Original Article

DOI: 10.7860/JCDR/2026/85630.24372

Dentistry Section

CBCT Analysis of Maxillary and Sphenoidal Sinuses for Forensic Age and Gender Estimation: A Retrospective Study

AMRUTA J POTEKAR[1], RASHMI VENKATESH[2], CHANDRAMANI B MORE[3], DEEPA J PATIL[4]

ABSTRACT

Introduction: Age and gender estimation are fundamental in forensic identification, especially in crime investigation, cases of mass disasters and unidentified body remains. Paranasal sinuses, especially maxillary and sphenoidal, are unique, durable, and sexually dimorphic and well-protected within skull, resistant to trauma and decomposition. Cone Beam Computed Tomography (CBCT) enables precise Three-dimensional (3D) morphometric analysis of these anatomical structures, making them valuable markers for forensic age and gender determination.

Aim: To evaluate the morphological (volumetric) characteristics of the maxillary and sphenoidal sinuses using CBCT to assess their potential in forensic age and gender estimation.

Materials and Methods: The present Institutional-based retrospective study was conducted between September 2025 to November 2025 on CBCT archives from Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India. CBCT Digital Imaging and Communications in Medicine (DICOM) files of maxilla/both arches covering maxillary and sphenoidal sinus was selected for analysis. Total CBCT scans of 142 individuals aged 21-75 years were analysed and volumetric measurements of bilateral maxillary and sphenoidal sinus were recorded by semi-automatic segmentation method using 3D Slicer software and statistically analysed to determine correlations with age and gender. Inclusion and exclusion criteria were strictly applied to ensure sample consistency. For statistical analysis Chi-square test, Mann-Whitney, Kruskal-Wallis tests and Logistic regression analysis were done, p-values less than 0.05 were regarded as statistically significant.

Results: Significant variations in sinus dimensions were observed between different genders and age groups. The median volumes of the maxillary sinus (males: 13,574.75 mm^3; females: 11,210.30 mm^3) and the sphenoidal sinus (males: 4,918.71 mm^3; females: 4,017.23 mm^3) were significantly greater in males than in females, with p-values of 0.023 and 0.02, respectively. Correlation analysis revealed a statistically significant (p-value <0.05) negative association between age and sinus volume, with advancing age linked to reduced volumes in the bilateral maxillary sinuses and the right sphenoidal sinus.

Conclusion: The CBCT imaging of the maxillary and sphenoidal sinuses provides valuable morphometric data that can aid in forensic identification. These anatomical structures demonstrate measurable differences across age and gender, supporting their utility as supplementary tools in forensic profiling.

Keywords: Cone beam computed tomography, Image processing, Paranasal sinus, Three-dimensional imaging, Volumetric analysis

INTRODUCTION

The primary focus of forensic radiological evaluation is the osseous skeleton, which plays a vital role in forensic medicine, particularly in anthropometric assessments. Bones commonly utilised for forensic identification such as the pelvis, skull, and long bones are often recovered in fragmented, incomplete, or commingled conditions, especially in mass disaster scenarios like airplane crashes, explosions, armed conflicts, and natural calamities. These circumstances pose significant challenges to both identification and accurate personal identification [1,2]. The craniofacial skeleton exhibits distinct sexual dimorphism and age-related morphological changes, making it a valuable tool in forensic dentistry for identification purposes. With ongoing advancements in diagnostic imaging, traditional two-dimensional radiography is increasingly being supplanted by three-dimensional modalities such as Computed Tomography (CT) and CBCT, offering enhanced accuracy and detail in forensic investigations [3,4]. Evaluation of the paranasal sinuses for forensic purposes has proven to be a reliable method. Several studies have indicated that the jaw and skull bones often remain intact, even in cases involving trauma or decomposition, making them valuable structures for identification [5-7]. The paranasal sinuses are air-filled chambers found in the bones that encircle the nasal cavities. The maxillary sinuses, located bilaterally within the maxillary bones, are the largest and earliest to develop among the paranasal sinuses. In contrast, the sphenoid sinuses, deeply embedded within the sphenoid body, benefit from a well-protected anatomical position that offers substantial resistance to externally induced traumatic damage [5-7].

