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Sexual Dimorphism In Primary Canines: A Study On The Reliability Of Morphometric Analysis

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Abstract

Aim: *To assess gender-based variations in primary canines and intercanine width among Indian children using odontometric measurements, aiding forensic and anthropological research.*

Materials and Methods: *A cross-sectional study was carried out using a digital Vernier calliper to measure 258 sets of maxillary and mandibular diagnostic dental casts, with a single examiner ensuring consistency. Measurements recorded included Mesiodistal width (MD), Cervico incisal height (CI), Labiolingual/Buccopalatal width (LL/BP), and Intercanine width (ICW) of the maxillary and the mandibular canines. Statistical analysis was done using SPSS (version 20.0).*

Results*: The mean linear dimensions of the primary canine with respect to MD, CI and LL/BP was higher in males as compared to females whereas females exhibited greater mandibular ICW. Significant differences were noted in MD width of 83, LL/BP widths and mandibular intercanine width, confirming sexual dimorphism.*

Conclusion*: The study confirms sexual dimorphism in primary canines, supporting forensic and anthropological applications.*

Keywords: *Odontometrics, primary canines, sexual dimorphism, intercanine width, forensic odontology, anthropological dentistry, morphometric analysis*

INTRODUCTION

The study of dental morphometrics is fundamental in forensic odontology, anthropology and clinical dentistry, providing valuable insights into variations in tooth dimensions and their significance in identification and diagnosis. Tooth size variability and sexual dimorphism have been extensively explored within dental anthropology and forensic odontology. The MD crown dimensions of both primary and permanent teeth offer critical information regarding genetic inheritance, evolutionary adaptations, and clinical applications. [1] Mesiodistal tooth dimensions play a pivotal role in occlusion, arch space prediction, & dental development assessment across different populations. [2]

Sexual dimorphism has been the focus of numerous studies, consistently demonstrating that males typically exhibit larger tooth dimensions than females, with the most pronounced differences observed in canines [2]. These variations are attributed to genetic and hormonal influences, particularly the role of the Y chromosome in determining tooth size differentiation. Importantly, these distinctions manifest early in dental development, as final crown size is attained before tooth eruption, reinforcing the genetic basis of sexual dimorphism in dentition. [3]

The transition from deciduous to permanent dentition is a crucial developmental stage that significantly impacts dental occlusion. Several studies indicate a strong correlation between the sizes of these teeth, suggesting that primary tooth dimensions can serve as predictors for permanent dentition. [4] These findings have important implications for diagnosing potential space discrepancies and planning early orthodontic interventions. [5]

Odontometric analyses have further emphasized inter-population variations in tooth dimensions. Research suggests that European populations generally possess smaller crown dimensions compared to African and Asian populations, who exhibit larger molar dimensions.[1] Such differences are often attributed to evolutionary and environmental factors influencing dental morphology over time. [6]

Despite extensive research on permanent dentition, there remains a notable gap in the literature regarding the morphometric characteristics of primary teeth and their potential application in sex estimation. [7] Permanent canines, in particular, exhibit significant sexual dimorphism, making them reliable indicators for gender determination in forensic investigations. [8] Primary teeth, including the central and lateral incisors, canines, first molars, and second molars, play a key role in forensic odontology and pediatric dental evaluations.

Research indicates that male teeth are typically larger than female teeth across various populations, with these differences linked to genetic, hormonal, and environmental influences [9] Moreover, racial and ethnic variations significantly influence tooth size and shape, underscoring the necessity for population-specific odontometric standards. [10]

Understanding variations in tooth morphology and dimensions plays a crucial role in forensic identification, as well as in clinical applications such as pediatric dentistry and orthodontics. By expanding the knowledge of dental development and morphological differences, such studies contribute to refining diagnostic methods and improving patient care.[11]

Building upon this foundation, the aim of the study is to comprehensively investigate sexual dimorphism in primary dentition by focusing on the morphometric characteristics of primary canines.

MATERIALS AND METHODS

Study design, Study setting and duration:

This study involves a morphometric analysis of primary teeth to assess gender dimorphism using a Vernier Caliper (150 mm, Japan) for precise measurements. Conducted in a controlled clinical setting, all measurements were performed by a single examiner to ensure consistency. Institutional Ethics Committee approval from the Institutional Ethics Committee of Maharaj Vinayak Global University, located in Jaipur, Rajasthan, India was obtained before the study commenced (MVGU/PHD/2021/754).The study population included Indian children from Gulbarga city with primary dentition. 258 sets of maxillary and mandibular diagnostic dental casts were analysed.

