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Anatomic Variation of Sphenoid Sinus and Related Structures

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Abstract
Over the past decades, instruments and techniques of the transsphenoidal approach have greatly improved. All of these procedures, whether microscopic or endoscopic, have to pass through the sphenoid sinus to reach lesions. The sphenoid sinus is surrounded by several vital anatomical structures. Knowing the details of the anatomy of the sphenoid sinus can guide the surgeon through difficult corners of this approach. To study anatomic Variation of Sphenoid Sinus and Related Structures. We studied 200 CT examinations of the paranasal sinuses at Saraswathi Institute of Medical Sciences, hapur, U.P. The age range was 18 to 70 years with mean age of 43.56 years of which 128 (64%) were males and 72 (36%) were females. The commonest pattern of intra-sphenoid sinus septation was the presence of single and complete septation (72%), followed by the presence of Double septa (one complete and the other incomplete) n (8%). Single and incomplete were seen in 6% of subjects. Absent intra-sphenoid sinus septation was seen in 7%. The most common pattern of attachment of intra-sphenoid sinus septation is sellar type followed by left ICA type with attachment to the optic canal and lateral wall being the least common.

Keywords: Trans-sphenoidal approach, Sphenoid sinus anatomy, Paranasal sinuses, Neurosurgical complications

Introduction
Over the past decades, instruments and techniques of the trans sphenoidal approach have greatly improved [1, 2]. More than 35 years ago, Hardy *et al*, established the transsphenoidal approach as the gold standard for sellar lesions [3-5].
All of these procedures, whether microscopic or endoscopic, have to pass through the sphenoid sinus to reach lesions. The sphenoid sinus is surrounded by several vital anatomical structures: the internal carotid arteries, optic nerve, cranial nerves III and IV inside the cavernous sinus, basilar sinus, and brain stem behind the clivus bone6.Vascular or neurological complications, though rare, can lead to permanent disability or even death [7, 8]. Knowing the details of the anatomy of the sphenoid sinus can guide the surgeon through difficult corners of this approach.
The sphenoid sinus is considered the most variable of the paranasal sinuses in terms of degree and type of pneumatisation, number and position of intra and intersinus septa, relation with the surrounding surgical risk elements: the II, III, IV, V, VI and Vidian nerves, the ICA inside the cavernous sinus and the pituitary gland [9, 10].
Computerized tomography is the most precise imaging technique to demonstrate paranasal sinuses [11, 12, 13]. CT screening of paranasal sinuses has the advantages of showing bony details (using wide window settings) and good soft tissue outlines (using narrow window setting).
Axial and coronal views may be useful for delineating the anatomical landmarks of the sinonasal cavity, but coronal CT scan provides most of the information required for an endoscopic clearance 14. Its advantage over axial CT scanning is that it shows progressively deeper structures as they are encountered by the surgeon during the operation (e.g., sphenoid sinus, in an antero-posterior direction).

Materials and Methods

Source of data: We retrospectively studied 200 NCCT examinations of the paranasal sinuses, taken between June 2022 and March 2023 at Saraswathi Institute of Medical Sciences.

Inclusion criteria

- Individuals in the age range of 18 to 70 years

Exclusion Criteria-

- Individuals with age less than 18 years,
- Individuals with previous surgery involving skull base/sphenoid sinus,
- Individuals with previous trauma causing hemosinus/ fractures around the skull base
- Individuals having space-occupying lesions around the skull base/sphenoid sinus

On the CT workstation after retrieval of data from picture archiving and communication system (PACS) multiplanar coronal, sagittal and axial reconstructions were performed. Reconstruction parameters were slice thickness
1.5 mm, recon increment 1.3 mm, field of view (FOV) 223 x 223 mm, window: osteo and kernel as H70 s sharp FR (head 70 smooth sharp fast reconstruction). Analysis of CT images was done on a picture (PACS) workstation monitor by an experienced radiologist. Sphenoid sinus was examined for number of compartments depending on absence or presence/number of septations and the place of attachment of these septations to the bony wall of sphenoid sinus. We also analysed the CT images for Depth {Antero-posterior diameter (APD)}, Width {Transverse diameter (TD)}, Height {Cranio-caudal diameter (CCD)}

In 14 cases in which the septa were absent, bilateral size measurements of those sinuses were not done.

The maximum Cranio-caudal diameter (CCD) diameter is measured in coronal sections (Figure 1) and Anteroposterior diameter (APD) and Transverse diameter (TD) are measured in axial sections (Figure 2).

