

ORIGINAL RESEARCH ARTICLE

## EVALUATION OF ANATOMICAL VARIATIONS OF SPHENOID SINUS USING COMPUTED TOMOGRAPHY IN A TERTIARY CARE CENTRE

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### ABSTRACT

#### OBJECTIVES

To delineate the anatomic variations of the sphenoid sinus that pose surgical risk and the many relationships that exist between the sinus and associated neurovascular systems.

#### METHODS

In total 380 computed tomography scans were evaluated in axial, coronal and sagittal planes with 1mm slices to study the type of sphenoid sinus pneumatization, protrusion and dehiscence of the ICA and ONC, presence of septations.

#### RESULTS

The most common SSP was sellar type (60%). Pneumatization of PP, ACP, GWS were seen in 16%, 18.4%, 21.05%, patients respectively Protrusion of ICA, ON, MN and VN were noticed in 27.1%, 31.5%, 18.1%, 20.5% of the patients respectively. Dehiscence of ICA, ON, MN and VN were noticed in 2.6%, 2.1%, 8.1% and 13.4% of patients respectively.

#### CONCLUSION

The sphenoid sinus's anatomical variations frequently result in complex symptoms and sometimes dangerous side effects. It is crucial to evaluate the anatomic variances using a CT scan in order to lower the risk of harm and complications during endoscopic sinus surgery.

## KEY WORDS

Sphenoid Sinus, Anatomical Variations, Septation, Pneumatization.

## INTRODUCTION

At the centre of the base of the skull is a complicated structure called the sphenoid bone, it is surrounded by the temporal bone laterally, the occipital bone posteriorly, and the frontal and ethmoidal bones anteriorly. It represents a transition between the intracranial and extracranial components of the skull<sup>[1]</sup> Because of its deep position inside the skull, the sphenoid sinus is the most difficult paranasal sinus to access.<sup>[2]</sup>

Assessing the sphenoid sinus clinically is more difficult than other paranasal sinuses (PNS).<sup>[1]</sup> The last sinus to be pneumatized is the sphenoid sinus, which is completed at the age of 12 after starting at birth.<sup>[1]</sup>

The sphenoid sinus is highly variable in terms of pneumatization, septations, and its relationship with nearby surgical risk elements like nerves, ICA, and pituitary gland.<sup>[3]</sup> Its pneumatization ranges from absent to extensive, which subsequently makes the bone that covers the carotid arteries, the optic nerves, and the vidian nerves to be thin or even missing. Therefore, the mentioned structures become vulnerable to iatrogenic injury.<sup>[2]</sup>

The trans-sphenoid route is regarded as the conventional method for pituitary adenomas surgery. The different routes to the sella: transethmoid, transnasal, trans-septal, whether microscopic or endoscopic, ultimately pass through the sphenoid sinus to reach the sella.<sup>[4]</sup>

Without knowledge of sphenoid sinus pneumatization, using a transsphenoidal technique can lead to serious consequences, including damage to crucial cranial arteries and nerves.<sup>[1]</sup>

CT is the most accurate method to visualize paranasal sinuses, providing detailed bone and soft tissue images. Coronal views are most useful for anatomical landmarks, especially for endoscopic clearance. Compared to axial scans, coronal CT reveals deeper structures encountered during surgery.<sup>[5-6]</sup>

The study aims to show the clinical significance and interrelationship of sphenoid sinus and related structures by using coronal CT scans to identify variations.

## Objectives and Aim

To assess the different types of anatomical variations of sphenoid sinuses among the cases.

## METHODOLOGY

This study was approved by the research ethics committee of the institution. A Cross sectional retrospective study has been performed in 380 paranasal CT scans collected between august - 2023- to February 2024 for a duration of 6 months at McGann Teaching Hospital, Shimoga Institute of Medical sciences.

Sample size was calculated based on study conducted by Gian Luca Fadda et al, who observed that the most common sphenoid sinus pneumatization was sellar type with a prevalence of 58.7%. Taking these values as reference, the minimum required sample size with 5% absolute precision and 95% confidence interval is 373 patients rounded off to 380 patients.

Inclusion criteria were tomography scans of individuals older than 18 years of age, with rhinosinusitis symptoms and request from physician ordering tomography assessment of the nose and paranasal sinus. Exclusion criteria were tomography scans identifying individuals with facial bone fractures, rhinosinusitis neoplasms, or rhinosinusitis of the posterior paranasal sinus, with a history of prior sinus or sphenoid surgery and massive polyposis.

