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Analysis of maxillary sinus volume of a group of population living on the southern border of Southeastern Anatolia

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ABSTRACT

Aims: This study aimed to assess the maxillary sinus volume (MSV) of people living in the south of the southeastern region of Anatolia by cone beam computed tomography (CBCT) in accordance with gender and age groups.

Methods: 400 maxillary sinus CBCT images of 200 patients were analyzed. To examine the correlation of maxillary sinus volume with age, all data were divided into six subgroups according to age. IRYS 15.1 software was used to obtain multiplanar images and volume measurement. SPSS package program version 25 was used to analyze the data. The Kolmogorov-Smirnov test was used to examine whether the data had a normal dispersion.

Results: In this study, 200 individuals, 110 (55%) women and 90 (45%) men, were included. When MSV was examined in accordance with age groups, statistically no remarkable difference was observed between the groups ($p>0.05$). In the comparison between men and women patients, a statistically important difference was showed in the right and left MSV, with men having a higher mean sinus volume than women ($p<0.05$).

Conclusion: MSV in men was found higher than in women. The mean MSV gradually decreases with age. However, in this study, no significant difference was observed in the average right and left MSV between age groups.

Keywords: Computed tomography, age group, gender, volume, maxillary sinus

INTRODUCTION

The maxillary sinus is an important paranasal sinus within the four pairs of paranasal sinuses. These are air cavities in the bone, connected to the nasal cavity through their ostium and surrounded by mucosa.[1] Maxillary sinuses, which continue to develop after birth, are formed in the 3rd and 4th intrauterine months.[2] The development of the maxillary sinus, which has the largest volume of the paranasal sinuses and is of the greatest interest to dentists due to its proximity to the teeth, starts in the 10th week of intrauterine life and reaches a volume of 6-8 cm^3 in the postnatal period. The first period in which it develops most rapidly volumetrically and becomes pneumatized is between the ages of 0-3, and the second period is between the ages of 7-12.[3,4] The adult size is 14-18 cm^3 on average, but it reaches this size around 18-20 years of age.[4,5]

At the base of the maxillary sinus is the alveolar bone of upper jaw, and at its ceiling is the lower wall of the orbit. It opens into the nasal cavity through the hiatus semilunaris.[6] The base of the maxillary sinus is flush with the floor of the nasal cavity until around age 12. With the eruption of persistent teeth, this level is displaced towards the top of the alveolar crest.[3] MSV may change as a result of systemic or pathological conditions. Alveolar bone resorption and sinus pneumatization, especially following tooth loss in the posterior region, cause the sinus to extend.[6] This situation can be explained by the periosteum in the Schneiderian membrane showing osteoclastic activity that triggers bone resorption.[7]

2D and 3D imaging techniques are used to evaluate the maxillary sinuses. In the initial diagnosis phase, evaluation is made with clinical examination and conventional radiography techniques.[8] 2D imaging techniques include Water's radiography, Caldwell, submentovertex, lateral sinus radiography and panoramic radiography. Among these techniques, Water's radiography provides the best visualization of the maxillary sinus. However, unwanted superpositions in 2D radiographs make it difficult to visualize the area to be examined. In this case, computed tomography (CT), one of the 3-dimensional techniques, has been evaluated as the gold standard in imaging the maxillary sinuses.[9] CT allows us to investigate the anatomy, variations, pathologies of the maxillary sinus

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and surrounding anatomical formations such as the nasal cavity in detail. These images are examined in axial, coronal and sagittal sections, allowing measurements to be made with determined parameters.[10] CBCT, which is more commonly used in dentistry than CT, is widely used due to its lower patient dose, more practical patient positioning, short exposure time, preventing movement artifacts, fewer metal artifacts, and better resolution.[11-13]

Panoramic radiography, CT, CBCT and magnetic resonance techniques are used to visualize maxillary sinus volumes (MSVs). Material ejection into the sinus, stereology (point counting method) and ellipsoid formula can be used to measure the MSV. However, in recent years, 3D techniques allow image processing and volume measurement using Hounsfield unit (HU) values. The area to be examined can be marked and tissue area, volume and density measurements can be made.[14] CBCT is more advantageous than CT in MSV measurements because it provides better image resolution and provides detailed images with less radiation.[11]

Unlike the existing studies in the literature that examine the MSV using 3D techniques,[4,14-18] there are a restricted number of studies examining the effect of environmental temperature on volume values.[19,20] Studies examining the effect of climate on MSV have been conducted in two different regions in Turkiye.[21,22]

This study aimed to evaluate the MSV of people living in the south of the southeastern region of Anatolia in accordance with gender and age groups using CBCT images.

