ORIGINAL RESEARCH

Evaluation of correlation between mesio-distal width of permanent incisors and arch width in a sample of Sri Lankan population

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Abstract

Objectives: This study examines the correlation between incisor width (IW) and arch width (AW) within the Sri Lankan population to establish population-specific dental parametric standards, thereby enhancing the fields of forensic odontology and evidence-based clinical dentistry.

Methods: A cross-sectional study was conducted to investigate a hypothesized correlation between the mesio-distal width (MD) of permanent incisors and arch width (AW), aiming to examine this relationship and assess sexual dimorphism in incisor width (IW), involving individuals aged 18 to 30 years, representing both sexes, with casts selected through random sampling. Measurements of maxillary and mandibular incisors, inter-canine, and inter-molar widths were taken using a digital vernier caliper, with each measurement triplicated. Pearson correlation coefficient and t-test were performed.

Results: A statistically significant correlation was observed among all upper arch dimensions ($p<0.05$), except for the average AW of the upper inter-molar region and average MD of the upper left lateral incisor (21). Lower AW significantly correlated with MD of lower incisors ($p<0.0001$). Males showed statistically higher IW mean values ($p<0.05$) than females, with the only exceptions being upper right (12) and left (22) lateral and lower left central incisors. IW and AW showed a significant correlation ($p<0.05$) in both arches for both sexes, with few exceptions. No significant correlation was found between the upper inter-molar width and the MD of 12, 21, and 22 in males. In females, the same lack of correlation was noted for 22 and lower right lateral incisors with respective inter-molar widths.

Conclusion: The findings suggest that the inter-canine AW may be the most reliable dimension predictable from the MD of incisors for both sexes and vice versa. The study also confirms sexual dimorphism in incisor size, with males exhibiting significantly larger MD values, with few exceptions. Future investigations into different populations would broaden the understanding of these relationships.

Keywords: Incisors, arch width, mesio-distal width, correlation, sexual dimorphism

DOI: https://doi.org/10.4038/slaj.v9i2.276

Sri Lanka Anatomy Journal 2025; 9(II): 41–54

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Introduction

Metric dental traits in dentistry are an important parameter that influences orthodontics, prosthodontics, restorative dentistry, and even anthropological and forensic studies. Knowing the size of the teeth and arch width in populations and individuals is critical for proper diagnosis, treatment planning, and evaluation of the prognosis. Dental crown dimensions play a crucial role in anthropological, evolutionary, and forensic studies, particularly in gender determination for forensic purposes (1).

As it affects obtaining an optimum occlusion, the mesio-distal dimension of teeth is crucial in orthodontics. Mesio-distal dimensions of the upper and lower teeth should be proportionate for a healthy bite. Although there are few exceptions, considerable size discrepancies between the upper and lower teeth, often referred to as intermaxillary mesio-distal size discrepancies, are typically seen in orthodontic patients and do not significantly vary based on sex, ethnicity, or malocclusion category. When assessing and arranging orthodontic patients' therapy, orthodontists should be aware of this frequent occurrence (1,2)

Dental traits are commonly used in forensic odontology and anthropology to determine sex, with mesio-distal and buccolingual widths being reliable measurements. Various factors, including genetics, epigenetics, and the environment, can affect tooth size variability. Notably, men may have larger dental crowns, especially in canines, making teeth valuable for human and sex determination (1).

From an aesthetic viewpoint, incisors are the focal point of a smile. In orthodontic smile analysis, the posed smile is scrutinized based on the extent of incisor and gingival display and the transverse dimension of the smile (3). The dental-facial appearance of young adults can significantly impact their social attractiveness, leading many to seek dental treatments to address aesthetic concerns. A crucial aspect of treatment involves determining the appropriate dimensions for restoring these anterior teeth (4). For example, in dentate individuals, the relationship between the maxillary central incisors and the incisive papilla serves as a reliable guide for positioning central incisor teeth to restore the labial contour in edentulous patients. The incisive papilla remains in a constant position even after tooth and bone loss, indicating its potential as a reliable reference point for estimating the position of anterior teeth in edentulous patients during denture placement (5). Similarly, if other stable dental or anatomical dimensions can be identified and correlated with natural tooth positions, they could serve as valuable reference points for accurately restoring dentition in edentulous patients.