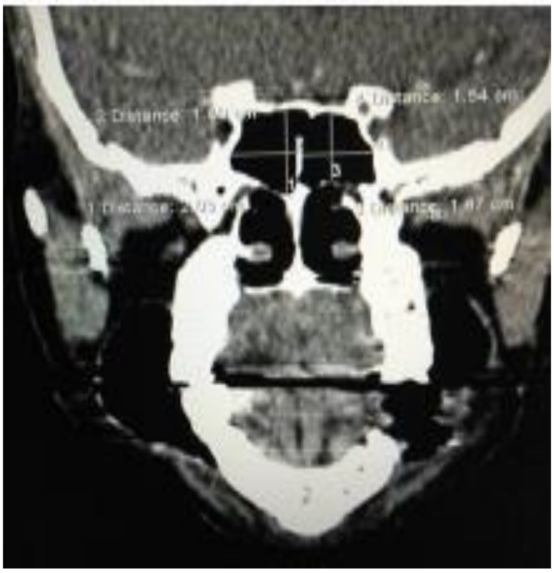

Fig 1

Fig 2

Statistical analysis

The data was analyzed using statistical software's SPSS v 25 continuous variables were described in terms of descriptive statistics like mean, standard deviation, minimum, maximum and range. Categorical variables were described in terms of frequency and percentage For statistical analysis the chi-square test was used to compare single septum and multiple septum with complete and incomplete groups. The $P < 0.05$ was considered statistically significant

Results

A total of 200 head NCCTs were evaluated retrospectively. The age range was 18 to 70 years with mean age of 43.56 years of which 128 (64%) were males and 72 (36%) were females. In the current study, the mean depth, width and height in females are found to be marginally less in comparison to males and are given in Table 1.

There was no significant statistical difference in the number and attachment of these septations to bony wall between male and female subjects.

The commonest pattern of intra-sphenoid sinus septation was presence of a single and complete septation (72%), followed by presence of Double septa (one complete and the other one incomplete) n (8%).

Single and incomplete was seen in 6% subjects. Absent intra-sphenoid sinus septation was seen in 7%.

The number of sphenoid sinus septations (presence/absence, main as well as accessory) and their prevalence is summarized in (Table 2).

The attachment of intra-sphenoid sinus septation is named after the underlying structure to which the posterior end of the septation is attached.

The most common pattern of attachment of intra-sphenoid sinus septation is sellar type followed by left ICA type and with attachment to optic canal being the least common.

The various types of attachment of the sphenoid sinus septa to the bony wall (named as per the underlying various vital structures) of sphenoid sinus and their prevalence is summarized in (Table 3).