The null hypothesis (H0) environmental temperature does not affect maxillary sinus volume according to age and gender.

METHODS

In this study, 400 maxillary sinus CBCT images of 200 patients, aged between 10 and 81, who were born and raised in Şanlıurfa and who applied to Harran University Faculty of Dentistry Dentomaxillofacial Radiology for diverse causes, were included. The research protocol was approved by Harran University Clinical Researches Ethics Committee (Date: 11.12.2023, Decision No: 23.23.08). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Informed consent form was obtained from the participants and they were informed about the scope of the study. These patients were divided into 6 subgroups with respect to age [10-19 age (n:34), 20-29 age (n:34), 30-39 age (n:36), 40-49 age (n:32), 50-59 age (n:35), 60 and over (n:29)] and MSVs were measured and the relationship with gender was analyzed.

To obtain the images, were used Castellini X Radius Trio Plus (Imola, Italy) CBCT images of all patients were taken with the same device, and images were obtained in sagittal, axial and coronal planes with the IRYS 15.1 software program. Midface fractures that disrupt the integrity of the maxillary sinus, pathological formations in the sinus, anatomical variations, patients with craniofacial anomalies, patients who have undergone a surgical operation involving the maxillary sinus, patients with systemic diseases affecting bone and images containing distorted artifacts were excluded from the study.

The manually examined region was drawn on the axially planned maxillary sections of the IRYS software and the details of the Hu products were displayed (Figure 1). In the volume properties, the Hu value was marked between the minimum sine and the average (Figure 2). The area is limited so that air, soft tissue, bone marrow centers of the surrounding bone tissue and nasal cavity cannot enter. For intra-observer agreement, 20% of the data was remeasured and intraclass correlation was calculated.

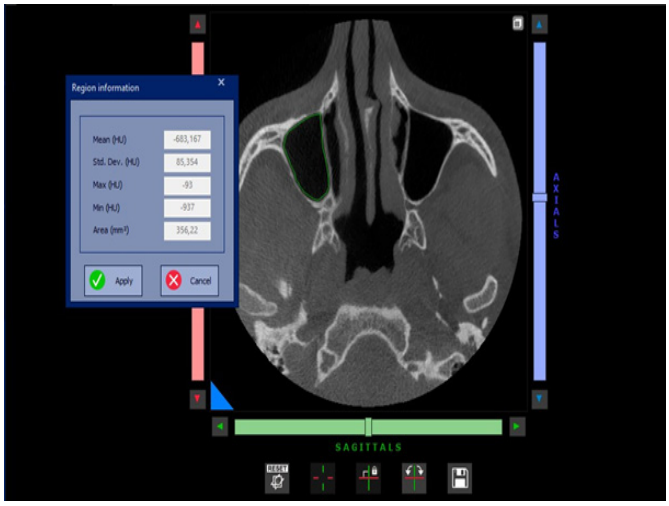

Figure 1. Drawing of the examined region and Hu values

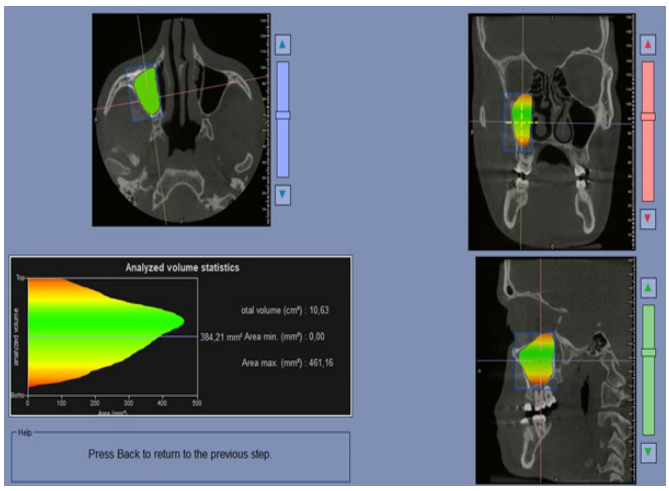

Figure 2. Determination of sinus boundaries in semi-automatic volume chambers

Statistical Analysis

The data obtained were analyzed using the SPSS 25 (Armonk, NY, IBM) package program. Whether the variables had a normal distribution was calculated with the Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) was performed to determine the difference between the groups in terms of right and left MSV values. If significant differences between group means were present, post-hoc pairwise multiple comparisons were made using the Tukey test. We tested Mann Whitney to compare the right and left average maximum sinus volume with respect to gender. Intra-observer agreement was calculated with the intraclass correlation coefficient test. P<0.05 was admitted as the importance grade.

