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Detailed Anatomical Analysis of the Sphenoid Sinus and Sphenoid Sinus Ostium by Cone-Beam Computed Tomography

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Abstract: The aim of this study is the evaluation of the anatomical structures of sphenoid sinus ostium used as a reference point for transsphenoidal surgery by cone beam computed tomography. The authors' study was performed using the cone-beam computed tomography images of 16 to 82-year old 200 (112 female, 88 male) patients (Newton 5G, Verona, Italy). Septum deviation of sphenoid sinus and the distance between 2 ostia were evaluated by coronal and axial sections, respectively. Pneumatization degree of sphenoid sinus, diameter of sphenoid sinus ostium, and distance lower edge of superior turbinate to sphenoid sinus ostium were measured by using sagittal sections. The sellar type was the most common pneumatization type of sphenoid sinus in authors' study. While the C-type septum deviation was observed as the most common, T-type deviation was the least type. Sphenoid sinus ostium was bilaterally in 71.5% of individuals, and it was not found in 10% of individuals included in the study. A significant decrease was determined in diameter of the left sphenoid sinus ostium with aging. The distances between 2 sphenoid sinus ostia were 7.30 ± 2.77 mm for women and 6.09 ± 2.58 mm for men, respectively. No statistical differences were found in women and men in terms of distances between the lower edge of the right and left superior turbinate and sphenoid sinus ostium on their sides. Consequently, making detailed preoperative radiological evaluation of anatomic variations of sphenoid sinus and sphenoid sinus ostium is important in terms of guiding the surgeon in the process of a successful transsphenoidal surgery.

Key Words: Cone-beam computed tomography, sphenoid sinus, sphenoid sinus ostium, transsphenoidal surgery

The sphenoid sinus is a double sinus located within the body of the sphenoid bone. Sizes, shapes, and pneumatization type vary from person to person. The bony septum that is located in the midline separates the 2 sinuses from each other.[1] The sinus was surrounded with many important anatomical structures, neighborhoods internal carotid artery in the lateral wall, optic nerve at the superolateral and pterygoid nerve (The Vidian Nerve) at the base of the spheoid sinus.[2] This sinus opens sphenoethmoidal recess by sphenoid sinus ostium that is located in the upper part of the front wall through the sphenoid sinus.[3] The diameter of sphenoid sinus ostium is 2 to 3 mm, it is situated 11 to 14 mm above the base level of the sinus, 4 to 5 mm in lateral of nasal septum, 30 degrees above the base of the nose.[4–6] The opening of sphenoid sinus ostium is one of the most important points in transsphenoidal surgery for surgeons. The surgical procedure is done by extending this opening. Closed or being in different positions of this opening can cause difficulty during surgical procedures.[7] During the endoscopic and surgical transsphenoidal approaches, finding the ostium is not always easy. So the detection of detailed anatomical analysis this natural way and adjacent structures prior to transsphenoidal surgery may reduce complication incidence.

The aim of this study is the evaluation of the anatomical structures of sphenoid sinus ostium used as a reference point for transsphenoidal surgery by cone beam computed tomography. At the same time, the anatomical variations and the pneumatization status of the sphenoid sinus were examined using the same method.

METHODS

Study Population

This study is a retrospective study conducted with the permission by the Ethics Committee of the Inonu University (Protocol No: 2015/39), Malatya, Turkey. The cone-beam computed tomography images (Newtom 5G, Verona, Italy) of patients between 16 and 82-year old (112 female, 88 male) admitted to the Inonu University, Faculty of Dentistry, Oral and Maxillofacial Radiology Department with dental causes between January 2012 and December 2014 dates were used.

Exclusion criteria:

- The patients had a surgical procedure before on sinuses and nasal cavity,
- The patients had an advanced inflammatory disease,
- The patients with benign and malignant lesions located or radiating in the study area.

