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**Original Research Article**

# Anatomical variations of sphenoid sinus among patients undergoing computed tomography of paranasal sinus

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## ABSTRACT

**Background:** The approach to sphenoid sinus still remains a clinical challenge, despite the arrival of endoscopy, computed tomography (CT) and functional endoscopic sinus surgery (FESS). The complex and variable anatomy of the sphenoid sinus can be difficult to appreciate with standard axial or coronal CT images of the sinus. The study was done with the objective to study the anatomy of the sphenoid sinus and its variations, and to compare the prevalence of variants obtained in our study with the reported cases in the literature.
**Methods:** The CT scans of 168 normal slides obtained from 84 patients with paranasal sinus were analysed using triplanar imaging provided by 64-slice spiral CT. The prevalence of each of the sphenoid sinus variation was also analysed.
**Results:** Results showed that the prevalence of pneumatization of the anterior clinoid process, greater wing of the sphenoid, and the pterygoid process was 17.85%, 22.61% and 32.14%, respectively. Protrusion of the internal carotid artery, optic nerve, maxillary nerve, and the vidian nerve was 47.61%, 36.90%, 25% and 26.19%, respectively. Dehiscence of internal carotid artery, optic nerve, maxillary nerve, and the vidian nerve was 30.95%, 29.76%, 14.28% and 22.61%, respectively. The prevalence of pneumatization in the Onodi cells was seen in 17.85% of the cases. Association of septa with an internal carotid artery was seen in 29.7% of the cases. Septa attachment to the optic nerve was also observed in 27.3% of the cases.
**Conclusions:** The triplanar imaging (section thickness of 1 mm) is a better three-dimensional image of the sphenoid sinus, compared to coronal imaging. Triplanar imaging guides the surgical approach of the sphenoid sinus with mentally reconstructed three-dimensional images.

**Keywords:** Anatomical variations, Sphenoid sinus, Computed tomography

## INTRODUCTION

Despite the advent of the endoscopy, functional endoscopic sinus surgery (FESS) and computed tomography (CT), the approach to sphenoid sinus (SS) still remains a clinical challenge. The SS is acknowledged as the most variable cavity of the human body and its accessibility is considered to be difficult.[1] SS is abutted by a lot of important structures, and its association with them is related to numerous anatomic variations.[2] Certain important vascular and neural structures might be detached from the SS by only a thin wall or they might be exposed within the SS. Consequential variations including an internal carotid artery, cavernous sinus, vidian and optic canals are closely associated to sphenoid sinuses.[3] In addition, anatomic differences might influence the SS to chronic or recurring sinusitis.[4]

The complex and variable anatomy of the SS can be difficult to appreciate with standard axial or coronal CT images of the sinus. The introduction of triplanar imaging with the inclusion of sagittal plane allows a detailed radiologic assessment of the frontal recess. Due to improved bone detail and discrimination, the triplanner CT imaging has largely replaced standard axial and multiplanar imaging. New low-dose CTs may be advantageous, as they reduce radiation exposure. Triplanar CT imaging is an important tool for sinus surgeon, as it aids in safe endoscopic sinus surgery (ESS).[5]

Mucosal abnormalities, in addition to bony anatomic variations of the SS, can be visualised by triplanar CT with much clarity.[4,6] Information on the amount of pneumatization and the diverse type of anatomic variants of the SS is essential for the suitable treatment of a SS-related disease.

The objective of this study was to assess the variation in the anatomy of the SS and compare the prevalence of variants obtained in this study with the reported cases in the literature.

## METHODS

This cross-sectional study was performed on 84 patients who were referred for CT scan of the paranasal sinuses (PNS) at the department of radiodiagnostics, CT and MRI centre of KLE Dr. Prabhakar Kore Hospital and MRC, Belgaum, India between January 2012 and December 2012. Patients aged more than 16 years whose SS anatomy was not altered by neoplastic disease and/or trauma were included in the study. They were advised to go through CT scan of PNS and instructed to clean their nose by blowing out any secretion. The scanning was done using Siemens SOMATOM Sensation 64-slice CT scanner. The images were obtained in the axial plane and then reconstructed in three planes with 1 mm thickness. They were loaded onto a CD with the help of DICOM Magic View software and Siemens SYNGO fast view software. The images were examined using triplanar imaging software.

