EVALUATION OF MAXILLARY SINUS VOLUME IN ADULT VIETNAMESE USING COMPUTED TOMOGRAPHY

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ABSTRACT

Objective: To investigate the dimensions of the maxillary sinus measured on maxillofacial computed tomography (CT) scans and estimate the volume of the maxillary sinus. This study aims to evaluate the differences in maxillary sinus size between males and females, as well as between the left and right sides of the normal maxillary sinus in Vietnamese adults.

Materials and methods: This is a cross-sectional, descriptive case series study. A total of 196 maxillary sinuses were examined using maxillofacial computed tomography (CT) scans from 98 Vietnamese individuals aged 18 and older, with no related sinonasal pathology, conducted at Can Tho University of Medicine and Pharmacy Hospital. The vertical, transverse, and anteroposterior diameters of the maxillary sinus were measured using the bone window on non-contrast maxillofacial CT scans. The sinus volume was estimated using a formula based on these measurements. Statistical analysis was performed to compare differences in the obtained parameters.

Results: The mean age of the study sample was 47.02 ± 12.076 years. The smallest measured sinus volume was 6.17 cm^3, the largest was 40.62 cm^3, and the average volume was 22.4672 ± 7.651 cm^3. The maxillary sinus volume in males was larger than in females, with a statistically significant difference ($p = 0.04 < 0.05$). No statistically significant difference was found in the maxillary sinus volume between the right and left sides.

Conclusion: Using computed tomography to evaluate maxillary sinus volume provides valuable insights into the morphological characteristics of the Vietnamese population, enhancing knowledge for clinical and anthropological applications.

Keywords: Maxillary sinus; Dimension; Computed tomography; Volume.

1. INTRODUCTION

The maxillary sinuses are a pair of air-filled cavities located within the maxillary bones bilaterally, with varying sizes and shapes among different ethnicities, ages, and genders, and even between the two sides of the same individual (Koji et al., 2009; Uthman et al., 2011). The maxillary sinuses reach their mature size around the age of 18-20, when the permanent teeth are fully developed. Genetic, environmental factors, and facial bone structure may influence this developmental process (Jovanic et al., 1984).

Maxillary sinus volume (MSV) has been studied in otolaryngology, dentistry, oral and maxillofacial surgery, and forensic science. This interest stems from the surrounding anatomical relationship with adjacent structures and its essential role in the respiratory system (Sarilita et al., 2021). Therefore, detailed knowledge of maxillary sinus anatomy is crucial for performing procedures such as functional endoscopic sinus surgery

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or surgery for trauma. While many studies have focused on the morphology, size, and volume of the maxillary sinus, most of the research has been conducted on different ethnic groups and using cadavers, dry skulls, or X-ray films. Computed tomography (CT), however, stands out as the most comprehensive and objective method for assessing disease severity, offering high sensitivity to changes induced by different interventions. The major advantage of CT is the excellent osseous anatomic detail that it provides, highlighting the boundaries of the maxillary sinus. Therefore, CT is the gold-standard imaging modality for inflammatory diseases of the paranasal sinuses (Giacomini et al., 2018). Our study uses multi-slice CT scanning based on existing images, which offers non-invasive advantages, allowing for the reconstruction of images and the examination of various dimensions as required for the research objectives, all from a single scan without any invasiveness. This first study focuses on assessing the volume and dimensions of the maxillary sinus in a Vietnamese population.

2. MATERIALS AND METHODS

2.1. Patient selection

This cross-sectional, descriptive case series study included 196 maxillary sinuses, examined using maxillofacial computed tomography (CT) scans from 98 Vietnamese individuals (43 males, 55 females). The 98 multi-slice CT images of the maxillofacial region were obtained between January 2024 and December 2024 at Can Tho University of Medicine and Pharmacy Hospital.

- Inclusion criteria: Patients aged 20 years or older with a CT scan of the sinuses demonstrating an intact bone structure in the paranasal sinus region and who have provided consent to participate in the study.

- Exclusion criteria: included patients with congenital craniofacial abnormalities, patients who had previously undergone sinus surgery, patients with a history of nasal sinus trauma or pathological conditions causing anatomical distortion in the skull-sinus landmarks, leading to bone formation or resorption, and patients under the age of 20.

2.2. Measurement Method

The CT images of the maxillofacial region were obtained using a Philips scanner. The scanning technique involved acquiring continuous axial slices parallel to the plane connecting the outer orbital rim and the external auditory meatus and remodelling in the other planes to meet the study's criteria. The radiology technologist chose a slice thickness of 1 mm.

The maxillary sinus volume was measured semi-automatically based on three dimensions in the CT scan planes, following the methodology by Sharma (Sharma et al., 2014).

The measurements were taken at the largest closed distance depending on the three CT plane images: Sagittal, coronal, and axial. These included the horizontal diameter, anteroposterior diameter, and vertical diameter. (Fig.1A-C)

Measure the vertical diameter (Height: H) of the maxillary sinus from the lowest point of the sinus floor to the highest point of the sinus roof on the coronal plane.