CT scan images were acquired from patients with informed consent. Data will be anonymous to maintain patient confidentiality. Images with a slice thickness > 3 mm, low resolution quality, and those with metallic artifacts that impair sinus visualization are excluded from the study. A Philips 128 slice MDCT scanner, is used to acquire images. Images are taken in the axial planes and then 0.65 mm and 1mm slices are reconfigured into coronal and sagittal planes. Patients will be placed in the supine position with their chin hyperextended and scan plane angled perpendicular to the hard palate. Axial scans are performed from the maxillary sinus floor to the level of the frontal sinus roof, in a plane parallel with the hard palate. Images are reviewed on the console with varying window levels and widths. The sphenoid sinuses are counted (single, double, and absent) and compared in both planes. The data reviewed in both axial and coronal planes, and the total number of septa are Based on the CT images, the following variables were assessed: type of septum, type of SSP, extension of pneumatization into great wing of sphenoid, anterior clinoid process, pterygoid process, protrusion and dehiscence of the ICA, ONC, MN, ONC.

## RESULTS

A total of 380 patients fulfilled the study entry criteria. All patients with ages ranging from 16 to 82 years. There were equal number of men and women. Anatomic variations of sphenoid sinuses were determined in coronal screening, sagittal views. In this study, 380 patients participated, out of which 190 (50%) were females, 190 (41.5%) were males. The participants' age ranged from 18 to 70, with a mean of ( $\pm$ SD) 45 ( $\pm$ 14.5) years. The mean age of males was 56, while for females was 38.

Our findings showed that anatomographic variants of sphenoid sinus were 229 (60%) sellar, 82(22%) presellar, 46(12%) postsellar, and 23 (6%) were conchal types of pneumatization (Figures 1, 2, 3 and 4; Table 1). We also found that pneumatization of the anterior clinoid process (ACP) was 70 (18.4%), pterygoid plates (PP) was 61 (16%), and the greater wing of sphenoid was (GWS) 80 (21.05%) (Figure 8,9,10 and 11; Table 3).

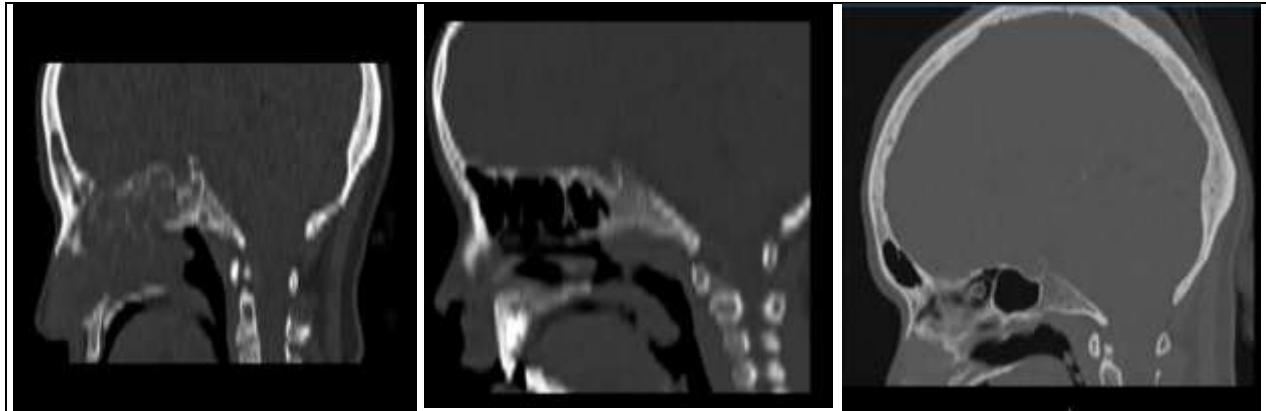
Septal bone septation of the sphenoid sinus in the population was single 272 (71.5%). That is, 272 (71.5%) complete and 57 (15%) incomplete, 44 (11.5%) accessory septa (all are complete), and (2.5%) 7 of cases no septation was seen. (Figures 5, 6 and 7; Table 2).