Forensic odontology, a niche field that integrates dentistry and forensic medicine, assumes a critical role in legal proceedings, natural calamities, accidents, and genetic studies (6). Sexual dimorphism of tooth dimensions can be especially useful in identifying young individuals without developed secondary sexual characteristics. Teeth dimensions of mandibular canines, premolars, molars, and maxillary incisors exhibit notable differences. In expansion of

this idea, tooth proportions such as the incisor index can aid in sex determination by comparing the mesio-distal dimension proportions of central and lateral incisors (7).

Moreover, the most precise identification method, which is DNA analysis, although, for a variety of reasons, may not always be achievable. Degraded tooth samples, particularly those from damp settings, may not be acceptable for DNA analysis because DNA might break down and become fragmented, making PCR amplification challenging or impossible. Another issue is potential DNA contamination (8). Furthermore, DNA analysis cannot be used in every case, as it is a time-consuming and expensive method for countries like Sri Lanka.

The extent of incisor and dental arch dimensions being sexually dimorphic has been the subject of numerous research, and it has been found that, on average, males have larger incisors and dental arches than females (1,9,10). Additionally, a few research that looked at the connection between the size of the dental arch and the size of the teeth concluded that there is a strong correlation between these two variables (11). Gender and ethnicity were shown to be the primary factors determining the dimensions of the maxillary central incisors in a comprehensive review and meta-analysis carried out in 2020 (4).

A 2021 study on 58 Caucasian patients found mesio-distal dimensions of upper teeth correlate with maxillary arch size, while lower teeth dimensions showed links with mandibular arch width, particularly between central incisors and inter-canine width, and lateral incisors and inter-molar width (12). A Malaysian study confirmed similar associations, emphasizing arch length and perimeter (11). A study done on 120 subjects highlighted maxillary arch width, length, and inter-alar width as key determinants of anterior tooth size. Additionally, an Indian study found positive correlations between mesio-distal dimensions of incisors, canines, and premolars, across crowded, spaced, and normal dentitions (13).

In historical Sri Lankan practices, when the necessity arose to ascertain an individual's age, conventional standards designed for Western populations were employed due to the absence of a normative database tailored to the Sri Lankan population (14). Notable differences in the length and crown diameters of both permanent and deciduous teeth have been observed between Sri Lankans and Caucasians (15).

The present study was undertaken to investigate the correlation between the mesio-distal width of incisors and arch width in a Sri Lankan population, with a focus on identifying sexual dimorphism in these measurements and their relationship with the aim of establishing a population specific database.

Methods

The present study was a descriptive cross-sectional quantitative study conducted to evaluate the correlation between the mesio-distal width of permanent incisors and arch width in relation to a sample of Sri Lankan population belonging to the age group of 18-30

years by original data collection. A total of 151 pairs of maxillary and mandibular casts were selected from individuals (60 males, 91 females), aged between 18 and 30 years. Subjects included were over 18 years of age, with the presence of all permanent teeth up to the second molars, non-carious, non-attrited, and intact teeth together with satisfactorily aligned teeth without spacing, rotation, crowding, or any malocclusion included in the present study. Also, the casts with air bubbles and broken teeth were excluded. Informed consent has been obtained from the participants. A brief record of the socio-demographic background to ascertain age, sex, date of birth, period of residence in the district, etc., had already been obtained and documented. Slovin's formula was applied to calculate the minimum required sample size.

Ethical clearance was taken from the Ethics Review Committee, Faculty of Dental Sciences, University of Peradeniya (ERC/FDS/UOP/UGR/2023/25).

The study casts which were made using irreversible hydrocolloid impression material (alginate; Aroma Fine, China) and dental stone (New Plastone, G-C. Co., Japan) available in the Comparative Human Biology Lab of the Department of Basic Sciences were used (Figure 1). Measurements were made by the same investigator with a digital vernier caliper, (Mitutoyo Digital Caliper, Japan) accurate to 0.01mm (Figure 2) as described by previous studies conducted in a similar manner (16,17).

The greatest mesio-distal width of the incisors was measured as shown in Figure 3 and the inter-canine and inter-molar width were measured as shown in Figure 4 and 5 respectively.

- Mesio-distal width: Greatest distance between the contact points on the proximal surface of the crown, measured with the callipers aligned along the mesio-distal axis of the tooth (Figure.3).
- Inter-canine distance: Distance between the cusp tips of the permanent canines (Figure.4).
- Inter-molar distance: Distance between the mesio-buccal cusp tips of the right and left maxillary and mandibular permanent first molars (Figure 5).

