

Gender Evaluation by Assessment of Maxillary Sinus Using Cone Beam Computed Tomography in North Indian Population: A Retrospective Study

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ABSTRACT

Background

Gender determination is an essential component of forensic identification, especially in cases involving fragmented skeletal remains. The maxillary sinus is one of the most durable structures of the craniofacial skeleton and can aid in gender determination. Cone Beam Computed Tomography (CBCT) provides accurate three-dimensional imaging and enables precise morphometric evaluation.

Aim

To evaluate the role of maxillary sinus dimensions in gender determination using CBCT scans in a North Indian population.

Materials and Methods

A retrospective study was conducted on 100 CBCT scans obtained from the Department of Oral Medicine and Radiology, D.J. College of Dental Sciences and Research, Modinagar. Bilateral maxillary sinus dimensions including height, width, length, and area were assessed. Statistical analysis was performed using SPSS software. Independent t-test and discriminant function analysis were used for comparison between genders.

Results

Males demonstrated significantly greater maxillary sinus height, length, and area compared to females. Mean sinus height was 37.51 ± 2.37 mm in males and 33.45 ± 2.56 mm in females. Mean sinus length was 38.94 ± 3.21 mm in males and 35.64 ± 3.04 mm in females. Mean sinus area in males was 1063.2 ± 18.11 mm² and 967.4 ± 17.55 mm² in females. The overall accuracy for gender determination was 79%.

Conclusion

Maxillary sinus morphometric analysis using CBCT can be used as a reliable adjunctive tool in forensic gender determination.

Keywords: Maxillary sinus, CBCT, forensic odontology, gender determination, sexual dimorphism.

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INTRODUCTION

Forensic odontology plays an important role in the identification of unknown individuals, particularly in cases involving natural disasters, criminal investigations, wars, and accidents.^{1,2} Gender determination forms the basis of personal identification and assists in narrowing down the

search for unknown remains. Traditionally, the pelvis and skull are considered the most reliable skeletal structures for sex determination; however, these structures may not always remain intact.

The maxillary sinus is the largest paranasal sinus and is anatomically protected by surrounding bone.^{3,4} Due to its resistance to destruction, it often remains preserved even after severe trauma or

decomposition. Sexual dimorphism in the maxillary sinus dimensions has therefore become an important area of forensic research.

Radiographic imaging methods are widely used for forensic investigations. Conventional radiographs have limitations due to superimposition and distortion. Cone Beam Computed Tomography provides high-resolution three-dimensional images with lower radiation exposure and enables precise linear and area measurements. Previous studies have reported variable accuracy rates in gender determination using maxillary sinus measurements.⁵⁻¹⁰

The present study was undertaken to evaluate the reliability of maxillary sinus dimensions in determining gender using CBCT imaging in a North Indian population.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Oral Medicine and Radiology, D.J. College of Dental Sciences and Research, Modinagar. Ethical clearance was obtained from the institutional ethical committee before commencement of the study.

A total of 100 CBCT scans were selected from the departmental database. The sample included 50 males and 50 females aged above 20 years. Patients with maxillary pathology, trauma, congenital anomalies, previous surgical interventions, or poor-quality scans were excluded.

CBCT images were obtained using the NewTom GiANO 3D CBCT machine. Bilateral maxillary sinus measurements were evaluated in axial and coronal sections.

Parameters assessed included:

1. Height of maxillary sinus
2. Width of maxillary sinus
3. Length of maxillary sinus
4. Area of maxillary sinus

MEASUREMENT OF THE HEIGHT OF MAXILLARY SINUS

The height was calculated as the greatest distance between the lowest point within the floor of maxillary sinus and the highest point of the roof across the coronal region.

Point A- the sinus roof's highest point.

Point B- the sinus floor's lowest point.

MEASUREMENT OF WIDTH OF THE MAXILLARY SINUS

The breadth was determined in axial view being the largest distance between the most medial and lateral points of the sinus.

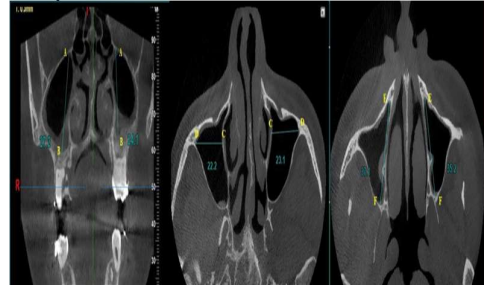
Point C- medial most point of the maxillary sinus.

Point D- furthest lateral point of the maxillary sinus

MEASUREMENT OF LENGTH (DEPTH) OF THE MAXILLARY SINUS

On the axial section, the length (depth) was measured as the greatest distance between the most anterior and most posterior points of the sinus. Point E is the most anterior point of the maxillary sinus. Point F is the most posterior point of the maxillary sinus.

Figure 1 : CBCT sections both coronal and axial showing Height, Width and Depth of Maxillary sinus



AREA OF MAXILLARY SINUS

The region of maxillary sinus was calculated using maximum maxillary sinus width x maximum length of the maxillary sinus (mm²).