Sample size calculation:

The sample size was determined based on data from a previous study by Xiao-Xi Lu et al. The following formula was used for the calculation:

$$n = \frac{(\sigma 1^2 + \sigma 2^2)/(z1\text{-}\alpha/2 + z1\text{-}\beta)^2}{\Delta^2}$$

Using a 95% confidence interval and 80% statistical power, the total sample size was calculated to be 258.

Study Sample:

The study consists of 258 sets of dental casts from 258 Indian children with primary dentition. A purposive sampling technique was used to select maxillary and mandibular diagnostic dental casts based on the study's inclusion criteria.

Eligibility Criteria:

Inclusion Criteria:

The study included healthy children with a full set of primary teeth, no developmental anomalies in tooth shape, and no dental crowding. Only children who expressed willingness to participate were included.

Exclusion Criteria:

Children with tooth attrition (physiological or pathological), malocclusion, crowding, rotation or misaligned teeth, as well as those with a history of restorative procedures, orthodontic treatment or trauma, were excluded. Other exclusions include partially erupted or missing primary teeth, syndromic conditions, cleft lip/palate and those undergoing radiotherapy or chemotherapy. Unwillingness to participate also disqualified candidates.

Study procedure:

Measurements were obtained from 258 sets of maxillary and mandibular diagnostic dental casts using a digital Vernier caliper. The data collection parameters include:

- Mesiodistal Width (MD): The maximum expanse between the proximal aspects of the crown.
- Cervico Incisal (CI): The measurement from the tip of the crown to the cementoenamel junction.
- Labiolingual/Buccopalatal Width: It is the measurement from the labial

side which faces the lip to the lingual or palatal side.

Intercanine Width (ICW): The distance between the cusps of the right and left canines in both arches.

Statistical Analysis:

Statistical analysis was performed using SPSS (version 20.0, IBM Corp, Armonk, NY, USA). The Shapiro-Wilk test was employed to assess the normality of the data distribution. To analyze gender differences in MD, CI, LL/BL and ICW dimensions, the Independent Student's t-test was used. The Unpaired t-test was applied to compare MD, CI, LL/BP, Maxillary ICW, and Mandibular ICW between boys and girls.

RESULTS:

Table 1: Odontometric Measurements of Primary Canines Stratified by Sex

Parameters	Gender	N	Mean	SD	SE
MD 53	Male	25	6.15	0.63	0.13
	Female	23	5.95	0.50	0.10
MD 63	Male	25	6.05	0.67	0.13
	Female	23	6.03	0.47	0.10
MD 73	Male	25	5.50	0.46	0.09
	Female	23	5.29	1.22	0.25
MD 83	Male	25	5.21	0.47	0.09
	Female	23	5.46	0.36	0.07
CI 53	Male	25	5.11	0.67	0.13
	Female	23	5.10	0.69	0.14
CI 63	Male	25	5.08	0.59	0.12
	Female	23	5.11	0.63	0.13
CI 73	Male	25	5.52	0.82	0.16
	Female	23	5.27	1.28	0.27
CI 83	Male	25	5.38	0.82	0.16
	Female	23	5.43	0.76	0.16
LL/BP 53	Male	25	4.94	0.75	0.15
	Female	23	4.18	0.34	0.07
LL/BP 63	Male	25	5.09	0.60	0.12
	Female	23	4.22	0.36	0.07
LL/BP 73	Male	25	4.56	0.56	0.11
	Female	23	3.75	0.88	0.18

LL/BP 83	Male	25	4.49	0.49	0.10
	Female	23	3.76	0.33	0.07
MaxillaICW	Male	25	30.11	4.30	0.86
	Female	23	30.33	2.23	0.46
MandibleICW	Male	25	22.42	2.36	0.47
	Female	23	24.32	2.48	0.52

Males exhibited slightly larger measurements across most parameters, particularly in labiolingual/buccopalatal (LL/BP) dimensions, suggesting greater buccopalatal tooth thickness. Maxillary intercanine width remains similar between sexes, whereas mandibular ICW is greater in females, indicating potential arch morphology differences (table 1).

