Original Article

Effect of sphenoid sinus volume and pneumatization type on isolated chronic sphenoid sinusitis (fungi and polyps)

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ABSTRACT

Objectives: In this study, we aimed to investigate the association of sphenoid volume and pneumatization type with pathologies, including unilateral isolated chronic sphenoid sinusitis with polyps (ICSSwP) and isolated fungal chronic sphenoid sinusitis (IFCSS).

Patients and Methods: A total of 26 patients (15 males, 11 females; mean age 49.9±15.0 years; range, 18 to 80 years) with unilateral isolated sphenoid inflammation, pathologically diagnosed as IFCSS (n=14) or ICSSwP (n=12) between January 2010 and December 2018 were included in this study. The sphenoid sinus volumes of the pathological and normal sides of the patients were compared. The sphenoid pneumatization types were also evaluated.

Results: In the IFCSS group, the pathological side volume was statistically significantly higher than the healthy side volume ($p<0.05$). In the ICSSwP group, the pathological side volume was statistically significantly lower than the healthy side volume ($p<0.05$).

Conclusion: Large sphenoid sinus volume is prone to IFCSS, while smaller sphenoid sinus volume is prone to ICSSwP. Therefore, it should be considered that difference in the right and left sphenoid sinus volume may have different etiological or predisposing effects for different pathologies.

Keywords: Computed tomography, endoscopic sinus surgery, isolated sphenoid sinus disease, sphenoid sinus volume.

The sphenoid sinuses (SS) are two pneumatized structures contained in the body of the sphenoid bone.[1] The SS are the most deeply situated paranasal sinuses surrounded by critical structures including the carotid arteries, dura mater, and cranial nerves (II, III, IV, V, and VI).[2] Various anatomical studies have shown a wide variation in sinus size, orientation, pneumatization, and bone thickness.[3] Isolated sphenoid sinus diseases (ISSDs) are relatively uncommon among pansinusitis cases, accounting for about 1 to 2% of all sinus pathologies.[4] Many allergic, infectious, and neoplastic pathologies are causes of ISSDs.[2] Due to its isolated location and difficulty in approaching anatomical features, ISSDs are often overlooked.[4] While the most common symptomatic finding is headache, rhinorrhea, postnasal drip, nasal obstruction, impaired vision, and neurological deficits may also present with inflammatory or neoplastic SS pathologies.[5,6] Physical examination of sphenoid disease is difficult due to its depth in the skull base and one of every three cases shows normal endoscopic examination.[7] Evaluation of anatomical structures with computed

Received: March 02, 2020 **Accepted:** August 28, 2020 **Published online:** September 21, 2020

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Doi: http://dx.doi.org/10.5606/Tr-ENT.2020.51523

Citation:
Başer E, Sarıoğlu O, İdil M, Çukurova İ, Arslan İB. Effect of sphenoid sinus volume and pneumatization type on isolated chronic sphenoid sinusitis (fungi and polyps). Tr-ENT 2020;30(2):58-65.

tomography (CT) is the gold standard in diagnosis.[8] Magnetic resonance imaging (MRI) is also used to evaluate patients with a suspected intracranial pathology.[9]

One meta-analysis on ISSDs indicated causes of sphenoid pathologies as follows: chronic sinusitis without polyps (28.3%), mucocele (20.3%), fungal sinusitis (12.5%), malignant neoplasm (7.7%), intracranial lesions (7.0%), benign neoplasm (5.7%), chronic sinusitis with polyps (3.4%), and other pathologies (4.7%).[2]

Various studies on different populations have classified sphenoid pneumatization types under either three or four categories. Classifications with three categories are classified as conchal, presellar, and sellar.[10,11] Classifications with four categories include conchal, presellar, incomplete sellar, and complete sellar.[12-14] In our study, SS pneumatization was classified as four types.

In our study, we aimed to investigate the association of sphenoid volume and pneumatization type with pathologies, including unilateral ICSSwP and IFCSS. To the best of our knowledge, this is the first study to evaluate the sphenoid volume and pneumatization type in isolated sphenoid inflammation.