Radiological Assessment

The radiological assessment was performed by using the NNT software program. The voxel value of the images used was 0.2 mm, the thickness and range of coronal and sagittal sections were determined 0.5 mm. The number and deviation type of septum in sphenoid sinus were evaluated by using coronal sections. In our study, the septum deviation was classified for the first time, including C-shaped, S-shaped, and tilt (Fig. 1). C-shaped and tilt ones were evaluated to divided into 2 subgroups according to showing left or right deviation. The pneumatization type of sphenoid sinus was assessed by using sagittal sections[8] (Fig. 1). The distances between 2 ostia were measured on axial images (Fig. 1). In

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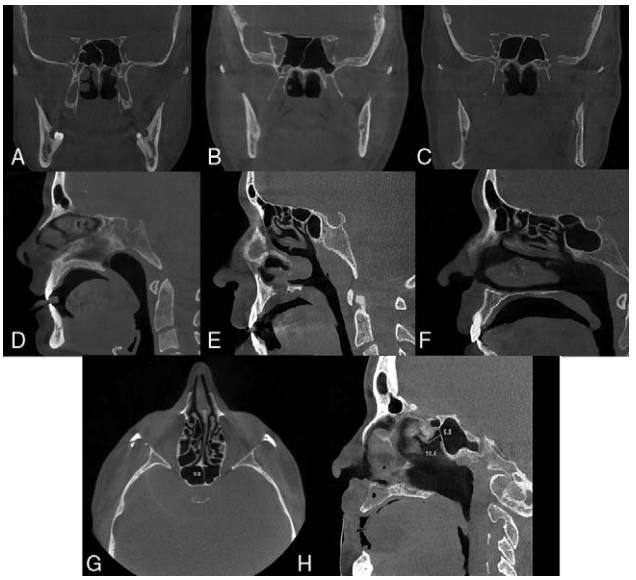

FIGURE 1. Septum deviation types of sphenoid sinus (A, C type; B, S type; C, tilt type); pneumatization types of sphenoid sinus (D, Conchal; E, Presellar; F, Sellar). (G) Measuring the distance between 2 ostium. (H) Measuring the diameter of ostium (6.8 mm) and the distance between ostium and the lower edge of superior turbinate (10.4 mm).

the axial sections that observed both ostia together, the distances were measured on middle sections by considering the section numbers. The presence of the sphenoid sinus ostium, the diameter, and the distance lower edge of the superior turbinate to sphenoid sinus ostium were measured by using sagittal sections. The diameter of ostium was measured from the widest points in obtaining sagittal sections. The distance between the lower edge of the superior turbinate to ostium was measured on sagittal section that can be measured the diameter of ostium (Fig. 1).

Statistical Analysis

The statistical analysis was performed by IBM SPSS Statistics 22.0 program. Mann–Whitney *U* test, independent samples *t* test, Pearson χ^2 test, Kruskal–Wallis test, and one-way analysis of variance analysis (ANOVA) were used for statistical analyses where appropriate. Tukey test for one-way ANOVA and Mann–Whitney *U* test with Bonferroni correction for Kruskal–Wallis test were used for multiple comparisons. $P < 0.05$ values were considered statistically significant.

RESULTS

Eighty-eight men (16–82-year old) and 112 women (18–73-year old) including total 200 patients were taken in this study. The sinuses were examined bilaterally on a total of 400 sides. The average age was determined as 39 ± 15 years in men and 41 ± 15 years in women.

The bilateral sellar-type pneumatization was shown as the most common pneumatization type of sphenoid sinus in male and female patients included in this study (Table 1). When we evaluated the pneumatization type according to the age groups, bilateral sellar-type pneumatization was shown in 82 (42.3%) individuals between 16 and 34-year old, 54 (27.8%) between 34 and 50-year old, and 58 (29.9%) individuals at 50 and upper years old (Table 2).

By assessing the number of septum, it was shown that there was only 1 septum in all individuals; but its shape and direction of deviation were different. C-shaped septum deviation was seen in 52 (46.4%), Tilt type was seen in 8 (7.2%) female patients. While S-shaped septum deviation was observed in 39 (34.8%) women, no septum was observed in 8 (11.6%) women. In men, S-shaped septum deviation was seen in 37 (42%), no septum was determined in 8 (9.1%). Thirty-five (39.8%) of men had C-shaped septum, 8 (9.1%) had tilt type (Table 1). When we evaluated the septum type according to age groups, C-shaped septum deviation was the most common type in individuals at 16 to 34-year old and 50 and upper years old, S-shaped septum deviation was the most common type in individuals at 35 to 50-year old. Tilt type was observed as the least type septum deviation in all age groups (Table 2).

