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ORIGINAL ARTICLE

Computed Tomography Analysis of the Nasal Septal Deviation and Related Paranasal Sinus Pathologies

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Abstract

Purpose: Nasal Septum Deviation (NSD), which is defined as a dislocated septum, is a prevalent condition that is mostly asymptomatic; however, it can cause difficulties such as nasal obstruction and rhinosinusitis symptoms. Other Paranasal Sinuses (PNS) disorders, e.g., Osteo Meatal Complex (OMC) obstruction, have been assumed to be correlated with NSD. This study investigates the possible correlation of specific radiological findings of PNS pathologies in patients with or without the existence and direction of NSD. We also discussed the different types of NSD and their incidence among different groups stored by age, gender, etc.

Materials and Methods: This is a cross-sectional study conducted at multiple imaging centers in Iran between July 2019 and February 2020 to estimate the prevalence of deviated nasal septum and correlate between NSD and other findings using paranasal sinus scans. All the individuals who met the inclusion and exclusion criteria were included in the study. NSD types have been classified based on Mladina's method.

Results: We prospectively reviewed PNS Computed Tomography (CT) scans obtained from 254 cases (82 men and 172 women), aged 18 to 81 years (mean: 35.53), evaluated over seven months. Out of 254 cases, 135 (53 %) patients had NSD, without any direction predominance (right-sided vs. left-sided), and equally distributed between genders. The most common NSD types were type V with a frequency of 42.22% and type III with a frequency of 24.44%. Other PNS CT findings were also investigated in our patients, like OMC obstruction, pansinusitis, mucocele, air-fluid level, mucosal thickening, and concha bullosa. There was no statistically significant correlation between any of these pathologies and NSD (P-value > 0.05).

Conclusion: Although NSD was observed in more than half of our cases' PNS CTs, there was no significant correlation between NSD and other findings in most subjects. This reveals that the effectiveness of septal repair surgeries in relieving patients' symptoms might not be as high as expected.

Keywords: Nasal Septal Deviation; Paranasal Sinuses; Paranasal Sinus Computed Tomography.

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1. Introduction

Nasal Septum Deviation (NSD) refers to the septum convexities to one side, accompanied mainly by the midline structures' deformities. Misalignment of both bone and cartilage of the nasal septum is common. Despite the uncertainty of NSD's true prevalence, numerous recent studies have evaluated it as high as 90% in adults [1]. Even though NSD's role in Ears, Nose, and Throat (ENT) disorders such as sinus pathologies is still undetermined, it is a prevalent complaint among patients presenting to ENT clinics (reported up to 62%) [2]. Genetics, trauma, and septal developmental abnormalities are the main factors leading to NSD [3]. NSD can be asymptomatic or cause nasal obstruction and rhinosinusitis symptoms (such as nasal congestion, facial pain, and postnasal drip) [4]. NSD is also associated with a higher incidence of Osteo Meatal Complex (OMC) obstruction, sleep apnea, nose bleeding, and respiratory problems [5].

Moreover, NSD can disrupt normal nose physiology by increasing the conchae volume. In addition to nose obstruction, swollen conchae have a compressive effect on surrounding structures, and by distorting drainage pathways, it leads to mucosal system blockage and secondary infections in all Paranasal Sinuses (PNS) [6]. PNS disorders include a wide range of pathologies, such as benign and malignant lesions, inflammation, and neoplasms [7]. The surrounding bone structures hinder the PNS examination. As a result, in order to confirm the clinical diagnosis of PNS lesions, imaging plays an indispensable role. For instance, Computed Tomography (CT) is an essential diagnostic tool for patients complaining about PNS conditions. Not only CT scan facilitates the diagnosis, but also it can determine the distribution and extent of PNS lesions [8]. Herein, we reviewed the PNS CT scan of 254 patients referred by the specialist in order to investigate the possible incidence of certain radiological findings of PNS pathologies in patients with or without NSD. The most common complaints or patients' referral reasons were pre-operative workups for cosmetic surgeries (42.12%) and headaches (32.28%). In addition, we aimed to study the common or uncommon PNS anatomic variations and correlate them with the presence of NSD. Finally, we discussed the different types of NSD and their incidence among different groups stored by age, gender, etc.

This study is significant because it helps understand the prevalence of different types of NSD and sinus conditions in a population. This information can aid in the diagnosis and treatment of such conditions, leading to improved patient outcomes and avoiding unnecessary surgeries like rhinoplasty because of NSD. Further, CT analysis provides a detailed and accurate assessment of these conditions, which allows for better planning and execution of medical or surgical interventions.

