Mesiodistal tooth width and tooth size discrepancies of Yemeni Arabians: A pilot study

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ABSTRACT

Objectives: The aims of this study were to determine the mean mesiodistal tooth size width and Bolton's anterior and overall ratios, find any possible sex differences, and study the frequency of tooth size discrepancies among Yemeni population and if there is a difference in tooth size between the right and left sides.

Materials and Methods: 176 subjects aged 13–25 years (94 females and 82 males) with different types of malocclusions (94 Angle Class I, 37 Class II division 1, 36 Class II division 2, and 9 Class III) were included in the present study. The mean mesiodistal tooth size width and Bolton's ratios were determined.

Results: The results showed that males had significantly larger teeth than females. The prevalence rates of clinically significant discrepancy greater than 2 SD were 29.53% and 14.20% in the anterior and overall tooth size ratios, respectively. Further, the results revealed that there were no significant differences in the tooth size width between right and left sides.

Conclusion: The findings of the present study indicate that there was no significant difference between Bolton's ratio and that of Yemeni population.

Key words: Tooth size, bolton ratio, Yemenis

INTRODUCTION

Ultimate orthodontic treatment is based on comprehensive diagnosis, treatment planning, and interpreting all of the findings correctly and wisely. Further, identification of tooth size ratios is one of the key aspects for prediction of treatment outcomes, achieving balanced occlusion, and obtaining stable interdigitation. However, Bolton's tooth size analysis[1,2] remains the most recognized method for detecting inter-arch tooth size discrepancies and gained wide acceptance in clinical orthodontics.

Reviewing related literatures revealed that variations in tooth size width and Bolton's ratios exist between sexes, racial and ethnic groups.[3-8] This distinctive variation has become a subject of interest for many researchers, which leads to establishment of normative standards for different racial groups.[9-15]

In the Middle East region, many researchers have evaluated the applicability of Bolton's tooth size ratios to some particular groups. Al-Khateeb and Abu Alhaija[13] and Al-Omari *et al*.,[15] in their studies on Jordanians' dentition, reported anterior and overall ratios that were very close to Bolton's ratios. Further, Al-Tamimi and Hashim[16] carried out a study on Saudi population and found that the anterior and overall ratios were very similar to Bolton's values. The same finding was reported by Nourallah *et al*.[17] for the Syrians and also by Mirzakouchaki *et al*.[18] in Iranian-Azari subjects. They concluded that Bolton's values can be used for Syrians and Iranian-Azari subjects. On the other hand, Uysal and Sari[19] in their study on Bolton's ratios among Turkish population found a significant difference from Bolton's values which cannot be applied to the Turkish. Thus, they insisted on using Turkish norms in case of treating Turkish orthodontic patients.

Numerous studies investigated the correlation between tooth size discrepancies and different malocclusion groups. Some

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Access this article online

Quick Response Code:

Website: www.jorthodsci.org

DOI: 10.4103/2278-0203.99760

reported significant differences,[20-23] whereas other reported no significant differences.[13,19,24,25]

With regard to Yemeni population, a PubMed search was conducted in June 2011 using the following key words: tooth size width, tooth size measurements, Bolton's ratios, and tooth size discrepancy. The result of this search revealed no published data were available for them. Also, with the recent fast-growing community demand for orthodontic treatment and the paucity of pertinent orthodontic data, such information related to clinical orthodontic practice in Yemen is of vital importance and needs to be addressed. The current study was therefore designed to determine the mean mesiodistal tooth size width and Bolton's anterior and overall ratios, find any possible sex differences, and study the frequency of tooth size discrepancies among Yemeni population.

MATERIALS AND METHODS

The material of this study comprised a study model of 813 subjects selected from dental students, patients seeking dental treatment at the Faculty of Dentistry, Ibb University, and from the first author's private orthodontic clinic in Ibb city, Yemen. The selection criteria were: Yemeni with Yemeni ancestry, all study casts were of good quality, all teeth were fully erupted from first molar in the right side to first molar in the left side in both upper and lower jaws, no proximal caries, restorations or abrasion, no previous or ongoing orthodontic treatment, no abnormal tooth morphology, and no transverse discrepancies such as crossbite.

