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Original Article

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Prevalence and Correlation of Concha Bullosa and Nasal Septal Deviation with Maxillary Sinus Mucosal Thickening Using Cone-Beam Computed Tomography

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Abstract

Background: This study aimed to assess the prevalence and correlation of Concha Bullosa (CB) and Nasal Septal Deviation (NSD) with maxillary sinus Mucosal Thickening (MT) using Cone-Beam Computed Tomography (CBCT).

Methods: This descriptive, cross-sectional study was conducted on CBCT scans of 228 females and 157 males (mean age of 44.82±15.10 years) retrieved from the archives of the Radiology Department of Shahid Beheshti Dental School. The images were evaluated by one oral and maxillofacial radiologist for presence/absence of NSD, CB, and maxillary sinus MT, and their correlations. Statistical analyses were performed by independent t-test, Chi-square test, and binomial test (alpha=0.05).

Results: The prevalence of CB, NSD, and MT was 61.6, 80, and 70.6%, respectively. NSD (p=0.131) and CB (p=0.211) had no significant correlation with MT. However, CB and NSD were significantly correlated (p=0.006). NSD had a significant correlation with contralateral presence of CB as well (p=0.000). The prevalence of CB was significantly higher in females ($p<0.05$), while the prevalence of NSD and MT was significantly higher in males ($p<0.05$).

Conclusion: The present study revealed no significant correlation between CB and NSD with maxillary sinus MT. Thus, in absence of clinical symptoms, patients with CB or NSD should not be necessarily referred for treatment of sinus abnormalities. However, considering the significant correlation of CB and NSD, in case of presence of one entity, the other one should be suspected.

Keywords: Cone-beam computed tomography, Maxillary sinusitis, Nasal septum

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Introduction

The internal surface of the maxillary sinus is covered with a thin mucosal lining of ciliated respiratory epithelium, which extends to the nasal cavity, and is known as the Schneiderian membrane. Infection and mucosal irritation are the potential etiologies for maxillary sinus Mucosal Thickening (MT). Sinusitis is the main etiology of MT in symptomatic patients (1). The mean normal thickness of the Schneiderian membrane is 0.8 *mm*. Membranes with a thickness > 3 *mm* are considered thick while those below 0.5 *mm* are considered thin (2). Chronic sinusitis may aggravate due to anatomical variations such as Nasal Septal Deviation (NSD) and Concha Bullosa (CB), since such anatomical complexities can obstruct the mucus drainage pathway and lead to development of allergic rhinitis, asthma, cystic fibrosis, and infection (3).

The mechanism of growth and development of paranasal sinuses has yet to be fully understood. However, several mechanisms have been proposed to describe the growth phenomena of paranasal sinuses including nasal airflow, development of the brain, muscle mass tension, facial structures, and recently, cellular mechanisms (cell adhesion and migration). Absence of airflow decreases the oxygen pressure, impairs the growth and development of paranasal sinuses, impairs the mucociliary clearance, and enhances bacterial proliferation.

The role of NSD and maxillary sinus volume in development of sinusitis has been scarcely evaluated (4). The nasal septum is composed of bone and cartilage, and divides the nasal cavity into two compartments at the midline. The bony part of the nasal septum is comprised of the palatine bone, maxillary crest, vomer bone, and the perpendicular plate of the ethmoid bone. These parts support the anterior segment and the main cartilage. Also, the nasal septum supports the external bony-cartilaginous structure of the nose (5,6). NSD refers to deviation of the bony or cartilaginous part of the nasal septum or both from the midline, which can cause respiratory problems following the reduction of nasal cavity volume. On maxillofacial Computed Tomography (CT) scans, NSD is the most common anatomical variant seen in 80% of healthy adults. Nasal obstruction at the side of NSD can cause eddy currents in the nose, nasal dryness, recurrent epistaxis, and chronic sinusitis. NSD can also affect the adjacent structures and obstruct the mucus drainage path, impair the mucociliary clearance, and lead to secondary infection of the sinuses specially the maxillary sinus due to obstruction (1). Nasal obstruction due to NSD can impair the function of vocal cords and cause esthetic and respiratory problems, sinusitis, and infection of the middle ear and upper airways.