SEX DETERMINATION BY DISCRIMINANT FUNCTION SCORE

The measured variables were used to determine sex using the discriminant function score: $D = 0.617 (\text{Length of Maxillary Sinus}) - 0.789 (\text{Width of Maxillary Sinus}) + 0.954 (\text{the height of Maxillary Sinus})$.

D scores more than zero indicate male while scores lower than zero indicate female.

RESULTS AND STATISTICAL ANALYSIS

Measurements were performed using dedicated imaging software. All values were recorded in millimeters and square millimeters. Statistical analysis was performed using SPSS software version 21. Independent t-test was used to compare male and female groups. Discriminant function analysis was performed to determine the accuracy of gender prediction. A p-value less than 0.05 was considered statistically significant. Among the 100 participants, 50 were males and 50 were females. The mean age of the study population was comparable between groups.

The mean maxillary sinus height in males was significantly greater than females. Males showed a mean height of 37.51±2.37 mm, whereas females demonstrated a mean height of 33.45±2.56 mm as seen in table 1. Similar statistically significant differences were observed in sinus length and area.

The mean width of the maxillary sinus was 27.37±2.11 mm in males and 27.36±2.77 mm in females, which was not statistically significant. The mean maxillary sinus length was 38.94±3.21 mm in males and 35.64±3.04 mm in females. The area of the maxillary sinus was also significantly higher in males (1063.2±18.11 mm²) compared to females (967.4±17.55 mm²) as seen in table 2,3 and 4.

Discriminant analysis revealed that the maxillary sinus could predict gender with an accuracy of 78% in males and 80% in females, with an overall prediction accuracy of 79%

The findings of the study indicate that height, length, and area are reliable indicators of sexual dimorphism, while width alone may not be sufficient for gender determination.

Table 1: Gender Based Comparison of Height of The Maxillary Sinus

Side	Mean ±SD (in mm)		Student's Unpaired „t“ test value	P value	Significance
	Male	Female			
Right Side	37.51±2.37	33.45±2.56	3.479	P=0.032'	Significant
Left Side	37.48±3.05	33.51±1.95	6.952	P=0.029'	Significant

Table 2: Comparison of Width of Maxillary Sinus based on Gender

Side	Mean ±SD (in mm)		Student's Unpaired „t“ test value	p value	Significance
	Male	Female			
Right	27.37±2.11	27.36±2.77	0.628	0.362#	Non-Significant
Left	27.76±2.94	27.49±3.28	0.743	0.283#	Non-Significant

Table 3: Gender Based Comparison of Length of Maxillary Sinus

Side	Mean ±SD (in mm)		Student's Unpaired „t“ test value	p value	Significance
	Male	Female			
Right	38.77±3.55	33.45±3.93	4.739	0.023'	Significant
Left	38.94±3.21	33.51±3.04	5.823	0.018'	Significant

Table 4: Gender Based Comparison of Area of Maxillary Sinus

Side	Mean ±SD (in mm ²)		Student's Unpaired „t“ test value	P value	Significance
	Male	Female			
Right Side	1063.2±18.11	967.4±17.55	2.532	P=0.033'	Significant
Left Side	1080.8±19.16	977.6±17.16	3.627	P=0.012'	Significant

DISCUSSION

The present study evaluated the usefulness of maxillary sinus morphometric analysis in gender determination using CBCT imaging. The results demonstrated significant sexual dimorphism in maxillary sinus height, length, and area.^{11,12}

The findings of this study are consistent with previous studies conducted by Uthman et al.³, Tambawala et al.⁷, Paknahad et al.⁹, and Ravali et al.¹¹, who reported greater maxillary sinus dimensions in males compared to females. The larger dimensions in males may be attributed to differences in craniofacial growth patterns, muscle mass, and hormonal influences.

In the present study, maxillary sinus width did not show statistically significant variation between gender. Similar observations were reported in earlier investigations by Vidya et al.⁵

and Soman et al.¹³ where width alone was considered a weak predictor of gender.

CBCT imaging offers several advantages over conventional radiography and medical CT scans.^{7,9,13} It provides three-dimensional evaluation with lower radiation dose, shorter scanning time, and excellent visualization of anatomical structures. The ability to accurately measure sinus dimensions makes CBCT a valuable tool in forensic investigations.

The overall gender prediction accuracy of 79% observed in this study is comparable to findings reported by Kandel et al.¹⁴ and Supraja et al.¹⁵ Although maxillary sinus measurements cannot independently establish gender with absolute certainty, they can serve as a useful adjunctive method when other skeletal structures are unavailable.

The study has certain limitations. The sample size was limited to a North Indian population and may not represent all ethnic groups. Future studies with larger sample sizes and volumetric analysis may improve prediction accuracy further.

CONCLUSION

Within the limitations of the present study, it can be concluded that CBCT-based morphometric analysis of the maxillary sinus is a valuable aid in forensic gender determination. Maxillary sinus height, length, and area demonstrated significant sexual dimorphism and showed good accuracy in predicting gender. CBCT can therefore be considered an effective and reliable imaging modality for forensic identification.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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