We also investigated the dehiscence and protrusion of sphenoid sinus in relation to internal carotid artery, optic nerve canal, maxillary nerve and vidian nerve (Table 4). Protrusion of the internal carotid artery into the sphenoid sinus was identified on the CT images of 103 (27.1%) patients: the right side alone was involved in 35 (9.2%) patients; the left alone in 51(13.4%) patients, and bilateral involvement was involved in 17(4.4%) patients. The dehiscence of the bony sphenoidal wall of the internal carotid artery occurred in 10 (2.6%) patients; the right side alone was involved in 6(1.8%) patients, left side alone in 4 (1.05%) patients, and bilateral involvement was observed in 1(0.26%) patients. 120(31.5%) cases had the optic nerve protrusion into the sphenoid sinus: right sided in 35(9.2%) case, left side in 73(19.2%) cases, and bilateral involvement in 12(3.15%) cases. However, dehiscence occurred in 8(2.1%) patients; right sided in 6(1.57%) cases, left side in 1 (0.26%) cases, and bilateral involvement in 1 (0.26%) cases. We also identified the presence of onodi cells only in two (2.5%) cases (Figure 6).

Protrusion of maxillary canal was encountered in 69(18.1%) patients of whom were bilateral, 29 were on the right side, and 36 were on the left side. Dehiscence of the bony wall of maxillary canal was seen in 31(8.1%) patients, of whom 7 were bilateral, 9 were right sided, and 15 were left sided.

Sphenoid Pneumatisation	Men	Women	Total
Sellar	135	94	229
Presellar	45	37	82
Postsellar	31	15	46
Conchal	14	9	23

*Table 1: Prevalence of anatomic variants of sphenoid sinus based on pneumatization*



*Figure 1: Conchal type Figure 2- presellar Figure 3- sellar*



*Figure 4- post sellar*

Intersphenoid Septae	Men n (%)	Women n (%)	Total (n = 380), n (%) <sup>b</sup>
Midline	56	35	91
Deviated to right.	73	45	118
Deviated to left.	38	25	63
Accessory septae.	15	29	44
Absent septae	5	2	7

*Table 2: Prevalence of anatomic variants of sphenoid sinus based on septations*



**Figure 5- Accessory sphenoid septa, Figure 6 – Septa attached to bilateral internal carotid artery. Figure 7- Intersphenoid septum deviated to right side**

<b>Pneumatization</b>	<b>Bilateral</b>	<b>Right Side</b>	<b>Left Side</b>	<b>Total</b>
ACP	13	23	34	70
GWS	22	15	43	80
PP	10	28	23	61

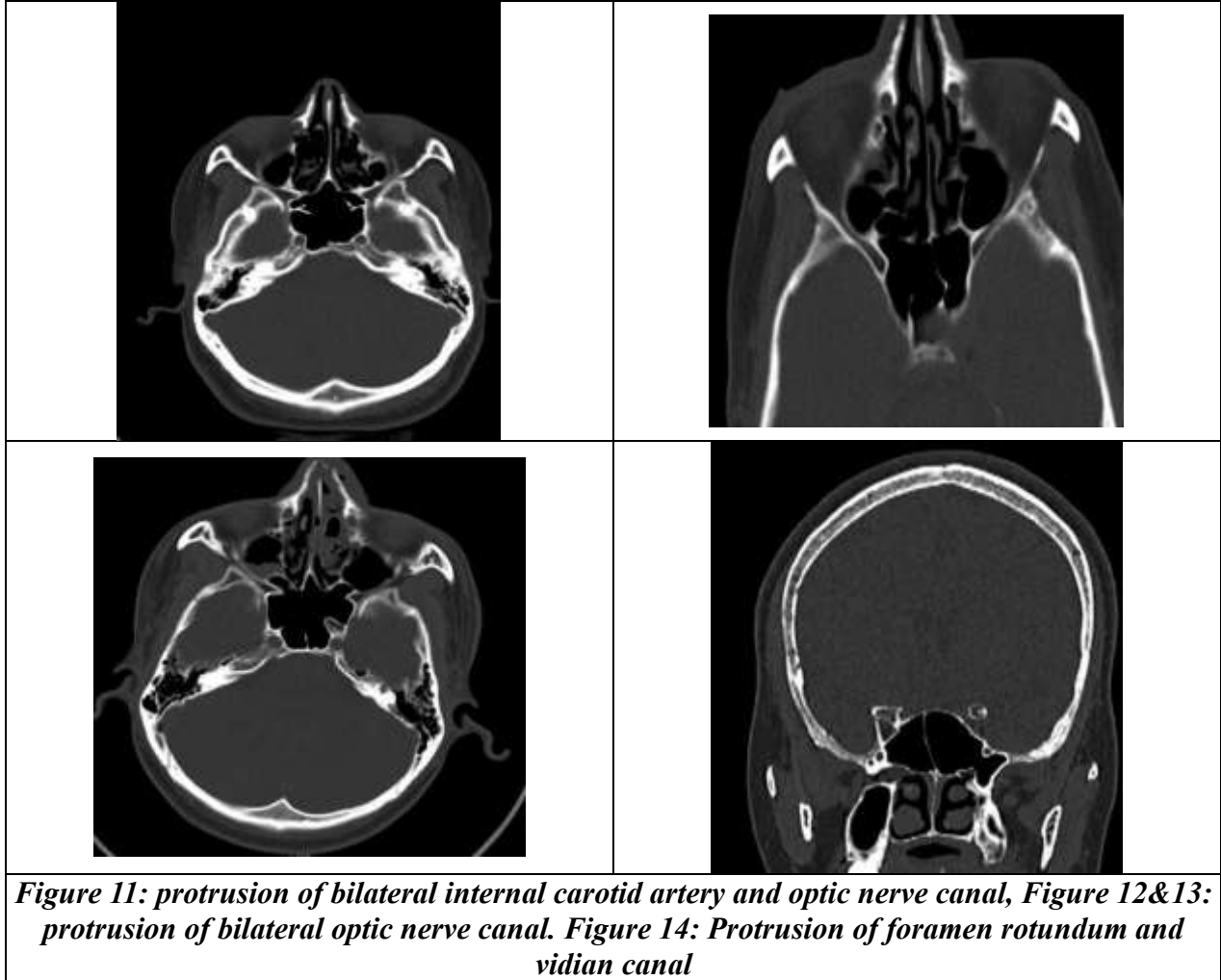
**Table 3: Prevalence of anatomic variants of sphenoid sinus based on pneumatization of Anterior clinoid process, greater wing of sphenoid and pterygoid process**



