Content available at: https://www.ipinnovative.com/open-access-journals

Journal of Dental Specialities

Journal homepage: https://www.jdsits.in/

Original Research Article

Validity of dental metric parameters in gender estimation: A comprehensive cast analysis

Sanchita Tiwari[1], Aakriti Singh[1], Nikita Gulati[1], Divya Shetty[2]*

[1]Dept. of Oral Pathology, ITS Dental College, Murad Nagar, Ghaziabad, Uttar Pradesh, India
[2]Dept. of Orthodontics, ITS Dental College, Murad Nagar, Ghaziabad, Uttar Pradesh, India

Abstract

Introduction: Teeth are among the most durable structures in the human body, making them crucial in forensic investigations, especially in gender determination when soft tissue evidence is absent. Odontometric measurements are considered reliable, population-specific tools in identifying sexual dimorphism.
Aim & Objective: To evaluate the validity of selected dental metric parameters—inter-canine width, arch length, and hard palate depth—for gender estimation using maxillary casts in an Indian population, and to develop a regression model to assist in forensic identification.
Materials and Methods: This cross-sectional study analyzed 100 maxillary dental casts (50 males, 50 females). Measurements of inter-canine width, arch length, and hard palate depth were recorded using digital calipers under standardized protocols. Statistical analysis was performed using SPSS software to evaluate sexual dimorphism and to construct a multivariate regression model for gender prediction.
Results: Significant sexual dimorphism was noted in inter-canine width and hard palate depth, with males showing greater dimensions ($p < 0.05$). The developed regression model, incorporating all measured parameters, achieved a gender prediction accuracy of 73.2%.
Conclusion: Dental metrics, particularly inter-canine width and palate depth, demonstrate significant reliability in gender estimation. This study reinforces the utility of odontometric data in forensic identification and emphasizes the importance of creating population-specific databases.

Keywords: Dental metric, Gender estimation, Cast analysis.

Received: 27-06-2025; **Accepted:** 29-07-2025; **Available Online**: 29-09-2025

1. Introduction

Forensic odontology plays a pivotal role in medico-legal investigations, particularly in cases of post-mortem identification where conventional techniques such as fingerprinting or facial recognition are rendered ineffective due to decomposition, trauma, or incineration. Among all hard tissues, teeth are considered the most durable and chemically stable, capable of withstanding extreme environmental conditions, thereby preserving vital anthropometric information long after other tissues deteriorate.[9,10]

Sexual dimorphism—morphological differences between males and females—has been extensively observed in dentition. These differences, influenced by genetic and hormonal factors during odontogenesis, make dental casts a non-invasive, reproducible, and reliable tool for gender estimation. Determining sex is a crucial first step in constructing a biological profile during forensic identification, as it significantly reduces the pool of potential matches. Several odontometric studies have demonstrated that canines, in particular, show marked dimorphism. Parameters such as mesiodistal canine width, inter-canine width, and the mandibular canine index have been reported as highly reliable indicators.[1-5]

*Corresponding author: Divya Shetty
Email: divyashetty@its.edu.in

https://doi.org/10.18231/j.jds.32917.1759126154

The utility of odontometric analysis has been expanded through parameters like inter-molar width, especially in cases where canines are missing, thereby strengthening the reliability of multiple indices in gender determination.[8] While some odontometric traits appear to hold universal value, others vary with ethnicity, genetic predispositions, and dietary habits.[6,7,11,12] For example, a Nigerian study highlighted significant dimorphism in inter-canine width, molar dimensions, and arch length, demonstrating their strong predictive value,[1] while Indian studies have reinforced the importance of establishing population-specific databases for accurate gender estimation.[2,5,7]

Against this background, the present study investigates maxillary dental casts within an Indian cohort to evaluate the validity of selected odontometric parameters. By applying regression models, the study aims to derive reliable predictive equations for gender estimation and assess their forensic applicability.

2. Materials and Methods

2.1. Sample selection

This cross-sectional study was conducted on a total of 100 maxillary dental casts (50 male, 50 female) procured from students and patients visiting the Department of Oral Pathology, ITS Dental College, Muradnagar. The inclusion criteria consisted of individuals aged between 18 and 30 years with a full set of permanent dentition, no significant occlusal attrition, and no history of orthodontic or prosthodontic treatment. Subjects exhibiting caries, malocclusion, dental anomalies, or craniofacial abnormalities were excluded from the study to maintain uniformity and accuracy of measurements.