The CBCT has emerged as a valuable imaging modality in oral and maxillofacial applications, offering three-dimensional visualisation similar to conventional CT but with several distinct advantages. Compared to traditional two-dimensional imaging, CBCT provides enhanced spatial accuracy and depth. Notably, it surpasses conventional CT in terms of lower radiation exposure, cost-effectiveness, wider availability, reduced scanning time, high-resolution output, and ease of image interpretation. CBCT data is stored in the standardised DICOM format, facilitating seamless telecommunication and compatibility with third-party imaging software. This format also allows for selective voxel display within the dataset, enabling precise volumetric visualisation [8].

Many medical image annotation software like Insight Segmentation and Registration Toolkit (ITK)-SNAP, 3D Slicer,Materialise Interactive

Medical Image Control System (MIMICS) etc., supports DICOM files and has segmentation tools for 3D volumetric analysis of anatomy and pathology. The 3D Slicer is available for free download and can be used on all platforms (Windows, macOS, Linux) and is completely open source. 3D Slicer software has AI-based automatic segmentation feature and also capable of supporting hundreds of segments per image [9,10]. Previous studies have demonstrated that sexual dimorphism exists in the anthropometric measurements of maxillary sinuses and sphenoidal sinus. However, mostly the measurements like height, width and length of the sinuses are considered. Very few researchers have done the volumetric analysis of the sinuses for forensic evaluation and many of the studies are CT based studies [11-14]. Therefore, the present study was designed with an aim to evaluate the volumetric morphology of the maxillary and sphenoidal sinuses using CBCT, with the objective of assessing their potential utility in age and gender estimation.

The null hypothesis (H0) was that there is no significant difference in the volumetric measurements of the maxillary and sphenoidal sinuses between males and females, or among different age groups, as measured by CBCT. Furthermore, there is no significant correlation between sinus volumes and demographic variables (gender and age).

The alternative hypothesis (H_1) was that there is a significant difference in the volumetric measurements of the maxillary and sphenoidal sinuses between genders and/or among different age groups, as measured by CBCT. Additionally, there exists a significant correlation between sinus volumes and demographic variables (gender and age).

MATERIALS AND METHODS

The present Institutional-based retrospective study was conducted between September 2025 to November 2025 on CBCT archives from Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India. CBCT DICOM files of maxilla/both arches covering maxillary and sphenoidal sinus taken between September 2024 to October 2025 were selected from archives for analysis. The study was approved by Institutional Ethical Committee (SVIEC/ON/DENT/SRP/Sep- 25/20 dated 08/09/2025).

Sample size calculation: Sample size calculation was based on the findings of the study conducted by Sivasamy I et al., [7]. In this article the right maxillary sinus volume showed a significant difference between males (mean=16147.98±5684.88 mm^3) and females (mean=12973.76±3904.85 mm^3), with a mean difference of 3174.22 mm^3. Using these values, the pooled standard deviation was calculated as 4870.9 mm^3, yielding an effect size (Cohen's d) of 0.65. Based on a two-sample t-test with a significance level of 0.05 and a power of 80%, the minimum required sample size was estimated to be 39 participants per group (approximately 78 in total). However, to enhance the robustness and generalisability of the findings, 142 CBCT scans were included in the study, thereby ensuring higher statistical power and reliability of results.

Inclusion and Exclusion criteria: CBCT DICOM files of maxillary arch (FOV: 12X5) covering maxillary and sphenoidal sinus of individuals between 21 to 75 years irrespective of gender were included for the study. The images were acquired from CS 9600 CBCT unit with exposure parameters of 120 KVp, 6.3 mA and 20.0 sec exposure time.CBCT files with poor quality image, artifacts and any pathology in maxillary and sphenoidal sinus were excluded.

