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Original article

Anatomical & Radiological Study of Sphenoid Air Sinus Variations among Egyptian Population: A Single Center Study

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ABSTRACT

Background:
Sphenoid sinus is a midline single paranasal sinus. Its development is variable with consequent anatomical variations. For sinus surgeons and endoscopists, it is very important to consider the anatomical variations of the sinus and its relation with optic nerve and other structures to avoid mishaps and hazardous serious complications.
The objective: was anatomical and radiological evaluation of the sphenoid sinus
Materials and methods:
The study was conducted on 100 patients and 25 dried skulls. CT scan was conducted to all patients to evaluate pneumatization, septation of the sinus, presence of Onodi cells and optic nerve relation to it. All results were statistically analyzed.
Results:
With CT scanning, the commonest type of pneumatization was the sellar (64%), followed by the pre-sellar (22%), the post-sellar (11%) and the least common was the conchal pneumatization (3%). The findings were matched with those of dried skulls examination except that the conchal type wasn't shown. Examinations of CT images of the patients showed absence of inter-sphenoid sinus septum in 3% with Inter-sphenoid sinus septation found in 97%. Out of them, (39%) had single inter-sphenoid sinus septum (main septum) with no accessory septa. Accessory septa were either vertical or horizontal and ranges from 1 to 4. Studying the relations between optic nerve and sphenoid sinus, the optic nerve was bilaterally symmetrical in 92.8% and asymmetrical in 7.2%.
Conclusions:
Anatomy of sphenoid sinus is very variable and as compared with previous literature it showed some variations with gender so it should be considered during surgery and endoscopy and well pre-assessed before any intervention.

INTRODUCTION

Paranasal sinuses are cavities within the skull bones. They develop with the facial skeleton from mainly cartilaginous and lesser contribution of membranous origin with unclear end point of development [1,2,3]. The sphenoid sinus develops during the eighth week of gestation and passes in different stages of development with progressive pneumatization starting from second year of early childhood till third decade. Pneumatization regresses thereafter [4]

The sphenoid sinus is located within the body of the sphenoid with occasional extension laterally to the greater and lesser wings and pterygoid plates of the sphenoid bone and may be posteriorly to the clivus [5,6,7] with important close relation to the optic nerve, optic chiasma, cavernous sinus, pituitary gland, and the internal carotid artery [8] Individual variations are associated with variability of the extension of sinus pneumatization, difference in number and position of the septa within, and the relation with surrounding structures[9,10].

Although sphenoid sinus is considered as one of the single paranasal sinuses, it is usually subdivided into two unequal spaces within the body of the sphenoid bone [11]. It is one or more vertical septa (main and accessory) that often divide it asymmetrically [12, 13, 14].The right and left halves are separated by the main septum that is more commonly shows lateralization than having median position. Septal deviation attributes to inequality of the sinus and the larger one is usually referred to as the 'dominant' sinus [5,14]The ostium of sphenoid sinus usually opens in the spheno-ethmoidal recess[3,15], about 7 cm from the base of the columella with 30° angulation with the nasal floor. During endoscopic examination, the postero-inferior end of the superior turbinate makes an important leading light as it points supero-medially towards this opening [14,16]

The Onodi cell is an important anatomical variant, defined as; the most posterior ethmoid cell located in the sphenoid bone, and communicates superolateral with the sphenoid sinus. It has a special importance because of the special relation with the optic nerves, sphenoid sinus, and pituitary fossa. Moreover, it might be mistaken as the sphenoid sinus itself [8,17,18]

Due to the deep position of the sinus, and important adjacent structures, the sinus surgery and endoscopy are very challenging and hazardous [7,17]. Comprehensive knowledge of sphenoid sinus anatomy is increasingly important with the increment of functional endoscopic sinus surgery that helps awareness of the exact configuration of a particular individual's sphenoid sinuses before surgery. This precise knowledge is vital to avoid complications [10].

This study aimed to evaluate the anatomy and radiologyof the sphenoid sinus in a sample of Egyptian population regarding; types of pneumatization, septation, prevalence of Onodi cell, and relation with optic nerve.

METHODS

The study was conducted on:One hundred adult patients (54 males and 46 females), with age ranged from 18 to 60 years randomly selected from the patients admitted to the Otorhinolaryngology department at the Alexandria Main University Hospital with nasal/ sinuses complaints. All selected individuals had neither history of sphenoid sinus diseases nor surgeries. CT scans were done to all after their consent. Written informed consent was obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Alexandria University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. Twenty-five dried adult skulls obtained from the museum of anatomy department of Alexandria University were used in the study. They were all for adults as identified by bone and suture ossification, they were sagittal sectioned and the medial side was examined to evaluate the type of pneumatization of sphenoid sinus. Sex of specimens wasn't considered due to difficulty of gender identification of separate bones.

Multi-slice CT technique**:** Non-contrast thin-collimation contiguous helical scanning with a maximum section thickness of no greater than 1 mm with the patient in supine position.Axial images of the sinuses were done and scans were reconstructed in the coronal, and sagittal planes by using high resolution algorithm bone windows. Image DICOM (Digital imaging and communications in Medicine) data were sent to an offline post processing workstation with a DICOM viewing software (Osirix or e-film). Septation would be best visualized on axial and coronal views [10].

Statistical analysis

All reported data were statistically analyzed using IBM SPSS software package version 24.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. Comparison between different groups regarding categorical variables was tested using Chi-square test. Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level [19].

RESULTS

Types of pneumatization of the sphenoid sinus: On CT examination, the most prevalent type was the sellar type (64%), and then the pre-sellar pneumatization (22%), the post-sellar pneumatization (11%) and the least type found was the conchal pneumatization (3%) that was all females. There was no statistically significant difference regarding neither gender nor side (figure 1, table 1& 2). Examination of dried skull specimens showed only 3 types; the commonest was the sellar type as shown in 50%, followed by the pre-sellar in 30% and the least common was the post-sellar that found only in 20%. The conchal type wasn't seen in any of the studied skull, a finding may be attributable to the small sample size. Like the radiological results, there was no statistically significant difference in the distribution of the types of pneumatization between right and left sides (figure 2, table 4).

