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Biometric Evaluation of Maxillary Central Incisors' Width, Length, and Width to Length Ratio in a Jordanian Sub-population

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ABSTRACT

Objectives: This study aims to measure the width, length, and width to length (W:L) ratio of the clinical crowns of an adult population's maxillary central incisors.

Materials and Methods: Retracted frontal images of the anterior teeth of 120 participants were obtained with digital photography under standardized conditions. Teeth measurements were obtained using (Image-J) software. Statistical analysis was performed using the IBM SPSS (version 29) at $\alpha = 0.05$. A t-test was used to analyze differences between the right and left maxillary central incisors, while an independent-sample t-test was used to assess gender differences in teeth dimensions and W:L ratios.

Results: In the studied sample, the average perceived width of the right and left maxillary central incisors was 8.57 mm for females and 8.75 mm for males, with statistically significant gender differences ($p = 0.039$ and $p = 0.040$, respectively). The average length was 9.79 mm in females and 10.22 mm in males, also showing significant gender differences ($p = 0.029$ and $p = 0.020$, respectively). However, when comparing the maxillary central incisor width and length values between the right and left sides of the dental arch, no statistically significant differences were observed (p-values > 0.05). For the W:L ratio, the average ratio was 87% in males and 88% in females. No statistically significant differences were found between the right and left sides ($p = 0.94$) or between genders ($p = 0.24$).

Conclusions: Significant gender differences were observed in both the width and length of maxillary central incisors, with males showing larger dimensions than females. No statistically significant differences were found between the right and left sides for width or length measurements. The W:L ratio showed no significant differences between genders or between sides of the dental arch.

Keywords: Maxillary central incisors, Tooth dimensions, Width to length ratio, Gender differences, Jordanian population, Dental aesthetics.

1. Introduction

The need for aesthetically pleasing smiles has grown in the last several years (1). In aesthetic dentistry, patients with multiple missing anterior teeth or tooth defects are frequently encountered. Correcting discrepancies in tooth size, whether related to length or width, remains a key objective for achieving optimal aesthetic outcomes (2). The maxillary central incisors (MCIs) play a pivotal role in dental aesthetics, phonetics, and function due to their prominent visibility during speech and smiling (3). Consequently, dental biometrics plays an essential role in achieving precise and harmonious restorative outcomes. Moreover, anthropologists and forensic odontologists greatly benefit from information on tooth dimensions specific to a population and a person's sex (4).

The MCI width to length (W:L) ratio can be represented as a percentage, calculated by dividing the

tooth's width by its length. In order to direct and rationalize the process of producing harmonious and aesthetically pleasing smiles, several researchers have tried to determine the optimal standard for this ratio and 80% has been reported as a standard aesthetic ratio (5-7). The growing focus on dental aesthetics has resulted in the publication of numerous guideline figures for restorative treatments. However, the variety of these guidelines often creates confusion for clinicians when determining the most appropriate tooth size, shape, and proportional relationships (7).

Over the years, several methods have been employed to measure the dimensions of maxillary anterior teeth. For instance, Sterrett et al. (1999) studied the W:L ratio of the clinical crowns of maxillary anterior teeth using diagnostic casts from a sample of 71 individuals. They reported an average ratio of 85% for central incisors (5). In contrast, a study at the University of Geneva in 2003 used photographs of extracted teeth for measurements and found an average W:L ratio of approximately 75% for the maxillary anterior teeth (8). In 2007, Chu and Hochman introduced an aesthetic measurement gauge to help clinicians achieve predictable results in surgical and restorative dentistry. They proposed an optimal W:L ratio of 78% for the central incisors (9). Other studies have suggested that the ideal W:L ratio for central incisors should generally fall between 75% and 80% (7). Similarly, Rosenstiel et al. evaluated dentists' preferences for anterior tooth proportions and found that most of them favored central incisors with W:L ratios between 75% and 78% (10).

