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Original Research Article

Variation of Sphenoid Sinus Pneumatization on CT scan in A Sample of Iraqi Patients

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Abstract: ***Background:*** Computerized tomography scan can show the detailed anatomy of the nose and paranasal sinuses. The sphenoid sinus is a very important corridor for the skull base because of its central position. This sinus has a great range of variation and can put structures around at risk during surgery. This study aims to examine the variation of the sphenoid sinus, and its relation to other structures around it, in this sample of Iraqi patients. ***Materials and Methods:*** CT scans of 122 patients, were obtained, and submitted for examination and measurements, during the period between September 2020 and September 2021. Observation of The sphenoid sinus pneumatization pattern, clival extension, Onodi cell, and lateral pneumatization of SS. As well as the SS measurements including the suprasellar depth, presellar depth, subsellar depth and sinus height. Exclusion was made for those with a previous history of sinus surgery and patients with tumours, sinonasal trauma or sinus fungal infection. ***Results:*** This study involved CT scans of 122 patients. The postsellar type of pneumatization was seen in 47.6%, sellar type 35.2% and presellar type 17.2%, while we did not see conchal type in this sample. Onodi cell was seen in 27.9%. The optic nerve, maxillary nerve, vidian nerve, and Carotid artery were protruding into the sinus in (35.2%), (14.8%), (46.8%) and (40.2%) respectively. We noticed that the full lateral type of lateral pneumatization is significantly associated with both vidian nerve protrusion and maxillary nerve protrusion; while right and left optic nerve protrusions were significantly associated with the corresponding side lesser wing type of lateral pneumatization, P - Value 0.001. ***Conclusion:*** Pneumatization of the sphenoid sinus has a great degree of variation in the population. Each patient has a different pneumatization pattern.

Keywords: Sphenoid sinus, variation, pneumatization, anatomy, CT scan.

INTRODUCTION

The high resolution computed tomography (HRCT) scan of the paranasal sinuses (PNS) provides an accurate and exact preoperative plan for the endoscopic sinus surgeon. Computed tomography (CT) scanning is currently the gold standard for evaluating the paranasal sinuses. It offers a structured image of the region anatomy, as well as anatomical variances, and thereby improves the surgical outcome in this area [1].

In skull base surgery, the sphenoid bone is extremely important. It enables the surgeons to safely reach the sella turcica, and surrounding areas for various skull base diseases and cerebrospinal fluid (CSF) leaks. In contrast to rhinosinusitis, which needs minimal involvement of the intersinus septation and skull base, skull base surgery frequently necessitates the removal of bone from the sphenoid sinus in order to access the skull base. The degree of pneumatization varies greatly, posing a risk to nearby structures such as the ophthalmic, vidian, maxillary, and internal carotid arteries. Moreover, damage to the sphenoid sinus's lateral, superior, or posterior walls could result in an unintentional CSF leak [2].

Therefore, this study aimed to detect variations in the sphenoid sinus in this sample of Iraqi patients. In this sample, the objectives are to detect the variations of the sphenoid sinus pneumatization pattern, clival extension, Onodi cell, as well as protrusion of vital

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structures around the sphenoid sinus, lateral pneumatization of these sinuses, and measurements of the dimensions of sphenoid sinuses.

MATERIALS AND METHODS

This was a cross sectional study conducted at Outpatient Clinic of ENT Unit in Al-Shaheed Ghazi Al-Hariri for Specialized Surgeries Teaching Hospital during a period of one year from September 2020 to September 2021.

Our patients had CT discs made in Martyr AlSadr general hospital by Tushiba 128-slice CT machine. The axial plane images were used to reconstruct the sagittal and coronal planes. All patient were examined in supine position.

Study patients and sample size

This study included CT scans from 122 patients who had already undergone a CT scan of their nose and paranasal sinuses for any cause and were examined and measured using the RadiAnt DICOM Viewer 2020.2 program software for Windows. Any CT that can show a clear outline of the sinus walls, even if it contains sinusitis or polyps, was included.