Only 176 subjects met the established criteria and were finally included in the present study. They were 94 females and 82 males with different types of malocclusions (94 Angle Class I, 37 Class II division1, 36 Class II division 2, and 9 Class III). The mean age was 19.11±3.01 years (range 13–25 years). Digital caliper was used to measure the mesiodistal tooth widths from the right first molar to the left first molar to the nearest 0.01 mm. The mesiodistal width of each tooth was measured at the widest distance between the contact points. The anterior and overall ratios were calculated as described by Bolton.[1,2] All measurements were done by one investigator.

Methodological Error

In order to assess the error of the method, 30 casts were randomly chosen and measured twice within the interval of 1 month. The results were compared using a paired *t*-test. No significant differences were found.

Statistical Analysis

The normality test of Shapiro–Wilk was applied to the data. The data were found normally distributed. Comparisons between sexes and between normal and malocclusion groups were done using Student's *t*-test. All statistical analyses were performed using SPSS 17.0 software (version 17.0, SPSS, Chicago, IL, USA). The level of significance was set at $P<0.05$.

RESULTS

The sample distribution according to sex and type of malocclusion is shown in Table 1.

53.4% of the subjects had normal occlusion and 46.5% presented with different malocclusion types (21% Class II division 1, 20.4% Class II division 2, and 5.1% Class III). Female subjects were dominant in each type of occlusion except that of Class II division 2 malocclusion.

Table 2 shows the mean and standard deviation (SD) of the mesiodistal tooth size widths of the 12 teeth in the maxillary and mandibular arches for the total sample and for the right and left sides. The results indicated that no significant tooth size differences were found between the right and left sides.

The comparison of the mesiodistal tooth size widths between males and females is shown in Table 3. Male subjects showed significantly larger upper central incisor, canine, and first premolar ($P<0.001$) than females. In the lower arch, males had larger lateral incisor, first and second premolars ($P<0.05$), canines, and first molar ($P<0.001$) than females. The cumulative tooth size width (the sum of the widths of individual teeth in each arch up to and including the first permanent molars) was significantly larger in males than in females in both the arches (upper, $P<0.05$; lower, $P<0.001$) and exceeded those of females by a sum of 2.04 mm in the maxilla and 2.22 mm in the mandible.

Table 4 shows the comparison of the mesiodistal tooth size widths between normal and malocclusion groups. No statistically significant differences were found between the groups.

Tables 5 and 6 show the mean and SD of the anterior and overall ratios for the total sample, comparisons between males and females, and between normal and malocclusion groups. No significant differences were found between sexes, normal and malocclusion groups in either anterior or overall ratios.

Table 7 shows the distribution of subjects with anterior and overall tooth size discrepancies outside 2 SD from Bolton's means. 29.53% of the sample (52 of 176 subjects) had anterior tooth width ratios greater than 2 SD from Bolton's mean (9.65% outside −2 SD and 19.88% outside +2 SD), whereas the prevalence rate of the clinically significant overall tooth size

Table 1: Sample distribution according to sex and malocclusion

Malocclusion	Male (*n*=82)	Female (*n*=94)	Total (%)
Class I	44	50	94 (53.4)
Class II division 1	11	26	37 (21)
Class II division 2	25	11	36 (20.4)
Class III	2	7	9 (5.1)

Table 2: Mesiodistal tooth widths for the total sample and for the right and left sides (mm)

