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Permanent Canine Morphometrics in the Saudi Arabian Population: A Sex-Based Comparison Using Mesiodistal and Cervicoincisal Widths

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Abstract: The present study aimed to evaluate the sex dimorphism in morphometrics of permanent canines using mesiodistal and cervicoincisal widths in the Saudi Arabian population. The study was performed using dental casts of patients attending the prosthodontics department, College of Dentistry, Majmaah University, Saudi Arabia. The inclusion criteria involved the presence of all four permanent canines (maxillary left and right (13 and 23) and mandibular left and right (33 and 43)) without any form of developmental anomalies or dental caries with a complete eruption. Mesiodistal width and cervicoincisal width were measured using a digital caliper, ensuring precision and consistency. Statistical tests included *t*-tests and correlation analyses using IBM Statistics (version 21) with $p \leq 0.05$ significance level. A total of 94 sets of dental casts of patients with a mean age of 24.6 ± 4.06 were available in the study for evaluation. Tooth 13 was found to have a higher mesiodistal width (8.12 ± 0.57 mm), while tooth 43 was observed to have a higher cervicoincisal width (9.3 ± 0.9 mm). The study observed gender-based differences in mean scores, with females generally having slightly lower mean scores in mesiodistal and where males ($p < 0.05$) observed with slightly low cervicoincisal widths compared to females. Positive correlations were found between age and mesiodistal and cervicoincisal scores across various dimensions ($p < 0.005$). There was evidence of difference in mesiodistal and cervicoincisal widths among antimeres. The percentage of sex dimorphism varied across dimensions, with some showing more pronounced gender-related differences. The study establishes the mesiodistal and cervicoincisal widths of all permanent canines can be used to identify sex dimorphism in the Saudi Arabian population.

Keywords: permanent canine; morphometrics; gender; dimorphism; anthropology

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1. Introduction

Morphometrics of teeth have been areas of interest in anthropological, forensic, and clinical studies [1]. The permanent canines are one of the most important teeth of the oral cavity because they are stable and have unique features [2,3]. The morphometrics of permanent canines have gained attention as a potential tool for sex dimorphism, aiding in forensic identifications and contributing to the understanding of population diversity [4–6]. Subsequently, the studies focusing on the morphometric analysis of permanent canines have expanded globally, aiming to explore the intricate variations within different populations [6–12]. Sex dimorphism, the morphological differences between males and females, is a prominent area of study within morphometrics [13–18]. Dental features, including permanent canines, exhibit varying degrees of gender dimorphism [19]. In forensic dentistry contexts where skeletal remains or dental evidence require identification analysis, identifying these differences can aid in gender determination [14–18]. The concept of utilizing dental characteristics for gender determination has gained momentum due to its potential accuracy and non-invasive nature. Numerous studies have portrayed the significance of morphometrics in gender identification and estimation, carried out on various subjects throughout the world [18–21].

Researchers have used morphometric analysis for sex identification in various populations using different teeth, such as maxillary molars, incisors, mandibular molars, and maxillary premolars [12–26]. Dental anthropologists have applied this method to understand population-specific variations in dental characteristics and their evolutionary implications [19]. Morphometric analysis of permanent canines within the Arabian population offers a compelling avenue for research due to the Arabian population's unique genetic heritage and cultural practices. The potential applications of morphometric analysis in forensic, anthropological, and clinical contexts underscore its significance. Alanazi et al. [26] investigated the initial findings of sex dimorphism morphometrics in permanent canines, laying the foundation for further investigations in this domain. Another study [27] from Saudi Arabia used a three-dimensional digital method and discriminant function analysis to investigate differences between male and female maxillary permanent canines in the Saudi population. The Arabian population, characterized by its unique genetic heritage and diverse practices, provides a unique platform to investigate morphometric variations in permanent canines. Different measurements were used to establish the morphometrics of permanent canines and sex identification in forensic and anthropological investigations involving various methods, including canines, mandibular parameters, and mesiodistal and labiolingual widths [8,12,14,16,19,22,24,26,27]. However, none of the studies used mesiodistal and cervicoiacial widths of both maxillary and mandibular canines for sex dimorphism determination. Therefore, the study aimed to establish the use of mesiodistal and cervicoincisal widths to identify sex differences and sex dimorphism.

2. Methodology

The research was conducted at the Department of Prosthodontics, Faculty of Dentistry, AlZulfi, Al Majmaah University. The research sample consisted of maxillary and mandibular dental casts from patients who required fixed prostheses.

Inclusion criteria:

- Dental casts belonged to patients of Saudi Arabian nationality.
- Both mandibular and maxillary dental casts contain both canines.
- All permanent canines did not exhibit any developmental shape anomalies, including double tooth and microdontic.
- All permanent canines showed no signs of caries, loss of tooth structure due to occlusal wear or trauma, or dental or occlusal abnormalities.
- The complete eruption of all canines.

Exclusion criteria:

- Dental casts belonged to the non-Saudi Arabian population.
- Dental casts did not have any of the four permanent canines.

- Any of the permanent canines displayed developmental abnormality.
- Any of the permanent canines dental caries and loss of tooth structures due to occlusal wear and dental trauma or dental/occlusal abnormalities.
- Partially erupted or impacted canines.

