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Original Article

Ear, Nose and Throat Section

Volumetric Analysis of Sphenoid Sinus in Patients with Symptomatic Nasal Septal Deviation: A Cross-sectional Study

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ABSTRACT

Introduction: Nasal Septal Deviation (NSD) is known to influence the anatomy of the paraseptal structures, such as the lateral nasal wall and middle turbinate, thereby causing changes in ethmoid cell volume and maxillary sinus. However, there is not much literature on the influence of NSD on sphenoid sinus volume.

Aim: To evaluate the effect of NSD on the volume of sphenoid sinus.

Materials and Methods: A cross-sectional study was conducted over a period of one year at a tertiary care hospital in Karnataka, India on 45 patients with symptomatic NSD. Diagnostic Nasal Endoscopy (DNE) and Computed Tomography (CT) scans of the nose and Paranasal Sinuses (PNS) were performed on all patients. NSD was classified into three types based on the degree of septal deviation on CT scan. Sphenoid sinus volumes were measured, and the relationship between NSD and sphenoid sinus volume was analysed using OSIRIX software on the MAC system. Statistical analysis was done using the Wilcoxon signed-rank test and the Kruskal-Wallis test.

Results: The mean age of the patients included in the study was 30.89±10.19 years. The male-to-female ratio was 2.75:1. The majority of the patients had NSD to the right (57%). NSD was found to be 1.3 times more frequent on the right-side compared to the left. The angle of NSD ranged between 2.10° and 18°. The majority of the patients were in group I (n=35), while group II and III had seven and three patients, respectively. The total ipsilateral volume was found to be 7.43±3.46 cm^3 and the contralateral volume was 7.98±4.19 cm^3. There was no statistically significant difference between ipsilateral and contralateral sphenoid sinus volumes in the population (p-value=0.781). When each group was compared, no significant difference between the total sphenoid cell volumes on the ipsilateral (p-value=0.557) and contralateral (p-value=0.405) sides of the NSD was seen.

Conclusion: NSD does not affect the volume of the sphenoid sinus, irrespective of the degree of septal deviation.

Keywords: Computed tomography, Nose, Paranasal sinuses, Volume

INTRODUCTION

The sphenoid sinus has always been of special interest to endoscopic and skull base surgeons owing to its strategic location and close proximity to important neurovascular structures like the pituitary gland, internal carotid artery, optic nerve, maxillary and pterygoid nerves. Located within the sphenoid body are two sphenoid sinuses, which are mostly asymmetric and vary in size and shape [1]. The volume of the sphenoid sinus varies based on the age, gender, and ethnicity of the population and is influenced by the type of sinus and pneumatisation variants associated with it [2]. There are several studies reported in English literature on the effect of NSD on the volume of ethmoidal and maxillary sinuses and the possible variation in the osteomeatal complex as a result of this [3-6]. However, there are very few studies on the effect of NSD on the sphenoid sinus [7,8]. A literature review shows the paucity of Indian studies on this topic. Venkatesh G et al., studied 130 CT scans of the nose and PNS at a tertiary care centre in Tamil Nadu to find a correlation between the side deviation of nasal and sphenoid septum. They found that the direction of deviation of the nasal septum could predict the side of deviation of the sphenoid septum [9]. However, they did not study the sphenoid sinus volume on either side of the septal deviation. Present study is probably the only Indian study in this regard. Since embryologically, the nasal septum develops earlier (six weeks of gestation) [10] than the sphenoid sinus, which begins to develop in the 2nd trimester [11], it is possible that the anatomical variation in the form of septal deviation may affect the development and pneumatisation of the sphenoid sinus; therefore, it may affect the volume and may also have a role in the formation of variations within the sphenoid sinus. In this study, the aim was to evaluate the effect of NSD on the volume of the sphenoid sinus.