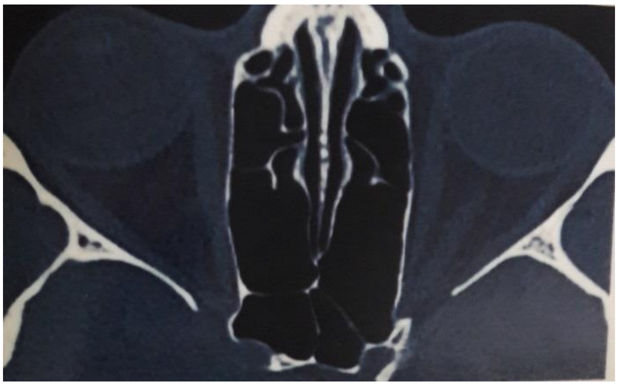

**Figure 1: Septal attachment to left internal carotid artery.**

**Figure 2: Left onodi cell with optic nerve bulge in its lateral wall.**

**Figure 3: Left anterior clinoid process pneumatisation, bilateral pterygoid process pneumatisation with left vidian nerve protrusion and left maxillary nerve dehiscence.**

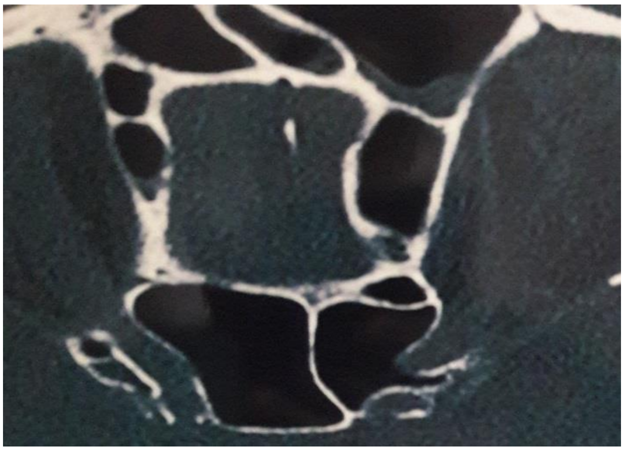

**Figure 4: Opticocarotid recess with protrusion of left internal carotid artery and dehiscence of left optic nerve.**

The findings were documented in MS Excel and presented in numbers and percentages.

## RESULTS

Table 1 presents the anatomic variation of SS determined by triplanar imaging. We assessed 84 (168 sides) triplanar 1-mm CT scans in the gantry for the anatomy variations of the SS. Pneumatization of the anterior clinoid process was observed in 15 cases (17.85%), out of which 7, 5, and 3 cases were bilateral, right sided and left sided, respectively. Pneumatization of the greater wing of sphenoid was observed in 19 cases (22.61%), out of which 8, 5, and 6 cases were bilateral, right sided and left sided, respectively. Pneumatization of the pterygoid process was seen in 27 cases (32.14%), out of which 14, 7, and 6 cases were bilateral, right sided and left sided, respectively.

**Table 1: Anatomic variation of the sphenoid sinus as determined by triplanar imaging (n=84).**

| Anatomic variations | Bilateral | Right | Left | Total (%) |
|---|---|---|---|---|
| **Pneumatization of the anterior clinoid process** | 7 | 5 | 3 | 15 (17.85) |
| **Prevalence of pneumatization of the greater wing of sphenoid** | 8 | 5 | 6 | 19 (22.61) |
| **Prevalence of pneumatization of the pterygoid process** | 14 | 7 | 6 | 27 (32.14) |
| **Prevalence of the internal carotid artery protrusion** | 20 | 12 | 8 | 40 (47.61) |
| **Optic nerve protrusion** | 18 | 7 | 6 | 31 (35.71) |
| **Prevalence of the maxillary nerve protrusion** | 7 | 8 | 6 | 21 (25) |
| **Vidian nerve protrusion** | 11 | 6 | 5 | 22 (26.19) |
| **Prevalence of the internal carotid artery dehiscence** | 10 | 11 | 5 | 26 (30.95) |
| **Optic nerve dehiscence** | 14 | 6 | 5 | 25 (29.76) |
| **Prevalence of the maxillary nerve dehiscence** | 4 | 5 | 3 | 12 (14.28) |
| **Vidian nerve dehiscence** | 10 | 5 | 4 | 19 (22.61) |
| **Onodi cells** | 0 | 6 | 9 | 15 (17.85) |
| **Septa directly related to the internal carotid artery** | 8 | 10 | 7 | 25 (29.7) |
| **Septa attachment to the optic nerve** | 7 | 9 | 8 | 23 (27.38) |

A protruding internal carotid artery into the SS was seen in 40 cases (47.61%), out of which 20, 12, and 8 cases were bilateral, right sided and left sided, respectively. The protrusion of the optic canal was present in 31 cases (36.90%). Out of 31 cases, 18, 7, and 6 cases were bilateral, right sided and left sided, respectively.

