10.21608/adjc.2025.338907.1664 Advanced Dental Journal
Volume 7 (2025) | Issue 2| Pages 172-182 ©Faculty of Dentistry-Cairo University

Original Article

CBCT Analysis of Septation and Extension of Sphenoid Sinus in a Sample of the Egyptian Population: A Retrospective Study

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Submitted: 29-11-2024
Accepted: 09-02-2025

Abstract

Aim: The aim of this study was to investigate the sphenoidal sinus septation and extension in a sample of Egyptian population. **Subjects and methods:** A total of 51 CBCT scans were included in this study. The age range was from 18 to 50 years. The SS were assessed regarding the configuration type, clival extension, and anterolateral and posterior extension. The association of the different assessed variables with sex and age was analyzed. **Results:** Septations were revealed in 98% of cases. The most common type was compound type followed by paired type. The most common form of the clival extension was subdorsal type then the occipital type and finally the dorsal and the combined types. Concerning the anterolateral extension 21.6% showed bilateral extension and 9.8% showed unilateral extension. Non-critical type of posterior extension was revealed in 78.4% while the critical type was reported in 21.6%. There was no statistically significant difference between sex and age, and configuration type of the sinus or pneumatization into clivus. **Conclusion**: The high variability of the SS requires an extensive knowledge and understanding of the sinus anatomy to protect the vital structures surround it and CBCT is an ideal choice for the sinus examination before surgical procedures

Keywords: Sphenoid sinus, anatomical variation, CBCT, Pneumatization

Introduction

Functional endoscopic sinus surgery (FESS) has become the optimal choice for the treatment of chronic rhinosinusitis of sphenoid sinus (SS), performing sphenoidotomy and sphenoid ostium opening. The SS is characterized by wide variations in its morphology and pneumatization that can result in serious complications **(Cellina et al, 2020)**. The possibility of surgical complications associated with FESS may be decreased by understanding of the sinus anatomy **(Şimşek and İşlek, 2024)**. The SS is the most

unapproachable paranasal sinus as it is located deeply in the skull. It starts to grow during the third year of life until reaching its adult size at 18 years **(Lee et al, 2012).** It is divided by a main septum into right and left sides.

The SS is surrounded by vital structures, such as the internal carotid artery, optic nerve, maxillary nerves and vidian nerves **(Şimşek and İşlek, 2024).** The main septum is placed in the midline but usually deviated to one side and may be in close relation to the optic nerve and internal carotid artery and sometimes may be attached to bone that covers these vital structures, so careful consideration is required to avoid unintended injury **(Famurewa et al, 2018; Singh et al, 2021)**. As well, the presence of accessory septations usually reduce the space of the sinus, so increasing difficulties in the placement of endoscopic surgical devices. The risk of injuring surrounding vital structures can be increased by overlooking these septal variations pre-operatively and the procedure time may be increased. Thus, to perform the endoscopic approaches of SS safely, it is crucial to know in detail about its septation **(Cellina et al, 2020**).

Pneumatization of the SS may range from absent to extensive and according to the extent of Pneumatization, the bone covering the vital structures may be thin or absent, increasing the iatrogenic injuries to these structures **(Hewaidi and Omami 2008)**. pneumatization sometimes extending into anterior clinoid processes, pterygoid processes, sphenoid greater wings, clivus **(Cellina et al, 2020)**. The development of imaging techniques facilitated the understanding of the normal anatomy and anatomical variations and aided in making the operations safer **(Sirikci et al, 2000)**.

Cone beam computed tomography (CBCT) has become a standard for radiographic assessment of complex structures and treatment planning in dental field. Additionally, CBCT is increasingly applied as an alternative to medical CT in the assessment of the paranasal sinuses due to its high resolution, three orthogonal planes presentation, and lower patient dose compared to CT **(Bornstein et al, 2014; Demiralp et al, 2019; Movahhedian et al, 2021)**.

These variations in the septation and extensions of pneumatization of the SS may facilitate entry into areas bordering the sinus and play a role in the selection of an appropriate surgical approach to avoid complications which may occur during or after surgeries. Therefore, the aim of this study was to investigate the sphenoidal sinus septation and extension in a selected sample of Egyptian population.