2. Materials and Methods

This prospective cross-sectional study was conducted at 5 Azar Hospital and other imaging centers in Gorgan between July 2019 and February 2020. The study population included all PNS scans requested by the specialist.

For the study, a non-contrast PNS CT scan with axial and coronal images was used, and the scan parameters were as follows:

- patient position: supine
- scout: perpendicular to the hard palate
- tube voltage and tube current: 125 kV and 80-160 mAs respectively
- scan extent: from the hard palate to above the end of the frontal sinuses
- scan direction: caudocranial
- scan geometry: field of view (FOV): 140-160 mm, slice thickness: 0.625-1.0 mm
- reconstruction kernel: bone kernel (e.g. 24000 HU), soft tissue kernel (e.g. 150 to 400 HU)
- multiplanar reconstructions: coronal and axial images

All scans were performed using a Siemens, Somatom emotion spiral 16 CT machine and examined by an expert radiologist and a trained radiology resident. An ENT specialist was consulted in cases where the resident and supervisor disagreed. The only inclusion criterion was the age older than 18 years, and the exclusion criteria were:

1. The presence of a suspected malignant lesion
2. Evidence in favor of surgical or medical interventions in the sinuses or nasal septum
3. The presence of more than one PNS scan in the database, which indicates a possible surgical or medical intervention at the site. In this case, only the initial image was considered for examination, and the following images were excluded

4. Deformity and evidence of recent direct trauma and bone fracture

Finally, 254 individuals were qualified for the study. PNS images were used to estimate the prevalence of Mladina's seven types of deviated nasal septum [9], the direction of the deviation of the situation of OMC (open or close), pansinusitis, mucocele [10], air-fluid level, mucosal thickness, and concha bullosa [11]. In order to classify the NSD type, we employed Meladina's method as follows:

- Type 1 is a vertical ridge in the valve area that does not extend to the nasal dorsum.
- Type 2 is characterized by a unilaterally vertical ridge that contacts the nasal valve, impairing its functionality.
- Type 3 has a vertical ridge in the deeper areas.
- Type 4 is an "S"-shaped deformity reaching the nasal dorsum. In type IV whichever side is anterior deviation is marked L or R.
- Type 5 is characterized by an almost flat septum on one side along with a basal horizontal spur at the base.
- Type 6 is characterized by a horizontal groove in the anterior septal region on one side and a ridge formed from a wing of intermaxillary bone on the contralateral side.
- A septum of type 7 has a lot of diversity (so-called "crumpled" septum).

There may be multiple ridges intrapositioned at different angles, oblique planes, broken surfaces, etc. Usually, it is a combination of some previously described types of septum deformities.

In this study, demographic variables were documented by a data collection form filled out based on the information in the patients' records. The data collection form included various variables such as age, sex, NSD, OMC obstruction, etc.

2.1. Data Analysis

Statistical analysis was performed using the Stats models package in the Python programming language [12]. In terms of the demographic characteristics of individuals, descriptive statistics were utilized to compute the mean and the standard deviation. Before analyzing quantitative data, the normal distribution of data was assessed using the Shapiro-Wilk test. Each hypothesis was analyzed by the Chi-Square test. For all tests, a significant level of 0.05 was considered.

3. Results

3.1. NSD

In total, 254 cases have participated in this study. The subjects' mean age was 34.33 years, and their age range was 18 - 81 years old. There were 82 (32.3 %) males and 172 (67.7 %) females among the participants. Out of 254 cases, 135 (53%) cases were diagnosed with NSD, and the most common types were type V with a frequency of 42.22% and type III with a frequency of 24.44% (Figures 1 A and B, respectively). The distribution of NSD types is presented in Table 1. Considering the direction of NSD (NSD arrow), there was a relatively equal distribution on the right and left sides with a frequency of 61(45.1%) and 63(46.6%), respectively.

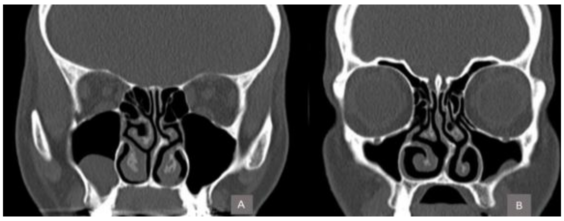

Figure 1. In this figure, non-enhanced coronal PNS CT scan images are used to illustrate two different types of NSD. A: Type V NSD (which is characterized by a severe deviation of the nasal septum that causes significant blockage of one or both nasal passages.) B: Type III NSD (which is characterized by a moderate deviation of the nasal septum that causes partial blockage of one or both nasal passages.)