While the sphenoid sinus ostium was observed bilaterally in 81 (72%) women, it was not seen in 10 (8.9%) women. The ostium was found in 62 (70.5%) of men, but it was never found in 10 (11.4%) men (Table 1). As the diameter of right sphenoid sinus ostium was found as 2.19 ± 0.83 and 2.34 ± 0.84 mm in women and men respectively, the diameter of left ostium was found as 2.20 ± 0.88 mm in women and 2.39 ± 0.93 mm in male. The distance between 2 sphenoid sinus

TABLE 1. Evaluation of the Pneumatization and Septum Deviation Type of Sphenoid Sinus and the Status of Sphenoid Sinus Ostium According to Sex

Parameters		Sex		Total n (%)
		Female n (%)	Male n (%)	
Pneumatization type	Bilateral presellar	1 (0.9%)	0 (0.0%)	1 (0.5%)
	Bilateral sellar	107 (95.5%)	87 (98.9%)	194 (97%)
	Bilateral conchal	0 (0.0%)	1 (1.1%)	1 (0.5%)
	Left presellar, Right sellar	1 (0.9%)	0 (0.0%)	1 (0.5%)
	Right presellar, Left sellar	2 (1.8%)	0 (0.0%)	2 (1%)
	Right presellar, Left conchal	1 (0.9%)	0 (0.0%)	1 (0.5%)
Deviation type	C-shaped with right deviation	27 (24. %1)	24 (27.3%)	51 (25.5%)
	C-shaped with left deviation	25 (22.3%)	11 (12.5%)	36 (18%)
	Tilt with right deviation	5 (4.5%)	2 (2.3%)	7 (3.5%)
	Tilt with left deviation	3 (2.7%)	6 (6.8%)	9 (4.5%)
	S-shaped	39 (34.8%)	37 (42%)	76 (38%)
	No septum	13 (11.6%)	8 (9.1%)	21 (10.5%)
The state of ostium	Bilateral	81 (72.3%)	62 (70.5%)	143 (71.5%)
	Only right sinus	12 (10.7%)	5 (5.7%)	17 (8.5%)
	Only left sinus	9 (8%)	11 (12.5%)	20 (10%)
	No ostium	10 (8. 9%)	10 (11.4%)	20 (10%)

TABLE 2. Evaluation of the Pneumatization and Septum Deviation Type of Sphenoid Sinus and the Status of Sphenoid Sinus Ostium According to Age Groups

Parameters		Age Groups n (%)			Total n (%)
		16–34 n (%)	35–50 n (%)	50 and Upper n (%)	
Pneumatization type	Bilateral presellar	1 (1.2%)	0 (0%)	0 (0%)	1 (0.5%)
	Bilateral sellar	82 (97.6%)	54 (100%)	58 (93.5%)	194 (97%)
	Bilateral conchal	0 (0%)	0 (0%)	1 (1.6%)	1 (0.5%)
	Left presellar, right sellar	1 (1.2%)	0 (0%)	0 (0%)	1 (0.5%)
	Right presellar, left sellar	0 (0%)	0 (0%)	2 (3.2%)	2 (1%)
	Right presellar, left conchal	0 (0%)	0 (0%)	1 (1.6%)	1 (0.5%)
Deviation type	C-shaped with right deviation	23 (27.4%)	13 (24.1%)	15 (24.2%)	51 (25.5%)
	C-shaped with left deviation	16 (19%)	6 (11.1%)	14 (22.6%)	36 (18%)
	Tilt with right deviation	1 (1.2%)	3 (5.6%)	3 (4.8%)	7 (3.5%)
	Tilt with left deviation	3 (3.6%)	4 (7.4%)	2 (3.2%)	9 (4.5%)
	S-shaped	31 (36.9%)	25 (46.3%)	20 (32.3%)	76 (38%)
	No septum	10 (11.9%)	3 (5.6%)	8 (12.9%)	21 (10.5%)
The state of ostium	Bilateral	54 (64.3%)	43 (79.6%)	46 (74.2%)	143 (71.5%)
	Only right sinus	10 (11.9%)	2 (3.7%)	5 (8.1%)	17 (8.5%)
	Only left sinus	10 (11.9%)	3 (5.6%)	7 (11.3%)	20 (10%)
	No ostium	10 (11.9%)	6 (11.1%)	4 (6.5%)	20 (10%)

