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ANATOMICAL VARIATIONS OF SPHENOID SINUS AND RELATIONSHIP WITH NEUROVASCULAR STRUCTURES. A RETROSPECTIVE ANALYTICAL STUDY USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Introduction: One of the human body's most diverse structures is thought to be the sphenoid sinus. This degree of variability is due to the great vulnerability of the sphenoid to pneumatization, which complicates surgical methods. The sphenoid sinus may interact closely with the cranial nerve II, optic nerve (ON) and internal branch of the carotid artery (ICA). CBCT is a useful option for assessing the anatomy presented in the maxillofacial region, as well as variability in this anatomy such as variable anatomical presentation of the sphenoid sinus.

Aim of the study: we aimed in this study to assess the variable anatomical presentations of the sphenoid sinus and its relationship with the nearby nerves and vessels via CBCT and correlating our findings with the potential influencing forensic factors.

Materials and methods: CBCT images were conducted on 51 scans selected randomly from the database. Two oral and maxillofacial radiologists assessed the scans, each of them has more than 10 years of experience. This was done in a darkened room. Sphenoid sinus pneumatization types and the relation with OP and ICA were assessed in each patient. Additionally, probable influential causes for example age, gender were analyzed.

Results: 51 patients were the total number of patients assessed by CBCT; the age range were from 18 to 50 years. The mean was 24.0196 ± 5.87023 (Min 18, Max 50).The conchal type wasn't found in any patient, 5 scans (9.8%) were presellar type, 11 of scans (21.6%) were sellar type, and 35 of scans (68.6%) were a postsellar type of pneumatization. 35 sides (34.3%) had no pneumatization around ICA, In 31 sides (30.4%) the ICA is close association to the SS, but does not invade into

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the sinus, 30 sides (29.4%) had less than 50% exposure in the SS. Only 6 sides (5.9%) had more than 50% exposure in the SS. Regarding to ON ,74 sides (72.5%) were smoothly touching to the SS, In 10 sides (9.9%) the ON was smoothly irrelevant to the SS, 18 sides (17.6 %) had less than 50% protrusion in the SS.

Conclusion: Sphenoid sinus is an anatomical structure that shows great variability; this inconsistency requires a comprehensive knowledge of its anatomy and what's it's in and what is around the sinus before surgeries from CBCT scans.

KEY WORDS: Sphenoid sinus, anatomical variations, neurovascular relation and CBCT

INTRODUCTION

There are four paired paranasal sinuses (PNSs), sphenoid sinus (SS) is one of them and located in the sphenoid bone body . It gains attention as it shows the greatest unpredictability and slightest reachability **(Schwerz Mann et al., 2022).** SS starts developing as a small cavity at birth, and the development completes till after puberty. It starts with posterior extension in the presellar area then it extend into the area below and behind the sella turcica, until it gains its full-size in adolescence **(Mohebbi et al., 2017 and Uthman et al., 2021).**

Sphenoid sinus is well-thought-out to be the most variable cavity in the human body. The variability is considered a reflection of the sinus great tendency to pneumatization **(Movahhedian et al., 2021)** .

Sphenoid sinus pneumatization allows for reachability to other parts in the skull base. SS has effects starting from partial encircling to the optic canals and as the sinus size increases it extends into the pterygoid processes roots or greater wing of sphenoid or even extend into the basilar part of the occipital bone**(Mohebbi et al., 2017and Schwerz Mann et al., 2022).**

Therefore, planning of surgical procedures requires a well awareness of the degree and direction of SS pneumatization. **(Wang et al., 2010 and Štoković et al., 2016)** Sphenoid sinus pneumatization degree is indicated by the placement of the posterior sinus wall with respect to the sella turcica **(Movahhedian et al., 2021).**

Also, SS have a crucial association with the ON and the cavernous sinus, which houses vital neurovascular structures like the ICA , ophthalmic, maxillary, and the Vidian nerves that might be harmed in surgeries **(Sethi et al., 2023).** This makes the surgical procedures in this area difficult and risky **(Yan et al., 2021).**

Understanding about normal anatomy and deviation from normal is an important cornerstone to understand the pathological processes in radiology. The clinical features and pathological findings are completed with the radiological findings. Identification and reporting of these anatomical variations by the radiologist are important for helping the operating surgeon to anticipate protentional technical challenges. This is critical for sidestepping iatrogenic scratches and considering pathogenesis courses that may happen in the sinus cavity **(Štoković et al., 2016 and Farhan et al., 2020).**

CBCT is a useful option for assessing anatomical structures, such as the sphenoid sinus anatomy, relations and variations **(Güldner et al., 2012).**

Few CBCT studies conducted in the Egyptian population in this area, so that the current study's objective was to evaluate the sphenoid sinus and its relationship to surrounding neurovascular structures as well the correlation with potential influencing factors in Egyptian population.

MATERIALS AND METHODS

Sample size calculation

The calculation of the sample size was done using data from a prior study by **(Güldner et al., 2012)** using power of 95% and 5% significance level and it was performed using G power. A total of 30 scans were needed.

