

Variations of the Nasal Septum in Adult Nigerians: Computed Tomography Study

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Int Arch Otorhinolaryngol 2023;27(2):e240–e247.

Abstract

Introduction The morphological variants of the nasal septum have been implicated in sinus pathology and pose a challenge during endoscopic surgeries.

Objective The present study aimed at evaluating the prevalence of nasal septum variants in adult Nigerians.

Methods The present study was performed at the Radiology Department of Delta State University Teaching Hospital, Nigeria, following ethical approval. Brain computed tomography (CT) scan images of 336 adults were evaluated for nasal septum variants. The angle of the deviated nasal septum was measured, and the severity was classified. Data were analyzed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). The angle of deviation was presented in means and standard deviation. Frequencies of the variants were presented in percentages. The Student *t*-test was used to compare the angle of deviation, while the chi-squared test was used to compare the frequencies in the different groups. A *p*-value < 0.05 was considered statistically significant.

Results The prevalence of straight and deviated nasal septum was 59.5% and 40.5%, respectively. Deviation was predominant in females (46%) and, more frequently, of moderate severity (75%). The angle of deviation was significantly larger in males ($12.55 \pm 2.99^\circ$) than in females ($11.13 \pm 2.41^\circ$; *p* = 0.003). Nasal spur had a prevalence of 11.9%, and its coexistence with deviated nasal septum was observed in 5.06%. Septal pneumatization was seen in 10 patients (3%).

Conclusion Deviation of the nasal septum occurred more in females and toward the left; however, the angle of deviation was significantly higher in males. Nasal septal spur and pneumatization were the least prevalent variants.

Keywords

- ▶ nasal
- ▶ septum
- ▶ variation

Introduction

The nasal cavity (NC), a space in the midface region, is divided into right and left compartments by the nasal

septum (NS), which forms the medial wall of the two cavities. The NS is cartilaginous anteriorly and bony on its posterior part, mainly comprising the perpendicular plate of the ethmoid bone superiorly and the vomer inferiorly.¹ It starts

received
January 9, 2021
accepted after revision
October 4, 2021

DOI <https://doi.org/10.1055/s-0042-1751283>.
ISSN 1809-9777.

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growing at the 6th week of gestation and is completed between 18 and 20 years old.² Therefore, it plays a vital role in the development of the nose and of the paranasal sinuses by giving an epiphyseal platform for the development of the facial skeleton.^{3,4}

The NS is located at the midline mainly up to the age of 7 years old; subsequently, deviation to either the right or the left side may occur.^{5,6} Deviation of the NS is caused by factors such as genetics, trauma, and connective tissue diseases such as Marfan syndrome and Ehlers-Danlos syndrome.⁷ The deviation may occur in the cartilaginous part, in the osseous part, or both, and may be associated with deformities or asymmetry in the adjacent turbinate.⁸ The following patterns of the NS have been documented; straight, deviated to the right, deviated to the left, sigmoidal, and reverse sigmoidal.^{2,9}

Nasal septal spur is an asymptomatic bone deformity that presents as any sharp angulation of the NS at the interface of the perpendicular plate of the ethmoid and the upper surface of the vomer.^{10,11} It is of great clinical importance since it may restrict nasal airflow as well as pose a great challenge during endoscopic surgery.¹² Pneumatization of the NS can occur within the posterosuperior portion of the septum, usually from the extension of air cells from the sphenoid sinus.^{11,12} When extensive, this pneumatization can block the ventilation and drainage of the paranasal sinuses, predisposing to sinus pathology.¹³

Computed tomography (CT) has been adopted largely as the method of choice in the evaluation of the sinonasal region due to its high spatial resolution and increasing availability.¹⁴ There is paucity of data regarding the variations of the NS in Delta State, Nigeria. Therefore, the present study aimed at elucidating the variants of the NS in adult Nigerians using CT.

Objectives

To determine the prevalence of the NS variants of adult Nigerians using CT.

To determine the gender differences in the occurrence of the variants.

To determine the angle and the severity of deviation of the NS.