The superior, middle and inferior conchae are bilaterally present in the nasal cavity. Pneumatization of the concha can lead to osteomeatal obstruction and impede mucociliary clearance of the sinuses. CB refers to pneumatization of the middle concha. NSD and CB can impair the airflow and lead to sinus problems. CB is an asymptomatic normal anatomical variant with a prevalence of 13 to 53%. However, it can cause infection or obstruct the airflow and mucus drainage path in some patients (7).

By the use of Cone-Beam Computed Tomography (CBCT), dental clinicians and otolaryngologists can now accurately detect anatomical abnormalities and pathologies in the nasal structure and paranasal sinuses. The conventional radiographic modalities are less efficient for detection of sinus abnormalities. Since inflamed mucosa can be easily detected on CBCT images, CBCT can be suggested as a standard imaging modality for precise assessment of the nasal cavity and paranasal sinuses (8). Accordingly, this study aimed to assess the prevalence and correlation of CB and NSD with maxillary sinus MT by using CBCT.

Materials and Methods

This descriptive, cross-sectional study was carried out on CBCT scans retrieved from the archives of the Radiology Department of Shahid Beheshti Dental School from 2018 to 2021. The study protocol was approved by the ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.DRC.REC.1399.074).

The sample size was calculated to be 385 according to previous studies by Bayrak *et al* (1) and Smith *et al* (8) assuming alpha=0.05, 95% confidence interval, d=5%, and prevalence of NSD and CB to be 50.6 and 67.5%, respectively.

The inclusion criteria were (I) available CBCT scans of patients taken for implant surgery, third molar surgical extraction, extraction of impacted teeth, *etc.* that visualized the maxillary sinuses and nasal septum, and (II) age over 18 years (to ensure complete development of the maxillary sinuses) (3).

The exclusion criteria were (I) bony lesions in the sinonasal or maxillofacial region, (II) evidence of traumatic injuries or previous surgery in the sinonasal or maxillofacial region, (III) evidence of systemic diseases or developmental disorders on images, (IV) evidence of syndromes or developmental anomalies in the head and neck region on images, and (V) poor-quality images, high level of noise, or high level of artifacts.

All CBCT images had been obtained with NewTom VGi CBCT scanner (QR, Verona, Italy) with a minimum field of view size of 12×8 *cm* with the exposure settings of 110 *kVp*, 150 *µm* minimum voxel size, 10 *mA*, and 3.3 *s* time. The images were reconstructed using NNT Viewer version 8 software, and were evaluated in coronal, axial, and sagittal sections. The age and gender of the patients were extracted from patient records, and presence/absence of CB, NSD and maxillary sinus MT was recorded for each patient by one oral and maxillofacial radiologist. To assess the intra-observer agreement, 20% of the images were randomly selected and evaluated again by the same observer after a 2-week period, and the intraclass correlation coefficient was calculated.

CB was considered as pneumatization of the middle concha of any size (Figure 1).

To assess the presence/absence of NSD, an axial section with 0.4 *mm* slice thickness visualizing the anterior nasal spine was first selected, and then on the axial section, the sagittal section line was selected such that it passed right from the center of the anterior nasal spine. Next, a coronal section visualizing both the anterior nasal spine and nasal septum was selected to ensure that the midline passed from both of them. NSD was defined as deviation over 4 *mm* from the midline in each compartment, and measured by the digital ruler of the software. The direction of deviation was also recorded as the direction towards which, the septum has a convexity (9) (Figure 2).