**Figure 8: Pneumatization of great wing of sphenoid, Figure 9&10: Pneumatization of anterior clinoid process and greater wing of sphenoid**

	<b>Bilateral</b>	<b>Right Side</b>	<b>Left Side</b>	<b>Total</b>
Protrusion				
ICA canal	17	35	51	103
ON canal	12	35	73	120
Foramen rotundum	4	29	36	69(18.1%)
Vidian canal	9	43	26	78

**Table 4 Prevalence of anatomic variants of sphenoid sinus based on protrusion of internal carotid artery canal,optic nerve canal,maxillary nerve canal (foramen rotundum ), vidian canal**



**Figure 11: protrusion of bilateral internal carotid artery and optic nerve canal, Figure 12&13: protrusion of bilateral optic nerve canal. Figure 14: Protrusion of foramen rotundum and vidian canal**

	Bilateral	Right Side	Left Side	Total
Dehiscence				
ICA canal	1	6	4	11
ON canal	1	6	1	8
Foramen rotundum	7	9	15	31
Vidian canal	5	17	29	51

**Table 5: Prevalence of Anatomical variations based on dehiscence of carotid canal wall, optic nerve canal, foramen rotundum, vidian canal.**



**Figure 15: Dehiscence of internal carotid artery on right side, Figure 16: Dehiscence of the wall of foramen rotundum, Figure 17: Dehiscence of the wall of vidian canal**

## DISCUSSION

The etiology of paranasal sinus lesions, which vary from inflammation to malignancy, is quite diverse and affects a large population.<sup>[7,8,9]</sup>

Increased frequency of anatomical changes in the sphenoid sinus can raise the risk of damage to significant neurovascular and glandular structures.<sup>[10]</sup> An optic nerve damage may result from extensive hyperpneumatization of the sphenoid sinus followed by pneumatization of the ethmoid sinus.<sup>[11]</sup> During endoscopic surgeries, variations in the locations, numbers, and insertions within the sinus septum may injure the internal carotid artery when it protrudes into the sinus lumen.<sup>[12]</sup> Hammer and Radberg identified three types of sphenoid sinuses: conchal, presellar, and sellar. The most prevalent pattern was the sellar variant, accounting for 85% of cases. The presellar and conchal variants comprised 11% and 2.5% of instances, respectively.