Inter-sphenoid sinus septation: Examination of the axial and coronal CT images of the patients showed absence of inter- sphenoid sinus septum only in 3% (patients with conchal type of pneumatization) and the inter-sphenoid sinus septation was found in the remaining 97% (figure 1d).

Out of these 97%, 39% had a single inter-sphenoid sinus septum (main septum) with no accessory septa that were vertical and complete in all scans. 58% revealed multiple inter-sphenoid sinus septa. They were one main inter-sphenoid sinus septum and from 1 to 4 accessory septa. A single accessory inter-sphenoid sinus septum was reported in 36%, 19% had double accessory septa, 2 2% with triple accessory septa and only 1% showed 4 accessory septa (figure 3, 4). Only statistically significant difference was shown in single septation which has been higher in males and more distributed in the right side of both sex (table 3) Accessory inter-sphenoid sinus septa; in the 58% with one or more accessory septa that were either vertical or transverse and each of them were either complete or incomplete seen as a bony spur or crest. The accessory septa were found to be either vertical (coronal) in 94% or transverse (horizontal) in 6%, (table 3, figure 4).

Presence of Onodi cell: Single Onodi cell was found in 36%, double Onodi cells in 24% (bilateral) and a single patient had 3 Onodi cells (1%) (figure 5). The distribution among males and females is shown in table 3. There was no statistical significance.

Optic nerve type: following to DeLano classification; 4 types of sphenoid sinus/ optic nerve relationships were recognized. Type I: the nerve was immediately adjacent to the sinus, without indentation of the wall or contact with the posterior ethmoid air cell. Type II: The nerve was next to the sinus, with indentation in its wall, with no contact with posterior ethmoid sinus. Type III: The nerve coursed through the sphenoid sinus with at least 50% of the nerve was surrounded by air. Lastly, Type IV: The nerve was adjacent to the sphenoid and posterior ethmoid sinus.The 3 cases with conchal pneumatization weren't included as the optic nerve wasn't related to the sphenoid sinus. Regarding the remaining 97 cases, the optic nerve was bilaterally symmetrical in 90 cases (92.8%) and asymmetrical in 7 cases (7.2%). On the right side; 62 optic nerves were of type I, 24 optic nerves were of type II, 7 nerves were of type III and 4 nerves were of type IV. On the left side; 63 optic nerves were of type I, 23 optic nerves were of type II, 7 nerves were of type III and 4 nerves were of type IV (figure 6). No significant difference regarding sex or side was reported (table 2)

Table 1: Comparison between male and female regarding types of pneumatization and optic nerve type

	Male "n=108"		Female "n=92"		Total "n=200"		X^2	P value
	No.	%	No.	%	No.	%		
Type of pneumatization								
Sellar	68	63.0	60	65.2	128	64.0	3.76	0.298
Presellar	26	24.1	18	19.6	44	22.0		
Postsellar	14	13.0	8	8.7	22	11.0		
Conchal	0	0.0	6	6.5	6	3.0		
Type of optic nerve	**Male "n=108"**		**Female "n=86"**		**Total "n=194"**			
Type I	65	60.2	60	69.8	125	64.4	7.25	0.062
Type II	24	22.2	23	26.7	47	24.2		
Type III	11	10.2	3	3.5	14	7.2		
Type IV	8	7.4	0	0.0	8	4.1		

Table 2: Comparison between right and left side in both male and female regarding types of pneumatization and optic nerve type

	Male "n=108"				Female "n=92"			
	Right "n=54"		Left "n=54"		Right "n=46"		Left "n=46"	
	No.	%	No.	%	No.	%	No.	%
Type of pneumatization								
Sellar	35	64.8	33	61.1	31	67.4	29	63.0
Presellar	12	22.2	14	25.9	10	21.7	8	17.4
Postsellar	7	13.0	7	13.0	5	10.9	3	6.5
Conchal	0	0.0	0	0.0	0	0.0	6	13.0
X^2, p	0.212, 0.899				0.458, 0.722			
Type of optic nerve	**Male "n=108"**				**Female "n=86"**			
	Right "n=54"		**Left "n=54"**		**Right "n=43"**		**Left "n=43"**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Type I	33	61.1	32	59.3	29	67.4	31	72.1
Type II	11	20.4	13	24.1	13	30.2	10	23.3
Type III	6	11.1	5	9.3	1	2.3	2	4.7
Type IV	4	7.4	4	7.4	0	0.0	0	0.0
X^2, p	0.273, 0.965				0.791, 0.673			

Table 3: Comparison between male and female regarding total number of septa and number of Onodi call(s).

	Male "n=54"		**Female "n=46"**		**Total "n=100"**		X^2	P value
	No.	**%**	**No.**	**%**	**No.**	**%**		
Total no. of septa								
No inter-sphenoid septa	0	0.0	3	6.5	3	3.0	3.631	0.09
Single septum (main)	17	31.5	22	47.8	39	39.0	2.789	0.095
Multiple (main + no. of accessory septa)	37	68.5	21	45.7	58	58.0	5.332*	0.021*
1	26	48.1	10	21.7	36	36.0	7.63*	0.01*
2	10	18.5	9	19.6	19	19.0	1.524	0.217
3	1	1.9	1	2.2	2	2.0	0.028	0.925
4	0	0.0	1	2.2	1	1.0	1.186	0,460
No. of Onodi call(s)								
0	18	33.3	21	45.7	39	39.0	2.36	0.51
1	20	37.0	16	34.8	36	36.0		
2	15	27.8	9	19.6	24	24.0		
3	1	1.9	0	0.0	1	1.0		

Table 4 : Type of Pneumatization in dried skulls in the right and left side.