Ethical clearance:

In this cross-sectional study, CBCT images were conducted on 51 scans selected randomly. Records were obtainable from the Oral and Maxillofacial Radiology Department database, Faculty of Dentistry, Cairo University. Approval was obtained by the Research ethical committee, faculty of Dentistry, Cairo University (ref number 24/3/23).

Eligibility criteria:

CBCT Scans that completely show sphenoid sinus for male and/or female patients 18-50 years old are included; as it is first detected at radiographs between the age 2 to 3 years and spreads mature size in puberty. Also, fungal infections in sinus are frequently seen in elderly patients > 50 years. while we excluded scans for patients with a history of surgery or trauma in SS area, scans reveal presence of nasal or facial neoplasms and signs of sinusitis as polyps or opacification and scans that show artifacts or distortion presenting in the area of SS. In addition, scans with anomaly in the craniofacial region were excluded.

Data analysis

For all patients, data about sex and age was recorded using a Microsoft Excel spreadsheet (Microsoft Office Excel, 2013). If data about patient`s gender not available, patient`s name will be used instead to identify the gender. Patients with names that carry mixed probability will be excluded.

All the images were acquired using Planmeca Promax 3D Mid machine (Planmeca, Helsinki, Finland), FOV 20 x 20 cm with exposure parameters of 400 µm, voxel size, 90 kVp and 8 mA for 13.5 sec and images were evaluated using Planmeca Romexis software version 6.4 (Planmeca Romexis®). Scans were assessed by two oral and maxillofacial radiologists, each of them has more than 10 years of experience, assessment was done in a darkened room. Adjustment of density and/or contrast of the images was made according to their subjective perception for better assessment and measurement procedures. Medium slice thickness was selected.

CBCT images were examined in sagittal, coronal and axial cuts of the whole volume (whole field of view). Assessment for right and left sides was made. Sinus assessment criteria mentioned in table (1) was made and added to the previous excel sheet. Neither the patients' clinical information nor their demographic information was revealed during the evaluation of the CBCT images.

Assessment was done by each observer 2 times with 2 weeks interval for inter-observational reliability. Disagreement in findings were discussed with the surgeon of more than 15 years of experience or excluded. Only the approved data was used for reporting and analysis.

TABLE (1) The variables used in the our study.

Variable	Plane examined	Descriptive criteria
Pneumatization type Classified according to relationship with the sella turcica**. (Sethi et al., 2023)**	Sagittal **(Fig.1)**	**Type I (Conchal)**: Absent or slight extension of the sinus. **Type II (Presellar):** Posterior border of the SS is in front of the anterior wall of sell turcica. **Type III (Sellar):** The sinus is placed between the sella`s anterior and posterior wall. **Type IV (Postsellar):** Posterior wall of the SS extend beyond the posterior border of sella.
Lateral Pneumatization of SS (Yesiltepe et al., 2022)	Coronal **(Fig.2)**	It comprises three subtypes: **1. The greater wing pneumatization**: pneumatization prolonged beyond the VR line (the vidian canal–foramen rotundum line). **2. The pterygoid pneumatization:** pneumatization outspreading inferior to the vidian canal into the pterygoid process. **3. The full lateral pneumatization:** include both the greater wing and pterygoid process pneumatization.
Lesser wing pneumatization **(Secchi et al 2018)**	Coronal **(Fig.3)**	Lesser wing pneumatization type extended in the direction of anterior clinoid process.
Relation with the **internal carotid artery (ICA)** **(Yan et al., 2021)**	Axial **(Fig.4)**	The grading standard of the ICA was based on the results of **Liu et al.,2002** **1) grade 0:** no relation between SS and ICA(no Pneumatization). **2) grade 1:** the ICA is adjacent to the SS, but does not protrude into the sinus. **3) grade 2:** < 50% exposure of the ICA. **4) grade 3**: > 50% exposure of the ICA, crossing SS.
Relation to optic nerve (ON) **(Movahhedian et al., 2021)**	Coronal, Axial **(Fig.5)**	**1. Smooth type**: There was no ON canal invagination in the cavity of the sinus, and 2 subcategories were taken into consideration: (a) Irrelevant: No relationship was found between ON and the SS . ON passed away from the SS. (b) Touching: There was a close association between the ON and SS without making any protrusion. **2. Prolonged type**: Invagination of the ON canals into the sinus cavity was seen. 2 subdivisions were detected: *(a) Lower than 50%:* protrusion < 50% of the canal. *(b) Greater than 50%:* protrusion > 50% of the canal.