Measure the horizontal diameter (Width: W) of the maxillary sinus from the innermost point of the sinus wall to the outermost point of the sinus wall, perpendicular to the vertical diameter, on the axial plane.

Measure the anteroposterior diameter (Anterioposterior dimension: AP) of the maxillary sinus from the most anterior point to the most posterior point on the sagittal plane.

Maxillary sinus volume (MSV) is calculated using the formula: (Sharma et al., 2014)

$$MSV = H \times W \times AP \times 0.52$$

2.3. Statistical analysis

The image data were stored on a hard disk and later analyzed on a computer using the Radiant 4.6.9 software. Data were processed and analyzed using SPSS 20.0 software.

3. RESULTS

A total of 196 maxillary sinuses from 55 females and 43 males were analyzed in this study.

The average age of the study sample was 47.1 years, with the youngest being 23 and the oldest 74 years. Females accounted for the majority at 56.1%.

3.1. Maxillary Sinus Dimensions

There were no significant differences between males and females in the vertical diameter and horizontal diameter, but the anteroposterior diameter tended to be larger in males than that of females when compared by using a t-test ($p < 0.05$).

All the measured diameter indices in our study followed a normal distribution, and no statistically significant differences were observed between the right and left sides.

3.2. Maxillary Sinus Volume

The smallest maxillary sinus volume was 6.17 cm^3, the largest was 40.62 cm^3, and the average volume was 22.47 ± 7.65 cm^3.

The average volume of the left maxillary sinus was 22.81 ± 7.99 cm^3, while the right side was 22.13 ± 7.79 cm^3, with no significant difference ($p = 0.2 > 0.05$) (Table 1).

Table 1. Anatomical Characteristics of Maxillary Sinus Dimensions

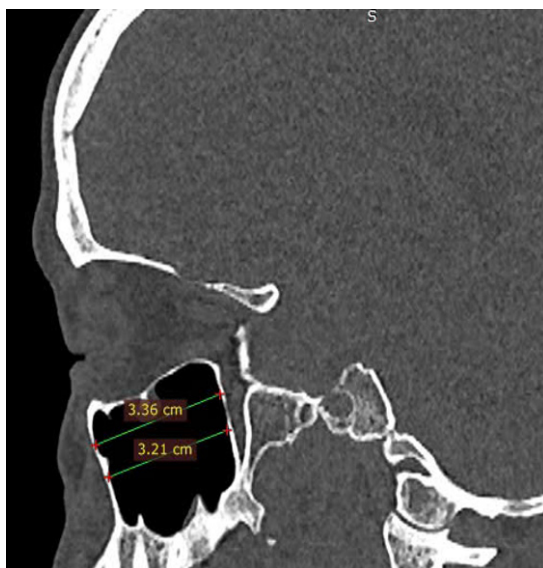| Anatomical Characteristics	Left Side			Right Side		
	Mini-mum	Maxi-mum	Average ± SD	Mini-mum	Maxi-mum	Average ± SD
Vertical Diameter (cm)	2.52	5.43	4.11 ± 0.59 Male: 4.26 ± 0.56 Female: 4.01 ± 0.61	2.63	4.98	3.99 ± 0.63 Male: 4.19 ± 0.68 Famale: 3.87 ± 0.59
Horizontal Diameter (cm)	1.76	3.97	2.79 ± 0.47 Male: 2.94 ± 0.50 Female: 2.71 ± 0.45	1.71	3.85	2.77 ± 0.46 Male: 2.89 ± 0.43 Female: 2.71 ± 0.47
Anteroposterior Diameter (cm)	2.53	4.83	3.68 ± 0.38 Male: 3.84 ± 0.34 Female: 3.58 ± 0.38	2.64	4.63	3.68 ± 0.35 Male: 3.76 ± 0.29 Female: 3.62 ± 0.37
Volume (cm^3)	7.15	40.62	22.81 ± 7.99 Male: 25.72 ± 8.44 Female: 21.01 ± 7.25	6.17	39.98	22.12 ± 7.79 Male: 24.58 ± 7.97 Female: 20.62 ± 7.40

The average maxillary sinus volume in males was 25.15 ± 7.78 cm^3, while the average volume in females was 20.81 ± 7.19 cm^3. The maxillary sinus volume was significantly larger in males than in females ($p = 0.04 < 0.05$) (Table 2).

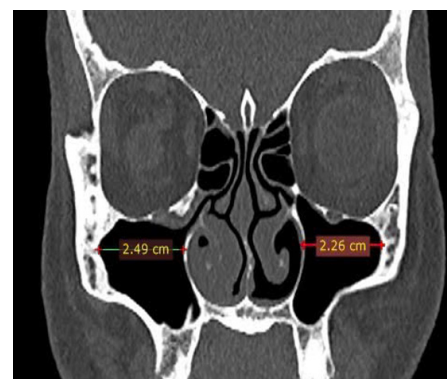**Table 2. Average Volume of Maxillary Sinus by Gender and Side**

Average volume		Male	Female
Average unilateral volume of the maxillary sinus (cm^3)	Left side	25.72 ± 8.44	21.01 ± 7.25
	Right side	24.58 ± 7.97	20.62 ± 7.40
Average volume of both maxillary sinuses (cm^3)		25.15 ± 7.78	20.81 ± 7.19

B. The height of the maxillary sinus was measured on the coronal reconstructed image and defined as the longest vertical distance from the lowest point of the sinus floor to the highest point of the sinus roof

C. The transverse dimension (width) of the maxillary sinus was measured on the coronal reconstructed image and defined as the longest perpendicular distance from the medial wall of the sinus to the outermost point of the lateral wall of the lateral process of the maxilla

A. Measuring the dimensions on the axial and coronal planes using Radiant software

Figure 1A-C. Measurement Method of Maxillary Sinus Dimensions Used in This Study

The antero-posterior dimension was measured on the sagittal reconstructed image and defined as the longest linear distance from the most anterior point to the most posterior point.