2.2. Ethical clearance

Ethical approval was obtained from the Institutional Ethics Committee of ITS Dental College. All participants provided informed written consent prior to participation, in adherence to the principles of the Declaration of Helsinki.

2.3. Measurement procedure

Maxillary impressions were obtained using alginate material, and dental casts were poured using Type III dental stone. The casts were allowed to set for 24 hours before measurement. A digital vernier caliper with a precision of 0.01 mm was used to measure the following dental parameters:

1. Inter-canine width (distance between the cusp tips of maxillary canines)
2. First and second premolar width
3. First and second molar width
4. Dental arch length (from the incisal midpoint to the posterior molar line)
5. Hard palate depth (from the deepest point of the palate to a horizontal line connecting the cusp tips of the first molars)

Each measurement was taken thrice by two independent observers to ensure interobserver and intra-observer reliability. The mean of the three readings was used for analysis.

2.4. Statistical analysis

The collected data was entered into SPSS (Statistical Package for Social Sciences) version 25. Descriptive statistics including means and standard deviations were calculated for each parameter. An independent Student's t-test was performed to assess statistical significance between male and female groups. Additionally, regression analysis was employed to evaluate the predictive capacity of the measured parameters for gender determination. A p-value of <0.05 was considered statistically significant.

3. Results

The analysis of 100 maxillary casts (50 male, 50 female) revealed notable sexual dimorphism in multiple dental metrics.

Inter-canine width: Males had a significantly wider inter-canine span (mean = 28.74 mm ± 1.23) than females (mean = 26.82 mm ± 1.11), with a p-value < 0.01, indicating a high degree of sexual dimorphism.

Arch length: Males showed greater arch length (mean = 43.55 mm ± 2.09) than females (mean = 41.12 mm ± 1.87), suggesting this parameter's utility in distinguishing between sexes.

Hard palate depth: A statistically significant difference was also noted here, with males exhibiting a deeper palate (mean = 17.62 mm ± 1.31) compared to females (mean = 15.89 mm ± 1.15), with a p-value < 0.01**.(Table 1)**

First and second molar widths: Males consistently displayed larger molar dimensions than females, confirming previous observations of greater bucco-lingual and mesio-distal widths in male dentition.

First premolar width: A slight reversal was observed here, with females exhibiting marginally greater widths, although this difference was not statistically significant.

3.1. Maxillary regression equation:

Gender = 3.453 - 0.681(Distal Canine Ridge) - 0.052 (Hard Palate Depth) + 0.014 (First Inter-Premolar Width)-Coefficient of determination (R^2): 73.2%**.(Table 2)**

3.2. Mandibular regression equation

Gender = 6.905 - 0.032(Second Molar Perimeter) - 0.040(Inter-Canine Width) - 0.024 (Anterior Segment Length)-Coefficient of determination (R^2): 64.3%**.(Table 3)**

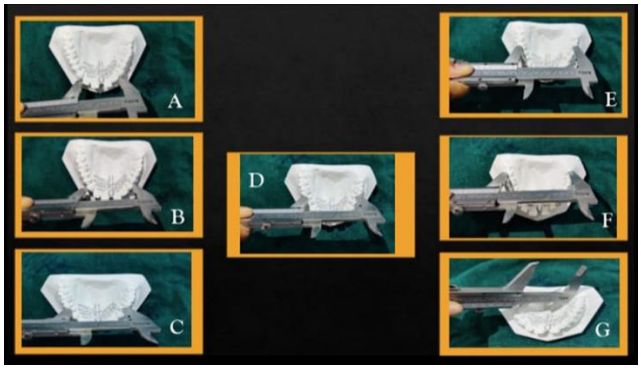

Figure 1: Measurement of transverse widths and palatal depth using a vernier caliper on the dental cast; **A:** Lateral inter incisor width; **B:** Inter canine width; **C**: First inter premolar width; **D:** Second inter premolar width; **E:** First inter molar width; **F:** Second inter molar width, and **G:** Hard palate depth.

