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ORIGINAL ARTICLE

Do Nasal Anatomical Variations Affect the Maxillary Sinus? A CBCT Volumetric Analysis

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ABSTRACT

Objective: This study aimed to determine the effect of the concha bullosa (CB) and the nasal septum deviation (NSD) on the volume of the maxillary sinuses using ITK-SNAP (http://www.itksnap.org/ download/snap/). **Methods:** A total of 70 CBCT scans were analyzed. Three groups were evaluated; control (absence of CB), unilateral CB, and bilateral CB. Moreover, scans were classified according to the NSD into control (no deviation), mild, moderate, and severe NSD deviation. The volume of each maxillary sinus was calculated using the ITK-SNAP. Intra-observer reliability analysis was performed by paired-sample t-test. Analysis of variance ANOVA and t-test were used to compare the mean bilateral maxillary sinus volumes. **Results:** Intra-observer reliability for the maxillary sinus volume exhibited no significant difference for both sides ($p > 0.05$). The mean volume of the right and left maxillary sinuses were 12.98±4.90 cm^3 and 13.18±4.99 cm^3, respectively. No significant difference between the volumes of both sides ($p > 0.05$) was found. The results showed no significant differences between the CB or NSD groups on both sides ($p > 0.05$). **Conclusion:** The two anatomical variations have no effect on the maxillary sinus volume. The open-source software ITK-SNAP is a valuable tool for volumetric analysis.

Key words: anatomy, cone beam ct, maxillary sinus, volumetric analysis

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INTRODUCTION

The sino-nasal cavity is frequently captured in cone beam computed tomography (CBCT) scans. For dentistry, the sino-nasal cavity is directly related to the alveolar bone, palate, and teeth. Accurate volumetric analysis of the sino-nasal cavity represents a challenging topic of clinical importance not only for ENT surgeons but also for oral and maxillofacial surgeons.[1] Imprecision may complicate pre-surgical implant planning, especially when bone grafts are needed or before sinus floor augmentation.[2,3] Many studies referred to failure of implant placement to the perforation of the Schneiderian membrane with a prevalence from 19.5% to 58%[4] that can be avoided by accurate volumetric assessment of the sino-nasal cavity and consideration of the anatomical variations. Moreover, in the ENT field, determining the maxillary sinus volume is essential in rhinoplasty and surgical manipulation.[5] The anatomical variations are considered the main etiology of sino-nasal pathology.[6] The high prevalence of anatomical variations in the sino-nasal cavity in the population makes it necessary to consider a complete examination of the whole volume acquired in the CBCT images, including this area, even in asymptomatic patients.[6–8] Concha bullosa (CB) and nasal septum deviation (NSD) are reported as the most common anatomic variants of nasal apparatus. In a prevalence study conducted by Katibe Tuğçe Temur and Burcu Evlice, they reported more than 60% of the cases with NSD and an average of 30% with CB.[9] CB is defined as a pneumatized middle turbinate. If large enough, it may completely fill the space between the septum and lateral nasal wall or compromise the mucociliary drainage, causing narrowing of the osteomeatal complex and consequently leading to sinus infection.[3,10] Other studies contradict these suggestions regarding the association between CB and chronic sinusitis.[11,12] NSD is considered a common problem that affects proper airflow. The presence of deviation may worsen snoring and increase the probability of sinus infection. Moreover, there is a possibility that NSD may act as a potential contributor to maxillary sinus volume (MSV) changes.[3]

A debate concerning the effect of CB and NSD on maxillary sinus volume has been found. Some studies suggest that the lack of airflow caused by these abnormalities results in low oxygen pressure, which subsequently restricts the growth of the maxillary sinus and leads to a small sinus.[10,13] Other studies stated contradictory statements and reported a positive relation between CB and the maxillary sinus volume. The MSV seems to be slightly greater in the presence of bilateral and/or oversized CB when compared to the absence of CB. The improper amount of ventilation caused by the CB may motivate an increase in the growth of the maxillary sinus.[3]

As a result, this work aims to determine the role of anatomical variations, such as the presence of CB and degree of NSD, on the MSV assessed by an open-source software ITK-SNAP.