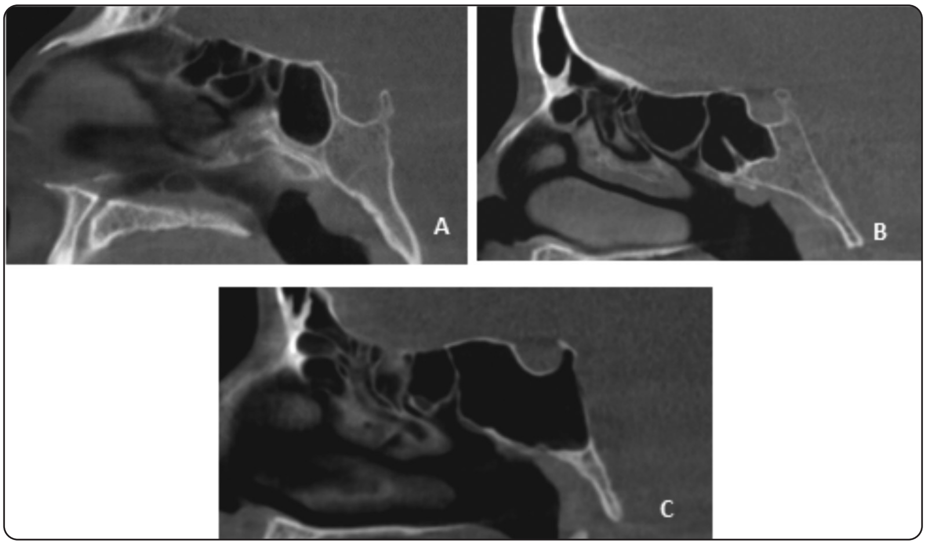

Fig. (1) Sagittal cuts of CBCT showing types of SS pneumatization in relation to the sella turcica: A: presellar type (Type II), B:sellar type (Type III) and C: post sellar type (Type IV).

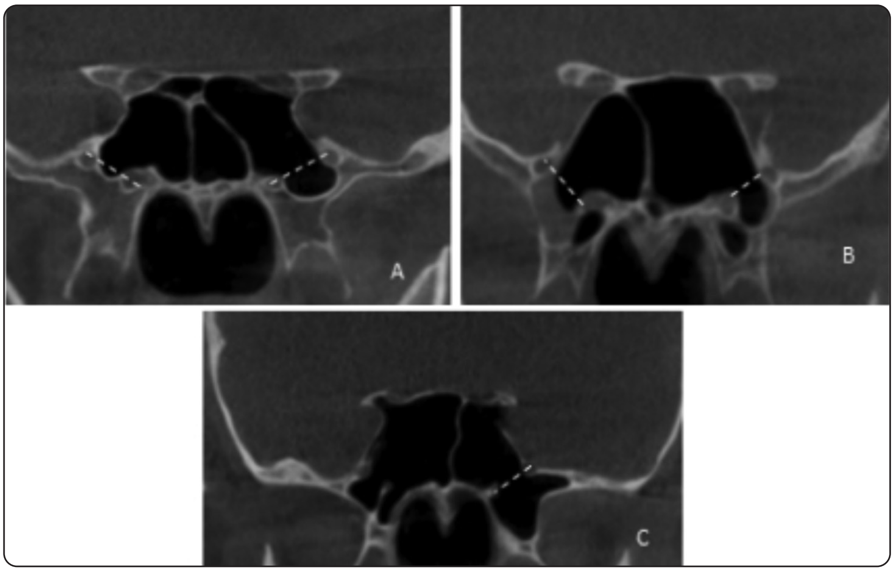

Fig. (2) Coronal cuts of CBCT showing the lateral SS pneumatization, A: greater wing pneumatization on the left side, B: bilateral pterygoid pneumatization and C: bilateral full lateral pneumatization.

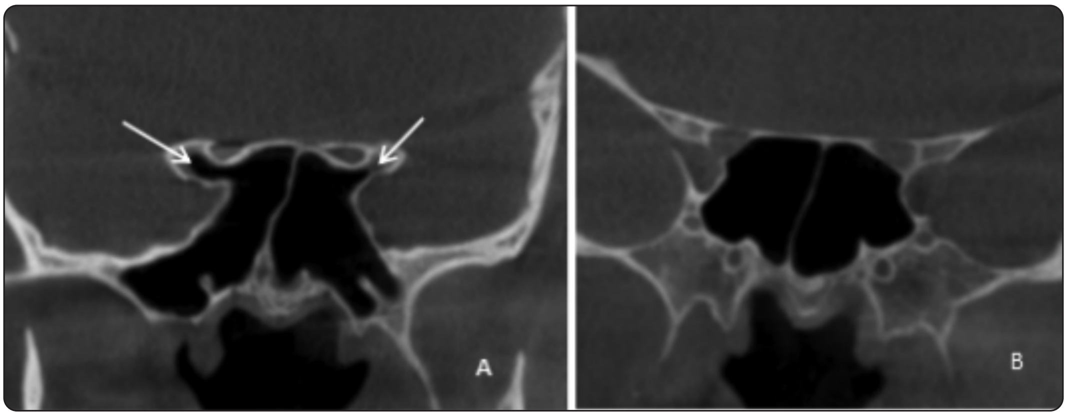

Fig. (3) Coronal cuts of CBCT showing: A: bilateral lesser wing pneumatization (white arrows) and full lateral pneumatization, B: no lesser wing pneumatization and no lateral pneumatization.

