



ORIGINAL RESEARCH

CORRELATION BETWEEN MAXILLARY SINUS (LINEAR AND VOLUMETRIC MEASUREMENTS) AND MID-FACE WIDTH USING CBCT: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: The maxillary sinus is a key anatomical structure in the craniofacial complex, and its morphology may reflect facial skeletal characteristics. Cone-beam computed tomography (CBCT) enables accurate three-dimensional evaluation of sinus anatomy. Understanding the relationship between sinus dimensions and facial measurements is valuable for clinical planning in dentistry, maxillofacial surgery, and forensic applications.

Purpose: To assess the correlation between maxillary sinus dimensions and facial width in healthy adults using CBCT, and to evaluate the influence of age, sex, and mandibular body length on sinus dimensions.

Materials and Methods: A cross-sectional study was conducted on CBCT scans of 40 healthy adults (13 males, 27 females; aged 18–44 years). Maxillary sinus volume, width, height, and length were measured bilaterally, along with facial width and mandibular body length. Pearson correlation was used to evaluate associations between variables. Sex differences and laterality were analyzed. Multiple linear regression models were constructed to determine the strongest predictors of sinus volume. Inter- and intra-observer reliability were assessed using intraclass correlation coefficients (ICC).

Results: After statistical analysis, we found that the maxillary sinus showed bilateral symmetry with no significant right–left differences. Facial width demonstrated a significant positive correlation with sinus dimensions, particularly on the right side ($p < 0.05$), indicating that wider facial structures are associated with larger sinus volume and linear dimensions. No significant associations were found between sinus measurements and age or mandibular body length. Although males exhibited slightly greater sinus dimensions than females, differences were not statistically significant. Multiple regression analysis identified sinus height and width as the strongest predictors of sinus volume (Adjusted R^2 up to 0.92). CBCT measurements showed excellent reproducibility.

Conclusion: Maxillary sinus dimensions correlate significantly with facial width in adults, suggesting coordinated growth of sinus anatomy and midfacial structures. CBCT provides reliable measurements for sinus evaluation and may aid in surgical planning, implantology, orthodontics, and forensic identification.

Keywords: Maxillary sinus, Facial width, CBCT, Craniofacial morphology, Sinus volume.

INTRODUCTION

The maxillary sinus is a crucial anatomical structure closely related to the upper posterior teeth, and its evaluation is essential in many dental procedures, mainly surgical and orthodontic treatments involving the sinus region¹.

The maxillary sinus is the largest among the paranasal sinuses and is situated just behind the anterior bony surface of the midface, occupying the body of the maxilla². It has a pyramidal shape, with its medial base forming a significant portion of the lateral wall of the nasal cavity³. The apex of the sinus extends toward the zygomatic process of the maxilla and, in some cases,

occupies a large part of the zygomatic bone. The roof of the sinus constitutes the floor of the orbit and shows notable ridges over the infraorbital canal⁴. The floor is primarily formed by the alveolar process of the maxilla and partly by the hard palate. The level of the maxillary sinus floor changes with age; around the age of 20 years, it reaches its lowest point due to the eruption of the maxillary third molars⁵.

During development, the skeletal components of the neurocranium and viscerocranium are closely associated with the formation of functional spaces such as orbits, nasal cavities, paranasal sinuses, and oral cavity, as well as with the growth of surrounding

soft tissues, including the brain, muscles, and connective tissue⁶. The dimensions of the facial skeleton show a strong correlation with the volume of the maxillary sinus⁴. Moreover, the shape and size of the maxillary sinus reflect the developmental pattern of the surrounding bony structures⁷. Therefore, it has been proposed that the maxillary sinus plays a role in midfacial growth and contributes to determining the overall shape of the midface⁸. Besides that, in forensic medicine, the maxillary sinus can be used for sex and age determination^{3,9,12}.

A study conducted by Song et al. (2009) evaluated the maxillary sinus volume and dimensions in different craniofacial deformities with mid-facial hypoplasia. The maxillary sinus volume, height, width, and depth significantly decreased in patients with Crouzon syndrome¹³.

