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RESEARCH ARTICLE

Variations of the Mesiodistal width of permanent teeth in a sample of patients attending Ajman University Dental College

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ABSTRACT:

The current study aims to measure the variations of the mesiodistal width of permanent teeth in a sample of patients attending Ajman University Dental Hospital. **Materials and Method**: A Descriptive cross-sectional study of 85 pretreatment study casts of patients (M:33, F:52) aged between 11-38 attending the Orthodontic unit at Ajman University Dental Hospital. The samples were selected randomly for measurements, which were performed using an electronic digital calibre. The width of an individual tooth is measured accurately from the mesial contact point to the distal contact point. The measurement was performed for all the 12 maxillary and mandibular teeth (from 16 to 26 and 36 to 46). The data put up in an excel sheet and sent to the statistician for analysis. **Results:** Class I and II showed a higher overall ratio and anterior ratio in males with no difference between the gender neither in the anterior or the overall ratio. At the same time, Class III malocclusion had a significant difference in both overall and anterior ratios. The maxillary 1st premolars and 2nd premolars teeth have insignificant mesiodistal differences between genders, while the maxillary canine and the 2nd premolar have a significant difference between right and left quadrants. The mandibular teeth showed no significant difference in mesiodistal width between right and left quadrants. **Conclusion:** The insignificant difference between the sample and Bolton in the anterior and posterior ratios in Class I & II cases explain the similarity of the racial feature. There is a significant difference in Class III between our sample and the Bolton original work.

KEYWORDS: Mesiodistal width of teeth, dental cast analysis, upper arch, lower arch, malocclusion.

INTRODUCTION:

Tooth size discrepancy (TSD) is a vital feature to diagnose to determine the final canines and molar relationship, the centerline, and esthetics in orthodontic treatment.[1,2,3,4] The mesiodistal width of teeth will affect the arch dimensions (length, width, and form).

The TSD is defined as the lack of symmetry of the mesiodistal width of individual tooth or groups of teeth when related to those within the same opposing arch.[1] It can also be defined as a relative excess of tooth structure in one arch to the other arch.[2]

The right and left-side variances that occur in different degrees in the population may cause interference with the standard dental function and esthetic appearance or, on the other hand, maybe so insignificant that it cannot be detected by mere observation.[5,6,7] Therefore, it seems that soft tissues try to compensate for underlying asymmetry.[8]

One of the objectives in comprehensive orthodontic treatment is to obtain an optimal final occlusion and optimal overbite and over-jet.[9] Many elements will impact the attainability of this goal, one of which is the relationship of the total mesiodistal width of the maxillary teeth to that of the mandibular teeth and the difference between mesiodistal widths in the teeth in the same arch between the teeth in the right side in

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comparison to that in the left side on the same arch either mandible or maxilla.[10,11,12]

Since patients with inter-arch tooth size discrepancies need either removal (e.g. proximal stripping) or addition (e.g. composite build-ups/porcelain veneers) of tooth structure to open or close spaces in the opposite arch, it is significant to determine the amount and location of a tooth size discrepancy before commencing any orthodontic treatment. The mesiodistal widths of teeth were first officially investigated by G.V. Black in 1902. He measured a significant number of human teeth and set up tables of mean dimensions, which are still used as references today.[13]

Orthodontists have used several methods to detect inter-arch tooth size discrepancies in patients presenting for orthodontic treatment.[14]

Ballard in 1944 calculated asymmetry in tooth size; he measures the teeth in five hundred sets of casts and compares the mesiodistal width of each tooth with the corresponding tooth in the opposite side of the dental arch.[15]

Bolton, in 1958, analyzed the relationship between the mesiodistal tooth width of maxillary and mandibular teeth by measuring the 12 teeth (from the 1st molar on one side to the 1st molar on the other side). The overall ratio calculated by dividing the summation of the mesiodistal (MD) width of the entire mandibular permanent teeth except for the second and third molars by the summation of the MD width of the corresponding twelve maxillary teeth. While the anterior ratio measured by dividing the total of the mandibular six anterior teeth by the corresponding maxillary teeth.[16,17,18]

Dental arch dimensions, including arch width, form and length, are essential values for the diagnosis, treatment, planning, and treatment outcomes concerning patients who are seeking orthodontic treatment in all age groups.[19]

In a Sudanese study, the arch length dimension exhibited the highest value with square arch form. The width dimensions increase with quite a change in the inter-canine region but appreciably more in the distal part of the arch. Men have a more massive arch form than females, and the ovoid arch form dominates in the Sudanese population.[20]
This study aims to measure how much variation of teeth we have between the right and left side and which teeth have the highest variations among others in both the upper and lower arch.

