Morphometric Analysis of Sphenoid Sinus in Patients With Nasal Septum Deviation

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Abstract: This retrospective study aimed to assess the association of the volume and types of the sphenoid sinus with deviated nasal septum by analyzing multislice computed tomography images. A total of 93 patients with a deviated nasal septum and 70 healthy controls were included in the study. Patients with sinonasal morbidities other than deviation were excluded. Three-dimensionally reconstructed computed tomography images of the study participants were acquired. A total of 326 sphenoid sinus volumes from the patient and control groups were obtained and compared between the groups. Sphenoid sinus volumes and the angle of the deviation were measured for standardization and assessment of the severity. Deviated nasal septum was found on the right in 49.5% (n = 46) and on the left in 50.5% (n = 47) of the study participants. Deviation angles were in the range from 7.2° to 22.4° and the mean value was 13.2° ± 5.0°. The measured volumes were in the range from 1.8 cm^3 to 9.6 cm^3 with a mean of 4.8 ± 1.5 cm^3. In the control group, the median values for the sphenoid sinus volumes were 4.40 cm^3 (0.80–8.90 cm^3) on the right and 4.20 cm^3 (0.90–8.70 cm^3) on the left. In the study group, sphenoid sinus volumes were found to be statistically significantly different between those on the ipsilateral and contralateral side of the septal deviation. Sphenoid sinus volumes were significantly smaller on the same side with septal deviation compared with those on the contralateral side. There was no statistical relationship between the presence of septal deviation, age and gender, and the type of sphenoid sinus.

Key Words: Septal deviation, sphenoid sinus type, sphenoid sinus volume, three-dimensional imaging

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The sphenoid sinus is located in relation to several different structures in the body of the sphenoid bone; therefore, approaching its anatomical location is not an easy intervention. The shape and size of the sphenoid sinus are variable and, in general, they are asymmetrical on both sides. The optic nerve, maxillary nerve, and the pterygoid nerve are found in close proximity to them. Other adjacent structures with critical importance include the hypophysis and the internal carotid artery.[1–3]

Several methods are available to perform surgical interventions in the sphenoid sinus. Among them are the trans-septal and trans-nasal approaches.[1,3,4] Intracranial skull base approach is also possible.[1,3,4] Another method is the endonasal endoscopic approach, which has increasingly become more common since it was introduced into the surgical practice. This method has been demonstrated to be useful for the surgical interventions for intrasellar pathologies.[5,6] In trans-sphenoidal interventions, type of pneumatization and septation in the sphenoid sinus is a critical procedure. Bulging in the previously mentioned surrounding vital anatomical structures is related to the extent of pneumatization used in this approach.[7]

The type and the morphometric features of the sinus are reported to be the predictors of the risk of iatrogenic injuries.[8] However, the number of studies characterizing the type and size of the sinus, comparing it by the age groups, is limited. There is a need for accumulation of data to standardize the classification of the sphenoid sinus to achieve better results in the surgical practice, especially to determine its position in the sella turcica. Computerized tomography (CT) is reported to be a useful clinical tool to determine the normal morphometric characteristics of the sphenoid sinus. Resulting data will enable clinicians to better identify pathological findings.[7,9] Furthermore, three-dimensional (3D) reconstruction of CT images allows good-quality imaging of the structures in the area of clinical interest, providing better options to determine and standardize the morphometric characteristics of the sphenoid sinus.[2,10,11]

Nasal airflow is an effective factor in the development of the skeletal architecture of the head and plays an important role in shaping the paranasal sinuses.[12] The nasal airflow occurs under the effect of the positive air pressure generated in the nasopharynx and allows the air for entering the paranasal sinuses so that it will be transferred to the bloodstream.[13–15] Therefore, a developing deviation of the nasal septum will affect the airflow in the cavity, altering the normal anatomical shaping of the paranasal sinuses.

This present study aimed to assess the relationship of the volume and type of the sphenoid sinus with the nasal septum deviation by analyzing this relationship using multislice computed tomography.

