



Prevalence of Anatomical Variations of Sphenoid Sinus and Its Adjacent Structures Pneumatization and Its Significance: A CT Scan Study

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Abstract

The purpose of our study was to assess the prevalence of variations and type of sphenoid sinus and its adjacent structures pneumatization and its significance. This prospective study included 114 patients who underwent CT of the paranasal sinuses. The CT scan in axial, coronal and mid sagittal section were analysed to assess the type of pneumatization of the sphenoid sinus and its adjacent structures like; anterior clinoid process, greater wing of sphenoid and pterygoid process. The sphenoid sinus pneumatization was classified into Conchal, Presellar, and Sellar types, later comprised of sellar and post-sellar types. Out of 114 cases of pneumatized sphenoid sinus, 5.2% cases were conchal type, 26.3% cases Presellar type and 68.4% cases sellar type. The one or more adjacent structures was pneumatized in 71 (62.2%) of cases. The adjacent structures which found to be pneumatized are anterior clinoid process in 26.3%, Pterygoid process in 23.6%, and greater wing of sphenoid in 12.3% cases. The pneumatization of adjacent structures was more prevalent in sellar type of sphenoid sinus, followed by pre-sellar type and no pneumatization in conchal type. The anterior clinoid process pneumatization was present in 26.1% of cases, in which 3 (2.6%) cases in pre-sellar type and 27 (23.5%) cases in sellar type. It was unilaterally pneumatized in 13 (11.4%) and bilaterally in 17 (14.9%) cases. The pterygoid process pneumatization was present in 27 (23.6%) of cases, unilateral in 16 (14%) cases and bilateral in 11 (9.6%) cases. The Greater wing of sphenoid pneumatization was found in 14 (12.3%) cases, no cases in conchal types, 2 (1.8%) in pre-sellar type, and 12 (10.4%) in sellar type. There was no statistically difference found in between right and left side of sphenoid sinus and its structure pneumatization. The extent of pneumatization of the sphenoid sinus has clinical and surgical implications in sinus diseases, sellar and central skull base lesions.

Keywords Anatomic variation · Pterygoid process · Anterior clinoid process · Greater wing of sphenoid · Sphenoid sinus · Trans-nasal endoscopic surgery

Introduction

Anatomy of Sphenoid Bone, Sphenoid Sinus

The sphenoid bone is one of the most complex bones of the cranium, deeply seated in the skull and is the most inaccessible. It forms the floor of the middle cranial fossa, medial wall of orbital apex and a part of the lateral wall of the skull. The sphenoid bone has body, lesser wing of sphenoid, greater wing of sphenoid, pterygoid process, anterior clinoid process and posterior clinoid process. The body of sphenoid bone contains sphenoid sinus, it has six walls superior, posterior, lateral, medial, floor/inferior and anterior. The cranial surface of superior wall has Planum sphenoidale, chiasmatic sulcus, tuberculum sellae, hypophysis fossa, dorsum sellae and on lateral wall it is surrounded by vital structures, such as

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the internal carotid artery, optic nerve and cavernous sinus (Fig. 1a). The pneumatization of sphenoid sinus vary greatly from no pneumatization to pneumatization up to clivus. The adjacent structures which can be pneumatized are anterior clinoid process, greater wing of sphenoid and pterygoid process. The neurovascular structures run in close relationship with these adjacent structures i.e., optic nerve and internal carotid artery lie in close relationship with anterior clinoid process, maxillary nerve lies in close relation with greater wing of sphenoid and vidian nerve and artery lie in close relation with pterygoid process. The pneumatization of these adjacent structures causes protrusion of these structures with increased risk of damage during surgery.

Pneumatization of Sphenoid Sinus

In literature, the sphenoid sinus has been classified into Conchal or foetal type, Presellar or juvenile type, Sellar or adult or Post sellar type. Some authors In their study, classified sphenoid sinus into conchal, Presellar and sellar types. In these studies, sellar types of pneumatization includes both sellar and post sellar while in some studies, sellar and post sellar considered as separate entities. The conchal type or the foetal-type represents a small sinus, separated from the sella turcica by about 10 mm of trabecular bone. The Presellar type or juvenile type is pneumatized to the level of the sella turcica. The sellar type or adult type is pneumatization of the sphenoid below the sella or further posteriorly. The most frequent type of pneumatization is the sellar type, which

appears in 75–86% of cases. followed by the Presellar type in 10–25%. The conchal or foetal type is usually found in less numbers of cases.

Anatomy of Adjacent Structures of Sphenoid Sinus

Greater Wing of Sphenoid

The greater wings of sphenoid are two strong processes, arises from the side of the sphenoid body and projects upward, laterally, and backward. It lies in between middle cranial fossa and infratemporal fossa. The superior or cerebral surface of each greater wing directed upward and forms floor of the middle cranial fossa, it is deeply concave, and has depressions for the convolutions of the temporal lobe of the brain. The Inferior or external surface forms roof of infratemporal fossa. Anteriorly it forms the posterior boundary of superior orbital fissure. The maxillary nerve runs in superior part of medial side of greater wing of sphenoid (Fig. 2). if greater wing gets pneumatized, the maxillary nerve bulges and floor of middle cranial fossa is thinned out. This pneumatization increases the risk of maxillary nerve injury and inadvertent entry into middle cranial cavity during endoscopic sinus and skull base surgery.

