Maxillary and mandibular anterior crown width/height ratio and its relation to various arch perimeters, arch length, and arch width groups

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ABSTRACT

Objective: To investigate the maxillary and mandibular anterior crown width/height ratio and its relation to various arch perimeters, arch length, and arch width (intercanine, interpremolar, and intermolar) groups. **Materials and Methods:** The calculated sample size was 128 subjects. The crown width/height, arch length, arch perimeter, and arch width of the maxilla and mandible were obtained via digital calliper (Mitutoyo, Japan). A total of 4325 variables were measured. The sex differences in the crown width and height were evaluated. Analysis of variance was applied to evaluate the differences between arch length, arch perimeter, and arch width groups. **Results:** Males had significantly larger mean values for crown width and height than females ($P \leq 0.05$) for maxillary and mandibular arches, both. There were no significant differences observed for the crown width/height ratio in various arch length, arch perimeter, and arch width (intercanine, interpremolar, and intermolar) groups ($P \leq 0.05$) in maxilla and mandible, both. **Conclusions:** Our results indicate sexual disparities in the crown width and height. Crown width and height has no significant relation to various arch length, arch perimeter, and arch width groups of maxilla and mandible. Thus, it may be helpful for orthodontic and prosthodontic case investigations and comprehensive management.

Key words: Arch length, arch perimeter, arch width, crown height, crown width/height ratio, crown width

INTRODUCTION

Variations in tooth size, tooth morphology, and tooth size ratio have been connected with diverse ethnic foundations and occlusion statuses.[1-9] Sexual dimorphism in crown dimension has relation to humanoid sex genes and hormones and is influenced by their imbalance.[10] Hereditary and ecological factors have strong effects on human teeth.[11] Correspondingly, the teeth width/height ratio has population and ethnic variations in relation to shape.[12] These ethnic variations must be considered in treatment planning especially to address esthetic concerns.[13]

Harmonious anterior teeth with proper size and shape were one of the most influential factors contributing to a pleasant smile in orthodontic, operative, and prosthodontic management. Lombardi[14] was the first

treatment providers to accentuate the status of dental proportions with different facial types. They mentioned that there was a recurring ratio noted between all teeth in relation with face from the central incisor to the first premolar. Levin[15] and Qualtrough and Burke[16] indicated that the most harmonious teeth proportion is 1:1.618 between central incisor to lateral incisor. However, conflicting reports[17-19] indicated that the

majority of beautiful smiles did not have these dental proportions. Several anatomic measurements have been proposed to aid in determining the correct size and shape of the anterior teeth in relation to the various facial land marks and types on various populations.[20-24]

The authors have identified that no relative analysis of the maxillary and mandibular anterior tooth width/height ratios in relation to various arch perimeters, arch length, and arch width (intercanine, interpremolar, and intermolar) groups for the Pakistani population has been previously done.

The purpose of this study was:
- To evaluate the anatomic crown width/height ratios of maxillary and mandibular anterior tooth for sexual dimorphism
- To evaluate the width/height ratios of maxillary and mandibular anterior tooth in relation to various arch perimeter groups
- To evaluate the width/height ratios of maxillary and mandibular anterior tooth in relation to various arch length groups
- To evaluate the width/height ratios of maxillary and mandibular anterior tooth in relation to various arch width groups:
  - Intercanine width
  - Interpremolar width
  - Intermolar width.

MATERIALS AND METHODS

Subjects
The study was a comparative retrospective design. The oral and dental investigations were carried out with careful selection of subjects from the Pakistani population. Ethical approval was granted by the Ethics Committee of the Universiti Sains Malaysia (USM/JEPeM/140376) and informed consent was obtained from subjects. This investigation was designed and conducted according to the guidelines of Strengthening the Reporting of Observational studies in Epidemiology (STROBE), and we applied the STROBE specification in this manuscript.[25]

Sample size calculation
The sample size was calculated at a power of 80%, utilizing estimated standard deviations (SDs) of 0.60 mm,[26] a biologically meaningful mean difference of 0.3 mm, and equal sample sizes.[27] The calculated sample size was 128 subjects (64 males and 64 females with a mean age 19.4 ± 1.9 SD). The following inclusion and exclusion criteria were used.

