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Bolton's intermaxillary tooth size ratios among Iranian schoolchildren

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Abstract

Objectives: The aims of the present study were to determine anterior and total tooth-width ratios in a representative Iranian sample in Tabriz city and compare them with the Bolton standards. **Study design:** A total of 54 Iranian schoolchildren (12-14 years old) in Tabriz were examined. Alginate impressions were taken for subjects and poured by the dental stone. The mesiodistal widths of the teeth were measured using a digital caliper. The overall and anterior Bolton's intermaxillary tooth size ratios for each model pair was calculated. **Results:** There were no significant differences ($p > 0.05$) between the right and left sides of the dental arch and a symmetry in size exists. There were no significant differences between genders for all teeth measured except for the maxillary central incisors, maxillary canines and mandibular canines. Anterior and overall Bolton ratios for males were 77.72 ± 0.25 and 92.44 ± 0.19 and for females were 78.48 ± 0.30 and 92.45 ± 0.23 percent, respectively. There were no statistically significant differences between males and females for the anterior and overall ratios. The anterior and overall Bolton ratios among Tabrizian schoolchildren were 78.10 ± 0.28 and 92.24 ± 0.21 percent, respectively. There was no statistically significant difference between these ratios and those were found in the Bolton study. **Conclusion:** No significant differences between the mesiodistal sizes of contralateral teeth were observed and a symmetry in size exists. There were no significant differences in the mesiodistal sizes of similar teeth between males and females except for the maxillary central incisors, maxillary canines and mandibular canines. Significant differences in Bolton ratio between males and females, and examined population (student from Tabriz, Iran) and the Bolton's weren't observed either.

Key words: *Tooth size ratio, Bolton ratio, tooth size discrepancy, Iranian population.*

Introduction

Andrews (1972) studied the dental casts of 120 non-orthodontic individuals with normal occlusion and concluded that there are six essential 'keys' required to achieve this normal occlusion. McLaughlin et al. (2001) stated that tooth size should be considered the 'seventh key' and without coordination between the sizes of the upper and lower teeth, it would be impossible to obtain a good occlusion during the final stages of orthodontic treatment called 'tooth size discrepancies' (TSD) (1).

Proffit (2007) defined TSD as a disproportion among the size of individual teeth. Without a correct match of the mesiodistal widths of the maxillary and mandibular teeth, it is difficult to obtain an ideal overjet and overbite and a good occlusion during the final stages of orthodontic treatment (1,2).

Orthodontic treatment should result in appropriate points of contact between neighboring teeth. Appropriate proportions in tooth sizes are needed to achieve this. However, some discrepancies between tooth sizes are not apparent until the final stages of orthodontic treatment (3,4). Consequently, there have been several studies suggesting methods of defining and measuring tooth size discrepancy, but the best-known study of tooth size disharmony in relation to treatment of malocclusion was by Bolton in 1958 (5).

Bolton (1958) developed a method for evaluation of maxillary to mandibular tooth-width proportions based on 55 subjects with excellent occlusions. He developed two ratios for estimating TSD by measuring the summed mesiodistal widths of the mandibular to maxillary teeth. The anterior Bolton index is obtained by dividing the mesiodistal size of the 6 mandibular anterior teeth (canine to canine) by the mesiodistal size of the 6 maxillary anterior teeth; the total Bolton index is obtained by dividing the mesiodistal size of the 12 mandibular teeth (first molar to first molar) by the mesiodistal size of the 12 maxillary teeth (1).

The indexes extrapolated from Bolton's study for a correct occlusion were anterior Bolton index = 77.2%, SD 1.65, and total Bolton index = 91.3%, SD 1.91. Bolton (1962) also suggested that a ratio greater than 1 SD from his reported mean values indicates a need for diagnostic consideration and a possible treatment need. Other authors have defined a significant discrepancy as a value more than 2 SD from Bolton's mean (1,3).

The subjects in Bolton's original sample were chosen to have excellent occlusions, so all the cases had Bolton ratios, which did not prevent a good occlusion by his definition.

Populations differ in interarch tooth-size relationships, and differences in tooth sizes are not systematic. The population and sex composition of Bolton's sample were not specified, but it is likely that the selection was biased (6).

A review of literature reveals that the incidence of TSD has been found to vary between different racial and population groups. Smith et al. found significant differences in Bolton's overall, anterior and posterior interarch ratios between Caucasians, Blacks and Hispanics and suggested that population specific standards are necessary for clinical assessments (6). Therefore, different norms and standards have been developed for different ethnic and racial groups. The incidence of TSD has been established for white Americans (6), black Americans (6), Chinese (7,8), Japanese (9), Spanish (4), South Americans (10-13), Turkish (14,15), and Saudi Arabian (16,17) populations. Normal measurements for one group should not be considered normal for every race or ethnic group. Different racial groups must be treated according to their own characteristics (12).