Measurements:

Maxillary were assigned as 13 and 23, and mandibular canines were assigned as 33 and 43, respectively. Mesiodistal and cervicoincisal crown dimensions (Figure 1) of maxillary and mandibular canines were measured using were recorded with the help of calibrated (0–200 mm/0–8″) digital caliper (0–150 mm/0–6″) (INSIZE Company, Derio, Spain, made in China). A single examiner performed the measurements, and Kappa statistics were used to evaluate intra-examiner reliability. The measured dimensions included were (i) the mesiodistal (MD) width of the maxillary and mandibular canines has been defined as the maximum expanse between the proximal aspects of the crown. (ii) The cervicoincisal (CI) width of maxillary and mandibular canines was defined as the maximum expanse between the cervical and incisal aspects of the crown. Canine measurements on both sides of both arches were recorded. The maximum expanse between the crown's cervical and occlusal aspects is the codimension of the maxillary and mandibular canines. A pilot study was performed using ten maxillary and mandibular dental casts after a two-week washout period. The same examiner repeated the measurements, including mesiodistal and cervicoincisal widths of the canines. These dental casts were not involved in the final study.

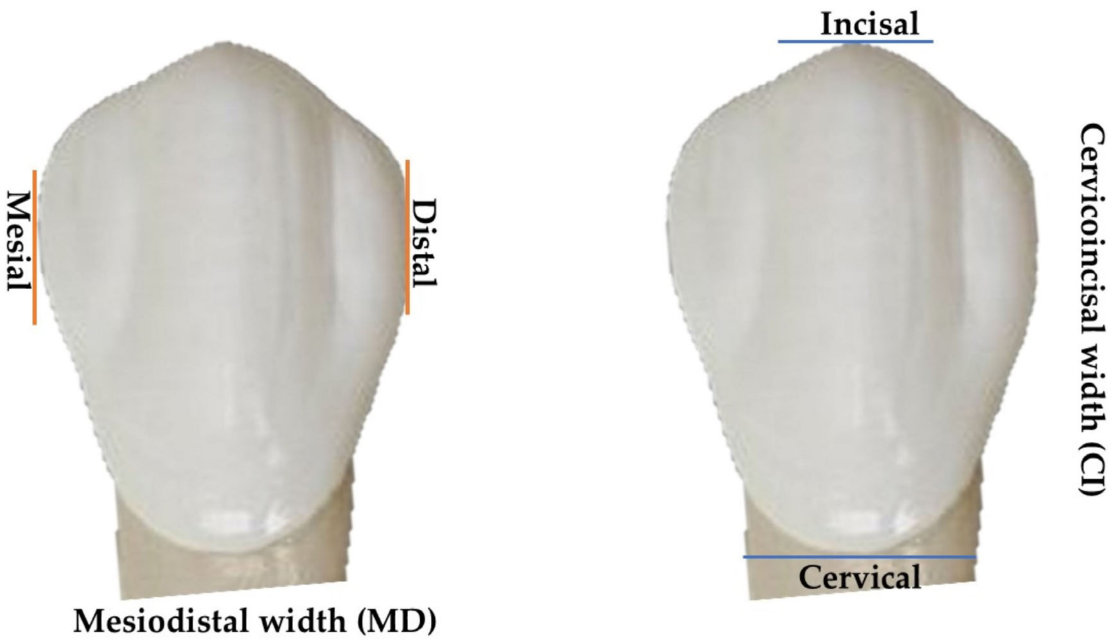

Figure 1. Illustrating the measurements used to estimate sex dimorphism among the study population.

Statistical Analysis:

Descriptive statistics were used for continuous and non-normally distributed data. Sensitivity and specificity calculations were performed for clinical case definitions. The collected data were statistically analyzed using SPSS software (Version 22.0). The mean, range, and standard deviation were calculated for the size of the teeth. To calculate sexual dimorphism, discriminant statistical analysis and Student's *t*-test were used. The Spearman correlation was employed for data analysis to identify the correlation between four permanent canine dimensions. Sex dimorphism in mandibular canines was calculated using the formula by Garn et al. [19]. Sex dimorphism = $(Xm \div Xf - 1) \times 100$, where Xm represents the mean width of male canines and Xf denotes the mean width of female canines. The statistical analysis was conducted on mesiodistal and cervicoincisal dimensions for teeth 13, 23, 33, and 43, along with an exploration of sex dimorphism. The accuracy percentage of sex identification through this method was later substantiated by contrasting the means and medians of teeth 13, 23, 33, and 43 with the established. A Student's *t*-test was used to compare the mean difference of all measurements between males and females. Pearson's correlation matrix was used to identify the correlation of mesiodistal and cervicoincisal widths of all permanent canines. The significance level was set at $p < 0.05$.