Craniofacial reconstruction surgeries are continually evolving globally to meet the increasing functional and aesthetic demands of patients. One of the most common orthognathic surgical procedures used for the correction of maxillary deformities is Le Fort 1 osteotomy. A study was conducted to investigate the prevalence of complications for patients who had undergone Le Fort 1 osteotomy. According to their findings, Le Fort 1 osteotomies affect maxillary sinus health. These osteotomies may lead to sinusitis symptoms postoperatively and iatrogenic alterations, such as a decrease in the maxillary sinus volume and the disruption of the integrity of the medial and lateral walls of the maxillary sinus¹⁴.

Therefore, clinicians must carefully consider maxillary sinus parameters when managing mid-facial bony structures, whether addressing trauma, congenital deformities, or performing orthognathic procedures such as Le Fort osteotomies¹⁵⁻¹⁷.

Dentofacial imaging technologies play an important role in evaluating the maxillary sinus morphology and dimensions. Conventional radiographs show limited information in three-dimensional (3D) structure analyses. In comparison with conventional two-dimensional (2D) radiographs, advanced imaging modalities provide 3D multi-planar images and information on dental and maxillofacial regions¹⁸. The use of 3D imaging modalities ensures accurate 3D visualizations of the maxillary sinus¹⁹. Computed Tomography (CT) was reported to be an excellent imaging modality and acts as the gold standard to evaluate the true anatomy of sinuses. However, its use is limited because of its high cost, high radiation dose, and restricted accessibility²⁰.

Recently, Cone beam computed tomography (CBCT) has been preferred as it provides (3D) images with great accuracy for linear measurements in the axial and coronal image planes in different areas of the maxillofacial region²⁰. Moreover, CBCT is overcoming the limitations of conventional

radiography by producing 3D images that allow a comprehensive evaluation of the anatomy of the region of interest, and it also offers lower radiation exposure for the patients when compared to conventional CT²¹.

Several studies have highlighted the relationship between midfacial development and maxillary sinus morphology^{4,10,22}. Additionally, previous research has examined the impact of congenital conditions, such as cleft lip and palate, on maxillary sinus size and volume²³. Other investigations have further explored the associations between maxillary sinus dimensions and volumetric parameters in relation to sex and age^{3,12,24-32}.

Given the limited research focusing on the Egyptian population and the significant influence of maxillary sinus anatomy in maxillofacial surgery, this study aims to explore the potential correlation between maxillary sinus volume and dimensions with midface width in this demographic.

MATERIALS AND METHODS

This retrospective cross-sectional study analyzed maxillofacial cone-beam computed tomography (CBCT) scans of adult Egyptian individuals. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Dentistry, Cairo University (May 30, 2023). Sample size calculation was performed using G*Power version 3.1.9.7³³. A power analysis was designed to have adequate power to apply a two-sided statistical test of the null hypothesis that there is no correlation between maxillary sinus linear and volumetric measurements with midface width, by adopting an alpha (α) level of (0.05), a beta (β) level of (0.2) (i.e., power=80%), a null hypothesis value of (0.5), and a correlation coefficient of (0.428) acquired from the results of a previous study³⁴. The predicted sample size (n) was found to be 40 cases. Sample size approval was granted by the Medical Biostatistics Unit (April 8, 2023). CBCT scans were collected from the database of the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Cairo University. A total of 40 scans (27 females and 13 males) were included based on the calculated sample size and predefined eligibility criteria. The inclusion criteria comprised Egyptian adults aged 18–44 years with no history of orthodontic or surgical treatment affecting maxillomandibular growth. Scans showing maxillary or craniofacial pathology, traumatic injuries, developmental anomalies, missing upper premolars or molars, or those with low image quality or artifacts were excluded. All CBCT images had been previously acquired for diagnostic or treatment planning purposes using standardized exposure parameters adapted to patient size. Datasets were exported in DICOM format and analyzed using Mimics software (version 21.0; Materialise, Leuven, Belgium). The maxillary sinuses

were segmented using a semi-automated region-growing approach to isolate the air-filled cavities from surrounding bone, with minor manual refinements applied when necessary. Three-dimensional models

were generated, and sinus volumes were automatically calculated in cubic millimeters (mm³) using the software's volume measurement function (Fig. 1).