METHODS

The present retrospective study was exempted from the review of the Research Ethics Committee as all included CBCT images were retrieved from the Oral and Maxillofacial Radiology Department records, Faculty of Dentistry, Ain Sham University, and were taken for reasons other than the purpose of this study. Between January 2020 to January 2022, a total of 200 maxillofacial CBCT scans were retrospectively analyzed from the Oral and Maxillofacial Radiology Department archive, Faculty of Dentistry, Ain Shams University, Cairo, Egypt. The medical history of the patients and their dental history were retrieved from the archived records. Images were excluded if one of the following criteria is present; the entire maxillary sinuses bilaterally were not captured, a history of sino-nasal surgery, a maxillofacial trauma, a fracture and/or maxillary sinus pathology. Patients with intrinsic sinus diseases such as sinusitis, polyps, tumors, or congenital deformities were excluded.

Moreover, external sinus diseases that originated from the adjacent teeth or nose were excluded as well. Finally, images with artifacts or in completed scan volume were removed from data analysis. Seventy patients (140 sides) with an age range of 20–60 years old were included in the results of this study.

Image analysis
All CBCT scans were selected from the database of the department's CBCT machine i-CAT next generation (Imaging Sciences International, Hatfield, PA). Axial, coronal, and sagittal planes of all the scans were viewed

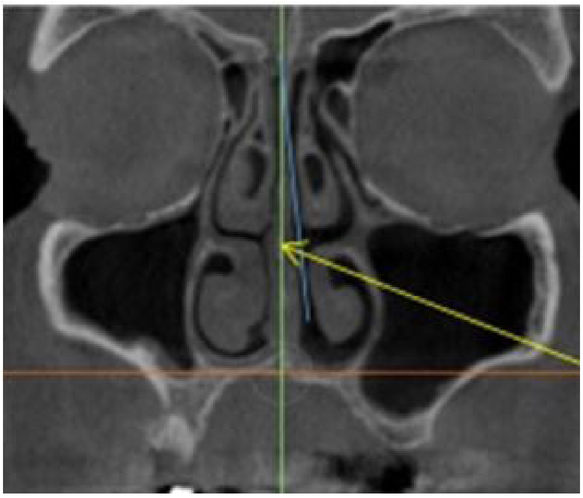

Figure 1. Coronal CBCT image demonstrating the technique of measuring the angle of NSD. The arrow points to the NSD angle that is formed between a linear line drawn from the maxillary spine to the crista galli and a line drawn from the crista galli to the most deviated part of the nasal septum.

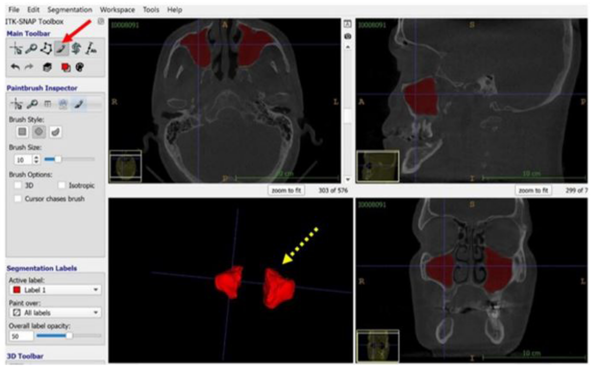

Figure 2. ITK-SNAP software after the completion of the bilateral maxillary sinuses segmentation (red volume and dashed yellow arrow). The solid red arrow shows the "paint brush" tool for manual adjustments of the automatic segmentation.

in a darkened room on a 21" DELL Flatron monitor (DELL, Precision T79110 XL, United States) with a screen resolution of 1920×1200 pixels and 64-bit color depth using the i-CAT vision software (Imaging Sciences International, Hatfield, PA).