Pterygois Process of Sphenoid Sinus

The pterygoid process projects inferiorly from the junction of the body and greater wing of the sphenoid bone, it bifurcates into a medial pterygoid plate and a lateral

Fig. 1 A Shows sphenoid bone cranial sides. *PS* Planum sphenoidale, *CS* Chiasmatic sulcus, *TS* Tuberculum sella, *HF* Hypophys fossa, *DS* Dorsum sella, *C* Clivus, *FO* Foramen ovale, *FS* Foramen spinosum, *GWS* Greater wing of sphenoid), **B** endoscopic view of sphenoid sinus showing lateral optico-carotid recess (pneumatized anterior clinoid process)

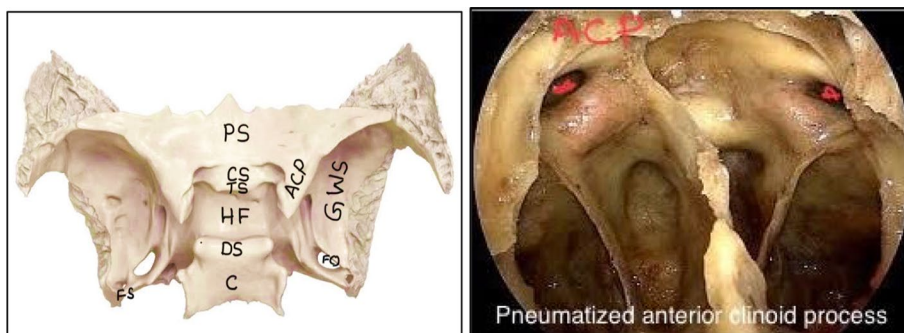
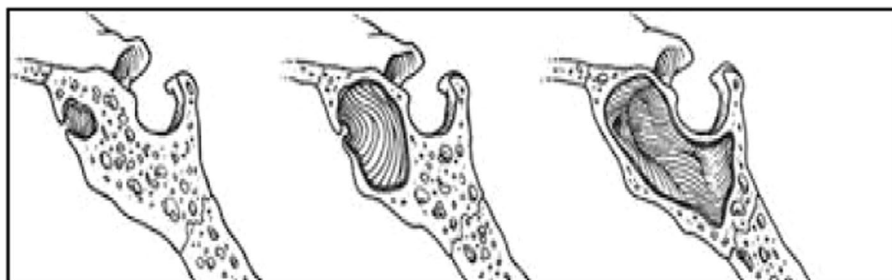


Fig. 2 Shows three types of sphenoid sinus pneumatization (Conchal, Presellar and sellar)



pterygoid plate. It is located posterior to maxilla and forms the posterior boundary of pterygomaxillary fossa (Fig. 2). The pneumatization causes the bulging of vidian canal which runs in floor sphenoid sinus. This pneumatization increases risk of damage to neurovascular structure runs in this canal and residual disease.

Anterior Clinoid Process

The anterior clinoid process (ACP) is located on medial part of posterior border of lesser wing of sphenoid process (Figs. 2, 3). The optic nerve, internal carotid artery, and ophthalmic artery lie in close relation with anterior clinoid process. The pneumatization of anterior clinoid process causes depression in between the optic nerve and inter carotid artery known as lateral optico-carotid recess (Fig. 3). This pneumatization causes bulging of this neurovascular structures into sphenoid sinus cavity with

increase risk of injury during endoscopic sinus and skull base surgery.

Pneumatization of Adjacent Structures

The structures around the sinus are very close particularly when sinus is well or hyper pneumatized. Sometimes, pneumatization of the sphenoid can involve in all its parts, like the greater and lesser wings, the pterygoid plates, basiocciput, and the anterior clinoid process [3]. In hyper or well pneumatized sphenoid sinus, the surrounding vessels and nerves are seen in the sinus cavity as irregularities or ridges (Fig. 1) [9, 10]. When sphenoid sinus pneumatizes the anterior clinoid processes, it can encroach the optic nerve and termed as optico carotid recess inside the sinus (Figs. 1b and 3a) [1, 3, 4, 11, 15]. According to literature, the incidence of pneumatization in the anterior clinoid process is between 11% and 29.3% [2]. The pneumatization of the sphenoid to the pterygoid processes is an extension of the sinus between the maxillary nerve and the nerve of the pterygoid canal (Vidian nerve) [6]. It can reach up to the posterior part of the maxillary sinus and it is reported to be present in between 37.5–43.6% of cases [3, 4, 18, 19] (Fig. 4).

Clinical Significance of Sphenoid Sinus and Its Adjacent Structures Pneumatization

The sphenoid sinuses are irregular cavities, with variability of pneumatization ranging from no pneumatization to extensive. The Pneumatization of sphenoid sinus may also extends into the, adjacent structures like anterior clinoid processes, the greater wings, the pterygoid process. According to the extent of sinus pneumatization and its adjacent structures the bone covering the carotid arteries, optic nerves, maxillary nerves, and vidian nerves can be thin or even absent, making these structures susceptible to iatrogenic injury during endoscopic skull base surgery. The sellar or post sellar type of sphenoid sinus leave a thin bone around. The presence of pneumatization of adjacent structures, like a pneumatized