Moreover, the post-sellar variation is a new subgroup that Hamid et al. introduced to the sphenoid sinus.<sup>[13]</sup> Hiremath provided the term "complete sellar variant" increases the likelihood of CSF rhinorrhea, emphasizing the importance of reporting its existence to prevent post-surgical CSF rhinorrhea.<sup>[5]</sup> There is a considerable variation in the sphenoid sinus pneumatization patterns, according to literature reports.<sup>[13-15]</sup>

Consistent with other authors,<sup>[16-20]</sup> the sellar type accounted for 60 percent of the patterns in our sample, with the presellar type accounting for 22 percent. The sellar type is recorded at extremely high percentages in earlier literature,<sup>[17-20]</sup> ranging from 78.5 to 93%. In our investigation, the conchal type was discovered in 6% of cases, which is more than reported in the literature (1-2%).<sup>[18-20]</sup> The presellar type was detected in 22% of cases, in line with previous studies ranging in between (10–38%).<sup>[3]</sup> No conchal type was detected by Wang et al.<sup>[21]</sup> Dal Secchi et al,<sup>[16]</sup> or Anusha et al.<sup>[22]</sup> A transsphenoidal approach to the sella always seems to be contraindicated in cases of conchal non-pneumatized sphenoid.<sup>[5,23]</sup>

Before surgery, computed tomography scans can be used to detect the protrusion of the ICA and ONC into the SS as well as their dehiscence, which can assist prevent injury during surgery.<sup>[21]</sup> Similar to the findings of Dal Secchi et al. (26%)<sup>[16]</sup> and Sirikci et al.(26.1%),<sup>[10]</sup> ICA protrusion into the SS was observed in 27.1% of patients in our assessment. A total of 10 instances (2.6%) had dehiscence of the ICA detected. According to published research, the range of ICA protrusion in the literature is often large, ranging from 5.2 to 67.0%,<sup>[17]</sup> whereas the range of its dehiscence is 1.5–5%<sup>[24,16,17]</sup> to 1.5%.<sup>[5,8,9,22]</sup>

While the rate of dehiscence was 2.1%, it was relatable to the literature (range 0.7–30.6%).<sup>[24-26,17,22]</sup> The rate of ONC protrusion was 31.5%, in line with the literature (range 2.3–35.6%).<sup>[25,26,17,22]</sup>

Protrusion of maxillary canal was encountered in 69(18.1%)patients in our study which is superior to that found by Elwany et al. and Heskova et al, but much lower compared to the findings of Araujo Filho et al. Dehiscence of the bony wall of maxillary canal was seen in 31(8.1%) patients, lower compared to.<sup>[4]</sup>

Protrusion of vidian canal into the sinus cavity was present in 78(20.52%) patients in our study which is superior to that found by Elwany et al. and Lupascu, but much lower compared to the findings of Araujo Filho et al.

Dehiscence of the bony wall of the vidian canal was identified in 51(13.4%) patients, but much lower compared to. <sup>[4]</sup>

ONC injury by protrusion or dehiscence can occur as a major complication when the IS is attached to it and has to be removed. Defects in the visual field, visual acuity or blindness<sup>[11]</sup> are the risks of injury to optic nerve canal.<sup>[5]</sup>

In the presence of Onodi cells, the ONC is more vulnerable to damage.<sup>[23]</sup> We discovered that the ON projecting into Onodi cells was present in 3.6% of our patients. There is a strong correlation between high SSP and dehiscence and/or protrusion of neurovascular structures. Sphenoid sinus septal bone variations are also considered the potential anatomographical variations illustrated in this region.<sup>[27,28]</sup> Intersphenoidal septa may also have attachment sites on the bone walls of the ICA and ONC; this is an anatomical risk factor during ESS, particularly in the event of a severe fracture.<sup>[5]</sup>

Serious intraoperative bleeding or blindness may result from an inadvertent fracture of the intersphenoidal septum, which connects to the ICA or ONC bone wall, during endoscopic sinus surgery. Verifying the anatomical characteristics of the SS is crucial to reducing the likelihood of accidental damage to these vital tissues during ESS.:

According to our research, 2.5% of the population included in the study had no septation at all, while around 71.5% of participants had a single septum. Of the cases with a single septum, 23.9% were midline, 31.05% were on the right side, and 16.5% were on the left; in contrast, 15% of the cases had a single incomplete septum and 11.5% had a double septum.<sup>[7]</sup>

While it was 2.7% in Nigerians<sup>[29,30]</sup> and 2.2% in other studies<sup>[31-33]</sup> only 2.5% of the individuals in our study had no septa. Considering that their sample sizes differ, their results are nearly identical. Our findings are supported by the fact that less than 2% of the various populations under study exhibit the uncommon occurrence of a sphenoid sinus without septation.<sup>[7]</sup>

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