To assess the maxillary sinus MT, the distance between the sinus floor and the uppermost border of the maxillary sinus mucosa was measured on the coronal section by using the digital ruler of the software. Values > 3 *mm* were considered as presence of maxillary sinus MT (10) (Figure 3). Maxillary sinus MT was categorized as localized, generalized, and Mucous Retention Cyst (MRC) (Figure 4).

Data were collected in Excel 2016, and analyzed using SPSS version 26. Independent t-test and Chi-square test were applied to analyze the correlation of NSD, CB, and MT with age and gender, respectively. The Chi-square test was used for pairwise comparisons of NSD, CB, and MT. Binomial test was applied to analyze the correlation of direction of NSD and direction of CB. A $p<0.05$ was considered statistically significant.

Results

A total of 385 images belonging to 228 females (59.2%) and 157 males (40.8%) were evaluated. The patients had a mean age of 44.82±15.10 years (range 18 to 85 years). The intraclass correlation coefficient

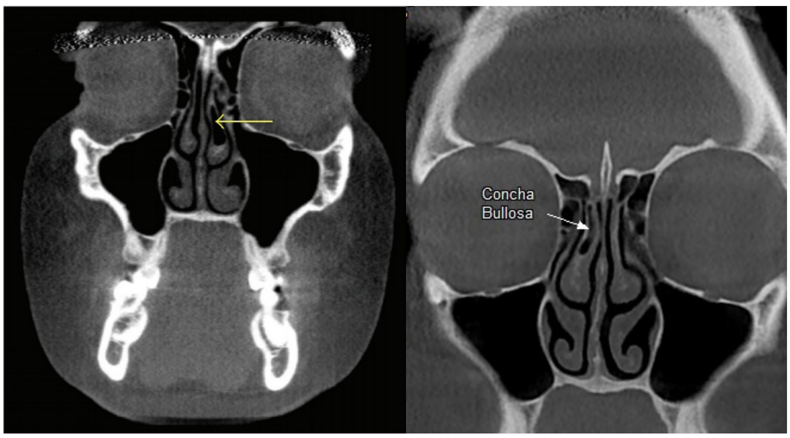

Figure 1. (Left) Concha bullosa on frontal view CBCT; (Right) Unilateral concha bullosa.

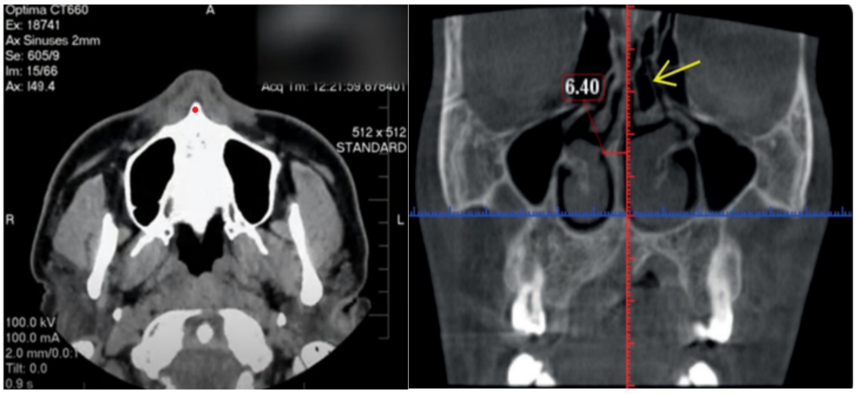

Figure 2. (Left) Anterior nasal spine on axial section; (Right) Nasal septal deviation.

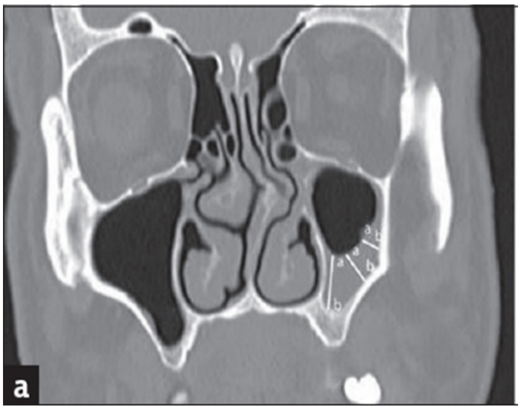

Figure 3. Unilateral (Left) and bilateral (Right) maxillary sinus mucosal thickening.