Sample size calculation

A study by **Güldner et al. 2012** was used for sample size calculation using power of 95% and 5% significance level and it was performed using G power. A total of 51 CBCT scans were required to be included in this study.

Subjects and methods

This retrospective cross-sectional study was approved by the Ethics committee, faculty of Dentistry Cairo university with code number (421024). Fifty-one CBCT scans were included in this study and selected randomly from Oral and Maxillofacial Radiology Department database, faculty of Dentistry Cairo university. The following inclusion criteria were implemented; Egyptian patients, both sexes of age range (18 - 50 years) and sufficient field of view (FOV) showing normal sphenoid sinuses. Scans that revealed signs of sinusitis as polyps or opacification of the sphenoid sinus, presence of nasal or facial neoplasms, and any craniofacial anomaly were excluded. As well, scans with insufficient FOV, low resolution and considerable artifacts were also 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. CBCT scans were evaluated using Planmeca Romexis software version 6.4 (Planmeca Romexis®). Assessment of the sphenoid sinus was performed by two oral and maxillofacial radiologists of more than 10 years of experience to assess the inter-observer reliability. During the assessment process, both observers were blinded to patients' data. Inconsistent findings were resolved by discussion with a third radiologist more than 15 years of experience or excluded. Assessment of CBCT images were performed in sagittal, coronal and axial according to the criteria mentioned in (Table 1).

Statistical analysis

Data management and statistical analysis were made using the Statistical Package for Social Sciences (SPSS) version 20. Type A intraclass correlation coefficients using an absolute agreement definition was used to assess the inter-observer reliability. Categorial data were summarized as count and percentage. The associations between assessed variables were evaluated using the Chi-squared test. One Way ANOVA test was used for age related comparisons. All p-values are two-sided. P-values ≤ 0.05 were considered significant.

Results

For inter-observer reliability values ranged from 0.996 to 0.9970 denoted reproducibility for observations. CBCT images of 51 patients; 14 (27.45%) males and 37 (72.54%) females were assessed, whose ages were ranging from 18 to 50 years with a mean of (24.0196 ± 5.87023). Septations were revealed in 50 cases (98%). The solitary type was found only in one case (2%). The paired type was present in 20 cases (39.2%); 13 sinuses (25.5%) were paired asymmetrically and 7 sinuses (13.7%) were paired symmetrically. The compound type was found in 30 scans (58.8%) (Table 2). Regarding the clival extension, the most common form of the clival extension was subdorsal type which was found in

40 cases representing (78.43%), then the occipital type which was found in 7 cases representing (13.73%) and finally the dorsal and the combined types which were found in 2 cases representing (3.92%) for each type (Table 3).

Concerning the anterolateral extension of the sinus, 35 cases (68.6%) had no extension bilaterally, 11 case (21.6%) showed bilateral extension, and 5 cases (9.8%) showed unilateral extension. Regarding the cases extended unilaterally, 3 cases (5.9%) extended toward the right side and 2 cases (3.9%) extended toward the left side (Table 4). Posterior extension was classified into critical and non-critical types. Non-critical type was revealed in 40 cases (78.4%) while the critical type reported in 11 cases (21.6%) (Table 5). There was no statistically significant difference between sex and age, and configuration type of the sinus or pneumatization into clivus.

Table (1): Description of the criteria applied in the assessment of the sphenoid sinus

Variable	Plane	Descriptive criteria
Configuration (Figure 1)	Coronal, Axial	*Solitary:* Absence of inter-sinus septum *Paired:* Presence of single inter-sinus septum *Compound:* Presence of more than one inter-sinus septum
Symmetry of paired sinus (Figure 1)	Coronal, Axial	*Symmetrical:* Inter-sinus septum is in the middle and non-deviated *Asymmetrical:* Inter-sinus septum is not in the middle and deviated towards right or left side.
Pneumatization (Figure 2 and 3)	Axial	*Anterolateral:* Protrusion extending past a transverse line drawn through the sphenoidal crest and the sphenoid sinus side. *Posteriorly* (according to the width between the posterior boundary of the SS and the clivus)
	Axial	Two types: *Critical:* clivus thickness < 2mm *Non-critical:* clivus thickness ≥ 2mm
	Sagittal	According to the pneumatization extension into the clivus: *Dorsal:* pneumatization extended above a line drawn from the sellae's floor to the dorsa sellae. *Subdorsal:* pneumatization did not extend below the vidian canal level or above the sellae's inferior margin *Occipital:* pneumatization extended below the horizontal plane level between the paired vidian canals' upper edges. *Combined:* occipital+dorsal