Sphenoid Sinus Septum Patterns

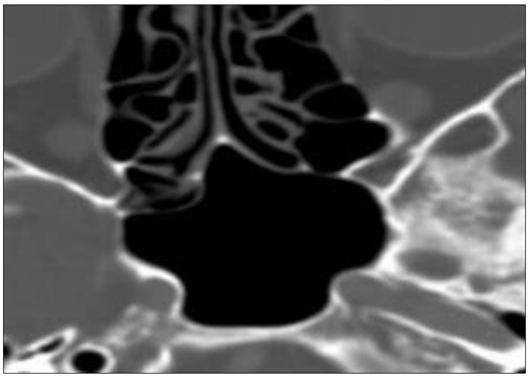

Fig 3A

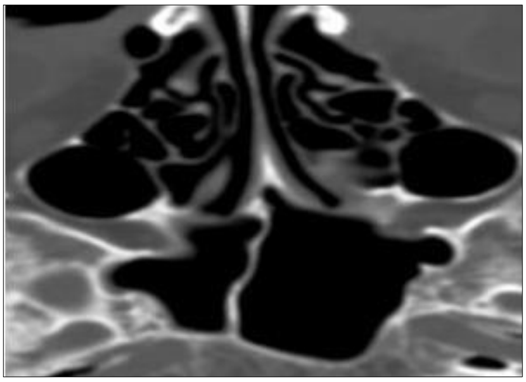

Fig 3B

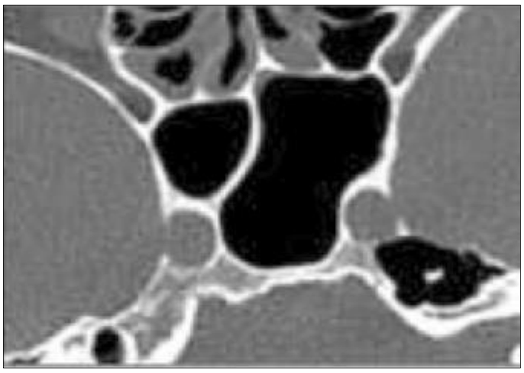

Fig 3C

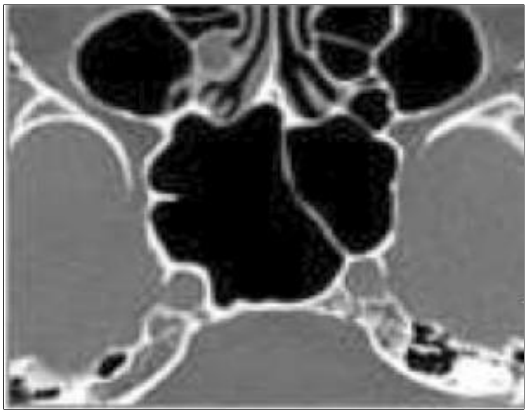

Fig 3D

Fig 3E

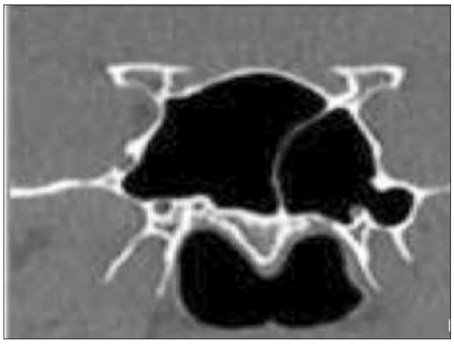

Fig 3F

Fig 3: Intersphenoid septum patterns: axial ncct image showing absent inter sphenoid septum A, single inter sphenoid septum B, Sphenoid septum attachment to right and left carotid protuberance C and D respectively, coronal images showing Sphenoid septum attachment to right and left optic nerve E and F respectively

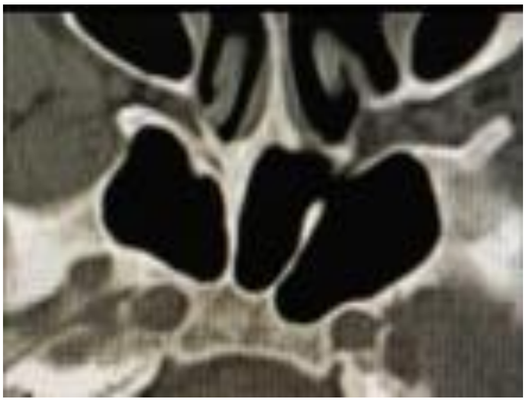

Fig 4A

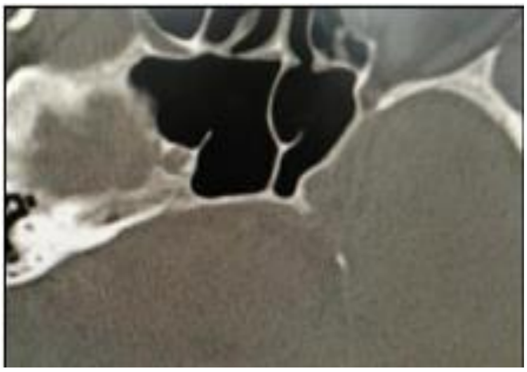

Fig 4B

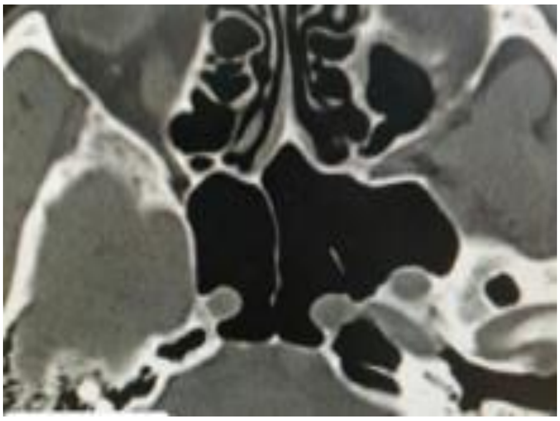

Fig 4C

Fig 4D

Fig 4: Axial NCCT images showing Double complete septae attaching to the posterior wall (A),double septae with complete one attaching to posterior wall and incomplete one to right carotid canal (B): and to the posterior wall in midline and to left carotid canal (C): and to bilateral carotid protuberance (D).

Table 1: Mean depth, width and height of sphenoid sinus in males and females.

Parameter	Male (n=119) Mean	SD	Female (n=67) Mean	SD
Right Depth	2.245cm	0.5316	2.047cm	0.8025
Left Depth	2.387cm	0.6632	2.006cm	0.5182
Right Width	1.555cm	0.3240	1.625cm	0.515
Left Width	1.652cm	0.4950	1.289cm	0.3784
Right Height	1.904cm	0.4281	2.01 cm	0.2987
Left Height	1.861cm	0.4281	1.705cm	0.3235

Table 2: Number of sphenoid sinus septations and their percentage.

