

Comparison of Tooth Size Discrepancy of Three Main Ethnicities in Malaysia with Bolton's Ratio

(Perbandingan Diskrepansi Saiz Gigi di antara Tiga Etnik Majoriti
di Malaysia dengan Nisbah Bolton)

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ABSTRACT

The objective of this study was to investigate the applicability of Bolton's ratios in orthodontic population of Malaysian main ethnicities; Malay, Chinese and Indians. Ninety convenient samples consisting of 30 pre-orthodontic study casts from each ethnic that fits the inclusion criteria were selected. The greatest mesiodistal widths of each tooth from six to six for overall ratio and three to three for anterior ratio were measured using a digital callipers linked to Hamilton Arch Tooth System software to the nearest 0.01mm. Means of the ratios were calculated using Bolton analysis. One sample t-test statistic analysis was carried out to compare the means with Bolton values of anterior ratio and overall ratio and one-way ANOVA was used to analyze comparison between ethnic groups of the anterior ratio and the overall ratio with the level of statistical significance set at $p < 0.05$. However, there were no significant differences when comparing Bolton values with Chinese and Indian anterior and overall ratios. The Bolton standards could be applied to Malaysian Chinese, Indians and Malay's female. Subsequently, a specific standard should be used for the Malays orthodontic population.

Keywords: Bolton's ratio; Malaysian ethnicities; tooth size discrepancy

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji pelaksanaan nisbah Bolton dalam populasi ortodontik etnik utama Malaysia iaitu; Melayu, Cina dan India. Sembilan puluh sampel selesa terdiri daripada 30 tuangan kajian pra-ortodontik daripada setiap etnik yang sesuai dengan kriteria inklusi telah dipilih. Kelebaran mesiodistal terbesar dari setiap gigi dari gigi enam ke enam untuk nisbah keseluruhan dan tiga ke tiga untuk nisbah anterior diukur dengan menggunakan kaliper digital yang di sambung dengan perisian "Hamilton Arch Tooth System" ke 0.01 mm yang terdekat. Min nisbah dikira menggunakan analisis Bolton. Satu sampel ujian-t analisis statistik dilakukan untuk membandingkan min dengan nilai Bolton nisbah anterior dan nisbah secara keseluruhan dan "one-way ANOVA" digunakan untuk membandingkan antara kumpulan etnik nisbah anterior dan nisbah secara keseluruhan dengan tahap tekal statistik ditetapkan pada $p < 0.05$. Namun, tidak ada perbezaan yang tekal dalam nilai Bolton dengan nisbah anterior dan secara keseluruhan Cina dan India. Standard Bolton boleh diaplikasikan pada kaum Cina, India dan perempuan Melayu di Malaysia. Selanjutnya, piawaian tertentu harus digunakan untuk penduduk ortodontik Melayu.

Kata kunci: Diskrepansi saiz gigi; etnik di Malaysia; nisbah Bolton

INTRODUCTION

A tooth-size discrepancy (TSD) conventionally has been described as a relative excess of tooth structure in one arch in relation to the other arch. It also widely defined as a degree of disproportion among the size of individual teeth (Proffit & Fields 2000; Proffit et al. 2007). Several methods have been used by orthodontist to measure and detect interarch TSD in orthodontic patients. A few methods which are still used today are Kesling's diagnostic setup, Howes' ratio of canine fossa width to total maxillary tooth width, and Neff's anterior coefficient (Stifter 1958).

A more popular tooth size analysis, Bolton analysis has been described by Bolton in 1958. The analysis method was developed after measurements taken from 55 cases with excellent occlusion, mostly had been treated

orthodontically with non extraction therapy. Two ratios, anterior and overall were developed for estimating TSD. It was suggested that for proper coordination of maxilla and mandibular teeth, anterior ratio of 77.2 ($\pm 1.65\%$) and overall ratio of 91.3 ($\pm 1.9\%$) are necessary. These ratios should be the tools used in orthodontic diagnosis that will allow orthodontist to gain insights into the functional and aesthetic outcome without the used of diagnostic setup (Bolton 1958; Bolton 1962).