	Right "n=25"		**Left "n=25"**		**Total "n=50"**		**X^2**	**P value**
	No.	**%**	**No.**	**%**	**No.**	**%**		
Type of pneumatization								
Sellar	13	52.0	12	48.0	25	50.0	0.106	0.948
Presellar	7	28.0	8	32.0	15	30.0		
Postsellar	5	20.0	5	20.0	10	20.0		
Conchal	0	0.0	0	0.0	0	0.0		

Figure 1:

High-resolution sagittal sections of CT scan showing different types of sphenoid sinus pneumatization; ST: sella turcica, SS: sphenoid sinus (SS):
(a) Sellar (b) Presellar (c)Post-sellar (c) Conchal

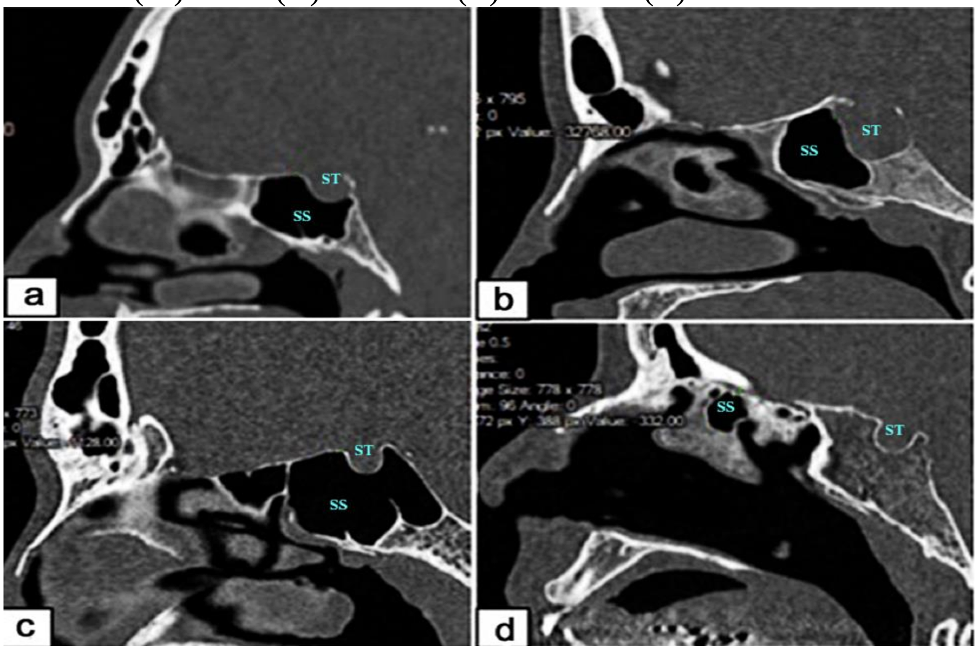


Figure 2:

Photographs of medial side of the left side of sagittal halves of skull bones showing different types of sphenoid sinus pneumatization; ACP: anterior clinoid process, PCP: posterior clinoid process, arrow: sphenoid sinus cavity: (a) Sellar (b) Presellar (c) Post-sellar

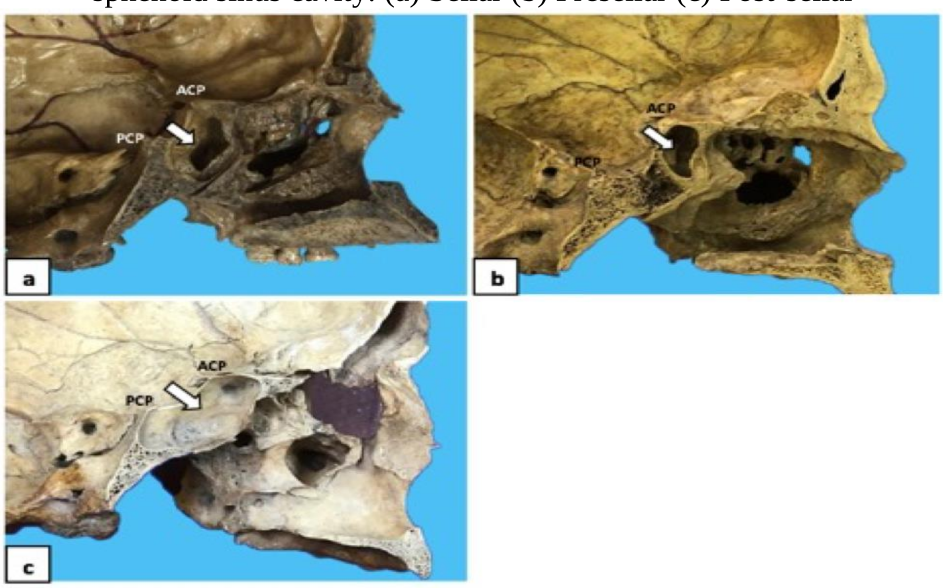


Figure 3:

High-resolution coronal sections of CT scan showing different types of septation; sphenoid sinus (SS), sphenoid body (SB):

a- No septation (conchal pneumatization)
b- Main single septum (white arrow).
c- Main septum (white arrow), with single accessory incomplete vertical septum (green arrow)

d- Main septum (white arrow), with multiple accessory vertical septa; 1 complete and 1 incomplete (green arrows)
e- Main septum (white arrow), with 3 accessory septa; 1 complete transverse septum (blue arrow), 1 complete vertical septum (blue arrow) and 1 incomplete vertical septum (green arrow)
f- Main septum (white arrow), with 4 accessory septa; 2 complete vertical (blue arrows) , 1 incomplete vertical and 1 incomplete transverse (green arrows)

