane were significantly related to the type of Vidian canal variations. Although this actually shows an internal consistency of SS and VC classification in the coronal plane, in fact, the lateral

pneumatization of the SS toward to anterior clinoid process correlates with the Vidian canal type and SS variation in the coronal plane [12, 18, 19].

The Vidian nerve runs through a bony tunnel along the floor of the sphenoid sinus. This canal connects the foramen lacerum with the pterygopalatine fossa. The location of this channel is variable and may differ with the degree of SS pneumatization. The pneumatization pattern of the Vidian canal has a number of implications during the operational approach. The fact that neighboring structures are surrounded by air or bone makes

**Table 3** Average age in different variations of the sphenoid sinus and associated structures

		N	m	SD	95% confidence interval for mean		Min	Max	p
					Lower bound	Upper bound			
RSSS	Pre-sellar	11	41.36	14.94	31.32	51.41	16	60	0.011
	Sellar	43	29.02	12.02	25.32	32.72	13	61	
	Post-sellar	208	30.95	11.92	29.32	32.58	12	77	
RSSC	Pre-Vidian	124	30.56	11.38	28.54	32.59	12	77	0.724
	Intercanal	55	32.16	14.04	28.37	35.96	13	65	
	Post-rotundum	83	31.11	12.29	28.42	33.79	15	69	
RVC	Completely within the SS	23	25.52	10.92	20.80	30.24	12	61	0.008
	On the floor or partially protruding into the SS	116	29.91	11.13	27.87	31.96	14	65	
	Completely embedded in the SC	123	33.20	13.05	30.87	35.53	13	77	
ROC	No indentation	38	32.79	12.46	28.69	36.89	13	69	0.017
	Indentation to SS wall	120	29.54	11.63	27.44	31.64	12	65	
	Protrudation to SS wall	67	34.51	11.12	31.79	37.22	17	61	
	Laterally to the SS and PEC	37	28.05	14.47	23.23	32.88	13	77	
RCC	No indentation,	97	29.29	12.15	26.84	31.74	12	69	0.156
	Indentation to SS wall	98	32.65	12.74	30.10	35.21	14	65	
	Protrudation to SS wall	63	30.84	11.16	28.03	33.65	16	77	
LSSS	Pre-sellar	13	37.08	14.77	28.15	46.01	13	60	0.186
	Sellar	39	30.26	12.86	26.09	34.43	13	61	
	Post-sellar	210	30.85	11.91	29.23	32.47	12	77	
LSSC	Pre-Vidian	116	30.42	11.38	28.33	32.52	12	77	0.631
	Intercanal	62	32.27	13.82	28.76	35.78	13	65	
	Post-rotundum	84	31.08	12.22	28.43	33.74	15	69	
LVC	Completely within the SS	27	24.56	10.69	20.33	28.79	12	61	0.003
	On the floor or partially protruding into the SS	112	30.43	11.07	28.35	32.50	14	65	
	Completely embedded in the SC	123	33.09	13.06	30.76	35.42	13	77	
LOC	No indentation	39	32.15	11.92	28.29	36.02	13	69	0.014
	Indentation to SS wall	119	29.71	11.85	27.55	31.86	12	65	
	Protrudation to SS wall	67	34.67	11.11	31.96	37.38	17	61	
	Laterally to the SS and PEC	34	27.44	14.92	22.23	32.65	13	77	
LCC	No indentation	98	29.47	12.22	27.02	31.92	12	69	0.221
	Indentation to SS wall	97	32.51	12.73	29.94	35.07	14	65	
	Protrudation to SS wall	63	30.84	11.16	28.03	33.65	16	77	

SS sphenoid sinus, RSSS right sphenoid sinus, sagittal plane, RSSC, right sphenoid sinus, coronal plane, RVC, right Vidian canal, ROC right optic canal, RCC right carotid canal, LSSS left sphenoid sinus, sagittal plane, LSSC, left sphenoid sinus, coronal plane, LVC left Vidian canal, LOC, left optic canal, LCC, left carotid canal, SC, sphenoid corpus, PEC posterior ethmoid cell

**Table 4** Spearman correlation analysis of sphenoid sinus variations and adjacent structures

		RVC type	ROC type	RCC type	LVC type	LOC type	LCC type
RSSS type	Spearman's rho	-0.230	0.073	0.311	-0.240	0.050	0.320
	p	0.000	0.236	0.000	0.000	0.419	0.000
RSSC type	Spearman's rho	0.324	-0.024	-0.079	0.310	-0.036	-0.086
	p	0.000	0.704	0.206	0.000	0.568	0.171
LSSS type	Spearman's rho	-0.227	0.055	0.278	-0.246	0.032	0.287
	p	0.000	0.379	0.000	0.000	0.614	0.000
LSSC type	Spearman's rho	0.306	-0.008	-0.051	0.285	-0.023	-0.057
	p	0.000	0.901	0.417	0.000	0.711	0.360