Inclusion criteria
- All patients were of Pakistani origin determined via interviews, with mutual paternities and ancestors without any multiethnic nuptials
- Subjects were aged 18–24 years
- Maxillary and mandibular well-aligned arches, with normal patterns of growth and development
- None of the participants had undergone orthodontic treatment, with all sound erupted permanent teeth (except third molars)
- Ideal occlusion with Class I molar and canine relationship with incisors according to the British Standards Institute[28]
- No crowding, cross bite and spacing
- Straight profile (identified by examining the profile view)
- No craniofacial anomalies
- No gingival or periodontal conditions or therapy that would undermine a healthy tissue-to-tooth relationship.

Exclusion criteria
- Interproximal caries or restorations
- Missing or supernumerary teeth
- Abnormal size or morphology of teeth
- Tooth wear that affected the tooth size measurements
- Damage to casts.

Cross-examination of subjects was done to diminish sample bias and error; with an experienced orthodontist and dentist contributing throughout the screening sittings. Dental impressions of the upper and lower arches of each subject were obtained with alginate impression material (Zhermack Orthoprint Alginate ISO 1563-ADA 18 Italy) and poured with dental stone (Type III hard plaster quick stone China) according to the manufacturer's instructions. A total of 4325 variables were measured.

Measurement of crown width, crown height and arch dimensions
Dental models of each subject for maxillary and mandibular arches were carefully selected according to inclusion and exclusion criteria. Crown width, crown height, arch length, arch perimeter, and arch width of the maxilla and mandible were obtained via digital caliper (Mitutoyo, Japan)[29] as follows.

Crown width measurement
The mesiodistal crown diameter of the tooth was measured from anatomical contact of one tooth to another from frontal side perpendicular to the long axis of the teeth.[12]

Crown height measurement
Crown height [Figure 1] was recorded as the greatest distance on buccal/labial surface from the occlusal/incisal line to cervical line parallel to the occlusal plane.[12,30]

Arch dimensions measurements
Arch perimeter
Arch perimeter[29,31] was measured as a segmental sum of linear lines on the right and left side of the arches [Figure 2c].

Arch length
Arch length was obtained using triangular shaped lines between the mesiobuccal cusp tips of first permanent molars and the central point between the incisors of each respective arch [Figure 2b].

Arch width of maxillary and mandibular variables
• Maxillary and mandibular intercanine widths were obtained between the cusp tips
• Maxillary and mandibular interpremolar widths were obtained between the cusp tips of maxillary first premolars
• Maxillary and mandibular intermolar widths were obtained between the mesiobuccal cusp tips of the maxillary and mandibular first molars respectively [Figure 2a].

Arch length, arch perimeter, and arch width grouping
The subjects were further grouped as follows:
• Arch length groups (small, average, and large): The numbers of subjects for small, average, and large arch length groups in the maxilla and mandible were 46, 44, and 38, respectively
• Arch perimeter groups (small, average, and large): The number of subject for small, average, and large arch perimeter groups in the maxilla and mandible were 44, 45, and 39, respectively
• Arch widths group (small, average, and large): The number of subject for small, average, and large arch width groups in the maxilla and mandible were 44, 45, and 39, respectively (intercanine, interpremolar, and intermolar width).

These groupings were determined based on data values of the mean ± 2SD, >2SD, and <2SD grouped in the average group, large group, and small group, respectively.[31]

Error study
Twenty percentage of dental casts were randomly selected for intraobserver errors. The time interval between the first and second readings was approximately 2 weeks. The method error (ME) was analyzed by the Dalhberg's formula:

$$ME = (\Sigma \, [x_1 - x_2]^2 / 2 \, [2n])^{1/2}$$

Where x_1 is the first measurement, x_2 the second measurement and n the number of repeated measurements.[32]