Materials and Methods

The present cross-sectional retrospective study was performed in the Radiology Department of Delta State University Teaching Hospital, in Oghara, following ethical approval by the Research and Ethics Committee of the Hospital (EREC/PAN/2020/030/0371). The study used brain CT images of 336 adult patients; 199 males and 137 females aged between 20 and 99 years old. These images were taken between June 1st, 2015 to June 30th, 2020 using a 64 slice CT scanner (Toshiba Aquillon, 2009, Japan) for various indications such as intracranial space occupying lesions, stroke, and embolism. Skull CT images of patients aged <20 years old were excluded from the study because the development of the paranasal

sinuses that drain into the nasal cavity is completed at 20 years old.¹⁵ Poor-quality CT images as well as those with artifacts or showing evidence of skull pathological lesions, trauma, and surgery at the face region were excluded from the study. The nasal septum was identified and studied on the 5-mm coronal and axial sections for variants such as deviation, spurs, and pneumatization. The direction of the deviation was recorded, and the angle of the deviation was measured on coronal images by the protractor provided by the Picture Archiving and Communications System, version 12.1 (Clearcanvas PACS, Montreal Canada). This angle was defined between the most deviated point of the septum and the midline. A vertical line from the crista Galli superiorly to the palate inferiorly was defined as the midline (► Fig. 1). The patients were classified based on the severity of the deviation of the NS, and the angle of deviation was classified as mild (< 9°), moderate (9–15°), and severe deviation (> 15°).¹⁶ The location of the nasal spur was noted as either on the right or the left side of the NS.

Data were analyzed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Data were classified according to gender. The age of the patients and the angle of deviation were presented in means and standard deviations (SDs), while the frequency of the variants was presented in percentages. An independent *t*-test was used to determine the differences between males and females. A paired *t*-test was used to evaluate for side differences in the deviation of nasal septum (DNS) angle. The chi-square test was used to evaluate gender differences in the prevalence of variants. A *p*-value < 0.05 was considered statistically

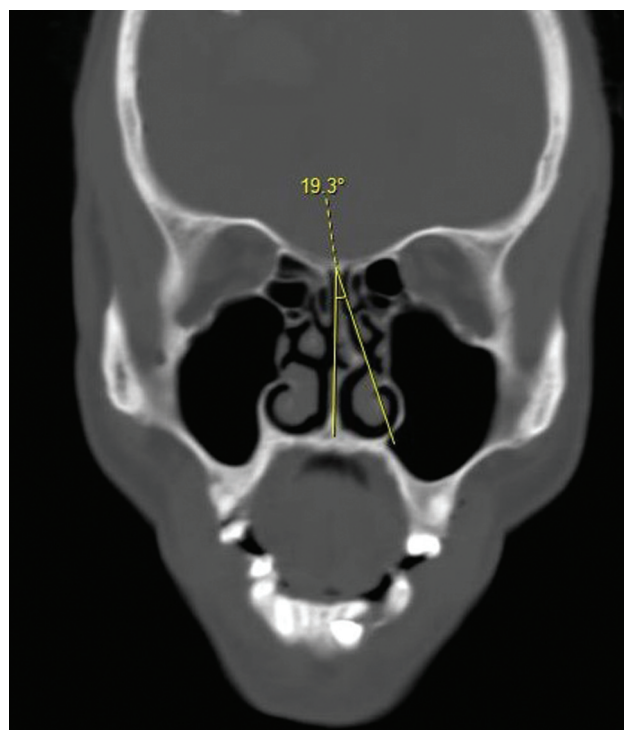


Fig. 1 Reformatted coronal cranial computed tomography image (bone window) showing the measurement of the angle of deviation of the nasal septum.

Table 1 Composition of the study population

Gender	n	Frequency (%)	Age range (years old)	Average age (years old)*
Male	199	59.2	21–93	51.29 ± 17.46
Female	137	40.8	20–99	56.18 ± 18.87
Total	336	100	20–99	53.29 ± 18.18

significant. The NS was classified into the patterns described by Saraswathi and Alana.¹⁷

Results

The present study utilized cranial CT scan images of 336 patients, comprising 199 males (59.2%) and 137 females (40.8%). The age range of these subjects was from 20 to 99 years old, with an average age of 53.29 ± 18.18 years old. The average age in females (56.18 ± 18.87 years old) was slightly higher than in males (51.29 ± 17.46 years old) (►Table 1).