Study Procedure

Total 320 CBCT scans were screened, verified for complete maxillary and sphenoidal sinus visibility and 142 scans matching the inclusion criteria were selected for further evaluation. The selected scans were exported to 3D Slicer (5.8.1) application for volumetric analysis. 3D Slicer was selected over other open-source software as it supports multidimensional data, allows measurement of areas, distances, angles, and volumetric calculations. Despite its advanced capabilities 3D Slicer has a user-friendly interface [9,10]. Bilateral maxillary and sphenoidal sinuses were identified and independently each sinus volumetric analysis was performed using semi-automatic segmentation method.The intraclass correlation coefficient analysis demonstrated excellent inter-observer (0.9) reliability for all sinus volume measurements.

The patient's DICOM dataset was imported into 3D Slicer and processed within the segment editor module. A new segmentation was created, and the paranasal sinus regions were isolated using the thresholding tool, which allowed differentiation of air filled cavities from surrounding osseous and soft-tissue structures. The intensity range was carefully adjusted to exclude cortical bone and mucosal lining, ensuring that only the aerated sinus volume was captured. To refine the segmentation, smoothing filters (such as median or Gaussian smoothing) were applied, which minimised irregular boundaries and enhanced anatomical fidelity.

Following segmentation, the segment statistics module was employed to compute volumetric measurements. This tool automatically calculates the three-dimensional volume of the segmented region, expressed in cubic millimetres, providing reproducible quantitative data. The segmented sinus was then visualised in the 3D rendering view, enabling verification of anatomical accuracy and correction of any segmentation errors. Finally, the volumetric results and 3D models were exported for documentation, statistical analysis, and integration into the research dataset [Table/Fig-1].