Statistical analyses
The data were verified and analyzed statistically using IBM SPSS Statistics version 22.0 (Armonk, NY: IBM Corp., USA) with the confidence level set at 5% ($P < 0.05$) to test for significance. Independent *t*-tests were applied to compare mean values between males and females crown width, crown height, and crown width/height ratio in relation to all variables. Analysis of variance was applied to evaluate crown width/height ratio in relation to the arch length, arch perimeter, and arch widths groups. The *post-hoc*
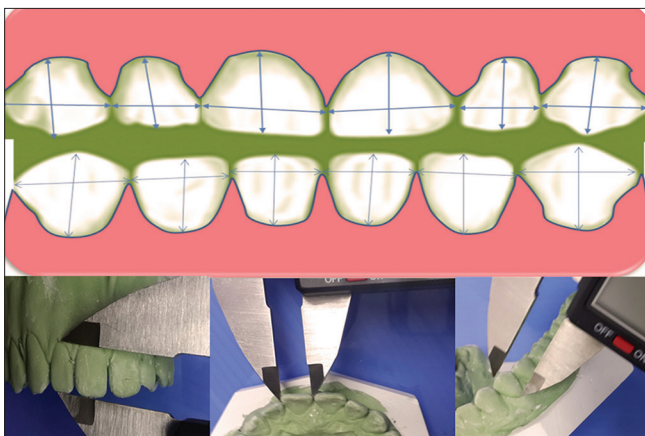
Figure 1: Crown width and height measurement via digital caliper
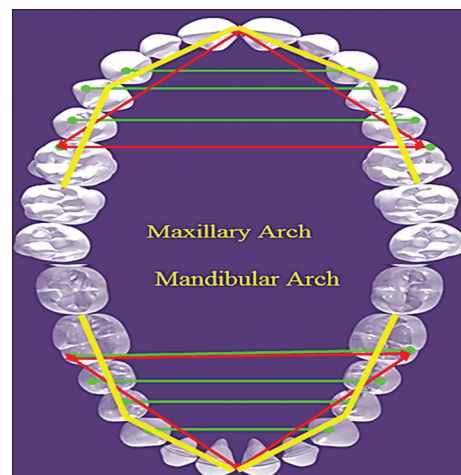
Figure 2: Arch dimension measurements (a) arch width (Green color) (b) arch length (yellow color) (c) arch perimeter (Red color)

Table 1: Maxillary and mandibular anterior (canine to canine) sexual disparities for crown width/height ratios						
Variables*	Sex	Mean	SD	95% CI		P
				Lower	Upper	
WHR11	Male	0.93	0.09	−0.04	0.02	0.544
	Female	0.94	0.09	−0.04	0.02	
WHR12	Male	0.89	0.11	−0.04	0.03	0.907
	Female	0.89	0.09	−0.04	0.03	
WHR13	Male	0.90	0.10	−0.09	−0.01	0.011
	Female	0.95	0.11	−0.09	−0.01	
WHR21	Male	0.93	0.09	−0.03	0.03	0.982
	Female	0.93	0.08	−0.03	0.03	
WHR22	Male	0.88	0.10	−0.03	0.03	0.977
	Female	0.88	0.09	−0.03	0.03	
WHR23	Male	0.90	0.10	−0.07	0.00	0.085
	Female	0.93	0.11	−0.07	0.00	
WHR31	Male	0.74	0.08	−0.06	0.00	0.041
	Female	0.77	0.09	−0.06	0.00	
WHR32	Male	0.87	0.55	−0.10	0.18	0.551
	Female	0.83	0.10	−0.10	0.18	
WHR33	Male	0.81	0.10	−0.04	0.03	0.685
	Female	0.81	0.10	−0.04	0.03	
WHR41	Male	0.74	0.08	−0.05	0.01	0.115
	Female	0.77	0.09	−0.05	0.01	
WHR42	Male	0.86	0.50	−0.09	0.17	0.522
	Female	0.82	0.08	−0.09	0.17	
WHR43	Male	0.80	0.10	−0.04	0.02	0.580
		0.81	0.09	−0.04	0.02	

*FDI notation, (P≤0.001), (P≤0.01) and (P≤0.05). WHR: Width/height ratio, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

tests of Bonferroni correction were performed for differences among the groups.