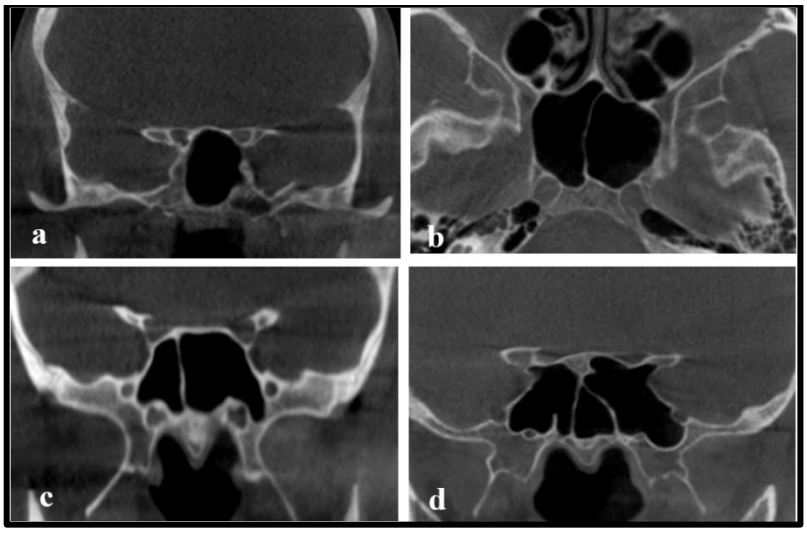

Figure1: Coronal and axial cuts of CBCT showing configuration of the sphenoid sinus: a) Coronal cut (solitary type), b) Axial cut (paired symmetrical), c) Coronal cut (paired asymmetrical), d) Coronal cut (compound sinus)

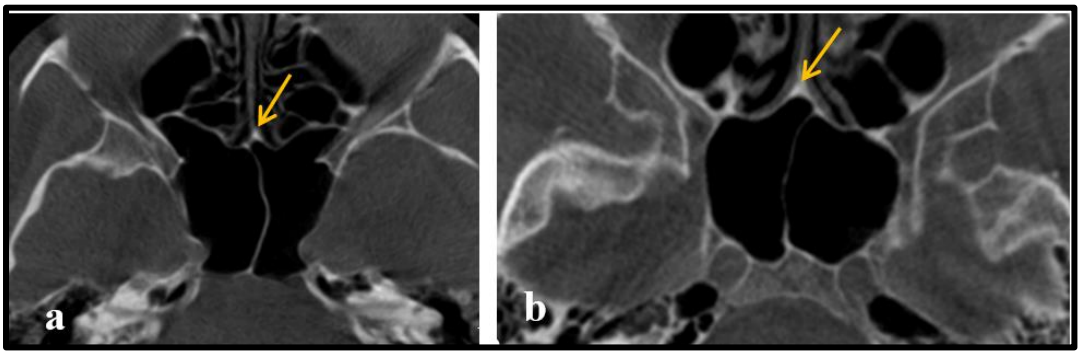

Figure 2: Axial cuts of CBCT showing the anteriolateral and posterior extension of the sphenoid sinus: a) anteriolateral extension with critical type, b: No anterior extension with non critrical type. Note: arrows indicate sphenoidal crest