3. Results

Overall, 94 patients attending the prosthodontic department, College of Dentistry, Majmaah University, Saudi Arabia, meet the study inclusion criteria. The study used ninety-four pairs of dental casts for fixed prosthesis, with 42% of these pairs belonging to females (N = 40) and 58% to males (N = 54). The patients' ages ranged from 18 to 37 years, with a mean age of 24.6 to 4.06 years. The age for males ranges from 19 years to 37 years, with a mean of 23.74 ± 3.73 years, while for females, the age range was from 18 years to 35 years, with a mean age of 24.57 ± 2.83 years. Kappa statistics showed the inter-examiner reliability was good, with a K value of 0.8 for mesiodistal widths and excellent cervicoincisal widths, with a K value of 0.89. The mean, standard deviation, and median scores for mesiodistal width and cervicoincisal width of all permanent canines have been summarized in Table 1. The mesiodistal widths for teeth 13, 23, 33, and 43 were 8.12 ± 0.58 mm, 8 ± 0.81 mm, 7.47 ± 0.59 mm, and 7.51 ± 0.57 mm, respectively. Tooth 13 showed a higher mesiodistal width (8.12 ± 0.58 mm), while tooth 33 showed a lower mesiodistal width among the four canines in the study population. The cervico incisal widths for teeth 13, 23, 33, and 43 were 8.92 ± 1.29 mm, 9.1 ± 1.27 mm, 9.11 ± 1.05 mm, and 9.30 ± 0.99 mm, respectively. Tooth 13 showed higher mesiodistal width, while tooth 13 showed lower cervicoincisal width among the four canines in the study population. The median score of mesiodistal widths for teeth 13 and 23 was found to be the same (8 mm), while for teeth 33 and 43, it was the same (7.5 mm). The median scores of cervicoincisal widths for teeth 13, 23, and 33 were found to be the same at 9 mm, while for tooth 43, it was 9.5 mm.

Table 1. The descriptive details of permanent canine mesiodistal width and cervicoincisal width.

Details	Sample (N)	13MD	23MD	33MD	43MD	13CI	23CI	33CI	43CI
Mean (mm)	94	8.12	8.00	7.47	7.51	8.92	9.10	9.11	9.30
Median (mm)	94	8.00	8.00	7.50	7.50	9.00	9.00	9.00	9.50
Standard deviation (mm)	94	0.579	0.815	0.597	0.573	1.29	1.27	1.05	0.995
Minimum (mm)	94	7.00	7.00	6.50	6.50	6.50	6.00	7.00	7.00
Maximum (mm)	94	9.50	9.50	9.00	9.00	12.0	12.0	11.5	11.5

MD = mesiodistal width; CI = cervicoincisal width.

Tooth 13 has been observed with more mesiodistal width (8.21 ± 0.57 mm) compared to its antimere tooth 23 (8 ± 0.81 mm). However, tooth 43 was observed with more mesiodistal width (7.51 ± 0.57 mm) compared to its antimere tooth 33 (7.47 ± 0.59 mm). Tooth 23 has been observed with more cervicoincisal width (9.1 ± 1.27 mm) compared to its antimere tooth 13 (8.92 ± 0.129 mm). In comparison, tooth 43 has been observed with more cervicoincisal width than compared to its antimere tooth 33 (9.11 ± 1.05 mm). The *t*-test revealed significant differences in mesiodistal width scores according to gender. The mean and standard deviation values were higher for mesiodistal width for teeth 13, 23, 33, and 43 in males compared to females, with a statistically significant difference (*p*

< 0.05). Females were observed with more cervicoincial width compared to males in the study population. In comparison, cervicoincisal width was significantly higher for teeth 13, 23, and 43 ($p < 0.05$). The cervicoincisal width for tooth 33 is higher without a statistically significant difference ($p < 0.05$). The comparison of mesiodistal width and cericoincisal width among the males and females is summarized in Table 2. In males, tooth 13 has been observed with more mesiodistal width (8.21 ± 0.64 mm) compared to its antimere tooth 23 (8.07 ± 1.01 mm). However, tooth 43 was observed with more mesiodistal width (7.65 ± 0.61 mm) compared to its antimere tooth 33 (7.62 ± 0.64 mm). Tooth 13 has been observed with less cervicoincisal width (8.78 ± 1.16 mm) compared to its antimere tooth 23 (8.87 ± 1.33 mm). In comparison, tooth 43 (9.15 ± 1 mm) has been observed with more cervicoincisal width than compared to its antimere tooth 33 (8.95 ± 1.0 mm). In females, tooth 13 has been observed with less cervicoincisal width (9.11 ± 1.43 mm) compared to its antimere tooth 23 (9.40 ± 1.15 mm). However, tooth 43 was observed with more cervicoincisal width (9.5 ± 0.96 mm) compared to its antimere tooth 33 (9.32 ± 1.09 mm). Tooth 13 has been observed with more mesiodistal width (7.99 ± 0.466 mm) compared to its antimere tooth 23 (7.9 ± 0.41 mm). In comparison, tooth 43 has been observed with more mesiodistal width 13 (7.33 ± 0.46 mm) than its antimere tooth 33 (7.28 ± 0.46 mm). The descriptive charts for mesiodistal width for all permanent canines (teeth 13, 23, 33, and 43) have been illustrated in Figure 2, whereas cervicoincisal (teeth 13, 23, 33, and 43) width descriptive charts were illustrated in Figure 3.

Table 2. The gender-based comparison in mean scores for mesiodistal width and cervicoincisal width of all permanent canines.