Table 2: Independent Samples t-Test Comparing Mesiodistal (MD) Widths of Primary Canines between Sexes

Measurements	t-value	p-value	Mean Difference	Std. Error Difference	95% confidence interval of the difference	
					Lower	Upper
MD 53	1.1940	0.2390	0.1958	0.16	-0.13	0.53
MD 63	0.0780	0.9380	0.0132	0.17	-0.33	0.35
MD 73	0.8000	0.4280	0.2090	0.26	-0.32	0.74
MD 83	-2.0140	0.0500	-0.2445	0.12	-0.49	0.00

*p<0.05

Males exhibited slightly larger measurements across the MD dimensions (table 2) (figure 1).

Table 3: Independent Samples t-Test Comparing Cervico-Incisal (CI) Widths of Primary Canines between Sexes

Measurements	t-value	p-value	Mean Difference	Std. Error Difference	95% confidence interval of the difference	
					Lower	Upper
CI 53	0.0190	0.9850	0.0037	0.20	-0.39	0.40
CI 63	-0.1870	0.8520	-0.0330	0.18	-0.39	0.32
CI 73	0.8140	0.4200	0.2504	0.31	-0.37	0.87
CI 83	-0.1850	0.8540	-0.0421	0.23	-0.50	0.42

No statistically significant differences were observed in CI dimensions between male and female subjects across all the canines, indicating minimal sexual dimorphism in this parameter (table 3) (figure 2).

Table 4: Independent Samples t-Test Comparing Labiolingual/Buccopalatal (LL/BP) Widths of Primary Canines between Sexes

Measurements	**t-value**	**p-value**	**Mean Difference**	**Std. Error Difference**	**95% confidence interval of the difference**	
					Lower	**Upper**
LL/BP 53	**4.4710**	**0.0001***	**0.7657**	**0.17**	**0.42**	**1.11**
LL/BP 63	**6.0780**	**0.0001***	**0.8746**	**0.14**	**0.58**	**1.16**
LL/BP 73	**3.8120**	**0.0001***	**0.8038**	**0.21**	**0.38**	**1.23**
LL/BP 83	**5.9730**	**0.0001***	**0.7315**	**0.12**	**0.48**	**0.98**

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*p<0.05

Highly significant differences ($p < 0.0001$) were observed in LL/BP measurements for all canines, with males consistently demonstrating greater dimensions. These findings highlight pronounced sexual dimorphism in buccopalatal tooth thickness (table 4) (figure 3).