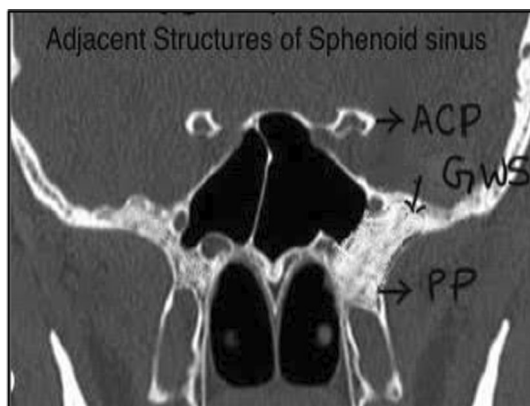
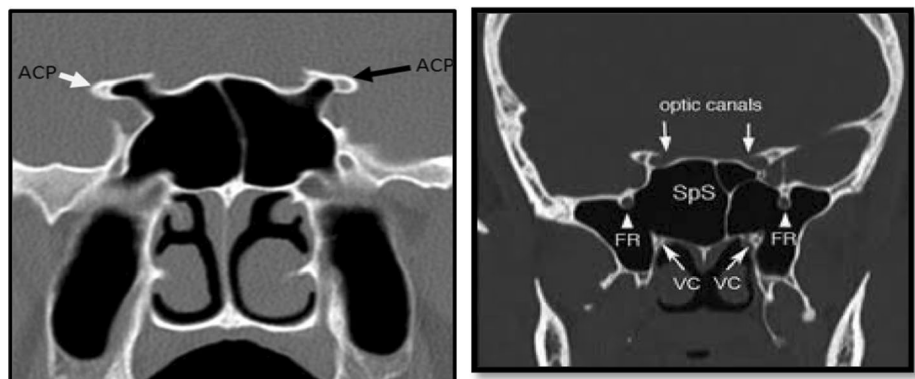


Fig. 3 CT coronal section showing adjacent structures of sphenoid sinus, **A** greater wing of sphenoid (GWS), **B** pterygoid process (PP), **C** anterior clinoid process (ACP)

Fig. 4 CT coronal section showing pneumatization of adjacent structures, **A** anterior clinoid process pneumatization, **B** showing Pterygoid process and greater wing of sphenoid sinus pneumatization



greater wing of sphenoid increase the risk of intraoperative complication like trauma to floor of middle cranial fossa with CSF rhinorrhoea, trauma to maxillary nerve it passes in ceiling and residual diseases because it is beyond the lateral boundary of sphenoid sinus and special attention might be required. A pneumatized Pterygoid process increases trauma to Vidian artery and nerve and residual diseases. A pneumatized anterior clinoid process makes a deep lateral optico-carotid recess with bulging of either optic nerve or internal carotid artery or both. The severity of pneumatized anterior clinoid process exposes these neurovascular structures to damage during sphenoid sinus surgery and residual diseases.

The widespread use of the endoscope in anterior and middle skull base surgery like transsphenoidal pituitary surgery, CSF rhinorrhoea surgery, optic nerve decompression and extension of the endoscopic skull base approach beyond the tuberculum sellae and planum sphenoidale for the management of lesions located in the suprasellar area. The injury to the internal carotid artery or optic nerve is a serious complication of transsphenoidal skull base surgery (Fig. 5).

Classification of endonasal approach for middle skull base

Sagittal plane	Coronal plane
Trans-planum	Transsellar
Transsellar	Trans-cavernous approach
Trans clival	Trans-pterygoid approach

Computerized tomography is the most precise imaging technique to demonstrate paranasal uses and sphenoid sinus. CT scan of sphenoid sinuses has the advantages of showing bony details (using wide window settings) and good soft tissue outlines (using narrow window setting). The Axial section is useful for delineating the anatomical landmarks of the sphenoid sinus, mid sagittal section is

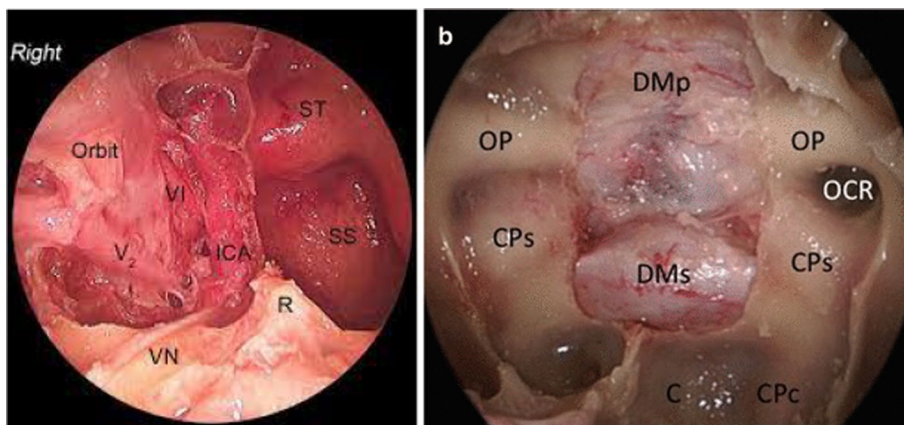
useful in delineating types of sphenoid sinus pneumatization and coronal CT scan provides most of the information i.e., pneumatization of anterior clinoid process, greater wing of sphenoid and pterygoid process, shape of sphenoid sinus cavity. CT scan provides information required for an endoscopic clearance of disease.

The complex anatomy, important surgical relationships of the sphenoid sinus with important neurovascular structures, recurrence of disease, residual disease and injury to neurovascular structures needs pre operative comprehensive knowledge of the variable pneumatization of the sphenoid sinus and adjacent structures. This knowledge will undoubtedly reduce the surgical complications associated with transsphenoidal and functional endoscopic sinus surgery. The aims of the study were to demonstrate the prevalence, clinical significance, and interrelationship of the anatomic variations of pneumatization of sphenoid sinus and adjacent structures.