MATERIALS AND METHODS

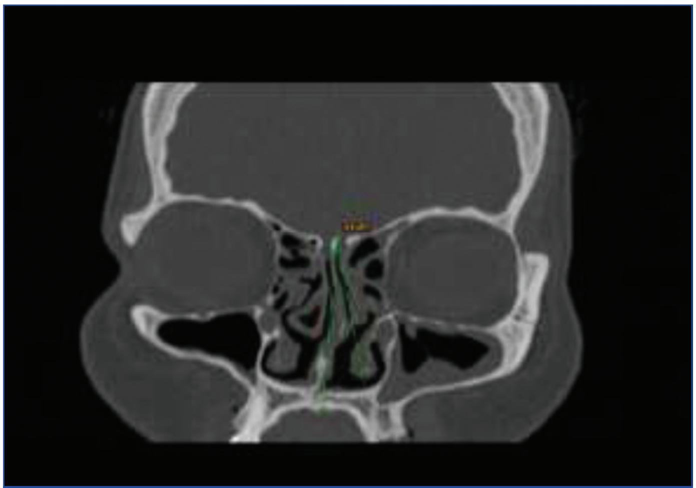
A cross-sectional study was conducted between March 2020 and March 2021 on 45 patients diagnosed with a symptomatic deviated nasal septum at Yenepoya Medical College Hospital, Mangaluru, Karnataka state, India, after obtaining clearance from the Institutional Ethics Committee (IEC) with ethical clearance protocol number YEC 2/264.

Inclusion criteria: Patients above the age of 18 years diagnosed with a symptomatic deviated nasal septum were included in the study.

Exclusion criteria: Patients with a history of previous nasal surgery, the presence of an S-shaped septal deviation on nasal endoscopy, sinonasal trauma, the presence of any maxillofacial anomalies, sinonasal polyposis, mass lesions/tumours of the sinonasal region, acute rhinosinusitis, pregnancy, and those below 18 and above 60 years of age were excluded from the study.

As the study was conducted during the Coronavirus Disease 2019 (COVID-19) pandemic, with fewer patients visiting the outpatient department for routine ENT problems, the sample size was relatively smaller.

A detailed history and ear, nose, and throat examination were carried out. All patients underwent DNE to confirm the presence of NSD and to rule out sinusitis or any other local pathology in the nose. This was followed by a CT scan of the nose and PNS using GE Bright speed 16-slice Multidetector Computed Tomography (MDCT). Axial and coronal cuts were taken with a slice thickness of 1 mm. The CT scan was analysed by the radiologist together with the primary investigator. The angle of deviation of the nasal septum was calculated using a protractor by measuring the angle between the apex of the septal deviation and the plate crossing the anterior nasal spine and crista galli. The method of NSD angle measurement on a coronal CT image is shown in [Table/Fig-1].



[Table/Fig-1]: Coronal CT image showing the method of measurement of Nasal Septal Deviation (NSD) angle.

Patients were grouped based on the NSD angle according to the Elahi MM et al., grading system [12,13].