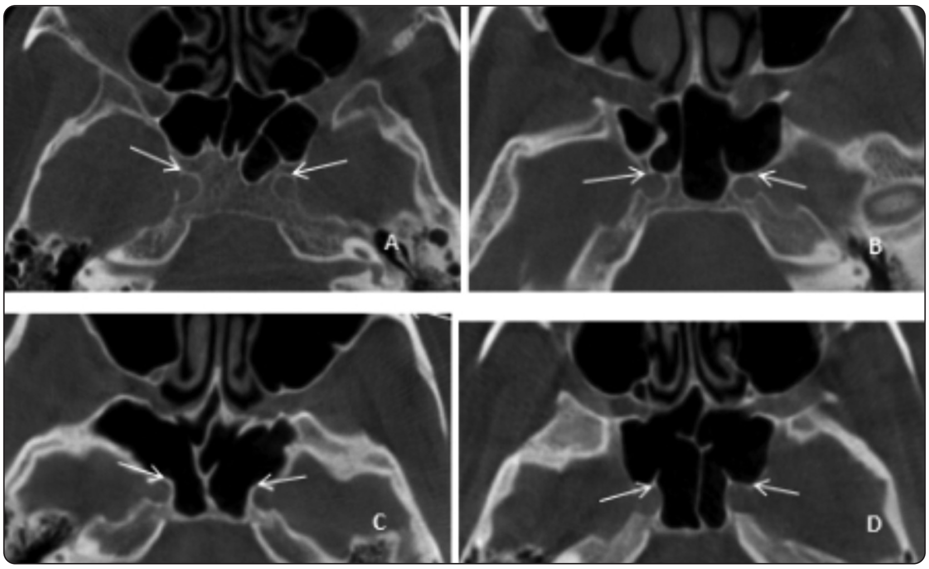

Fig. (4) Axial cuts of CBCT showing relation of sphenoid sinus to ICA : A:grade 0, B: grade1, C: grade 2 and D: grade3.

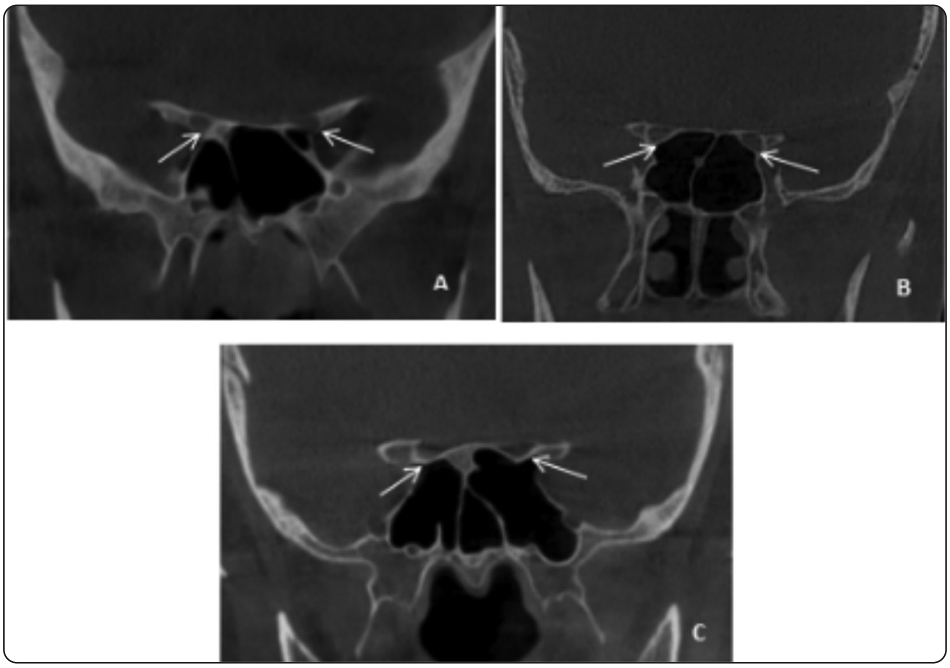

Fig. (5) Coronal cuts of CBCT showing relation of sphenoid sinus to the optic nerve (ON): A: smooth (irrelevant), B: smooth (touching) and C: prolonged type (protrusion less than 50%).

RESULTS

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20 was used for data management and statistical analysis. Categorial data were briefed as count and percentage. Chi-squared test was used to evaluate the associations between variables of interest. Age related comparisons was assessed by One Way ANOVA test . All p-values are two-sided. P-values ≤0.05 were considered significant.

Demographic data

51 patients were evaluated with CBCT. The age range was from 18 to 50 years and the mean of 24.0196 ± 5.87023 (Min 18, Max 50). The study population comprised of 14 males (27.45%) and 37 females (72.54%).