MATERIALS AND METHODS:

A cross-sectional study was conducted at the College of Dentistry, Ajman University, Ajman, UAE. The study was announced after obtaining approval from the Research and Ethical committee of the University. All participants consented to the study's objectives, and informed consent was obtained from each patient before enrollment in the study.

Power analysis (sample size calculation):
Sample size calculation was done using the G*Power 3.17 (Franz Faul, University Kiel, Germany 2013) software based on the previous result of the paper entitled: Tooth Size Discrepancy among Different Malocclusion Groups in a Sudanese Sample. By Mahmoud, Nosaiba et al., 2017

Sample size estimated formula:

$$n = \frac{(Z_{\beta} + Z_{\alpha/2})^2 \, 2\,\sigma^2}{E^2}$$

where $Z_{\alpha/2}$ and Z_{β} are critical values, σ is the standard deviation of the outcome variable, n is the required sample size. E is the margin of error, α, which is the probability of having type I error, was set at a 5% level of Significance, and β is the probability of having type II error ($1-\beta = 80\%$). A total sample size of Eighty-five casts was calculated and power of 80%, with α of 0.05.

Selection Criteria:
Pretreatment study casts of 85 orthodontic patients reporting to the Orthodontic Unit, Faculty of Dentistry, Ajman University, were used in this study; 33 study casts were of males, and 52 were of females, and the sample included a random selection of malocclusion divisions. All patients were aged between 11 and 38 years.

The following inclusion criteria were used in the collection of the study casts: high-quality study models; all the permanent teeth were present and fully erupted, from right first permanent molar to the left first permanent molar; no extraction or interproximal stripping was performed; no developmental anomalies (e.g. hypodontia) or abnormality in the tooth size (e.g. microdontia/macrodontia).

The exclusion criteria include: Damaged or broken study cast models; gross restorations, build-ups, crowns, onlays, class II and mesio-ocluso-distal restorations that affect the mesiodistal diameter of the tooth; congenitally missing, extracted, impacted and grossly carious teeth.

Study measurement:
The samples were selected randomly for measurement. The measurements were performed using an electronic digital calibre (Figure 1). The width of each tooth is measured from the mesial contact point to the distal contact point. The measurement was performed for all the 12 maxillary and mandibular teeth (from the first permanent molar on the right to the first permanent molar on the left on each arch)—the data stored in an excel sheet and sent to the statistician for analysis.

Bolton's ratios were selected and used as guidance in this research (77.2±1.65% for the anterior and 91.3±1.91% for the overall ratio, respectively).

The anterior and overall tooth size ratios were computed for each subject as described by Bolton:

$$\text{Anterior Ratio \%} = \frac{Sum\ of\ Mandibular\ 6}{Sum\ of\ Maxillay\ 6} \times 100$$

$$\text{Overall Ratio \%} = \frac{Sum\ of\ Mandibular\ 12}{Sum\ of\ Maxillary\ 12} \times 100$$

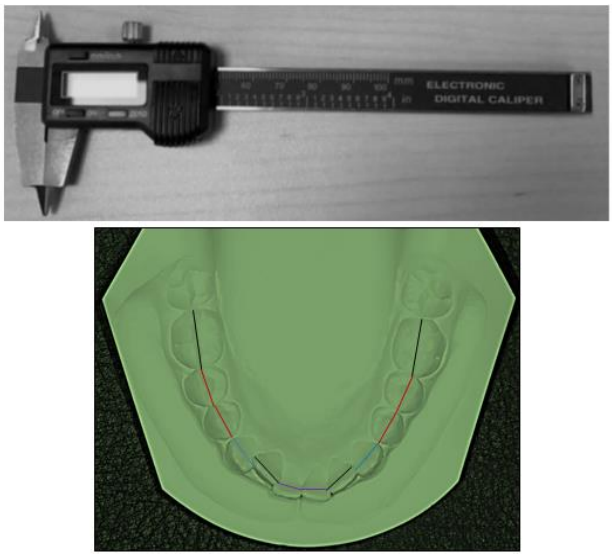

Figure 1. Teeth measurement using electronic digital calibre

Statistical Analysis:
The raw data collected from measuring the mesiodistal (MD) width of permanent teeth within each cast was recorded and analyzed using Statistical Package for the Social Sciences (SPSS) for windows 10, version 26.0 (IBM Corp., Chicago, USA).