The presence of CB was observed and recorded on the coronal images. Patients were divided into unilateral CB, bilateral CB, or the control group without CB. The NSD was evaluated by measuring the angle of NSD, defined as "the angle between the crista galli and the most prominent point of deviation."[3] The NSD angle was measured by scrolling through the coronal images until the slice where the most deviated part of the nasal septum was identified. The angle of NSD was formed between a linear line drawn from the maxillary spine to the crista galli and a line drawn from the crista galli to the most deviated part of the nasal septum, as shown in (Figure 1). The convex side of the curvature defined the direction of the deviation. The patients were divided into four groups according to the measured angle of NSD: the control group consisted of patients without NSD, mild (less than 9°), moderate (9°-15°), and severe (greater than 15°).[14]

Volumetric analysis of the maxillary sinus

CBCT scans of the patients were exported in Digital Imaging and Communications in Medicine (DICOM) format and then imported into the open-source software ITK/SNAP[15] version 2.4.0 (Kitware, New York, USA). Images were demonstrated in sagittal, coronal, and axial slices. Semiautomatic segmentation was used to measure the volume of the maxillary sinus.

The maxillary sinus on each side was identified, and then by using the "active contour segmentation mode "tool, the region of interest (ROI) was selected in all three views (coronal, axial, and sagittal). Next, the "Segment 3D "tool was used, and an appropriate threshold level was adjusted. The bubble points were then added to the ROI. When the "Start segmentation" tool was used, the software automatically segmented the ROI starting from the bubble points using the contrast differences on the greyscale images. Afterward, manual segmentation and editing of the segmented edges were performed using the "paint brush" tool to ensure correct segmentation (Figure 2). The volume of the maxillary sinus was computed automatically in cubic millimeters by the program.

All measurements were done by one oral and maxillofacial radiologist with more than ten years of experience and repeated at a one-month interval to assess the intra-observer reproducibility.

Statistical analysis

Statistical analysis was performed with SPSS 23 (Originally Statistical Package for the Social Sciences). Data were presented as percentages (%), or mean and standard deviations (SD). Intra-observer reliability analysis was carried out by paired-sample t-test. The student t-test was used to compare the mean bilateral maxillary sinus volumes. Differences in the maxillary sinus volume on both sides between CB and NSD groups were assessed by analysis of variance ANOVA and t-test. Statistical significance was determined at $p < 0.05$.

RESULTS

CBCT scans of seventy individuals with 140 healthy maxillary sinuses are included in the study. The age range is between (20 and 60) years old. Intra-observer reliability for the volume of the maxillary sinus reveals no significant difference for both sides ($p < 0.01$), as shown in (Table 1).

The mean value and SD of the volume of the right and left maxillary sinuses were 12.98±4.90 cm^3 and 13.18±4.99 cm^3, respectively. The overall mean maxillary sinus volume was 13.08±4.98 cm^3. The results of the student t-test revealed no statistically significant difference between the volumes of both sides ($p > 0.05$).

Regarding CB, individuals were classified into three groups: control, unilateral or bilateral CB. Among the seventy scans, unilateral CB was found in 14 (20%) individuals and bilateral CB in 13 (18.57%) individuals. At the same time, the remaining 43 (61.43%) individuals were assigned to the control group. Table 2 showed the results of ANOVA that was used to compare the right and the left maxillary sinus volumes within the three groups. The results demonstrated no significant differences between any of these groups on both sides ($p > 0.05$). Moreover, the t-test showed no significant difference between the two sides in each group separately, as shown in the last row of Table 2.

Regarding NSD, individuals were classified into four groups, either having mild, moderate, and severe NSD or having a straight nasal septum (control group). NSD was found in 49 individuals (70%); Of these, twenty individuals (40.8%) had mild NSD, nineteen individuals (38.8%) had moderate NSD, and ten individuals (20.4%) had severe NSD. Twenty-one individuals (30%) were assigned to the control group. The percentage of the left side NSD was higher than the deviation towards the right side (59.18 % and 40.82%), respectively.

The results of the ANOVA showed no significant difference in the volume of the right or the left maxillary sinus between all groups ($p = 0.198$ and 0.703), respectively. Moreover, the t-test revealed no significant difference between the two sides in each group separately (Table 3). Thus, the presence or absence of NSD did not affect the sinus volume.