A substantial body of evidence indicates that the size of maxillary anterior teeth can vary significantly among individuals and across different populations. These variations are influenced by several factors, including sexual dimorphism, race, genetics, and environmental conditions. Research has shown that human populations exhibit distinct differences in dental crown size, with gender-specific variations also being consistently reported (11). Several studies have investigated the dimensions of maxillary anterior teeth within Arab populations. For instance, a study focusing on the Saudi population reported that the maxillary central incisors had an average width of 8.60 mm and an average length of 9.71 mm, resulting in a W:L ratio of approximately 89%. This suggests a squarish form of anterior teeth in this group (12). Another study by Al-Kaisy et al. (2018) conducted in Kurdish and Arab populations to analyze the anatomic crowns of maxillary anterior teeth reported that the W:L ratio of maxillary central incisors in Arab populations tends to be higher than the predicted ideal ratio of 80%, with reported values ranging between 88% and 90% (13). These findings emphasize the importance of considering population-specific norms in dental-treatment planning to achieve optimal aesthetic outcomes.

To the best of the authors' knowledge, limited research has specifically focused on the dimensions of maxillary central incisors in Jordan. Therefore, this study aimed to assess the width, length, and W:L ratio of the clinical crowns of maxillary central incisors in an adult population in Jordan.

2. Materials and Methods

Approval for the study was obtained from the Institutional Review Board (IRB) of Jordan University of Science and Technology prior to commencement. All participants were required to provide informed consent. A power analysis was performed, assuming a large effect size, 0.8 power, and a significance level of 0.05, indicating that a minimum of 110 participants was necessary. A total of 120 participants (60 men and 60 women) were recruited to ensure equal gender distribution.

The inclusion criteria for participants were as follows: Jordanian nationality from the same Mediterranean ethnic group, normal skeletal relationships, Class-I incisal relationship with normal overjet and overbite according to Angle (14), within 18-30 years of age, no interdental spacing, crowding, or restorations, and no evidence of gingival or periodontal alteration or disease. Participants were excluded from this study if they had a history of orthodontic treatment, prosthodontic treatment in the anterior teeth, obvious defects, alterations to the incisal edge or proximal surfaces of the teeth due to restorative interventions, caries, attrition, loosening, or any deformities in the anterior teeth region. All participants received oral hygiene instructions, and an in-clinic cleaning of dental plaque and calculus was provided when necessary. To ensure consistency and minimize measurement variability, the data was collected by a single operator (A.S.).

For each participant, a standardized colored photograph was taken using a Canon EOS 800D DSLR camera equipped with a 105mm 2.8 EX DG Macro

Sigma lens and a twin flash. The camera settings were standardized and set to the following values: aperture F16, shutter speed 1/160s, and ISO 100. A camera mounted on a photographic stand was used to capture images aligned parallel to the horizontal plane of the floor. A consistent distance was maintained between the camera lens and the tip of the participant's nose. A head stability device, equipped with a level centered on the patient's face, ensured that the interpupillary line remained parallel to the floor. Photographs were taken from a frontal, perpendicular angle to the face, with a meter ruler attached to the head stability device for calibration purposes. Participants were seated upright in a natural head position, and images were captured with the lips retracted using a dental cheek retractor to ensure clear visualization of the teeth (Figure 1).

Figure 1: A frontal photograph showing maxillary central incisors' perceived measurements

The photographs were then imported into an image processing software (ImageJ 1.52a) that allowed calibration and measurement of dental parameters using software caliber. Vertical and horizontal tooth measurements were conducted as illustrated in Table 1.

Table 1: Summary of clinical measurements

Clinical measurements	Definitions
Vertical tooth measurements	
Crown length (L)	The distance between the gingival margin and the incisal edge of the right and left maxillary central incisors on a line parallel to the long axis.
Horizontal tooth measurements	
Crown width (W)	The maximum distance between mesial and distal contact points.

For teeth measurements, the width and length of both maxillary central incisor teeth were recorded using the software's measurement tool. The perceived width was measured at the mesiodistal contact points of teeth, and the length of the maxillary central incisors was measured from the zenith of the tooth to the incisal edge (15). Each measurement was recorded 3 times, and the average of the recordings was calculated. If measurements differed by more than 0.2 mm, the procedure was repeated (16).

For each photograph, the W:L ratio was calculated by dividing the tooth width by the tooth length. Statistical analysis was performed using statistical software (IBM SPSS Statistics, v29.0; IBM Corp), with $\alpha = 0.05$ and a 95% confidence interval. A t-test was used to analyze the differences between the right and left maxillary central incisors, while an independent-sample t-test was applied to assess the gender differences in the

dimensions and W:L ratios of the maxillary central incisors.