METHODS

Computerized tomography images of the cranium and paranasal sinuses of patients were retrospectively reviewed and analyzed using the records in the archives of Istanbul Medipol University, Faculty of Medicine. A total of 93 patients with a deviated nasal septum, and who were either 16 years old or older, were included in the study consecutively. In addition, among the individuals, who

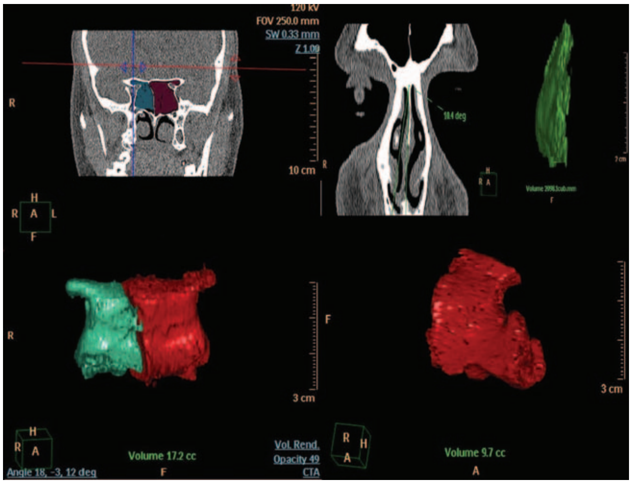

FIGURE 1. Three-dimensional reconstructed image of the right and left sphenoid sinus volume. Measurement of the septal deviation angle and septal deviation volume.

were investigated for cephalalgia etiology; 70 healthy controls without a deviated septum or any other sinonasal pathological findings were included in the study to constitute the control group. A retrospective chart view of the participants was performed in the institutional archiving system. The patients were excluded when sinonasal morbidities other than deviation in the nasal septum were identified. Other exclusion criteria were the presence of a diagnosis of acute or chronic rhinosinusitis, a history of maxillofacial trauma, previous surgical interventions to the nasal and/or paranasal sinuses, detection of cranial or pituitary tumors, existing benign or malignant paranasal sinus tumors, and the presence of a multilobulated sphenoid sinus or an S-shaped septum deviation. The study was approved by the institutional Ethics Committee of Kahramanmaraş Sütçü Imam University.

A multislice computed tomography device (MSCT, Philips Brilliance ICT 256; Philips Medical Systems, Eindhoven, The Netherlands) (scan setting 120 kV, 150 mAs) was used for the acquisition of the images from the included participants. A scan field of view of 236 mm, collimation of 128 9 0.625, and an image matrix of 512 9 512 were used. Scanning was performed with a 2-mm slice thickness, and then, axial and coronal images were reconstructed. The sphenoid sinus volumes were calculated with a volume-rendering technique automatically using a workstation (Extended Brilliance Workspace, version 4.5.2.4031, Philips Medical Systems). The mean volumes of the bilateral sphenoid sinuses were calculated separately for either group (Fig. 1). The volumes involving the deviated septums and the angles of deviation were calculated using the same workstation. The resulting values were used for determining the extent of the septal deviation severity and to establish standardization. Deviation angle was defined as the angulation between the 2 imaginary lines; one extending from the maxillary spine to the crista galli and the other from the crista galli to the apex of the septal deviation (Fig. 1). The cavity between the mucosal concave side of the deviation and the midline, vertically intersecting with the maxillary spine and the crista galli, was accepted as the septal deviation volume, which was calculated by taking the sum of the respective volumes along the entire anterior-posterior length of the nasal septum (Fig. 1).

STATISTICAL ANALYSIS

In the statistical evaluation of the data, the normal distribution of the variables was examined with the Kolmogorov–Smirnov test. It was observed that the variables did not conform to normal distribution. The Wilcoxon test was used for comparison of paired tests, while the Mann–Whitney U test was used to compare 2 independent groups and Kruskal–Wallis H test was used for comparison of 2 groups. The statistical parameters of the variables with no normal distribution were expressed with median (min–max). The distribution relationship between categorical variables was examined by χ^2 test and exact test. Statistical parameters were expressed by ratio (%) and frequency (n). The relationship between the variables was examined by Spearman correlation test. Statistical significance was accepted as $P < 0.05$. IBM SPSS version 22 (IBM SPSS for Windows version 22, IBM Corporation, Armonk, NY) was used to evaluate the data.