Collected measurements were organized and tabulated as descriptive results, which include the Frequencies of different independent variables in terms of prevalence (Gender and Types of malocclusion), as well as measuring the central tendency by the mean and dispersion by the Standard Deviation for each tooth (MD width in mm) in different Quadrants, within each group and separately for males and females. After that, the Assumption of normality was checked to confirm the validity of the parametric test using the Shapiro-Wilk test with a significant level of 0.05; most of the data were normally distributed with P>0.05 for each tooth as well as the Bolton Ratio including the anterior and overall ratio, except few teeth Showed deviation from the normally distributed values (p<0.05) and they are (According to FDI numbering system): Maxillary Right Lateral Incisor (#12), Maxillary Left 1st molar (#26), Maxillary Left 2nd Premolar (#25), Mandibular Left 2nd premolar (#35), Mandibular Right 1st Molar (#46) and Mandibular Right Central Incisor (#41).

Student's t-test was selected to compare each tooth with the counterpart one (e.g. Maxillary Left 1st Molar with Maxillary Right 1st Molar), except for the teeth that revealed non-normally distributed sample in which Wilcoxon Signed-Ranks test was performed.

Furthermore, the One-Way ANOVA test was performed to determine the level of difference between the groups, namely, gender and malrelationship groups with the dependent variables (each tooth and anterior and overall tooth size discrepancy. While Post-hoc comparison test (LSD was used for multiple comparisons between the groups when the ANOVA test was significant. On the other hand, the level of difference between the groups, namely, Gender and malocclusion groups, with the dependent variables that were not normally distributed, were determined using Wilcoxon-Mann-Whitney and Kruskal-Wallis tests.

Additionally, a two-way multivariate analysis of variance (two-way ANOVA) was also used to determine the significance level between gender and the tooth size discrepancy (anterior ratio and overall ratio) along with each type of malocclusion followed by multiple comparisons to specify the difference.

To ascertain the relationship between the anterior Bolton ratio and the overall ratio, Pearson's correlation coefficients and a linear relationship by multiple regression analysis - beta coefficient (β) - was chosen. It validates if an independent variable is linearly related to the other ones.

Lastly, an Independent t-test was used to compare the current result with the Bolton Study result in July 1958. The statistically significant level (p-Value) was set at below 0.05 with a 95% confidence interval.

RESULTS:

In this current study, Eighty-five casts were used from patients attending Ajman University Dental Clinic, in

which 33 were males and 52 were females, with an average age of 17.92±5.70 years old (min=11, max=38, Range = 27 years old). The distribution of the malocclusion seen in (Table 1).

Table 1: Distribution of the sample gender and malocclusion.

		Type of Malocclusion			Total
		Class I	Class II	Class III	
Gender	Male	14	14	5	33 (38.8%)
	Female	21	23	8	52 (61.2%)
Total		35 (41.2%)	37 (43.5%)	13 (15.3%)	85 (100%)

The Significance in the Shapiro-Wilk test was $p>0.05$ in most of the data indicating normally distributed values for each tooth, as well as the Bolton tooth size discrepancy, including the anterior and overall ratio. Fewer teeth revealed deviation from the normally distributed data ($p<0.05$), and they include teeth number 12, 26, 25, 35, 46, and 41 according to the FDI numbering system.

Evaluation of dental symmetry in the upper and lower arches showed in detail in (Table 2). Most of the measured teeth revealed a slight mean difference with no statistically significant values ($p>0.05$) when student's t-test and Wilcoxon signed ranks test was performed except for the mandibular right 1st molar, which demonstrates a significant mean difference comparing to the mandibular left 1st molar ($P<0.007$) with a mean and SD of 10.60±0.58 and 10.70±0.57 of the right and left sides respectively (Table 2).

Table 2: Comparative Evaluation of the right and left maxillary and mandibular teeth.