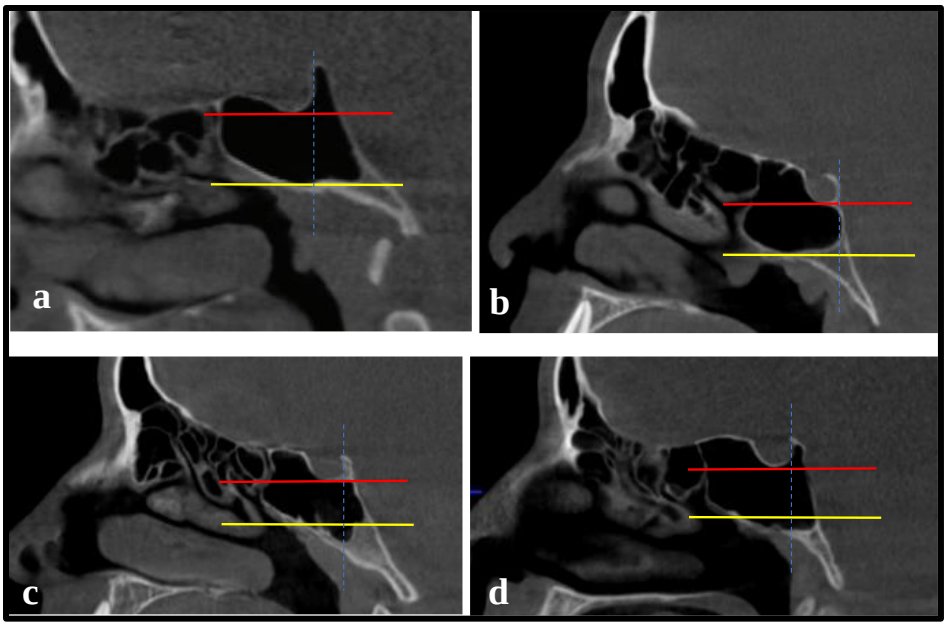

Figure 3: Sagittal cuts of CBCT showing pneumatization of sphenoid sinus into clivus: a) Dorsal type, b) Subdorsal, c) occipital, d) Combined type. Note: Red line: the floor of the sella and yellow line: limits of Vidian canal

Table (2): Prevalence of the configuration types of the studied sphenoid sinuses

	Sinus configuration				
		Paired			
	Solitary	Paired asymmetrical	Paired symmetrical	compound	Total
Frequency	1	13	7	30	51
Percentage	2%	25.5%	13.7%	58.8%	100%

Table (3): Prevalence of extension of sphenoid sinus into clivus

Clivus extension	Frequency	%
Subdorsal	40	78.43 %
Occipital	7	13.73%
Dorsal	2	3.92 %
Combined	2	3.92%
Total	51	100%

Table (4): Prevalence of anterolateral extension of sphenoid sinus

	No extension	Bilateral extension	Unilateral extension		Total
			Right	Left	
Frequency	35	11	3	2	51
Percentage	68.6%	21.6%	5.9%	3.9%	100%

Table (5): Prevalence of posterior extension of sphenoid sinus.

	Non-critical type	Critical type	Total
Frequency	40	11	51
Percentage	78.4%	21.6%	100%

Discussion

The sphenoid sinus is a very significant trial in the surgical procedure of the lesions inside and around sella turcica. As a result of numerous anatomical variations of the sphenoid sinus, surgical steps may require more bone drilling and others require more delicate dissection (**Nepal et al, 2020)**. The sphenoid sinus is infrequently symmetrical because of the presence of intra-sinus septa and variable degrees and directions of pneumatization. Only a thin bone layer may separate the sinus from the surrounding vital structures in well-pneumatized sinus. Therefore, the knowledge about the sinus pneumatization is critical in choosing the safest surgical approach to the base of the skull **(Papavasileiou et al, 2020).** Thus, the aim of this study is to investigate the septation and extension of sphenoid sinus in a sample of the Egyptian Population using CBCT.

The sphenoid sinus reaches the adult size in adolescence and the sinus pathology - like fungal infection - is commonly to be detected in elderly patient**s (Yağmur et al, 2023)**, thus, the age range of the patients included in the present study was from 18 to 50 years. In this study, the SS was classified according to its configuration into solitary, paired, and compound depending on the presence or absence of inter-sinus septa and the number of dividing septa. The compound type (multiple septa) was the most common configuration type at 58.8%. **Sareen et al, 2005, Tan and Ong 2007 and Schwerzmann et al, 2021** found 80%, 65.6%, and 62% of their samples were of compound type respectively. While **Hamid et al, 2008 and Štoković et al, 2016** observed the multiple septa only in 8.7% and 27.5% respectively.

The solitary type (no septa) was found only in one case 2% in our sample. This is similar to **Schwerzmann et al, 2021.** Different percentages were also reported by previous studies; whereas **Sirikci et al, 2000 and Tan and Ong, 2007** did not detect any SS of solitary type, **Singh et al, 2021 and Hamid et al, 2008** noticed that 7.4% and 10.8% of their cases were of solitary type respectively. On the other hand, studies by **Dal Secchi et al, 2018 and Odat et al, 2019** recorded higher frequencies, as 61% and 83.3% of their cases revealed solitary type respectively.