Materials and Methods

This prospective study comprised of 114 paranasal computerized tomography scans of patients who presented with symptoms nasal, paranasal sinus disease, skull base disease and maxillofacial trauma. The CT scans of patient with carcinoma, erosion of bone by tumour, fracture at the level of sphenoid sinus, and apneumatized sphenoid sinus were excluded from study. For this tomographic study, the sphenoid sinus computerized tomography was performed in Axial scan, coronal scans and mid sagittal on all the patients. The types of sphenoid sinus pneumatization were determined on mid sagittal section and axial section and pneumatization of adjacent structures were determined on coronal section. In this study, the sphenoid

Fig. 5 Shows surgical approach to middle skull base trans cavernous approach, trans sellar approach



sinus pneumatization has been classified into conchal, Pre sellar and Sellar type. The sellar type included both sellar and post sellar types of pneumatization.

Measurement of Pneumatization of Sphenoid Sinus

A. Conchal (Foetal) type—The conchal type or the foetal-type represents a small sinus, separated from the sella turcica by about 10 mm of trabecular bone. The posterior sinus border is 10 mm anterior to the sella turcica in Mid sagittal plane.

B. Presellar (Juvenile) type—The Presellar type or juvenile type is pneumatized to the level of the sella turcica. Posterior sinus border is situated to the level of sella turcica in mid sagittal plane.

C. Sellar (Post-sellar or adult) type sinus—The sellar type or adult type is pneumatization of the sphenoid below the sella or further posteriorly. The posterior sinus border is situated posterior to the sella turcica mid sagittal plane up to clivus (Fig. 6).

Measurement of Pneumatization of Adjacent Structures

To obtain proper evaluation of the pneumatization of adjacent structures, 2-mm contiguous slice thickness CT scan of sphenoid sinus was performed in coronal and axial planes. The existence of the following variants was investigated; pneumatization of pterygoid process (PP), anterior

clinoid process (ACP), and greater wing of sphenoid (GWS), i.e., floor of middle cranial fossa either unilateral or bilateral is noted. For comparison of right and left side, the anterior clinoid process, greater wing of sphenoid and pterygoid process of both sides were considered as separate entities in Table 2 for analysis purpose.

Anterior clinoid process pneumatisation—The presence of lateral optico-carotid recess indicates presence of pneumatized anterior clinoid process, deeper the LOCR denotes the greater pneumatization of anterior clinoid process.

Pterygoid process pneumatization—Pterygoid process pneumatization is recognized if it extends beyond a horizontal plane crossing the vidian canal.

Greater wing of sphenoid pneumatisation—The pneumatization of greater wing of sphenoid is defined as extension beyond a vertical line crossing foramen rotundum (Fig. 7).

The data were collected and analysed statistically by using Chi-square test and contingency coefficient C. Statistical analysis used Chi-square test to evaluate the association between the anatomic variants (p-values less than 0.01 were accepted statistically significant), and contingency coefficient C to assess the degree of association between the two variables.

Fig. 6 Shows methods of measurements of different types of pneumatization of sphenoid sinus

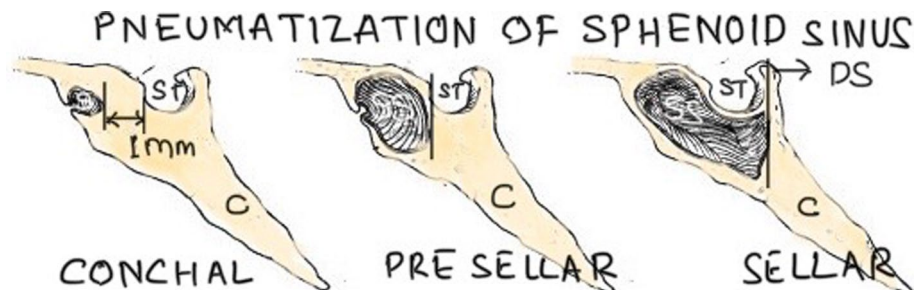


Fig. 7 A Shows CT scan coronal view showing pneumatized anterior clinoid process, B CT scan coronal view showing the boundaries of greater wing sphenoid and pterygoid process pneumatization. GSW Greater wing of sphenoid, ON Optic nerve, FR Foramen rotundum, VC Vidian canal, C internal carotid artery, SS Sphenoid sinus

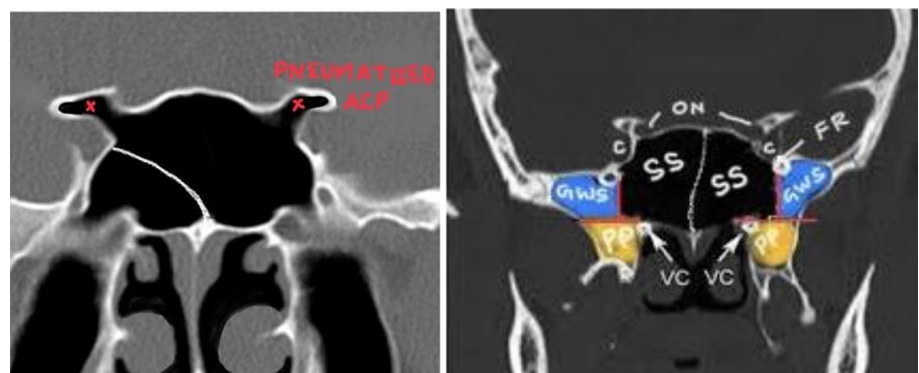


Table 1 Shows the types of pneumatization of sphenoid sinus on CT scan on mid sagittal section

Type of sinus	M	F	Total
Conchal	06	00	06 (5.2%)
Presellar	11	19	30 (26.3)
Sellar/post sellar	47	31	78 (68.4%)
Total	64	50	114 (100%)

Observation

This study comprised of CT scan of 114 adult patients, 57.7% male and 43.3% female, who have pneumatized sphenoid sinus. The CT scan with apneumatized sphenoid sinus were excluded from study.