Measured Tooth		Mean ± SD		*T*-value	*P*-value	Overall MD width
		Right Side	Left Side			
Maxillary Arch	First Molar	10.16±0.51	10.19±0.67	-0.579	0.095	10.18±0.59
	Second Premolar	6.44±0.47	6.41±0.45	0.667	0.670	6.43±0.46
	First Premolar	6.66±0.44	6.63±0.52	0.792	0.431	6.65±0.48
	Canine	7.35±0.62	7.30±0.54	1.672	0.098	7.32±0.58
	Lateral Incisor	6.39±0.55	6.31±0.50	2.161	0.057	6.35±0.53
	Central Incisor	8.28±0.53	8.25±0.49	1.265	0.209	8.26±0.51
Mandibular Arch	First Molar	10.60±0.58	10.70±0.57	2.230	0.007	10.65±0.57
	Second Premolar	6.87±0.46	6.84±0.44	-0.814	0.343	6.86±0.45
	First Premolar	6.63±0.50	6.62±0.49	-0.360	0.720	6.63±0.49
	Canine	6.45±0.57	6.49±0.58	1.021	0.310	6.47±0.57
	Lateral Incisor	5.63±0.38	5.66±0.44	0.949	0.345	5.65±0.41
	Central Incisor	5.17±0.38	5.09±0.36	-2.200	0.068	5.13±0.37

Comparison of the mean MD width of each tooth to gender revealed that there was a tendency for most of the measured teeth to exhibit a significant difference between males and females ($p<0.05$) in which males exhibit wider MD width in all teeth than females in the selected sample (Table 3). In contrast, Maxillary left first and second premolars showed no significant difference between males and females ($p<0.110$), ($p<0.071$) respectively, although the mean MD width of the upper left first and second premolars in males (6.75±0.56 and 6.52±0.42, respectively) is higher than MD width in females (6.56±0.48 and 6.34±0.46, respectively) (Table 3).

One-way ANOVA was used in comparisons of different malrelationship. Three malocclusion groups (Class I, Class II and Class III) and the MD width of each tooth ($p>0.05$). Conversely, according to the ANOVA test, the Maxillary left canine showed the least MD width in Class II malocclusion (7.13±0.60) followed by Class III malocclusion (7.40±0.63) and the highest MD width demonstrated by Class I malocclusion (7.43±0.40) with a significant difference between the groups ($p<0.046$). Multiple comparisons between groups using pairwise comparisons (LSD test) of involved malocclusion showed a significant difference between Class I and Class II malocclusion ($p<0.018$), the current analysis also demonstrated no significant difference between Class III and other types of malocclusion ($p>0.05$) (Table 4).

Similarly, the Kruskal Wallis test revealed a significant difference between the malalignment groups in respect to maxillary left second premolar ($p<0.018$) in which Class III malocclusion showed the highest MD width mean of 6.73±0.27—followed by Class II malocclusion with the mean of 6.37±0.49 and the least MD width present in Class I malocclusion (6.34±0.43). Multiple comparisons between groups using pairwise comparisons (Mann-Whitney U test) of involved malocclusion showed a significant difference between Class III and Class I malocclusion ($p<0.006$) as well as Class III and Class II ($p<0.012$), the present analysis also proved that no significant difference between Class I and Class II malocclusion ($p<0.734$) (Table 3).

Table 3: Comparison between malocclusion groups as well as Gender variables to each tooth.