Number of sphenoid sinus septation	Number of individuals (N = 200) n (%)
Absent	14 (7)
Single and complete	144 (72)
Single and incomplete	12 (6)
Double and complete	6 (3)
Double septa (one complete and the other one incomplete)	16 (8)
More than two septa (one main and others accessory)	8(4)

Table 3: Type of attachment of septations to sphenoid sinus wall and their percentage.

Type of attachment to the wall of sphenoid sinus	(N = 186) n (%)
Left internal carotid artery (ICA)	43 (23.1)
Right ICA	12 (6.4)
Posterior wall (sellar)	93 (50)
Lateral wall	8(4.3)
Posterior wall and left ICA	15 (8.06)
Posterior wall and right ICA	7 (3.8)
Lateral wall and carotids	6(3.23)
Optic nerve	2 (1.07)

Discussion

The versatility of the trans-sphenoidal approach is based on solid foundations: it is the least traumatic route to the sella turcica, it avoids brain retraction, and it provides an excellent visualization of the pituitary gland and related anatomical structures. It also provides lower morbidity and mortality rates when compared with transcranial procedure 15. There is usually an intersphenoid septum within the sphenoid sinus. The septum usually deviates to either side, separating the sinus into two unequal parts, thereby resulting in an asymmetrical appearance of the sella turcica floor, of which the surgeon must be aware of.

Knowledge of the number and configuration of sphenoid septum/septa, the attachment of these septum to sphenoid sinus wall and ICAs may guide the surgeon.

In this study we measured the size of sphenoid sinus (depth, width and height) and observed the number of septa and their pattern of attachments to the sinus wall. In our study all the dimensions of the sphenoid sinus in females is marginally less than that of the males.

In our study group, we determined the ratios of the cases with absent septa in 7 %, single and complete septa 72%, single and incomplete septa 6%, double and complete septum 3% ,double and incomplete septum 8%, more than 2 septa 4% respectively. Hamid O *et al.* and Idowu OE *et al*, also reported single septation as the most common anatomic variation in their study [16, 17]. However Idowu *et al*, reported the septum towards right side in most cases [16]. Values of single septum quoted by Wani *et al.* (2019),18 Lokwani *et al* (2018), [19] Wiebracht *et al.* (2014), [20] Hamid *et al* (2008) [17] are similar to our study. Slightly lesser incidence of single septum was observed by Kashyap *et al*, (2017), [21] Battal *et al*, (2014), [22] (table 4.)

World literature shows great variation in the prevalence of more than one intra-sphenoid sinus septations from as high as 95% to as low as 7.1%. Double septa were found in 11% in present study and more than 2 septa in 4%. The attributable factor for these variations seems to be small sample size in majority of these studies. Insertion of these multiple septa to the walls of sphenoid sinus is crucial for trans-sphenoidal surgery23-26. After sellar attachment, the next most common site of attachment was to the internal carotid artery (29.5%) in present study (23.1% to left ICA and 6.4% to the right ICA). Double septations attached most commonly to the posterior wall and to either of ICA (11.86 %).

Other rare sites of attachment in present study were lateral wall, combined lateral wall and ICA and optic nerve.

Bademci G *et al*, reported septal insertion to either of the carotid canal in 25.5% cases, however Abdullah BJ *et al*, reports carotid canal attachment in 12.9% cases, and Hamid O *et al*, in 6.75% cases [17, 27].

Table 4

Author	Number of cases	Modality of study	Absent septum	Single septum (Complete+ Incomplete)	Double septa (Complete+ Incomplete)	Multiple septa (Complete+ Incomplete)
Hamid *et al.* (2008) [17]	296	CT / MRI	10.8%	71.6%	10.8%	6.8%
Wani *et al.* (2019) [12]	591	NCCT	5.9%	79.7%	11%	3.4%
Kashyap *et al.* (2017) [11]	80	CT	5.0 %	67.5 %	21.25 %	6.25 %
Battal *et al.* (2014) [18]	314	CT	1.3 %	64.3 %	20.1 %	14.0 %
Wiebracht Zimmer (2014) [14]	90	HRCT	4%	75%	3%	-
Lokwani *et al.* (2018) [13]	260	CT	2.3%	79.6 1 %	18.1%	-
Present study (2023)	200	CT	7%	78%	11%	4%

Conclusion

The anatomy of the sphenoid sinus can be quite complex. The great amount of anatomic variation is attributed to the extent of sphenoid sinus pneumatization, varying number and position of septae, and the relationship with surrounding structures.

Enrichment of the knowledge of the sphenoid sinus anatomic variation will aid in reducing complications. Surgeons must meticulously study the preoperative imaging to become familiar with the nuances and variations unique to each case and proceed accordingly to decrease the risk of complications.

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