**Original Article** 

# Sinus Maxillaris Morphometric Measurements and Comparative **Anatomy Between Genders**

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## ABSTRACT

Objective: This study aimed to investigate the usability of the maxillary sinus as a criterion in gender determination by comparing the dimensions of the maxillary sinuses in adult males and females using cone-beam computed tomography (CBCT).

Methods: Our study was designed to measure individuals' bilateral maxillary sinus height, width, and depth with CBCT. A total of 100 patients, 50 women and 50 men between the ages of 18 and 70, were included in the study. The height (H), width (W), and depth (D) of the sinus were measured in the coronal and axial planes, and their statistical significance was evaluated.

**Results:** In our results, the confidence interval was determined as 95% and P < .05, was considered significant. Right height (P < .05) .001), right width (P=.045), and left height (P=.015) parameters were statistically higher in males than in females. In the discriminant analysis, the parameter that gave the best discrimination was the right height with 63%.

Conclusion: In our study, it was observed that the sinus maxillaris dimensions were larger in male individuals than in female individuals, but it was concluded that it is not a definitive criterion on its own and can be used as a supporting one.

Keywords: Anatomy, cone-beam computed tomography, morphometry, sinus maxillaris

## INTRODUCTION

Sinus maxillaris is the largest pyramid-shaped paranasal sinus located in the maxillary bone under the eye. In a newborn, it is the size of a pea and is filled with fluid.1 The maxillary sinuses form around the eighth week of embryonic development and extend to the roof of the permanent teeth with the loss of primary teeth. As the development continues, the sinuses take their final form as the nasal mucosa progresses toward the maxilla bone.<sup>2</sup> Its development continues from the age of 3 and completes between the ages of 12 and 17, or after the eruption of permanent teeth<sup>1</sup>. Unique development of sinus maxillaris describes the massive quantity of anatomical variation. One of the most important aspects of determining identity is determining gender. Many of the bones in the human skeleton are significant in establishing gender. Gender determination can be determined at a rate of 90% from the skull, 95% from the pelvis, 98% from the skull and pelvis, 95% from the long bones and pelvis, 90%-95% from the skull and long bones, and 80%-90% from the long bones alone, according to the literature.<sup>3,4,5</sup>

The craniofacial skeleton has been used in various instances for prediction of the age and sex of individuals. Identification becomes easier if the entire skeleton or body is intact.<sup>6</sup> However, in some cases, it becomes difficult to access healthy cycle data because, especially in mass disasters such as explosions, wars, natural disasters, and plane crashes, the state of the bone becomes fragmented, missing, or confused. Therefore, it is important to use denser bones, such as the maxillary sinus, and thus diversify the skeletal area to be examined for sex identification.<sup>7,8</sup>

Radiography has been used as a forensic tool in human identification, especially when body integrity is disrupted

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due to trauma, body parts are dispersed, or body parts are burned. If only images are available as data, it can help measure the correct dimensions for certain measurements. Gender determination can be made using formulas applied to measurements.<sup>9</sup> Among many radiographic methods for determining bone dimensions, panoramic radiographs give us the following advantages: both sinuses and cone beam computed tomography (CBCT). The mentioned method is preferred because it reduces the possibility of overlapping, helps with precise measurement of structures, can produce three-dimensional images using volumetric rendering, and can be viewed in different planes. In examination of the components in the maxillofacial region, teeth are adjacent to the sinus floor, especially in the posterior maxillary region. For this reason, in this study, it was investigated whether gender determination could be made in a reliable way using CBCT.6

## MATERIAL AND METHODS

In the design of this study, the aim was to measure and compare the height, width, and depth of the bilateral maxillary sinuses of individuals with CBCT. A total of 100 patients, 50 female and 50 male, between the ages of 18 and 70, were included in the study. A patient consent form was not required in our study, which was considered a retrospective study. The tomography scans were taken from the archives of Erzincan Binali Yıldırım University, Oral and Dental Health Training and Research Hoaspital. Approval was received from the Erzincan Binali Yıldırım University. Clinical Research Ethics Committee on February 20, 2023 (241777-2023-02/8).