RESULTS

Method error

Dahlberg's formula was used to determine the ME, which did not exceed 0.006 and 0.05 mm for the linear variables of teeth crown width and crown height, respectively. The combined errors for all of the variables were small and considered to be within acceptable limits.[32]

Sexual disparities in crown width/height ratios

Table 1 shows no significant difference for the crown width/height ratios, except the maxillary right canine (WHR13) and mandibular left central incisor(WHR31).

Disparities in relation to arch length, arch perimeter, and arch widths groups of the maxilla

Tables 2-6 show the maxillary arch perimeter, arch length, and arch width (intercanine, interpremolar, and intermolar) groups in relation to crown width/height ratios respectively. There were no significant differences observed in relation to all groups ($P \leq 0.05$). Except few variables for the intercanine and inter first molar arch width for the

Table 2: Mean crown WHR of maxillary six anterior teeth in relation to various UAPG								
Variables	UAPG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR11	1.00	0.93	0.08	0.91	0.96	0.61	1.00	0.55
	2.00	0.92	0.09	0.90	0.95			
	3.00	0.95	0.09	0.92	0.98			
WHR12	1.00	0.89	0.08	0.86	0.91	0.24	1.00	1.00
	2.00	0.88	0.11	0.84	0.91			
	3.00	0.90	0.11	0.86	0.93			
WHR13	1.00	0.93	0.10	0.90	0.96	1.00	1.00	1.00
	2.00	0.93	0.11	0.90	0.96			
	3.00	0.92	0.13	0.88	0.97			
WHR21	1.00	0.93	0.08	0.91	0.96	0.39	1.00	0.85
	2.00	0.92	0.09	0.90	0.95			
	3.00	0.94	0.09	0.91	0.97			
WHR22	1.00	0.87	0.08	0.85	0.90	0.07	1.00	0.34
	2.00	0.87	0.10	0.84	0.90			
	3.00	0.89	0.11	0.86	0.93			
WHR23	1.00	0.91	0.10	0.88	0.94	1.00	1.00	1.00
	2.00	0.93	0.09	0.90	0.96			
	3.00	0.91	0.11	0.87	0.95			

*FDI, notation, P≤0.001, P≤0.01 and P≤0.05. UAPG: Upper arch perimeter groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

Table 3: Mean crown WHR of maxillary six anterior teeth in relation to various UALG								
Variables	UALG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR11	1.00	0.93	0.08	0.91	0.96	1.000	1.000	0.684
	2.00	0.92	0.09	0.90	0.95			
	3.00	0.95	0.09	0.92	0.98			
WHR12	1.00	0.89	0.08	0.86	0.91	1.000	1.000	1.000
	2.00	0.88	0.11	0.84	0.91			
	3.00	0.90	0.11	0.86	0.93			
WHR13	1.00	0.93	0.10	0.90	0.96	1.000	1.000	1.000
	2.00	0.93	0.11	0.90	0.96			
	3.00	0.92	0.13	0.88	0.97			
WHR21	1.00	0.93	0.08	0.91	0.96	1.000	1.000	1.000
	2.00	0.92	0.09	0.90	0.95			
	3.00	0.94	0.09	0.91	0.97			
WHR22	1.00	0.87	0.08	0.85	0.90	1.000	0.914	0.839
	2.00	0.87	0.10	0.84	0.90			
	3.00	0.89	0.11	0.86	0.93			
WHR23	1.00	0.91	0.10	0.88	0.94	1.000	1.000	1.000
	2.00	0.93	0.09	0.90	0.96			
	3.00	0.91	0.11	0.87	0.95			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. UALG: Upper arch length groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