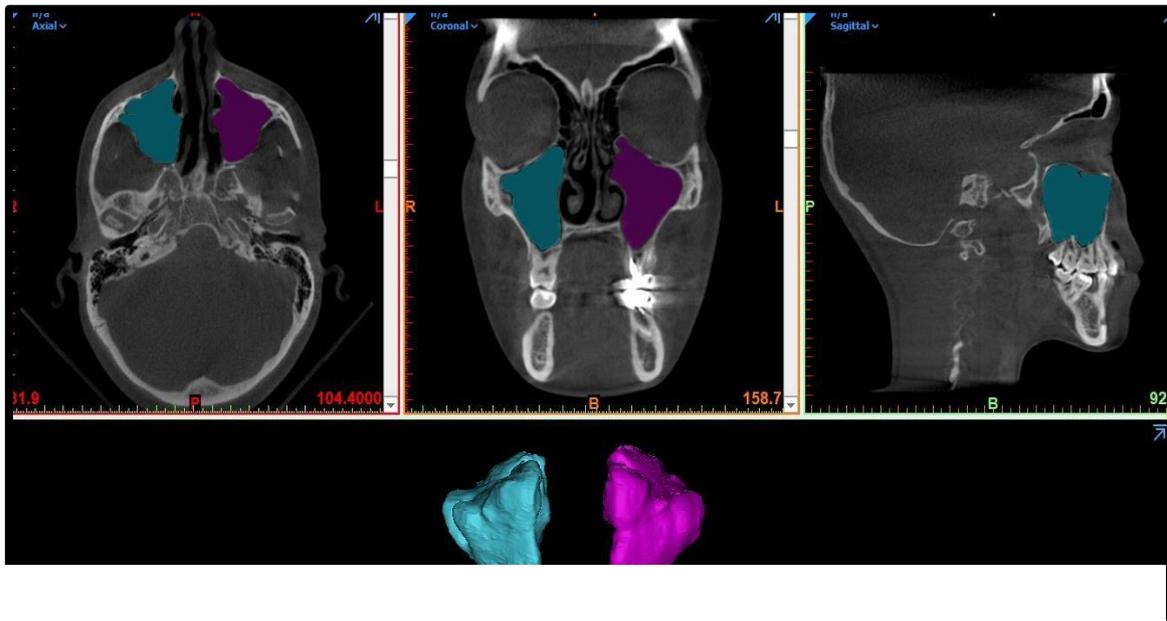


Figure 1. 3D segmentation of the right and left maxillary sinus presented in the multiplanar CBCT

Linear measurements were obtained bilaterally multiplanar reconstructed images as follows **fig.2,3,4.**

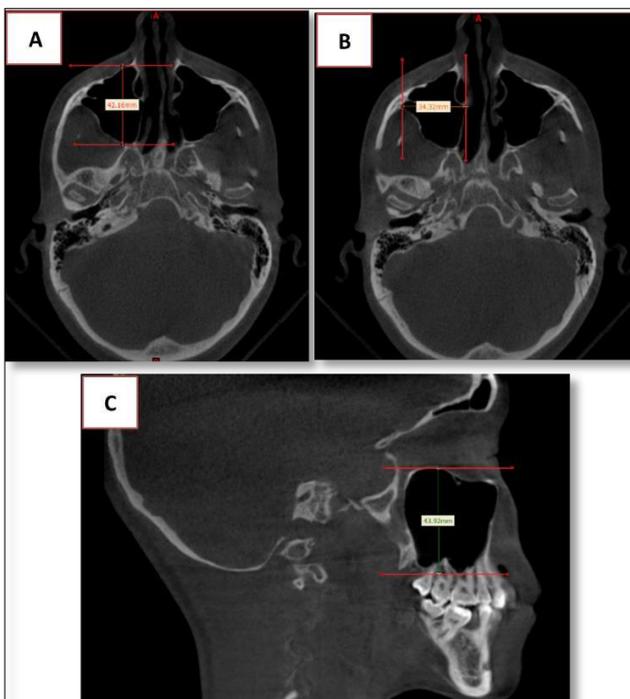


Figure 2.Maxillary sinus linear measurements. (A) Maxillary sinus length (MSL). (B) Maxillary sinus width (MSW). (C) Maxillary sinus height (MSH).