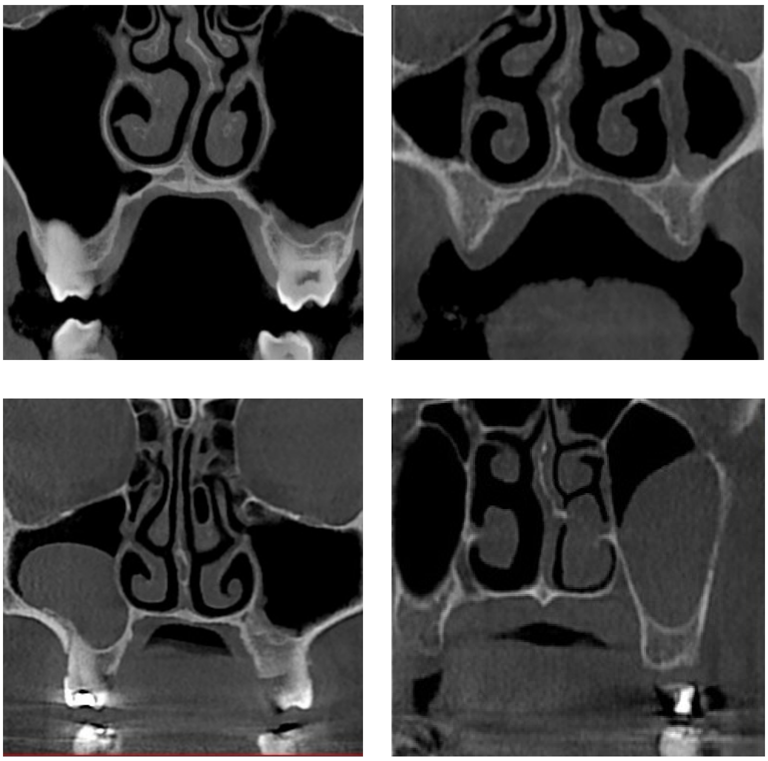

Figure 4. Maxillary sinus mucosal thickening; (upper left) Localized form; (upper right) Generalized form; (lower left) MRC; MRC plus NSD (lower right).

Table 1. Prevalence of CB in our study population

CB	Number	Percentage
Absent	148	38.4
Right	55	14.3
Left	49	12.7
Bilateral	133	34.5
Total	385	100.0

Concha Bullosa (CB).

was found to be >98% for all the variables, indicating excellent intra-observer agreement.

CB
Table 1 presents the prevalence of CB in our study population. Of all, 237 patients (61.6%) had CB, including 153 (67.10%) females and 84 (53.5%) males. According to the Chi-square test, the prevalence of CB in females was significantly higher than that in males (p=0.007). The mean age of the patients with and without CB was 44.13 years and 45.41 years, respectively with no significant difference (independent t-test, p=0.543).

NSD
Of all the patients, 308 (80%) had NSD, which was in the right side in 157 (40.8%), and in the left side in 151 (39.2%) patients. The prevalence of NSD was 75% (n=171) in females and 87.26% (n=137) in males. The Chi-square test showed that the prevalence of NSD in males was significantly higher than that in females (p=0.003).
The mean age of the patients with and without NSD was 44.75 years and 45.07 years, respectively with no significant difference (independent t-test, p=0.866).