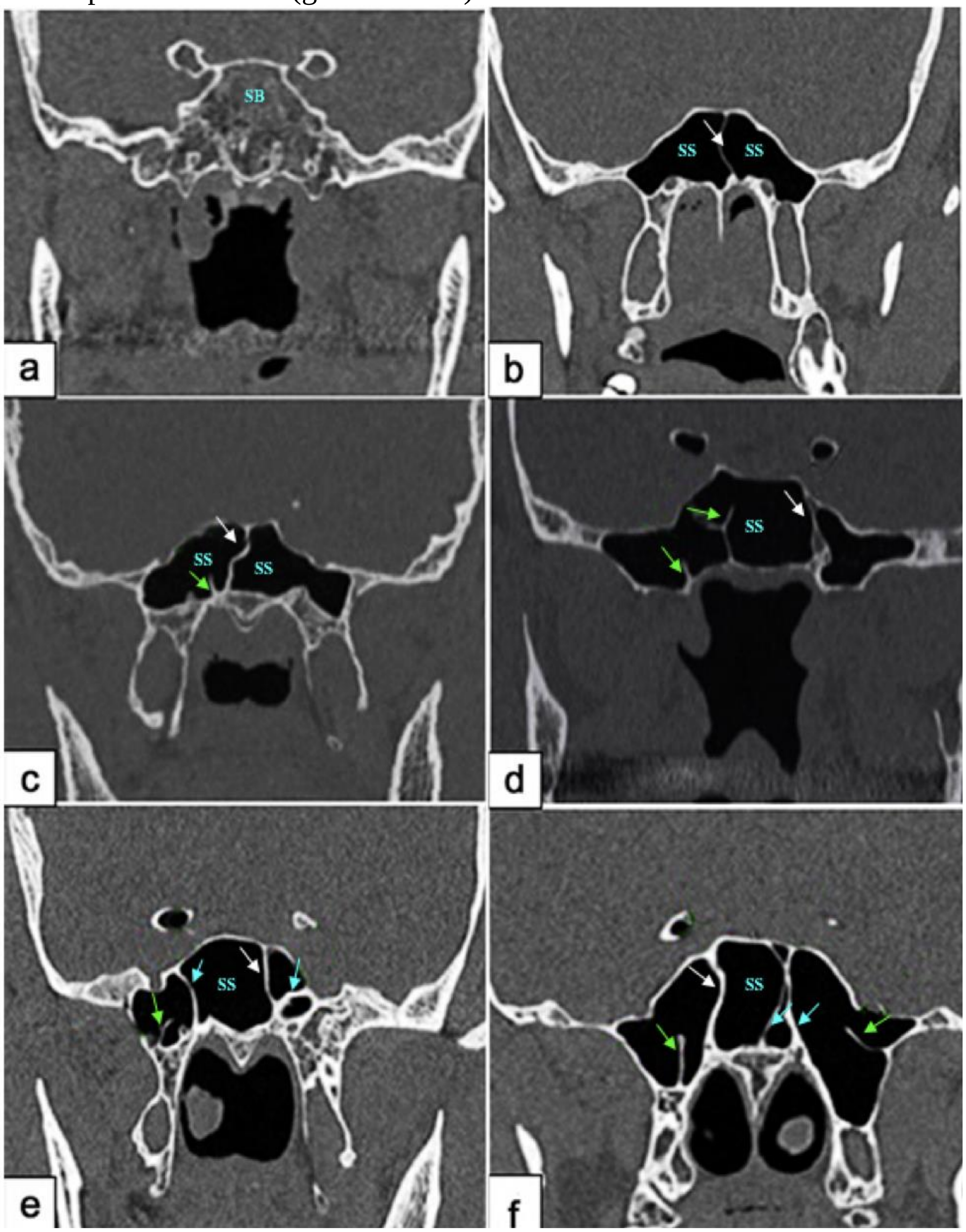


Figure 4:
High-resolution coronal sections of CT scan showing transverse accessory septation; sphenoid sinus (SS):
a- Complete transverse septum (blue arrow)
b- Incomplete transverse septum (green arrow)

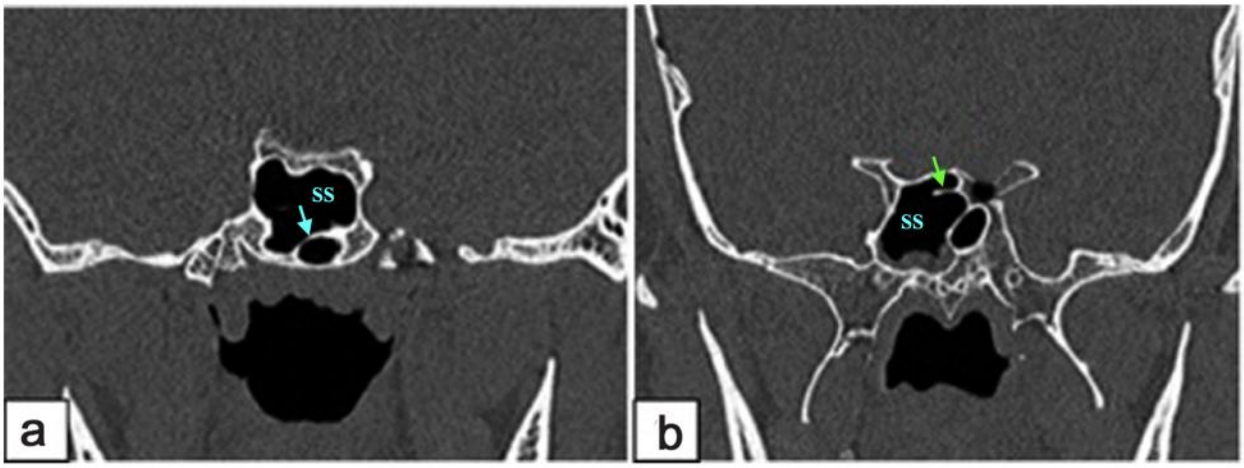


Figure 5:
High-resolution coronal sections of CT scan showing Onodi cell(s) (green arrows), sphenoid sinus (SS):
a- No Onodi cell.
b- Single Onodi cell.
c- 2 Onodi cell.
d- 3 Onodi cell.