In the selection of individuals to be included in the study, the following criteria were taken into account: being over 18 years of age, CBCT images showing the right and left maxillary sinuses' wall, images not containing blurry or cutoff maxillary sinus fragments, and no pathological abnormalities in the sinus area. The criteria for exclusion from the study are as follows: no CBCT image; CBCT is not suitable for evaluation due to artifact or technical inadequacy; patients with tumoral lesions; and patients with maxillofacial deformity.

## MAIN POINTS

- Sinus maxillaris measurements are also valid for gender discrimination in the Turkish population.
- Sinus maxillaris measurement, which is not easily distorted, is an up-to-date and useful method for gender determination.
- The most significant parameter in gender determination via the sinus maxillaris is the right height criterion.

The CBCT Planmeca Promax 3D that we use (Helsinki, Finland) device shooting parameters and tomographies taken with a 90 Kv and 6 mA 80 mm × 80 mm device were retrospectively examined in 1 mm coronal and axial sections. We made morphometric measurements of the maxillary sinus using RadiAnt software and its standard features.

Height (H) evaluated in coronal section was determined by recording the distance from the lowest point to the highest point of the maxillary sinus floor (Figure 1).

Width (W) evaluated in axial section was determined by recording the distance of the medial sinus wall to the most lateral part of the maxillary sinus (Figure 2).

Depth evaluated in axial section (D) was determined by recording the distance from the front to the back of the medial wall (Figure 2).

The Statistical Package for the Social Sciences Statistics software for Windows, version 22.0, (IBM SPSS Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistics are as follows: percentage, frequency, mean, standard deviation, median, and minimum-maximum values. The Shapiro–Wilk test was used to evaluate the normality of the right and left height, width, and depth values. Since they showed a normal distribution, parametric test procedures were preferred. Afterwards, the independent groups *t*-test was used to determine the relationship between parameters. Since the age distribution did not exhibit normality according



**Figure 1.** Evaluation of height in axial section. H, height—the distance from the lowest point to the highest point of the maxillary sinus floor.



**Figure 2.** Evaluation of width in axial section. W, width—the distance of the medial sinus wall to the most lateral part of the maxillary sinus; D, depth—distance from the front to the back of the medial wall.

to the Shapiro–Wilk test, the nonparametric Spearman's rho correlation test was applied. The results were evaluated within the 95% confidence interval, and P < .05 was considered significant. Descriptive data for both sides are shown in (Table 1).

### RESULTS

The total sample consisted of 100 patients (50 women and 50 men) from the Erzincan Binali Yıldırım University Oral and Dental Health Training and Research Hospital.

#### Maxillary Sinus Height Measured in the Coronal Plane

When maxillary sinus height is evaluated, for the male group, the mean value of the right side was (37.146  $\pm$  5.6 mm) and the mean value of the left side was (37.028  $\pm$  6.91 mm), while the mean value of the right side was (32.942  $\pm$  6 mm) and the mean value of the left side was calculated as (33.880  $\pm$  6 mm) for the female group. In terms of height, the average values of men on both sides were significantly higher than those of women.

#### Maxillary Sinus Width Measured in the Axial Plane

When maxillary sinus width is evaluated, the average values measured for the male group are  $(25.970 \pm 4.84 \text{ mm})$  on the right side and  $(25.142 \pm 5.22 \text{ mm})$  on the left side. The measured values for women are  $(24.174 \pm 3.93 \text{ mm})$  and  $(23.576 \pm 4.701 \text{ mm})$  on the right and left, respectively, which shows that the average values of men are higher than women in terms of width.

#### Maxillary Sinus Depth in the Axial Plane

When maxillary sinus depth is evaluated, the average value recorded for the male group on the right side was  $36.226 \pm 3.91$  mm, and on the left side, it was  $35.922 \pm 4.54$  mm. The average values recorded for the female group were calculated as  $35.368 \pm 3.81$  mm on the right and  $35.204 \pm 4.069$  mm on the left. When considered as a depth criterion, the average values for men are again high (Table 1).

Right height (P < .001), right width (P = .045), and left height (P = .015) parameters were statistically higher in males than in females (Table 1).