RESULTS

In this study, 400 maxillary sinuses belonging to a total of 200 participants, 110 women (55%) and 90 men (45%), were examined, and the MSV was calculated by dividing it into 6 subgroups according to age and its relationship with gender was evaluated. Group 1 between the ages of 10-19, group 2 between the ages of 20-29, group 3 between the ages of 30-39, group 4 between the ages of 40-49, group 4 between the ages of 50-59, those aged 60 and over were named group 6. Right and left mean sinus volume values are shown in Table 1. Intra-observer agreement intraclass correlation coefficient was detected high level (1.00). No significant difference was found between age groups in terms of combined regulation of MSVs (p>0.05). When comparing the right and left average MSV, it was significantly higher in men than in women (p<0.05) (Table 2).

Table 1. Distribution of right and left maxillary sinus volume between age groups

Maxillary sinus volume (cm^3)	Groups	Mean	SD	p value
Right maxillary sinus	Group 1	12.99	4.76	0.116
	Group 2	12.88	4.45	
	Group 3	11.91	3.67	
	Group 4	11.13	4.33	
	Group 5	11.31	4.45	
	Group 6	10.62	4.52	
Left maxillary sinus	Group 1	13.62	5.15	0.165
	Group 2	13.90	4.17	
	Group 3	11.93	4.15	
	Group 4	12.16	4.18	
	Group 5	11.62	4.88	
	Group 6	11.71	5.17	

SD: Standard deviation

Table 2. Distribution of right and left maxillary sinus volume in female and male

Gender	Female	Male
n	110	90
Right maxillar sinus volume (cm^3)	9.72	14.44
Left maxillary sinus volume (cm^3)	10.39	15.09
p value	0.000*	0.000*

*: Statistically significant (p<0.05)

DISCUSSION

In this study, MSV was calculated comparatively between different age groups. No statistically remarkable difference was showed in the analysis between groups. Considering the relationship with gender, the statistical difference and the fact that the number of men is less than the number of women may cause this result.

Ariji et al.[23] calculated MSVs in axial CT images of 115 patients. While the MSV increased until the age of 20, it decreased thereafter. They found that sinus volume changes with age correlated with skeletal size and physique. No substantial difference was found between genders or between right and left MSVs. In study, the average MSV was highest in the 10-19 age group and decreased in older participants, which is similar to this study. Urooge et al.[24] examined the effect of sexual dimorphism on the maxillary sinus with CBCT, they found no difference in sinus volume between genders. In this study, the sinus volume of men was found to be higher than that of women. Finding different results from our study may be due to the effect of racial and regional differences.

Ekizoğlu et al.[25] Maxillary sinus volume was calculated using the ellipsoid formula on 380 maxillary sinus CT images of 140 patients (70 women, 70 men). Volume values were found to be higher in men than in women, and this result is compatible with this study. In another study, Sahlstrand-Johnson et al.[15] found no significant difference between age and sinus volume when they examined the right and left maxillary sinus CT images of 60 patients (32 women, 28 men). Similar to this study, the average sinus volume of men was found to be higher than that of women. In addition, maxillary sinus volume was measured automatically with the ellipsoid formula and volume measurement program, and the results of these two techniques were calculated to be compatible. It also includes measurements of the maximum wideness, depth and height of the maxillary sinus using the ellipsoid formula as the volume measurement method. However, the complex structure of the maxillary sinus may not reflect the accuracy of these millimetric values.

Değermenci et al.[26] calculated the MSV using the ellipsoid and stereological method (point counting method) in cranial CT. İn their study of 361 individuals between the ages of 0 and 18, found that sinus volume was directly proportional to age and reached its maximum dimension at the age of 16. No substantial difference was found between gender and right-left side. In our study, a significant difference was found with respect to gender. The younger age groups in this study help us observe the maximum size of the maxillary sinus. While the older age groups in our study may provide information about the decrease in MSV with age, it is insufficient to examine the maximum size. Another study that calculates the volume using the stereological method is the study of Karakas et al.[27] in their study where they examined the paranasal sinuses with CT, it was determined that men had a larger sinus volume than women, and this result is compatible with this study.

Bornstein et al.,[16] who measured volume via CBCT systems calculated the right and left MSVs of 87 patients. The MSV in men was found to be larger than in women, and no significant relationship was found between both sides. These results were reported by Shresta et al.[17], who used a separate 3D software program. It is compatible with the work of.