The protrusion of the maxillary canal was seen in 21 (25%) cases, out of which 7, 8 and 6 cases were bilateral, right sided and left sided, respectively. A protruding vidian canal into the sinus cavity was present in 22 (26.19%) cases, out of which 11, 6, and 5 cases were bilateral, right sided and left sided, respectively.

The dehiscence of bony wall of the internal carotid artery into the SS was observed in 26 cases (30.95%), out of which 10, 11, and 5 cases were bilateral, right sided and left sided, respectively. The dehiscence of bony wall of the optic canal was present in 25 cases (29.76%). Out of 25 cases, 14, 6, and 5 cases were bilateral, right sided and left sided, respectively.

The dehiscence of bony wall of the maxillary canal was encountered in 12 (14.28%) cases, out of which 4, 5, and 3 cases were bilateral, right sided and left sided, respectively. The dehiscence of bony wall of the vidian canal was identified in 19 (22.61%) cases, out of which 10, 5, and 4 cases were bilateral, right sided and left sided, respectively.

The Onodi cells were found in 15 (17.85%) cases, out of which 6 and 9 cases were right sided, and left sided, respectively. The septa, directly related to internal carotid artery, was present in 25 (29.7%) cases, out of which 8, 10, and 7 cases were bilateral, right sided, and left sided, respectively. The septa attachment to optic nerve was present in 23 (27.38%) cases, out of which 7, 9, and 8 cases were bilateral, right sided, and left sided, respectively.

## DISCUSSION

In the literature, the prevalence of anterior clinoid process pneumatization is well documented. In a study conducted by Bolger et al, 13% of 202 paranasal sinus CT scans had anterior clinoid process pneumatization.[4] In this study, researchers examined CT scans with a slide thickness of 3 mm. Unal et al observed pneumatization of the anterior clinoid process in 24.1% of 260 cases, for which coronal sinonasal CT cuts were also obtained at 3 mm slice thickness.[7] De Lano et al, observed anterior clinoid process pneumatization in only 13 (4%) of 300 slides.[8] Coronal images acquired at a slide thickness of 4 mm were used in this study. Sirikci et al. established anterior clinoid process pneumatization in 2.3% of 92 paranasal sinuses using coronal CT scans studied at 2.5 mm slice thickness.[3] However, in the present study anterior clinoid process pneumatization was observed in 15.3% of cases. The differences in the prevalence of anterior clinoid process can be due to the differences in the studied population or the different thickness of the CT scan slides.

In the current study, pneumatization of greater wing of sphenoid was found in 22.6% of cases. Similarly, in the studies performed by Earwaker and Hewaidi et al, pneumatization of greater wing of sphenoid was established in 10.7% and 20% of cases, respectively.[9,10]

Pneumatization of the pterygoid process is defined when it extends beyond a perpendicular plane intersecting the vidian canal. In the current study, we establish that pneumatized pterygoid process was present in 32.2% of cases, whereas Bolger et al discovered pterygoid process pneumatization in 43.6% of cases without defining the pneumatization of the pterygoid process.[4] Sirikci et al stated pneumatization of the pterygoid process in 29.3% of the cases.[3]

In the presence of pterygoid process pneumatization, the central skull base can be accessed. Endoscopic endonasal trans pterygoid approaches (EETA) makes use of the pneumatization of the pterygoid process to control lesions of the middle and posterior skull base.[11] Therefore, pneumatization of the pterygoid process provides an important route for endoscopic biopsy of skull base lesions and endoscopic repair of cerebrospinal fluid leaks.