Type of Sphenoid Sinus Pneumatization

Out of 114 pneumatized sphenoid sinuses, 5.2% were Conchal type, 26.3% Presellar and 68.4% were Seller type. The seller type of pneumatization of sphenoid sinus included both sellar and post sellar and was commonest (Table 1). These findings were noted on mid sagittal section (Fig. 8).

Pneumatization of Adjacent Structures

The Structures which are closed to body of sphenoid bone can be pneumatized are anterior clinoid process, pterygoid process and greater wing of sphenoid. The pneumatization of adjacent structures was present in 62.2% of cases and absent 37.8% of cases (Table 2). It was unilateral in 29 (25.4%) cases and bilateral in 42 (36.8%) cases (Table 3).

Table 2 Shows prevalence of pneumatization of adjacent structures of sphenoid sinus

	Adjacent structures pneu- matized	No Adjacent structure pneu- matized	Total
Number of cases	71 (62.2%)	43 (37.8%)	114 (100%)

Table 3 Shows prevalence of unilateral and bilateral pneumatization of adjacent structures

	Unilateral	Bilateral	Total
Anterior clinoid process	13 (11.4%)	17 (14.9%)	30/114 (26.3%)
Pterygoid process	11 (9.6%)	16 (14%)	27/114 (23.6%)
Greater wing of sphenoid	05 (4.4%)	09 (7.9%)	14/114 (12.3%)
Total	29 (25.4%)	42 (36.8%)	71/114 (62.2%)

Pneumatization of the Greater Wing of Sphenoid Bone

The Greater wing of sphenoid pneumatization was found in 14 (12.3%) cases, no cases in conchal types, 2 (1.8%) in pre-sellar type, and 12 (10.4%) in sellar type (Table 4). The greater wing was pneumatized unilaterally In 5 (4.4%) cases and bilaterally in 9 (7.9%) of cases (Table 3). No significant difference was found in between left and right sides (Fig. 7a).

Pneumatization of Pterygoid Process

The pterygoid process pneumatization was found in 27 (23.6%) cases, no cases in conchal type of sphenoid sinus, 5 (4.4%) cases in Pre sellar type, and 22 (19.2%) cases in sellar type (Table 4). The pterygoid process was pneumatized on both sides in 16 (14%) cases and one side in 11 (9.6%) cases (Table 3). No significant difference was found between both sides (Fig. 7b).

Fig. 8 Showing the types of pneumatization of sphenoid sinus on CT scan on mid sagittal section

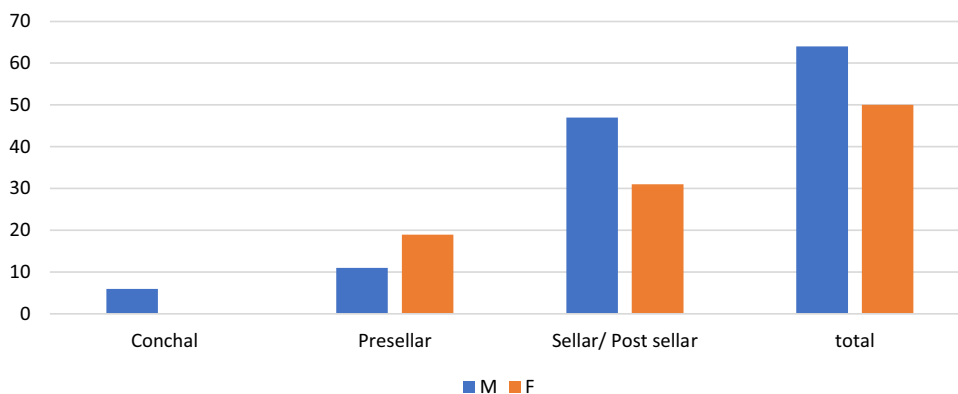


Table 4 Shows prevalence of pneumatization of adjacent structures in different types of sphenoid sinus

	Conchal	Presellar	Sellar	Total
Anterior clinoid process	00	3 (2.6%)	27 (23.5%)	30 (26.3%)
Pterygoid process	00	5 (4.4%)	22 (19.2%)	27 (23.6%)
Greater wing of sphenoid	00	2 (1.8%)	12 (10.4%)	14 (12.3%)
Total	00	10 (8.7%)	61 (53.5%)	71 (62.2%)/114