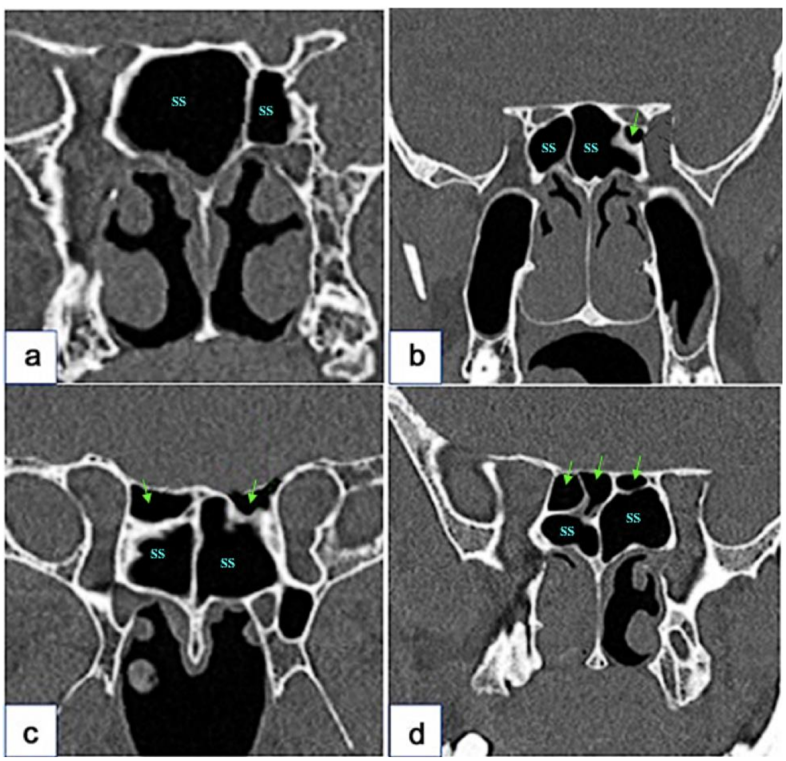
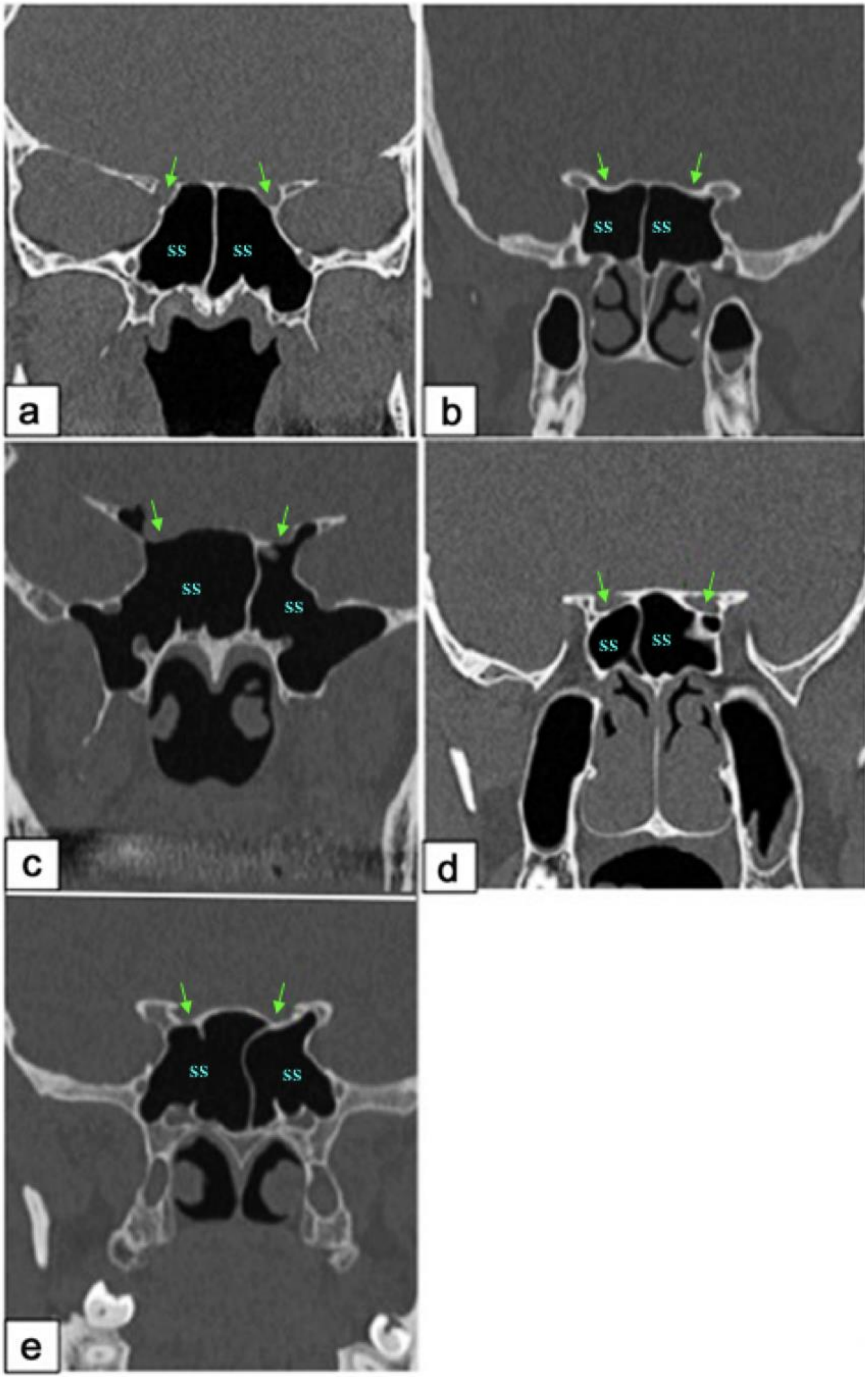