Pneumatization type:

No conchal type was detected, 5 of scans (9.8%) were presellar type, 11 of scans (21.6%) were sellar type, and 35 of scans (68.6%) were a postsellar type of pneumatization. The results were summarized in table 2 .

TABLE (2) Prevalence of SS pneumatization (51 CBCT scans)

Peumatization Type	Frequency	Percent %
Presellar	5	9.8 %
Sellar	11	21.6 %
Postsellar	35	68.6 %
Total	51	100.0 %

Lateral extension

The lateral extension was examined in the right and left side in 51 scans so 102 sides were examined.

51 sides (50%) had no lateral extension. The other types of the lateral extension, such as ptergoid extension, greater wing extension and full lateral extension, was found in 51 sides (50%). The most common lateral extension type was the full lateral extension which was detected in 39 sides (16 right, 23 left) representing (38.2%). Followed by the pterygoid extension which was found in 7 sides (4 right, 3 left) representing (6.9%). Then, the greater wing extension being the least and just seen in 5 sides (3 right, 2 left) representing (4.9%). The results are summarized in table 3.

TABLE (3) Lateral extension of sphenoid sinus

Type of extension	No extension		Lateral extension						Total
			Greater wing		Pterygoid		Full lateral		
Side	Right	Left	Right	Left	Right	Left	Right	Left	
Number	28	23	3	2	4	3	16	23	
Total	51		5		7		39		102 sides
Percent %	50%		4.9%		6.9%		38.2%		100%

Lesser wing extension

The lesser wing extension was detected for the right and left side in 51 scans. 30 scans had no extension bilaterally, 13 scans had bilateral extension and 8 scans showed unilateral extension (5 in the right side and 3 in the left side) Table 4.

TABLE (4) Lesser wing extension of sphenoid sinus

	No extension	Bilateral extension	Unilateral extension		Total
			Right	Left	
Frequency	30	13	5	3	51
Percentage	58.8%	25.5%	9.8%	5.9%	100%

ICA dehiscence and indentation

Only one case showed dehiscence of the ICA representing 2%.The dehiscence was bilateral.

ICA grading

The grading of ICA was detected for right and left sides. So that, we had 102 sides for 51 scans.

35 sides (34.3%) had no pneumatization around ICA (grade 0), 19 sides were at right side and at 16 were at left side. In 31 sides (30.4%) the ICA is approximate to the SS (grade 1), but does not invade into the sinus,14 sides were at right side and at 17 were at left side. 30 sides (29.4%) had less than 50% exposure in the SS (grade 2). Only 6 sides (5.9%) had more than 50% exposure in the SS (grade 3), 3 in the right side and 3 in the left side as shown in table 5.

TABLE (5) Relation of ICA to SS

ICA grade	Grade 0		Grade 1		Grade 2		Grade 3		Total
Side	Right	Left	Right	Left	Right	Left	Right	Left	
Number	19	16	14	17	15	15	3	3	
Total	35		31		30		6		102 sides
Percent %	34.3%		30.4%		29.4%		5.9%		100%

ON dehiscence and indentation

None of the cases showed dehiscence of the ON. The indentation of ON was found in 100% of the cases.

ON grading

The relation of ON to the sphenoid sinus was detected for right and left sides. So that, we had 102 sides for 51 scans. 74 sides (72.5%) were smoothly touching to the SS,40 sides were at right side and at 34 were at left side. In 10 sides (9.9%) the ON was smoothly irrelevant to the SS, 5 for each. 18 sides (17.6 %) had less than 50% protrusion in the SS, 40 sides were at right side and at 34 were at left side.as shown in table 6.

Regarding influence of age and gender on pneumatization type: There was no significant difference between presellar type (24.8±5.31), Sellar (22.73±3.35) and post sellar (24.31±6.58) years, (p=0.730). In males, post sellar type was noted in 71.4%, sellar in 21.4% and presellar in 7.1%; in comparison to 67.6%, 21.6%, 10.8% in females respectively;without a discernible gender difference(p=0.922).

Correlation between lateral extension and all grades of internal carotid artery (Table 7)

Right side: In the non-extension group, grade 0 was observed in 57.16%, grade 1 in 25% and grade 2 in 17.9%, in comparison to 33.3%, 66.7% and 0% respectively in the greater wing (GW), 25%, 0% and 75% respectively in pterygoid, while in GW+pterygoid, grade 0 was observed in 6.3%, grade 1 in 31.3%, grade 2 in 43.8% and grade 3 in 18.8%. The difference in prevalence of ICA grades in different lateral extension types was statistically significant (p=0.007).

Left side: In the non-extension group, grade 0 was observed in 56.5%, grade 1 in 34.8% and grade 2 in 8.7%, in comparison to 50%, 50% and 0% respectively in the greater wing (GW), 0%, 33.3% and 66.7% respectively in pterygoid, while in GW+pterygoid, grade 0 was observed in 8.7%, grade 1 in 30.4%, grade 2 in 47.8% and grade 3 in 13%. The difference inprevalence of ICA grades in different lateral extension types was statistically significant (p=0.011).