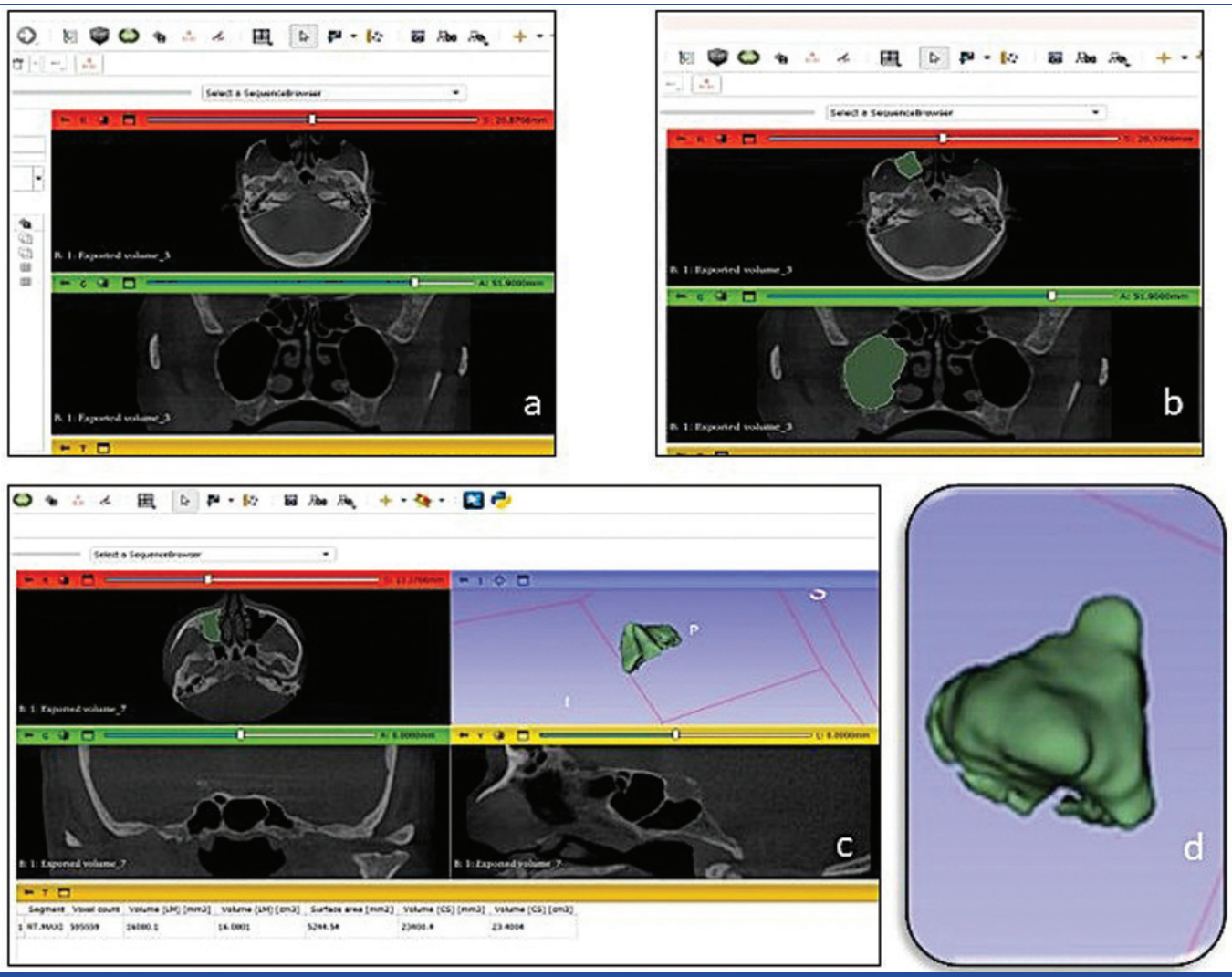
STATISTICAL ANALYSIS

Differences in sample size between genders across age groups were tested using the chi-square test. All the parameters were checked for their normality using Shapiro-Wilk test. It was found that all variables were violating normality assumptions and hence further analysis was carried out using "Non-parametric" (Mann-Whitney, Kruskal-Wallis) tests. Logistic regression analysis was done to check the accuracy of paranasal sinuses for gender determination. Standard deviations and means were used to express the variables. The p-values less than 0.05 were regarded as statistically significant.

RESULTS

Total 142 (n) scans out of the 320 CBCT volumes were selected as per the inclusion and exclusion criteria for 3D volumetric assessment of maxillary and sphenoidal sinus. Out of 142 scans 70 (49.3%) scans were from males and 72 (50.7%) scans were from females. Further the scans were divided in to five sub-groups based on age. The male to female distribution was not significant amongst different age groups (Chi-square value 2.713; p-value 0.607) [Table/Fig-2].

The total median volume of the maxillary was significantly greater in males (13,574.75 mm^3) compared to females (11,210.30 mm^3), with the difference reaching statistical significance (p=0.023). Sidewise median volumetric measurements in males were found to be 14,640.80 mm^3 on the right side and 12,472.50 mm^3 on the left. In females, the right maxillary sinus volume measured 11,994.50 mm^3, while the left-side measured 10,999.60 mm^3. The sphenoidal sinus volume was also greater in males (4,918.71 mm^3) than in females (4,017.23 mm^3), with the difference being statistically significant. With respect to sphenoidal sinus, sidewise volumetric measurements in males were found to be 5403.22 mm^3 on the right-side and 5102.51 mm^3 on the left. In females, the right sphenoidal sinus volume measured 3650.32 mm^3, while the left side measured 4315.01 mm^3. Further analysis revealed that the statistically significant difference in sinus volume between genders was confined to the right side for both the maxillary and sphenoidal sinuses [Table/Fig-3,4].



[Table/Fig-1]: Workflow of semi-automatic segmentation in 3D Slicer for maxillary sinus volume assessment: a) Importing CBCT data in DICOM format; b) Segmentation using interactive thresholding; c) Volume estimation via quantification; d) 3D reconstruction of the maxillary sinus.