Figure 1: Mandibular study cast

Figure 2: Mitutoyo Digital vernier caliper

Figure 3: Mesio-distal width measurement of maxillary incisor

Figure 4: Maxillary inter-canine width measurement

Figure 5: Mandibular inter-molar width measurement

All the measurements were taken by a single examiner to eliminate inter-observer error, and each reading was taken three times, and the average of three values were obtained to minimize the intra-observer error.

The presence of outliers was detected using box plots, and normality was assessed using Kolmogorov-Smirnov and Shapiro-Wilk's tests. Descriptive statistics were generated for each dimension, including means and standard deviations, categorized by sex and side. To ascertain whether significant differences exist between the mean values of measurements for males and females on the right and left sides, Student's t-tests were conducted. A significance threshold of $p<0.05$ was adopted to determine the statistical significance of the analyses. Additionally, the relationship between the mesio-distal width of incisors and arch width was explored using Pearson's correlation coefficients, with correlations interpreted as weak (0.00-0.30), moderate (0.30-0.70), and high (0.70-1.00). The statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS), Version 23.

Results

The Cronbach's alpha value was obtained as 0.7659 indicates good internal consistency reliability for the measurements. This suggests that the items or variables in the instrument are moderately to highly correlate with each other, enhancing the validity of the research findings.

Teeth are numbered in the following figures and tables according to the FDI (Fédération Dentaire Internationale) World Dental Federation notation system. The descriptive statistics of all the measurements including mean, standard error of mean, standard deviation, minimum, median, and maximum are given in Table 1.

Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk's tests, and since all p-values were greater than 0.05, normality assumptions were met for all variables. Consequently, the Pearson correlation coefficient was employed to examine the correlation between the mesio-distal width of permanent incisors and arch width with correlations interpreted as weak (0.00-0.30), moderate (0.30-0.70), and high (0.70-1.00).

Table 1: Descriptive Statistics of the measurements (n=151)

Variable	Mean	SE Mean	StDev	Minimum	Median	Maximum
11MD	8.338	0.044	0.537	6.623	8.307	9.880
12MD	6.565	0.045	0.557	4.930	6.537	7.857
21MD	8.365	0.045	0.549	6.633	8.393	9.643
22MD	6.603	0.045	0.558	4.997	6.583	7.967
31MD	5.186	0.029	0.361	4.193	5.203	6.120
32MD	5.725	0.032	0.398	4.300	5.757	6.903
41MD	5.198	0.028	0.343	4.333	5.233	5.993
42MD2	5.715	0.031	0.385	4.497	5.693	6.867
UIM	51.405	0.282	3.466	37.570	51.403	61.430
LIM	44.407	0.269	3.306	37.360	44.383	56.790
UIC	34.282	0.198	2.438	25.120	34.393	40.647
LIC	26.090	0.186	2.289	21.203	25.720	34.893

(StDev- Standard Deviation, SE- Standard Error, MD- Mesio-distal Width, UIM- Upper Inter Molar Width, LIM- Lower Inter-molar Width, UIC- Upper Inter-canine Width, LIC- Lower Inter-canine Width)

Table 2: Pearson Correlation Coefficient (Rho) between the mesio-distal width of upper permanent incisors and upper arch width

Correlation	Rho value	p-value
11MD vs. UIM	0.349	0.000011
11MD vs. UIC	0.412	1.5164×10^{-7}
12MD vs. UIM	0.229	0.005
12MD vs. UIC	0.353	0.000009
21MD vs. UIM	0.339	0.00002
21MD vs. UIC	0.376	0. 000002
22MD vs. UIM	0.151	0.064
22MD vs. UIC	0.395	5.1948×10^{-7}

(MD- Mesio-distal Width, UIM- Upper Inter Molar Width, UIC- Upper Inter-canine Width)