Although Bolton analysis has proven extremely useful in clinical setting to act as a guide for extreme TSD, its application is not without limitations. First, Bolton's estimates of variation were underestimated because the samples were derived from perfect Class I occlusions (Crosby & Alexander 1989; Freeman et al. 1996 & Smith

et al. 2000). Second, the population and gender composition of Bolton’s sample were not specified, which implies potential selection bias (Smith et al. 2000).

Most studies indicated that normal measurements for one group should not be considered normal for other race and ethnic groups. Different racial group must be treated according to their own characteristics. Bolton data has not meet the same TSD ratios mean for some of other populations with marked statistical differences found in studies carried out by other authors in the Peruvian population (Bernabě et al. 2004), Turkish population (Uysal & Sari 2005), Spanish population (Paredes et al. 2006) and Polish population (Wedrychowska-Szulc et al. 2010). As for Asian population, in agreement with results of previous studies on several other populations, Bolton’s anterior ratio was not applicable to the Southern Chinese (Ta et al. 2000) and Japanese population (Endo et al. 2007) and suggestive of specific standard tooth size ratios for the populations.

To date, this is the first study on TSD among Malaysian majority ethnics. However there are similar studies done only on Malay population (Abdullah 2007) and on dental students in the University of Malaya (Othman et al. 2008). The purpose of this study was to assess the applicability of Bolton’s ratios by accomplishing the following; to calculate and compare the anterior and overall ratios among the 3 majority ethnic groups in Malaysia; Malay, Chinese and Indian. Further comparison will be made between the mean of anterior and overall ratios of each ethnic and the general Malaysian data with Bolton’s original study.

MATERIALS AND METHODS

A total of 90 samples consisting of 30 (15 males and 15 females) orthodontic study casts from each ethnic group that fit the criteria shown in Figure 1 were selected. The pretreatment study casts were taken from patients undergoing orthodontic treatment in Dental Faculty, University of Malaya. All subjects were between 14 and 24 years of age.

Measurements of the greatest mesiodistal width of each tooth were taken with the digital callipers tips held perpendicular to the long axis of each tooth from the first molar to the first molar of each cast. The mesiodistal widths from the contact points of canine to canine for anterior ratio and first molar to first molar for overall

ratio were measured on each cast to the nearest 0.01 mm. The callipers were connected to a computer running the Hamilton Arch Tooth System (HATS) software which calculates the Bolton analysis and recommends the tooth size correction.

Five study casts were randomly selected for assessment of reproducibility. The same examiner repeated the measurements two weeks after the first measurement and was compared as described by Houston (1983). Coefficients of reliability were 0.950 and 0.923 for overall and anterior ratios, respectively and these results showed that the measurements could be repeated with high accuracy.

Data distribution was evaluated using histogram to check for normal distribution. Analysis of variance (ANOVA) was used to compare Bolton data between ethnic groups. One sample *t*-test was used to compare the means from study samples with Bolton’s values. All statistical analyses were carried out using Statistical Package for Social Sciences (SPSS) system version 12.0 with the level of statistical significant determinant in this study is $p < 0.05$.

RESULTS

The mean values of anterior ratio and overall ratio in each ethnic group are demonstrated in Table 1 and 2 respectively and one-way ANOVA was used to analyse the comparison between ethnics of the anterior ratio and the overall ratio. For Malays, the anterior and overall ratio are $(78.93 \pm 2.67\%)$ and $(92.51 \pm 2.21\%)$ showing the highest ratio mean, with the lowest anterior and overall ratio displayed by Chinese at $(76.55 \pm 2.68\%)$ and $(90.93 \pm 1.87\%)$, and Indians at $(77.77 \pm 2.89\%)$ and $(91.37 \pm 2.26\%)$ respectively. The ANOVA test is significant for both anterior ratio ($p = 0.005$) and overall ratio ($p = 0.015$). Subsequent post hoc test with Bonferroni procedure shows that there were significant differences ($p < 0.05$) found between Malays and Chinese of the anterior ratio ($p = 0.004$) and overall ratio ($p = 0.015$).