Tooth	Male N = 54		Female N = 40			95% Confidence Interval of the Difference		
	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	Lower	Upper	*p*-Value
13MD	8.21	0.64	7.99	0.446	−0.24	−0.48	−0.01	0.045 *
23MD	8.07	01.01	7.9	0.411	−0.45	−0.83	−0.08	0.018 *
33MD	7.62	0.644	7.28	0.466	−0.25	−0.49	−0.01	0.042 *
43MD	7.65	0.611	7.33	0.461	−0.27	−0.50	−0.04	0.024 *
13CI	8.78	1.16	9.11	1.43	−0.87	−1.38	−0.37	0.001 *
23CI	8.87	1.33	9.40	1.15	−0.68	−1.18	−0.18	0.008 *
33CI	8.95	1.0	9.32	1.09	−0.40	−0.82	0.02	0.061
43CI	9.15	1.0	9.50	0.961	−0.41	−0.81	−0.01	0.044 *

MD = mesiodistal width; CI = cervicoincisal width; * $p < 0.05$ (statistically significant).

The Pearson's correlation matrix for mesiodistal width is shown in Figure 4. The mesiodistal width of tooth 13 strongly correlated with the MD width of teeth 23 (0.547), 33 (0.732), and 43 (0.709) with statistical significance ($p < 0.01$). Tooth 23's mesiodistal width strongly correlated with the mesiodistal width of teeth 33 (0.569) and 43 (0.542) with statistical significance ($p < 0.01$). The mesiodistal width of tooth 33 exhibited a statistically significant correlation with the mesiodistal width of tooth 43 (0.889), with a *p*-value of less than 0.01.

Pearson's correlation matrix for cervicoincisal width is shown in Figure 5. The cervicoincisal width of tooth 13 strongly correlated with the cervicoincisal width of teeth 23 (0.808), 33 (0.672), and 43 (0.609) with statistical significance ($p < 0.01$). Tooth 23's CI width strongly correlated with the cervicoincisal width of teeth 33 (0.642) and 43 (0.659) with statistical significance ($p < 0.01$). The cervicoincisal width of tooth 33 exhibited a statistically significant correlation with the cervicoincisal width of tooth 43 (0.724), with a *p*-value of less than 0.01.

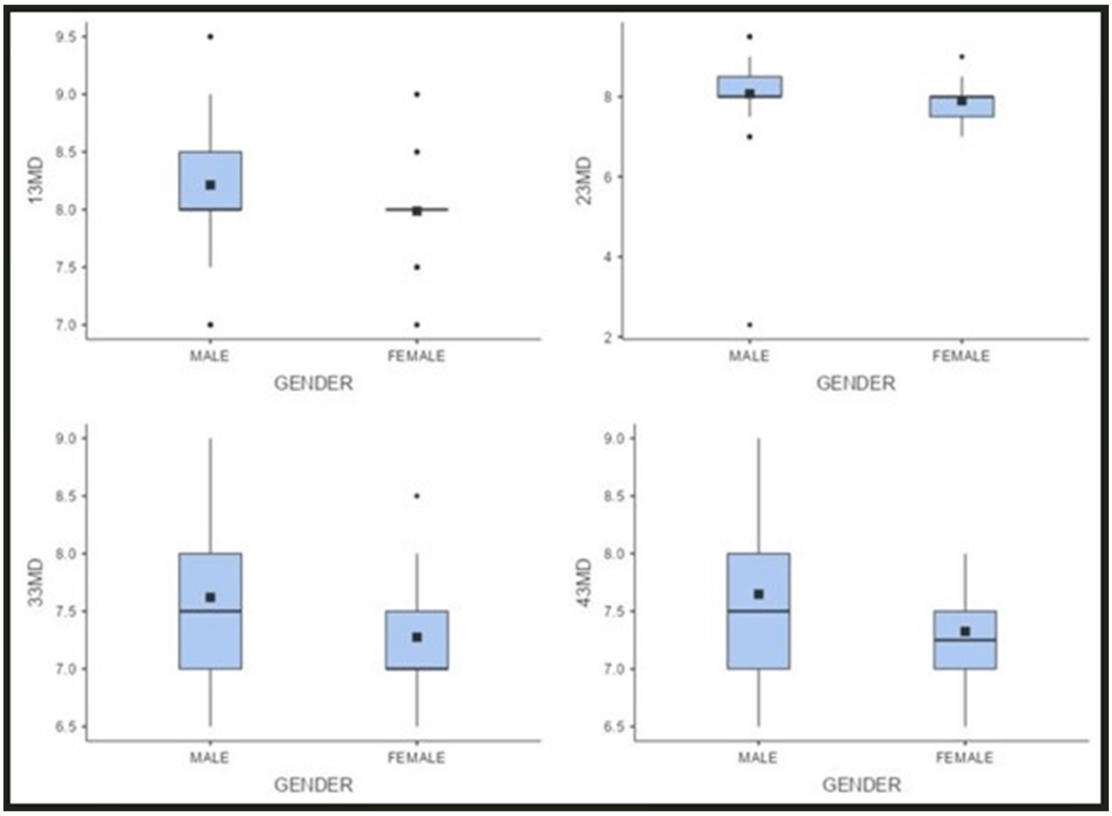

Figure 2. The descriptive charts illustrate the mesiodistal (MD) width distribution of permanent canines among the study population. MD = mesiodistal width.