In the current study, protrusion of the internal carotid artery was observed in the sphenoid in 47.6% of cases. In a study conducted by Sirikci et al and Unal et al, protrusion of internal carotid artery was established 26.1% and 30.3% of cases, respectively.[3,7] Studies conducted by Sethi et al, Elwany et al, and Hewaidi GH et al, identified carotid artery protrusion in 93%, 29%, and 41% of cases, respectively.[2,10,12]

In the current study, dehiscence of the artery was established in 30.95% of cases. However, in a study by Kennedy et al, dehiscence on the bony wall of the internal carotid artery was discovered in 25% of cases.[13] In another studies conducted by Sareen et al, Sirikci et al and Unal et al, dehiscence of the carotid artery was established to be in 5%, 23%, and 5.3% of cases, respectively.[3,7,14]

In our series, it has been established that protrusion of the optic nerve was in 35.7% of the cases. In the studies conducted by Dessi et al, Rahmati et al, and Anusha et al, protrusion of optic nerve was found in 8%, 33%, and 2.3% of the cases, respectively.[15-17]

In the current study, dehiscence of the optic nerve was established in 29.8% of the cases. However, a study conducted by Fuji et al established that 4% of optic nerves were dehiscent of bone in the lateral wall of sphenoid.[18] If there is any protrusion or dehiscence, optic nerve injury can be due to surgical trauma or they may result in sinus disease complication. Moreover, blindness might result from infection of SS or due to pressure from a mucocoele on the optic canal or nerve.[19]

In our study, the maxillary nerve protrusion was established in 25% of the cases. On the other hand, a studies conducted by Unal et al, Tomovic et al, and Hewaidi et al, maxillary nerve protrusion was found in 30.3%, 25.9%, and 24.3% of the cases, respectively.[7,10,20]

In the current paper, dehiscence of the maxillary nerve was established in 14.2% of the cases. However, in the studies conducted by Unal et al, Hewaidi et al, and Tomovic et al, dehiscence of maxillary nerve was discovered in 3.5%, 13%, and 7.4% of cases, respectively.[7,10,20] In another study conducted by Sareen et al, no sinus with maxillary nerve protrusion nor dehiscence was seen.[14]

In the study performed by Lang and Keller and Hewaidi et al, the vidian canal was protruded into the sinus cavity in 18% and 27% of the cases, respectively.[10,21] A study conducted by Pandolfo et al highlighted that there is a variable relationship between the vidian canal and the SS, and they have brought into the notice that vidian neuralgia might result causing deep pain in the nasal cavity.[22] In the present study, protrusion of the vidian nerve was established in 26.1% of the cases.

In the current study, septa were related to an internal carotid artery in 25 cases. In the study carried out by Fernandez-Miranda et al, out of 27 sphenoid sinuses in real cases, 23 (85%) had two septa touching the internal carotid artery. Out of 27 sphenoid sinuses, examined from cadavers, 24 (89%) had one septation inserted in the internal carotid artery.[23]

In this current study, Onodi cells were seen in 15 (17.9%) cases. In the paper by Tomovic et al Onodi cells were present in 65.3% of the cases. In the same publication, subgroup analysis of the cohort revealed that Onodi cells were present in 83.3% of Asians, 73.1% of whites, 57.0% of African-Americans, and 62.7% of Hispanics.[20] In another study conducted by Berjis et al, 37.8% of patients had Onodi cells.[24] It should be remembered that identification of Onodi cells is required prior to the endoscopic sinus and skull base surgery because of their intricate relationship with the carotid arteries and optic nerves.

During analysis of the CT scans, it was noted that septa attachment to the optic nerve was prevalent among 23 cases. In the publication by Unal et al, 22 out of 56 cases had bony septum attached to the optic nerve.[7] During surgery, the surgeon must have knowledge about the septum associated with the optic nerve. Lack of knowledge may result in fracturing the bony septum, causing optic nerve injury.

## CONCLUSION

The study established a high prevalence of protrusion and dehiscence of the internal carotid artery and optic nerve, whereas the prevalence of protrusion and dehiscence of maxillary nerve was less common. The prevalence in this study was comparable with other previous studies. Some of the difference observed was probably due to the difference in the definitions of the various anatomical variations. So we felt that standard definitions and strict anatomical criteria should be followed while analysing CT of the SS. We used a slice of 1 mm thickness. This resolution helped in a better delineation of the complex sphenoid anatomy. We feel that using triplanar imaging workstation software certainly helps in locating the variations of the SS. Hence, we suggest triplanar imaging for preoperative CT assessment for all sinus surgeries. We also feel that a similar study should be done with multiple experts reviewing the scans and hence reducing the interobserver variability and inherent individual bias.

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