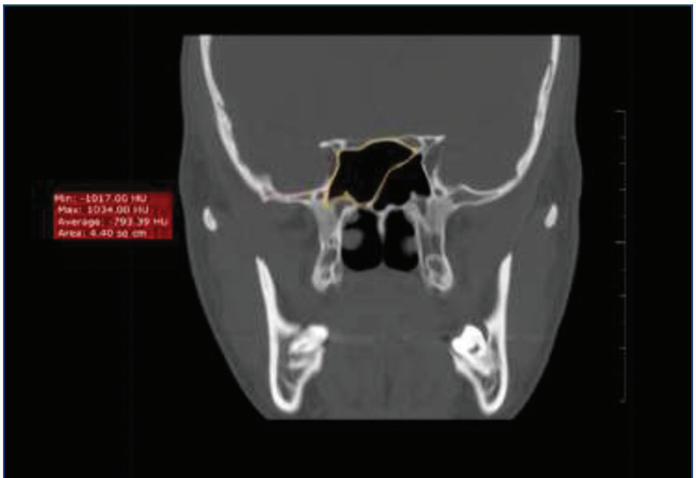
Group I: NSD ≤9°

Group II: 9 < NSD ≤15°

Group III: NSD >15°

Based on the extension of pneumatisation and the degree of exposure of the sella turcica, the sphenoid sinus was classified as Apneumatised-Sinus Agenesis, Conchal-Slightly pneumatised, small sinus not related to sella turcica, presellar-Pneumatisation not extending beyond the vertical plane of sella turcica, Sellar-Pneumatisation of the sphenoid sinus reaching the vertical plane of the clinoid process, involving both the anterior wall and floor of sella turcica, postsellar-Pneumatisation extending beyond sella turcica, reaching the basilar part of the occipital process [14].

Volumetric analysis of the ipsilateral and contralateral sphenoid sinus was done using OSIRIX software on the MAC system [Table/Fig-2].



[Table/Fig-2]: Coronal CT image showing measurement of sphenoid sinus volume.

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) version 20.0 IBM SPSS Statistics (released by IBM Corp. in 2011), was used to perform the statistical analysis. Descriptive statistics for the explanatory and outcome variables were calculated using the mean, median, and interquartile range for continuous variables, and frequency and proportions for categorical variables. Inferential statistics, such as the Wilcoxon signed-rank test, were applied to compare the statistical difference in the volume of the sphenoid sinus with respect to the side of the NSD. The Kruskal-Wallis test was used to compare the mean angle of NSD within the three groups and the volume of the sphenoid sinus within each group. The significance level was set at 5%.

RESULTS

A total of 45 patients were included in the study, of which 33 were males and 12 were females. The male-to-female ratio was 2.75:1. The mean age of the patients included in the study was 30.89±10.19 years. Forty of the patients presented with nasal obstruction as their chief complaint, three presented with a headache, and the remaining two with epistaxis. The majority of the patients, 57.8%, had NSD towards the right (n=26). The angle of NSD ranged between 2.10° and 18°. Patients were divided into three groups according to the severity of their NSD, as previously described. Group I had 35 patients, Group II had seven patients, and Group III had three patients. The NSD angle characteristics of the groups are described in [Table/Fig-3].

Variable	Group I	Group II	Group III
n	35	7	3
%	77.78	15.55	6.67
NSD angle mean±SD (°)	5.50±1.99	10.7±1.15	17.0±1.00
NSD angle range (°)	2.10-9.00	9.50-13.00	16.00-18.00

[Table/Fig-3]: Nasal Septal Deviation (NSD) group characteristics.

The total sphenoid cell volume, independent of group and side of NSD, was 21.9±9.1 cm^3 on the right and 7.19±3.95 cm^3 on the left-side. There was no statistically significant difference between the sphenoid cell volumes between the right and the left-side (p=0.109).

The total ipsilateral volume was found to be 7.43±3.46 cm^3 and the contralateral volume was 7.98±4.19 cm^3. There was no statistically significant difference between ipsilateral and contralateral volumes in the population (p-value=0.781).

When the ratio of ipsilateral and contralateral volume in each group was assessed, there was no statistical difference in the values (p-value=0.220). When the difference between the contralateral and ipsilateral volumes was assessed, there was no statistical difference in the values between each group (p-value=0.236) [Table/Fig-4].

Variable	Group I	Group II	Group III	p-value*
Ipsilateral volume (cm^3)	7.71±3.74	6.01±2.18	7.65±1.54	0.557
Contralateral volume (cm^3)	8.21±4.35	8.14±3.96	4.98±1.78	0.405
V ipsilateral/v contralateral	1.24±1.12	0.93±0.67	1.71±0.76	0.220
V Contralateral-v ipsilateral	0.50±4.59	2.13±4.24	-2.67±2.79†	0.236

[Table/Fig-4]: Comparison of total sphenoid volume characteristics between the groups.
*Kruskal Wallis test was used
†Negative value indicates ipsilateral volume was larger than contralateral

The volume of the sphenoid sinus was analysed using the Wilcoxon signed-rank test in patients with a deviated nasal septum. It was observed that in patients with NSD to the right, the volume reduced on the side of NSD, whereas in cases with NSD to the left, the volume increased on the side of NSD. There was no statistically significant difference in the volume of the sphenoid sinus towards the side of deviation, with a p-value of 0.18 on the left-side and a p-value of 0.25 on the right-side [Table/Fig-5].