TABLE (6) Relation of ON to SS

ON Grade	Smooth touching		Smooth irrelevant		Less than 50% protrusion		Total
Side	Right	Left	Right	Left	Right	Left	
Number	40	34	5	5	6	12	
Total	74		10		18		102 sides
Percent %	72.5%		9.9%		17.6%		100%

TABLE (7) Correlation between lateral extension and all grades of Internal Carotid artery (ICA) (chi square test)

			Lateral extension (Right)				Total	P value
			No extension n=28	Greater wing n=3	Pterygoid n=4	GW +Pterygoid n=16		
ICA Grade (Right)	Grade 0	Count	16	1	1	1	19	.007*
		%	57.1%	33.3%	25.0%	6.3%	37.3%	
	Grade 1	Count	7	2	0	5	14	
		%	25.0%	66.7%	.0%	31.3%	27.5%	
	Grade 2	Count	5	0	3	7	15	
		%	17.9%	.0%	75.0%	43.8%	29.4%	
	Grade 3	Count	0	0	0	3	3	
		%	.0%	.0%	.0%	18.8%	5.9%	

			Lateral extension (left)				Total	P value
			No extension n=23	Greater wing n=2	Pterygoid n=3	GW+Pterygoid n=23		
ICA Grade (Left)	Grade 0	Count	13	1	0	2	16	.011*
		%	56.5%	50.0%	.0%	8.7%	31.4%	
	Grade 1	Count	8	1	1	7	17	
		%	34.8%	50.0%	33.3%	30.4%	33.3%	
	Grade 2	Count	2	0	2	11	15	
		%	8.7%	.0%	66.7%	47.8%	29.4%	
	Grade 3	Count	0	0	0	3	3	
		%	.0%	.0%	.0%	13.0%	5.9%	

Significance level p≤0.05, *significant

Correlation between lateral extension and all grades of Optic nerve (Table 8)

Right side: In the non-extension group, smooth touching was observed in 82.1%, smooth irrelevant in 17.9% and Protrusion <50% in 0%, in comparison to 33.3%, 0% and 66.7% respectively in the greater wing (GW), while in pterygoid all cases were smooth touching. In GW+pterygoid, Smooth touching was observed in 75%, Smooth irrelevant in 0%, and protrusion <50% in 25%. Protrusion >50% was not encountered in this study. The difference in prevalence of Optic nerve grades in different lateral extension types was statistically significant (p=0.004).

Left side: In the non-extension group, smooth touching was observed in 69.6%, smooth irrelevant in 17.4% and Protrusion <50% in 13%, in comparison to 50%, 0% and 50% respectively in the greater wing (GW), while in pterygoid, smooth touching, smooth irrelevant and protrusion <50% were equally presented (33.3% each). In GW+pterygoid Smooth touching was observed in 69.6%, Smooth irrelevant in 0%, and Protrusion <50% in 30.4%. Protrusion >50% was not encountered in this study. The difference in prevalence of Optic nerve grades in different lateral extension types was not statistically significant (p=0.221).

TABLE (8) Correlation between lateral extension and all grades of optic nerve (OP), (chi square test)

			Lateral extension Right				Total	P value
			No extension n=28	Greater wing n=3	Pterygoid n=4	GW+Pterygoid n=16	n=51	
ON Grade (right)	Smooth touching	Count	23	1	4	12	40	.004*
		%	82.1%	33.3%	100.0%	75.0%	78.4%	
	Smooth irrelevant	Count	5	0	0	0	5	
		%	17.9%	.0%	.0%	.0%	9.8%	
	Protrusion <50%	Count	0	2	0	4	6	
		%	.0%	66.7%	.0%	25.0%	11.8%	

			Lateral extension Left				Total	P value
			No extension n=23	Greater wing n=2	Pterygoid n=3	GW+Pterygoid n=23	n=51	
ON Grade (Left)	Smooth touching	Count	16	1	1	16	34	.221 ns
		%	69.6%	50.0%	33.3%	69.6%	66.7%	
	Smooth irrelevant	Count	4	0	1	0	5	
		%	17.4%	.0%	33.3%	.0%	9.8%	
	Protrusion <50%	Count	3	1	1	7	12	
		%	13.0%	50.0%	33.3%	30.4%	23.5%	

Significance level p≤0.05, *significant, ns=non-significant

Correlation between gender and all grades of internal carotid artery (table 9)

Right side: In males, grade 0 was observed in 35.7%, grade 1 in 14.3%, grade 2 in 35.7% and grade 3 in 14.3%; in comparison to 37.8%, 32.4%, 27% and 2.7% in females respectively. There was no statistically significant gender difference (p=0.283).

Left side: In males, grade 0 was observed in 28.6%, grade 1 in 21.4%, grade 2 in 42.9% and grade 3 in 7.1%; in comparison to 32.4%, 37.8%, 24.3% and 5.4% in females respectively.There was no statistically significant difference between the genders (p=0.551).