DISCUSSION

The maxillary sinus exhibits the largest volume among the paranasal sinuses. Knowledge about its anatomy is essential to the dentists because of the close anatomical proximity to the oral cavity and dental structures, the increased rate of implant treatments, and open or closed sinus lift surgery.[2] With the increased applications of CBCT for maxillofacial imaging, recognizing anatomical variations, abnormalities, and pathologies within the nasal cavity and the surrounding paranasal sinuses has become easier for dentists.[16] It has been suggested that the presence of incidental findings in the sino-nasal cavity may disturb the proper airflow and consequently causes volumetric changes in the maxillary sinus.[17] Therefore, our study was conducted to assess the impact of two common anatomical variations on the volume of the maxillary sinus.

Table 1. Intra-observer reliability.

Maxillary Sinus Volume		Volume		Differences		Paired-Test	
		1st reading	2nd reading	Mean	SD	t	p
Right side	Range	1.22-25.6	1.3-25.96	0.128	0.575	1.857	0.068
	Mean ±SD	12.985±4.963	12.857±5.075				
Left side	Range	3-26.44	3-26.93	-0.091	1.139	-0.671	0.505
	Mean ±SD	13.179±4.989	13.271±5.212				

Table 2. Comparison between the control, unilateral, or bilateral CB groups.

Maxillary Sinus Volume		Control	Unilateral CB	Bilateral CB	ANOVA	
					F	p
Right side	Range	1.22-25.6	10.38-20.47	8-14.8	1.659	0.19
	Mean ±SD	12.66±5.74	15.03±2.55	11.82±2.36		
Left side	Range	3-26.44	9.3-19.89	7.7-20	0.266	0.76
	Mean ±SD	12.98±5.68	14.05±3.38	12.89±4.06		
t-Test	t	-0.25	0.74	-0.81		
	p	0.80	0.46	0.42		

Table 3. Comparison between the four groups of NSD.

Maxillary Sinus Volume		NSD groups				ANOVA	
		Control	Mild	Moderate	Severe	F	p
Right side	Range	7.1-23.89	3.4-25.3	1.22-25.6	8-23.48	1.59	0.19
	Mean ±SD	13.22±4.27	13.80±5.44	11.00±4.99	14.607±4.80		
Left side	Range	7.9-26.44	3-26.26	3.89-24.6	7.7-23.75	0.47	0.70
	Mean ±SD	13.322±4.807	13.85±5.98	12.05±4.49	13.678±4.41		
t-Test	t	-0.07	-0.02	-0.67	0.45		
	p	0.94	0.97	0.50	0.65		

Regarding the CB, cases were divided into unilateral CB, bilateral CB, and the control group without CB. In addition, they were classified into four groups according to the NSD; mild, moderate, severe, or the control group with no deviation. The grouping and the classifications were added to correlate the change in the volume of the maxillary sinus with the degree of the anatomical variation, not only the presence or absence of it. The segmentation method was chosen for the volumetric analysis of the maxillary sinus instead of the linear measurements. A previous study reported that due to the non-uniform boundary of the maxillary sinus, the linear measurements are less accurate with lower reliability compared to the volumetric analysis.[18]

Numerous third-party software programs are available in the market to perform segmentation on CBCT images, such as Mimics, ITK-Snap, OsiriX, Dolphin 3D, InVivo Dental, and On-demand 3D. The accuracy of these software programs for 3D analysis of the upper airway has been compared by other authors,[19] and they found that all six imaging software programs were reliable. In the present study, ITK-SNAP was used because it is an open-source, and user-friendly program which allows regional segmentation for the active contour of different anatomical structures scanned with various imaging modalities, including CT, MRI, and CBCT.[20] The results of the intra-observer agreement showed a reliable reproducibility of volumetrically measuring the maxillary sinus using this software.

The mean maxillary sinus volume in this study was 13.08±4.97 cm^3, which agrees with the reported range from 11.1±4.5 to 23.0±6.7 cm^3 in the previous studies.[21–23] Moreover, the left maxillary sinuses have a mean volume slightly greater than that of the right maxillary sinuses but with no statistical significance (13.17±4.98) and (12.98±4.96), respectively. This result aligns with some authors,[14] while in other studies,[2,24] the authors reported a volume difference between sides of the same individual, but also with no statistical significance.