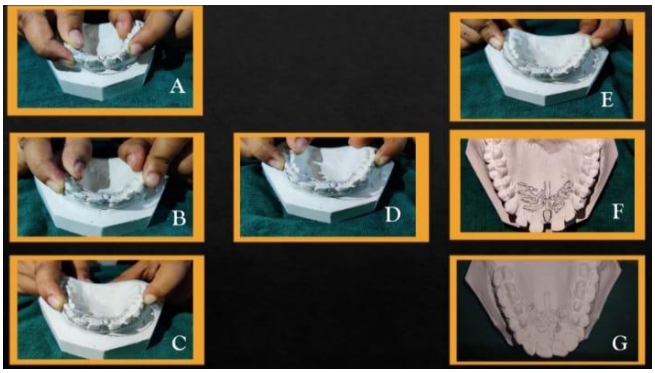

Figure 2: Measurement of various perimeters and anatomical features on the dental cast; **A:** Lateral incisor perimeter; **B:** Canine perimeter/anterior segment length; **C:** First premolar perimeter; **D:** Second premolar perimeter; **E:** First molar perimeter; **F:** Presence of distal canine ridge, and; **G:** Absence of distal canine ridge.

Table 1: Descriptive statistics table showing mean, standard deviation, and P-values (T-test analysis) for all measured parameters according to gender. Parameters with P-value <0.05 are statistically significant, with highlighted values indicating strong sexual dimorphism in dimensions

Measured Parameters	Gender	N	Mean±SD	p Value
Lateral Inter Incisor Width	Male	46	27.17±4.416	.001
	Female	54	24.12±4.758	
Inter Canine Width	Male	46	33.02±5.256	.000
	Female	54	29.18±4.780	
First Inter Pre Molar Width	Male	46	34.42±6.588	.018
	Female	54	31.94±3.462	
Second Inter Pre Molar Width	Male	46	39.88±4.630	.001
	Female	54	35.92±6.621	
First Inter Molar Width	Male	46	46.24±5.252	.000
	Female	54	42.73±4.433	
Second Inter Molar Width	Male	46	52.41±5.457	.002
	Female	54	46.95±10.279	
Anterior Segment Length	Male	46	48.92±9.807	.000
	Female	54	40.93±8.670	
Posterior Segment Length	Male	45	82.34±12.408	.137
	Female	54	78.62±12.225	
Total Dental Arch Length	Male	46	37.65±5.682	.345
	Female	54	36.71±4.183	
Lateral Incisor Perimeter	Male	45	31.89±5.485	.123
	Female	54	29.90±6.979	
Canine Perimeter	Male	46	49.33±10.035	.000
	Female	54	41.20±8.530	
First Premolar Perimeter	Male	46	65.58±9.516	.004
	Female	54	59.85±9.810	
Second Pre Molar Perimeter	Male	46	82.43±8.405	.000
	Female	54	74.65±8.507	
First Molar Perimeter	Male	46	101.11±9.543	.000
	Female	54	92.55±7.886	
Second Molar Perimeter	Male	46	124.62±12.946	.003
	Female	54	115.54±16.732	

Table 2: Mutiple linear regression model summaries for sex determination using maxillary parameters. Regression analysis of maxillary parameters including distal canine ridge, hard palate depth, and first interpremolar width. The final model achieved the highest accuracy with an R^2 value of 0.732. These findings suggest that the selected odontometric and palatal variables can serve as significant indicators for gender estimation.

Group	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Maxilla	Distal canine ridge	.797[a]	.636	.628	.306
	Distal canine ridge Hard palate depth	.840[b]	.706	.693	.278
	Distal canine ridge Hard palate depth First inter premolar width	.856[c]	.732	.714	.269

Table 3: Multiple linear regression model summaries for sex determination using mandibular and maxillary parameters. Regression analysis of mandibular parameters including second molar perimeter, intercanine width, and anterior segment length. The third model demonstrated the highest predictive accuracy with an R^2 value of 0.643

Group	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Maxilla	1	.631[a]	.398	.385	.394
Mandible	Second molar perimeter	.737[b]	.543	.533	.344
	Second molar perimeter Inter canine width	.779[c]	.606	.589	.323
	Second molar perimeter Inter canine width Anterior segment length	.802[d]	.643	.620	.310

The regression model incorporating all measured parameters yielded a coefficient of determination (R^2) of 73.2%, indicating that the selected dental measurements could predict gender with substantial reliability. Sensitivity and specificity analyses further confirmed the robustness of this model, especially when inter-canine width and hard palate depth were used in combination.