Exclusion Criteria

Previous history of sinus surgery, tumors, sinonasal trauma, sinus fungal infection and severe nasal polyposis or diseases that make it difficult to recognize the outlines.

These were excluded because they cause or may cause bone destruction that may make it difficult to delineate the anatomical landmark.

Observed Parameters

Sphenoid sinus pneumatization pattern

The sphenoid sinus was observed in the midsagittal section, for pneumatization pattern. If the distance between the posterior wall of the sinus and the anterior sellar wall was equal to or greater than 1 cm, the sphenoid sinus was classified as conchal. While it was regarded as presellar if, the posterior sinus wall was less than 1 cm anterior to the anterior sellar wall (Fig 1). On the other hand, it was regarded as sellar if the posterior sinus wall lay between the anterior and posterior sellar walls (Fig 2) and postsellar if the posterior sinus wall was posterior to the posterior sellar wall (Fig 3).

Clival extension

Classified as:

- Subdorsal: The pneumatization lies between the inferior margin of the sella and the level of the vidian canal (Fig 4).
- Dorsal: The pneumatization extends posteriorly above the level of the inferior margin of the sella into the dorsum sella (Fig 3).
- Occipital: The pneumatization extends below the level of the vidian canal posterior to the posterior sellar wall.
- Combined: Both dorsal and occipital.

Onodi cell

All CTs examined for Onodi cells and recorded as right left or bilateral.

Vital structures around the SS

The optic nerve (ON), maxillary nerve (MN), vidian nerve (VN), and carotid artery (CA) were all examined for protrusion or dehiscence.

Lateral pneumatization of SS

The lateral extension of SS pneumatization was examined and categorized using a line tangent to the medial edges of the maxillary and vidian nerves and a line that is tangent to the inferior margin of the vidian nerves as follows:

1. **Greater wing** of sphenoid pneumatization goes laterally beyond the maxillary nerve.
2. **Pterygoid process** pneumatization goes below the level of the inferior margin of the vidian nerves.
3. **Full lateral** pneumatization occurs when both the pterygoid and the greater wing are pneumatized.
4. **Lesser wing:** Anterior clinoid process pneumatization

The dimensions of the sphenoid sinus were taken using the length-measuring tool in RadiAnt DICOM Viewer version 2020.2.3 (64-bit). The measures were made for the maximum sphenoid sinus width in the axial view as well as the presellar width of the sphenoid sinus.

In the sagittal view, we measured the suprasellar depth, which is the depth in the highest part of the sinus, and the presellar depth, which is measured from the midpoint of the face of the Sella in this plan. While the maximum subsellar depth corresponds to the most posterior part of the infrasellar sphenoid sinus, the sinus height corresponds to the highest part of the seller face. These measures were applied even if an Onodi cell was present. If the midsagittal plan came exactly with a sinus septum, the immediate para sagittal plan was taken.

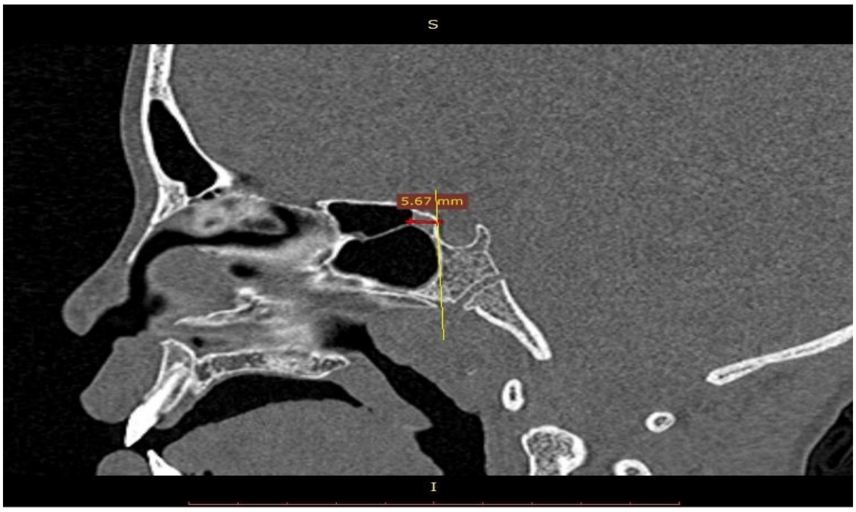

Figure 1: Presellar sphenoid sinus pneumatization example

Figure 2: Sellar sphenoid sinus pneumatization example. Sinus extends posterior to the ant sellar wall (yellow line) but not posterior to the posterior sellar wall (red line)