ostium was determined as 7.30 ± 2.77 and 6.09 ± 2.58 mm in women and men, respectively. The distance between the lower edge of the right superior turbinate and right sphenoid sinus ostium was determined 8.96 ± 2.40 mm in women, 9.12 ± 2.23 mm in men. The distance between lower edge of the left superior turbinate and left ostium was determined as 9.10 ± 2.22 mm in women and 9.41 ± 2.25 mm in men (Table 3). When we evaluated the presence of ostium, the ostium was found bilaterally in 54 (64.3%) individuals at 16 to 34-year old, in 43 (79.6%) individuals at 35 to 50-year old, in 46 (74.2%) individuals at 50 and upper years old. The ostium was not found in 10 (11.9%) individuals aged 16 to 34-year old, in 6 (11.1%) individuals aged 34 to 50-year old, in 4 (6.5%) individuals aged 50 and upper years old (Table 2). The diameter of right sphenoid sinus ostium was determined as 2.29 ± 0.72 mm, the diameter of left sphenoid sinus ostium was determined as 2.38 ± 0.91 mm in individuals between 16 and 34-year old. In individuals between 35 and 50-year old, the diameter of right and left sphenoid sinus ostium was defined as 2.28 ± 0.85 and 2.17 ± 0.70 mm, respectively. The diameter of right ostium was defined as 2.16 ± 0.96 mm, the diameter of left ostium was defined as 2.27 ± 1.07 mm in individuals at 50 and upper years old. The significant decrease was determined in diameter of the left sphenoid sinus ostium with aging ($P = 0.031$). The distance between 2 sphenoid sinus ostium was determined as 6.65 ± 2.62 mm in individuals at 16 to 24-year old, 7.48 ± 2.45 mm in individuals at 35 to 50-year old, 7.28 ± 3.00 mm in individuals at 50 and upper years old. The distance between the lower edge of right superior turbinate and right sphenoid sinus ostium was determined as 9.00 ± 2.19, 9.19 ± 2.08, 8.89 ± 2.73 mm in individuals at 16 to 24-year old, 35 to 50-year old, 50 and upper years old, respectively. The distance between the lower edge of left superior turbinate and left sphenoid sinus ostium was determined as 9.31 ± 2.19, 9.4 ± 2.52, 9.53 ± 2.31 mm in individuals at 16 to 24-year old, 35 to 50-year old, 50 and upper years old, respectively (Table 4).

TABLE 3. Values of Diameter of Sphenoid Sinus, the Distance Between Two Ostiums and the Lower Edge of Superior Turbinate to Ostium According to Sex

Parameters	Sex	Mean ± SD	*P* Value
The diameter of right ostium	Female	2.19 ± 0.83	0.286*
	Male	2.34 ± 0.84	
The diameter of left ostium	Female	2.20 ± 0.88	0.226*
	Male	2.39 ± 0.93	
The distance between lower edge of the right superior turbinate to ostium	Female	8.96 ± 2.40	0.668**
	Male	9.12 ± 2.23	
The distance between lower edge of the left superior turbinate to ostium	Female	9.10 ± 2.22	0.387**
	Male	9.41 ± 2.25	
The distance between 2 ostiums	Female	7.30 ± 2.77	0.410*
	Male	6.81 ± 2.58	

SD, standard deviation.
*,**$P < 0.05$ values were considered statistically significant.