3. Results

The current study analyzed the data collected from a sample of 120 participants, 60 males and 60 females. The mean age was calculated to be 23.53 ± 2.34 years. Intra-operator reliability was assessed using the intraclass correlation coefficient (ICC) on data from the first 30 subjects, showing a strong correlation of 0.98 - 0.99 (P<0.001) and an excellent reliability (17).

The average widths of the upper right and left maxillary central incisors were 8.65 ± 0.52mm and 8.66 ± 0.52mm, respectively. There were no significant mean differences between the maxillary central incisors' measurements between the right and left sides of the dental arch. The average lengths of the upper right and left maxillary central incisors were 10.01 ± 1.09 mm and 10.00 ± 1.06 mm, respectively with no significant differences observed between the right and left sides of the arch. For the W:L ratio, the mean value for both the right and left central incisors in the sample was 87%. No significant differences were observed between the right and left sides of the arch (Table 2).

Table 2. Maxillary central incisors' measurements (mm) in both sides of the dental arch

Dimension	Right				Left				P-value
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	
LI	5.4	12.5	10.01	1.09	6.0	12.4	10.0	1.06	0.95
WI	7	10	8.65	0.52	6.9	9.8	8.66	0.52	1.00
W:L	0.69	1.57	0.87	0.10	0.69	1.42	0.87	0.09	0.94

LI: length of the central incisor. WI: width of the central incisor.
W:L ratio: width-to-length ratio of the right central incisor.

For gender differences, males had larger anterior teeth dimensions than females, with a right maxillary central incisor width of 9.79 ± 0.98 mm in females, *versus* 10.22 ± 1.15mm in males and a left maxillary central incisor width of 9.78 ± 0.95 mm in females, *versus* 10.23 ± 1.11mm in males. The differences were statistically significant (p = 0.029 and 0.020). The average W:L ratio was 0.88 ± 0.10 for females and 0.87 ± 0.09 for males with no statistically significant gender differences (p = 0.24) (Table 3).

Table 3: Maxillary central incisors' dimensions (mm) in both genders

Dimension	Females		Males		P-value
	Mean	SD	Mean	SD	
LRI	9.79	.98	10.22	1.15	0.03
LLI	9.78	.95	10.23	1.11	0.02
WRI	8.56	.565	8.75	.44	0.04
WLI	8.57	.58	8.74	.45	0.04
W:L	0.88	0.10	0.87	0.09	0.24

LRI: length of the right central incisor. LLI: length of the left central incisor.
WRI: width of the right central incisor. WLI: width of the left central incisor.
W:L ratio: width-to-length ratio of the central incisor.

4. Discussion

For aesthetically pleasing restorative results, it is crucial to consider the dimensions of maxillary anterior teeth. A mathematical or geometrical relationship between teeth is believed to offer a template for achieving an aesthetically pleasing smile. Various tooth parameters have been evaluated across different populations to establish reliable correlations that can assist the restorative dentist in predicting satisfactory restorative results.

In the literature, two primary methods have been used to calculate the dimensions of the maxillary central incisors. Some studies have employed direct measurements of the teeth using a caliper (18), while

others have utilized an indirect approach, measuring tooth dimensions from 2D photographs of the mouth or dental casts to obtain the necessary data (19). In the literature, the methods for measuring the width of maxillary central incisors (MCIs) are generally classified into two main categories: perceived measurements and actual measurements. This classification is based on the perspective from which the dimensions are assessed and the tools or techniques used to capture these measurements.

The perceived measurement group involves evaluating the MCI dimensions from a frontal view, which represents how the teeth are seen in a natural smile or when viewed directly from the front. These measurements are often obtained using frontal photographs of the teeth or through the frontal projection of dental casts. This approach emphasizes the aesthetic presentation of the teeth and their visibility within the smile zone, making it particularly valuable in studies focusing on dental aesthetics and smile analysis.

On the other hand, the actual measurement group focuses on capturing the true physiological dimensions of the MCIs. These measurements are typically obtained using direct methods, such as employing a digital caliper to measure the physical teeth or their replicas on dental casts. This approach aims to provide the most precise and anatomically accurate dimensions of the teeth, without being influenced by perspective or angulation.