The type of sphenoid sinus was also assessed on both the ipsilateral and contralateral sides of NSD. The postsellar type of sinus was found to be the most common on both ipsilateral and contralateral sides of the NSD, followed by the sellar type [Table/Fig-6].

Pneumatisation was seen in 41 sinuses. It was observed that 12 pairs of sphenoid sinuses had a greater volume on the non pneumatised side than on the pneumatised side. Of these, six were of the postsellar type and six of the sellar type. It was also

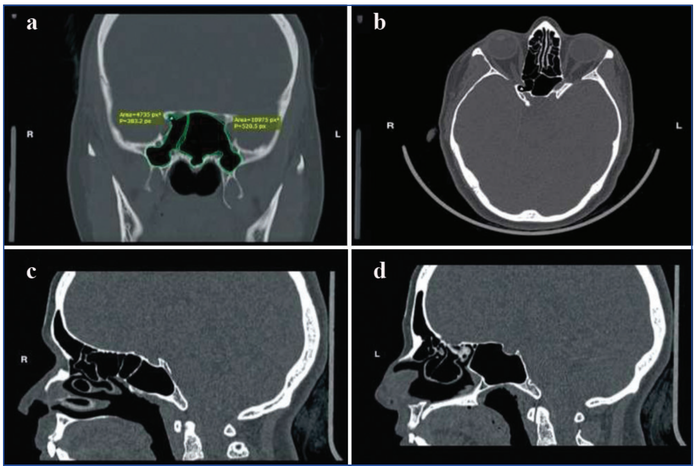
Nasal Septal Deviation (NSD)	Side of sphenoid sinus	N	Minimum	Maximum	Mean	Median	IQR	p-value
Left	Left	19	2.60	14.12	7.41	7.00	3.93	0.18
	Right	19	2.16	14.90	6.35	5.2	5.31	
Right	Left	26	3.20	17.00	8.83	8.04	6.25	0.25
	Right	26	2.60	17.12	7.81	7.00	4.4	

[Table/Fig-5]: Comparison of the mean volume of sphenoid sinus based on the side of Nasal Septal Deviation (NSD) using Wilcoxon sign test.

Side of NSD	Type of sphenoid sinus	Frequency
Ipsilateral	Postsellar	17
	Presellar	14
	Sellar	14
Contralateral	Postsellar	24
	Presellar	7
	Sellar	14

[Table/Fig-6]: Distribution based on the type of sphenoid sinus on the ipsilateral and contralateral sides of Nasal Septal Deviation (NSD) measurement.

found that the postsellar type of sinus had a greater volume without pneumatisation as compared to the sellar type with pneumatisation in the same individual [Table/Fig-7].



[Table/Fig-7]: CT Nose and PNS-coronal (a) and axial (b) views showing the area of right and left sphenoid sinus with anterior clinoid process pneumatisation(*) on the left-side, (c) and (d) are sagittal images showing sellar type of sinus of the right and postsellar type on left-side. The volume of the right and left sphenoid sinus was 7.8 cm^3 and 16 cm^3, respectively.

DISCUSSION

Among the paranasal sinuses, the sphenoid sinus holds the credit for being of special interest to both ENT and skull base surgeons alike, thanks to its strategic location and proximity to important neurovascular structures. It serves as the gateway to access central skull base lesions for the endoscopic endonasal surgeon. The approach is most preferred due to the panoramic view offered by the endoscope, minimal invasiveness, and fewer complications, which significantly reduce morbidity and mortality. Therefore, knowledge of the volume of the sphenoid sinus, the anatomic variations associated with it, and the various factors that may influence the volume, is of great value. The influence of factors such as age, race/ethnicity, gender, side, type of sinus, and pneumatisation variants on the volume of the sphenoid sinus has been extensively studied [2,15].