Arch	Tooth	Total (*n*=176)				Right		Left		*P* value
		Mean	SD	Max.	Min.	Mean	SD	Mean	SD	
Maxillary arch	Central incisor	8.45	0.60	10.21	6.84	8.43	0.60	8.46	0.60	0.70
	Lateral incisor	6.44	0.60	8.51	4.95	6.48	0.62	6.40	0.59	0.21
	Canine	7.43	0.45	8.89	5.89	7.45	0.43	7.40	0.46	0.06
	1st premolar	6.58	0.50	7.83	5.33	6.54	0.50	6.62	0.51	0.12
	2nd premolar	6.27	0.53	8.25	4.91	6.27	0.54	6.27	0.53	0.97
	1st molar	9.88	0.60	12.00	8.60	9.92	0.61	9.84	0.58	0.19
Mandibular arch	Central incisor	5.16	0.46	7.00	4.09	5.16	0.47	5.17	0.45	0.78
	Lateral incisor	5.67	0.46	7.00	4.00	5.68	0.45	5.66	0.48	0.65
	Canine	6.57	0.43	8.00	5.25	6.58	0.43	6.56	0.43	0.65
	1st premolar	6.67	0.51	8.00	5.50	6.64	0.50	6.71	0.51	0.21
	2nd premolar	6.73	0.52	8.50	5.31	6.69	0.51	6.78	0.53	0.12
	1st molar	10.69	0.70	12.50	8.86	10.67	0.72	10.72	0.69	0.53

Table 3: Comparison of mesiodistal tooth widths between male and female groups (mm)

Arch	Tooth	Male (*n*=82)		Female (*n*=94)		*P* value
		Mean	SD	Mean	SD	
Maxillary arch	Central incisor	8.57	0.56	8.34	0.61	0.0003
	Lateral incisor	6.50	0.52	6.40	0.66	0.11
	Canine	7.57	0.41	7.30	0.44	0.0001
	1st premolar	6.68	0.50	6.49	0.49	0.001
	2nd premolar	6.33	0.53	6.22	0.53	0.06
	1st molar	9.95	0.65	9.82	0.55	0.05
	Cumulative tooth width	91.19	4.91	89.14	4.96	0.01
	Mean difference			2.04		
Mandibular arch	Central incisor	5.21	0.44	5.12	0.48	0.09
	Lateral incisor	5.74	0.44	5.62	0.48	0.02
	Canine	6.73	0.43	6.42	0.38	0.00001
	1st premolar	6.74	0.51	6.61	0.50	0.02
	2nd premolar	6.80	0.55	6.67	0.49	0.02
	1st molar	10.87	0.74	10.54	0.62	0.00001
	Cumulative tooth width	84.20	4.70	81.97	4.43	0.001
	Mean difference			2.22		

Table 4: Descriptive comparison of mesiodistal tooth width for normal and malocclusion groups (mm)

Arch	Tooth	Normal (*n*=94)		Malocclusion (*n*=82)		*P* value
		Mean	SD	Mean	SD	
Maxillary arch	Central incisor	8.41	0.65	8.49	0.53	0.21
	Lateral incisor	6.39	0.62	6.51	0.57	0.07
	Canine	7.41	0.44	7.44	0.46	0.48
	1st premolar	6.59	0.50	6.57	0.51	0.71
	2nd premolar	6.25	0.56	6.30	0.50	0.37
	1st molar	9.88	0.65	9.88	0.54	0.94
	Cumulative tooth width	89.86	5.39	90.37	4.59	0.50
	Mean difference			0.51		
Mandibular arch						
	Central incisor	5.13	0.49	5.20	0.42	0.19
	Lateral incisor	5.66	0.50	5.69	0.42	0.55
	Canine	6.58	0.44	6.56	0.42	0.64
	1st premolar	6.70	0.52	6.64	0.49	0.26
	2nd premolar	6.73	0.56	6.74	0.47	0.78
	1st molar	10.69	0.73	10.69	0.67	0.97
	Cumulative tooth width	82.98	5.10	83.04	4.18	0.93
	Mean difference			0.05		

discrepancy was found in 14.20% of the sample (25 of 176 subjects) (1.70% outside −2 SD and 12.5% outside +2 SD).

DISCUSSION

It has been reported that early adulthood dentition is the period of choice for obtaining accurate tooth size measurements as teeth in this stage have less damage and less attrition in most individuals.[12,26] For this reason, the age range of the subjects included in this study was between 13 and 25 years, in an attempt to minimize the influence of such factors on the actual tooth size measurements.

In the present study, no statistically significant differences were found in the mesiodistal tooth size widths between left and right sides. The same was reported by Hattab *et al*.[7] for Jordanians and Hashim and Al-Ghamdi[12] for Saudi population who have the same ethnic background. The finding of the present study also supports other studies carried out on other racial groups.[27-29] On the other hand, this finding is not in line with the results of other authors who found a definite difference between left and right tooth measurements.[13,30,31] Based upon the present study, it can be suggested that either right or left side measurements could be taken to represent the tooth size of this population.