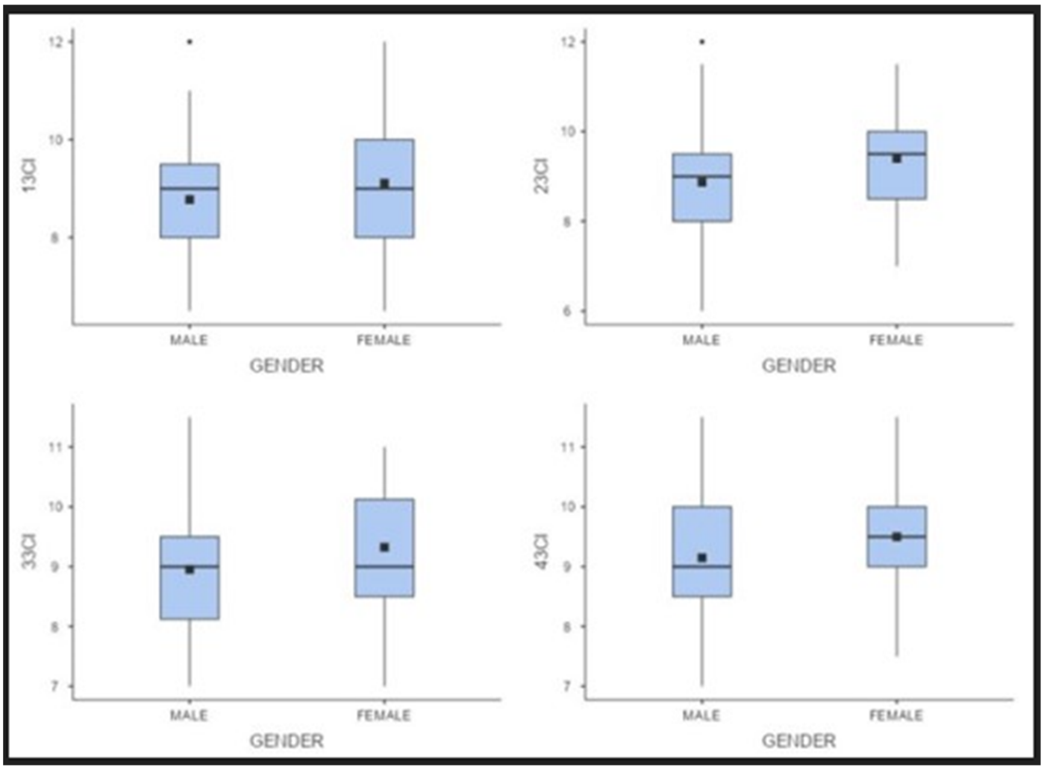

Figure 3. The descriptive charts illustrate the cervicoincisal (CI) width distribution of permanent canines among the study population. CI = cervicoincisal width.

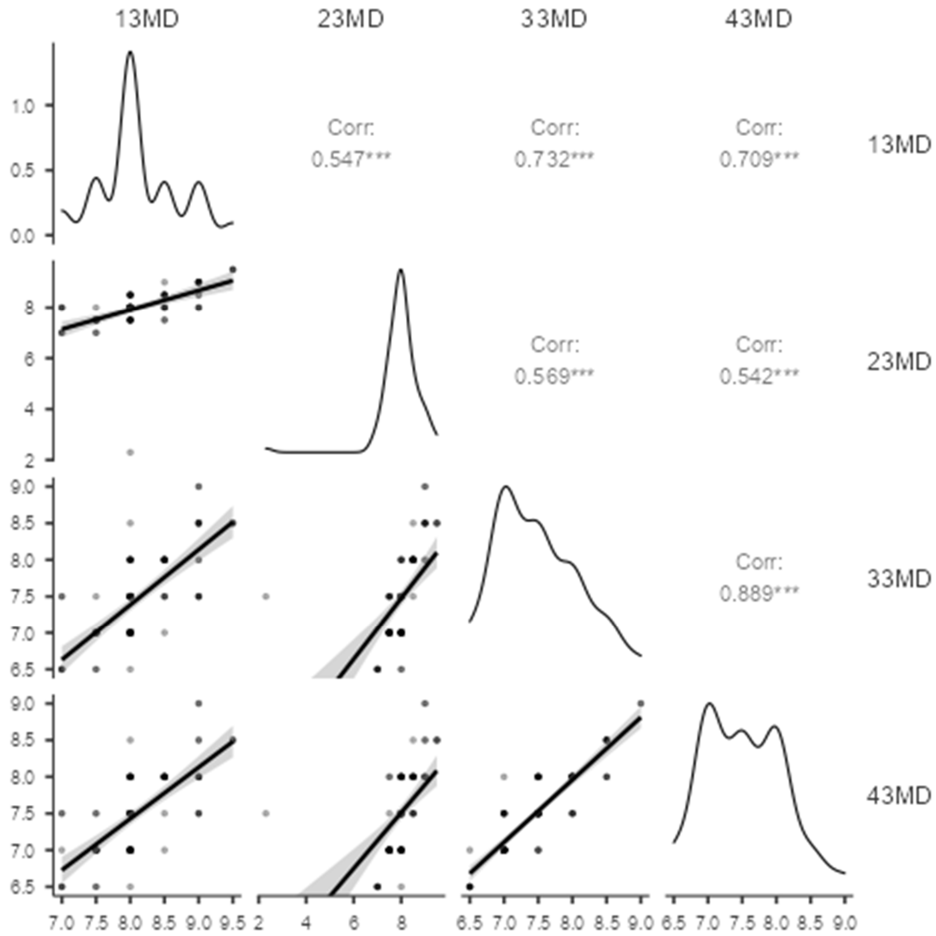

Figure 4. Correlation of mesiodistal width among permanent canines in the Saudi Arabian population. MD = Mesiodistal width.