Figure 6:
High-resolution coronal sections of CT scan showing types of optic nerve (green arrow)/ sphenoid sinus (SS) relationship:
a. Bilateral type I
b. Bilateral type II
c. Bilateral type III
d. Right type IV, left type I
e. Left type II, right type III


ss
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DISCUSSION

Functional endoscopic sinus surgery (FESS) is of increasing importance due to its popular use in treatment of different pathologies, not only in sphenoid sinus, but also extending beyond it to the neighborhood structures. The trans-nasal approach to the pituitary in the management of gland neoplasms is among the commonest uses of it. FESS has the advantage over trans-cranial surgical approaches due to fewer hazards with lower morbidity and mortality rates. The deep situation, relations and variations of sphenoid sinus pneumatization interacts together making sphenoid sinus surgery and endoscopy critical and of high risk of complications. Preoperative imaging has to be taken as a prognostic and evaluation tool in all patients who would be referred to endoscopic sinus surgery. The anatomical variations and their impact are subject of high interest [20].

In the current study, detailed anatomical and radiological examination of sphenoid sinus revealed 4 types of pneumatization; the commonest was the sellar type followed by the pre-sellar, the post-sellar and the rarest was the conchal type. The last was shown only in radiological examination and not in the anatomical reported data may be due to limited sample size. Variations between sides was reported however wasn't statistically significant. Sex variations weren't significant also on radiological examination. CT scans of the patients in different orientation revealed also different number of septa (main and accessory) that varied from no septation (in conchal pneumatization), single main septum and main with accessory septa up to 4 septa. Accessory septa were either vertical or horizontal, complete or incomplete. Significant difference between sex (more prevalent in males) and side (commoner in the right side) was only reported in case of single septum. The relation between the optic nerve and sphenoid sinus was also examined and adopting DeLano's classification, the 4 types were shown in CT scans. From the commonest down, type I was the commonest, type II, type III, and the rarest was type IV. No significant difference regarding gender or side.

Researchers implemented more than a classification for sphenoid sinus pneumatization; two, three and four types were described. *Elwany et al* [21], and *Nikakhlagh et al.* [22]reported two types of pneumatization of the sphenoidal sinus: pre-sellar (less common 20-27%) and post-sellar (more common 71-80%). In accordance with the current study results, *Anusha et al*. [23] considered 3 types: conchal, pre-sellar and sellar. According to them, the sellar type was the commonest of 55-93%, followed by the pre-sellar in 7-24% and the least prevalent was the conchal type as reported in only 0.3-28% [2,23].

Unlike the current results, *Tan et al.* [24] described a higher prevalence of conchal pneumatization of sphenoid sinus, in 28% of their sample. The pre-sellar type of pneumatization is usually intermediate in frequency in most studies that mimic the present data. *Refaat & Basha* [25],reported a dominance of the post-sellar pneumatization, as the dominant type was found in cases with protrusion and dehiscence of close neurovascular (ON, ICA) structures indicating this type is of high-risk during intervention, this result was agreed with the current data and mimic to the current results, *Degaga et al*. [26],in his work on Ethiopian population, reported incidence of conchal pneumatization only in 2%, pre-sellar in 25.5%, sellar in 50%, and 22.5% of post-sellar pneumatization.

The results of different studies are variable and the incidence ranged from 2-14% in conchal type, 5-44% pre-sellar, 41-83% sellar, and 2-43% post-sellar [9,10].These results concurred with those of present work with mild difference in frequency of the post-sellar type. The reported variations in prevalence of different patterns of pneumatization might be attributed to the lack of a standard classification, variable methods of imaging analysis, and different races that would be subjectively considered by surgeons [10,23].

In accordance with the present work, *Kayalioglu et al.* [6] described no incidence of Conchal pneumatization in males, and very low incidence in females (1.7%). However, they reported the pre-sellar type in 5.6% of males and 2.8% of females, a data unlike that of the current work. They reported a prevalence of the sellar pneumatization in 24.4% of males and 23.9% of females and that was near figures to the present study. The post- sellar type in *Kayalioglu et al* work was described in 19.5% of males and 22.2% of females unlike the current findings that showed lower incidence with no significant difference regarding gender variation.

The type and extent of sphenoid sinus pneumatization is crucial and of great importance in any intervention of the sellar region. For adequate intervention with minimal hazards, detailed preoperative radiological assessment is highly recommended through CT and MRI. The evaluation of sinus septation is of special importance [27].With the usage of high-speed drills, trans-sphenoidal endoscopy is achievable with the conchal pneumatization however it is still a bony obstacle, that would hinder straightforward approach to the sella [28]. According to *Hamid et al.* [27], the inter-sphenoid sinus septum showed lateralization, with the sinus divided into two unequal parts to the extent that the septum might deviate quite laterally and end at ICA or the optic nerve. These septa were variable in number and orientation. *Sareen et al*. [13] described the multiple as the commonest. In the present study, it was found that a single inter-sphenoid sinus septum was present in 39% that mimic the results of the work of *Lupascu et al.* [29] and disagreed with others who reported higher incidence such as *Priya TSG et al.* [30] who reported 83.3% incidence of single inter-sphenoid sinus septum.