Aktuna Belgin et al.[14] divided 200 patients with right and left maxillary sinus CBCT images into five age groups and according to gender. In these images, MSVs were calculated in a different 3D software programme by limiting the HU values. No difference was found between right and left MSVs. While there was no significant difference between men and women, the MSV values of women in the 18-24 age group were lower than men. The method used and the relationship between the right and left sides are compatible with our study. Saccucci et al.[28], who calculated volume using a 3-dimensional software programme, found no difference between genders, unlike this study. Saccucci et al.[28] they performed maxillary sinus volume calculations using 3D software in 52 patients (26 women, 26 men). Contrary to this study, no differences between genders were detected. This situation can be explained by the small sample size examined and the difference in ethnicity and climatic conditions.

Güleç et al.[4] scanned right and left CBCT images of 133 participants (49 males, 84 females) and measured MSVs. It was found that MSV did not differ significantly with respect to gender and age. Although the age distribution of the patients in our study was in parallel with the results of this study, the mean MSV was found to be larger in male patients in terms of gender. Unlike these two studies conducted in Anatolia, the changing demographic structure as a result of high migration mobility in our region affects the results of our study. In addition, the mean MSV was found to be less in our study. The observation of smaller MSV in our region where the environmental temperature is high can be supported by the results of studies examining this issue in the literature.[19,20] MSV was found higher than our study in studies conducted in cities with hot climates such as Antalya and Adana in the south of Anatolia.[21,22] We think it may be due to differences in humidity in the air and differences in measurement techniques used. Tastemur et al.[22] in their MSV measurements in Sivas province, where the cold climate effect was observed, they concluded that the average sinus volume values are higher than in this region.

Sarilita et al.[18], who examined 194 maxillary sinus images of 97 patients between the ages of 0 and 25 from the Indonesian population, calculated the sinus volume using different 3D software. While MSV increased until the age group of 16-20, these values decreased between the ages of 20-25. In our study, the average MSV in the 10-19 age range was higher than in the 20-29 age range, which is compatible with this study.

Cohen et al.[29] who measured volume using the software program of the CT device, divided the patients into two groups according to age: 25-64 years old and over 65 years old. MSV was found to decrease significantly in individuals over 65 years of age. MSV was calculated of men greater than of women. The fact that the sinus volume values of the 60 and over age group, the oldest population in this study, were lower, was consistent with this study.

Limitations

Inability to know patients' blood calcium levels, growth hormone levels, not knowing whether individuals are treated for sinusitis. In studies with cold climates, higher measurements were made compared to this study. In future studies, it is recommended to compare the northern and southern regions to prove the effect of cold on MSV.

CONCLUSION

In this study, MSV was evaluated numerically using CBCT images. The average MSV decreases with advancing age. However, no substantial difference was detected between age groups. MSV in men was found higher than in women. Lack of humidity and high temperature in the living area may cause the MSV to be smaller. The MSV data obtained in our study can be a resource for various orthodontic, maxillofacial surgery and medical specialties examining the head and neck region.

ETHICAL DECLARATIONS

Ethics Committee Approval
The research protocol was approved by Harran University Ethics Committee (Date: 11.12.2023, Decision No: 23.23.08).

Informed Consent
All patients signed the free and informed consent form.

Referee Evaluation Process
Externally peer-reviewed.

Conflict of Interest Statement
The authors have no conflicts of interest to declare.

Financial Disclosure
The authors declared that this study has received no financial support.