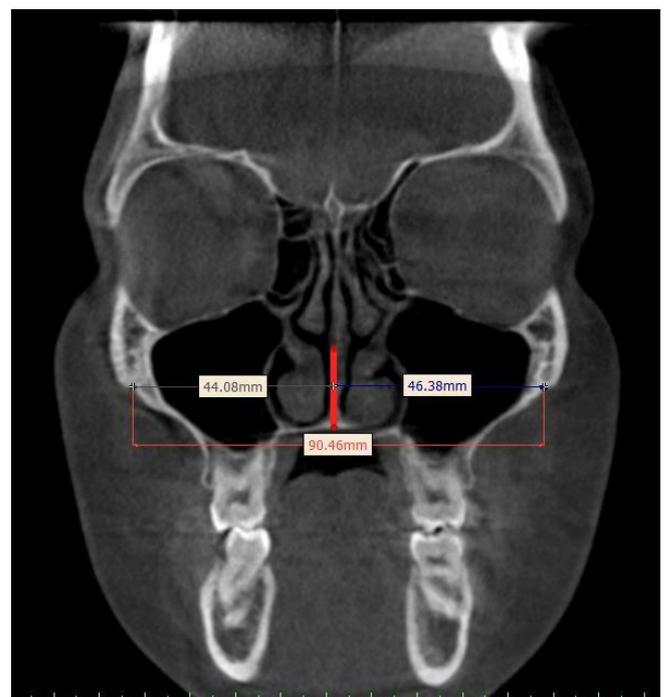


Figure 3 Midface width measured on coronal CBCT image

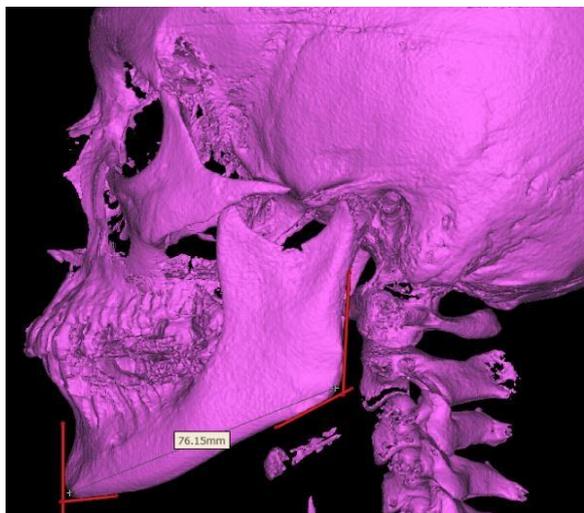


Figure 4 Mandibular body length measured on 3D reconstruction as the linear distance from Gonion (Go) to Gnathion (Gn).

Maximal anteroposterior diameter (maximal length) of the maxillary sinus (MSL) was measured, involving the longest distance from the most anterior point of the anterior wall of the maxillary sinus to the most posterior point of the posterior wall of the maxillary sinus on the adjusted axial image.

- **Maximal horizontal diameter (maximal width) of the maxillary sinus (MSW)** was measured involving the longest distance perpendicular from the most prominent point of the medial wall of the maxillary sinus to the most prominent point of the lateral wall of the maxillary sinus on the adjusted axial image.
- **Maximal vertical diameter (maximal height) of the maxillary sinus (MSH)** was measured involving the longest distance from the lowest point of the inferior wall of the maxillary sinus to the highest point of the superior wall of the maxillary sinus in the adjusted sagittal image.
- **Midface width on CBCT adjusted coronal image** was measured as the distance between the most lateral and inferior points of the maxillozygomatic suture (zm point) on both sides.
- **Mandibular body length** was measured in the 3D reconstruction as a linear distance between the identified two consistent anatomical landmarks: Gonion (Go): The most posterior-inferior point on the angle of the mandible. Gnathion (Gn): The most anterior-inferior point on the mandibular symphysis

Sampling and addressing potential sources of bias

All scans were independently evaluated by two experienced oral and maxillofacial radiologists blinded to the patients' demographic data and to each other's findings. To assess reliability, 50% of the scans were re-evaluated by the main investigator after a two-

week interval for intra-observer reliability and by another radiologist for inter-observer reliability. Discrepancies were resolved by consensus. Random selection of scans and blinding during image interpretation were applied to minimize potential sources of bias.