The present study investigated the relationship of the volume of the maxillary sinus with two common anatomical variations of great clinical significance (CB and NSD). Concerning CB, it was observed in 38.5% of the sample; 20% have single unilateral CB, and 18.6% have bilateral CB. The relation between CB and the volume of the maxillary sinuses has been studied with conflicting findings. One study reported no significant change in the maxillary sinus volume with the presence of CB.[5] While in their study, they also reported a significant inverse relationship between the nasal septum deviation and the volume of the maxillary sinus. The studies conducted by some other authors did not find a relationship between unilateral CB and maxillary sinus volume.[10,14] Similar results were reported by some authors.[25] However, others suggested that the presence of CB would obstruct the ostiomeatal complex and consequently affect the sinus volume, but their results showed a non-significant association.[25]

Despite the agreement of the current study with the previous studies, as shown in Table 2, the results of another article[3] were contradictory. The authors reported a significantly higher sinus volume in the presence of bilateral CB compared to the unilateral CB and the control groups. A similar conclusion was reported by other authors, where NSD is reported to be a common anatomical variation of the nasal cavity.[27] In the present study, more than two-thirds (70%) of the studied sample have NSD, primarily mild or moderate NSD (40.8% and 38.7%, respectively). Similar prevalence was reported in the studies conducted by other authors.[3,27]

In the current study, septal deviation did not show any significant effect on the volume of the maxillary sinus. Several studies assessing the same relation found similar results. Some authors found no significant difference between mild, moderate, and severe deviation groups.[29] Moreover, others reported that NSD was not associated with higher sinus volume on the affected side.[3] Similar results were reported by other authors.[16] Moreover, other researchers reported a non-significant association between NSD, and MSV, although in their study NSDs were not classified based on the severity, such as mild, moderate, and severe. They attributed these results to the relatively small sample size and different methodologies used.[25]

Conflictingly, other studies reported different mixed findings. Some authors found that moderate and severe deviations had a significant relation with the maxillary sinus volume, while mild septal deviations did not.[14] Similar results were reported by one study, where the authors related the asymmetry of the maxillary sinuses to the septal deviation.[29] In another study, higher maxillary sinus on the contralateral side to severe septal deviation volumes was reported. At the same time, no significant effect was found in the case of mild and moderate septal deviations.[13] Additionally, other authors reported a significant effect only in the case of moderate nasal septum deviation.[30] It should be noted that a different imaging modality was used in these two previous studies.

It has been suggested that a relation exists between NSD and the combined presence of other anatomical variations, such as CD.[31] The studies that found a significant relation between NSD and CD proposed that the space created due to the deviation of the nasal septum may induce the pneumatization of the middle turbinate[11,13,32] that the increased size of CB may push the septum in the opposite direction. Some studies found a statistically significant association between the presence of unilateral or dominant CB and the higher incidence of the contralateral direction of NSD. In their study, 35.5% (n = 76) of the patients had NSD co-existing with CB. A higher percentage of 58% (n = 70) was observed in the current study sample population.[27] The different percentages may be attributed to the different geographic presentations of the study samples. On the other hand, others reported no association between NSD and CB.[33] Moreover, one study concluded that there was no relation between the presence of NSD and a co-existing CB.[16]

The limitation of the current study was it only included individuals with no signs of sinus problems. The absence of a symptomatic population may affect the relationship between the CB, NSD, and sinus volume. Further studies with larger sample sizes are required, especially for cases with severe NSD. In addition, other observers and analyzers are recommended.