Age group (Years)	Gender n (%)		Total n (%)
	Male	Female	
21-30 y	19 (46.2%)	20 (53.8%)	39 (100.0%)
31-40 y	12 (44.4%)	15 (55.6%)	27 (100.0%)
41-50 y	15 (53.6%)	13 (46.4%)	28 (100.0%)
51-60 y	8 (38.1%)	13 (61.9%)	21 (100.0%)
>60 y	16 (59.3%)	11 (40.7%)	27 (100.0%)
Total	70 (49.3%)	72 (50.7%)	142 (100.0%)

[Table/Fig-2]: Age and gender distribution of study participants.
Chi-square value=2.713; p-value=0.607; Not significant

Values	Maxillary sinus volume (mm^3)		Sphenoidal sinus volume (mm^3)	
	Male	Female	Male	Female
Median	13574.7500	11210.3000	4918.7100	4017.2250
Q1	10275.3875	9818.4350	3492.2725	3253.8025
Q3	16052.8750	14244.5750	6706.8025	5318.3950
U statistics	1961.0		1947.0	
p-value	0.023*		0.020*	

[Table/Fig-3]: Comparison of average values of sinus volumes between gender.
* SD: Standard deviation, *Statistical test applied: Mann-Whitney test *Significant at p<0.05

Gender estimation accuracy was assessed using logistic regression analysis, yielding a combined accuracy of 62% for bilateral maxillary and sphenoidal sinus volumes and the results are detailed in [Table/Fig-5]. Age-related changes in sinus volume were statistically evaluated using the Kruskal-Wallis test. The mean volumes of both the maxillary and sphenoidal sinuses demonstrated a decreasing trend with advancing age. Statistically significant differences were observed in the bilateral maxillary sinuses and the right sphenoidal sinus [Table/Fig-6]. Spearman's rank correlation analysis revealed a strong negative correlation for both the right and left maxillary sinuses with age, with p-values less than 0.001 [Table/Fig-7].

DISCUSSION

Paranasal sinuses, as unique anatomical structures, exhibit considerable individual variability that remains relatively preserved even after skeletal decomposition. Consequently, sinus morphometry provides valuable adjunctive information for forensic identification, especially when other skeletal markers are fragmented or unavailable [1,3,4]. The present retrospective study aimed to evaluate the maxillary and sphenoidal sinuses volume using CBCT to assess their potential role in forensic age and gender estimation. In this study, CBCT DICOM images were used for volumetric assessment

Statistics	Male				Female			
	Right maxillary sinus	Left maxillary sinus	Right sphenoidal sinus	Left sphenoidal sinus	Right maxillary sinus	Left maxillary sinus	Right sphenoidal sinus	Left sphenoidal sinus
Median	14640.80	12472.50	5403.22	5102.51	11994.50	10999.60	3650.32	4315.01
Q1	10209.10	9321.87	2853.27	2906.56	10052.00	8823.83	2529.56	3066.79
Q3	17705.85	16663.05	7058.93	6889.61	14214.60	15159.00	5952.64	5680.02

U statistics	1857.00		2143.00		1905.00		2184.00	
p-value	0.007*	0.125	0.012*	0.172				

[Table/Fig-4]: Sidewise comparison of average values of sinus volumes (in mm^3) between gender.
*Statistical test applied: Mann–Whitney U test.*Significant at p<0.05

Variables	df	Sig.	Exp(B)	95% CI for Exp(B)	
				Lower	Upper
Right maxillary sinus	1	0.040	1.0000964	1.0000042	1.0001886
Left maxillary sinus	1	0.915	.9999949	0.9999004	1.0000894
Right sphenoidal sinus	1	0.778	0.9999920	0.9999364	1.0000476
Left sphenoidal sinus	1	0.546	1.0000301	0.9999324	1.0001279
Constant	1	0.022	0.254		

Observed		Predicted		
		Sex		Percentage correct
		Male	Female	
Sex	Male	39	30	56.5
	Female	24	49	67.1
Overall percentage		62.0		