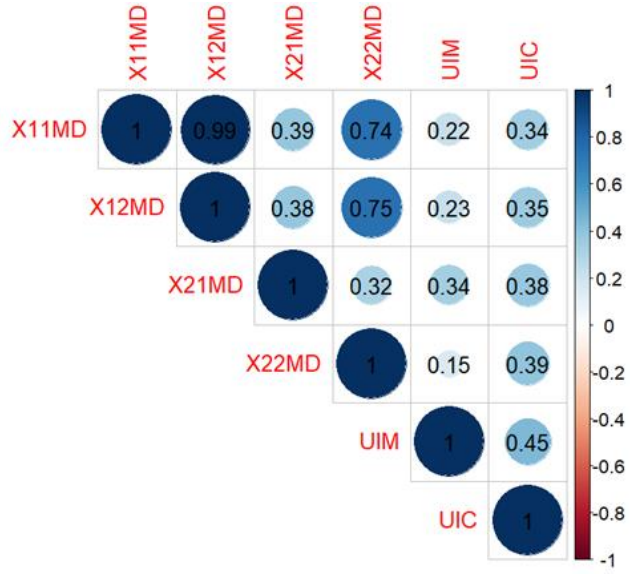

Figure 6: Correlation plot of the mesio-distal width of upper permanent incisors and upper arch width

Table 1: Pearson Correlation Coefficient (Rho) between mesio-distal width of lower permanent incisors and lower arch width

Correlation	Rho value	p-value
31MD vs. LIM	0.280	0.000508
31MD vs. LIC	0.412	1.4227×10^{-7}
32MD vs. LIM	0.311	0.000102
32MD vs. LIC	0.486	2.6356×10^{-10}
41MD vs. LIM	0.354	0.000008
41MD vs. LIC	0.422	6.7075×10^{-8}
42MD vs. LIM	0.344	0.000015
42MD vs. LIC	0.466	1.6015×10^{-9}

(MD- Mesio-distal Width, LIM- Lower Inter-molar Width, LIC- Lower Inter-canine Width)

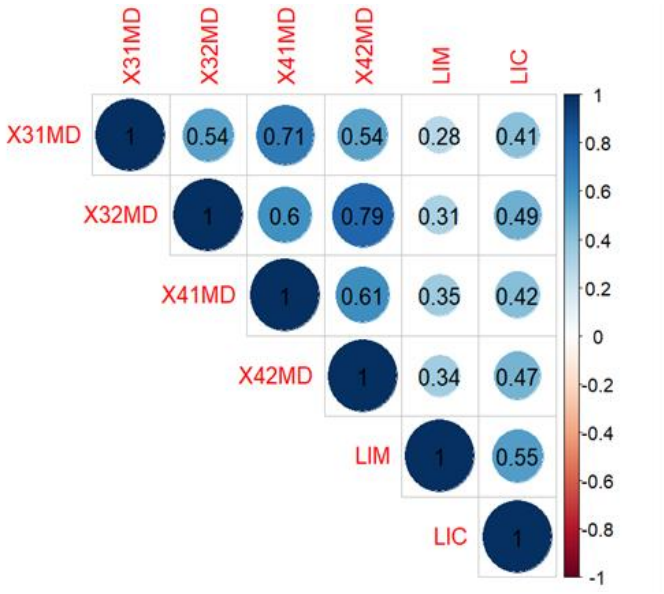

Figure 7: Correlation plot of the mesio-distal width of lower permanent incisors and lower arch width

A statistically significant correlation was observed among all upper arch dimensions (p-value < 0.05), except for the average arch width of the upper inter-molar region and the average mesio-distal width of upper permanent left lateral incisors (rho = 0.151, p-value = 0.064, Table 2, Figure.6). The mesio-distal width of all lower permanent incisors showed a statistically significant correlation with lower arch width (p-value < 0.0001, Table 3, Fig 7).

To ascertain whether significant differences exist between the mean values of measurements for males and females on the upper and lower incisors (Figures 8, 9 and 10), two sample t-tests were conducted, with a p-value <0.05 considered statistically significant.

Statistically significant differences (p-value < 0.05) were found between males and females in 11MD, 21MD, 32MD, 41MD, and 42MD with male measurements being statistically higher than those for females (Table 4).

In males only, the average upper inter-molar width did not show a statistically significant correlation (p < 0.05) with the mesio-distal width of the upper right lateral incisor (12), upper left central incisor (21), and upper left lateral incisor (22). Similarly, females only showed a lack of correlation between the upper inter-molar width and the mesio-distal width of the upper left lateral incisor (22) (Table 5).

A statistically significant correlation (p < 0.05) was observed between lower incisor width and lower arch width in both sexes, except in females between the average mesio-distal width of tooth 42 and the average lower intermolar width (Table 6).