In the statistical analysis performed using the *t* test in independent groups, no statistically significant difference

Table 1. Descriptive Analyses of Variables and Comparison of Measured Variables								
Parameters (mm)	Gender	N	Mean	Standard Deviation	Standard Error Mean	Р	t value	
Right height (H)	F	50	32.942	6.0052	0.8493	.001	3.62	
	М	50	37.146	5.5943	0.7912			
Right width (W)	F	50	24.174	3.9399	0.5572	.045	2.035	
	М	50	25.970	4.8401	0.6845			
Right depth (D)	F	50	35.368	3.8183	0.5400	.270	1.109	
	М	50	36.226	3.9161	0.5538			
Left height (H)	F	50	33.880	6.7767	0.9584	.015	2.475	
	М	50	37.028	5.9108	0.8359			
Left width (W	F	50	23.576	4.7019	0.6650	.118	1.575	
	М	50	25.142	5.2248	0.7389			
Left depth (D)	F	50	35.204	4.0695	0.5755	.407	0.833	
	М	50	35.922	4.5410	0.6422			

P < .05 was considered significant.

Р	t
.648	0.457
.290	1.061
.687	0.404
	<b>P</b> .648 .290 .687

Table 2. Correlation Between Sides—Maxillary Sinus

P < .05 was considered significant.

was seen in the height, width, and depth parameters on the right and left sides (Table 2). Discriminant analysis was applied among the parameters found to be statistically significant. The right height parameter was found to be the most effective parameter in gender determination. When it is evaluated which measurement value is the most effective indicator in determining gender; it has been unterstood that the right height value is the most effective value to determining gender (Table 3).

The coefficients for the discriminant functions were obtained. Values of the common part in formula: Canonical Discriminant Function Coefficients (CDFC) (joint) = (-6 .039+0.172×Right height) (Table 4). Accordingly, if the value found was below zero, it was determined as female. and if above zero, it was determined as male. It was observed that the right height value provided 63% correct gender determination.Correct classification rates between groups are 63% accurate (Table 5).

Table 3. Best discriminant variable table. The right height value can explain the entire result. When it is evaluated which measurement value is the most effective indicator in determining gender, it has been understood that the right height value is the most effective value in determining gender.

**Structure Matrix** Function 1 Right height (H) 1.000 Left height (H)<sup>a</sup> 0.665

Pooled within-group correlations between discriminating variables and standardized canonical discriminant functions

0.564

Variables ordered by absolute size of correlation within function. <sup>a</sup>This variable was not used in the analysis.

Right width (W)

Table 4. Discrimnant Function Coefficinets				
Canonical Discriminant Function Coefficients				
	Function			
	1			
Right height (H)	0.172			
Constant	-6.039			
Unstandardized coefficients				

Table 5. Correct classification rates between groups

Classification

			Predicted Group Membership		
		Gender	F	М	Total
Original	Count	F	29	21	50
		М	16	34	50
	%	F	58	42	100
		М	32	68	100

#### DISCUSSION

Due to its geological structure, our country is a region where earthquakes, landslides, and similar natural disasters occur very frequently. Mass deaths occur due to these disasters. In addition, identification becomes an important problem in cases where mass deaths occur, such as in major epidemics, plane crashes, and fires. In forensic cases resulting in death, the first step in identifying the person is to determine their gender. When evaluating skeletal materials, structures that are difficult to deteriorate are first considered. Sinus maxillaris usually does not undergo deterioration.<sup>10</sup>

Considering the structure and location of the sinus maxillaris, magnetic resonance imaging (MRI) and computed tomography (CT) are considered the ideal standards to define the anatomy of this space. However, their use is limited due to high radiation, high cost, and limited access. This disadvantage has been overcome with the introduction of CBCT.11

Computed tomography scans provide health convenience and comfort thanks to their short-term and 3D images. Computed tomography devices have advantages as well as disadvantages. Computer tomography devices are difficult to transport and emit more radiation than CBCT devices. At the same time, the cost of CBCT devices is lower. Multidetector CTs have lower spatial resolution and higher radiation doses compared to CBCT. For this reason, it would be better to choose CBCT in cases requiring maxillofacial imaging. Conducting our study with a CBCT device gave us an advantage.<sup>10</sup>

Saccucci et al.,<sup>11</sup> found that there is no significant sexual dimorphism between individuals of different sexes.