A straight NS was observed in the majority of the patients ($n = 200$; 59.5%) and was more common in males ($n = 126$; 63.3%) than in females ($n = 74$; 54.0%) (►Fig. 2A). However, this did not show any statistically significant gender difference ($p = 0.154$). Deviation of the NS from the midline was seen in 136 subjects (40.5%) (►Fig. 2B and 2C). We report a preponderance of this variant among females ($n = 63$; 46%). The frequency of DNS was lower in males ($n = 73$; 36.7%). Deviation of the NS to the left was slightly more common ($n = 72$; 52.9%) than deviation to the right ($n = 64$; 47.1%). There was a statistically significant gender difference between DNS to the right and DNS to the left ($p = 0.022$ and $p = 0.047$, respectively) (►Table 2). We also report a statistically significant difference between the deviation of the NS to the right and to the left ($p = 0.001$). None of the patients had the sigmoid or reverse sigmoid types of DNS. ►Tables 3 and 4

show the comparison of the prevalence of DNS and NS patterns in different study populations, respectively.

The average angle of deviation of the NS (DNS angle) was $11.89 \pm 2.82^\circ$, being higher in males ($12.55 \pm 2.99^\circ$) than in females ($11.13 \pm 2.41^\circ$). There was a statistically significant gender difference in the DNS angle ($p = 0.003$). Deviation of the NS toward the right occurred at a significantly higher angle ($12.11 \pm 2.55^\circ$) than deviation to the left ($11.54 \pm 2.8^\circ$) ($p = 0.027$). This pattern was also seen in males and females (►Table 5).

Based on the angle of deviation, most patients with DNS ($n = 102$; 75%) had moderate deviation, which was more prevalent in females ($n = 47$; 34.3%) than in males ($n = 55$; 27.6%). Mild deviation was the second most common type ($n = 18$; 13.2%) and, similarly, showed a female preponderance ($n = 13$; 9.5%) when compared with their male counterparts ($n = 5$; 2.5%). These 2 severities of deviation showed statistically significant gender differences ($p = 0.024$; $p = 0.043$). The severe form of DNS was the least prevalent ($n = 16$; 11.8%) and more common in males ($n = 13$; 6.53%) than in females ($n = 3$; 2.2%); however, the gender difference was not statistically significant ($p = 0.168$).

Nasal septum spur was seen in 40 (11.9%) subjects, including 21 (10.6%) males and 19 (13.9%) females. In 24 (60%) and 16 (40%) of these cases, the spur was located on the right and left sides, respectively. The spur was located on the right side of the NS in 11 males (5.5%) and 13 (9.5%) females.