Table 3 highlights the calculated sex dimorphism percentages of permanent canines using mesiodistal and cervicoincisal widths. The percentage values indicate the degree of difference between male and female mean scores. Tooth 23 (5.77%) showed a higher percentage of sex dimorphism, while tooth 33 (3.33%) showed a lower rate of dimorphism for the mesiodistal width of permanent canines. For cervicofacial width, tooth 13 (10.4%) showed higher sex dimorphism, while tooth 33 (4.43%) was observed with lower sex dimorphism. Notably, dimensions of cervicoincisal widths for teeth 13, 23, and 33 showed relatively higher sex dimorphism percentages, suggesting more pronounced sex-related differences in those dimensions. Thus, the present study demonstrates sex-based differences in mean scores, positive correlations between age and both mesiodistal and cervicoincisal scores, and varying degrees of sex dimorphism across different dimensions. The findings collectively provide insights into the relationship between sex and various craniofacial dimensions. The results indicated a significant sex dimorphism in canine widths, suggesting that these dental measurements can serve as reliable indicators for determining the sex of individuals within the studied population.

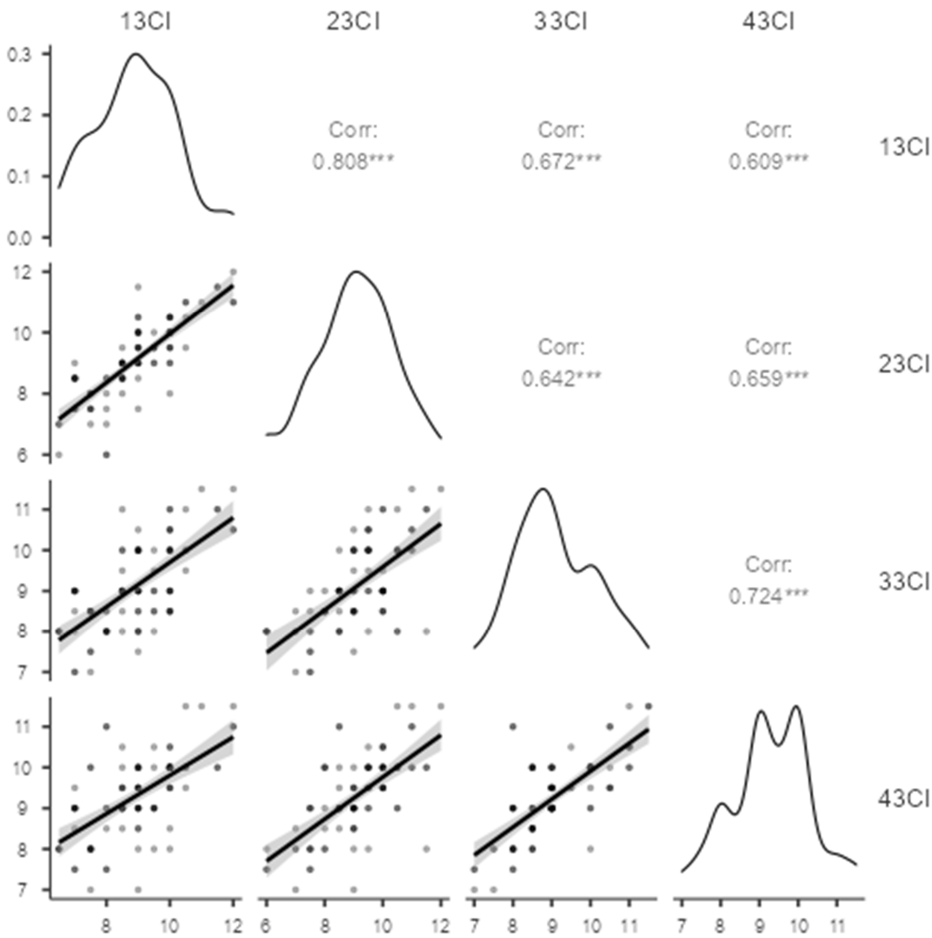

Figure 5. Correlation of cervicoincisal width among permanent canines in the Saudi Arabian population. CI = cervicoincisal width.

Table 3. The sex dimorphism of the study population based on mesiodistal width and cervicoincisal width.

Dimension	Mean (Male)	Mean (Female)	Sex Dimorphism (%)
13MD	8.29	8.05	2.98
23MD	8.24	7.79	5.77
33MD	7.68	7.43	3.33
43MD	7.72	7.45	3.62
13CI	9.51	8.64	10.4
23CI	9.54	8.86	7.67
33CI	9.34	8.94	4.47
43CI	9.56	9.15	4.48

MD = mesiodistal width; CI = cervicoincisal width.

4. Discussion

Recent global research has emphasized morphometric analysis of these teeth, particularly within the genetically distinct Arabian population. The permanent canines, which are corner teeth with unique characteristics, are used to study sex dimorphism and population-specific dental variations [5]. Studies have reported significant differences in various dimensions between male and female permanent canines [20–28]. This synchronization emphasizes the sex dimorphism that frequently occurs in dental traits and supports the validity of canine morphometrics as reliable for sex identification. This study supports the idea that the look of Arabian permanent canines is different for men and women.