The Malaysian anterior and overall value compared with Bolton’s ratios of $77.2 (\pm 1.65\%)$ and $91.3 (\pm 1.91\%)$, respectively displayed of no significant differences ($p > 0.05$) (Table 3). Table 4 summarizes that Bolton data is applicable to Malaysian Chinese and Indian ($p > 0.05$) but not for Malay’s sample ($p < 0.05$).

Inclusion criteria	Exclusion criteria
1. Good quality pretreatment study models	1. Clinically visible dental caries, proximal restorations (Class II amalgam or composite), buildups, crowns, onlays that affect the tooth’s mesiodistal diameter
2. Fully erupted and complete permanent dentitions from first molar to first molar	2. Congenital defects or deformed teeth
3. Malay, Chinese, and Indian ethnicity. Ethnicity determinant was according to patient’s name and race in the registration form	3. Obvious interproximal or occlusal wear of teeth
	4. Previous or ongoing orthodontic treatment

FIGURE 1. Inclusion and exclusion criteria

TABLE 1. ANOVA - Anterior ratio in each ethnic group

Ethnic Group	N	Mean (%)	SD (%)	F-statistic (df)	P value
Malay	30	78.93	2.67		
Chinese	30	76.55	2.68	5.57(2)	0.005*
Indian	30	77.77	2.89		

*Statistical significant at the level of significance 0.05

DISCUSSION

Ethnicity has a close association with genetics and hereditary. It is of no doubt that the ethnicity will affect the TSD greatly between population and ethnics (Othman & Harradine 2006). However, this is an exception if the population has intermarried and not considered 'pure' ethnic. Similar traits may be observed in the two different populations that originate from the same continent and on the other hand, the same ethnic from different country may not have the same findings of TSD. In agreement with this study in which the results displayed ethnicity specific means.

Bolton data has not meet the same TSD ratios mean from some of other populations with marked statistical difference found in studies carried out by a few authors in the Peruvian population (Bernabé et al. 2004), Turkish population (Uysal & Sari 2005), Spanish population (Paredes et al. 2006) and Polish population (Wedrychowska-Szulc et al. 2010). Generally these studies concluded of high prevalence rate of either posterior or anterior TSD of more than two standard deviation above Bolton's mean and a specific standard are required for the population for clinical assessment (Othman & Harradine

TABLE 2. ANOVA - Overall ratio in each ethnic group

Ethnic Group	N	Mean (%)	SD (%)	F-statistic (df)	P value
Malay	30	92.51	2.21		
Chinese	30	90.93	1.87	4.40(2)	0.015*
Indian	30	91.37	2.26		

*Statistical significant at the level of significance 0.05

2007). Contrary with the current preliminary study, there were no significant differences noted if compared the general Malaysian data in combination with Bolton means. This conflicting result might be due to the small sample size used in present preliminary study.

Paredes et al. (2006) reported that for a study conducted among Spanish population, the anterior and total width ratios are greater than Bolton's with mean of $78.32\% \pm 2.45\%$ and $91.97\% \pm 1.95\%$, respectively. Smith et al. (2000), on a study of three populations; discussed that different populations studied exhibited significantly different relationships between the lower and upper teeth. Whites showed the smallest overall ratio, followed by Hispanics and Blacks. He concluded that interarch tooth size relationships are population and gender specific. Bolton's original data do not represent Turkish population, and from a study conducted by Uysal & Sari (2005), a population specific normative study was performed. In establishing the normative data, they concluded that a discrepancy in the overall ratio was found in 18% of Turkish subjects with normal occlusions, and anterior ratios outside two standard deviations from the Bolton mean in 21.3 per cent of their sample similar to the finding of this study which shows significant differences of Bolton ratios of Malays sample. A more recent study of TSD on Turkish population (Oktay & Ulukaya 2010) also demonstrated that for both overall and anterior ratios, the means and standard deviations were larger than in Bolton's study. They concluded that the probable reason for the findings may be the types of population that constituted the samples.