PATIENTS AND METHODS

A total of 26 patients (15 males, 11 females; mean age 49.9±15.0 years; range, 18 to 80 years) with unilateral isolated sphenoid inflammation, pathologically diagnosed as IFCSS (n=14) or ICSSwP (n=12) between January 2010 and December 2018 were included in this study. Patients with a history of sinus fracture due to head injury, and previous surgery of nasal and paranasal regions were excluded from the study. The SS volumes of the pathological and normal sides of the patients were compared. The sphenoid pneumatization types were also evaluated. A written informed consent was obtained from each patient. The study protocol was approved by the Izmir Tepecik Training and Research Hospital Ethics Committee (No. 2019/11-6). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Evaluation of SS volume and shape

In the examination of SS shape, the relationship between the anterior and posterior wall of the sella turcica with the posterior wall of the SS was evaluated. The shape of the SS was classified as conchal, presellar, incomplete sellar, and complete sellar, as previously defined[15] as Conchal: SS is a small shape in front of the anterior wall of the sella turcica; Presellar: SS is in front of the sella turcica, but not toward the rear, while the posterior SS wall is located in front of the anterior wall of the sella turcica; Incomplete sellar: the posterior wall of the SS is between the anterior and posterior wall of the sella turcica; Complete sellar: the posterior wall of the SS is located behind the posterior wall of the sella turcica.[16]

All CT scans were performed using a 64-slice CT scanner (Aquilion 64; Toshiba Medical Systems Corp., Tochigi, Japan) with 0.5 mm collimation, 120 kV, and 150 mAs. Coronal, axial, and sagittal reformatted images in 2-mm slice thicknesses were examined in the bone window.

For volumetric measurements, all multidetector CT angiography data were sent to a workstation (Aquarius workstation; TeraRecon Inc., CA, USA) via internal network connections, providing three-dimensional post-processing options, and multi-planar image reformatting. The SS volume measurements and the SS shapes (conchal, presellar, incomplete sellar, and complete sellar) were performed twice by a single radiologist with seven years of experience for each of the SS.

Statistical analysis

Statistical analysis was performed using the Number Cruncher Statistical System (NCSS) 2007 software (NCSS LLC, Kaysville, UT, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. The Man-Whitney U test was used for the comparison of the variables which did not show normal distribution. The Wilcoxon signed-rank test was used for intra-group comparisons. The Pearson chi-square test and Fisher-Freeman-Halton test were used to compare the qualitative data. A p value of <0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

Baseline demographic and clinical characteristics of the patients are shown in Table 1.

Of the patients, 46.2% (n=12) had a pathology on the right side and 53.8% (n=14) had a pathology on the left side. The mean pathological side volume was 4.31±2.35 (range, 1.03 to 8.08) cm^3,

Table 1. Baseline demographic and clinical characteristics of patients

	n	%	Mean±SD	Median	Min-Max
Age (year)			49.9±15.0	52	18-80
Sex					
Male	15	57.7			
Female	11	42.3			
P side					
Right	12	46.2			
Left	14	53.8			
P volume			4.3±2.4	3.83	1.03-8.08
H volume			4.5±2.4	3.94	0.38-11
Pneumatization type					
Complete sellar	14	53.8			
Incomplete sellar	3	11.5			
Conchal	1	3.8			
Presellar	8	30.8			
Pathology					
IFCSS	14	53.8			
ICSSwP	12	46.2			

SD: Standard deviation; Min: Minimum; Max: Maximum; P: Pathological; H: Healthy; IFCSS: Isolated fungal chronic sphenoid sinusitis; ICSSwP: Isolated chronic sphenoid sinusitis with polyps.

Table 2. Comparison of pathology results

	Pathology										Test value
	IFCSS (n=14)					ICSSwP (n=12)					
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Age (year)			52.4±15.8	54.5	24-80			47.1±14.1	50	18-64	Z:-0.721 0.494*
Sex											χ^2:0.004 0.951†
Male	8	57.1				7	58.3				
Female	6	42.9				5	41.7				
P side											χ^2:1.474 0.267†
Right	8	57.1				4	33.3				
Left	6	42.9				8	66.7				
Pneumatization type											χ^2:1.562 0.924‡
Complete sellar	8	57.1				6	50.0				
Incomplete sellar	1	7.1				2	16.7				
Conchal	1	7.1				0	0				
Presellar	4	28.6				4	33.3				

SD: Standard deviation; Min: Minimum; Max: Maximum; P: Pathological; IFCSS: Isolated fungal chronic sphenoid sinusitis; ICSSwP: Isolated chronic sphenoid sinusitis with polyps; * Mann-Whitney U test; † Pearson chi-square test; ‡ Fisher-Freeman-Halton: Pneumatization type.