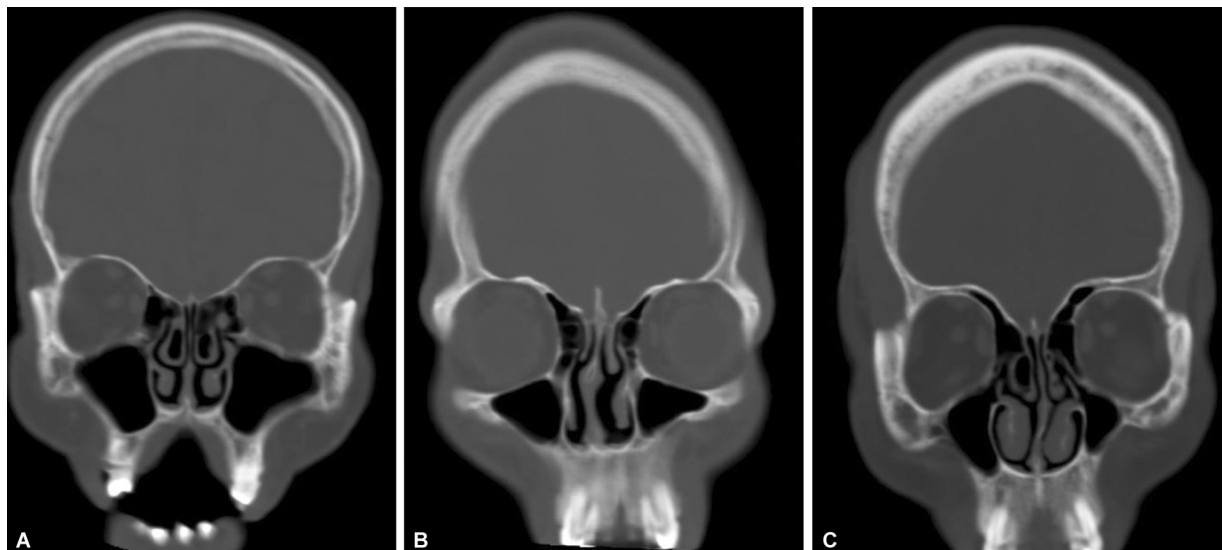


Fig. 2 Reformatted coronal cranial computed tomography images (bone window) depicting different patterns of the nasal septum (A): Straight nasal septum; (B): Deviation to the right; (C): Deviation to the left.

Table 2 Prevalence of deviation of the nasal septum

DNS	To the Right		To the Left		Total prevalence	
	n	%	n	%	n	%
Male	36	18.1	37	18.6	73	36.7
Female	28	20.4	35	25.5	63	46
Total	64	47.1	72	52.9	136	40.5
<i>p</i> -value	0.022		0.047			

Abbreviation: DNS, deviation of the nasal septum.

Table 3 Comparison of deviation of the nasal septum in different countries

Author	Country	n	DNS (%)
Earwaker, ⁵	Australia	800	44
Baradaranfar and Labibi ²¹	Iran	120	45
Adeel et al. ¹⁸	Pakistan Asia	77	26
Al-Abri et al. ²⁴	Oman	360	80
Shpilberg et al. ¹⁹	New York	192	98.4
Kaya et al. ²²	Turkey	350	89.7
Onwuchekwa et al. ¹	Nigeria	110	20.91
Abhishek et al. ³	India	77	32
Simoes et al. ²⁵	Brazil	1005	80.7
Alshaikh et al. ¹¹	Saudi	291	38.8
Yazici ²³	Turkey	225	55.1
Hadi et al. ²⁰	Iraq	75	72
Shokri et al. ¹²	Iran	250	90.4
Kantun et al. ²⁶	Mexico	110	38.2
Present study	Nigeria	336	40.5

Abbreviation: DNS, deviation of the nasal septum.

The left sided NS spur had a slightly higher prevalence in males (10, 5.0%) than in females (6, 4.4%). However, the gender differences of this variant were not statistically significant ($p=0.166$ and $p=0.785$ on the right and left sides, respectively) (►Fig. 3A and ►Table 6). The side differ-

ence in the occurrence of NS spur was also not statistically significant ($p=0.256$). The comparison of the prevalence of NS spur in various study populations is shown on ►Table 7. We observed the coexistence of DNS with NS spur in 17 subjects (5.06%), with a higher incidence in males ($n=11$; 5.5%) than in females ($n=6$; 4.4%), although the gender difference was not statistically significant ($p=0.356$). Pneumatization of the NS was seen in 10 patients (3%), with similar prevalence in males (3%) and females (2.9%); therefore, no statistically significant gender difference was established ($p=0.960$) (►Fig. 3B).

Discussion

We report straight midline NS in 59.5% of our study population, with a higher incidence in males (63.3%) than in their female counterparts (54%). However, this gender difference was not statistically significant ($p=0.154$), implying that gender does not influence the existence of a straight NS. Lower incidences of straight NS, such as 33.75, 40.9, and 50% have been reported in the Indian population by Saraswathi et al.,⁹ Verma et al.,⁷ and Saraswathi et al.,¹⁷ respectively (►Table 4). The prevalence of straight NS could be higher in our study probably due to the differences in race and geographical location.