Statistical analysis

Statistical analysis was performed with R statistical analysis software version 4.5.1 for Windows (35).

Categorical data were presented as frequency (n) and percentage (%) values. Continuous data were presented as means, standard deviation (SD), median, minimum, and maximum values. They were examined for normality by viewing the distribution and using the Shapiro-Wilk test. Age data were nonparametric; however, all other measurements were normally distributed. Correlation analyses were performed using point-biserial correlation (for sex) and Spearman's correlation for other variables. Comparisons of mean values of different sexes were performed using independent t-tests. Laterality analyses were performed using paired t-tests. Multivariable linear regression models predicting sinus volume were confirmed for linearity (by visual inspection of residuals versus fitted values), normality of residuals (by methods mentioned earlier), and for homoscedasticity (by using the Breusch-Pagan test). Inter-observer reliability analyses were performed using one-way random ICC (Intraclass correlation coefficient) models, while for intra-observer reliability, two-way mixed ICC models were used. The significance level was set at $p < 0.05$ for all tests.

RESULTS

The descriptive analysis of the maxillary sinus and facial dimensions revealed that, on the right side, the mean sinus volume was approximately $15,739 \text{ mm}^3$ with a standard deviation of $5,055 \text{ mm}^3$, ranging from $6,218 \text{ mm}^3$ to $27,927 \text{ mm}^3$. The mean sinus width, length, and height on the right side were 30.6 mm, 38.9 mm, and 37.4 mm, respectively.

On the left side, the mean sinus volume was slightly higher at $16,246 \text{ mm}^3$ ($SD = 4,729 \text{ mm}^3$), ranging from $5,970 \text{ mm}^3$ to $29,441 \text{ mm}^3$. The mean sinus width, length, and height were 31.1 mm, 39.1 mm, and 37.8 mm, respectively. The mean facial width for the entire sample was 87.4 mm ($SD = 4.32 \text{ mm}$), while the mean mandibular body length was 73.7 mm ($SD = 4.72 \text{ mm}$). These findings indicate that left sinus volumes were marginally greater than those of the right side, though the differences were small and not statistically significant.

Correlation analysis was presented in **Table 1**, demonstrating a moderate, positive, and statistically significant relationship between facial width and most sinus parameters on the right side. The right sinus volume ($r = 0.45$, $p = 0.004$), width ($r = 0.41$, $p = 0.009$), length ($r = 0.46$, $p = 0.003$), and height ($r =$

0.39, $p = 0.013$) all showed significant positive correlations with facial width

On the left side, a similar trend was observed, though the strength of the correlations was slightly weaker. The left sinus volume ($r = 0.38$, $p = 0.017$) and width ($r = 0.35$, $p = 0.030$) were significantly correlated with facial width, whereas the correlations for length ($r = 0.27$, $p = 0.089$) and height ($r = 0.29$, $p = 0.066$) did not reach statistical significance. These results suggest that facial width is a meaningful predictor of sinus size, especially in relation to sinus volume and width, with the right side showing stronger and more consistent associations than the left.

Table 1. Correlations between sinus measurements and facial width.

Side	Measurement	Correlation coefficient (95% CI) with facial width	p-value
Right	Sinus volume (mm ³)	0.45 (0.16 to 0.67)	0.004*
	Sinus width (mm)	0.41 (0.11 to 0.64)	0.009*

CI: Confidence interval; * significant ($p < 0.05$); ns: not significant.

No statistically significant correlations were found between any of the sinus measurements and the mandibular body length. The correlation coefficients for both sides were low and non-significant.

The correlation between sinus dimensions and age was not statistically significant for either side. All correlation coefficients were weak and negative, suggesting a minimal or negligible inverse relationship. Since all participants were adults, this finding confirms that sinus development has already stabilized and that sinus volume does not vary markedly with age within this age range. When comparing sinus dimensions between males and females, the mean values for males were consistently higher across all measurements on both sides; however, none of these differences reached statistical significance ($p > 0.05$).