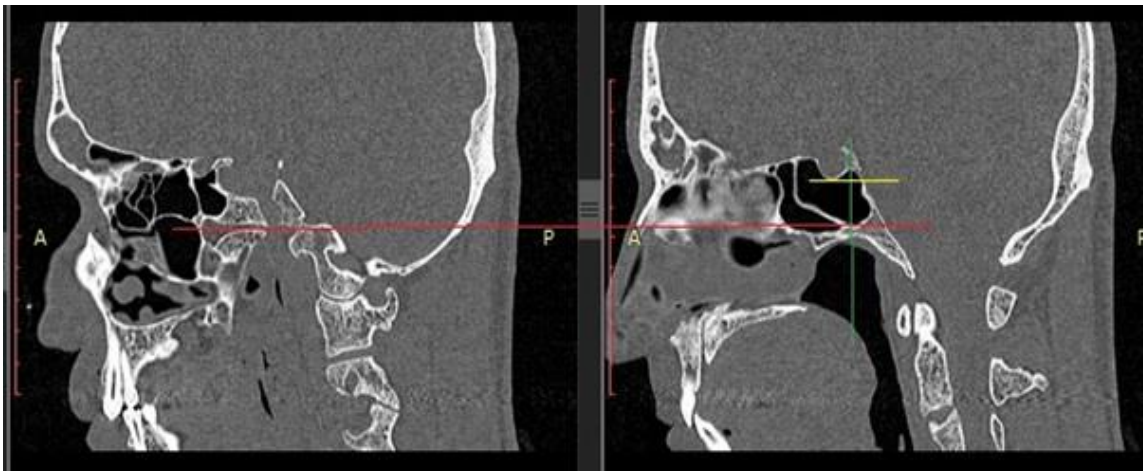

Figure 3: Postsellar SS with dorsal clival pneumatization with vidian canal level shown in the left and the level extended to the right (red line) the level of post. Sellar wall shown (green line) the inferior margin of sella (yellow line)