Most research on TSD investigated the effect of sexual dimorphism. They did not, however, demonstrate a common trend, with most of the studies finding no differences in the prevalence of TSD between males and females (4,7,13-17).

There appears to be no published data on the prevalence of TSD in a representative sample of the Iranian population. Therefore, the aims of the present study were to determine anterior and total tooth-width ratios in a representative Iranian sample in Tabriz city and compare them with the Bolton standards.

Materials and Methods

-Ethical approval

Written consents were obtained from the parents of all students who underwent examination and/or impression taking.

-Sample

A total of 54 Iranian schoolchildren (12-14 years old) in Tabriz, the largest city in the northwest of Iran with a population over 1.5 million were examined. This group includes equal number of the both genders. Alginate impressions were taken for subjects who fulfilled the following criteria:

1. Azari-iranian ancestors (Caucasian) at least from one previous generation
2. All permanent teeth erupted (except third molars)
3. No interproximal caries or restorations
4. No missing or supernumerary teeth
5. No abnormally sized or shaped teeth
6. Minimal or no tooth wear
7. No previous orthodontic treatment
8. Normal occlusion with Class I relationship, no arch discrepancy and normal overjet and overbite

Impressions were poured on the same day with hard dental stone, using standard procedures for material mixing, impression disinfection, and taking into consideration correct storage of impressions until they were poured. The dental casts were not soaped or waxed.

-Measurements

The measurements were carried out using a digital caliper (Guanglu Measuring Instrument Co., China) with an accuracy of 0.01 mm. The mesiodistal widths of the teeth were measured twice by the same examiner and in the condition of any difference more than 0.2 mm, the measurement was repeated and the mean of the closest values was reported.

The overall and anterior ratios for each model pair was calculated using the following equations: Overall ratio = sum of the mesiodistal diameter of 12 mandibular teeth x 100/ sum of the mesiodistal diameter of 12 maxillary teeth; Anterior ratio = sum of the mesiodistal diameter of 6 mandibular teeth x 100/ sum of the mesiodistal diameter of 6 maxillary teeth. These ratios were compared to Bolton results.

-Statistical analysis

Statistical analysis was carried out using SPSS 13.0 analytic software. The Kolmogorov-Smirnov test showed a regular frequency distribution, so we could use parametric statistical tests. An independent sample t-test was used to measure differences between genders and a one sample t-test to compare the intermaxillary ratio of this study and one was found in the Bolton study. Significance was set at the 5 per cent level (P < 0.05).

Results

-Tooth measurements

The mean, standard deviation (SD), and standard error of the mean (SEM) of the mesiodistal tooth measurements are shown in table 1. The results showed that there were no significant differences (p > 0.05) between the right and left sides of the dental arch and a symmetry in size exists (Table 1).

-Tooth size ratio and gender

There were no significant differences between genders for all teeth measured except for the maxillary central incisors, maxillary canines and mandibular canines (P

= 0.020, P = 0.027 and P = 0.040 respectively). Males had larger tooth sizes in these exceptions. Anterior and overall tooth size ratios for males were 77.72±0.25 and 92.44±0.19 and for females were 78.48±0.30 and 92.45±0.23 percent, respectively. There were no statistically significant differences between males and females for the anterior and overall ratios (P = 0.312 and P = 0.986, respectively).

-Tooth size ratio in Tabrizian schoolchildren

The anterior and overall ratios for the TSD among Tabrizian schoolchildren were 78.10±0.28 and 92.24±0.21 percent, respectively. There was no statistically significant difference between these ratios and those were found in the Bolton study (P = 0.460 and P = 0.632, respectively).

Discussion

The Bolton sample was obtained from 55 models with excellent occlusion, 44 orthodontically treated and 11 untreated. In our sample, all 54 models also had optimal occlusions (Class I with no arch discrepancy) and the same age, a direct statistical comparison between groups was possible. However, the sex composition of Bolton's patients was not specified (1,4,9), in this study there was equal number of the both genders, and the age of the sample was relatively young (12-14 years old) in order to minimize the influence of tooth wear.

Most of the other investigations derived their sample from an orthodontic population (3,5,9). In a few studies, the samples comprised a normal population chosen from schoolchildren (1). This study chose its sample among the Iranian schoolchildren.

No significant difference between measurements of contra-lateral teeth was found and therefore, there were symmetry of the tooth sizes. This finding agrees with many previous studies (18).

The results demonstrated no significant difference in mesiodistal tooth width between males and females for

Table 1. The mean, standard deviation (SD), and standard error of the mean (SEM) of the mesiodistal tooth measurements.