In the current study, an absent inter-sphenoid sinus septum was found in 3 patients (3%) similar to *Fasunla et al.* [31] who described it in 2.7% of their cases, while *ELKammash et al.* [32] reported higher frequency as 13.2%. we reported accessory inter-sphenoid sinus septa in 58 patients (58%) very close to data reported by *Kayalioglu et al[6]*. who found it in 52%. A lower incidence (13.2%) was reported by *Dündar et al.* [33] A horizontal septum incidence is very variable in literature. It was reported in 0.8% by *Priya et al.* [30] and in 7.5% by *Vidya et al.* study [34] comparable to 5% incidence in our study. *Battal et al*. [35] did not visualize any transverse septum in their study. In Ethiopian population *Degaga et al* [26] reported single complete septum in 77.5%, single incomplete in 11.5%, double in 10% and totally absent in only 1%, a data different from those reported in the present work.

Because of the very variable design of sphenoid sinus septation, ranging from complete absence of any septation up to main septum with 4 accessory septa with variable number, extent and orientation, Pre-operative radiological assessment should be considered in any intervention of the sinus otherwise hazardous damage of relative structures is a risk with trauma to the septa of sphenoid sinus that may extend to the wall and thus to the close relations as optic nerve and internal carotid artery [36].

Thimmaiah VT & Anupama C [37] reported the prevalence of Onodi cells in 62.96% in males and 37.31% in females on their study sample who were visualized by MDCT in agreement with results of the present study as Onodi cell was found in 61% of cases. A different prevalence was reported by *Kasemsiri et al.* [38] on that population sample as Onodi cell was found in 49.5% with the combined type was the commonest. Others reported an incidence varied from 42% to 65% [8, 10] ,this finding might be attributable to the use of different technique with different orientation and racial difference. Onodi cell is a common variation of the pattern of pneumatization of sphenoid sinus that should be assessed preoperatively with special care to reduce the risk of optic nerve trauma.

Regarding the relation of optic nerve with sphenoid sinus, the current results agreed with those reported by *Gupta et al*. who made it according to Delano's classification, as reported type I with the highest incidence followed by type II then type III and the least common was type IV [39].

Nikakhlagh S. [22] described low incidence of optic nerve dehiscence close to the present results (8%). Meanwhile, *Efendic et al*. [1] and *Mamatha et al. [9]* reported higher incidence than the currently reported data ranging from 18-

50%. As with variable relation between optic nerve and the wall of sphenoid sinus, the trans-sphenoidal approach and intervention should be taken with caution to avoid nerve injury especially in cases with close relation, dehiscence and bulge of the nerve into the sinus.

CONCLUSIONS

All data regarding variation in the anatomy of sphenoid septum, septation, extension and close relations are very variable as using different diagnostic measures and also racial and sex differences are expected. Proper visualization of sphenoid sinus with CT scan and careful radiological assessment would help surgeons and endoscopists avoiding hazardous misshapes during intervention. Sex and side differences are expected and should be considered in sinus surgery and intervention.

REFERENCES

1. Efendić A, Muharemović E, Skomorac R, Bečulić H, Šestić S, Halilović B. Anatomic variations of posterior paranasal sinuses and optic nerve. Med Glas (Zenica). 2017;14 (1):49-54
2. Budu V, Mogoanta CA, Fanuta B, Bulescu I. The anatomical relations of the sphenoid sinus and their implications in sphenoid endoscopic surgery. Rom J Morphol Embryol. 2013; 54 (1):13-6
3. Nemzek WR, Brodie HA, Hecht ST, Chong BW, Babcook CJ, Seibert JA. MR, CT, and plain film imaging of the developing skull base in fetal specimens. Am J Neuroradiol. 2000; 21(9):1699-706
4. Cellina M, Gibelli D, Floridi Ch, Toluian T, Pittino CV, Martinenghi C, etal. Sphenoid sinuses: pneumatisation and anatomical variants—what the radiologist needs to know and report to avoid intraoperative complications. Surg Radiol Anat. 2020; 42 (9): 1013–1024
5. Anusha B, Baharudin A, Philip R, Harvinder S, Shaffie BM. Anatomical variations of the sphenoid sinus and its adjacent structures: a review of existing literature. Surg Radiol Anat. 2014; 36 (5):419-27
6. Kayalioglu G, Erturk M, Varol T. Variations in sphenoid sinus anatomy with special emphasis on pneumatization and endoscopic anatomic distances. Neurosciences (Riyadh). 2005; 10 (1):79-84
7. Kapur E, Kapidžić A, Kulenović A, Sarajlić L, Šahinović A, Šahinović M. Septation of the Sphenoid Sinus and its Clinical Significance. Int J Collab Res Intern Med Public Health. 2012; 4(10):1793-802
8. Wada K, Moriyama H, Edamatsu H, Hama T, Arai C, Kojima H. Identification of Onodi cell and new classification of sphenoid sinus for endoscopic sinus surgery. Int Forum Allergy Rhinol. 2015; 5 (11):1068-76
9. Mamatha H, Saraswathi G, Prasanna L. Variations of sphenoid sinus and their impact on related neurovascular structures. Curr Neurobiol. 2010; 1(2):121-4
10. Tomovic S, Esmaeili A, Chan NJ, Shukla PA, Choudhry OJ, Liu JK. High-resolution computed tomography analysis of variations of the sphenoid sinus. J Neurol Surg B Skull Base. 2013; 74(2):82-90
11. Batra PS, Citardi MJ, Gallivan RP, Roh H-J, Lanza DC. Software-enabled CT analysis of optic nerve position and paranasal sinus pneumatization patterns. Otolaryngol Head Neck Surg. 2004; 131(6):940-5
12. Famurewa OC, Ibitoye BO, Ameye SA, Asaleye CM, Ayoola OO, Onigbinde OS. Sphenoid Sinus Pneumatization, Septation, and the Internal Carotid Artery: A Computed Tomography Study. Niger Med J. 2018;59(1):7-13
13. Sareen D, Agarwal A, Kaul J, Sethi A. Study of sphenoid sinus anatomy in relation to endoscopic surgery. Int J Morphol. 2005; 23(3):261-6
14. Jaworek-Troć J, Zarzecki M, Bonczar A, Lourdes N. Kaythampillai, Rutowicz B, Mazur M etal. Sphenoid bone and its sinus— anatomo-clinical review of the literature including application to FESS. Folia Medica Cracoviensia. 2019; 2: 45–59
15. Dalgorf DM, Harvey RJ. Sinonasal anatomy and function. Am J Rhinol Allergy. 2013; 27 Suppl 1:S3-6
16. Casiano RR. A stepwise surgical technique using the medial orbital floor as the key landmark in performing endoscopic sinus surgery. Laryngoscope. 2001; 111(6):964-74
17. Reddy UDMA, Dev B. Pictorial essay: Anatomical variations of paranasal sinuses on multidetector computed tomography-How does it help FESS surgeons? Indian J Radiol Imaging. 2012;22(4):317-24
18. Meybodi AT, Vigo V, Benet A. The Onodi Cell: An Anatomic Illustration. World Neurosurg. 2017; 103: 950.e5-950.e6
19. Dawson-SaundersBandTrappR.Basicandclinical biostatics. 3rd ed., Lang Medical Book, McGrow Hill Medical Publishing Division. 2001; 161-218.
20. Unal B, Bademci G, Bilgili YK, Batay F, Avci E. Risky anatomic variations of sphenoid sinus for surgery. Surg Radiol Anat. 2006; 28(2):195-201