RESULTS

In the patient group, 51.6% (n = 48) of the participants were females and 48.3% (n = 45) were males. The age range in the patient group varied from 16 to 82 years, with a median of 34 years. The distribution of gender and age was similar in the control group. The nasal septum was deviated on the right in 49.5% (n = 46) of the patients and it was on the left in 50.5% (n = 47). Deviation angles ranged from 7.2° to 22.4° and their mean was 13.2 ± 5.0°. Deviation volumes were between 1.8 and 9.6 cm^3 and the mean deviation volume was 4.8 ± 1.5 cm^3. Deviation angles were found to be statistically significantly correlated with the deviation volumes in the positive direction (r = 0.979, $P < 0.05$) (Fig. 2). In the control group, the median volumes of the right and left sphenoid sinuses were 4.40 (0.80–8.90) and 4.20 (0.90–8.70) cm^3, respectively. No statistically significant findings were observed to relate the sinus volumes on either side in the control group. However, in the patient group, sphenoid sinus volumes were significantly smaller on the ipsilateral side with the deviation compared to the control group and compared to the sphenoid sinus volumes contralateral to the deviation ($P < 0.05$). In the subgroup of patients with a deviation on the left, the median sphenoid sinus volumes on the right and left were found to be 5.00 (0.90–8.10) cm^3 and 3.70 (0.70–6.80) cm^3, respectively. In the right-sided deviation group, the median volumes on the right and left were 4.85 (2.80–6.30) cm^3 and 5.90 (4.60–8.90) cm^3, respectively (see Supplemental Digital Content, Table 1, http://links.lww.com/SCS/A709). No significant correlations of the septal deviation angle and septal deviation volume to the sphenoid sinus volume were found ($P > 0.05$).

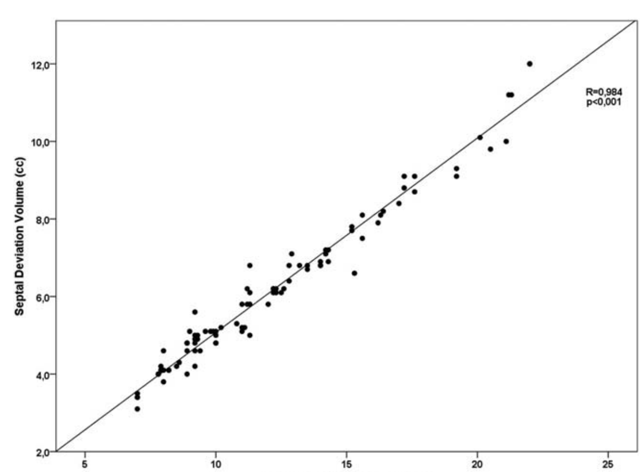

FIGURE 2. Graphic showing the positive correlation between the septal deviation angle and septal deviation volume.

The most prevalent sellar type sphenoid sinus was detected in 77.4% of the patients with SD and 80% in the control group without SD. The second most prevalent type was presellar (20.2%), whereas only 1 conchal (1.2%) sinuses were found in both groups (see Supplemental Digital Content, Table 2, http://links.lww.com/SCS/A710). There was no statistical significance when compared with right and left sinus volumes compared to age and sex. No significant differences in the volume were detected by the gender in neither age group. The median sphenoid sinus volumes were 4.50 cm^3 on the right and 4.60 cm^3 on the left in either gender. However, the right and left sinus volumes were statistically significantly different in the presence of septal deviation. In the patient group with a deviation in the nasal septum, the sphenoid sinus volumes were found to be 4.90 (0.90–8.10) cm^3 on the right and 5.00 (0.70–8.90) cm^3 on the left (see Supplemental Digital Content, Table 3, http://links.lww.com/SCS/A711).

DISCUSSION

Guided by the modern imaging techniques, there has been a rise in trans-sphenoidal endoscopic surgeries since the introduction of endoscopic methods. This innovative method is commonly used for the surgical treatment of the diseases of the craniofacial skeleton, as well as for approaching the pituitary gland. This observed trend revealed the critical need to establish the morphological and morphometric characteristics and the spatial location of the sphenoid sinus. A unique morphological feature of the sphenoid sinus is the presence of hallmarks on its surfaces, created by the surrounding neurovascular structures. Pneumatization during the endoscopic sphenoid sinus surgery enhances these marks on the internal surfaces of the sphenoid sinus borders due to the facilitated contact with these structures, including the optic, maxillary, and the pterygoid nerves, as well as the hypophysis and the internal carotid artery,[1–3] which are critically important for the living human body. Their close vicinity increases the awareness for the essence of establishing the morphological characteristics of the sphenoidal sinus accurately in the medical and surgical practice.[2,8,16,17]