The frequency of deviation of the NS from the midline was 40.5%, which was higher than the 20.91% documented by Onwuchekwa et al.¹ among adult Nigerians in Rivers State. This was probably due to the differences in the populations studied. Similarly, Abhishek et al.³ and Adeel et al.¹⁸ reported a lower prevalence of DNS in the Indian (32%) and Pakistani (26%) populations. These low incidences may be ascribed to the consideration of only severely angulated NS that blocks almost half of the nasal cavity and impinges on adjacent structures or to strict criteria of definition involving deviation > 1 mm or > 4 mm.^{11,19,20} Studies from other countries revealed higher frequencies of DNS compared with our findings. Wide ranges of 55.1 to 89.7% and of 45 to 90.4% were documented in Turkey and Iran, respectively, and these may suggest possible differences within a population group.^{12,21-23} Studies performed in Oman and Iraq reported a prevalence of 80 and 72%, respectively.^{20,24} Among Australians, Earwaker⁵ reported a prevalence of 44%, while the

Table 4 Comparison of the nasal septum patterns in different populations

Author	Verma et al. ⁷	Saraswathi and Vijayan ⁹	Saraswathi and Alana ¹⁷	Present study, 2020
Country	India	India	India	Nigeria
n	149	80	100	336
Type of NS pattern	%	%	%	
Straight	40.9	33.75	50	59.5
DNS to the right	8.05	30	11	19
DNS to the left	2.7	22.5	12	21.4
Sigmoid	20.1	5	4	0
Reverse sigmoid	28.2	8.75	3	0

Abbreviation: NS, nasal septum.

Table 5 Angle of deviation of the nasal septum

DNS angle	Total sample	Females	Males	<i>p</i> -value
Average	11.89 ± 2.82°	11.13 ± 2.41°	12.55 ± 2.99°	0.003
DNS to the right	12.11 ± 2.55°	11.35 ± 2.31°	12.87 ± 2.43°	0.041
DNS to the left	11.54 ± 2.8°	10.96 ± 2.44°	12.12 ± 2.53°	0.038

Abbreviation: DNS, deviation of the nasal septum.

majority of the American population possessed this variant (98.4%).¹⁹ The frequency range in Latin Americans was from 38.2% in Mexicans to 80.7% in Brazilians (► **Table 3**).^{25,26} This wide variation in the prevalence of DNS has been accredited to genetic, geographical, and environmental factors as well as to discrepancies in the definition of DNS based on the degree of arcing and extent of NC obstruction.^{11,20} Some studies consider any arcing of the septum, either osseous, cartilaginous, or osseocartilaginous, while some may consider it normal rather than a variant of normal.^{11,18}

We report a female preponderance of DNS ($n = 63$; 46%) (► **Table 2**). Deviation to the left was more prevalent (52.9%) than to the right (47.1%), with the incidences of both types being significantly higher in females (25.5 and 20.4%) than in males (18.6 and 18.1%) ($p = 0.022$; $p = 0.047$). These findings imply that gender plays a role in the existence of

deviation of the NS and its high frequency in females may suggest the influence of hormones as well as of genetic composition. The predominance of DNS to the left was similarly documented among Iranians and Indians.^{17,27,28} On the other hand, the predominance of DNS to the right has been reported in Australia, Malaysia, Saudi Arabia, Turkey, and India.^{5,7,9,16,23,29–31} Deviation to the right was equal to DNS to the left among Indian subjects.³

We did not observe any sigmoid and reverse sigmoid shapes of the nasal septum, which contrasts reports by Saraswathi and Vijayan,⁹ Saraswathi and Alana,¹⁷ and Verma et al.⁷ in India. A low prevalence of sigmoid shaped and reverse sigmoid NS was documented by Saraswathi and Vijayan.⁹ (5 and 8.75%, respectively) and Saraswathi and Alana.¹⁷ (4 and 3%, respectively) (► **Table 4**). Conversely, the Indian population studied by Verma et al.⁷ had higher