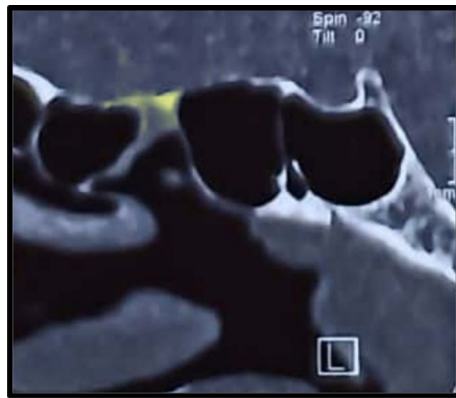


Fig. 9 CT scan midsagittal section shows Sellar type of pneumatization of Sphenoid sinus

Pneumatization of Anterior Clinoid Process

The anterior clinoid process pneumatization was present in 30 (26.3%) of cases, in which no cases in conchal type, 3 (2.6%) cases in pre-sellar type and 27 (23.5%) of cases in sellar type (Table 4). The anterior clinoid process was pneumatized in 13 (11.4%) cases on one side and in (17 (14.9%) cases on both sides (Table 3). No significant difference was found between right and left side (Fig. 9) (Tables 5, 6).

For comparison of right and left sides the adjacent structures were counted as separate entity. Out of 228 adjacent structures, 47 (20.6%) anterior clinoid process, 42 (18.8%) pterygoid process and 23 (10%) greater wings of sphenoid sinus were pneumatized (Table 7). No statistically significant difference found (Fig. 10).

Table 5 Show comparison of prevalence of pneumatization of adjacent structures on both sides

	Right side	Left side	Total
Pneumatized adjacent structures	57	56	113 (49.6%)
Non-pneumatized adjacent structures	57	58	115 (50.4%)

Discussion

Type of Sphenoid Sinus Pneumatization

The incidence of the sellar type of pneumatization in literature is found in 53–89% of cases, the presellar type in 10–38% and the conchal type in 0–9%. In our study, the sellar type of sphenoid sinus was found in 68.4% of the

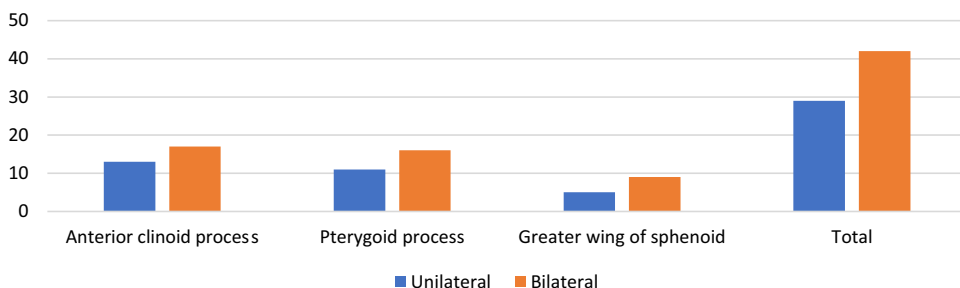
Table 6 Shows the prevalence of pneumatization of adjacent structures in different types of sphenoid sinus (Both sides counted as different unit)

	Conchal type		Pre sellar type		Sellar type		Total
	Right	Left	Right	Left	Rt	Lt	
Non pneumatized adjacent structures	06	06	21	20	30	32	115 (50.4%)
Pneumatized adjacent structures	00	00	09	10	48	46	113 (49.6%)
Total number of adjacent structures	06	06	30	30	78	78	228 (100%)

Table 7 Shows prevalence of pneumatization of adjacent structures on both sides in different type of sphenoid sinus (Both sided were counted as different unit)

	Conchal type		Pre sellar type		Sellar type		Total
	Right	Left	Right	Left	Rt	Lt	
Anterior clinoid process	00	00	2	3	23	19	47 (20.6%)
Pterygoid process	00	00	5	5	17	16	43 (18.8%)
Greater wing of sphenoid	00	00	2	2	08	11	23 (10%)
Total	00	00	09	10	48	46	113/228

Fig. 10 Shows prevalence of unilateral and bilateral pneumatization of adjacent structures



cases. This is similar to Lupascu et al. [14] who reported sellar type in 69% of cases but above Hamid et al. [6] who reported sellar type in 55% of cases and Nathan et al. [16] in 54% of cases. Our findings are much lower than various studies like Hammer et al. [7] (86%), Kayalioglu et al. [12] (89%), El Kammash et al. [5] (85.7%), Idawu et al. [10] (83%), and Dal Secchi et al. [4] (98%). The pre sellar type of pneumatization of sphenoid sinus was found in 26.3% and the conchal type in 5.2% of the cases. In his study, Lupascu et al. [14] found that pre sellar type of sphenoid sinus in 28% and conchal type in 3% of cases which is similar to our study. El Kammash et al. [5], Kayalioglu et al. [12] and Dal Secchi et al. [4] findings are different and on lower side as compared to our study. These variations may be due ethnic variations (Fig. 11).

Pneumatization of Adjacent Structures

Patients with pneumatization of pterygoid processes, anterior clinoid processes and greater wing of sphenoid has a significantly higher volume than unaffected subjects. If pneumatization of sphenoid sinus extends to the pterygoid processes, the sinus is observed to extend between two nerves, maxillary nerve and the nerve of the pterygoid canal (vidian nerve) [2]. A pneumatized pterygoid process might accumulate purulent exudate and result in chronic sinusitis [17].