In the context of the current study, the teeth measurements were obtained using standardized digital photographs. The perceived parameters were calculated based on these images. This method was chosen because, as highlighted by findings from a systematic review, measuring perceived teeth dimensions using digital photographs has been shown to offer higher accuracy and reproducibility compared to other techniques. Digital photography allows for standardization of image capture, easier calibration, and the ability to repeatedly analyze the same image without introducing variability caused by repeated physical measurements (2).

The current study has established updated norms for the mesiodistal diameters of maxillary central incisors in a Jordanian sub-population. These newly derived mesiodistal diameter norms are presented 8 years after the previous norms for permanent dentition as previously reported by Shaweesh (2017). The current study found that the mean perceived width of the maxillary central incisors was 8.57 mm in females and 8.75 mm in males (4). In comparison, the previous study reported slightly lower mean values, with 8.4 mm for males and 8.1 mm for females. These differences may be attributed to variations in methodology among the studies. In the previous study, teeth dimensions were measured from study casts using a manual Vernier caliper to determine the actual mesiodistal width. In contrast, the current study utilized standardized photographs to measure the perceived widths of the maxillary central incisors. Additionally, the previous study's sample included orthodontically treated patients, whereas the current study specifically excluded individuals with a history of orthodontic treatment as such treatment has been reported to significantly alter the natural dimensions, positions, and angulations of teeth, particularly in the inter-canine region (20).

For the W:L ratio, the current study's findings of 87% are consistent with several published studies conducted on diverse populations. These studies indicate that the ideal W:L ratio of 80% was not observed in the examined groups. Reported ratios include Saudis (89%) (15), Kurds (90%), Arabs (89%) (13), Turks (6), and Malaysians from different ethnic backgrounds, such as Chinese (85.6%), Malay (86%), and Indians (87%) (21). This collective evidence suggests that the traditionally accepted standard of 80% may not universally apply across diverse populations, emphasizing the importance of considering ethnic and regional variations when planning aesthetic dental restorations to achieve optimal results.

Concerning gender tooth size differences, the findings of the current study revealed that males exhibited larger tooth dimensions compared to females. This observation is consistent with the existing literature, which indicates that most racial groups display sexual dimorphism in the size of anterior teeth, with men generally having wider and longer maxillary central incisors than women (5,18,22,23). The current study findings align with the literature's extensively documented variations in tooth size between the dentitions of both genders, including the Jordanian study by Shaweesh (4) and other relevant studies (24,25).

However, for the W:L ratio, no significant differences were observed between genders, which is consistent with previous findings in the literature (2,11,22,26). Therefore, rather than the tooth size, the W:L ratio was reported to be the most consistent

reference (27). A study by Radia et al. (2016) reported that men recorded larger face and tooth measurements than women, however, the W:L ratios were similar in both genders (26). The consistent W:L ratio in both genders, despite differences in the individual teeth width and length, suggests that the proportional W:L relationship is maintained regardless of overall tooth size differences.

This study used 2D digital photographs for measurements which have been extensively used in the literature; however, despite efforts to standardize and fix head positioning, slight discrepancies may still exist between actual and measured values due to factors such as the curvature of the dental arch and the angle at which the photographs were taken. Also, the exclusion of individuals with orthodontic treatments could potentially limit the scope and generalizability of the results. For future work, incorporating 3D imaging techniques may enhance the accuracy of measurements, as 3D techniques like CBCT and intraoral scanning capture actual teeth dimensions, providing more accurate and repeatable measurements by eliminating issues such as distortion, arch curvature, and magnification seen in 2D imaging. Additionally, expanding the study to include and compare a more diverse population, such as both orthodontic and non-orthodontic patients, would provide a more comprehensive understanding of how orthodontic treatment may influence the natural size and shape of the maxillary central incisors, leading to a more comprehensive understanding of maxillary central incisor characteristics across different groups.

5. Conclusions

Within the limitations of this study, the following conclusions can be drawn:

- The average width of the MCIs in the sample was 8.66 mm and the average length was 10 mm.
- No significant differences were found across the maxillary central incisors' measurements between the right and left sides of the dental arch.
- Significant gender differences were found across the maxillary central incisors' measurements.
- The average W:L ratio of the MCIs in males was 87% and 88% in females, with no significant differences between the right and left sides nor between genders.

Conflict of Interests

The authors have no conflict of interests to declare related to this study.

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