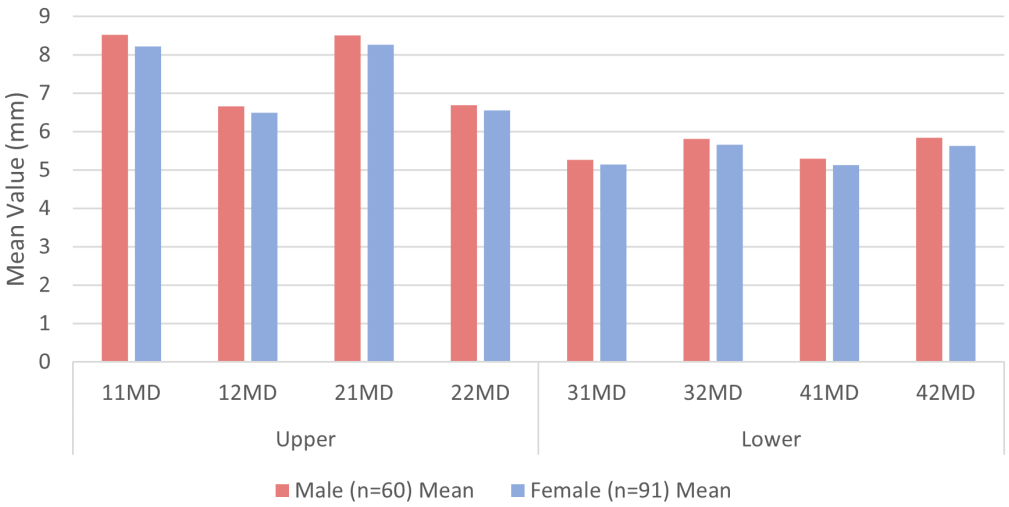

Figure 8: Comparisons of mean values of measurements for males and females on upper and lower incisor mesio-distal widths

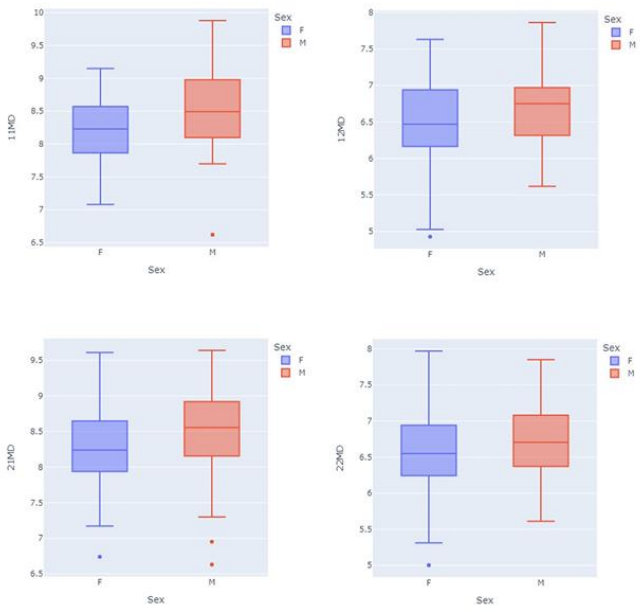

Figure 9: Comparison of distribution of measurements for males and females on upper incisor mesio-distal widths using boxplots

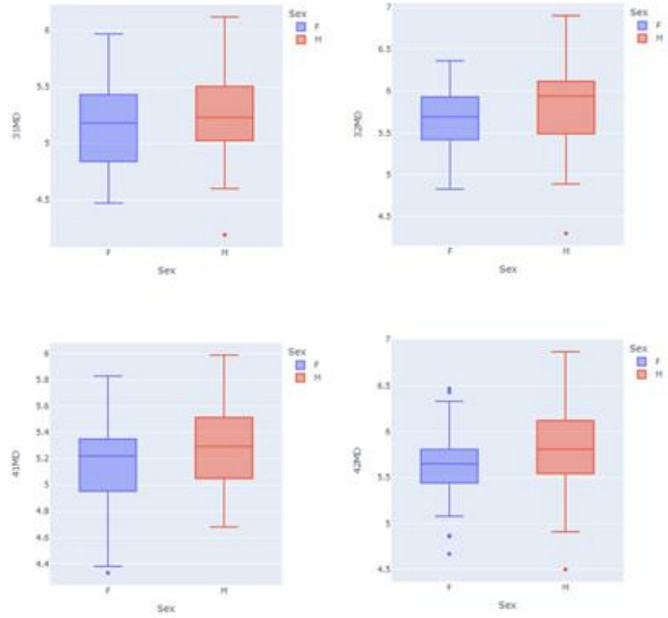

Figure 10: Comparison of distribution of measurements for males and females on lower incisor mesio-dental widths using boxplots