NSD alters the dynamics of nasal airflow by causing intranasal volume changes between the two nasal cavities, which is compensated for by the paraseptal structures. Firat AK et al., studied the effect of NSD on total ethmoid cell volume and found that the total ethmoid cell volume decreased on the side of the deviation with an increase in the degree of NSD [3].

The present study attempted to evaluate the effect of NSD on the volume of the sphenoid sinus. Embryologically, the sphenoid sinus develops later than the nasal septum. The septum completes its development by 17 years of age, while sphenoid pneumatisation starts after the third year of life, and the sinus reaches mature size by puberty (12-14 years of age) [16]. The nasal septum, being a midline structure, a deviation in the septum could contribute to volume changes in the sphenoid sinus by altering the dynamics of airflow into and out of the sinus.

Orhan I et al., retrospectively analysed CT images of 93 patients in Turkey, using a volume rendering technique automatically using a workstation. They studied the association of volume and type of sphenoid sinus with NSD. They concluded that sphenoid sinus volumes were smaller on the side of NSD as compared to the contralateral side. However, they could find no statistically significant correlation between NSD and sphenoid sinus volume [7]. There was no association between NSD and the volume of the sphenoid sinus in the present study. The degree of NSD also did not show any correlation with the volume characteristics of the sinus.

The most common type of sphenoid sinus was found to be the postsellar type, both on the ipsilateral and contralateral side of NSD. This was probably due to the racial factor-present study was done on the Indian population and, as evidenced by earlier studies, Asians tend to have larger skulls, which explains the higher volume of the sphenoid sinus [17]. The postsellar type is also known to be most prevalent in the Iranian and Brazilian populations [18,19].

In the present study, the postsellar type of sphenoid sinus showed a greater volume compared to the sellar and presellar types. The postsellar type of sinus had a greater volume without pneumatisation compared to the sellar type with pneumatisation in the same individual. This suggests that the volume of the sphenoid sinus depends on the type of sinus and probably pneumatisation does not contribute to a significant increase in volume. However, since present study had a smaller sample size of 45 patients and did not find sinuses with extensive pneumatisation, the role of pneumatisation in determining the volume of the sphenoid sinus cannot be commented. A similar study done by Oliveira JM et al., showed that the volume of the sphenoid sinus was neither influenced by the age nor gender of the individual. According to this study, the volume of the sphenoid sinus was influenced by the type of the sinus and the side (right sinus or left sinus) [18].

Literature review shows that most studies done on volumetric analysis of the sphenoid sinus focused on retrospective analysis of reconstructed CT images of the patients. There are no prospective studies so far correlating symptomatic NSD and sphenoid sinus volume characteristics. Though NSD is a very common condition, the majority of the cases remain asymptomatic and therefore undiagnosed. The advantage of this study was that clinical evaluation of the cases was done by DNE, enabling us to select patients with only symptomatic NSD before performing the CT-based volumetric analysis, allowing for better clinicoradiological correlation.

Limitation(s)

The limitations of present study were that, being a time-bound study with definitive criteria of selection of only symptomatic cases of NSD, our study population was small. Present study included NSD, which was significant enough to cause symptoms. Authors did not take into account the high NSD in these patients, which may have had a bearing on sphenoid sinus volume, since the sinus is located higher up and more posterior to the nasal cavity. This leaves us with a scope for further research on this topic.

CONCLUSION(S)

The postsellar variant was the most common type of sphenoid sinus irrespective of the side of NSD. The volume of the sphenoid sinus depends on the type of the sinus. NSD does not affect the volume of the sphenoid sinus, irrespective of the degree of septal deviation.

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