We found that pterygoid process was pneumatized in 23.9% of cases. The 18.8% of pterygoid process were found to be pneumatized if the pterygoid process was

taken as different entity. This difference is because of some cases have unilateral pneumatized pterygoid process. In literature, a wide range of pneumatize pterygoid process was reported. Bolger et al. [2] identified pterygoid process pneumatization in 43.6% of cases. Lupascu et al. [14] reported pneumatize pterygoid process in 33%, Kazkayasi et al. [11] in 39.7% of cases, Kajoak et al. [13] in 40.3% cases, Hewaidi and Omami [8] in 29% of cases, Siricki et al. [17] in 29.3% of cases Turkdogan et al. [19] in 36.75% of cases which is higher. This wide range of prevalence may be attributed to the use of different criteria. It is noteworthy that review of CT scan images for the presence of pterygoid process pneumatization is much more sensitive than cadaveric dissection. The pterygoid process was commonly pneumatized in 19.2% of cases in sellar type of sphenoid sinus, followed by presellar in 4.4% of cases and no pneumatized pterygoid process was found in conchal type sphenoid sinus (Figs. 12, 13).

If anterior clinoid process get pneumatized, the lateral optic carotid recess observed on lateral wall of sphenoid sinus. In our study, the anterior clinoid process was most frequent pneumatized adjacent structure found in 20.6% of anterior clinoid process and in 26.3% of cases. This difference is due to unilateral pneumatization was found in some cases. These results are higher than Lupascu et al. [14] (10%), and Kazkayasi et al. [11] Kajoak et al. [13] (13.9%), Bolger et al. [2] (13%), Hewaidi and Omami [8] (15.3%), Torkdogan (21.25%) and Kazkayasi et al. [11] (17.2%) of the patients. Our results were similar to Siricki et al. [17] (29.3%), Birsen et al. (24.1%) Obviously, the reported

Fig. 11 Shows prevalence of pneumatization of adjacent structures in different types of sphenoid sinus

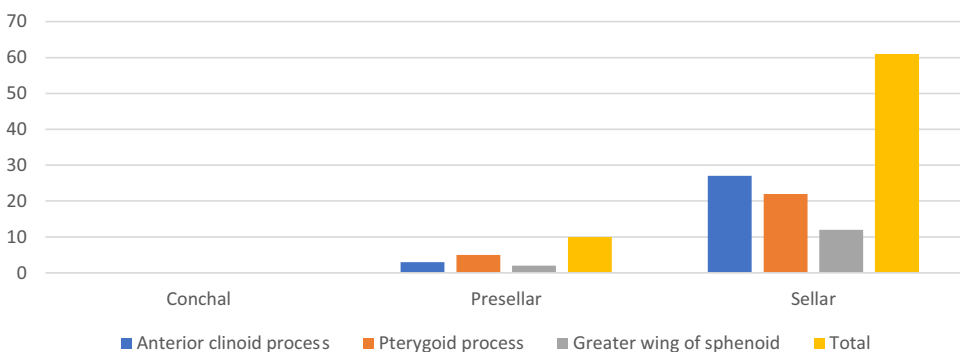


Fig. 12 A Shows pneumatization of adjacent structures greater wing of sphenoid, B coronal CT scan showing pneumatized pterygoid process

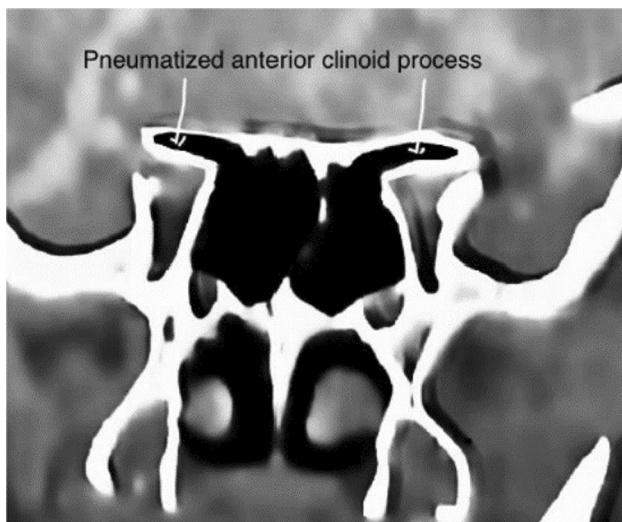
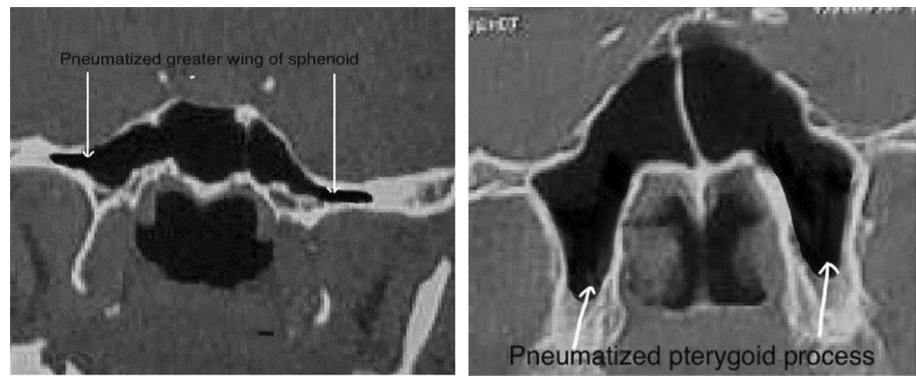


Fig. 13 Coronal CT scan showing pneumatized anterior clinoid process

prevalence rates vary considerably. This may reflect differences among the studied populations. however, it is more likely that thin CT scan sections are substantially more precise. Thus, the previous reports of prevalence of anterior clinoid process pneumatization based on thick-cut CT scan review may underestimate the prevalence of this anatomic variant. The varied amounts of pneumatized ACP might be related to ethnic background. In sellar type sphenoid sinus

the anterior clinoid process was pneumatized in 23.5% of cases, and rest 2.8% cases in sellar type, no pneumatized anterior clinoid process was found in conchal type of sphenoid sinus. The pneumatize anterior clinoid process contributed to the varied position and relation of ON to the sphenoid sinus thereby increasing their vulnerability to iatrogenic injury (Figs. 14, 15).