The degrees and directions of pneumatization vary across different types of sphenoid sinus structures. Pneumatization of the sphenoid sinus is classified based on the posterior sinus wall location in respect to the position of sella turcica. Three types of sphenoid sinus pneumatization have been defined, which are the conchal, presellar, and sellar types based on the extension of pneumatization in relation to sella turcica.[1,8,18] Another classification comprises 4 types of sphenoid sinus pneumatization, which were the conchal, presellar, sellar, and postsellar types.[8] Currently, the later classification, focused on the sellar region, is almost basic to trans-sphenoidal surgery methods.[1,19,20]

Anusha et al[20] conducted a study on 279 patients to investigate the prevalence of types of sinuses. The study reported that sellar type was the most frequent (93%), followed by the pre-sellar and conchal types at 6.7% and 0.3% rates respectively. Seddighi et al[21] conducted a study on 64 adults with pituitary adenomas to examine the extent of pneumatization. They reported the presence of the sellar type in 34 patients (59.4%), the pre-sellar type in 10 (15.6%), and the conchal type in 16 (25%) patients. In our study, we detected the distribution of the types similar in both the patient and the control groups. We observed the sellar type mainly at a rate of 78.5%, followed by the presellar type (20.2%), and the conchal type (1.2%). There was no significant difference between the study group and the control group in terms of sphenoid sinus type.

Oliveira et al[22] examined the morphology of the sphenoid sinus on 25 men and 25 women using CT with 3D reconstruction and computer graphic applications. The authors observed that the variation of the spatial location and the volume were significantly more variable in males compared to the opposite sex. Therefore, one can suggest that the method in Oliveira et al study may be used for assessing sexual dimorphism. However, our study revealed no significant differences in sinus volumes by gender. Similar to our study results, Yonetsu et al[23] reported no differences in the aeration volume by gender. The volume of the sphenoid sinus was not dependent on neither gender nor age ($P > 0.005$).

In our study, the presence of a deviated nasal septum was associated with the data characterizing sphenoid sinus asymmetry. In the individuals without a septal deviation, the sphenoid sinus was found symmetrical. While the right and left sphenoid sinus volumes were not affected by age and gender, the presence of septum deviation affected these volumes. In our study, we found that the volume of sphenoid on the side with septum deviation was smaller. Teul et al[24] reported the influence of septal deformities on the development of nasal cavity structures. We are of the opinion that, upon observing our study findings, the asymmetric appearance of the sphenoid sinus may be influenced by a deviated nasal septum as suggested by Teul et al.[24] This phenomenon has been further supported by the fact that osteomeatal complex disease or ethmoid bulla prominence may be associated with symmetric or asymmetric septation, affecting the sphenoid sinus pneumatization.[1,25]

CONCLUSION

Surgical access to the hypophysis is highly determined by the type of the sphenoid sinus. A well-developed sinus is associated with easier trans-sphenoidal access; however, increases in the extent of sphenoid sinus pneumatization are accompanied with an increased bulging of the neurovascular structures into the sinus cavity, as well as with an aggravated sinus extension into other parts of the sphenoid. Our study demonstrated that the sellar type sphenoid sinus was most common in either gender or each age group. An asymmetrical sphenoid sinus structure was also detected more commonly in the patients with a deviated nasal septum. We concluded that the presence of a deviated nasal septum was associated with sphenoid sinus asymmetry and/or pneumatization, affecting the development of other anatomical structures in the nasal cavity.

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Stability of Orbital Floor Fracture Fixation After Endoscope-Assisted Balloon Placement: Erratum

In the article that appeared on page e669 of the October 2017 issue of the *Journal of Craniofacial Surgery*, a portion of the abstract and Results section were incorrect. In the abstract, the correct text is as follows:
The ratio of change in the maxillary sinus volume (maxillary sinus volume 6 months after surgery/maxillary sinus volume at balloon removal) for all subjects was 0.90 to 1.04 (0.96 ± 0.04, mean $\pm$ SD).

In the Results section, the correct text is as follows:

The maxillary sinus volume for all subjects at the time of balloon removal was 16.13 to 31.79 mL (23.14 ± 4.94, mean $\pm$ SD), whereas the maxillary sinus volume 6 months after injury was 15.55 to 29.36 mL (22.31 ± 4.79, mean $\pm$ SD). The difference in the maxillary sinus volume (maxillary sinus volume upon balloon removal – maxillary sinus volume 6 months after injury), that is, the amount of enlargement in the orbital volume was -1.16 to 2.43 mL (0.83 ± 1.09, mean $\pm$ SD). The ratio of change in the maxillary sinus volume for all subjects was 0.90 to 1.04 (0.96 ± 0.04, mean $\pm$ SD) (Fig. 2).

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