Correlation between gender and all grades of optic nerve (table 9)

Right side: In males, Smooth touching was observed in 57.1%, Smooth irrelevant in 21.4% and Protrusion <50% in 21.4%; in comparison to 86.5%, 5.4% and 8.1% in females respectively. The difference between genders was not statistically significant (p=0.07)

Left side: In males, Smooth touching was detected in 57.1%, Smooth irrelevant in 14.3% and Protrusion <50% in 28.6%; in comparison to 70.3%, 8.1% and 21.6% in females respectively. It was not statistically significant that there was a gender difference(p=0.648).

Inter observer agreement: An excellent inter-observer repeatability (0.997; Confidence interval 0.996 to 0.9970 denoted reproducibility for observations.

TABLE (9) Comparison of prevalence within gender of all grades of (ICA) and (ON) (chi square test)

			Gender		Total	P value
			Male n= 14	Female n=37		
ICA. Grade Right	Grade 0	Count	5	14	19	.283 ns
		%	35.7%	37.8%	37.3%	
	Grade 1	Count	2	12	14	
		%	14.3%	32.4%	27.5%	
	Grade 2	Count	5	10	15	
		%	35.7%	27.0%	29.4%	
	Grade 3	Count	2	1	3	
		%	14.3%	2.7%	5.9%	
ICA Grade Left	Grade 0	Count	4	12	16	.551 ns
		%	28.6%	32.4%	31.4%	
	Grade 1	Count	3	14	17	
		%	21.4%	37.8%	33.3%	
	Grade 2	Count	6	9	15	
		%	42.9%	24.3%	29.4%	
	Grade 3	Count	1	2	3	
		%	7.1%	5.4%	5.9%	
			Gender		Total	P value
			Male n= 14	Female n=37		
ON Grade Right	Smooth touching	Count	8	32	40	.07 ns
		%	57.1%	86.5%	78.4%	
	Smooth irrelevant	Count	3	2	5	
		%	21.4%	5.4%	9.8%	
	Protrusion <50%	Count	3	3	6	
		%	21.4%	8.1%	11.8%	
ON Grade Left	Smooth touching	Count	8	26	34	.648 ns
		%	57.1%	70.3%	66.7%	
	Smooth irrelevant	Count	2	3	5	
		%	14.3%	8.1%	9.8%	
	Protrusion <50%	Count	4	8	12	
		%	28.6%	21.6%	23.5%	

Significance level p≤0.05, ns=non-significant

DISCUSSION

The most variable structure in our body is the sphenoid sinus, which is also the hardest to access. A full surgical recognizing of the normal anatomy, its pneumatization and the role of putative influencing factors is beneficial for precise diagnostic , pathological information and evaluation of SS before surgical operations to overcome any complications that lead to mortality. Gaining a grasp of CBCT facilitates more accurate diagnosis and, consequently, more predictable dental intervention planning. As a result, CBCT is being used more frequently. The Evidence Based Guidelines from the European Commission state that the practitioner must assess the full volume and be able to identify potential diseases or incidental discoveries in addition to the region of concern**(Martina et al., 2020, Fadda et al., 2022 and Yesiltepe et al., 2022)**

Pneumatization type:

Recent advances in trans-sphenoidal sinus procedures and their usefulness in accessing lesions including the middle cerebral fossa, retroclival region, and foramen magnum have made the study of pneumatization patterns of SS more important **(Sethi et al., 2023)**. SS can be classified into four different types and its recognition done on the sagittal planes according to relationship to anterior and posterior wall of the sella turcica **(Cellina et al., 2020)**.

Postsellar pneumatization type is the predominant type in our research with (68.6%). Similar to our study, **Li et al., 2010**,using CT scans of Chinese population, found that the postsellar pneumatization type was the most common with (46.7%). While, in the study made by **Hamid et al., 2008** on the Egyptian population ,using CT and MRI scans for patients operated for pituitary adenomas , showed that the sellar pneumatization was the most prevalent type with (54.7%). Also, studies made by **Vaezi et al., 2015 and Güldner et al., 2012** showed prominent sellar pneumatization types with (73.7%) and (57.2%) respectively.

In our study, there was no conchal pneumatization type which is identical to the studies performed by **Sareen et al., 2005 and Rahmati et al., 2016**. While, in **Hamid et al., 2008** study there were (2%) of patients with conchal pneumatization.

Regarding influence of age and gender on pneumatization type

In the current study, the age and sinus type did not significantly differ similar to studies of **Tomovic et al 2012. , Craiu et al., 2015 and Movahhedianet al ., 2021** ,in contrast to the study done by **singh etal.,2021** who found that a greater percentage was the post-sellar extension between 15 and 59 years old. Regarding the relation to gender, our study showed no significant correlation between type of pneumatization and gender in accordance to the research studies done by **Guldner et al., 2012, Craiu et al., 2015 and Rahmati et al., 2016.** It was against the studies of **Movahhedianet al ., 2021** and **singh et al., 2021** who showed a striking correlation between gender and sinus type, among males and females the post-sellar extension was found with significantly higher percentage.