From a study on the white, blacks and Hispanics, significant differences were also found in the overall, anterior and posterior interarch ratios between the three populations (Smith et al. 2000). They found that from the

TABLE 3. One sample t-test. Comparison of bolton study and the present study: mean values

Variable	Malaysian Mean	Bolton Mean	P Value
N	90		55
Anterior Ratio	77.7 (2.89)	77.2 (1.65)	0.07
Overall ratio	91.6 (2.20)	91.3 (1.91)	0.19

TABLE 4. One sample T-Test to compare bolton's value to each ethnic

Ethnic	Anterior Ratio			Overall ratio		
	Malay	Chinese	Indian	Malay	Chinese	Indian
Mean	78.93	76.55	77.77	92.51	90.93	91.37
SD	(2.68)	(2.68)	(2.89)	(2.13)	(1.87)	(2.26)
Bolton Mean (SD)		77.20 (1.65)			91.30 (1.91)	
P Value	0.001*	0.200	0.290	0.290	0.850	

*Statistical significant at the level of significance 0.05

study on 180 preorthodontic casts, the Bolton ratio are only applicable to their white females sample and concluded the ratios should not be indiscriminately applied to white males, blacks or Hispanics. It is because the relationships between the sizes of the mandibular and maxillary teeth are dependent on population, gender and arch segment lengths. The larger the maxillary arch segment length, the greater the discrepancy between Bolton's ratios and the actual ratios. These findings is in agreement with the current findings of Malaysian majority ethnics in which the Bolton anterior ratio cannot be applied to Malay's sample.

As for Asian population, in agreement with results of previous studies on several other populations, Bolton's anterior ratio was not applicable to the Southern Chinese (Ta et al. 2000) and Japanese (Endo et al. 2007) population, and suggestive of specific standard tooth size ratios for the populations. The study on the Southern Chinese children (Ta et al. 2000) comprises of 1247 samples of early permanent dentition, the Bolton standards is applicable only to those with Class I children, but not to those with Class II or Class III occlusions. They also found that tooth size discrepancy to be more frequent in the anterior region especially in the Class III occlusion group. A study on Singaporean Chinese by Lew and Keng (1991) reported that the anterior ratio was comparable with the Bolton standard in excellent Class I occlusion, even though Singaporean Chinese had smaller maxillary central incisors and larger maxillary lateral incisors.

There were no statistically significant differences found in the Bolton ratios for the six anterior teeth and the 12 teeth within the different malocclusions in the Jordanian sample according to Al-Khateeb and Abu Alhaija (2006). In their discussion, it was mentioned that the difference in the results between this study and the other investigations might be attributed to the sample size, method of analysis and large standard deviation found in this study. Although tooth size is strongly influenced by genetic and hereditary, but individual variations due to environment and diet may also play an important role in the population variability. Consideration has to be taken as each individual from different population may practice a different lifestyle. The limitation of the current study is the sample size does not represents the population ratios and further recommendation is to carry out study on bigger samples and various centres in order for the data to be valid and to be accepted as a norm for each ethnic.

CONCLUSION

There were no significant difference displayed between Bolton value and Malaysian value in combination. The Bolton standards can be applied to Malaysian Chinese and Indians but not to Malays orthodontic population. Subsequently, a specific standard should be used for the Malays orthodontic population. Significant differences in the ratio between Malays and Chinese suggest that

population specific standards are necessary for clinical assessments.

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