DISCUSSION

The sphenoid sinus is deeply located in the skull and is the most inaccessible paranasal sinus. The size and morphology of this sinus vary between individuals.[1] The sphenoid sinuses are associated with back side of each nostril called the sphenoid sinus ostium that is located midline.[9]

The transsphenoidal surgery held first in 1907 has become standard procedure for sphenoid sinuses and intracranial lesions and the importance of the surgical anatomy and neighborhoods of the sphenoid sinuses have increased. Therefore, it should be evaluated radiologically before surgery sphenoid sinuses and surrounding structures.[10] In this study, the anatomical structures and neighborhoods of the sphenoid sinuses and the sphenoid sinus ostium were assessed by using cone-beam computed tomography.

When we evaluated the pneumatization type of sphenoid sinus, it was observed that the sellar type was dominant type in individuals. In recent studies, it was shown that the most common pneumatization type was the sellar-type pneumatization, too.[2,11–16] In a study, the pneumatization type was classified as conchal, presellar, sellar, and postsellar. In another study that was evaluated pneumatization type between ethnic groups, it was identified the sellar type was the most common type in African-Americans (53.8%), the postsellar type was the most common in Spanishs (48.2%) and Caucasus

TABLE 4. Values of Diameter of Sphenoid Sinus, the Distance Between Two Ostiums and the Lower Edge of Superior Turbinate to Ostium According to Age Groups

Parameters	Age Groups	Mean ± SD	*P* Value
The diameter of right ostium	16–34	2.29 ± 0.72	
	35–50	2.28 ± 0.85	0.620
	50 and upper	2.16 ± 0.96	
The diameter of left ostium	16–34[a]	2.38 ± 0.91	
	35–50[b]	2.17 ± 0.70	0.031
	50 and upper[b]	2.27 ± 1.07	
The distance between lower edge of the right superior turbinate to ostium	16–34	9.00 ± 2.19	
	35–50	9.19 ± 2.08	0.743
	50 and upper	8.89 ± 2.73	
The distance between lower edge of the left superior turbinate to ostium	16–34	9.31 ± 2.19	
	35–50	9.4 ± 2.52	0.880
	50 and upper	9.53 ± 2.31	
The distance between 2 ostiums	16–34	6.65 ± 2.62	
	35–50	7.48 ± 2.45	0.313
	50 and upper	7.28 ± 3.00	

$P < 0.05$ values were considered statistically significant.
a, b, Different letters indicate significant differences in each column.

(56%). Only sellar (50%) and postsellar (50%) type pneumatization was seen in Asians.[14]

The location of the sphenoid sinus ostium must be known to determine the correct input path in transsphenoidal surgery. The opening of the sphenoid sinus ostium, relations to surrounding structures are important and should be known for surgeons.[17] In our study, it was determined that the sphenoid sinus ostium was found bilaterally in most individuals. When we evaluated the diameter of sphenoid sinus ostium according to age, a significant decrease was determined in the left diameters of sphenoid sinus ostia.

The furthest distance between 2 ostia was determined as 14.34 ± 2.32 mm in a recent study.[18] While the ostium was found in 43 patients who underwent computed tomography angiography with different reasons, it was not found in 7 patients of them.[19] In a study examining 32 dry skulls, it was shown that the sphenoid sinus ostium was found in most of the samples. The widest diameter of right and left sphenoid sinus ostium was determined as 5.61 and 5.63 mm, respectively. It was reported that the data obtained from this anatomical study confirmed the variability of the location of the sphenoid sinus ostium discovered during transsphenoidal surgery.[20]

In our study, when we evaluated the number and the deviation type of the septum of the sphenoid sinus, while the most common deviation type of the septum was C-shaped, the least type was tilt type in both sexes and all age groups. It was shown 1 septum was found in individuals included in the study. In a study that evaluated the presence or absence of the sphenoid sinus ostium, 53.7% of individuals had only 1 septum, 46.3% of them had more than 1.[11] In another study examining 48 Asians cadaveric heads, the septum was located at the midline in 16.6% of samples, deviated to the left in 56.3% of them and was deviated to the right in the others.[12]

In conclusion, knowledge of the anatomical variations of sphenoid sinus and sphenoid sinus ostium of making a detailed preoperative radiological assessment is required for a successful transsphenoidal surgery process. The good preoperative radiological examination of the anatomical variations of this formation may minimize the complications that can occur during the operation.

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