Maxillary sinus MT
Of all the patients, 272 (70.6%) had maxillary sinus MT, which was in the right side in 63 (16.4%), in the left side in 68 (17.7%), and bilateral in 141 (36.6%) patients. The frequency of localized, generalized, and MRC forms was 51.7% (n=199), 16.1% (n=62), and 2.9% (n=11), respectively. Of all, 143 (62.71%) females and 129 (82.16%) males had MT. The prevalence of MT in males was significantly higher than that in females (p=0.000).
The mean age of the patients with and without MT was 44.55 and 44.95 years, respectively with no significant difference (independent t-test, p=0.914).

Correlation of NSD and MT
Of 308 patients with NSD, 223 (72.4%) had MT. Of 77 patients without NSD, 49 (63.6%) had MT. The Chi-square test demonstrated that NSD had no significant correlation with MT (p=0.131).
NSD had no significant correlation with localized (p=0.056), generalized (p=0.387), or MRC (p=1.000) forms of maxillary sinus MT either. Of 157 patients with NSD in the right side, 95 (60.5%) showed MT of the same side; out of which, 24.2% showed MT only in the right side and 36.3% showed MT at both sides. Of 151 patients with NSD in the left side, 100 (66.2%) indicated MT in the same side; out of which, 26.5% showed MT only in the left side and 39.7% at both sides.

Correlation of CB with MT
No significant correlation was noted between CB in general and MT (p=0.211). table 2 presents the frequency of localized, generalized, and MRC forms of MT in patients with and without CB. The Chi-square test represented no significant correlation between localized (p=0.569) and MRC (p=1.000) forms of maxillary sinus MT with CB. However, CB had a significant correlation with generalized form of maxillary sinus MT (p=0.010).
Of 55 patients with right-side CB, 28 (50.9%) had MT of the same side; out of which, 16.4% had MT of the right side only, and 34.5% had MT at both sides.
Of 49 patients with left-side CB, 28 (57.1%) had MT of the same side; out of which, 12.2% had MT of the left side only, and 44.9% had MT at both sides.

Correlation of NSD with CB
Of 308 patients with NSD, 200 (64.9%) had CB. Of 77 patients without NSD, 37 (48.1%) had CB. The Chi-square test showed a significant correlation between NSD and CB (p=0.006).
Table 3 presents the frequency of right, left and bilateral CB based on the presence/absence and side of NSD. According to the binomial test, a significant correlation existed between the direction of NSD and direction of CB (p=0.000). It appeared that CB could occur in the opposite direction of NSD, since in

Table 2. Frequency of localized, generalized, and MRC forms of MT in patients with and without Concha Bullosa (CB); Mucosal Thickening (MT); Mucous Retention Cyst (MRC)

MT		CB		Total
		Absent	Present	
Localized	Absent	75 40.3%	111 59.7%	186 100.0%
	Present	73 36.7%	126 63.3%	199 100.0%
MRC	Absent	144 38.5%	230 61.5%	374 100.0%
	Present	4 36.4%	7 63.6%	11 100.0%
Generalized	Absent	115 35.6%	208 64.4%	323 100.0%
	Present	33 53.2%	29 46.8%	62 100.0%
Total		148 38.4%	237 61.6%	385 100.0%

Table 3. Frequency of right, left and bilateral CB based on the presence/absence and side of NSD

		CB				Total
		Absent	Right	Left	Bilateral	
NSD	Absent	40 51.9%	11 14.3%	7 9.1%	19 24.7%	77 100.0%
	Right	50 31.8%	18 11.5%	34 21.7%	55 35.0%	157 100.0%
	Left	58 38.4%	26 17.2%	8 5.3%	59 39.1%	151 100.0%
Total		148 38.4%	55 14.3%	49 12.7%	133 34.5%	385 100.0%

Concha Bullosa (CB); Nasal Septal.
Deviation (NSD).

patients with both NSD and CB, the two anatomical variants were in the same side in 30%, and in opposite sides in 70% of the cases.

Discussion

Chronic rhinosinusitis is a common condition that involves over 2% of the world's population, and can decrease the quality of life of patients. The correlation of anatomical variations of the sinonasal area and the occurrence of rhinosinusitis has been extensively studied. However, this correlation is still a matter of controversy (11).