The mesiodistal and cervicoincisal widths show that this sex dimorphism is clear in the Arabian population of permanent canines. The present study observed similar findings to those of previous studies reported in the literature [26,29–36]. Numerous studies have demonstrated that morphometrics is very important in shedding light on the degree of sex dimorphism in dental traits between various ethnic groups [25–27,37–40]. There may have been significant sex dimorphism in canine dimensions; Alanazi et al. [26] reported that mesiodistal, cervicoincisal, and buccolingual widths could be used for the identification of sex dimorphism. This study is the only one that examined all measurements to establish sex dimorphism within the Saudi Arabian population. Satish et al. [36] postulated that morphometrics of teeth are valuable tools for the identification of sex dimorphism. Priya et al. [25] also confirmed the existence of sex disparities in the measurements of teeth. Soundarya et al. [37] used permanent maxillary and mandibular incisors, canines, and molars to study sex dimorphism. Sivakumar et al. [38], Devi et al. [39], and Ilayaraj et al. [40] investigated estimating age and gender in various populations using dental metrics. Ishwarkumar et al. [41] evaluated the development of permanent dentition for age and sex estimation in the South African population. Vishwakarma et al. [42] investigated the forensic inferences of sexual dimorphism using permanent mandibular canines. Lund et al. [43] identified notable sex dimorphism in a Swedish population using tooth metrics and emphasized the importance of considering ethnic diversity in dental metric research. Richardson et al. [35] conducted a study on the mesiodistal width dimensions of permanent teeth in African Americans. Their findings reinforced the concept that dental sex dimorphism is a pervasive phenomenon, echoing the present study's discernment of gender distinctions within permanent canine dimensions. Moreover, this concurrence in outcomes across diverse populations serves as a testament to the robustness of canine dimensions as gender determinants. Reddy et al. [44] conducted a study on morphometrics in the Northern Indian population, demonstrating that they could also estimate sex dimorphism using the mandibular canine index. Rao et al. [45] opined that tooth metrics are one of the accurate tools to identify sex dimorphism, and subsequently, Rai et al. [46] established the use of morphometrics in sex identification. Duraiswamy et al. [47] reported that they used the mandibular canine index to measure sex dimorphism in regions with varying fluoride levels, highlighting the importance of this index in various contexts. Gupta et al. [48] investigated the morphometric parameters for sex estimation and opined that the dental metrics are indicators of sexual dimorphism. Similar to the current study, their findings support the inclusion of dental measurements in the range of tools available for sex assessment. This convergence highlights the crucial role of morphometrics in identifying sex differences and highlights the study's significant contribution. Together, these studies show the different ways that morphometrics can be used and how sexual dimorphism can be slightly different in different settings. They also show how important it is for dental anthropology and forensic research to have reference data that is specific to a population.

Researchers have found that the mesiodistal width and inter-canine width of maxillary canines are significantly different between men and women. Usually, men have higher mean values than women. Previously published studies [27,48–51] have confirmed these findings, specifically highlighting the more pronounced sex differences in mesiodistal width in the right maxillary canine. A recent study [26] from Saudi Arabia used mesiodistal width, canine index, intra-canine width, and labiolingual widths were utilized to estimate sex dimorphism. A recent prospective study evaluated only mesiodistal width and canine index, and the results aligned with previous research [21–27]. Notably, a study focusing on the Saudi Arabian population reported an unusual case of reverse sex dimorphism, where males had a lower mean mesiodistal width for maxillary canines compared to females. This is in contrast to the results of an Indian study, which revealed a higher percentage of sex dimorphism in the maxillary intra-canine width, specifically highlighting the more dimorphic nature of the right canine compared to the left [48]. A Chinese study revealed a slightly higher percentage of sex dimorphism in tooth 23's mesiodistal width compared to the right [49]. The present study found that males exhibited significantly greater mesiodistal widths for both right and left maxillary canines compared to females, documenting findings from earlier studies within the Saudi Arabian demographic [26,27,52,53]. However, a conflicting study reported no significant differences in mesiodistal width between genders for the right and left maxillary canines. In contrast, research from Nigeria indicated that the mesiodistal width of the left maxillary canine was significantly larger in males than in females [54]. In the present study, it was evident that the males tended to have higher mean values of mesiodistal and females had more cervicoincisal widths ($p < 0.05$). These finding support the prior insight on canines tend to have different measurements in male sand females [55].

The work of Kanchan and Krishan [56] stands as a light in the field of sex determination from skeletal remains, amplifying the study's forensic ramifications. Similar to the current study's perseverance in gender identification by dental metrics, their rigorous anthropometric analysis of hand proportions revealed gender identities. This resonance further solidifies the integrative use of morphometrics and anthropometric procedures in the broad field of forensic science. The study's ability to identify the distinctive dental characteristics that are inherent to the Arabian population is a notable outcome. This finding supports the assertions made by Verhoff et al. [57], emphasizing the crucial role that genetic factors play in determining dental morphology. The distinctive dental traits identified in this community result from the genetic inheritance and cultural traditions intrinsic to the Arabian population. This discovery highlights the wide range of human dental differences as well as the complex interaction between heredity and cultural factors. The research conducted by Soundarya et al. [37] supports the total nature of Arabian dental traits. Their research into sexual differences in tooth shapes and sizes, especially in the canines, molars, and maxillary and mandibular incisors, gives us new ways to think about the complicated aspects of dental variety. Franceschettie et al. [58] reported the significance of appropriate training and experience, which could significantly improve the accuracy of age assessments. Nonetheless, in the present study, a single examiner was involved in the data analysis. According to the Kappa statistics, the inter-examiner reliability was good, with a K value of 0.8 for mesiodistal widths, and it was excellent for cervicoincisal widths, with a K value of 0.89.