Measured Tooth		Gender (Mean ± SD)			Malocclusion Groups (Mean ± SD)			
		Male	**Female**	***P*-value**	**Class I**	**Class II**	**Class III**	***P*-value**
Maxillary Right	1st Molar	10.36±0.49	10.03±0.48	0.003	10.10±0.49	10.17±0.55	10.25±0.42	0.646
	2nd Premolar	6.63±0.46	6.32±0.44	0.003	6.44±0.45	6.39±0.51	6.58±0.40	0.453
	1st Premolar	6.84±0.40	6.55±0.43	0.003	6.70±0.45	6.62±0.43	6.69±0.46	0.704
	Canine	7.60±0.66	7.19±0.54	0.003	7.42±0.53	7.21±0.66	7.55±0.68	0.166
	Lateral Incisor	6.60±0.47	6.26±0.57	0.005	6.53±0.46	6.35±0.55	6.14±0.70	0.078
	Central Incisor	8.55±0.50	8.11±0.48	0.000	8.29±0.51	8.26±0.58	8.33±0.46	0.911
Maxillary Left	1st Molar	10.42±0.52	10.05±0.73	0.015	10.19±0.48	10.17±0.88	10.29±0.45	0.839
	2nd Premolar	6.52±0.42	6.34±0.46	0.071	$6.34±0.43^{A}$	$6.37±0.49^{A}$	$6.73±0.27^{B}$	0.018*
	1st Premolar	6.75±0.56	6.56±0.48	0.110	6.67±0.49	6.60±0.51	6.64±0.65	0.854
	Canine	7.51±0.56	7.16±0.49	0.003	$7.43±0.40^{A}$	$7.13±0.60^{B}$	7.40±0.63	0.046*
	Lateral Incisor	6.48±0.45	6.21±0.50	0.014	6.39±0.48	6.32±0.46	6.09±0.59	0.189
	Central Incisor	8.50±0.48	8.09±0.42	0.000	8.22±0.47	8.29±0.54	8.22±0.37	0.809
Mandibular Right	1st Molar	10.83±0.49	10.45±0.59	0.003	10.64±0.39	10.50±0.74	10.77±0.47	0.308
	2nd Premolar	7.03±0.45	6.77±0.45	0.009	6.88±0.39	6.80±0.50	7.05±0.52	0.235
	1st Premolar	6.83±0.47	6.50±0.48	0.003	6.63±0.45	6.59±0.54	6.77±0.52	0.544
	Canine	6.78±0.56	6.24±0.46	0.003	6.47±0.53	6.41±0.64	6.50±0.46	0.845
	Lateral Incisor	5.74±0.37	5.56±0.37	0.029	5.64±0.35	5.62±0.35	5.63±0.55	0.983
	Central Incisor	5.29±0.40	5.10±0.35	0.024	5.17±0.36	5.20±0.40	5.09±0.39	0.646
Mandibular Left	1st Molar	10.91±0.46	10.57±0.59	0.006	10.71±0.41	10.58±0.65	11.01±0.59	0.064
	2nd Premolar	6.96±0.39	6.76±0.46	0.045	6.88±0.39	6.77±0.45	6.93±0.54	0.454
	1st Premolar	6.77±0.49	6.52±0.46	0.022	6.66±0.38	6.53±0.54	6.74±0.57	0.324
	Canine	6.82±0.56	6.27±0.49	0.000	6.50±0.48	6.46±0.66	6.51±0.61	0.948
	Lateral Incisor	5.88±0.48	5.53±0.36	0.000	5.61±0.47	5.74±0.39	5.59±0.50	0.336
	Central Incisor	5.22±0.31	5.00±0.37	0.007	5.11±0.37	5.06±0.35	5.11±0.40	0.823

*indicate a significant difference between the groups in multiple comparison test (LSD for Maxillary left canine and Kruskal Wallis for the Maxillary left 2nd premolar) (P<0.05).

Table 4: Mean± SD for Bolton tooth size Discrepancy within each malocclusion group and when all groups are combined.

	Class I	**Class II**	**Class III**	***P*-value**	**Overall**	**95% Confidence Interval for Mean**
	(Mean ± SD)					
Anterior Ratio	77.93±2.79	79.27±2.86	78.76±2.53	0.132	78.64±2.82	78.03-79.25
Overall Ratio	91.43±2.28	91.58±2.33	92.07±1.94	0.684	91.59±2.24	91.11-92.07

Tooth size discrepancy based on Bolton analysis was reported in the present study; the overall mean ratio for all combined classes was 91.59±2.24, and for the anterior ratio it was reported as 78.64±2.82, there was no statistically significant difference in both anterior ratio (p=0.132) and overall ratio (p=0.684) between the different malocclusion groups (Table 4).

When the three malocclusion groups were compared to gender to determine the difference in tooth size discrepancy based on Bolton analysis, Class I and II showed a higher anterior and overall ratio in males with no difference between the gender neither in the anterior nor the overall ratio (p>0.05). However, Class III malocclusion showed a significant difference in both the anterior ratio (p<0.013) and overall ratio (p<0.046), respectively. The mean of the anterior and overall ratios was higher in females (80.04±2.09 and 92.89±2.09, respectively) than seen in males (76.72±1.74 and 90.74±0.32, respectively). However, when combining the malocclusion groups, no statistically significant difference was detected between both genders to the anterior ratio (p=0.326) and posterior ratio (p=0.591) (Table 5).