Table 4: The differences between the mean values of measurements for males and females on the upper and lower incisor mesio-distal widths. (MD- Mesio-distal Width)

Variable		Male (n=60)		Female (n=91)		t-value	p-value
		Mean	SD	Mean	SD		
Upper	11MD	8.523	0.595	8.216	0.459	3.39	0.001*
	12MD	6.665	0.528	6.499	0.569	1.83	0.069
	21MD	8.511	0.602	8.269	0.492	2.59	0.011*
	22MD	6.682	0.538	6.551	0.568	1.43	0.154
Lower	31MD	5.263	0.377	5.148	0.347	1.56	0.122
	32MD	5.818	0.457	5.664	0.344	2.23	0.028*
	41MD	5.291	0.342	5.136	0.311	2.77	0.006*
	42MD	5.841	0.450	5.631	0.311	3.15	0.002*

Table 5: Pearson Correlation Coefficient (Rho) between the mesio-distal width of upper permanent incisors and upper arch width for males and females.

Correlation	Male		Female	
	Rho Value	p-value	Rho Value	p-value
11MD vs. UIM	0.268	0.038	0.279	0.007
11MD vs. UIC	0.396	0.002	0.339	0.001
12MD vs. UIM	0.155	0.238	0.219	0.037
12MD vs. UIC	0.395	0.002	0.289	0.006
21MD vs. UIM	0.189	0.149	0.381	0.00016
21MD vs. UIC	0.323	0.012	0.352	0.001
22MD vs. UIM	0.108	0.413	0.126	0.234
22MD vs. UIC	0.336	0.009	0.408	0.000087

(MD- Mesio-distal Width, UIM- Upper Inter-molar Width, UIC- Upper Inter-canine Width)

Table 6: Pearson Correlation Coefficient (Rho) between mesio-distal width of lower permanent incisors and lower arch width for males and females.

Correlation	Male		Female	
	Rho Value	p-value	Rho Value	p-value
31MD vs. LIM	0.284	0.028	0.225	0.032
31MD vs. LIC	0.415	0.001	0.385	0.000143
32MD vs. LIM	0.280	0.031	0.240	0.022
32MD vs. LIC	0.496	0.000055	0.416	0.000045
41MD vs. LIM	0.342	0.007	0.256	0.014
41MD vs. LIC	0.427	0.001	0.346	0.001
42MD vs. LIM	0.328	0.010	0.199	0.059
42MD vs. LIC	0.528	0.000015	0.259	0.013

(MD- Mesio-distal Width, LIM- Lower Inter-molar Width, LIC- Lower Inter-canine Width)

Discussion

In modern dentistry achieving successful dental treatment outcomes is made possible by multidisciplinary approaches that address both functional and aesthetic concerns of patients. Diagnostic casts serve as physical records of a patient's dentition which aids in meticulous examination and treatment planning, ultimately contributing to optimal patient outcomes. One group of researchers even concluded in their study that, in the majority of orthodontic cases, study models alone provide enough information for treatment planning (18).

The present study investigated the relationship between the mesio-distal width of permanent incisors and the arch width in a Sri Lankan population. One hundred fifty-one pairs of dental casts were measured for this purpose by randomly sampling a Sri Lankan population belonging to the age group of 18-30 years. Measurements were taken three times each by a single examiner and subsequently the average of the results was taken to enhance intra-observer reliability.

The study confirms the existence of sexual dimorphism in the mesio-distal widths of upper and lower incisors, with males exhibiting statistically larger mesiodistal dimensions ($p < 0.05$) compared to females for all incisors except the upper lateral incisor and the mandibular left central incisor. This finding aligns with established literature demonstrating generally larger tooth sizes in males compared to females (1,4,9,10). Notably, our observation regarding the upper lateral incisors exhibiting the least sexual

dimorphism concurs with previous research by Al-Khatib et al. (2011).

Further analysis revealed that when evaluating the correlations between upper arch dimensions and upper incisor mesio-distal widths separately for males and females, a greater number of statistically significant positive correlations were exhibited by the female sample. In the upper arch, a significant positive correlation was observed between mesio-distal widths of the most upper incisors and upper arch dimensions except the upper inter-molar width with right lateral incisor, left central incisor, left lateral incisor in males, and left lateral incisor in females. For the lower arch, the mesio-distal widths of the lower incisors displayed a statistically significant, positive correlation with the lower arch width, with only one exception found in females, where the lower left central incisor did not exhibit a significant correlation with the lower inter-molar arch width.