Although limiting the age range to 15 to 25 years was justified for the intended audience, it might impede the extrapolation of results to other age groups. Furthermore, even though the sample size is large, it might not include all of the variances that are present in the population. To address these limitations and anticipate future strategies, Alsaigh and Alrashdi [59] suggested expanding the age range to include additional segments and utilizing new imaging techniques for increased precision. This study examines canine sex dimorphism using dental casts and intraoral measurements. In the present study, the Gran method [19] has been used, which is different from previous studies that used Moorrees and Reed's method [30]. Research on sex dimorphism often relies on dental casts for morphometric analysis, yet some studies indicate that intra-oral measurements may yield less accurate results [60]. Zitkiewicz et al. [61] reported that it is crucial to understand the relationship between genetic and environmental factors that influence tooth shape and size. Banerjee et al. [28] reported that sex dimorphism through morphometric factors adds to this discourse, emphasizing the necessity for precise measurement techniques.

The authors advocate for the use of dental casts in morphometric analysis due to their simplicity, reliability, and cost-effectiveness. Only a few studies [4,20,22,26,29,37] used both maxillary and mandibular canines for the analysis and also supported the use of permanent canines to identify sex dimorphism. Nonetheless, both maxillary and mandibular permanent canines were used in the present study for the evaluation. The majority of the studies utilized dental study casts to measure the tooth dimensions [26,37,38,41,46,51,54], while a Saudi Arabian study [39] and a Chinese study [49] used scanned three-dimensional models to measure the tooth dimensions in their study. However, the present study employed dental study casts to measure the tooth dimensions. A recent Indian study [39] used digital vernier calipers to measure tooth dimensions clinically, so the results were not comparable with the present study. Most researchers have used digital vernier calipers to measure tooth dimensions in their studies [26,28,37,38,41,46,51,54]. The present study used digital vernier calipers to measure the mesiodistal and cervicoincisal widths. However, in a recent study from Saudi Arabia, 3Shape® Ortho Analyzer™ software (3Shape 2020, Copenhagen, Denmark) was used to measure the tooth dimensions [27]. Similarly, a Chinese study used reverse engineering software to measure the tooth dimensions [49]. A South Indian study [40] used panoramic radiographs to evaluate morphometric analysis of permanent canines and molars. The authors measured pulp-tooth area ratios to estimate age in their study sample. However, these findings were not comparable with the present study.

The study of dental morphology and morphometrics, particularly in the context of permanent canines, has been very popular in anthropology and forensic sciences [62]. Sex dimorphism, which distinguishes male and female morphological features, is one of the important topics in this research arena. Morphometrics has fundamental utility beyond forensic identification and contributes to a better understanding of the various populations [63,64]. The present study aimed to systematically examine and precisely collect data and interpret the findings within the broader form of existing knowledge. It emphasizes the significance of this research in showing the multifaceted features of Arabian dental variation, hence improving forensic odontology and anthropological insights. Although the study provides valuable insights, it is important to recognize its inherent limits. Some studies from India [28,48] and Saudi Arabia [65,66] looked at the mandibular canine index in more detail. They found that tooth 33 was more different between males and females. In the present study, the authors found tooth 13 8.12. The present study did not measure the canine standard index. However, a reasonably adequate sample and the involvement of a single examiner limit the study's findings, restricting the generalizability of the results. Pearson's correlation revealed a robust correlation between the mesiodistal and cervicoincisal widths across all permanent canines. None of the published studies reported the correlation matrix for the mesiodistal and cervicoincisal widths of both permanent maxillary and mandibular canines. The majority of the studies [4–27] used the mesiodistal width of permanent canines for sex dimorphism. Despite this, this study adopts a novel approach to morphometric analysis, measuring both the mesiodistal and cervicoincisal widths. This will serve as a model for future research on canine metrics. Previous researchers [26–28,37–39,41,46] have primarily focused on mesiodistal widths, highlighting a gap in the literature. The present study aims to establish the use of cervicoincisal width for sex dimorphism. One of the limitations of the present study is the lack of calculation of the standardized canine index and intra-canine width. The lack of measurement of the intracranial width in the study prevents the discriminant function analysis for sex estimation, which is also considered a limitation of the present study. Various researchers used intraoral scanners, digital models, and digital vernier calipers to measure the dimensions of permanent canines in their study. The current study emphasizes the importance of digital vernier caliper measurements and advanced digital techniques, which align with the broader goal of improving methodological accuracy in tooth morphometrics.

5. Conclusions

Despite the limitations of the study, it has significantly established sex dimorphism in the Saudi Arabian population through the use of permanent canines. Males were observed to have comparatively more mesiodistal width than females, whereas females were found to have more cervicoincisal width than males. The study also found that cervicoincisal and mesiodistal widths of permanent canines can be used to identify sex dimorphism among the Saudi Arabian population.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data will be available upon request to the corresponding authors. They are not publicly available in accordance with the consent provided by participants for the use of confidential data.

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