Bolton tooth size ratio among qatari population sample: An odontometric study

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ABSTRACT

Objectives: To establish the overall and anterior Bolton ratio among a sample of Qatari population and to investigate whether there is a difference between males and females, as well as to compare the result obtained by Bolton.

Materials and Methods: The current study consisted of 100 orthodontic study participants (50 males and 50 females) with different malocclusions and age ranging between 15 and 20 years. An electronic digital caliper was used to measure the mesiodistal tooth width of all maxillary and mandibular permanent teeth except second and third molars. The Student's *t*-test was used to compare tooth-size ratios between males and females and between the results of the present study and Bolton's result.

Results: The anterior and overall ratio in Qatari individuals were 78.6 ± 3.4 and 91.8 ± 3.1, respectively. The tooth size ratios were slightly greater in males than that in females, however, the differences were not statistically significant ($P > 0.05$). There were no significant differences in the overall ratio between Qatari individuals and Bolton's results ($P > 0.05$), whereas statistical significant differences were observed in anterior ratio ($P = 0.007$).

Conclusions: Within the limitation of the limitations of the present study, definite conclusion was difficult to establish. Thus, a further study with a large sample in each malocclusion group is required.

Key words: Anterior ratio, Bolton ratio, malocclusion, overall ratio

INTRODUCTION

Teeth are arranged in harmony with each other and with other structures in the face and the mouth, including the muscles of mastication, the tongue, and the bones of maxilla and mandible. The presence of deciduous and permanent dentition is important in mastication as well as in esthetics. Patients attending orthodontic clinics normally complain of either crowding or spacing or both, which represents a big esthetic and functional problem.[1]

Several investigators when measuring the tooth width follow the contact method using either a pair of dividers with millimeter ruler[2-5] or sliding calipers.[6,7] On the other hand, noncontact methods include prints of the dental cast.[8] Television images[9] and photographs of dental casts have also been used, and can be considered a reliable and efficient source of data. Further, laser holograms of occlusal surfaces have also been used for tooth width measurement.[10,11] Furthermore, three-dimensional analysis of dental casts can also be obtained and used by means of stereophotogrammetry[12] and Optocom.[13]

In orthodontics, dental casts are still considered as a fundamental diagnostic tool.[14] From the dental cast, one can analyze tooth size, shape, alignment, rotations of the teeth, presence or absence of teeth, arch form and symmetry, and occlusal relationship.[15]

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Access this article online

Quick Response Code:

Website: www.jorthodsci.org

DOI: 10.4103/2278-0203.197395

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How to cite this article: Hashim HA, AL-Sayed N, AL-Hussain H. Bolton tooth size ratio among qatari population sample: An odontometric study. J Orthodont Sci 2017;6:22-7.

The importance of having a certain relationship between the maxillary and mandibular teeth has attracted the attention of several investigators over the years. Bolton[5] was the first to publish his analysis of mesiodistal tooth size dimensions and their effect on occlusion. He proposed that the overall ratio of the sum of mesiodistal width of the 12 mandibular teeth divided by the sum of the 12 maxillary teeth was 91.3%, and the anterior ratio for the 6 upper and lower anterior teeth was 77.2%. Bolton arranged tables to predict the congruity between the maxillary and mandibular arches, and concluded that it results in ideal overbite, ideal overjet, and ideal posterior occlusion. He also emphasized that the tooth ratios could without difficulty be a diagnostic aid that could aid orthodontists to gain an insight into the functional and esthetic outcome of a case without the use of diagnostic setup.

Lundstrom[16] observed a large biological dispersion in the tooth size ratio, which was great enough to have an impact on the final teeth position, teeth alignment overbite, and overjet in a large number of patients. However, other investigators have speculated that incisor inclination,[17] interincisal angle, labiolingual tooth thickness[17,18] overbite, and overjet might influence ideal tooth size relationship. Despite this, many clinicians are still using Bolton analysis as their primary guide for predicting tooth size discrepancies.

Lavelle[19] investigated tooth size ratio in different racial groups (Caucasoid, Mongoloid, and Negroid). Forty cases in each group were investigated. He found that the overall and anterior ratios were greater among Negroids than Caucasoids, whereas the Mongoloids were intermediate.

Crosby and Alexander[20] conducted a study on the occurrence of tooth size discrepancies among patients with different malocclusions (Classes I, II; division 1 and 2; and Class II surgical cases). They reported no difference in the incidence of tooth size discrepancies in different malocclusion groups. They observed, however, that a large number of patients within each group had tooth size discrepancies greater than two standard deviations of Bolton's mean.