Table 4: Mean crown WHR of maxillary six anterior teeth in relation to various UAICWG								
Variables	UAICWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR11	1.00	0.93	0.07	0.91	0.95	0.212	0.070	0.000
	2.00	0.90	0.09	0.87	0.93			
	3.00	0.97	0.09	0.94	1.00			
WHR12	1.00	0.87	0.09	0.84	0.90	1.000	0.014	0.002
	2.00	0.86	0.08	0.83	0.88			
	3.00	0.93	0.11	0.90	0.97			
WHR13	1.00	0.92	0.09	0.89	0.95	1.000	0.278	0.068
	2.00	0.90	0.11	0.87	0.94			
	3.00	0.96	0.12	0.92	1.00			
WHR21	1.00	0.93	0.07	0.91	0.95	0.158	0.039	0.000
	2.00	0.90	0.08	0.87	0.92			
	3.00	0.97	0.09	0.94	1.00			
WHR22	1.00	0.87	0.09	0.85	0.90	0.574	0.068	0.002
	2.00	0.85	0.08	0.82	0.87			
	3.00	0.92	0.11	0.88	0.95			
WHR23	1.00	0.91	0.09	0.89	0.94	1.000	0.493	0.082
	2.00	0.89	0.10	0.86	0.92			
	3.00	0.94	0.12	0.91	0.98			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. UAICWG: Upper arch intercanine width groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

small versus large and average versus large group were observed ($P \leq 0.001$), ($P \leq 0.01$), and ($P \leq 0.05$).

Disparities in relation to arch length, arch perimeter, and arch widths groups of the mandible
Tables 7-11 show the mandibular arch perimeter, arch length, and arch width (intercanine, interpremolar, and intermolar) groups in relation to crown

width/height ratios, respectively. There were no significant differences observed in all groups ($P \leq 0.05$).

Correlation for width/height ratio and its relation to various arch dimensions
Table 12 shows the correlation coefficients determined between the measured maxillary and mandibular crown width/height ratios values and the

Table 5: Mean crown WHR of maxillary six anterior teeth in relation to various UAIPMWG

Variables	UAIPMWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR11	1.00	0.93	0.08	0.90	0.95	1.000	0.362	0.124
	2.00	0.92	0.09	0.89	0.95			
	3.00	0.96	0.09	0.93	0.98			
WHR12	1.00	0.88	0.09	0.85	0.91	1.000	0.563	0.252
	2.00	0.87	0.11	0.84	0.90			
	3.00	0.91	0.10	0.88	0.94			
WHR13	1.00	0.92	0.11	0.88	0.95	1.000	1.000	1.000
	2.00	0.92	0.10	0.89	0.95			
	3.00	0.94	0.11	0.91	0.97			
WHR21	1.00	0.92	0.08	0.90	0.95	1.000	0.101	0.028
	2.00	0.91	0.08	0.88	0.94			
	3.00	0.96	0.09	0.93	0.99			
WHR22	1.00	0.87	0.08	0.85	0.90	1.000	0.440	0.257
	2.00	0.86	0.10	0.83	0.90			
	3.00	0.90	0.10	0.87	0.93			
WHR23	1.00	0.90	0.10	0.88	0.93	1.000	0.684	1.000
	2.00	0.91	0.10	0.88	0.95			
	3.00	0.93	0.11	0.90	0.97			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. UAIPMWG: Upper arch inter premolar width groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

Table 6: Mean crown WHR of maxillary six anterior teeth in relation to various UAIMWG

Variables	UAIMWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR11	1.00	0.94	0.09	0.92	0.97	0.076	1.000	0.005
	2.00	0.90	0.08	0.88	0.93			
	3.00	0.96	0.08	0.93	0.99			
WHR12	1.00	0.89	0.09	0.86	0.92	0.548	0.676	0.036
	2.00	0.86	0.09	0.83	0.89			
	3.00	0.91	0.11	0.88	0.95			
WHR13	1.00	0.92	0.10	0.88	0.95	1.000	0.852	1.000
	2.00	0.92	0.10	0.89	0.95			
	3.00	0.94	0.12	0.91	0.98			
WHR21	1.00	0.94	0.08	0.91	0.97	0.122	1.000	0.013
	2.00	0.90	0.08	0.88	0.93			
	3.00	0.95	0.08	0.93	0.98			
WHR22	1.00	0.88	0.09	0.85	0.90	0.752	0.313	0.019
	2.00	0.85	0.09	0.83	0.88			
	3.00	0.91	0.11	0.88	0.94			
WHR23	1.00	0.90	0.09	0.87	0.93	1.000	0.676	1.000
	2.00	0.92	0.10	0.89	0.95			
	3.00	0.93	0.12	0.89	0.97			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. UAIMWG: Upper arch inter molar width groups; WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

corresponding arch dimension groups values. There were low correlations observed for the maxillary and mandibular arches with *R* values ranging from 0.17 to 0.42 and 0.26 to 0.29, respectively.