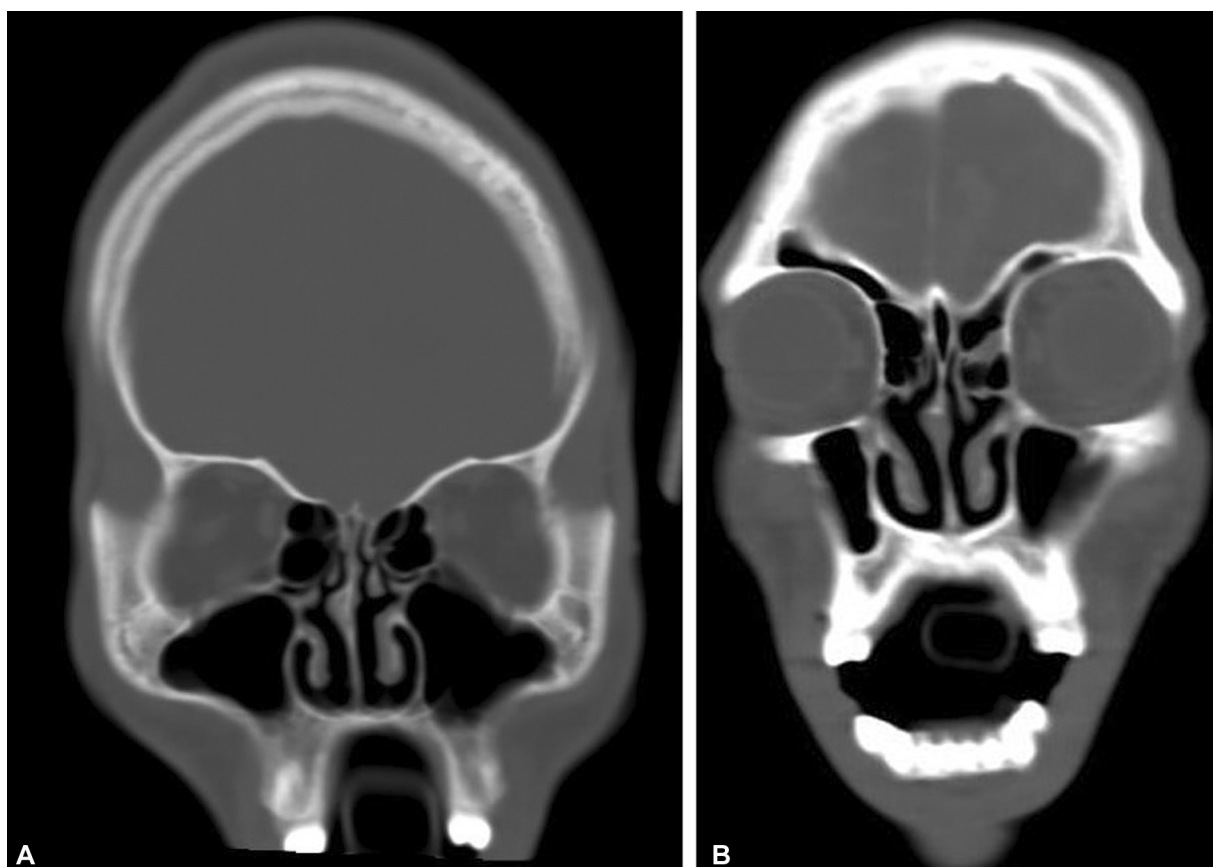


Fig. 3 Reformatted coronal cranial computed tomography image (bone window) demonstrating (A): Nasal septal spur; (B): Pneumatization of the nasal septum.

Table 6 Prevalence of nasal septum spur

Variant		Right		Left		Total prevalence	
		n	%	n	%	n	%
NS spur	Male	11	5.5	10	5.0	21	10.6
	Female	13	9.5	6	4.4	19	13.9
	Total	24	60	16	40	40	11.9
	p-value	0.166		0.785			

Abbreviation: NS, nasal septum.