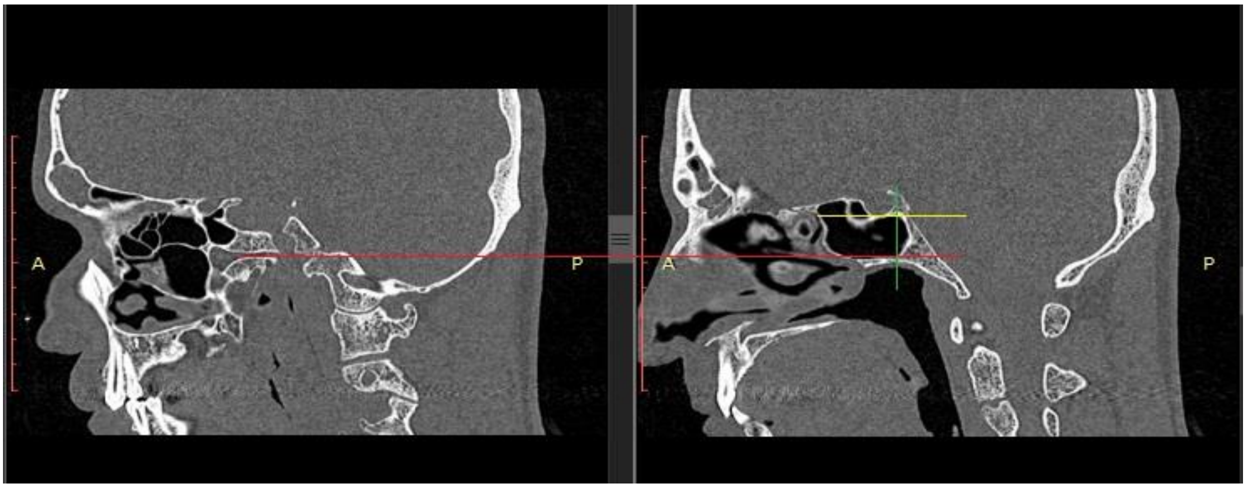

Figure 4: Postsellar subdorsal clival pneumatization

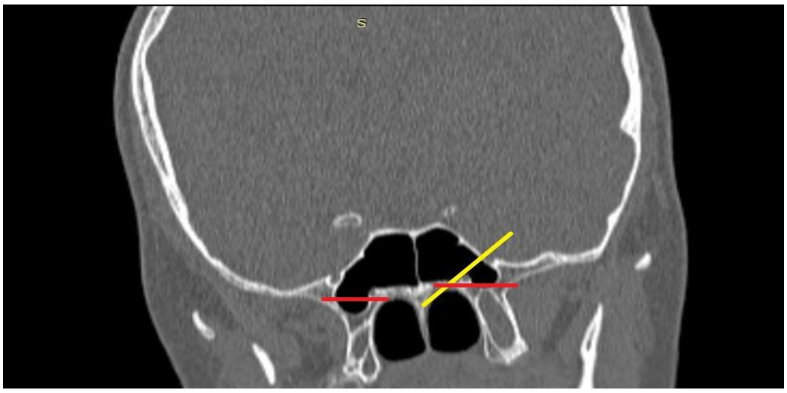

Figure 5: Greater wing and Full lateral pneumatization. on LT side, the greater wing pneumatization extends beyond the line tangent to the medial margin of the maxillary and vidian nerve (yellow line) but not beyond the level of inferior margin of vidian nerve (red line); RT Full lateral pneumatization notice that the RT side pneumatization extends below the red line (Pterygoid process) together with the greater wing pneumatization

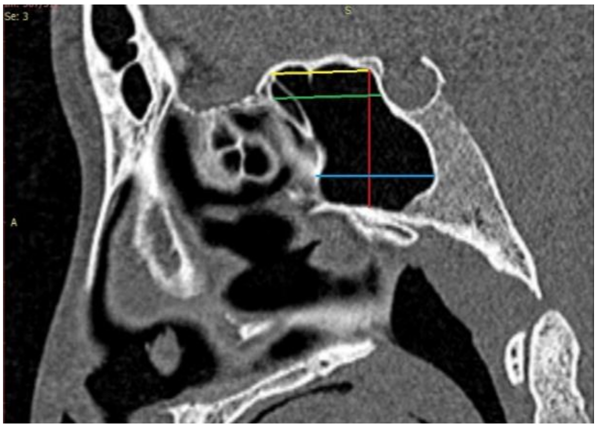

Figure 6: The four sagittal measurements; suprasellar (yellow line), presellar (green line), subsellar (blue line) and sinus height (red line)

Statistical analysis

The data analysed using Statistical Package for Social Sciences (SPSS) version 26. The data presented as mean, standard deviation and ranges. Categorical data presented by frequencies and percentages. Chi square test was used to assess the association between categorical variables, while fisher exact test was used instead when the expected frequency was less than 5. A level of P – value less than 0.05 was considered significant.

RESULTS

In this study, 85 (69.1%) males, 38 (30.9%) females. Age ranged between 20 and 62 years old, mean age was 40.3 years and standard deviation (SD) of ± 7.2 years.

For the pneumatization pattern of the sphenoid sinus, the postsellar type was seen in 58 (47.6%) patients, followed by the sellar type 43 (35.2%). The least type seen was the presellar type 21 (17.2%). We did not see the conchal type in the current sample (Table 1).

Of the postsellar type, 28/59 were dorsal type, 30/59 were subdorsal. We did not see the other types in this study. The dorsal clival pneumatization is noticed in either a bilateral pattern or unilateral pattern. Thirteen of 29 were bilateral, whereas 15/28 were unilateral; nine were left-sided pneumatization of the dorsal sella and six were right-sided (Table 2).