The results of the present study revealed that male subjects exhibited larger tooth size width than female subjects in both upper and lower jaws. This difference was also observed in the cumulative tooth size widths, where males exceeded those of the females by 2.04 mm in the maxilla and 2.22 mm in the mandible [Table 3]. This finding is in agreement with those reported for other Arabian groups of Iraqis,[5] Jordanians,[7,13,15] and Saudis,[12] and also for other racial groups.[4,11,14]

Table 5: Descriptive comparison of anterior and overall ratios for male and female groups (%)

	Total (*n*=176)		Male (*n*=82)		Female (*n*=94)		*P* value
	Mean	SD	Mean	SD	Mean	SD	
Anterior ratio	78.08	3.22	78.12	2.97	77.96	3.45	0.75
Overall ratio	92.16	2.46	92.35	2.21	92.00	2.65	0.35

Table 6: Comparison of anterior and overall ratios between normal and malocclusion groups (%)

	Normal (*n*=94)		Malocclusion (*n*=82)		*P* value
	Mean	SD	Mean	SD	
Anterior ratio	78.36	5.24	77.86	4.62	0.51
Overall ratio	92.49	5.41	92.02	4.88	0.54

Ghose and Baghdady[5] have suggested that it is more appropriate to compare any such data obtained from a specific group to those drawn from other similar ethnic groups of the same area living in different geographic locations. Since our current data were drawn from Yemenis – inhabitants of the Arabian Peninsula – who are considered, historically speaking, to be the origin of all Arabs, we believed that it would be interesting to first compare our results with those of other Arabian groups living in the same geographic area and then with other racial groups. Ghose and Baghdady[5] compared the tooth size of Iraqis, Bedouins, and Yemenis (Yemeni Jewish immigrated to Israel upon its establishment in 1948 and later); all these groups live in the Arabian Peninsula. They found significant decrease in the tooth size width from north to south, and Yemenis were found to have the smallest tooth size, followed by Bedouins and Iraqis. This is actually what was observed in our present study when tooth widths of Yemeni Arabians were compared with those of Saudis[32] and Jordanians[13] who belong to the same geographic area [Table 8]. It was interesting to find out a real gradual increase in the tooth size from south to north, with Yemenis (south part) showing the smallest tooth size, followed by Saudis (middle part) and Jordanians (north part).

The results of the present study showed that the mean Bolton's anterior ratio of Yemenis was 78.08±3.22%, whereas the mean Bolton's overall ratio was 92.16±2.46%. Although the anterior and overall ratios for Yemenis found in the present study were very close to Bolton's values of 77.2±1.65% and 91.3±1.91%, however, the SD of both anterior and overall ratios of our result are larger than those of Bolton's results. This might have been caused by the fact that 46.5% of our subjects (82/176) had malocclusions and Bolton's subjects had excellent occlusion.

According to the results of the present study, no statistically significant differences were found in the anterior and overall ratios between males and females. This finding is in agreement with those of previous studies on other populations.[9,13,15,19-21,24,25,32] Further, there were also no statistically significant associations between tooth size ratios and malocclusion groups. This finding is in line with those reported by Al-Khateeb and Abu Alhaija,[13] Crosby and Alexander,[24] and Alkofide and Hashim,[33] who failed to find significant differences in the Bolton's ratios within the different malocclusions. On the other hand, some investigators have demonstrated an existing correlation between tooth size discrepancies and malocclusion groups.[20-23]

Bolton[1,2] suggested that a ratio greater than 1 SD from his reported mean values indicates a need for diagnostic consideration. More recently, 2 SD outside the Bolton's

Table 7: Distribution of subjects with anterior and overall tooth size discrepancies (%)

	Anterior ratio no (%)			Overall ratio no (%)		
	Outside –2 SD	-2 SD to +2 SD	Outside +2 SD	Outside -2 SD	-2 SD to +2 SD	Outside +2 SD
	<73.89	73.89–80.50	>80.51	<87.47	87.48–95.12	> 95.13
Total (176)	17 (9.65)	124 (70.45)	35 (19.88)	3 (1.70)	151 (85.79)	22 (12.5)