A strong, positive, and statistically significant relationship was found among all sinus parameters, regardless of side. Sinus width, length, and height each demonstrated strong correlations with sinus volume (r ranging between 0.74 and 0.88, $p < 0.001$). These findings indicate that as one linear dimension of the sinus increases, the others increase proportionally, suggesting that sinus pneumatization occurs in a harmonious and balanced manner across all dimensions.

The comparison between right and left sinus measurements showed no statistically significant differences for any dimension. Both sides exhibited nearly symmetrical values for sinus volume, width, length, and height ($p > 0.05$). Multiple linear regression models were presented in **Table 2** to identify which sinus dimensions most effectively predicted sinus volume. For the right side, the model was statistically significant ($F = 141.39$, $p < 0.001$) and explained 92% of the variance in sinus volume (Adjusted $R^2 = 0.92$). All predictors showed significant positive relationships with sinus volume, with the regression coefficients (β) indicating that for each 1 mm increase in sinus width, length, and height, the sinus volume increased by approximately 391 mm³, 330 mm³, and 425 mm³, respectively.

For the left side, the regression model was also statistically significant ($F = 69.97$, $p < 0.001$) and accounted for 84% of the variance (Adjusted $R^2 = 0.84$). The coefficients showed that for every 1 mm increase in sinus width, length, and height, the sinus volume increased by approximately 434 mm³, 261 mm³, and 381 mm³, respectively. These results demonstrate that sinus height and width are the strongest predictors of sinus volume, while sinus length contributes to a lesser extent. Reliability analysis revealed excellent consistency for all measurements. Interobserver reliability coefficients (ICC) ranged between 0.92 and 1.00, while intra-observer ICC values ranged from 0.99 to 1.00, all statistically significant ($p < 0.001$). This confirms high measurement accuracy and reproducibility across all assessed parameters, validating the reliability of the CBCT-based measurements used in this study.

Table 2. Regression models predicting sinus volume.

Side	Measurement	Coefficient (95% CI)	p-value
Right	Sinus width (mm)	391.19 (202.80 to 579.58)	<0.001*
	Sinus length (mm)	330.01 (119.79 to 540.22)	0.003*
	Sinus height (mm)	424.53 (279.26 to 569.80)	<0.001*
Left	Sinus width (mm)	433.63 (201.06 to 666.20)	<0.001*
	Sinus length (mm)	260.76 (30.19 to 491.34)	0.028*
	Sinus height (mm)	381.20 (196.09 to 566.32)	<0.001*

CI: Confidence interval; * significant ($p < 0.05$).

DISCUSSION

Evaluating changes in maxillary sinus dimensions in relation to midfacial measurements may contribute to understanding the growth model of the maxillary sinus and its correlation with facial anatomical structures^{36,37}. Therefore, this study investigated the correlation between maxillary sinus linear and volumetric dimensions and midfacial width and length in adult Egyptian individuals.

The analysis comprised 40 CBCT scans. CBCT was selected as the imaging modality of choice due to its superior spatial resolution, lower radiation exposure, and cost-effectiveness relative to conventional computed tomography³⁸. Maxillary sinus volumes were obtained using semi-automated segmentation in MIMICS software. This method offers improved accuracy and efficiency over manual techniques while maintaining anatomical precision^{39,40}. The reliability of MIMICS for volumetric analysis has been previously validated^{28,41}.

In the present study, the mean maxillary sinus volume (MSV) was 15.74 cm³ on the right side and 16.25 cm³ on the left, values that fall within the commonly reported adult range of approximately 14–18 cm³^{12,17,42-45}. These findings are consistent with Pokhrel et al. (2025), who reported comparable mean volumes in a Nepalese population using CBCT⁴². Similar values were also reported in European samples by Fernandes (2004), whereas smaller volumes were observed in Zulu individuals in the same study, suggesting ethnic variability⁴⁶. In contrast, larger MSVs have been reported in Japanese populations by Kawarai et al. (1999), reflecting differences in craniofacial morphology and volumetric assessment techniques⁴⁷. Slightly lower but comparable values have been documented in Turkish and Sri Lankan populations^{47,48}. Overall, variations in MSV across studies are likely attributable to demographic factors, craniofacial characteristics, imaging modality, and segmentation methodology. The results of the present study,

therefore, fall within the expected physiological range and align with previously reported data when population and methodological differences are considered.