Table 7 Prevalence of nasal septum spur in different populations

Author	Country	n	NS spur (%)
Earwaker ⁵	Australia	800	3.25
Shpilberg et al. ¹⁹	New York	192	32.3
Chandel et al. ⁸	India	120	11.6
Hadi et al. ²⁰	India	75	32
Alshaikh and Aldhuraïs ¹¹	Saudi	291	32
Shokri et al. ¹²	Iran	250	34.8
Gungor and Okur ³⁴	Turkey	320	43.8
Mohammed et al. ¹⁴	Saudi	392	29.3
Nadwi et al. ²⁹	India	86	46.8
Current study	Nigeria	336	11.9

Abbreviation: NS, nasal septum.

incidences of sigmoid and reverse sigmoid NS (20.1 and 28.2%, respectively). These findings may infer the existence of differences among individuals within the same population group. The absence of these two patterns in our population shows that the difference in race, geographical location, environment, and genetics may perhaps play a role in the development of sigmoid and reverse sigmoid NS.

The average DNS angle in our study was $11.89 \pm 2.82^\circ$, with males having significantly higher angles ($12.55 \pm 2.99^\circ$) than females ($11.13 \pm 2.41^\circ$) ($p = 0.003$). This suggests that gender has a great influence on the DNS angle. In contrast, Serifoglu et al.¹⁶ documented a higher DNS angle in Turkish females (14.18°) than in their male counterparts (13.88°). These angles were higher than our findings; furthermore, they did not establish a statistically significant gender difference ($p = 0.660$). This, therefore, suggests that the extent of deviation varies in different populations and geographical areas, as well as races. Findings from our study revealed that the deviation of the NS to the right occurred at a significantly higher angle ($12.11 \pm 2.55^\circ$) than deviation to the left ($11.54 \pm 2.8^\circ$; $p = 0.027$), unlike the reports by Serifoglu et al.,¹⁶ who documented a slightly higher incidence of deviation to the left (14.05°) than to the right (13.1°); however, this was not statistically significant. This discrepancy could be ascribed to the differences in the number of CT images of patients with DNS evaluated, since Serifoglu et al.¹⁶ used

more images ($n = 203$) than the number used in our study ($n = 136$). Furthermore, this difference may probably suggest that the direction of deviation may influence the degree/severity in some population groups based on different genetic makeup and different environmental factors.

Moderate DNS was the most prevalent type (75%), followed by mild DNS (13.2%), with both having a statistically significant female preponderance (34.3%; $p = 0.024$ and 9.5%; $p = 0.043$). Severe DNS had the lowest incidence (11.8%) and was more common in males (6.53%) than in females (2.2%). The gender difference was not statistically significant ($p = 0.168$). This trend was similarly described in the Indian population by Bagri et al.⁶ with an almost equal incidence of 35.4, 33.1, and 31.5% for moderate, mild, and severe deviation, respectively. However, these authors used a different grading scale of $< 7^\circ$, between 7.1 and 11° , and $> 11^\circ$ for mild, moderate, and severe deviation, respectively. On the other hand, Serifoglu et al.,¹⁶ in their study among the Turkish, used the same grading system utilized in our study but reported a different trend comprising severe deviation as the most predominant type (40.9%), followed by moderate deviation (37.9%), and, lastly, mild deviation (21.2%). This discrepancy could be ascribed to the differences that exist in populations, differences in the number of CT images with DNS evaluated, as well as different environmental factors in various geographical locations that may influence the airflow dynamics within the NC, hence affecting the degree of deviation of the NS.