DISCUSSION

Current research investigates the crown width/ height ratio in relation to arch perimeter, arch length, and arch width groups (intercanine, interpremolar, and intermolar) for the first time. However, Alam and Iida investigated only mesiodistal tooth size and tooth size ratio in relation to these groups via cone beam computed tomography acquisitions.[31] In orthodontic diagnosis and treatment planning, the evaluation of the tooth size and tooth size discrepancy is an

Table 7: Mean crown WHR of mandibular six anterior teeth in relation to various LAPG

Variables	LAPG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR31	1.00	0.74	0.08	0.72	0.77	0.823	0.481	1.000
	2.00	0.76	0.10	0.73	0.79			
	3.00	0.77	0.07	0.75	0.79			
WHR32	1.00	0.80	0.09	0.77	0.83	0.596	1.000	1.000
	2.00	0.91	0.67	0.71	1.12			
	3.00	0.84	0.08	0.81	0.86			
WHR33	1.00	0.82	0.07	0.79	0.84	0.535	1.000	0.239
	2.00	0.79	0.10	0.76	0.82			
	3.00	0.83	0.12	0.79	0.86			
WHR41	1.00	0.74	0.08	0.71	0.76	1.000	0.107	0.714
	2.00	0.75	0.10	0.73	0.78			
	3.00	0.78	0.07	0.75	0.80			
WHR42	1.00	0.80	0.08	0.78	0.83	0.753	1.000	1.000
	2.00	0.89	0.61	0.71	1.08			
	3.00	0.84	0.07	0.81	0.86			
WHR43	1.00	0.80	0.07	0.78	0.82	1.000	0.753	0.116
	2.00	0.78	0.09	0.75	0.81			
	3.00	0.82	0.12	0.79	0.86			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. LAPG: Lower arch perimeter groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

Table 8: Mean crown WHR of mandibular six anterior teeth in relation to various LALG

Variables	LALG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR31	1.00	0.75	0.09	0.72	0.78	1.000	1.000	1.000
	2.00	0.76	0.09	0.73	0.78			
	3.00	0.77	0.08	0.74	0.79			
WHR32	1.00	0.91	0.67	0.70	1.12	0.638	1.000	1.000
	2.00	0.80	0.08	0.78	0.83			
	3.00	0.84	0.10	0.81	0.87			
WHR33	1.00	0.79	0.10	0.76	0.82	1.000	0.219	0.479
	2.00	0.80	0.09	0.77	0.83			
	3.00	0.83	0.11	0.80	0.87			
WHR41	1.00	0.75	0.08	0.72	0.77	1.000	0.643	0.777
	2.00	0.75	0.09	0.72	0.78			
	3.00	0.77	0.08	0.75	0.79			
WHR42	1.00	0.90	0.61	0.71	1.09	0.545	1.000	1.000
	2.00	0.80	0.07	0.78	0.82			
	3.00	0.83	0.08	0.80	0.86			
WHR43	1.00	0.80	0.10	0.77	0.83	1.000	0.981	0.311
	2.00	0.79	0.08	0.76	0.81			
	3.00	0.82	0.11	0.78	0.85			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. LALG: Lower arch length groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale, UALG: Upper arch length groups

essential rung and such investigation was generally determined by conventional plaster study model analysis.[33]

The clinical responsibility of the orthodontist is to visualize the macro-, mini-, and micro-esthetics and to design a pleasant smile.[34-36] Current research investigates the crown width/height ratio for the very first time. These investigated norms can be used as a reference in relation to orthodontic and prosthodontic treatment of patients. There was significant difference observed in the worn and nonworn crown width/height ratio.[12] Therefore, in treatment plan, crown width/height ratio must be kept in consideration for the ideal overjet, overbite, and proper interdigitation to be achieved.