Upper arch	Mean	SD	SE	Lower arch	Mean	SD	SEM
Upper right central	8.41	0.52	0.28	Lower right central	5.23	0.33	0.23
Upper left central	8.37	0.58	0.25	Lower left central	5.22	0.34	0.25
Upper right lateral	6.52	0.44	0.22	Lower right lateral	5.73	0.40	0.25
Upper left lateral	6.50	0.47	0.23	Lower left lateral	5.69	0.41	0.21
Upper right canine	7.66	0.44	0.25	Lower right canine	6.66	0.45	0.30
Upper left canine	7.64	0.44	0.19	Lower left canine	6.66	0.45	0.21
Upper right first premolar	6.88	0.39	0.25	Lower right first premolar	6.90	0.46	0.25
Upper left first premolar	6.91	0.37	0.28	Lower left first premolar	6.90	0.45	0.26
Upper right second premolar	6.46	0.53	0.24	Lower right second premolar	6.92	0.45	0.24
Upper left second premolar	6.41	0.42	0.26	Lower left second premolar	6.92	0.45	0.18
Upper right first molar	9.76	0.53	0.20	Lower right first molar	10.77	0.69	0.29
Upper left first molar	9.77	0.52	0.23	Lower left first molar	10.80	0.69	0.20

Table 2. Anterior and overall tooth size ratios in different populations.

Population	Author	Anterior ratio (%)	Overall ratio (%)
White Americans	Bolton (1958) (1)	77.2	91.3
	Crosby and Alexander (1989) (2)	77.5	91.4
	Smith <i>et al.</i> (2000) (6)	79.6	92.3
Black Americans	Smith <i>et al.</i> (2000) (6)	79.3	93.1
Spanish	Smith <i>et al.</i> (2000) (6)	80.5	93.4
	Paredes <i>et al.</i> (2006) (4)	78.32	91.97
Dominican	Santoro <i>et al.</i> (2000) (10)	78.1	91.3
Peruvian	Bernabé <i>et al.</i> (2004) (11)	78.09	91.33
Brazilian	Freire <i>et al.</i> (2007) (12)	77.83	91.46
Chinese	Ta <i>et al.</i> (2001) (8)	77.5	90.9
	Nie and Lin (1999) (7)	81.52	93.27
Japennese	Endo (2007) (9)	78.39	91.60
Saudi Arabian	Al-Tamimi and Hashim (2005) (17)	77.4	91.4
Turkish	Uysal <i>et al.</i> (2005) (15)	78.26	89.88
	Akyalcin <i>et al.</i> (2006) (14)	78.15	91.34
Jordanian	Al-Omari <i>et al.</i> (2008) (1)	78.6	92.2
Iranian (Tabriz city)	Present study	78.10	92.24

most teeth, except for the maxillary central incisors, maxillary canines and mandibular canines which were larger among male group. This agrees with the results of most previous studies which have reported some degrees of sexual dimorphism in tooth size measurements (2,19-21). Based on most previous investigations, males possess larger tooth crowns than females in contemporary human populations, although the degree of dimorphism varies within different populations.

The results of this investigation showed that there were no statistically significant differences between males and females for the anterior and overall ratios. Although, the tooth size ratios for females were larger, the differences were small. This finding disagrees with most studies (4,7,14,16,17). Although those studies demonstrated a tendency for larger Bolton ratios in males, the differences were not statistically significant. However, some other studies showed a sex difference in the overall ratio among different populations, suggesting a sex difference in the tooth size ratio may be population specific (6,11,15).

Table 2 compares the anterior and overall tooth size ratios for Iranian (Tabriz city) with other populations. A review of literature of studies shows that significant differences exist among the various ethnic groups. Therefore, tooth size ratios have been established for different ethnic and racial groups. The measurements reported here for Iranian (Tabriz city) were close to the mean anterior and overall Bolton ratios. In addition, the findings of the present study supports the results of tooth size ratios reported for most of the other populations (Table 2).

However, this study showed values of anterior ratio (78.10) and overall ratio (92.24) very similar to those

suggested by Bolton (4) (anterior ratio = 77.2 / overall ratio = 91.3), these values were slightly larger than in Bolton's. The reason for this finding might be the population of the sample and the ethnic groups. Similar findings of large anterior or overall ratios compared with Bolton's were obtained by previous studies of different populations (4,6-8,10,11,14,15).

Conclusions

In the present investigation, the anterior and overall tooth size ratios for Iranian schoolchildren were established. The findings showed the following:

1. There were no significant differences between the mesiodistal sizes of contralateral teeth and symmetry in size exists.
2. There were no significant differences in the mesiodistal sizes of similar teeth between males and females except for the maxillary central incisors, maxillary canines and mandibular canines.
3. There were no significant differences in Bolton ratio between males and females.
4. There were no significant differences in tooth size ratio between the examined population (student from Tabriz, Iran) and the Bolton's.

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