Pneumatization of the greater wings of sphenoid sinus increases the risk of inadvertent penetration into the middle cranial fossa and cerebrospinal fluid (CSF) leakage and injury to maxillary nerve. Pneumatization of greater wing of sphenoid, i.e. floor of middle cranial fossa, is inadequately reviewed in the literature. According to literature, the pneumatization of greater wings varies between 0 and 20% [8, 11, 14], and between 30 and 50% [8, 11, 13, 17], respectively. According to our study, the greater wing of sphenoid was pneumatize in 10% of cases which is similar to Lupascu et al. [14] (8%) while lower as compared to Kajoak et al. [13] (34.8%), Hewaidi and Omami [8] (20%), Dal Secchi et al. [4] (47%),.

We found pneumatization in 49.6% and no pneumatization in 50.4% of adjacent structures. The prevalence of pneumatization of one or more adjacent structure is almost 50% of cases. These anatomical abnormalities were commonly found in sellar type of sphenoid sinus which is most common type of sphenoid sinus pneumatization. These are important anatomical abnormalities to be ruled out pre operatively to

Fig. 14 Showing prevalence of pneumatization of adjacent structures of both sides

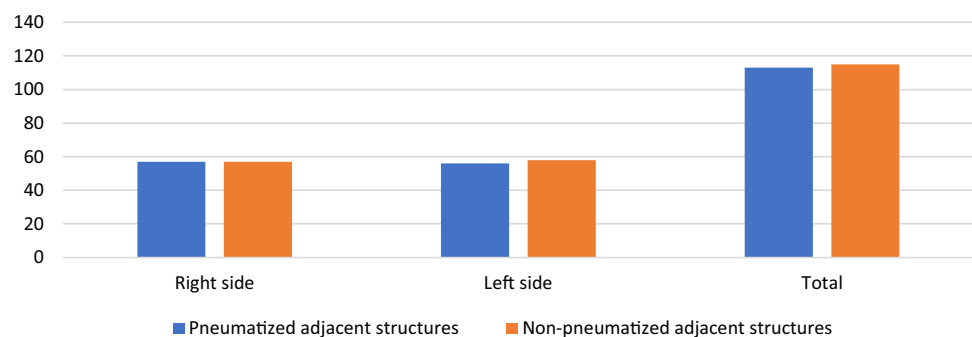
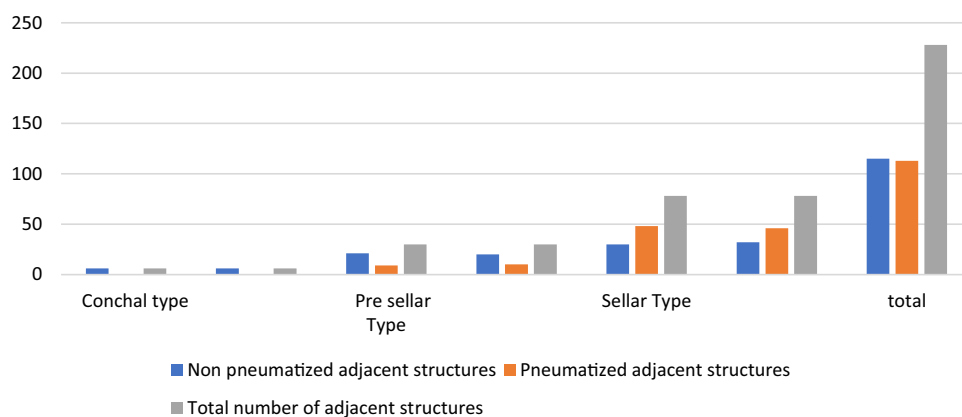


Fig. 15 Shows the prevalence of pneumatization of adjacent structures in different types of sphenoid sinus (Both sides counted as different unit)



avoid injury to important structures during surgery and also complete clearance of disease is required if involved.

Conclusions

The anatomical variations of the pneumatization of sphenoid sinus and its adjacent structures are common. The Protrusion of the internal carotid artery and/or optic nerve was strongly associated with ipsilateral or bilateral pneumatization of the anterior clinoid process. The prevalence of Protrusion and dehiscence of the internal carotid artery and optic nerve were high. The internal carotid artery and optic nerve may not be well protected and thus could be damaged during endoscopic sphenoid or skull base surgery. Protrusion and dehiscence of the maxillary nerve were present if greater wing was pneumatized. Protrusion of the Vidian canal into the sinus cavity was strongly associated with pneumatization of the pterygoid process, on the same side. Coronal CT screening should be used in the pre-surgical evaluation of patients under consideration of endoscopic sphenoid sinus surgery and skull base surgery to rule out these anatomical variations to minimize perioperative neural and vascular injury.

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Declarations

Conflict of interest There is no conflict of interest.

Human and Animal Rights This research does not involve human or animals.

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