RSSS, right sphenoid sinus, sagittal plane, RSSC, right sphenoid sinus, coronal plane, RVC, right Vidian canal, ROC, right optic canal, RCC, right carotid canal, LSSS, left sphenoid sinus, sagittal plane, LSSC, left sphenoid sinus, coronal plane, LVC, left Vidian canal, LOC, left optic canal, LCC, left carotid canal

it difficult to see the desired structure. The Vidian canal may be completely embedded in the SS corpus. In the literature, Yeğın et al. [6] reported as 39%, Yazar et al. [20] as 36%, and Adin et al. [21] as 48% as embedded in the sphenoid corpus. In our study, we found that 46.9% of them were embedded in the sphenoid corpus, and it was the most common type. The fact that these studies were also conducted in a specific local population, and the results are different may mean a possible ethnic anatomical change. In our study, we detected the second type protruding towards the sphenoid sinus. Lang and Keller [22] reported that the Vidian canal protrudes into the sinus cavity in 18% and Hewaidi and Omami in 27% [23]. Adin et al. [21] reported 44% rate of the Vidian canal protruding into the sphenoid sinus. We found similar results in the study reported by Adin et al. [21]. This is because these studies were conducted in similar regions in Turkey. Arabic and Kurdish populations live in these regions intensively. This highlights the importance of ethnicity in sinus pneumatization. In this study, as in previous studies, there was no significant gender preference [19, 21, 24].

The optic canal is a cylindrical canal running obliquely through the lesser wing of sphenoid bone near the base where it joins the body of sphenoid. It transmits the optic nerve and ophthalmic artery. It can compress the sphenoid sinus in the superior section. In our study, optic canal indentation was 45.8 % on the right side and 45.9% on the left side, and optic canal protrusion was 25.6 % on the right side and 25.9% on the left side. No gender difference was detected. In the study of Asal et al. [10] indentation rate was determined as 11.3 and 9.9% in males and females. Hewaidi and Omami [23] reported that 35.6% of the patients had optic nerve protrusion and 30.6% had optic nerve indentation. In another study, Fuji et al. [25] reported that 4% of the optic nerves were indentation on the sphenoid bone. Previous studies reported a wide range of protrusion rates of 8 to 70% [23]. In our study, the separation rate was found to be relatively high compared to the literature, and the protrusion rate was found to be relatively low. We think that the different results obtained from these studies are based on regional differences and ethnic origins again. Previously, a significant correlation of the anterior clinoid process (lateral expansion of SS) with the OC variations was reported, but lateral or cranial pneumatization of SS in this study did not show a significant relation with OC in this study [5, 12, 18].

In our study, carotid canal protrusion to the sphenoid sinus wall was present 22% in males and 25.3% in females. Dehiscence in carotid canal was detected more in females (42%) compared to males (29%). Asal et al. [10] reported that 32.1% of the patients had internal carotid artery

protrusion into the sphenoid on the right and 23.9% on the left. Hewaidi and Omami [23] reported that 41% of patients had internal carotid artery protrusion towards the sphenoid bone. Gibelli et al. [26] reported the rate of internal carotid artery protrusion as 46.2%. Otherwise, the prevalence of ICA protrusion has been reported in a wide range in the literature, generally varying between 3.9 and 41.0% [12]. Our study is compatible with the literature. A preoperative evaluation of the sphenoid sinus with CT will help prevent possible complications. Variations of SS on the sagittal plane was significantly related CC variation in presented study, but there was no data for a valid comparisons in the literature. Also the course of this internal carotid artery adjacent to the SS and the cranial expansion potential of the SS may be related this association. Additionally, as demonstrated in the current literature, SS pneumatization and expansion essentially determine the variation of associated structures such as CC and OC [17, 26].

Although this study predominantly sampled from a relatively single ethnic population, it supports that, as intended, variations of the SS and associated structures are primarily associated with a pattern of SS pneumatization or enlargement. Repeating similar studies in larger samples from different ethnic origins will yield more valid results.

## Conclusion

Pneumatization of SS significantly affects the development of surrounding vital structures, especially with increasing age and gender. So, it should be strongly advised a preoperative radiological evaluation of patients. A PNSCT or magnetic resonance imaging must be obtained routinely preoperatively to reduce the risk of morbidity and mortality.

## Abbreviations

RSSS	Right sphenoid sinus, sagittal plane
RSSC	Right sphenoid sinus, coronal plane
RVC	Right Vidian canal
ROC	Right optic canal
RCC	Right carotid canal
LSSS	Left sphenoid sinus, sagittal plane
LSSC	Left sphenoid sinus, coronal plane
LVC	Left Vidian canal
LOC	Left optic canal
LCC	Left carotid canal

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## Authors' contributions

SŞ contributed to the conceptualization, data curation, formal analysis, methodology, supervision, writing—the original draft, and review and editing of the study. AI contributed to the concept of the study, data curation and data analysis, methodology, supervision, writing—the original draft, and review and editing of the study. All authors read and approved the final manuscript.

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**Availability of data and materials**

The datasets generated during and analyzed during the current study are available from the corresponding author upon reasonable request.

**Declarations****Ethics approval and consent to participate**

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The institutional review board was approved for the study (1118-949/27.06.2022, Mardin Provincial Health Directorate). Consent to Participate is not applicable as it is a retrospective study.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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