Figure 1: Graphical comparison of MD width between males and females

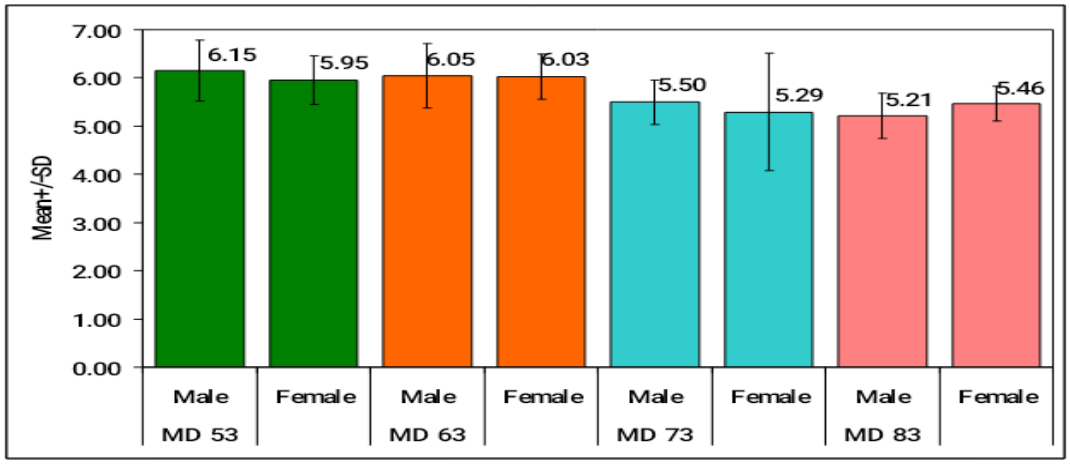

Figure 2: Graphical comparison of CI height between males and females

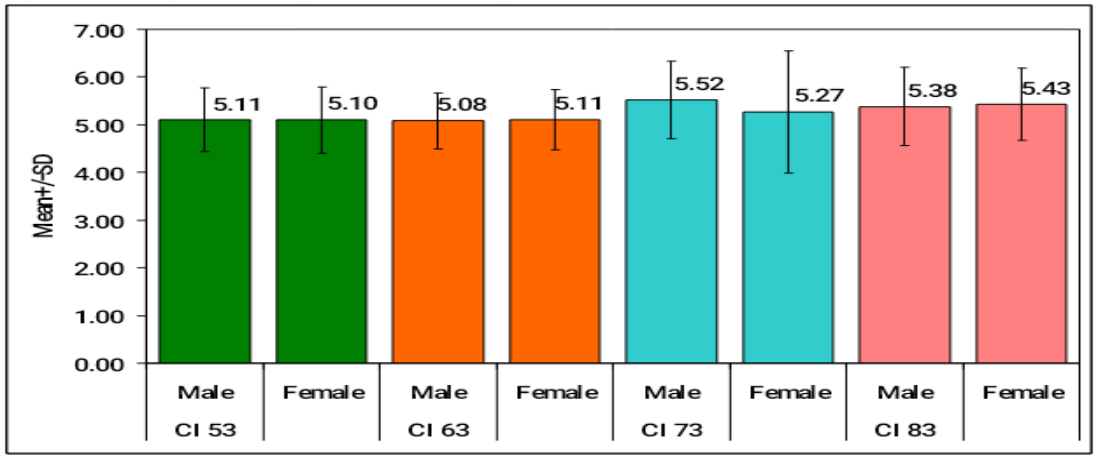

Figure 3: Graphical comparison of LL/BP width between males and females

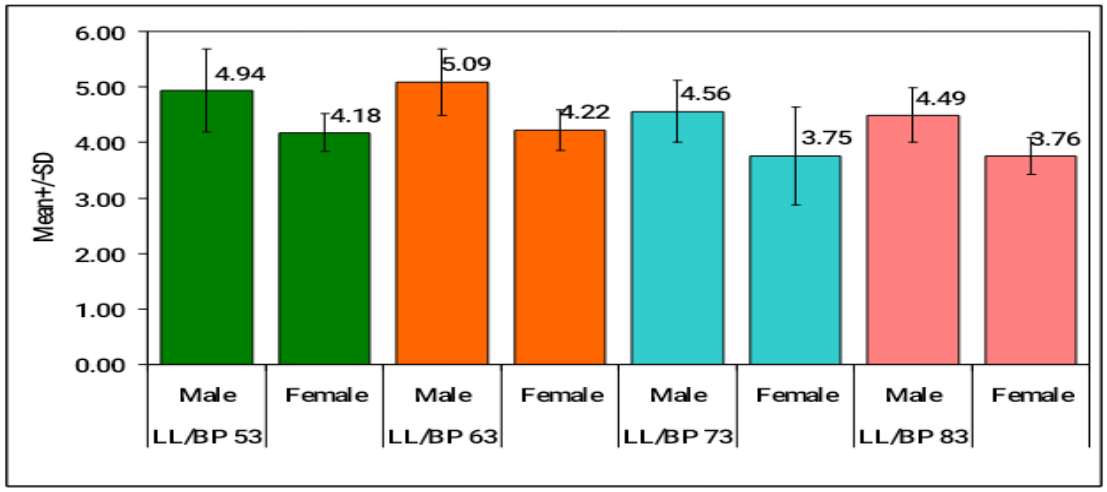

Table 5: Independent Samples t-Test for Maxillary and Mandibular Inter-Canine Widths by Sex

ICW	t-value	p-value	Mean Difference	Std. Error Difference	95% confidence interval of the difference	
					Lower	Upper
MaxICW	-0.2220	0.8250	-0.2228	1.00	-2.24	1.80
ManICW	-2.7190	0.0090*	-1.9014	0.70	-3.31	-0.49

*p<0.05

While no significant difference was found in maxillary ICW between sexes (p = 0.825), mandibular ICW was significantly higher in females (p = 0.009), suggesting a potential morphometric variation specific to the mandibular arch (table 5) (figure 4).