Table 1. Prevalence of different NSD types

NSD type	Frequency	Percentage
V	57	42.22
III	33	24.44
II	14	10.37
I	13	9.63
IV	11	8.15
VI	7	5.19
VII	0	0

3.2. Other Radiological Findings

In addition to NSD, other radiological findings were also assessed on patients' PNS CT scans, including OMC obstruction, pansinusitis, mucocele, air-fluid level, mucosal thickening, and concha bullosa. In this study, we intended to investigate the correlation between these abnormalities and NSD. As a result, the distribution of cases with these abnormalities divided concerning NSD presence and their corresponding P-value (obtained from the Chi-squared test) are presented in Table 2. As depicted, there is no significant relationship between any of these pathologies and NSD (P > 0.05).

Table 2. The frequency of structural abnormalities and variants in patients with NSD

Radiological findings	Total	NSD Positive	NSD Negative	P-value
OMC obstruction Positive	21	11	10	0.76
Pansinusitis Positive	16	8	8	0.99
Mucocele Positive	12	4	8	0.51
Air-fluid level Positive	22	9	13	0.72
Mucosal thickening Positive	98	40	58	0.16
Concha bullosa Positive	139	59	80	0.156

3.3. Demographic Data

The recorded demographic data consists of age and gender. The possible correlation of demographic data with the presence of PNS abnormalities is listed in Table 3. Also, Table 3 consists of a dedicated part for each radiological finding (NSD, OMC. obstruction, …).

The following information is presented in each part of this table:

1. In order to study the age factor, the mean value and the age range of the patients with corresponding radiological findings are reported. In addition, patients were divided into three different age ranges ((18-30), (30-55), and > 55). Afterward, a Chi-squared test between the age group and the presence of each radiological finding was carried out, and the outcoming P-value is reported in the age row under the P-value column.
2. In order to study the gender factor, the number of patients with the corresponding radiological finding and their percentage relative to the total cases diagnosed with the mentioned pathology is noted separately for both genders. Additionally, a Chi-square test between the gender and pathologies was carried out, and the resulting P-values are reported.
3. For each radiological finding, the patients can be classified into subgroups based on specific pathology types. Table 3 consists of the number of patients in each of these subgroups for the corresponding PNS abnormality.

As depicted, there was a statistically significant difference between the age groups for obstruction of OMC and mucosal thickening (P < 0.05). The prevalence of these two findings evidently increases with age. Nevertheless, no significance was reported for other radiological findings. Furthermore, there were statistically significant differences between the genders considering the presence of mucosal thickening, concha bollusa, and pansinusitis (mucosal thickening and concha bollusa were more prevalent in females, and the opposite was observed for pansinusitis) (P < 0.05). However, no significance was observed for NSD, OMC obstruction, mucocele, and air-fluid level versus gender (P > 0.05) Table 3.

3.4. Correlation between Sinusitis and NSD

Considering the frequency of pansinusitis in patients with and without NSD, the incidence of pansinusitis was equal (50%), which confirmed no statistically significant relationship between NSD and pansinusitis (P > 0.05) Table 4.

3.5. Distribution of Anatomical Variations

In this section, the possible correlation between characteristics of the recorded radiological findings (i.e., their direction) was evaluated against the NSD direction. For each pathology except NSD, patients were divided into four subgroups: 1. Right-oriented pathology, 2. Left-oriented pathology, 3. Bilateral pathology, 4. Absence of pathology. The frequency of patients in each of these subgroups against NSD directions (1. right-arrowed NSD, 2. left-arrowed NSD, and 3. Without NSD) is presented in Table 5.