In the current study, 39.2% showed paired type SS. Based on the location and deviation of inter-sinus septa, 25.5% of 39.2% was of asymmetrical type. This is close to **Singh et al, 2021** who reported that the paired type was 40% of cases. However, **Sirikci et al, 2000, Hamid et al, 2008, Rennie et al, 2017 and Thakur et al, 2021** found higher incidences as the paired type was of 80%, 71.6%, 90.2% and 68% respectively in their

studies. **Sirikci et al, 2000, Tan and Ong, 2007, Lee et al, 2012, Singh et al, 2021 and Thakur et al, 2021** found that asymmetrical type was the common type at 42.3%, 83.4%, 68%, 85.1% and 58.25%, and while, **Rennie et al, 2017** found that inter- sinus septum was mainly placed centrally in 55.4%. The number and location of the septa play a vital role in the orientation during the surgical procedure as the disorientation within the sinus may cause injuries to vital structures. Also, abnormal septation may lead to inadequate ventilation or drainage of the sinus prompting the sinus infection **(Sirikci et al, 2000)**.

According to **Wang et al, 2010** the of extension SS into clivus can be classified into dorsal, subdorsal, occipital, and combined types. This study revealed that the most common form of the clival extension was subdorsal type which represented 78.43% of cases followed by the occipital type at 13.73% and finally the dorsal and the combined types were found at 3.92%. **Wang et al, 2010** found that the subdorsal type was the most common type at 63.2%, followed by dorsal, combined and occipital types at 23.5%, 11.8% and 1.5% respectively. **Hiremath et al, 2018** found that the subdorsal type was the most common form at 65%, followed by dorsal at 4%, occipital at 3.8% and combined type at 3.8%. **Lu et al, 2011** found that the subdorsal type was the most common type at 71.9%, followed by occipital, dorsal and combined types at 14.6%, 12.4% and 1.1% respectively. In contrast to **Yesiltepe et al, 2022** found that the highest prevalence type was the occipital type at 69.4% followed by the subdorsal type at 17.6% then, the combined type at 9.4% and finally the dorsal type at 3.5%.

In the current study, the posterior extension into clivus was classified into critical and non-critical types. Non-critical type was revealed in 78.4% while the critical type reported in 21.6% of cases. Although, the access to lesions placed in the clivus and petrous apex is easy in the critical type, there is a risk of perforating the clivus due to the thin thickness of bone in this region **(Haetinger et al, 2006)**. **Dal Secchi et al, 2018** identified the posterior extension in 78% of all cases, 42% of cases were of critical type and 36% were of non-critical type. **Haetinger et al, 2006** detected posterior extension in 69% of cases, 44% were of the critical type. The present study revealed that 68.6% of cases had no anterolateral extension bilaterally, 21.6% showed bilateral anterolateral extension and 9.8% presented unilateral anterolateral extension. **Lu et al, 2011** recorded the anterolateral extension in only 5.5% of cases.

Different results of the mentioned studies may be due to using different classification methods, different sample size, racial differences, anatomical variations and differences in the pneumatization process of sinuses in different sex and age groups.

Conclusion

The most common configuration type of the SS was the compound type, followed by the paired type, while the solitary type was the least. The most common form of the clival extension was

subdorsal type then, the occipital type, followed by the dorsal and the combined types. Most sinuses showed no extension bilaterally in the anterolateral direction. The non-critical type was the most frequent type of the posterior extension of the SS. There was no significant difference between sex and age, and configuration type of the sinus or pneumatization into clivus.

Conflict of Interest: No conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Ethics: This study protocol was approved by the ethical committee of the faculty of Dentistry-Cairo university on: 29/10/2024, approval number: 421024

Data Availability: available upon request.

CRediT Author statement:

Author 1: Data collection and analysis - writing and reviewing the manuscript.

Author 2: Data analysis-writing and reviewing the manuscript.

Author 3: Writing, editing and reviewing the manuscript.

Author 4: Data collection and analysis - writing and reviewing the manuscript.

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