Table 9: Mean crown WHR of mandibular six anterior teeth in relation to LAICWG								
Variables	LAICWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR31	1.00	0.76	0.09	0.74	0.79	1.000	1.000	1.000
	2.00	0.75	0.09	0.72	0.78			
	3.00	0.76	0.08	0.74	0.78			
WHR32	1.00	0.82	0.10	0.79	0.85	1.000	0.594	0.463
	2.00	0.81	0.09	0.78	0.84			
	3.00	0.93	0.67	0.72	1.14			
WHR33	1.00	0.80	0.10	0.77	0.83	1.000	0.570	0.495
	2.00	0.80	0.07	0.78	0.82			
	3.00	0.83	0.11	0.79	0.86			
WHR41	1.00	0.76	0.08	0.73	0.78	1.000	1.000	1.000
	2.00	0.75	0.09	0.72	0.78			
	3.00	0.76	0.08	0.73	0.78			
WHR42	1.00	0.81	0.09	0.78	0.83	1.000	0.437	0.467
	2.00	0.81	0.09	0.78	0.83			
	3.00	0.92	0.61	0.73	1.11			
WHR43	1.00	0.79	0.09	0.76	0.82	1.000	0.570	0.423
	2.00	0.79	0.07	0.77	0.81			
	3.00	0.82	0.12	0.78	0.86			

*FDI, notation, $P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$. LAICWG: Lower arch intercanine width groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale, UAICWG: Upper arch intercanine width groups

Table 10: Mean crown WHR of mandibular six anterior teeth in relation to various LAIPMWG								
Variables	LAIPMWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR31	1.00	0.74	0.07	0.72	0.76	0.136	1.000	0.874
	2.00	0.78	0.10	0.75	0.81			
	3.00	0.76	0.08	0.73	0.78			
WHR32	1.00	0.81	0.09	0.78	0.83	1.000	0.541	0.858
	2.00	0.83	0.10	0.80	0.86			
	3.00	0.92	0.67	0.71	1.13			
WHR33	1.00	0.79	0.08	0.76	0.82	1.000	0.211	0.898
	2.00	0.81	0.09	0.78	0.84			
	3.00	0.83	0.12	0.79	0.87			
WHR41	1.00	0.74	0.07	0.72	0.76	0.250	1.000	1.000
	2.00	0.77	0.10	0.74	0.80			
	3.00	0.75	0.08	0.73	0.78			
WHR42	1.00	0.80	0.08	0.77	0.82	1.000	0.417	0.720
	2.00	0.82	0.09	0.79	0.85			
	3.00	0.91	0.61	0.72	1.10			
WHR43	1.00	0.78	0.08	0.75	0.80	0.814	0.061	0.488
	2.00	0.80	0.09	0.77	0.83			
	3.00	0.83	0.12	0.79	0.86			

*FDI, notation, ($P \leq 0.001$), ($P \leq 0.01$) and ($P \leq 0.05$). LAIPMWG: Lower arch inter premolar width groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

Through our study, we found out that there is significant sexual difference in the Pakistani population in the mean crown width/height ratios of maxillary and mandibular anterior six teeth ($P \leq 0.05$). However, there were no significant differences observed in relation to the arch length, arch perimeter, and arch width groups ($P \geq 0.05$). As study on Bangladeshi population reported no significant difference in the mean crown width/height ratios of maxillary anterior teeth between the various facial groups ($P > 0.05$).[24]

Our research investigated the maxillary and mandibular anterior teeth width/height ratio with ideal overjet, overbite, and proper interdigitation in relation to arch perimeter, arch length, and arch width groups (intercanine, interpremolar, and intermolar).

Table 11: Mean crown WHR of mandibular six anterior teeth in relation to various LAIMWG