Table 5: * Two-way ANOVA for Malocclusion across Gender revealed the following:
Anterior Ratio: p<0.019, F= 4.19; Overall Ratio: p<0.124, F= 2.14

	Males			**Females**			**F**	**P-value***
	(Mean ± SD)	**SE**	**N**	**(Mean ± SD)**	**SE**	**N**		
Class I								
Anterior Ratio	79.00±2.77	0.716	14	77.22±2.63	0.585	21	3.71	0.063
Overall Ratio	91.88±1.93	0.597		91.13±2.48	0.487		0.90	0.350
Class II								
Anterior Ratio	79.86±2.75	0.716	14	78.91±2.93	0.559	23	0.96	0.333
Overall Ratio	92.00±2.42	0.597		91.32±2.28	0.465		0.73	0.400
Class III								
Anterior Ratio	76.72±1.74	1.199	5	80.04±2.09	0.948	8	8.75	0.013
Overall Ratio	90.74±0.32	0.998		92.89±2.09	0.789		5.03	0.046
TOTAL								
Anterior Ratio	79.02±2.78	0.48	33	78.40±2.85	0.39	52	0.975	0.326
Overall Ratio	91.76±2.02	0.35		91.49±2.37	0.33		0.290	0.591

The correlation coefficient was reported between the overall ratio and anterior ratio of tooth size discrepancy, in which there was a robust positive correlation (r=0.704) revealed a high value of overall ratio associated with the high value of the anterior ratio (direct linear proportion) (Table 6).

Table 6: correlation coefficient of Pearson's multiple correlations that measure the linear correlation between variables. * Predictors: (Constant), overall ratio, anterior ratio

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.704*	0.496	0.490	2.01466

In the linear regression analysis, the overall ratio was used as coefficients of independent variables (β), and the constant (α) was the values of the anterior ratio. The prediction equation displayed a strong association between each independent and dependent variable. The anterior ratio was positively (0.888) and independently related to the overall ratio with a high significance level (p<0.000) indicating that anterior ratio is considered as a good predictor of the overall ratio (Table 7).

Table 7: Multiple linear regression analysis tests. Dependent Variable: Anterior Ratio

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	-2.725	9.003		-0.303	0.763
Overall Ratio	0.888	0.098	0.704	9.040	0.000

Anterior and overall ratios found in the present sample were greater than from Bolton's American population, with no significant difference in the overall ratio (p=0.430). In contrast, a significant difference reported in the anterior ratio (p<0.001) (Table 8).

Table 8 compares the Bolton study population and the current study in relation to anterior ratio and overall ratio using an unpaired t-test (independent t-test), p<0.05.

	Present Study (n = 85)	Bolton Study (n = 55)	*T* - value	*P*-value
Anterior Ratio				
Mean ± SD	78.64±2.82	77.2±1.65	3.424	0.001
SE	0.31	0.22		
Min – Max	72.74 – 85.65	74.5 – 80.4		
Overall Ratio				
Mean ± SD	91.59±2.24	91.3±1.91	0.791	0.430
SE	0.24	0.26		
Min – Max	86.32 – 97.62	87.5 – 94.8		

DISCUSSION:

Orthodontic treatment ought to result in appropriate points of contact between adjacent teeth. Right proportions in tooth sizes are needed to achieve an optimal result. However, some discrepancies between tooth sizes are not apparent until the final stages of orthodontic treatment.[21]

Since differences in tooth sizes have been reported with different ethnic groups,[22, 23] most practitioners nowadays prefer using norms for the ethnic groups they are treating. The Bolton's tooth size ratio, Peck and Peck ratios and the width/length ratio have been obtained from an American population; accordingly, their reliability is still questionable when applied to different ethnic groups.[24]

Several studies have been conducted comparing tooth size differences on different populations such as Sudanese[1], Libyans[17], Spanish[21], Nepalese[24], Japanese[25] and many other populations.

The original Bolton sample was obtained from their study, in which 55 models with excellent occlusion 44 orthodontically treated and 11 untreated.[26] In this present study the sample consisted of pretreatment study casts of 85 orthodontic patients reporting to the Department of Growth and Development, Ajman University, College of Dentistry, 33 study casts were of males, and 52 were of females. The sample included a random selection of malocclusion groups. All patients were aged between 11 and 38 years. The sample size calculation showed an excellent representation number for patients attending orthodontic clinics at Ajman University. This study is a cross-sectional design. Although this type of research lies in the lower third of the evidence hierarchy, it is the best design for this study.