4. DISCUSSION

A total of 196 maxillary sinuses were examined using 98 CT scan images in our study, with females representing a higher proportion than males (56.1%). The average age of the study sample was 47.1 years, with the youngest being 23 and the oldest 74. Overall, our study had a relatively even distribution across age groups, with the average age being higher than the average age in the studies by Emirzeoglu, Cohen, and Tassoker (Emirzeoglu et al., 2007; Cohen et al., 2018; Tassoker et al., 2020). This difference may be due to the random selection of patients in the study sample.

The average values for the vertical diameter, horizontal diameter, and anteroposterior diameter in our study were 4.05 ± 0.59 cm, 2.79 ± 0.45 cm, and 3.68 ± 0.35 cm, respectively. Compared with Kiruba's 2014 study, the width, height, and depth of the maxillary sinuses in males on both sides were approximately 27.8, 28.2, 39.9, 39.6, and 40.0, 39.7 mm, while in females, they were 26.6, 26.7, 36.8, 37.1, and 36.6, 37.4 mm (Kiruba et al., 2014).

The average maxillary sinus volume in our study was 22.47 ± 7.65 cm^3, with a notable difference in maxillary sinus volume between males and females. Specifically, the volume of the maxillary sinuses in females was found to be smaller than in males. Previous studies have assessed gender differences in maxillary sinus volume, consistently reporting that males have significantly larger sinuses than females (Cohen et al., 2018; Kiruba et al., 2014; Wu et al., 2024; Yeung et al.,2019). This study also demonstrated no significant difference in the average volume between the left and right maxillary sinuses (p = 0.2 > 0.05), similar to the results reported by Sarilita et al (2021).

Table 3. Comparison of Maxillary Sinus Volumes with Other Authors

Author	Year	Measurement Method	Average Maxillary Sinus Volume (cm^3)	
			Left Side	Right Side
Our Study (Viet Nam)	2024	Three-dimensional formula	Male: 25.72 ± 8.44 Female: 21 ± 7.25	Male: 24.57 ± 7.97 Female: 20.61 ± 7.39
Yeung et al. (Hong Kong, China)	2019	Volume measurement software	Male: 19.9 Female: 15.6	
Tassoker et al. (Turkey)	2020	Volume measurement software	Male: 17.332 ± 7.183 Female: 12.704 ± 3.983	Male: 16.106 ± 5.524 Female: 12.699 ± 4.184
Cohen et al. (Israel)	2018	Volume measurement software	Male: 14.61 ± 5.15 Female: 12.26 ± 3.91	Male: 14.16 ± 4.58 Female: 12.19 ± 4.01

The differences in average maxillary sinus volume between our study and other research may be attributed to variations in the study samples, particularly differences in ethnicity and geographical regions. Regarding the measurement method, using CT-scan to assess maxillary sinus dimensions has the advantage of generating a 3D model of the sinus, providing an estimation closest to the actual volume. However, this method is influenced by the operator, measurement technique, and whether an estimation formula or software is used. Przystańska et al. (2018) conducted a study on 170 patients, comparing maxillary sinus volume by using automated software and formulas. They concluded that the difference between these two methods was not statistically significant, suggesting that volume formulas can be reliably applied in clinical practice. Therefore, depending on the research objectives and practical considerations, different methods for determining maxillary sinus volume can be utilized, all of which can yield valuable and meaningful information. By using Sharma et al.'s formula to determine maxillary sinus volumes, we found that it is easy to apply and produces reliable results. This first study focused on the maxillary sinus volume and dimensions of 196 maxillary sinuses in a Vietnamese population; however, the sample size remains relatively limited.

5. CONCLUSION

The first study measured maxillary sinus volumes using 98 computed tomography (CT) scans with 196 maxillary sinuses in Vietnamese, reporting average values for vertical diameter, transverse diameter, and anteroposterior diameter of 4.05 ± 0.59 cm, 2.79 ± 0.45 cm, and 3.68 ± 0.35 cm, respectively. The average maxillary sinus volume was recorded as 22.47 ± 7.65 cm^3, with a noted difference between males and females. These findings contribute to a more comprehensive and detailed understanding of the morphological characteristics of the maxillary sinus, particularly in the Vietnamese population. With these results, surgeons can gain a better understanding of paranasal sinus anatomy and can apply it in performing maxillary balloon sinuplasty more safely.

Ethical approval

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