Table 3. Prevalence and age/gender distribution of some PNS CT findings depicted in correlation with their type

Presence of NSD (135 cases)			P-value	Significance
Age	Mean Range	35.53 (18 – 81)	0.69	No
Gender	Female Male	84(62%) 51(38 %)	0.06	No
NSD direction	Right Left Type IV (anterior)	61(45%) 64(48%) 10(7%)		
Obstruction of OMC (21 cases)			**P-value**	**Significance**
Age	Mean Range	45.95 (18 – 81)	0.01	Yes
Gender	Female Male	11 (52%) 10 (48%)	0.18	No
Presence of mucocele (12 cases)			**P-value**	**Significance**
Age	Mean Range	35.41 (19 – 56)	0.8	No
Gender	Female Male	7 (59%) 5 (41 %)	0.69	No
Type	Ethmoidal Sphenoidal Maxillary	1 (8.5%) 1 (8.5%) 10 (83%)		
Presence of air-fluid level (22 cases)			**P-value**	**Significance**
Age	Mean Range	46.4 (19 – 81)	1.7	No
Gender	Female Male	12 (54%) 10 (46%)	0.25	No
Type	Frontal Ethmoidal Sphenoidal Maxillary	4 (13%) 2 (7%) 4 (13%) 20 (67%)		
Presence of mucosal thickening (139 cases)			**P-value**	**Significance**
Age	Mean Range	38.74 (18 – 75)	0.00	Yes
Gender	Female Male	79 (57 %) 60 (43%)	0.049	Yes
Type	Frontal Ethmoidal Sphenoidal Maxillary	41 (16%) 57 (22 %) 42 (16%) 116 (46%)		
Presence of concha bollusa (96 cases)			**P-value**	**Significance**
Age	Mean Range	35.55 (18 – 75)	0.28	No
Gender	Female Male	72 (75%) 24 (25%)	0.00	Yes
Type	Lamellar Bulbar Extensive	41(40%) 45(43%) 18(17%)		
Presence of pansinusitis(16cases)			**P-value**	**Significance**
Age	Mean Range	42.75 (19 – 68)	0.06	No
Gender	Female Male	6 (37%) 10 (63 %)	0.02	Yes

Table 4. Relationship of NSD and pansinusitis

Radiological finding		NSD (135 cases) Present	Absent	P-value	Significance
Pansinusitis(16cases)	Present	8	8	0.99	NO
	Absent	111	127		

Table 5. Frequency of some PNS CT findings in patients with and without NSD grouped by type/direction

Radiological findings		NSD Right	NSD Left	NSD Absent	P-value	Significance
OMC obstruction	Right	0	1	2	4.6	No
	Left	0	1	4		
	Bilateral	5	3	5		
	Absent	56	59	118		
Radiological findings		**NSD Right**	**NSD Left**	**NSD Absent**	**P-value**	**Significance**
Mucocele	Right	2	2	2	0.62	No
	Left	1	2	2		
	Bilateral	0	1	0		
	Absent	58	59	125		
Radiological findings		**NSD Right**	**NSD Left**	**NSD Absent**	**P-value**	**Significance**
Air-fluid level	Right	2	3	1	0.53	NO
	Left	2	2	2		
	Bilateral	3	1	6		
	Absent	54	58	120		
Radiological findings		**NSD Right**	**NSD Left**	**NSD Absent**	**P-value**	**Significance**
Mucosal thickening	Right	8	8	12	0.72	No
	Left	3	10	7		
	Bilateral	20	26	45		
	Absent	30	20	65		
Radiological findings		**NSD Right**	**NSD Left**	**NSD Absent**	**P-value**	**Significance**
Concha bullosa	Right	5	8	8	0.32	No
	Left	7	6	6		
	Bilateral	11	16	29		
	Absent	38	34	86		

In the comparative study, the NSD direction did not significantly impact any measured anatomical variants of other radiological findings (P > 0.05). This insignificance was observed both in total cases and in cases sorted by the direction of pathology.

Based on PNS scans, OMC obstruction was identified in 8% (n = 21) of cases. It was right-sided in 14% (n = 3), left-sided in 24% (n = 5), and bilateral in 62% (n = 13) of the patients. Mucocele was observed in 5% (n = 12) of the patients. It was bilateral only in 1 patient (9%), right-sided in 50% (n = 6) and left-sided in 41% (n = 5) of the cases. Concha bullosa was detected in 38% (n = 96) of patients of whom 58% (n = 56) were bilateral, 20% (n = 19) left-sided, and 22% (n = 21) were right-sided (Table 5).

4. Discussion

Displacement of the nasal septum to one side causes a deviated septum. Even though the exact cause of NSD has not been established yet, birth trauma, minor trauma in early life, traffic accidents, and violence have been suggested as its leading causes in the literature [13]. NSD can disturb nasal physiology and combine with other PNS disorders. In different studies, the incidence of NSD ranges from 14.1% to 80% [13]. According to our study results, 135 patients (53%) were diagnosed with NSD in their PNS CT scans, without any direction predominance (right-sided vs. left-sided), and equally distributed between genders. The frequency of NSD patients in our study was in agreement with the frequency reported by Köse *et al*. [14]. Although it differs from Yazici study, which suggested a tendency for right-sided septal deviation among male patients, female patients have been diagnosed more with left-sided septal deviation [15]. Moreover, one study in Saudi Arabia found that NSD is more common in males than in females, but there was no statistically significant difference between the frequency of right and left sides based on gender [16].