Lew and Keng[21] carried out an odontometric measurement of anterior teeth crowns size in a Chinese population sample with normal occlusion. They pointed out that tooth size ratio for the 6 anterior teeth compared favorably with those originally published by Bolton,[5] although the interincisal angle, overbite, and overjet were statistically different.

Hashim and Murshid[22] investigated the intermaxillary tooth size ratio in Saudi individuals aged 13 to 20 years with different type of malocclusions. They found no significant difference in the mean of tooth size ratio of overall and anterior ratios when compared with Bolton's mean. Their study confirmed previous reports that different types of malocclusions do not affect the Bolton ratio.

Saatci and Yukay[14] investigated the role of different type of tooth extraction in creating tooth size discrepancies before treatment. They found that Bolton's values were statistically significant for the first premolar extraction and insignificant for others. They concluded that the removal of the first 4 premolars created the most severe tooth size discrepancies, whereas the extraction of all 4 second premolars crated fewer discrepancies.

Rudolph *et al*.[18] reported that variation in the labiolingual tooth thickness might produce inaccuracies in the Bolton analysis. They designed and tested a new formula that took into account the labiolingual tooth thickness for predicting anterior tooth size discrepancies. They found that patients with thin incisor at the occlusion contact (<2.75 mm) had a stronger correlation with intermaxillary ratio than patients with thick teeth (>2.75 mm). The higher correlation coefficient for the thin teeth indicates that size discrepancies in these cases by using this method are more sensitive. In case of thick incisors, the sensitivity of this method in predicting tooth size discrepancies decreases, and a diagnostic setup may be indicated. Killiany[23] noted that including the tooth thickness in the prediction model would improve the detection of intermaxillary tooth size discrepancy. However, the analysis is still not as accurate as using a diagnostic setup.

Nie and Lin[24] conducted a study among Chinese population to compare intermaxillary tooth size discrepancies among different malocclusion groups for both sexes. They found significant difference in tooth size ratios between the groups in which Class III group had a higher mean value than Class I and Class II (CLIII > CLI > CLII). However, sexual dimorphism for these ratios did not exist in each group.

Heusden *et al*.[25] carried out an experimental study on the effect of tooth size discrepancies on occlusion. They observed that severe tooth size discrepancies only slightly affect occlusion, and the effect of generalized tooth size discrepancies appears to be limited.

Basaran *et al*.[26] performed tooth size measurements on pretreatment models of patients with normal occlusion. The tooth size ratios and one-way analysis of variance test showed no sexual dimorphism for these ratios in each of the five groups, hence, the sexes were combined for each group. Then, these ratios were compared among different malocclusion groups. The results showed no significant difference between subcategories of malocclusion, and hence these groups were combined as Class I, Class II, and Class III. No significant difference was found for all the ratios between the groups.

Uysal *et al*.[27] aimed to identify the possible sex differences in tooth size ratios between males and females to determine whether there is a difference in the incidence of tooth size discrepancies for both the anterior and overall ratios when comparing with Angle Class I; Class II, division 1; Class II,

division 2; and Class III malocclusion groups. Their result revealed that significant sex difference was found only in the overall ratio for normal occlusion individuals ($P < 0.001$). All malocclusion groups showed statistically significant higher overall ratios than the normal occlusion group ($P < 0.001$). There were no statistically significant differences among malocclusion groups. They recommended that further investigations are needed to explain the probable racial differences and relationships between malocclusion and tooth size measurements.

When searching the literature, no odontometric study was noted among Qatari population. Furthermore, no previous study investigated the intermaxillary tooth size ratio (Bolton ratio) among the Qatari population. Thus, the aims of the present investigation were to establish the overall and anterior ratio among the Qatari population sample and to investigate whether there was a significant difference between males and females, as well as to compare it to the result obtained by Bolton.

MATERIAL AND METHODS

The present study consisted of 100 pretreatment orthodontic casts of Qatari patients who sought orthodontic treatment (50 males and 50 females). The inclusion criteria were:

1. Qatari individuals.
2. Age range from 15 to 20 years.
3. Class1, II, III molar and canine relationship.
4. Crowding, spacing (<3 mm), and rotation of the teeth.
5. No large interproximal restoration.
6. No previous orthodontic treatment.
7. All permanent teeth fully erupted in both jaws from the right first molar to the left first molar.

Cast Measurement

The measurements were made directly on the un-soaped dental casts. One operator took all the measurements under natural neon light. Electronic digital caliper was used in the measurements. The procedure for measuring the mesiodistal tooth width was performed as described by Hunter and Priest.[28] The caliper beaks were inserted from the buccal (labial) and held occlusally parallel to the long axis of the tooth. The beaks were then closed until gentle contact with the contact points of the tooth was made.