CONCLUSION

CB and NSD are common anatomical variations in the nasal cavity. However, their presence did not influence the volume of the maxillary sinus. ITK-SNAP software is recommended for 3D measurements and segmentation of CBCT scans as it provides a repeatable and easy semiautomatic segmentation method that facilitates the results of this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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REFERENCES

1. Kempf HG, Dikta K, Lehnerdt G. Cone beam computed tomography in the ENT area as routine tool. Laryngorhinootologie. 2022; 101(S 02):S235.
2. Etemadi S, Seylavi G, Yadegari A. Correlation of

the maxillary sinus volume with gender and some of craniofacial indices using cone beam computed tomography. Biosci Biotech Res Comm. 2017; 10(3):580-6.
3. Al-Rawi NH, Uthman AT, Abdulhameed E, Al Nuaimi AS, Seraj Z. Concha bullosa, nasal septal deviation, and their impacts on maxillary sinus volume among Emirati people: A cone-beam computed tomography study. Imaging Sci Dent. 2019; 49(1):45-51.
4. Alsufyani N, El-Hakim H, Major P. Prevalence of maxillary sinus hypoplasia and association with variations in the sinonasal complex: A cone beam CT study. Clin Oral Investig. 2021; 25(9):5463-71.
5. Zakariaee Jubari A, Torkzadeh A. Relationship between maxillary sinus volume and nasal septal deviation concha bullosa and infundibulum size using cone-beam computed tomography (CBCT). Caspian J Dent Res. 2022; 11(1):56-63.
6. Papadopoulou AM, Bakogiannis N, Skrapari I, Bakoyiannis C. Anatomical variations of the sinonasal area and their clinical impact on sinus pathology: A systematic review. Int Arch Otorhinolaryngol. 2022; 26(3):e491-8.
7. Khalid AB, Siddiqa A, Haider SI, Alam G, Butt NA. Anatomical variations on routine CT scans observed in the paranasal sinuse. Pak J Med Health Sci. 2022; 16(03):731-3.
8. Pavan KB, Kumar M, Ramya M, Manohar KK. The frequency of anatomical variations of paranasal sinuses on computed tomography. Eur J Mol Clin Med. 2021; 8(4):2421-7.
9. Temur KT, Evlice B, Öztunç H. Evaluation of paranasal sinus anatomic variations and mucosal changes with cone beam computed tomography. Balkan J Dent Med. 2022; 26(1):27-32.
10. Demir UL, Akca ME, Ozpar R, Albayrak C, Hakyemez B. Anatomical correlation between existence of concha bullosa and maxillary sinus volume. Surg Radiol Anat. 2015; 37(9):1093-8.
11. Stallman JS, Lobo JN, Som PM. The incidence of concha bullosa and its relationship to nasal septal deviation and paranasal sinus disease. AJNR Am J Neuroradiol. 2004; 25(9):1613-8.
12. Kim HJ, Jung Cho M, Lee JW, Tae Kim Y, Kahng H, Sung Kim H, Hahm KH. The relationship between anatomic variations of paranasal sinuses and chronic sinusitis in children. Acta Otolaryngol. 2006; 126(10):1067-72.
13. Kapusuz Gencer Z, Ozkırış M, Okur A, Karaçavuş S, Saydam L. The effect of nasal septal deviation on maxillary sinus volumes and development of maxillary sinusitis. Eur Arch Otorhinolaryngol. 2013; 270(12):3069-73.
14. Kalabalık F, Tarım Ertaş E. Investigation of maxillary sinus volume relationships with nasal septal deviation, concha bullosa, and impacted or missing teeth using cone-beam computed tomography. Oral Radiol. 2019; 35(3):287-95.
15. Yushkevich P, Jilei H, Pouch A, Ravikumar S. ITK-SNAP. Version 2.4.0 [software]. Penn Image Computing and Science Laboratory (PICSL). Available from: http://www.itksnap.org/download/snap/
16. Smith KD, Edwards PC, Saini TS, Norton NS. The prevalence of concha bullosa and nasal septal deviation and their relationship to maxillary sinusitis by volumetric tomography. Int J Dent. 2010; 2010:404982.
17. Oz AZ, Oz AA, El H, Palomo JM. Maxillary sinus volume in patients with impacted canines. Angle Orthod. 2017; 87(1):25-32.
18. Aktuna Belgin C, Colak M, Adiguzel O, Akkus Z, Orhan K. Three-dimensional evaluation of maxillary sinus volume in different age and sex groups using CBCT. Eur Arch Otorhinolaryngol. 2019; 276(5):1493-9.
19. Weissheimer A, Menezes LM, Sameshima GT, Enciso R, Pham J, Grauer D. Imaging software accuracy for 3-dimensional analysis of the upper airway. Am J Orthod Dentofacial Orthop. 2012; 142(6):801-13.
20. Hacl A, Costa ALF, Oliveira JM, Tucunduva MJ, Girondi JR, Nahás-Scocate ACR. Three-dimensional volumetric analysis of frontal sinus using medical software. J Forensic Radiol Imaging. 2017;11:1-5.
21. Alshiddi HA, Alkhaldi AK, Almas K, Alsaati MA, Alzahrani SS, Aljubair MF, Siddiqui İ, Smith S. Comparison of digital and manual determination of maxillary sinus volume: A CBCT study. J Int Dent Med Res. 2022; 15(2):691-9.
22. Barros F, Fernandes CMDS, Kuhnen B, Scarso Filho J, Gonçalves M, Gonçalves V, Serra MDC. Three-dimensional analysis of the maxillary sinus according to sex, age, skin color, and nutritional status: A study with live Brazilian subjects using cone-beam computed tomography. Arch Oral Biol. 2022; 139:105435.
23. Tiwari ST, Shrikrishna U, Jaseemudheen MM. Gender determination by measuring maxillary sinus volume using computed tomography. J Health Allied Sci NU. 2023; 13:64-72.
24. Sahlstrand-Johnson P, Jannert M, Strömbeck A, Abul-Kasim K. Computed tomography measurements of different dimensions of maxillary and frontal sinuses. BMC Med Imaging. 2011; 11:8.
25. Göçmen G, Borahan MO, Aktop S, Dumlu A, Pekiner FN, Göker K. Effect of septal deviation, concha bullosa and haller's cell on maxillary sinus's inferior pneumatization; A retrospective study. Open Dent J. 2015; 9:282-6.
26. Tassoker M, Magat G, Lale B, Gulec M, Ozcan S, Orhan K. Is the maxillary sinus volume affected by concha bullosa, nasal septal deviation, and impacted teeth? A CBCT study. Eur Arch Otorhinolaryngol. 2020; 277(1):227-33.
27. Kucybała I, Janik KA, Ciuk S, Storman D, Urbanik