On the other hand, Sharma et al.,<sup>12</sup> Gomes et al.,<sup>13</sup> and Kanthem et al.,<sup>14</sup> Prabhat et al.,<sup>15</sup> and Uthman et al.<sup>16</sup> compared the maxillary sinus width and height measurement values and concluded that the maxillary sinus dimensions of male individuals are larger than those of female individuals. We found similar findings in our study.

According to Uthman et al.<sup>16</sup>, the parameter in which sexual dimorphism is most evident is the height of the maxillary sinus. Paknahad et al.<sup>17</sup> also observed that the most significant parameter in gender estimation is maxillary sinus height. In our study, we observed that the right maxillary sinus height is the most significant parameter in gender estimation. Sheikh et al.<sup>18</sup> observed that in the Indian population, the height values of the left maxillary sinus were higher than the right height values, and the width of the right maxillary sinus was higher than the left, and stated that the most significant measurement parameter was the width of the left maxillary sinus. In our study, no significant statistical difference was found between the right and left sides, and the height of the right maxillary sinus was observed to be the most significant parameter.

Urooge and Patil<sup>19</sup> found that the width of the left maxillary sinus in women was greater than in men. According to this study, they stated that gender can be determined accurately from the left maxillary sinus with a rate of 60%. In our study, no variable was found to be higher in women than in men, and we concluded that 63% accurate gender determination can be made from the height of the right maxillary sinus. Möhlhenrich et al.<sup>20</sup> stated that tooth loss causes a decrease in maxillary sinus volume and that women's maxillary sinus sizes are always smaller than men. In our study, the values of male individuals were higher.

There are studies in the literature that evaluate the dimensions using CT. Fernandes observed that the maxillary sinuses of individuals living in Zululand were narrower in European men than in women and that the right maxillary sinus was larger than the left maxillary sinus. In our study, when the right and left sides were evaluated, no significant statistical difference was found, and the right width value in men was significantly higher than in women.<sup>21</sup> Ahmed et al.9 evaluated the maxillary sinus in terms of width, height, and depth and found the height and width parameters to be significantly higher in men than in women and observed the left maxillary sinus width as the best distinguishing parameter with a prediction of 64.4% in women and 52.6% in men. In our study, in terms of width, unlike this study, the right width value was found to be significantly different, and the right height value was observed as the most discriminatory parameter at a rate of 63%. Durum Polat et al. found a significant difference in terms of right maxillary sinus height, right depth, and left maxillary sinus width. In our study, a significant difference was found in terms of right and left maxillary sinus height and right width values. Conducting our study with CBCT gives us an advantage considering the disadvantages of CT.<sup>3</sup>

Ceena et al. examined the height, width, and volume values. The right and left height and right width were found

to be statistically significant, and it was observed that the best discriminant parameter was the left height. These findings are compatible with our study, but we found differently that the right height parameter was the most discriminatory parameter. We observed that it is a significant parameter.<sup>6</sup> Havva et al. measured the sinus maxillary values in terms of width, height, and volume. Except for the right maxillary sinus volume, they observed a significant difference in other parameters (right and left height, right and left width, and left volume) in men compared to women. In our study, width, depth, and height were examined. A statistically significant difference was found in terms of right and left height and right width.<sup>10</sup> Riki et al. evaluated the maxillary sinus in terms of width, height, depth, and volume, and unlike our study, they found the right width value to be significantly higher in women than in men. In gender determination, the parameters right height, right volume, left width, and left volume can be used in 80% of cases. In our study, we observed that only the right height parameter was the most significant parameter in gender determination.7

In the current study, unlike in other studies, when analyzed according to age, it was concluded that there was a significant, negative, low-level correlation between age and the right height, left height, and right width values.

In our study, the diameters of the sinus maxillaris were measured, and data that could be useful for surgical procedures were obtained. In addition, the evaluation of the paranasal sinuses contributes greatly to determining gender for identification in forensic cases. In our study, it was observed that the sinus maxillaris dimensions were larger in male individuals than in female individuals, but it was concluded that it is not a definitive criterion on its own and can be used as a supporting one.

**Ethics Committee Approval:** Ethics Committee permission was obtained from Erzincan Binali Yıldırım University Clinical Research Ethics Committee on February 20, 2023 (241777-2023-02/8).

**Informed Consent:** N/A. Permission was obtained from the hospital management to use patient data.

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