The measurements included the mesiodistal of 12 maxillary and mandibular teeth from the right first permanent molar to left permanent first molar. The measurements were made as carefully as possible to avoid any damage on instrumental contact.

To examine the tooth size relationship between the maxillary and mandibular teeth, the Bolton formulae[5] were computed as follows:

$$46\_\text{Overall ratio} = \frac{\text{Sum of mesiodistal tooth width of mandibular 36 to}}{\text{Sum of mesiodistal tooth width of maxillary 16 to 26}} \times 100$$

$$43\_\text{Anterior ratio} = \frac{\text{Sum of mesiodistal tooth width of mandibular 33 to}}{\text{Sum of mesiodistal tooth width of maxillary 13 to 2}} \times 100$$

Error of the Method

Ten orthodontic casts were selected randomly and measured and re-measured with 1-week interval by one of the coauthors (HA).

Statistical Analysis

Student's *t*-test was used to assess the error of the method, and to compare males and females, and to compare the result of the present study and that of Bolton's. The level of significance was $P < 0.05$.

RESULTS

When performing the *t*-test no statistical significant difference was observed between the first and second measurements [Table 1]. Table 2 presents the overall and anterior ratio of the present study, i.e., 91.8 (SD: 3.1) and 78.6 (SD: 3.4), respectively. It can be seen from Table 3 that the mean anterior ratio for males was 79.1 (SD: 3.5) whereas for females was 78.1 (SD: 3.3). Table 4 shows that the overall ratio for males was 92.4 (SD: 2.9) whereas for females was 91.2 with (SD: 3.2). The overall ratio and the anterior ratio were slightly greater in males than females [Table 5]. No statistical significant differences were found in tooth size ratios between both the genders.

The comparison of tooth size ratios between the present study and Bolton's result are presented in Table 6. The results reveal that the mean and standard deviation of the overall and anterior ratio in the present study were slightly greater than Bolton's results. The statistical analysis exhibited no significant difference in the overall ratio but showed statistical significant difference in the anterior ratio.

DISCUSSION

Bolton stated that the mesiodistal tooth size of the maxillary and mandibular arches must relate to each other to obtain an optimal occlusion at the completion of the orthodontic treatment. If a patient has significant tooth-size discrepancy, orthodontic alignment into optimal occlusion may not be possible.[5,18] Crosby and Alexander[20] reported that a large percentage of orthodontic patients possess significant tooth-size discrepancies. Therefore, orthodontists should be aware of these discrepancies before beginning an orthodontic treatment.

Table 1: Error of the method of the individual teeth in the upper and lower jaw

Upper jaw												
Hc	16	15	14	13	12	11	21	22	23	24	25	26
Mean reading first week	9.7	6.577	6.786	7.64	6.847	8.491	8.453	6.853	7.638	6.752	6.488	9.666
Mean second week	9.75	6.574	6.886	7.667	6.811	8.611	8.6	6.875	7.648	6.715	6.502	9.796
P	0.816	0.982	0.682	0.908	0.863	0.647	0.580	0.891	0.969	0.868	0.941	0.584
Comment	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lower jaw												
Mean reading first week	10.166	6.904	6.942	6.659	5.855	5.316	5.333	5.881	6.55	6.999	6.897	10.087
Mean reading second week	10.275	7.042	7.076	6.775	5.87	5.381	5.579	5.867	6.695	7.005	6.98	10.357
P	0.748	0.437	0.566	0.554	0.921	0.707	0.294	0.926	0.330	0.968	0.654	0.412
Comment	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS - Not significant

Table 2: Bolton overall ratio and anterior ratio for males and females combined

Ratio type	Mean	SD	Sample size
Overall ratio	91.8	3.1	100
Anterior ratio	78.6	3.4	100

SD - Standard deviation

Table 3: Bolton anterior ratio for males and females of the present study

Gender	Mean	SD	Sample size
Males	79.1	3.5	50
Females	78.1	3.3	50

SD - Standard deviation

Table 4: Bolton overall ratio for males and females of the present study

Gender	Mean	SD	Sample size
Males	92.4	2.9	50
Females	91.2	3.2	50

SD - Standard deviation

Table 5: Comparison of overall and anterior ratio means values of the present study between males and females

Ratio type	Gender	*N*	Mean	SD	*P*	*P*
Overall ratio	Males	50	92.4	2.9	0.0.1122	NS
	Females	50	91.2	3.2		
Anterior ratio	Males	50	79.1	3.5	0.1122	NS
	Females	50	78.1	3.3		