This study assessed the prevalence and correlation of CB and NSD with maxillary sinus MT by using CBCT. The prevalence of CB was found to be 61.6% in the present study. This value was 53.7% in a study by Koo *et al* (12), 67.5% in a study by Smith *et al* (8), 37% in a study by Sogono and Songco (13), and 44.6% in a study by Balikci *et al* (14). The closest value to our obtained value was reported by Smith *et al* (8) who also reported similar results to the present study regarding no significant effect of CB and NSD on maxillary sinusitis.

The prevalence of NSD was found to be 80% in the present study. This value was 89.2% in a study by Mladina *et al* (15), 81.7% in a study by Madani *et al* (11), 59.5% in the study by Balikci *et al*, (14), 65% in a study by Stallman *et al* (7), and 86.6% in a study by Moshfeghi *et al* (16).

In the current study, the overall prevalence of maxillary sinus MT was 70.6%. This value was 63.2% in the study by Balikci *et al* (14). The prevalence of maxillary sinus abnormalities was 59.97% in a study by Drumond *et al* (17).

In the present study, the prevalence of localized, generalized, and MRC forms of maxillary sinus MT was 51.7, 16.1 and 2.9%, respectively. Also, the prevalence of maxillary sinus with normal mucosa was 29.4%. In a study by Taghiloo and Halimi (18), the prevalence of sinusitis and mucositis was 28 and 44%, respectively. Normal sinus mucosa had a prevalence of 28%. Their results regarding the prevalence of normal maxillary sinus mucosa were similar to the present findings.

The present results revealed significantly higher prevalence of NSD in males compared with females while the prevalence of CB was significantly higher in females than males. However, Smith *et al* (8) found no significant correlation between gender and NSD.

The present results indicated no significant effect of NSD and CB on maxillary sinus MT. However, the results suggested that NSD can play a role in development of CB. In the present study, CB had a significant correlation with generalized form of maxillary sinus MT. Calhoun *et al* (19) showed a possible correlation between CB and NSD with rhinosinusitis. They also detected some sinus abnormalities on CT scans of asymptomatic patients. However, the prevalence of these abnormalities was higher in symptomatic patients. Also, they found a considerably high prevalence of sinus abnormalities in children. Children were not included in the present study since age over 18 years was an inclusion criterion of the present study. The prevalence of CB was 29% in a study by Calhoun *et al* (19). It had a much lower prevalence in those without sinus involvement. Also, CB was more prevalent in symptomatic compared with asymptomatic patients. However, Calhoun *et al* (19) found a correlation between bilateral CB and anterior ethmoid sinus disorders, and did not assess its correlation with maxillary sinus abnormalities. Balikci *et al* (14) demonstrated sinus abnormalities in 67.4% of patients with CB. This rate was 68.4% in the present study. The correlation between CB and sinus abnormalities was not significant in the study by Balikci *et al* (14). In the study by Stallman *et al* (7), 73% of the patients with CB, and 78% of those without CB had inflammation of the paranasal sinuses. In the present study, 68.4% of those with CB and 74.3% of those without CB showed maxillary sinus MT. Similar to the present study, Stallman *et al* (7) found no significant correlation between the presence of CB and paranasal sinus abnormalities. Javadrashid *et al* (20) detected no significant correlation between CB and paranasal sinusitis either.

The present study could not find a significant correlation between NSD and maxillary sinus MT. Madani *et al* (11) reported that NSD was the most common anatomical variant in patients with chronic rhinosinusitis. In the study by Balikci *et al* (14), 61.9% of the patients with NSD had sinus abnormalities. This value was 72.4% in the present study. Balikci *et al* (14) found no significant correlation between NSD and sinus abnormalities, and Stallman *et al* (7) demonstrated no significant correlation between NSD and sinusitis. Calhoun *et al* (19) pointed to the significant role of NSD in development of sinus pathologies. They reported significantly higher prevalence of NSD in patients with sinus abnormalities, and showed that it had a higher prevalence on CT scan of patients with impairments of the osteomeatal complex, and anterior and posterior ethmoid sinuses. They found no significant correlation between NSD and maxillary sinusitis.