Table 3. Comparison of volumes of P and H sides according to pathology results

	Pathology						
	IFCSS (n=14)			ICSSwP (n=12)			IFCSS (n=14)
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	
P volume (cm³)	4.7±2.4	4.24	1.03-8.08	3.8±2.3	3.56	1.19-7.95	Z:-0.926 0.374†
H volume (cm³)	3.7±1.8	3.79	0.38-8.18	5.6±2.8	5.53	0.9-11	Z:-2.058 0.041*†
Test value		Z:-2.105			Z:-2.276		
P		0.035*‡			0.023*‡		

SD: Standard deviation; Min: Minimum; Max: Maximum; † Mann-Whitney U test; ‡ Wilcoxon signed-rank test; * p<0.05. SD: P: Pathological; H: Healthy; IFCSS: Isolated fungal chronic sphenoid sinusitis; ICSSwP: Isolated chronic sphenoid sinusitis with polyps.

while the mean healthy side volume was 4.53±2.42 (range, 0.38 to 11) cm³. Pneumatization type was complete sellar in 53.8% (n=14) cases, presellar in 30.8% (n=8), incomplete sellar in 11.5% (n=3), and conchal in 3.8% (n=1). The pathology result was IFCSS in 53.8% (n=14) and ICSSwP in 46.2% (n=12) of the patients (Table 2). There was no statistically significant difference between the pathology groups in terms of age, sex, pathological sides, and pneumatization types ($p>0.05$). In addition, there was no significant difference between the volumes of the pathological sides in terms of the pathology results ($p>0.05$).

On the other hand, the healthy side volume was statistically significantly higher in the ICSSwP cases compared to the IFCSS cases ($p=0.041$ vs. $p<0.05$, respectively). In the IFCSS group, the pathological side volume was statistically significantly higher than the healthy side volume ($p<0.05$) (Figure 1). In the ICSSwP group, the pathological side volume was statistically lower than the healthy side volume ($p<0.05$) (Table 3, Figure 2). Also, there was no statistically significant difference in pathological and healthy side volumes according to sex between the IFCSS and ICSSwP groups ($p>0.05$) (Table 4).

DISCUSSION

An ISSD is a rare disease which accounts for 1 to 3% of all sinus diseases and poses various

Table 4. Comparison of P and H volumes according to sex

	Male			Female			Test value
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
IFCSS							
P volume (cm³)	4.5±2.6	4.24	1.0-8.02	5.1±2.3	4.46	2.87-8.08	Z:-0.258 0.796*
H volume (cm³)	3.3±1.6	3.79	0.4-5.12	4.2±2.0	3.64	2.47-8.18	Z:-0.194 0.846*
ICSSwP							
P volume (cm³)	3.2±1.6	3.51	1.19-5.49	4.6±3.0	3.60	1.54-7.95	Z:-0.731 0.465*
H volume (cm³)	5.2±2.5	5.74	0.90-8.48	6.0±3.3	5.11	2.10-11.0	Z:-0.081 0.935*

P: Pathological; H: Healthy; SD: Standard deviation; Min: Minimum; Max: Maximum; IFCSS: isolated fungal chronic sphenoid sinusitis; ICSSwP: Isolated chronic sphenoid sinusitis with polyps; * Mann-Whitney U test.