Onodi cell was seen in 34 (27.9%) of the patients. Of those fifteen were bilateral, 13 on the right and six on left (Table 3).

The vital structures around the sphenoid sinus were examined for protrusion in the sphenoid sinus. The optic nerve was protruding in 43 (35.2%), divided into bilateral 22 (18%) and unilateral found as RT 9 (7.4%) and LT 12 (9.8%).

Maxillary nerve protrusion was seen in 18 (14.8%) patients. 12 (9.8%) bilateral and 3 (2.5%) for each of the RT and LT, while it was absent in 104 (85.2%).

Vidian nerve protrusion was seen more frequently than the other vital structures. It was noted that 57 (46.8%) patients, 54 (44.3%) bilateral and 3 (2.5%) on the left side.

Carotid protrusion is found in 49 (40.2%) of the cases, with 30 (24.6%) being bilateral, 6 (4.9%) being on RT, and 13 (10.7%) being on the left only (Table 4).

The lateral pneumatization of the sinus is shown in (Table 5) for the right and left sides.

The most common pattern seen was the greater wing pneumatization. While the pterygoid pneumatization was seen only in the full lateral pattern.

The dimensions of the sphenoid sinus were measured as mentioned in the patens and methods section. The mean maximum width of the sphenoid sinus in this sample was 3.81 cm, ranging from 2.52 cm to 5.98 cm. The mean of maximum presellar width was 1.47 cm, ranging from 0.59 cm to 3.22 cm. On the other hand, the mean suprasellar depth was 1.53 cm, ranging from 0.83 to 2.26 cm. The mean presellar depth was 1.64 cm, ranging from 0.91 to 2.34 cm. The mean subsellar depth was 2.84 cm, ranging from 1.54 to 3.76 cm. The sinus height mean was 2.32, ranging from 1.71 to 2.98 cm (Table 6).

We noticed that full lateral pneumatization significantly associated with vidian nerve protrusion (Table 7 & 8) and maxillary nerve protrusion (Table 9 & 10); while right and left optic nerve protrusions were significantly associated with right and left lesser wing pneumatization (Tables 11 and 12 respectively). We found no association between right greater wing lateral pneumatization and both vidian and maxillary nerves protrusion on the corresponding sides, P – value higher than 0.05.

Table 1: Types of sphenoid sinus pneumatization

Type	No. (n= 122)	Percentage (%)
PRESELLAR	21	17.2
SELLAR	43	35.2
POSTSELLAR	58	47.6
CONCHAL	0	0

Table 2: Types of dorsal clival pneumatization

Type	No. (n= 122)	(%) of postsellar	(%) of total
Dorsal	13	46.4	10.7
RT Dorsal	6	21.4	4.9
LT Dorsal	9	32.2	7.4

Table 3: Incidence of Onodi cell in the sample

Onodi	No. (n= 122)	Percentage (%)
Bilateral	15	12.3
Right	13	10.7
Left	6	4.9
Absent	88	72.1

Table 4: Protrusion of the vital structures into the SS

	Optic Protrusion	(%)	Maxillary Protrusion	(%)	Vidian Protrusion	(%)	Carotid Protrusion	(%)
Bilateral	22	18.0	12	9.8	54	44.3	30	24.6
Right	9	7.4	3	2.5	0	0	6	4.9
Left	12	9.8	3	2.5	3	2.5	13	10.7
Absent	79	64.8	104	85.2	65	53.2	73	59.8

Table 5: incidence of lateral pneumatization of the SS in right and left sides

	Right (n= 122)	(%)	Left (n= 122)	(%)
FULL LATERAL	13	10.7	15	12.3
FULL LATERAL + LESSER WING	6	4.9	10	8.2
GREATER + LESSER WING	8	6.6	14	11.5
GREATER WING	36	29.5	37	30.3
LESSER WING	7	5.7	6	4.9
NONE	52	42.6	40	32.8

Table 6: Mean dimensions of the sphenoid sinus in the sample with minimum and maximum measure recorded