NS - Not signifi cant; SD - Standard deviation

Table 6: Comparison between the present study result and Bolton's means values

	N	Mean	SD	*P*	*P*
Overall ratio					
Present study	100	91.8	3.1	0.305	NS
Bolton study	55	91.3	1.91		
Anterior ratio					
Present study	100	78.6	3.4	0.007	S
Bolton study	55	77.2	1.65		

NS - Not signifi cant; S - Signifi cant; SD - Standard deviation

The treatment alternatives for tooth-size discrepancies include restoration of relatively small teeth, interproximal stripping of relatively large teeth, modification of crown angulation or inclination, and extraction.[29]

Bolton[17] and Tuverson[30] indicated that overbite, overjet, and interincisal angle might influence ideal tooth-size relationships. However, no definite conclusions have been drawn regarding the effect that overbite, overjet, and interincisal angle have on the accuracy of tooth-size analysis. In the present study, the intericisal angle was not included in the measurements.

When reviewing the literature, it was observed that most of the studies regarding tooth-size ratio were conducted on a sample of both treated and untreated cases[5,31,32] or on groups of orthodontic patients with malocclusion.[20] However, the present study data were collected from a sample of untreated individuals who presented with different malocclusions. The results show that the mean of the overall ratio was not statistically significant from Bolton's[5] results whereas the anterior ratio showed statistical significant difference. This difference could be attributed to the presence of several patients presented with Class III malocclusion. As mentioned earlier in the study of Nie and Lin[24] who found a significant difference in tooth-size ratios between the groups in which Class 111 group had a higher mean value than Class I and Class II. The same finding was reported by Othman and Harradine.[34]

However, Basaran[26] observed no significant difference for both ratios between the groups of malocclusion, which is in disagreement with the results of Othman and Harradine[34] and Nie and lin.[24] Crosby and Alexander supported the same finding.[20] They conducted a study in orthodontically treated patients with varying malocclusions (Class I, Class II, Division 1, Class II Division 2, and Class II surgery) and concluded that no significant differences in the incidence of tooth-size discrepancies among the malocclusion groups. Comparison between the present and abovementioned studies is not relevant because the sample of the present study was not classified into different malocclusion classes.

However, the results of the present investigation were in agreement with the results reported by Nie and Lin[24] in a Chinese population where no significant difference in tooth-size

ratios was observed between the combined groups of malocclusion and normal occlusion. Hashim and Murshid noted the same result.[22] They investigated tooth-size discrepancies among Saudi patients with different types of malocclusion combined.

Sexual dimorphisms in tooth-size ratio have long been established.[19,33] However, Bolton,[5] Stifter,[35] and Crosby and Alexander[20] did not consider gender and racial differences when analyzing tooth-size discrepancy. On the other hand, Lavelle[19] investigated the degree of sexual dimorphism. He found that the overall and anterior ratios were greater in males than in females, without indicating whether or not the difference was significant. The difference in tooth-size ratio between genders was investigated in the present study and no statistical significant difference was observed. This was in line with the result obtained by Lavelle,[19] Nie and Lin,[24] and Hashim *et al*.,[36] and in disagreement with the findings of Smith *et al*.[33]

The differences in samples (treated, untreated, and malocclusion groups) and methods of the various studies could account for dissimilar findings, an adequate explanation for the disparate results could not be found.

Recently, Pizzol *et al*.,[37] based on studies by Bolton[5] and Neff,[31] introduced two simplified formulas derived from Bolton analysis to predict if there were any tooth size discrepancies between both arches. They concluded that both formulas employed for the alternative method may be used to substitute the traditional method because each demonstrated, on average, differences of less than 0.58 mm when compared with Bolton's method, with no clinical significance. These formulas make the prediction of tooth size discrepancy easier and saving time without using the prediction tables.

The results obtained in the present study indicate that firm conclusion is difficult to draw. Because this sample is relatively small, a further representative study with a large sample in each malocclusion group is required.

CONCLUSIONS

The results of the present study led to the following conclusions:

1. The means of the anterior ratio and the overall ratio were found to be 78.6 (SD ± 3.4) and 91.8 (SD ± 3.1), respectively;
2. There was no statistical significant difference between males and females in tooth-size ratios.
3. There were no significant differences between the present study and Bolton's study for overall ratio whereas a significant difference was observed in anterior ratio.

Financial Support and Sponsorship

Nil.

Conflict of Interest

There is no conflict of interest.

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