Javadrashid *et al* (20) revealed high prevalence of NSD in patients with frontal, maxillary, ethmoid, and sphenoid sinusitis. They stated that NSD>3.5 degrees was a risk factor for paranasal sinusitis. Taghiloo and Halimi (18) reported a significant correlation between NSD and sinusitis. In the present study, NSD had no significant correlation with generalized maxillary sinus MT. Hamadan *et al* (21) demonstrated that the para-septal abnormalities were common in sinusitis patients. Nonetheless, they found no significant correlation between NSD or CB with increased prevalence of sinusitis on CT scans. The same result was obtained by Sogono and Songco (13). Consistent with the present study, they stated that detection of NSD and CB in routine rhinoscopy does not necessarily indicate the presence of sinus mucosal inflammation (21).

The present study revealed a significant correlation between CB and NSD. Adequate documentation to support or refute the effect of CB and NSD on sinusitis does not exist. Nonetheless, Stallman *et al* (7) found a significant correlation between CB and NSD of the contralateral side. It is not known whether CB leads to NSD or vice versa. On CBCT images, when CB is present, nasal septum is deviated such that its convexity appears on the opposite side of CB (7).

In the study by Balikci *et al* (14) 84% of the patients with CB also had NSD. This rate was 64.9% in the present study. In line with the present study, Balikci *et al* (14) found a significant correlation between CB and NSD of the opposite side while no significant correlation was noted between CB or NSD with sinus abnormalities. It appears that CB can be accompanied by NSD; however, it is not known with certainty that CB and NSD can cause sinusitis (14). Subbotina and Kokhanov (22) reported considerably high prevalence of CB in the contralateral side in cases with unilateral NSD. However, CB had no significant correlation with sinusitis (22).

Shetty *et al* (23) described two theories to explain the correlation of NSD and conchal hypertrophy. According to the first theory, hypertrophy is a compensatory reaction to NSD. According to the second theory, unilateral growth of nasal concha due to genetic factors or trauma early in life can compress the nasal septum during childhood and puberty. They showed that the hypertrophic concha and CB can affect the severity of NSD. Also, they recommended CBCT (due to low patient radiation dose) for assessment of NSD, CB, and nasal conchal hypertrophy (23). Koo *et al* (12) demonstrated a strong correlation between the prevalence of CB and NSD of the contralateral side. Also, in total, patients with NSD had higher frequency of anatomical variants such as pneumatization of the middle, superior and inferior concha. In the present study, the correlation between these two anatomical variants was explained by the two theories described by Shetty *et al* (23-25).

According to the present results, presence of NSD or CB does not justify requesting further imaging for patients with no history of sinusitis. Also, due to the presence of a significant correlation between NSD and CB, in case of presence of one of them, the possibility of presence of the other increases.

Further studies are required on a larger sample size to increase the accuracy and generalizability of the results. Also, future studies are recommended on the role of anatomical variations in airway obstruction and sinus disorders particularly maxillary sinusitis.

Conclusion

The present study did not reveal a significant correlation between CB and NSD with maxillary sinus MT. Thus, in absence of clinical symptoms, patients with CB or NSD should not be necessarily referred for treatment of sinus inflammatory conditions. However, considering the significant correlation of CB and NSD, in case of presence of one entity, the other one should be suspected.

Acknowledgements

The study was approved by the ethical committee on 4/7/1399 with code IR.SBMU.DRC.REC.1399.074. It should be noted that the patients had referred to the radiology department of the faculty for various treatment cases; therefore, the additional dose of radiation was not applied due to our research, and the field size was not increased due to our study.

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