Dimension (cm)	Mean ± SD	Minimum	Maximum
Maximum width of SS	3.81 ± 0.86	2.52	5.98
Presellar maximum width	1.47 ± 0.44	0.59	3.22
Suprasellar depth	1.53 ± 0.37	0.83	2.26
Presellar depth	1.64 ± 0.3	0.91	2.34
Subsellar depth	2.84 ± 0.55	1.54	3.76
Sinus height	2.32 ± 0.31	1.71	2.98

Table 7: Association between right full lateral pneumatization and right vidian nerve protrusion

Right Full lateral Lateral pneumatization	Right vidian nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 54	No (%) n= 68		
Yes	18 (100.0)	0 (0)	18 (14.8)	**0.001**
No	36 (34.6)	68 (65.4)	104 (85.2)	

Table 8: Association between left full lateral pneumatization and left vidian nerve protrusion

Left Full lateral Lateral pneumatization	Left vidian nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 57	No (%) n= 65		
Yes	21 (87.5)	3 (12.5)	24 (19.7)	**0.001**
No	36 (34.6)	62 (65.4)	98 (80.3)	

Table 9: Association between right full lateral (lateral pneumatization) and right maxillary nerve protrusion

Right full lateral Lateral pneumatization	Right maxillary nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 15	No (%) n= 107		
Yes	9 (50.0)	9 (50.0)	18 (14.8)	**0.001**
No	6 (5.8)	98 (94.2)	104 (85.2)	

Table 10: Association between left full lateral (lateral pneumatization) and left maxillary nerve protrusion

Left full lateral Lateral pneumatization	Left maxillary nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 15	No (%) n= 107		
Yes	12 (50.0)	12 (50.0)	24 (19.7)	**0.001**
No	3 (3.1)	95 (96.9)	98 (80.3)	

Table 11: Association between right lesser wing lateral pneumatization and right optic nerve protrusion

Right lesser wing lateral pneumatization	Right optic nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 31	No (%) n= 91		
Yes	18 (85.7)	3 (14.3)	21 (17.2)	**0.001**
No	13 (12.9)	88 (87.1)	101 (82.8)	

Table 12: Association between left lesser wing lateral pneumatization and left optic nerve protrusion

Left lesser wing lateral pneumatization	Left optic nerve protrusion		Total (%) n= 122	P - Value
	Yes (%) n= 34	No (%) n= 88		
Yes	24 (80.0)	6 (20.0)	30 (24.6)	**0.001**
No	10 (10.9)	82 (89.1)	92 (75.4)	

DISCUSSION

A CT scan is a great tool for showing the variable anatomical structures of the nose and paranasal sinuses. This tool is particularly useful in the planning of basic and advanced endoscopic sinus procedures. The sphenoid sinus architecture differs from patient to patient. A small sphenoid sinus is present at birth with progressive enlargement starting at age three during pneumatization of the sphenoid bone [3].

This means that the more is the pneumatization, the more the protrusion of the structures around the sinus. Four pneumatization patterns have been described with reference to the sella turcica. These pneumatization patterns are important for surgical planning of transphenoid approaches to pituitary tumors.

In this study, there was no case of conchal type. This goes with what Hiremath *et al.*, find [4]. We also find presellar type 17.2%, sellar 35.2% and postsellar 47.6%, which is also close to Hiremath *et al.*, but they classified the pneumatization pattern as conchal, presellar and sellar (complete and incomplete) [4]. We used a classification that has four types: conchal, presellar, sellar, and postsellar, because we think it is more precise and the types are more understood nomenclature when sellar and postsellar are used rather than incomplete and complete.

Sareen *et al.*, reported 75% postsellar and 25% sellar, but they had only 20 cases in their study [5].

In their review, Budu *et al.*, discovered that the sellar type of pneumatization occurs in 75–86% of cases, and the presellar type in 10–25%. They also used three types pneumatization pattern [6].

Rahmati *et al.*, find no conchal case, (1.9%) presellar, (14.6%) sellar, and (83.5%) postsellar pneumatization [8]. Rahmati's findings were similar to those of Secchi *et al.*, who discovered 98 percent sellar and barely 2% presellar with no conchal type [8].