NSD has been classified and quantified in several systems. We utilized the most common NSD classification method (i.e., Mladina's classification) and sorted NSD patients into six groups. Our Observation indicated that type V was by far the most prevalent, with a rate of 42.22 %. The same conclusion has been reported in the Rao *et al*. study [17]. Applying the same classification method, wee *et al.* [18] detected type II (41.4%) and type I (35.4%) as the most common types. Moreover, the presence of NSD was not associated with age, and in general, NSD may be observed from infancy to old age. Several studies showed an increase in the prevalence of certain types of NSD with age increase, while other types of NSD declined. As a result, in general, age does not have a definitive effect on the incidence of NSD [1].

In our study, patients were mainly referred for a PNS CT as a pre-operative assessment for cosmetic surgeries. On the other hand, headache is reported as the most frequent PNS CT referral reason in the literature [19]. A relatively high prevalence of rhinoplasty surgery in Iran has caused this difference in the referral reason compared with other studies [20].

The correlation between NSD and the direction of sinusitis is controversial in the literature. For example, Karki *et al.* [21] reported no correlation between NSD and maxillary sinusitis on the same side. On the other hand, Fadda *et al.* found a correlation between the left-sided NSD and left maxillary sinusitis [22]. In another study, a higher incidence of bilateral maxillary sinusitis was stated by Kucybała *et al.* [6] in NSD patients. Razavi *et al.* studied maxillary sinus volume, finding that men have considerably higher right and left maxillary sinus volumes than women, and that maxillary sinus volume decreases with age. In contrast, the maxillary sinus volume significantly decreased on the same side as the deviated septum [23]. However, we did not find a significant relation between NSD and pansinusitis, which could be rooted in the limited number of cases with both NSD and pansinusitis in their PNS CT.

Concha bullosa is asymptomatic in most cases and frequently mentioned as a normal variant; nevertheless, in a few individuals, it may result in complications such as infection or drainage impairment [13]. Erkan *et al.* suggested that both NSD and concha bullosa might physically affect each other [24]. Additionally, Rajashree *et al.* have discussed an association between contralateral concha bullosa and NSD [25]. However, there was no significant correlation between these two in Köse *et al.* study [14], which was similar to the result of our study. All of those studies reported different incidences, possibly due to differences in the target population. The correlation between NSD and concha bullosa is not yet evident, and future studies including different age groups are required to explore any possible relation.

Paranasal sinus mucoceles are epithelium-lined cystic masses filled with mucus resulting in obstruction of sinus ostia. Although the literature indicates that the frontal and ethmoidal sinuses are more frequently affected by mucocele [21], we noticed the maxillary sinus to be affected the most. Usually, there is no known cause for the maxillary sinus mucocele, but it may be due to chronic infection, allergy, or trauma [22]. In one-third of patients with maxillary sinus mucocele, the chief complaint is headache.

Other symptoms are swelling and numbness of the cheeks and hemifacial pain [26].

Mucosal layer thickening is an inflammatory reaction that occurs following trauma, infection, chemical agents, foreign body reactions, or neoplasms. In approximately half of the cases, the affected sinus is maxillary [27]. We found thickened mucosa in 46% of PNS CTs. Mucosal thickening has been reported to be significantly associated with advancing age. In addition, mucosal thickening has been found to be more prevalent in males [27]. Both of these findings were in good agreement with our results.

One limitation of this study is the lack of cases with particular PNS CT findings, such as mucocele or pansinusitis. In addition, a more comprehensive study would consist of control subjects from the healthy population instead of the subjects referred by specialists. However, it seems unrealistic to perform CT on normal subjects. Hence, in our study, the NSD-free group was chosen as the control group.

5. Conclusion

In conclusion, observed in more than half of the cases, NSD was a common radiographic finding in our patients. In general, we could not find a significant correlation between NSD, and other abnormal findings detected in PNS CT in the majority of cases. This suggests that septal repair surgeries might not be as effective as expected in relieving patients' symptoms. Further study of the effectiveness of septal repair can be carried out by comparing patients before and after such surgeries.

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