Variables	LAIMWG	Mean	SD	95% CI		P		
				Lower	Upper	1 versus 2	1 versus 3	2 versus 3
WHR31	1.00	0.75	0.10	0.72	0.78	1.000	1.000	1.000
	2.00	0.76	0.07	0.74	0.78			
	3.00	0.77	0.08	0.74	0.79			
WHR32	1.00	0.81	0.11	0.78	0.84	1.000	0.401	0.505
	2.00	0.82	0.08	0.79	0.84			
	3.00	0.94	0.69	0.72	1.16			
WHR33	1.00	0.79	0.10	0.77	0.82	1.000	0.087	0.176
	2.00	0.80	0.09	0.77	0.83			
	3.00	0.84	0.11	0.80	0.88			
WHR41	1.00	0.75	0.09	0.72	0.77	1.000	0.761	1.000
	2.00	0.75	0.08	0.73	0.78			
	3.00	0.77	0.08	0.74	0.79			
WHR42	1.00	0.80	0.09	0.77	0.83	1.000	0.312	0.466
	2.00	0.81	0.08	0.79	0.84			
	3.00	0.93	0.63	0.72	1.13			
WHR43	1.00	0.79	0.10	0.76	0.82	1.000	0.108	0.115
	2.00	0.79	0.07	0.76	0.81			
	3.00	0.83	0.11	0.79	0.87			

*FDI, notation, ($P \leq 0.001$), ($P \leq 0.01$) and ($P \leq 0.05$). LAIMWG: Lower arch inter molar width groups, WHR: Width/height ratio, 1: Small, 2: Average, 3: Large, CI: Confidence interval, SD: Standard deviation, FDI: Federation Dentaire Internationale

The research results showed no significant difference in relation to these groups of ideal occlusion [Tables 3-11]. Other studies investigated the ideal occlusion in relation to maxillary and mandibular tooth size ratios and found significant differences in relation to these groups.[31] But current research found no significant difference for crown width/height ratio to various arch groups and low correlations [Table 12].

For the Pakistani population the tooth were investigated in mesiodistal, buccolingual, and diagonal dimension.[37]

The upshot of this study would be advantageous for both manufacturer and clinician. The current data can be used as reference, in order to create a natural pleasant esthetic smile and look. Especially during planning orthodontic, implant therapies, periodontal surgeries, and dental prosthesis procedures involving maxillary and mandibular esthetic zone. Currently, there are many manufacturers' products of artificial teeth in various dimensions. Not all products are suitable for every person as there are variations in natural tooth size and shape from one person to another. By using the crown width/height ratio values obtained in this study, the proposed width/height, and there ratio can be calculated for each ethnic group and thus may accurately determine the ideal tooth shape and size in the esthetic zone. Therefore, such investigations are needed to be carried out in other population. Furthermore the norms will be of great

Table 12: Correlation coefficients (R) and coefficients of determination (R^2) between maxillary crown WHR and its relation to various arch dimensions

Variables	R and R^2	Max 3-3 CWHR	Mand 3-3 CWHR
APgp	R	0.20	0.27
	R^2	0.04	0.07
ALgp	R	0.17	0.27
	R^2	0.03	0.07
ICWgp	R	0.42	0.24
	R^2	0.18	0.06
IPMWgp	R	0.24	0.29
	R^2	0.06	0.08
IMWgp	R	0.17	0.26
	R^2	0.03	0.07

APgp: Arch perimeter groups, ALgp: Arch length groups, ICWgp: Intercanine width groups, IPMWgp: Inter premolar width groups, IMWgp: Inter molar width groups, Max 3-3 CWHR: Maxillary canine to canine crown WHR, Mand 3-3 CWHR: Mandibular canine to canine crown WHR correlation coefficients, R^2: Coefficients of determination, WHR: Width/height ratio

value in forensic dentistry, and dental anthropology. Human teeth and arch size have lots of variations in size in relation to culture, race, and sex.[11,37,38]

CONCLUSION

- Significant sexual dimorphisms were observed in the crown width/height ratios of maxillary and mandibular anterior teeth in few variables
- There were significant differences observed for crown width/height ratios of maxillary arch Intercanine and Inter first molar arch width groups (small vs. large and average vs. large)

- There were no significant differences observed for crown width/height ratios of maxillary and mandibular anterior tooth in relation to:
  - Maxillary and mandibular arch perimeter groups
  - Maxillary and mandibular arch length groups
  - Mandibular arch width inter first premolar width groups
    - Mandibular arch width groups in:
    - Intercanine width groups
    - Inter first premolar width groups
    - Inter first molar width groups

Conflicts of interest

There are no conflicts of interest.

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