It was found that a statistically significant positive correlation exists between the mesio-distal width of upper permanent incisors and all upper arch dimensions ($p < 0.05$) except between the average arch width of the upper inter-molar region and the average mesio-distal width of upper permanent left lateral incisors. In contrast, the mesio-distal width of all lower permanent incisors showed a statistically significant correlation with the lower arch inter-canine and inter-molar widths ($p < 0.0001$). This consistency between incisor size and overall lower arch width might suggest a potentially stronger relationship in the mandible compared to the maxilla. This finding contrasted with the findings of Cremonini et al. (2021), in which it was noted that they observed stronger correlations between mandibular incisor dimensions and only the inter-canine distance, while maxillary correlations encompassed all incisors with inter-canine, and inter-molar distances.

Previous research by Cremonini et al. (2021) also identified a significant correlation between the mesio-distal dimensions of upper canines and molars and maxillary arch size. Similarly, they found statistically significant correlations between specific lower tooth dimensions and mandibular arch size, particularly for central incisors and inter-canine width and lateral incisors and inter-molar width. However, it is crucial to acknowledge that correlation does not imply causation. For instance, investigations into dental crowding and its association with tooth size and arch dimensions have shown a link between crowding and smaller dental arches rather than larger tooth dimensions (19). However, a causal relationship solely based on arch size is not fully supported. Howe et al. (1983) did not observe consistent crowding in symmetrical, uniformly small arches compared to non-crowded arches, suggesting other contributing factors. A previous study done on a Malay population noted that mesio-distal crown dimensions are more interrelated with arch length and arch perimeter than arch widths except the inter-canine distance (11).

The study's focus on a Sri Lankan population requires caution when generalizing the findings as it does not account for potential ethnic, regional, or socio-economic variations within the country itself, which might influence dental dimensions. The use of

convenience sampling might introduce selection bias and a lack of generalizability. This poses a risk of getting skewed results while reducing the potential of reaching a broad conclusion. Additionally, the restricted age range of 18 – 30 years may limit the applicability of findings across different age groups, particularly in paediatric or older populations.

Maxillary central incisor dimensions are known to vary across populations due to genetic and environmental factors (4). Future investigations across different ethnic populations and diverse geographical regions would be valuable to establish a broader understanding of these relationships. Similarly, a larger sample size might have been able to detect potentially weaker but meaningful correlations and increase the generalizability of the study. Future research, including a wider range of teeth, including canines and premolars, could offer more comprehensive insights and value as these teeth are often preserved in forensic context.

Conclusion

The present study confirmed sexual dimorphism in incisor width, with males exhibiting statistically significant larger mesio-distal widths compared to females for all measured teeth except the upper lateral incisors and the mandibular left central incisor.

Significant correlations between incisor width and arch dimensions were observed, particularly in the mandibular arch, where lower incisor widths consistently correlated with arch widths in both sexes. Inter-canine width was shown to be the most reliable arch dimension that is predictable from incisor width for both sexes. In females, most incisor widths showed strong predictive ability for their corresponding arch dimensions.

The present study identified patterns of correlation between incisor width and arch dimensions, thus suggesting the ability to predict these dimensions in case of limited availability of data in forensic identification, anthropological studies and clinical planning. However, future research with larger and more diverse populations is needed to enhance generalizability.

Acknowledgement

Authors would like to express their sincere gratitude to Professor B.M.H.S.K. Banneheka, Head of the Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya, and Professor A.K.S. Arambawatta, Head of the Comparative Human Biology Lab, Faculty of Dental Sciences, University of Peradeniya, for facilitating access to the necessary resources from the Comparative Human Biology Lab, and Mr. A.M.S.C. Alahakoon, Ms. A.P. Abeysundara, and the supporting staff of the Comparative Human Biology Lab, Faculty of Dental Sciences, University of Peradeniya, for their invaluable guidance during data collection.

Conflict of interests: There are no conflicts of interest related to this study.

Author contribution: All authors have made substantial contributions to the conception, design, acquisition of data, analysis, and interpretation of the research. Each author has critically revised the manuscript and approved its final version.

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