4. Discussion

The findings of the present study reaffirm the forensic significance of dental measurements in sex determination. Teeth, owing to their mineralized structure, persist longer than most tissues and retain measurable morphological features crucial for anthropological profiling.[9,10] The observed dimorphism in inter-canine width and hard palate depth is consistent with earlier reports, which recognize these variables as dependable predictors.[2,4,12]

Comparisons with international datasets, such as the Nigerian study by Anyanwu et al., show a degree of universality in certain parameters[1]. However, variation in others, including premolar dimensions, supports the hypothesis that odontometric traits are influenced by environmental, dietary, and genetic factors.[6,7,11] Dietary consistency, masticatory stress, and regional genetic patterns likely contribute to these variations, thereby reinforcing the need for population-specific standards.[7,12]

The application of regression analysis in the present study enhances the predictive dimension of odontometric research. The high R^2 values in maxillary (73.2%) and mandibular (64.3%) models underscore their robustness in forensic contexts. Importantly, the use of multiple parameters in combination provides higher accuracy than reliance on a single metric.

Nevertheless, certain limitations must be acknowledged. The modest sample size and reliance on manual two-dimensional measurements may limit generalizability. Future studies should incorporate advanced technologies such as 3D scanning and AI-driven image analysis to improve measurement precision and reduce observer bias.[13-15] Expanding the research across diverse Indian subpopulations would also help build a comprehensive odontometric database, thereby improving the reliability and applicability of gender estimation methods in forensic casework.

5. Conclusion

This study validates the efficacy of dental metric analysis in gender determination within an Indian context. Statistically significant dimorphism in parameters such as inter-canine width, arch length, and palate depth underscores their potential in forensic identification protocols. These findings advocate for the development and integration of region-specific odontometric datasets to enhance the accuracy of sex determination in forensic and anthropological investigations.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Anyanwu GE, Udoaka AI, Igwe B, Egwu OA, Esom EA. Dental and facial parameters: index for posthumous gender determination. *Acta Sci Ana*t. 2022;1(5):22–9.
2. Bharti PV, Sivapathasundharam B, Einstein A. Efficacy of "Dimodent" sex predictive equation assessed in an Indian population. *J Forensic Odontostomatol*. 2011;29(1):51–6.
3. Acharya AB, Mainali S. Limitations of the mandibular canine index in sex assessment. *J Forensic Leg Med*. 2009;16(2):67–9.
4. Boaz K, Gupta C. Dimorphism in human maxillary and mandibular canines in establishment of gender. *J Forensic Dent Sci.* 2009;1(1):42–4.
5. Gorea RK, Sharma M. Odontometric study of canines in Indian population for sex determination. *J Indo Pac Acad Forensic Odontol*. 2010;1:34–7.
6. Hashim HA, Murshid ZA. Mesiodistal tooth width in Saudi population: a preliminary report. *Saudi Dent J*. 1993;5(2):68–72.
7. Prabhu S, Acharya AB. Odontometric sex assessment in Indians. *Forensic Sci Int*. 2009;192(1-3):129.e1–5.
8. Daniel MJ. Comparison of inter-canine and inter-molar width as an aid in gender determination. *J Indian Acad Forensic Med*. 2014;36(2):168–72.
9. Gustafson G. Forensic odontology. London: Staples Press; 1966.
10. Krogman WM, Iscan MY. The human skeleton in forensic medicine. 2nd ed. Springfield: Charles C Thomas; 1986.
11. Basnet BB, Singh RK, Parajuli PK, Shrestha P. Correlation between facial measurements and occlusal vertical dimension: an anthropometric study in two ethnic groups of Nepal. *Int J Dent Sci Res*. 2014;2(6):171–4.
12. Bishara SE, Treder JE, Damon P, M Olsen. Changes in the dental arches and dentition between 25 and 45 years of age. *Angle Orthod*. 1996;66(6):417–22.
13. Cattaneo C. Forensic anthropology: developments of a classical discipline in the new millennium. *Forensic Sci Int*. 2007;165(2-3):185–93.
14. Buikstra JE, Ubelaker DH. Standards for data collection from human skeletal remains: proceedings of a seminar at the Field Museum of Natural History, organized by Jonathan Haas. Fayetteville, Ark.: Arkansas Archeological Survey. 1994.
15. Forensic odontological sex determination of Ajnala skeletal remains based on the statistical equations generated from the odontometrics of known teeth. *Forensic Sci Int: Rep*. 2019;1:100044.

Cite this article: Tiwari S, Singh A, Gulati N, Shetty D. Validity of dental metric parameters in gender estimation: A comprehensive cast analysis. *J Dent Spec*. 2025;13(2):198-202.