[Table/Fig-5]: Accuracy of maxillary and sphenoidal sinus volumes for gender determination using logistic regression analysis.
*B: regression coefficient; SE: standard error; Wald: Wald Chi square statistic; df=degrees of freedom; Sig.: p-value; Exp(B): Odds ratio; CI: Confidence interval

Age group (Years)	Statistics	Right maxillary sinus	Left maxillary sinus	Right sphenoidal sinus	Left sphenoidal sinus
21-30	Median	15637.5000	15256.8000	6280.3800	4789.3800
	Q1	13507.3000	11001.4000	4816.7000	3482.1800
	Q3	19152.4000	17085.6000	8327.3800	5758.7200
31-40	Median	11726.9000	11171.2000	4137.2600	3696.6200
	Q1	10051.5000	8875.4900	2912.7300	2627.4200
	Q3	16080.2000	14772.6000	5583.2200	9141.5800
41-50	Median	12290.2500	10526.0500	3740.5600	4954.0200
	Q1	8783.9750	8876.3500	2446.6775	3876.8800
	Q3	16304.9725	14559.8550	5648.8200	5676.4475
51-60	Median	11281.4000	11101.4000	3591.4300	4123.0700
	Q1	8041.4100	7614.3650	2529.5600	2748.6550
	Q3	15484.1500	15879.0000	6151.0350	6615.6600
>60	Median	11265.7000	10136.4000	3201.7000	4102.3000
	Q1	9834.2300	8974.8900	1643.6200	3101.3200
	Q3	12134.3000	12472.5000	4287.0900	4754.9700
H Statistics		23.243	14.732	23.711	3.727
p-value		<0.001*	0.005*	<0.001*	0.444

[Table/Fig-6]: Comparison of average values of maxillary and sphenoidal sinus volumes between age groups.
*Kruskal - Wallis Test, Significant at p<0.05

Variables	Age (r, p)*	Right maxillary sinus (r, p)	Left maxillary sinus(r, p)	Right sphenoidal sinus (r, p)	Left sphenoidal sinus (r, p)
Age	–	-0.370, <0.001*	-0.321, <0.001*	-0.335, <0.001*	-0.137, 0.103
Right maxillary sinus	-0.370, <0.001*	–	0.597, <0.001*	0.244, 0.003*	0.163, 0.052
Left maxillary sinus	-0.321, <0.001*	0.597, <0.001*	–	0.131, 0.119	0.305, <0.001*
Right sphenoidal sinus	-0.335, <0.001*	0.244, 0.003*	0.131, 0.119	–	0.105, 0.215
Left sphenoidal sinus	-0.137, 0.103	0.163, 0.052	0.305, <0.001*	0.105, 0.215	–

[Table/Fig-7]: The Spearman's rank correlation coefficients (r) and corresponding p-values between age and sinus volume measurements.
*r: range, p: p-value, Significant at p<0.05, Negative r values indicate an inverse relationship, while positive values indicate a direct relationship

of the maxillary and sphenoidal sinuses through segmentation methods in 3D Slicer. Researchers have also employed ITK-SNAP, MIMICS, and other commercial real-time segmentation software for volumetric analysis of various anatomical structures [5,7,12].