An increase in the DNS angle is commonly associated with concha bullosa and inferior turbinate hypertrophy on the contralateral side; therefore, the presence of a large angle of deviation requires further evaluation for the presence of these other variants.⁶ A severe deviation can cause resultant compression of the structures on the lateral wall of the nasal cavity, including the nasal turbinates and meatus.¹ This leads to the narrowing of the infundibulum with resultant obstruction of the osteomeatal complex, consequently impairing the normal mucous flow and drainage.^{16,29,30,32} This ultimately predisposes to recurrent inflammation and infection of the maxillary, frontal, and anterior ethmoid paranasal sinuses, which drain mainly through the middle meatus.¹⁹ Furthermore, some studies have demonstrated a significant association between DNS and chronic rhinosinusitis (CRS).³³ Severe deviation may influence the volume of the maxillary sinus, further predisposing to maxillary sinus pathology.⁶ Awareness of the severity of DNS in a patient may, therefore, explicate recurrent symptoms of recurrent rhinosinusitis or chronic rhinosinusitis such as sleep apnea, repetitive sneezing, nose bleeding, and difficulty in breathing.¹⁶

We observed NS spur in 11.9% of the subjects, which was almost similar to the prevalence of 11.6% among Indians reported by Chandel et al.⁸ In contrast, another study among Indians documented a high incidence of 46.8%, which may suggest the existence of variations in the prevalence of NS spur within a given population.³⁰ Earwaker⁵ documented a lower frequency of 3.25% in Australians. Higher incidences of 32, 32.3, 34.8, and 43.8% have been documented by studies performed in Iraq, America, Iran, and Turkey, respectively.^{12,19–21,34} Among Saudi Arabians, the range

varied from 29.3 to 32%^{11,14} (► **Table 7**). These discrepancies may depict that NS spur varies in different geographical regions due to variations between different populations. Our study found no statistically significant side ($p = 0.256$) and gender ($p = 0.166$; $p = 0.785$) differences in the prevalence of NS spur, thus implying that its occurrence is not influenced by gender predilection or by the side of its location. Understanding the prevalence of NS spurs is important to surgeons before endoscopic procedures through the nose, such as trans-sphenoidal pituitary surgeries and functional endoscopic sinus surgeries (FESS). This may help the surgeons to know what challenges to anticipate during the procedure and plan for appropriate approaches and maneuvers to overcome them.³²

The concomitant occurrence of DNS along with a septal spur was observed in 5.06% of the patients, with a higher prevalence in males (5.5%) than in females (4.4%). However, this gender difference was not statistically significant ($p = 0.356$). Among Turkish, Australians, Indians, Brazilians, and Iranians, the incidence of both DNS and a septal spur was 8.2, 15.25, 29, 33.4, and 36%, respectively,^{5,6,12,22,25} which were higher than the findings of our study, perhaps due to genetic and population differences. The knowledge of the coexistence of these two variants in our population may expound on the pathophysiology of CRS.³³ This is because the co-occurrence of a severe DNS and a large NS spur may lateralize the middle concha, compromising the OMC by impinging onto the middle meatus, leading to obstruction of mucous flow with subsequent rhinosinusitis.^{11,22}

We report pneumatization of the NS in 3% of the patients with an almost similar incidence in males (3%) and females (2.9%). This low incidence was correspondingly reported by Dasar et al.³² in the Turkish population. Conversely, a higher incidence of 76% was reported in Americans by Shpilberg et al.²⁰ Among the Saudi Arabians, the incidence was reported to range from 5.8 to 15%.^{11,35} Among Indians, this variant showed a frequency ranging from 6.5 to 39.9%.^{13,36} Its incidence among Iranians was reported to be 40%.¹² This, therefore, implies that the extension of the sphenoid sinus air cells into the posterior part of the NS varies between different population groups as well as within individuals of the same population, which could be attributed to geographical, environmental, and genetic differences. It is paramount for clinicians, surgeons, and radiologists to know the incidence of this variant in the population, since an extensive pneumatization of the NS can block the ventilation and drainage of the middle meatus, hence predisposing to sinus pathology.¹³ A diseased NS air cell may resemble an encephalocele on CT; therefore, they may be misleading. In these cases, therefore, magnetic resonance imaging (MRI) is of utmost importance for a definitive diagnosis.¹¹

Conclusion

Deviation of the NS occurred more in females and toward the left, although the angle of deviation was significantly higher in males. Nasal septal spur and pneumatization were the least prevalent variants. We recommend further studies to

evaluate the association of these variants with CRS and their impact on endoscopic surgery in Nigeria.

Conflict of Interests

The authors have no conflict of interests to declare.

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