A. Nasal septal deviation and concha bullosa - Do they have an impact on maxillary sinus volumes and prevalence of maxillary sinusitis? Pol J Radiol. 2017; 82:126-33.

28. Aydın S, Taskin U, Orhan I, Altas B, Oktay MF, Toksöz M, Albayrak R. The analysis of the maxillary sinus volumes and the nasal septal deviation in patients with antrochoanal polyps. Eur Arch Otorhinolaryngol. 2015; 272(11):3347-52.
29. Orhan I, Ormeci T, Aydin S, Altin G, Urger E, Soylu E, Yilmaz F. Morphometric analysis of the maxillary sinus in patients with nasal septum deviation. Eur Arch Otorhinolaryngol. 2014; 271(4):727-32.
30. Karataş D, Koç A, Yüksel F, Doğan M, Bayram A, Cihan MC. The effect of nasal septal deviation on frontal and maxillary sinus volumes and development of sinusitis. J Craniofac Surg. 2015; 26(5):1508-12.
31. Erkan SO, Erkan ZA, Tuhanioğlu B, Haytoğlu S, Güney Z. The relationship between septal deviation and concha bullosa. Turkish J Ear Nose Throat. 2017; 27(2):74-8.
32. Sazgar AA, Massah J, Sadeghi M, Bagheri A, Rasool E. The incidence of concha bullosa and the correlation with nasal septal deviation. B-ENT. 2008; 4(2):87-91.
33. Javadrashid R, Naderpour M, Asghari S, Fouladi DF, Ghojazadeh M. Concha bullosa, nasal septal deviation and paranasal sinusitis; A computed tomographic evaluation. B-ENT. 2014; 10(4):291-8.

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