Figure 4: Graphical Comparison of maxillary and mandibular Inter-Canine widths between genders

DISCUSSION:

Morphometric assessments of dental structures have long been utilized in forensic odontology and anthropological research to estimate sex, particularly in juvenile remains where secondary sexual characteristics are not yet fully developed. The dimensions of primary canines, which includes the mesiodistal (MD), labiolingual (LL), cervicoincisal (CI) and intercanine widths (ICW), serve as crucial indicators in determining gender differences. This study aimed to assess the effectiveness of morphometric measurements of primary canines in identifying sexual dimorphism among Indian children.

The findings of this study indicate that the mean linear dimensions of the primary canine with respect to MD, CI and LL/BP was higher in males as compared to females, suggesting the existence of sexual dimorphism in primary canines. Our study establishes that the sexual dimorphism is most pronounced in mandibular ICW and LL/BP dimensions, highlighting significant differences between sexes in these measurements. The greater mandibular intercanine width (ICW) observed in females suggests potential differences in arch morphology. These findings are in line with prior research, which attributes the larger tooth dimensions in males to prolonged amelogenesis and increased enamel deposition. [13] Similar trends were documented by Singh (2017) [14], reinforcing the patterns observed in this study. Additionally, Burgueno et al. (2018)[16] noted that primary teeth erupt earlier in boys than in girls, potentially influencing the size variations seen in later stages of development.

In the present study statistically significant differences were identified in MD 83 and LL/BP widths. These results corroborate prior research by Moss & Moss-Salentijn (1977)[13] who highlighted the strong dimorphism in primary canines. According to Singh (2017)[14] the MD and LL dimensions of primary teeth demonstrated mean sexual dimorphism percentages of 2.35% and 0.56%, respectively. Additionally, Lukacs (2023)[17] emphasized that morphogenetic fields play a significant role in determining variability in primary tooth dimensions, further supporting the developmental basis of sexual dimorphism observed in our study.

In the present study no significant difference was found in maxillary ICW between sexes, whereas mandibular ICW was significantly greater in females. This suggests sex-based differences in dental arch morphology, particularly in the mandibular region. Previous studies, such as those by Foster (1969)[15], have indicated that males generally have larger maxillary arch dimensions, while mandibular differences may be influenced by variations in arch shape rather than size. Similar trends were reported in Chinese children, where mandibular dimensions varied more prominently between sexes than maxillary dimensions.[18] Burgueno et al. (2018)[16] also noted that dental arch development follows a sex-specific trajectory, reinforcing the significance of mandibular ICW differences in different populations.

The present study found that maxillary ICW was significantly greater than mandibular ICW in both sexes, with a larger difference observed in males. This suggests that sex-based variation in intercanine widths is an important factor in dental development. These findings are in line with previous research, including Singh (2017)[14], who noted comparable patterns in maxillary dimensions, attributing them to more pronounced arch development in males.

Foster (1969)[15] also noted that males tend to exhibit greater dental arch spacing, which could contribute to these differences. Burgueno et al. (2018) [16] suggested that the sequence of primary tooth eruption may influence these variations, reinforcing the developmental aspect of sexual dimorphism in intercanine widths. The integration of morphogenetic field theory and eruption timing, as discussed by Lukacs (2023) [17] and Burgueno et al. (2018)[16], provides a more comprehensive framework for understanding odontometric sexual dimorphism. This study reaffirms the existence of sexual dimorphism in primary canines, especially evident in the LL/BP dimensions and mandibular inter-canine width. The results align with earlier studies and further validate the use of odontometric measurements as a valuable tool in forensic and anthropological investigations [12]. Future research should explore population-specific variations in odontometrics to refine sex determination methods further.

CONCLUSION

The present study establishes the presence of sexual dimorphism in primary canines, with notable differences observed in LL/BP dimensions and mandibular inter-canine width. Males generally exhibit larger mesiodistal and buccolingual dimensions, whereas females demonstrate greater mandibular intercanine width, indicating potential differences in dental arch morphology. These findings highlight the role of odontometric measurements in understanding sex differences in dental development.Additionally, understanding sexual dimorphism in primary dentition can assist in early diagnosis and treatment planning in pediatric dentistry.Future studies should increase the sample size and utilize advanced imaging techniques to enhance the accuracy of sex determination.

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