Many methods have been employed to measure tooth width including using manual callipers,[23] digital callipers directly connected to the computer,[27] and a digitalized scanned dental cast.[28] Several authors have conducted comparisons between the digital calliper and the scanned dental models.[28, 29] It was concluded that using a digital calliper with a direct connection to the computer gives the most reliable measurements with reduced data transfer errors. In this present study, a digital calliper was used to measure the mesiodistal width of each tooth; all readings were manually entered.

Several evidence-based studies indicated that tooth-size ratios are ethnicity, race, and sex-specific.[30, 31] The results from this present study showed no statistically significant difference between Bolton ratios obtained for our sample group and the original values of Bolton. An earlier study by Lavelle showed that both anterior and overall ratios were greater in blacks than Caucasians, with those in Asians being intermediate.[32] A recent study evaluated the applicability of Bolton's tooth-size ratio to different populations and the two genders, concluded that Bolton's ratios applied only to Caucasian and should not be indiscriminately applied to blacks or Hispanics.[32]

Several studies have been conducted to evaluate Bolton's tooth size ratios on different ethnic groups. More recent research estimated that Bolton's ratios on Japanese populations with varying types of malocclusion found a statistically significant difference in the anterior ratio from Bolton's standard. However, no statistically significant difference was found in the overall ratio from the Bolton standard. No statistically significant sex differences were found in the anterior or overall ratio in any group. No significant differences in anterior or overall ratios were found among the malocclusion groups.[30]

Another study on the Nepalese population found that the mean anterior and overall tooth size ratios varied significantly from Bolton's original ratios. Earlier research found that the anterior and overall tooth-size ratios for Spanish populations are larger than the original Bolton's ratios, and that difference was statistically significant.[33]

Many studies indicated that tooth size ratios are gender specific[30, 31, 34, 35]. This present study shows no statistically significant difference in Bolton ratio from original values. There were no significant gender differences in tooth size ratio between males and females in Class I and Class II malocclusion. In contrast, the anterior tooth size ratio was significantly larger in females than in males in Class III malocclusion.

Different researchers studied the coronal tooth dimensions of the maxillary anterior teeth. They found that the mean tooth width for the permanent dentition was central incisor > canine > lateral incisor. In contrast, the mean tooth width of the primary teeth is canine > central incisor > lateral incisor.[36, 37, 38, 39]

In this present research, males exhibited larger values than females. This difference was statistically significant, except for upper left 1st and second premolars, in which the difference was not significant between the two genders. There was no statistically significant difference in teeth size between the three malocclusion groups (Class I, Class II or Class III).

CONCLUSION:

- There are no significant differences between the mesiodistal teeth size of right or left quadrants of the same arch except for the left maxillary canine and the 2nd premolar.
- The present sample's anterior and overall ratios were greater than from Bolton's American population, with no significant difference in Class I and II, while Class III malocclusion showed a substantial difference in both the anterior and the overall ratio.
- There was no statistically significant difference in mesiodistal tooth width when comparing the three malocclusion groups, but males show larger mesiodistal teeth width than females.
- The maxillary 1st premolar and 2nd premolar teeth have no mesiodistal width difference between genders, while the maxillary canine and the 2nd premolar have a significant difference between right and left quadrants.
- The mandibular teeth showed no significant difference in mesiodistal width between right and left quadrants.

RECOMMENDATIONS:

We recommend a further study on a larger sample taking into consideration racial group differences.

LIST OF ABBREVIATIONS:

(TSD): Tooth size discrepancy.
(MD): Mesiodistal
(SPSS): Statistical Package for the Social Sciences
(BSI) British standards institute's incisor classification
(LSD): Least significant difference

ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

Ethical approval was verified from Ajman University (Ref: D-P-F-H-2019-Oct.21). A written informed agreement was obtained from all participants and their parents or guardians. Participants were free to withdraw their consent at any stage.

AVAILABILITY OF DATA AND MATERIALS:

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

COMPETING INTERESTS:

The authors announce that they have no competing interests.

AUTHORS' CONTRIBUTIONS:

All the authors approved the final draft of the manuscript. IKD measured the casts, KHH and MHA, done the statistical analysis and result writing. ASA contributed to discussion writing. AOM contributed to data analysis and manuscript writing; AOM contributed to participants recruitment and data collection. AOM contributed to the conceptual framework of the project.

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