Comparison of the right and left maxillary sinuses in the present study revealed no statistically significant difference, indicating a high degree of bilateral symmetry in sinus morphology. To minimize potential confounding factors, individuals with posterior tooth loss were excluded, as unilateral dentition differences are known to influence maxillary sinus pneumatization and may affect side-to-side comparisons.

These findings are consistent with previous studies reporting general bilateral symmetry of the maxillary sinuses in healthy individuals, with minor variations considered within normal anatomical limits^{3,9,10}. Similarly, Gulec et al. (2020) found no significant difference between right and left maxillary sinus volumes in a CBCT-based study of 133 subjects²⁸. Although slight asymmetries may occur, they are typically minimal and clinically insignificant, potentially arising from localized functional or anatomical factors such as masticatory dominance or nasal septal deviation⁴⁹. The documented increase in sinus volume following posterior tooth loss further supports the exclusion criteria applied in the present study to ensure reliable bilateral comparisons⁵⁰.

Strong and statistically significant positive correlations were observed among all maxillary sinus parameters (volume, height, width, and length), indicating proportional sinus expansion during pneumatization. Regression models predicting sinus volume from linear dimensions demonstrated high explanatory power (adjusted R² = 84–92%), suggesting that linear CBCT measurements can reliably estimate sinus volume.

These findings are consistent with previous studies reporting that linear sinus dimensions serve as accurate predictors of volumetric measurements when

3D reconstruction is unavailable⁵¹⁻⁵³. However, the relative contribution of each linear dimension varied between sides. On the right side, sinus height showed the strongest influence on volume, followed by width and length, whereas on the left side, width was the strongest predictor, followed by height and length.

Overall, these results indicate that maxillary sinus volume is primarily influenced by vertical and transverse expansion, with the anteroposterior dimension playing a lesser role. This observation agrees with previous CBCT-based studies highlighting width by Alhazmi et al. (2019), and height by Uchida et al. (1998) as major determinants of sinus volume^{51,54}. Anatomically, this pattern reflects the predominant inferior and lateral directions of maxillary sinus growth and pneumatization toward the alveolar process and zygomatic buttress^{28,55}.

A notable finding of the present study was the moderately strong, statistically significant positive correlation between midfacial width and all right-side maxillary sinus measurements (volume, height, width, and length). This supports the concept that the surrounding skeletal framework influences maxillary sinus pneumatization and occurs proportionally with transverse midfacial dimensions⁵⁶.

These results are consistent with Alhazmi et al. (2019), who demonstrated moderate to strong correlations between maxillary sinus volume and transverse maxillary measurements using CBCT, with volumetric assessment showing stronger associations than linear dimensions⁴. Similarly, Fathy et al. (2022) reported positive correlations between maxillary sinus volume and midfacial width parameters, including bizygomatic and zygomaxillary widths, in an Egyptian population, with stronger associations observed in females¹⁰.

In the present study, the left side showed a significant positive correlation between midfacial width and both sinus volume and width, whereas correlations with sinus height and length were not significant. This partial asymmetry contrasts with the findings of Fathy et al. (2022), who reported predominantly left-sided correlations, and may reflect minor anatomical asymmetry or measurement variability¹⁰.

Additional support for the relationship between sinus morphology and midfacial width comes from Przystańska et al. (2018), who reported strong associations between sinus width and transverse facial dimensions, while sinus volume was more closely related to vertical and anteroposterior facial parameters²². All these findings reinforce the role of transverse midfacial dimensions as key determinants of maxillary sinus size.

In the present study, no significant correlation was found between maxillary sinus dimensions and mandibular body length, indicating that sinus morphology is more closely associated with midfacial skeletal parameters than with the lower facial skeleton.

This independence likely reflects the distinct embryological origins and developmental pathways of the maxilla and mandible. These findings are consistent with Alqahtani et al. (2023), who reported no significant association between maxillary sinus volume and mandibular body length (Co–Gn) in an adult CBCT-based analysis⁵⁷.

In contrast, Yili et al. (2020) observed a positive correlation between maxillary sinus volume and mandibular length in a younger population aged 5–20 years⁵⁸. Differences in developmental stage most plausibly explain this discrepancy, as both mandibular growth and sinus pneumatization are ongoing during childhood and adolescence. By contrast, the adult-only sample in the present study represents a post-maturational phase, in which growth-related associations are less likely to be detected.