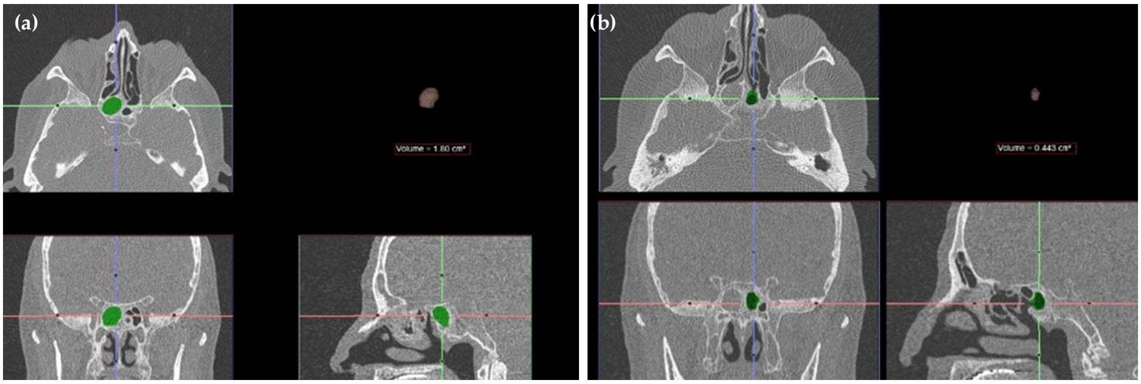

Figure 1. ***(a)*** *Right IFCSS (pathological side volume).* ***(b)*** *Right IFCSS (healthy side volume).*
ICSSwP: Isolated chronic sphenoid sinusitis with polyps; IFCSS: Isolated fungal chronic sphenoid sinusitis.

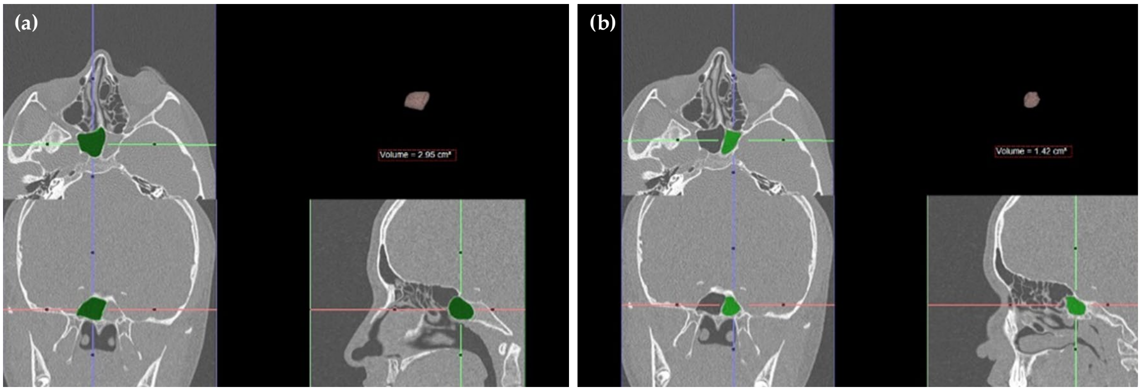

Figure 2. ***(a)*** *Left ICSSwP (healthy side volume).* ***(b)*** *Left ICSSwP (pathological side volume).*
ICSSwP: Isolated chronic sphenoid sinusitis with polyps; IFCSS: Isolated fungal chronic sphenoid sinusitis.

difficulties in diagnosis and treatment compared to other sinus diseases.[17] Inflammatory etiologies are responsible for 61 to 82% of all isolated sphenoid pathologies, followed by neoplastic lesions.[18,19] Diagnosis of an ISSD is the most difficult of all sinus diseases due to lack of specific symptoms and its rarity.[8]

An ISSD may manifest in CT imaging as a wide pathological spectrum varying from mucosal thickening to sinus opacity. However, the ability to differentiate between sinus wall expansion and erosion and demonstrating bone details is also valuable.[6] The CT imaging, with the additional role of MRI, is considered the gold standard for the diagnosis and treatment of SS diseases based on radiological imaging. Nevertheless, histological diagnosis of the lesion confirms the final definite diagnosis.[17] All patients included in our study had pathologically confirmed diagnoses.

Development of the SS begins in the fourth month of fetal life, with the bilateral invagination of the posterior nasal capsule toward the sphenoid bone. The sinus is opaque in infants under one year of age. Despite the lack of aeration, the SS is usually present at birth.[20] While the time of aeration start may vary in many studies, it usually starts at age two or three.[21] The age of achieving adult size and mean volume also varies in previous studies.[20] In general, SS aeration expands with age due to the growth of the sphenoid bone. However, it regresses and decreases in older age. High-resolution helical CT scanning enables more detailed volumetric assessment of age-related changes in the sphenoid aeration.[22]

Volume measurements of the SS provide important information. Some studies have even shown that the SS can be used as a criterion for sexual dimorphism, but it is still controversial.