In this study, we had 47.5% clival extension. The subdorsal type was slightly more than the dorsal type. This is going with what Hiremath *et al.*, found, but they found a higher percentage [4].

We found Onodi cell in (27.9%) of the patients. This is close to Özdemir *et al.*, when they found Onodi cell prevalence 21.2% of a sample of 508 patients [9], while Senturk et al found Onodi in 52.7% of 618 patients [10], and Abdo *et al.*, found Onodi cell (31.9%) their 210 sample [11]. Dawood found incidence 44.7% of 300 patient made in Iraq [12].

For vital structures protrusion, we had optic nerve protrusion in this sample (35.2%), divided into bilateral 22 (18%) and unilateral found as RT 9 (7.4%) and LT 12 (9.8%). This is close to what Hewaidi and Omami found in the Libyan population [13]. Braggs and Kiran found optic protrusion incidence (26.1%) in their study [14]; while Al-Tameemi and Hassan fond it to be (18.5%) in their study on 100 Iraqi patients [15].

Maxillary nerve protrusion was seen in (14.2%) of patients in our study, while carotid artery protrusion was seen in (35.2%), which are higher in Hewaidi and Omami study, (24.3%) and (41%) respectively [13]. Vidian nerve had the highest protrusion rate in our sample, (46.8%) and it is higher than Hewaidi and Omami study [13]. These structures are more vulnerable for injury during surgery when protruding into the sinus. Therefore, it is wise to read the CT scan carefully emphasizing this aspect.

The most common form of lateral sphenoid sinus pneumatization identified in our sample was greater wing pneumatization, which indicates that there is pneumatization in the floor of the middle cranial fossa, increasing the risk of CSF leak in this area.

In our sample, lateral pneumatization of this sinus was reported in 57.4% on the right and 67.2% on the left. This goes with what Hiremath *et al.*, found in their study (59.7%) of 1000 sinuses, but they found the pterygoid pneumatization more prevalent unlike our study in which we found the greater wing pneumatization the more prevalent [11]. This may show ethnic variation because they took 500 Indian patients.

These measures are going with Wiebracht *et al*., [2] and Zada *et al*., when they reported that the presellar width and maximum width 1.27 cm amd 3.01 cm respectively [16]. On the other hand, Mutlu *et al*., found the maximum width 3.17 cm and the infrasellar (subsellar) depth 2.76 cm [17].

Full lateral pneumatization was shown to be significantly related to vidian nerve and maxillary nerve protrusion (P-value 0.05). This is consistent with the findings of El-Zanfaly *et al*., Rahmati, and Hewaidi & G. M. Omami, who discovered high significant significant connections between pterygoid process pneumatization and Vidian nerve protrusion, as well as a high significant link between greater wing pneumatization and maxillary nerve protrusion (p 0.001). It's important to note that full lateral pneumatization indicates the presence of both pterygoid process and greater wing pneumatization.

Optic nerve protrusions were shown to be related with lesser wing pneumatization in this study. El-Zanfaly *et al*., Rahmati, and G. H. Hewaidi & G. M. Omami all observed a significant link between anterior clinoid process pneumatization and optic nerve protrusion (p 0.001) [7, 13, 18].

Degaga *et al*., on the other hand, find no significant correlation between anterior clinoid process pneumatization and optic nerve protrusion (P- value 0.747) but they found significant relation between Dehiscence of optic nerve and pneumatization of anterior clinoid process (P- value 0.046) [19].

CONCLUSION

- Pneumatization of the sphenoid sinus has varies greatly from person to person. Each patient has a different pneumatization pattern that may lead to different sinus morphology faced by the surgeon in each case operated.
- CT scan is an important and useful tool that can reveal the precise nasal and paranasal sinuses anatomy. It is wise to use it in every nasal operation, especially in trans-nasal endoscopic skull base surgery.
- Vital structures may protrude into the sphenoid sinus and they may be at risk of injury if not recognized.
- In this study, the sample size is insufficient, and does not reflect the appropriate population. We recommend further studies with larger sample, or extension of this study, by adding more patients, to get more relevant results.

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