Author Contributions
All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

REFERENCES

1. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. *Dentomaxillofac Radiol*. 2019;48(8):20190205.
2. Şakul BU, Bilecenoğlu B. Baş ve boynun klinik bölgesel anatomisi. Özkan Matbaacılık: 2009.
3. Ogle OE, Weinstock RJ, Friedman E. Surgical anatomy of the nasal cavity and paranasal sinuses. *Oral Maxillofac Surg Clin North Am*. 2012;24(2):155-166.
4. Gulec M, Tassoker M, Magat G, Lale B, Ozcan S, Orhan K. Three-dimensional volumetric analysis of the maxillary sinus: a cone-beam computed tomography study. *Folia Morphol*. 2020;79(3):557-562.
5. Magat G, Tassoker M, Lale B, Güleç M, Ozcan S, Orhan K. Comparison of maxillary sinus volumes in individuals with different dentofacial skeletal patterns: a cone-beam computed tomography study. *EÜ Diş Hek Fak Derg*. 2023;44(1):17-23.
6. Temur KT. Maksiller sinüs patolojilerinin ve osteomeatal kompleksin radyolojik olarak değerlendirilmesi. *Arş Kaynak Tarama Derg*. 2018;27(3):328-345.
7. Jasim HH, Al-Taei JA. Computed tomographic measurement of maxillary sinus volume and dimension in correlation to the age and gender: comparative study among individuals with dentate and edentulous maxilla. *J Baghdad Coll Dent*. 2013;325(2204):1-7.
8. MacDonald-Jankowski DS, Li TK. Computed tomography for oral and maxillofacial surgeons. Part I: spiral computed tomography. *Asian J Oral Maxillofac Surg*. 2006;18(1):7-16.
9. Dedeoğlu N, Altun O, Bilge OM, Sümbüllü MA. Evaluation of anatomical variations of nasal cavity and paranasal sinuses with cone beam computed tomography. *Evaluation*. 2017;13(2):36-41.
10. Weber AL. History of head and neck radiology: past, present, and future. *Radiology*. 2001;218(1):15-24.
11. Seth V, Kamath P, Venkatesh M, Prasad R. Cone beam computed tomography: third eye in diagnosis and treatment planning. *Virtual J Orthod*. 2011;9(1):1.
12. Palomo JM, Kau CH, Palomo LB, Hans MG. Three-dimensional cone beam computerized tomography in dentistry. *Dent Today*. 2006;25(11):130.
13. Özer SGY. Konik ışınlı bilgisayarlı tomografi'nin endodontide uygulama alanları. *GÜ Diş Hek Fak Derg*. 2010;27(3):207-217.
14. 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):1493-1499.
15. 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(1):8.
16. Bornstein MM, Ho JKC, Yeung AWK, Tanaka R, Li JQ, Jacobs R. A retrospective evaluation of factors influencing the volume of healthy maxillary sinuses based on CBCT imaging. *Int J Periodontics Restorative Dent*. 2019;39(2):187-193.
17. Shrestha B, Shrestha R, Lin T, et al. Evaluation of maxillary sinus volume in different craniofacial patterns: a CBCT study. *Oral Radiol*. 2021;37(4):647-652.
18. Sarilita E, Lita YA, Nugraha HG, Murniati N, Yusuf HY. Volumetric growth analysis of maxillary sinus using computed tomography scan segmentation: a pilot study of Indonesian population. *Anat Cell Biol*. 2021;54(4):431-435.
19. Butaric LN. Differential scaling patterns in maxillary sinus volume and nasal cavity breadth among modern humans. *Anatomic Rec*. 2015;298(10):1710-1721.
20. Holton NE, Yokley TR, Franciscus RG. Climatic adaptation and neandertal facial evolution: a comment on Rae et al. (2011). *J Hum Evol*. 2011;61(5):624-627.
21. Selcuk OT, Erol B, Renda L, et al. Do altitude and climate affect paranasal sinus volume? *J Craniomaxillofac Surg*. 2015;43(7):1059-1064.
22. Taştemur Y, Öztürk A, Sabancıoğulları A, et al. The relationship between anatomical variations and paranasal sinus volumes with climate and altitude. *Cumhuriyet Med J*. 2022;44(4):420-429.
23. Ariji Y, Kuroki T, Moriguchi S, Ariji E, Kanda S. Age changes in the volume of the human maxillary sinus: a study using computed tomography. *Dentomaxillofac Radiol*. 1994;23(3):163-168.
24. Urooge A, Patil BA. Sexual dimorphism of maxillary sinus: a morphometric analysis using cone beam computed tomography. *J Clin Diagn Res*. 2017;11(3):ZC67.
25. Ekizoglu O, Inci E, Hocaoglu E, Sayin I, Kayhan FT, Can IO. The use of maxillary sinus dimensions in gender determination: a thin-slice multidetector computed tomography assisted morphometric study. *J Craniofac Surg*. 2014;25(3):957-960.
26. Degermenci M, Ertekin T, Ülger H, Acer N, Coskun A. The age-related development of maxillary sinus in children. *J Craniofac Surg*. 2016;27(1):e38-e44.
27. Karakas S, Kavakli A. Morphometric examination of the paranasal sinuses and mastoid air cells using computed tomography. *Ann Saudi Med*. 2005;25(1):41-45.
28. Saccucci M, Cipriani F, Carderi S, et al. Gender assessment through three-dimensional analysis of maxillary sinuses by means of cone beam computed tomography. *Eur Rev Med Pharmacol Sci*. 2015;19(2):185-193.
29. Cohen O, Warman M, Fried M, et al. Volumetric analysis of the maxillary, sphenoid and frontal sinuses: a comparative computerized tomography-based study. *Auris Nasus Larynx*. 2018;45(1):96-102.