In the present study, no statistically significant correlations were found between maxillary sinus measurements and age. This finding contrasts with several studies reporting age-related reductions in sinus volume or dimensions, particularly in samples including wide age ranges. Ozsoy et al. (2025) and Aktuna Belgin et al. (2019) reported significant negative correlations between age and sinus volume using CBCT-based volumetric analyses⁴, while Otsuki et al. (2023) demonstrated that sinus dimensions increase until early adulthood and gradually decline thereafter⁵⁹. Similar age-related reductions in sinus pneumatization were reported by Wu et al. (2022) and Elshentnawi et al. (2025), although the latter noted weak predictive power^{60,61}. Conversely, studies focusing on adult populations have frequently reported minimal or non-significant associations between age and sinus volume. Tanaka et al. (2021), Bornstein et al. (2019), Asantogrol et al. (2021), and Gulec et al. (2020) found no significant age-related changes in maxillary sinus volume in adults, suggesting that the influence of age diminishes after craniofacial growth is complete.

Overall, these findings suggest that maxillary sinus dimensions stabilize in adulthood and that age is not a primary determinant of sinus morphology in dentate adults, consistent with previous observations by Emirzeoglu et al. (2007) and Jun et al. (2005)^{51,62}.

In the present study, males exhibited slightly larger mean maxillary sinus dimensions than females; however, these differences were not statistically significant. This finding is consistent with several CBCT- and CT-based studies reporting minimal or non-significant sex-related differences in maxillary sinus volume; these studies suggest that maxillary sinus volume alone has limited discriminatory power for sex determination^{12,29-32}.

Conversely, other investigations have reported significantly larger sinus volumes in males. Studies in Saudi⁶³, Egyptian⁶⁴, South Indian⁶⁵, and Turkish⁶⁶ populations demonstrated greater male maxillary

sinus volumes using both formula-based calculations and segmentation techniques, with some achieving high accuracy in sex classification.

The absence of statistically significant sex differences in the present study may be attributed to subtle volumetric variations and a relatively limited sample size, which may have reduced the power to detect minor sex-related differences reported in larger cohorts. Although males demonstrated numerically higher values, the substantial overlap between male and female measurements indicates that maxillary sinus volume should not be used as a standalone parameter for sex determination. Instead, it may serve as a supplementary variable within a comprehensive morphometric or forensic assessment, in agreement with recent systematic reviews⁶⁷.

Inter- and intra-observer reliability analyses demonstrated excellent agreement (ICC = 0.92–1.00 and 0.99–1.00, respectively; $p < 0.001$), confirming the high precision and reproducibility of CBCT-based maxillary sinus measurements, consistent with previous reports⁶⁸.

Study Limitations

This study was limited by a relatively small sample size and predominance of younger adults. Additionally, only healthy individuals were included, which limits applicability to pathological conditions such as chronic sinusitis, trauma, or skeletal malocclusion.

CONCLUSION AND RECOMMENDATION

Finally, we concluded that maxillary sinus dimensions showed bilateral symmetry and a moderate positive correlation with midfacial width, indicating a link between sinus growth and midfacial development. No significant effects of sex, age, or mandibular length were observed. CBCT proved reliable for measurement. Further large-scale and longitudinal studies across populations are recommended to confirm these findings and explore clinical and forensic applications.

DECLARATION

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Author contributions

AAH: Conceived and designed the study, sample collection, data entry, interpretation of data, drafting the article, and approval of the final article. HSM: Contributed to study design, data interpretation, revising the drafted article, and approval of the final article. HO: Coding the data, contributed to data

analysis, revising the drafted article, and approval of the final article.

Ethical policy and institutional review board statement

The current study was approved by the ethical committee of the Faculty of Dentistry, Cairo University, Egypt (approval number 1523) (approval date 30/5/2023), and it complies with the Declaration of Helsinki (2013). The trial is registered on.

Patient declaration of consent

Patient declaration of consent was obtained in a Helsinki declaration consent form in their native language (Arabic). Provided is the English version of said form and a signed Arabic one by one of the study participants.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [AAH], upon reasonable request.

Not applicable

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