In the present study, the volumes of both the maxillary and sphenoidal sinuses were found to be significantly greater in males than in females, thereby leading to rejection of the null hypothesis. These findings are consistent with those of previous morphometric studies-based on two-dimensional measurements and/or three-dimensional analyses-conducted using various imaging modalities such as lateral cephalograms, CT scans, and CBCT. Sivasamy I et al., conducted a study on a central Indian population, reporting average maxillary sinus volumes of 15,526.65 mm^3 in males and 12,980.06 mm^3 in females. The sphenoidal sinus volumes were 4,380.22 mm^3 in males and 4,054.08 mm^3 in females. These measurements closely align with those observed in our study of a western Indian population, reinforcing the utility of both sinuses in forensic sex determination [7]. The binary logistic regression accuracy was modest, with an overall correct prediction rate of 62%. Similar accuracy rates were shown in a study conducted by Sivasamy I et al., [7]. Research conducted by Vidya CS et al., examined 30 buried skulls of known sex, which were imaged using 3D axial multislice CT scans. Focusing on the maxillary sinuses, the researchers used SyngoVolume (Siemens) software to automatically estimate the bilateral maxillary antral volumes. The study found that the maxillary sinus volume was greater in males compared to females [11]. Uthman AT et al., used helical CT for measuring the width, length, height, and total distance across both maxillary sinuses. The authors found that the maxillary sinus height showed sexual dimorphism, with an accuracy rate of 71.6% [15]. Similarly, Gibelli D et al., reported mean sphenoid sinus volumes of 10.005±5.101 cm^3 in males and 7.920±3.176 cm^3 in females in their volumetric assessment study [16]. Waluyo RF et al., conducted a study using CBCT images that revealed sexual dimorphism in the two-dimensional parameters of the maxillary sinus [17]. Present study revealed the accuracy of gender determination for as 60.6% and 57.7% for right and left maxillary sinus respectively. Sidhu R et al., measured the dimensions of the maxillary sinus using lateral cephalograms, and their Discriminant Function (DF) analysis correctly classified 76% of the original grouped cases, with an overall sensitivity of 80% and specificity of 72% [18]. Furthermore, a DF analysis based on the sinus volumes and dimensions achieved a gender prediction accuracy of 69.81% in a study conducted by Sharma SK et al., [19]. In contrast, Barros FD et al., did not observe significant differences in maxillary sinus area or volume between sexes [20].

In the present study, adult sinus volumes were categorised based on different age groups. The mean volumes of both the maxillary and sphenoidal sinuses showed a significant reduction with advancing age, indicating a negative correlation between age and sinus volume and thereby supporting rejection of the null hypothesis. This feature may be useful in forensic age estimation. Similarly, Ariji Y et al., in their CT-based study, observed that maxillary sinus volume increased up to the age of 20 years, followed by a gradual decline [14]. In forensic odontology, paranasal sinus measurements have proven to be reliable indicators for age and gender identification. The findings of the present study demonstrated that CBCT-derived volumetric

data can be effectively utilised for the analysis of paranasal sinuses, thereby supporting their application in forensic identification.

Limitation(s)

As the present study was conducted on a population from western India (Gujarat), the findings may not be generalisable to other regions. To develop a comprehensive database for forensic investigations, further research employing a multicentre approach across diverse geographic populations is recommended.

CONCLUSION(S)

The CBCT of the maxillary and sphenoidal sinuses yields critical morphometric data useful for forensic age identification and also has 62% accuracy for gender determination. These anatomical features exhibit quantifiable variations with respect to age and sex and hence it can be used along with other craniofacial parameters in forensic profiling.