Lateral extension

Pneumatization of the pterygoid processes may deposit purulent exudate and cause chronic sinusitis,whereas pneumatized greater wings raises the possibility of penetration into the middle cranial fossa and cerebrospinal fluid (CSF) leakage **(Hamid et al., 2008&Secchi et al 2018).** Unfortunately, in our study, the most common lateral extension type was the full lateral extension which was detected in 38.2% . This was agreeable with **Wang et al.2010** who reported complete lateral extension of SS as the most common type. This was in contrast with **Secchi et al.2018** , whose study reported that the greater wing lateral type extension was the most frequently found (47%) and **Hiremath et al.2021** who found that the pterygoid extension was most common (52.4%); followed by full lateral extension (45.7%) .

Lesser wing extension

30 scans had no extension bilaterally(58.8%), 13 scans had bilateral extension (25.5%)and 8 scans showed unilateral extension (5 in the right side(9.8%) and 3 in the left side(5.8%). **Secchi et al 2018** found that the lesser wing extension was found in 13% of his cases . By **Hewaidi GH, Omami GM 2008** found that 46 patients (15.3%) had lesser wing extension. **Bolger et al 1991** observed the percentage of lesser wing extension was 13.3% of which 6.9% was unilateral and 6.4% was bilateral. **De Lano et al.1996** found lesser wing extension in only 13 of 300 sides (4%). By study done by **Sirikci et al 2000** the lesser wing extension was reported in 27 (29.3%) patients. **Unal et al 2006.**, who detected lesser wing extension in 24.1% of 260 CT data sets. It appears that there is a significant variation in the reported prevalence rates. This could be a reflection of variations within the populations under study.

Relation to the Internal Carotid Artery

Sareen et al., 2005 was in line with the current study who found one sinus with dehiscence. **Farhan et al., 2020** data observed that two cases had ICA dehiscence one case of unilateral (left-sided) and one case of bilateral.

In the present study 34.3% had no pneumatization around ICA (grade 0), 30.4% the ICA approximate to the SS (grade 1) , 29.4% had less than 50% exposure in the SS (grade 2) and 5.9% had more than 50% exposure in the SS (grade 3), studies done by **Guldner et al.,2012** found that 10.5% of his cases protruded and 89.5% had smooth course and **Nitinavakarn et al. 2005& Thakuret al., 2021** observed 10.2% and 12.88% ICA protrusion respectively, which were slightly less when compared to other studies done by **Tan & Ong, 2007, Hewaidi et al.2008 and Movahhedian et al., 2021** reported 67%, 41% and 41% protrusion respectively. These great variations, mostly because the protrusion is defined according to various criteria.

Because of the variability in anatomical relation of internal carotid artery with sphenoid sinus , it is more likely to sustain an accidental injury during surgery that could result in potentially fatal bleeding. The only way to avoid this is to carefully review the scan before beginning any surgery(**Thakuret al., 2021).**

Correlation between lateral extension and all grades of ICA

In current study a noteworthy association exists between the internal carotid artery protrusion and the pneumatization of pterygoid process similar to the studies done by **Dal Secchi et al.,2018, Asal et al., 2019, and Cellina et al., 2020**

Relation to the optic nerve

During SS surgery, ONC damage via protrusion or dehiscence might happen as a serious side effect. Damage to the visual field, visual acuity, or blindness could result from the danger of harm **(Eggers et al., 2011 and Fadda et al., 2022).**

In our study none of the cases showed dehiscence of the ON. The indentation of ON was found in 100% of the cases , in contrast to the studies done by **Fuji et al. 1979, Unal et al. 2006, Hewaidi & Omami 2008, Guldner et al., 2012 and Fadda et al., 2022** who found that dehiscence of the optic nerve was observed in 4%, 8%, 30.6% , 16.1% and 1.5 respectively.

In our study 17.6 % had less than 50% protrusion in the SS, However, previous researches done by **Savvateeva et al., 2010, Kurzweg et al., 2010 and Movahhedian et al., 2021** revealed a broad spectrum of protrusion rates of 8 to 70%., **Cellina et al., 2020** documented ranges of optic nerve protrusion from 2.8 and 35.6%. **Hewaidi & Omami 2008, Guldner et al., 2012** and **Fadda et al., 2022** observed the protrusion in 35.6%, 30% and 13 %of cases respectively. The difference could be the consequence of using a different radiography modality, defining protrusions differently, applying different methodological analyses, or having a different patient group in terms of patient count and ethnicity.

CONCLUSION

In the present study, we have attempted to emphasize how crucial it is to understand the different anatomical differences related to the sphenoid sinus and it's relation to surrounding nerves and vessels as ICA and ON. CBCT imaging of the sphenoid sinus and its surrounding structures is a valuable tool when a patient has an illness that needs to be evaluated before surgery or therapy to prevent consequences including harm to the ICA, optic nerve damage, severe hemorrhage, or pituitary gland damage.

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