Since the SS is critical in the surgical treatment of the pituitary gland and can provide access to other parts of the skull base, the evaluation of volume is also important for patients with variant craniofacial morphology.[23] The SS volume is one of the most relevant parameters for planning a surgical intervention, and few population studies have been published over time.[24]

In this study, the IFCSS and ICSSwP patients were included to attain a certain amount of data. The SS is a rare localization for fungal inflammation. Review of the literature revealed that only 89 (13%) of 683 cases of paranasal fungal inflammations were located in the SS. The main goal of treatment in IFCSS is to remove fungal residue from the affected sinus and to enable appropriate aeration and drainage from the sinus.[25] Of note, ICSSwP is rare and polyps commonly form from the SS ostium. Its treatment includes polyp excision and opening of the SS ostium.[26]

Emirzeoglu et al.[27] reported a mean bilateral sphenoid volume of 13.6 cm^3. Karakas and Kavakli[28] found a total bilateral sphenoid volume of 9.68 cm^3. Many studies have reported different results. In a CT study, Sánchez Fernández et al.[29] used the axial and coronal sections of the paranasal sinuses to pass through the inner bone walls and calculated volume for each sinus using area, circumference, and diameter measurements on the x and y axes. They reported a mean adult SS volume of 3.5 cm^3. In another study using CT in a total of 260 Asian patients under the age of 25 years, Park et al.[30] examined the volume of paranasal sinus development and found the mean SS volume to be 3.47 cm^3 after the completion of development. This discrepancy can be attributed to the specialist taking measurements, ethnic origin, device which was used, program, and method. Therefore, we believe that the methodology we used in our study (i.e., comparison of pathological and healthy sides) is valuable. In our study, total SS volume was found to be 8.4 cm^3 among the IFCSS patients and 9.53 cm^3 among the ICSSwP patients. The SS volume of both patient groups is consistent with the literature data.

Gibelli et al.[24] reported that the SS volume was significantly higher in males compared to females for all SS types (conchal, presellar, sellar, and postsellar). Similarly, Pirinc et al.[15] found a significantly higher SS rate in males than females. There are also studies which report that there is no significant difference in the SS volume between male and female cases.[22] In our study, no statistically significant difference was observed in the volume measurements of pathological and healthy sides according to sex between the IFCSS and ICSSwP patients.

Furthermore, Senturk et al.[31] showed that unilateral presence of the Onodi cell was associated with decreased SS volume on the same side. To illustrate, the SS volume was significantly lower on the side with the Onodi cell compared to the side without. However, bilateral presence of the Onodi cell decreased both left and right sphenoid volumes. Similarly, previous studies suggested that it had a significant lowering effect on the total SS volume.[27] On the other hand, Emirzeoglu et al.[27] and Kawarai et al.[32] reported no significant difference between the right and left SS volume. To the best of our knowledge, there is no study investigating the SS volume in patients with a SS pathology, yet. In our study, the pathological side SS volume was significantly higher compared to the healthy side SS volume among the IFCSS patients. In contrast, the SS volume was significantly lower in the pathological side, compared to the healthy side among the ICSSwP patients. Previous studies have shown that anatomical variation and differences may cause a predisposition to development of sinus diseases.[33] Our findings also suggest that the difference between the left and right SS volumes play a role in obtaining formation of various pathologies of the SS. Beyond doubt, the evaluation of volume along with other anatomical variations would be even more clinically relevant.

Pneumatization is classified as four different types according to the relationship between the SS posterior wall and the anterior and/or posterior wall of the sella turcica. Pirinc et al.[15] conducted a study on SS pneumatization and found that the most common pneumatization type was complete sellar type in both males and females (43.4% and 39.6%, respectively), while the least common type was presellar pneumatization (7% and 10.9%, respectively). Lu et al.[33] conducted a CT study in 200 adult cases and 18 cadavers, and reported that the most common pneumatization type was complete sellar in both groups (both males and females) and the least common type was conchal type. In our study, the most common pneumatization type was complete sellar type in both the IFCSS and ICSSwP groups (57.1% and 50.0%, respectively), consistent with the literature. Additionally, there was no statistically significant difference between the groups according to the pneumatization types. In other words, the effect of SS pneumatization type was not observed as an etiological or predisposing factor for the development of ISSD. Although our results may be a coincidence, we believe that it would provide an inspiration for future studies and sharing the results in larger series would contribute to the literature. In the light of further studies, preoperative SS volume assessment can provide an insight into the pathology.

The main limitations to this study include its small sample size and the lack of evaluation of other causes of ICSS.

In conclusion, a greater SS volume is prone to IFCSS, while a smaller SS volume is prone to ICSSwP. Therefore, it should be considered that the difference in the right and left SS volume may have different etiological or predisposing effects for different pathologies.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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