21. Elwany S, Yacout YM, Talaat M, El-Nahass M, Gunied A, Talaat M. Surgical anatomy of the sphenoid sinus. J Laryngol Otol. 1983; 97(3):227-41
22. Nikakhlagh S, Saki N, Saki G, Tahmasebi M, Davoodi M, Rahim F. Anatomical Variations of Carotid Artery and Optic Nerve in Sphenoid Sinus Using Computerized Tomographic Imaging. Jentashapir J Health Res. 2014; 36 (5): 419- 27
23. Anusha B, Baharudin A, Philip R, Harvinder S, Shaffie BM, Ramiza RR. Anatomical variants of surgically important landmarks in the sphenoid sinus: a radiologic study in Southeast Asian patients. Surg Radiol Anat. 2015; 37(10):1183-90
24. Tan H, Ong Y. Sphenoid sinus: an anatomic and endoscopic study in Asian cadavers. Clin Anat. 2007; 20(7):745-50
25. Refaat R , Basha MA. The impact of sphenoid sinus pneumatization type on the protrusion and dehiscence of the adjacent neurovascular structures: A prospective MDCT imaging study. Acad Radiol. 2020; 27(6):e132-e139
26. Degaga TK, Zenebe AM, Wirtu AT, Woldehawariat TD, Dellie ST, Gemechu JM. Anatomographic Variants of Sphenoid Sinus in Ethiopian Population. agnostics (Basel). 2020; 10(11):970
27. Hamid O, El Fiky L, Hassan O, Kotb A, El Fiky S. Anatomic variations of the sphenoid sinus and their impact on trans-sphenoid pituitary surgery. Skull base. 2008; 18(01):009-15
28. Ozdemir Sevinc, Merih Is; Cagatay Baru, Aliriza Erdogan. Anatomic Variations of Sphenoid Sinus Pneumatization in a Sample of Turkish Population: MRI Study. Int J. Morphol. 2014; 32(4):1140-1143
29. Lupascu M, Comsa GI, Zainea V. Anatomical variations of the sphenoid sinus-a study of 200 cases. ARS Medica Tomitana. 2014; 20(2):57-62
30. Priya TSG, Kumar NV, Guru AT, Nalinakumari SD. An anatomo- imagistic study of intersphenoidal sinus septum. IJAR. 2016; 4(1):2015-20
31. Fasunla A, Ameye S, Adebola O, Ogbole G, Adeleye A, Adekanmi A. Anatomical Variations of the Sphenoid Sinus and Nearby Neurovascular Structures Seen on Computed Tomography of Black Africans. East central African J Surg. 2012; 17(1):57-64
32. ELKammash TH, Enaba MM, Awadalla AM. Variability in sphenoid sinus pneumatization and its impact upon reduction of complications following sellar region surgeries. Egypt J Radio Nucl Med. 2014; 45(3):705-14
33. Dündar R, Kulduk E, Soy FK, Aslan M, Kilavuz AE, Sakarya EU. Radiological evaluation of septal bone variations in the sphenoid sinus. J Med Updates 2014;4(1):6-10
34. Vidya C, Raichurkar K. Anatomic Variation of Sphenoid Sinus in Mysore Based Population: CT scan Study. Int J Anat Res. 2015; 3(4):1611- 14
35. Battal B, Akay S, Karaman B, Hamcan S, Akgün V, Sarı S. The relationship between the variations of sphenoid sinus and nasal septum. Gulhane Med J. 2014;56(4):232-7
36. Kazkayasi M, Karadeniz J, Arikan OK. Anatomic variations of the sphenoid sinus on computed tomography. Rhinology. 2005; 43(2):109-114
37. Thimmaiah VT, Anupama C. Pneumatization patterns of onodi cell on multidetector computed tomography. Journal of Oral and Maxillofacial Radiology. 2017; 5(3): 63- 66
38. Kasemsiri P , Thanaviratananich S, Puttharak W. The prevalence and pattern of pneumatization of Onodi cell in Thai patients. J Med Assoc Thai. 2011;94(9):1122-6
39. Gupta AK, Gupta B, Gupta N, Tripathy N. Computerized tomography of paranasal sinuses: a roadmap to endoscopic surgery. Clin Rhinolog Int J. 2012; 5:1-10

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