REFERENCES

[1] Rainio J, Lalu K, Ranta H, Penttila A. Radiology in forensic operations. Leg Med (Tokyo). 2001;3(1):34-43.
[2] Di Vella G, Campobasso CP, Dragon M, Introna F Jr. Skeletal sex determination by scapular measurements. Boll Soc Ital Biol Sper. 1994;70(12):299-305.
[3] Ono I, Ohura T, Narumi E, Kawashima K, Matsuno I, Nakamura S, et al. Three-dimensional analysis of craniofacial bones using three-dimensional computed tomography. J Craniomaxillofac Surg. 1992;20(2):49-60.
[4] Deshpande AA, Munde AD, Mishra SS, Kawsankar KD, Sawade RV, Mandar B. Determination of sexual dimorphism of maxillary sinus using cone beam computed tomography in a rural population of Western Maharashtra: A retrospective cross-sectional study. J Family Med Prim Care. 2022;11:1257-61.
[5] Cohen O, Warman M, Fried M, Shoffel-Havakuk H, Adi M, Halperin D, et al. Volumetric analysis of the maxillary, sphenoid and frontal sinuses: A comparative computerized tomography-based study. Auris Nasus Larynx. 2018;45:96-102.
[6] Sherif NAE-H, Sheta AAE-M, Ibrahim ME, Kaka RAE-M, Henaidy MF. Evaluation of the paranasal sinuses dimensions in sex estimation among a sample of adult Egyptians using multidetector computed tomography. J Forensic Radiol Imaging. 2017;11:33-39.
[7] Sivasamy I, Ramakrishna P, Johaley S, Sikdar SD, Jain SK, Diwan RK. Evaluation of maxillary and sphenoidal sinuses volume and bizygomatic width using cone beam computed tomography: A promising tool for sex determination. J Indian Acad Oral Med Radiol. 2024;36(3):297-300.
[8] Venkatesh E, Elluru SV. Cone beam computed tomography: Basics and applications in dentistry. J Istanb Univ Fac Dent. 2017;51(3 Suppl 1):S102-S121.
[9] Galbusera F, Cina A. Image annotation and curation in radiology: An overview for machine learning practitioners. EurRadiol Exp. 2024;8(1):11.
[10] 3D Slicer [Internet]. Boston (MA): Surgical Planning Laboratory, Brigham and Women's Hospital; [cited 2025 Nov 8]. Available from: https://www.slicer.org/.
[11] Vidya CS, Shamasundar NM, Manjunatha B, Raichurkar K. Evaluation of size and volume of maxillary sinus to determine gender by three-dimensional computerized tomography scan method using dry skulls of South Indian origin. Int J Curr Res Rev. 2013;5:97-100.
[12] 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):1493-99.
[13] Wanzeler AMV, Alves-Junior SM, Ayres L, da Costa Prestes MC, Gomes JT, Tuji FM. Sex estimation using paranasal sinus discriminant analysis: A new approach via cone beam computerized tomography volume analysis. Int J Legal Med. 2019;133(6):1977-84.
[14] 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):163-68.
[15] Uthman AT, Al-Rawi NH, Al-Naaimi AS, Al-Timimi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. J Forensic Sci. 2011;56(2):403-8.
[16] Gibelli D, Cellina M, Gibelli S, Oliva AG, Codari M, Termine G, et al. Volumetric assessment of sphenoid sinuses through segmentation on CT scan. SurgRadiol Anat. 2018;40(2):193-98.
[17] Waluyo RF, Priaminiarti M, Yuniastuti M, Soedarsono N, Susilo BT. Measurements of sex-related differences in maxillary sinus and mandibular canal characteristics using cone beam computed tomography. Forensic Imaging. 2020;21:200371.
[18] Sidhu R, Chandra S, Devi P, Taneja N, Sah K, Kaur N. Forensic importance of maxillary sinus in gender determination: A morphometric analysis from Western Uttar Pradesh, India. Eur J Gen Dent. 2014;3(1):53-58.
[19] Sharma SK, Jehan M, Kumar A. Measurements of maxillary sinus volume and dimensions by computed tomography scan for gender determination. J Anat Soc India. 2014;63(1):36-42.
[20] Barros F, Fernandes CMS, Kuhnen B, Scarso Filho J, Goncalves M, Serra MC. Maxillary sinuses height, width and depth of Brazilian subjects and influence of sex, age, skin color and nutritional status: A CBCT study. Forensic Imaging. 2022;31:200522.

PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Student, Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India.
2. Professor and Head, Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India.
3. Professor, Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India.
4. Professor, Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Rashmi Venkatesh,
Professor and Head, Department of Oral Medicine and Radiology, K M Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Piparia, Waghodia Taluk-391760, Vadodara, Gujarat, India.
E-mail: drrashmivenkatesh@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Dec 10, 2025
- Manual Googling: May 16, 2026
- iThenticate Software: May 18, 2026 (9%)

ETYMOLOGY: Author Origin

EMENDATIONS: 9

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Nov 29, 2025**
Date of Peer Review: **Jan 20, 2026**
Date of Acceptance: **May 20, 2026**
Date of Publishing: **Sep 01, 2026**