Table 8: Mesiodistal tooth width in Yemenis compared with other Arabian populations

Arch	Yemeni (*n*=176)		Saudi (*n*=30)*		Jordanian (*n*=140)**	
	Mean	SD	Mean	SD	Mean	SD
Upper						
Central incisor	8.45	0.60	8.64	0.57	9.57	0.67
Lateral incisor	6.44	0.60	6.68	0.53	7.35	0.63
Canine	7.43	0.45	7.60	0.50	8.50	0.65
1st premolar	6.58	0.50	6.94	0.45	7.66	0.54
2nd premolar	6.27	0.53	6.61	0.37	7.24	0.64
1st molar	9.88	0.60	10.56	0.52	11.28	0.61
Lower						
Central incisor	5.16	0.46	5.45	0.64	5.86	0.39
Lateral incisor	5.67	0.46	5.98	0.48	6.43	0.49
Canine	6.57	0.43	6.68	0.47	6.57	0.52
1st premolar	6.67	0.51	6.90	0.52	7.75	0.58
2nd premolar	6.73	0.52	7.08	0.43	7.76	0.80
1st molar	10.69	0.70	10.93	0.58	11.74	0.69

*Murshid and Hashim (1993) **Al-Khateeb and Abu Alhaija (2006)

mean ratio has been accepted as a clinically significant ratio for determining tooth size discrepancy. In the present study, the ratios outside 2 SD from Bolton's mean were used as values indicating clinically significant tooth size discrepancy.[14,18,20,21,25,34]

The present study found that 29.53% of the sample (52 of 176 subjects) had anterior tooth width ratios greater than 2 SD from Bolton's mean. This finding is similar to those reported by Santoro *et al*. (28%)[9] and Freeman *et al*. (30.6%),[35] and higher than those observed by Crosby and Alexander (22.9%),[24] Araujo and Souki (22.7%),[22] Bernabe *et al*. (20.5%),[10] Othman and Harradine (17.4%),[36] Al-Omari *et al*. (23.7),[15] and Endo *et al*. (14.4),[34] and less than that of Othman *et al*. for Malaysian (47.5%) population.[37]

The prevalence rate of clinically significant overall tooth size discrepancy of the present sample was 14.2% (25 0f 176 subjects). This rate was relatively similar to those reported by Freeman *et al*. (13.4%)[35] and Santoro *et al*. (11%) for Dominican American,[9] higher than those found by Bernabe *et al*. (5%) for Peruvian,[10] Othman and Harradine (5.4%),[36] Endo *et al*. (7.6%) for Japanese,[34] and Al-Omari *et al*. (9.5%) for Jordanians,[15] and less than that of Akyalcin *et al*. (48%) for the Turkish.[25]

On the basis of the foregoing, it is clear that Bolton's ratios can be applied and used for Yemeni orthodontic patients. However, it is probably necessary to perform regular tooth size analysis since a large number of Yemeni subjects included in the present study possess tooth size discrepancy that may affect the final treatment results. Moreover, further studies are required to isolate the probable cause of these discrepancies by including larger sample of Yemeni subjects, in general, and also by including more subjects in each type of malocclusion, in particular.

CONCLUSIONS

1. The results of the present study provide the mean mesiodistal tooth size width and Bolton's ratios which could be useful clinical information for orthodontic practice in Yemen.
2. There were no significant differences in the tooth size width between right and left sides.
3. Males showed significantly larger teeth than females.
4. The prevalence rate of clinically significant discrepancy greater than 2 SD was 29.53% and 14.20% in the anterior and overall tooth size ratios, respectively.
5. The findings of the present study indicate that there was no significant difference between Bolton's ratio and that of Yemeni population.

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How to cite this article: Al-Gunaid T, Yamaki M, Saito I. Mesiodistal tooth width and tooth size discrepancies of Yemeni Arabians: A pilot study. J Orthodont Sci 2012;1:40-5.

Source of Support: Nil, **Conflict of Interest:** None declared.