Research Article

A Study of Bolton's Analysis on Permanent Dentition of Nepalese Citizen of Lumbini Province

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ABSTRACT

Introduction: To achieve a good occlusion with satisfactory intercuspation of teeth and a correct overjet and overbite, the maxillary and mandibular teeth must be proportional in size. This cross-sectional study was conducted to assess the Bolton's tooth size discrepancy in a sample of the Nepalese population of Lumbini Province.

Materials and Method: One hundred twenty-five study casts (50 males and 75 females) were made after making impression of individuals with normal occlusion. Impression was made using alginate impression material, study casts were made using dental stone type III, and bases were made using dental plaster type II. Individual mesiodistal width of the teeth were measured using a digital vernier caliper to the nearest 0.01mm for the calculation of Bolton's anterior and overall ratio. The ratios were then compared between male and female.

Result: One hundred twenty-five study casts (50 males and 75 females) were made after making impression of individuals with normal occlusion. Impression was made using alginate impression material, study casts were made using dental stone type III, and bases were made using dental plaster type II. A statistically significant difference between the summed mesiodistal widths were found between males and females using Independent sample t-test. There was no sexual dimorphism concerning Bolton's ratio in samples. The overall ratio and anterior ratio were 91.70 ± 1.28 and 77.09 ± 1.57 for males and 91.79 ± 1.34 and 77.29 ± 1.71 for females respectively. The combined overall ratio was 91.75 ± 1.32 and anterior ratio which was 77.21 ± 1.65. Individual mesiodistal width of the teeth were measured using a digital vernier caliper to the nearest 0.01mm for the calculation of Bolton's anterior and overall ratio. The ratios were then compared between male and female.

Conclusion: The sum of mesiodistal dimensions of teeth were greater in males, however, no sexual dimorphism was found in the Bolton ratio. Further, statistically significant difference was found in the overall ratio from Nepalese population when compared to the original ratio by Bolton.

KEYWORDS: Anterior ratio, Bolton's analysis, Overall ratio, Tooth size discrepancy

INTRODUCTION

A tooth size discrepancy is defined as a disproportion among the sizes of individual teeth.[1] To achieve a good occlusion with the correct overbite and overjet, the maxillary and mandibular teeth must be proportional in size. The mesiodistal widths of teeth were first formally investigated by G.V. Black in 1902.[2] For the maxillary teeth to fit well with the mandibular teeth, there must be a definite proportionality of tooth size. The sum of the widths of the mandibular teeth must be somewhat smaller than the sum of the widths of the maxillary teeth because the mandibular teeth are aligned along an arc that is smaller than that of the maxillary teeth.[3]

The analysis, developed by W.A. Bolton and published in 1958, involved finding a ratio of size between the

maxillary and mandibular teeth by measuring the mesiodistal width of each tooth, excluding the second and third molars by measuring 55 casts with excellent occlusions. Bolton developed two ratios for determining the inter-arch tooth size discrepancy. One of the ratios was made by comparing the twelve teeth from the first molar to the contralateral first molar while the other ratio involved the anterior teeth from canine to canine. Bolton established ideal anterior and overall ratios with mean values of 77.2% and 91.3%, respectively, for proper harmony of maxillary and mandibular teeth.[4]

Bolton's analysis is widely used to assess tooth size discrepancy and helps in achieving an excellent finish at the end of the treatment. Tooth size discrepancy may vary in different populations.5,6 Gender differences have also been observed.[5,7] The purpose of this study was to assess Bolton's tooth size discrepancy in a sample of the Nepalese population of Lumbini Province.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Universal College of Medical Sciences (UCMS), College of Dental Surgery, Bhairahawa, Nepal. This study was approved by the Institutional Review Committee, Universal College of Medical Sciences, Bhairahawa, Nepal (UCMS/IRC/220/19). The duration of the study was from November 2019 to August 2021.

The inclusion criteria were:

1. Nepalese citizen of Lumbini Province
2. Angle's Class I molar and canine relation with no or minimal crowding (1 to 3 mm)
3. Normal overjet (2 to 3 mm) and overbite (1 to 2 mm)
4. Fully erupted permanent dentition from the first molar to the first molar
5. Age range 14 – 24 years

The exclusion criteria were:

1. Tooth agenesis
2. Missing teeth or fixed partial dentures
3. Grossly decayed tooth
4. Interproximal or occlusal wear of teeth
5. Congenital defects and deformed teeth
6. Spacing

Sample size was calculated using the formula:

$$\text{Sample size} = \frac{z^2 \sigma^2}{e^2}$$

where, Standard deviation (σ) = 1.99 (Hong et al. 2008)[8]

Z value (z) = 1.96

Level of precision (e) = 0.35% = 0.0035

Sample size = $1.96^2 \times 0.0199^2 / 0.0035^2$

= 124.188

≈ 125

Impression was made using alginate impression material (Coltene Whaledent Pvt. Ltd, India) and study casts were made using dental stone type III (Orthokal, Kalabhai Karson Pvt. Ltd, India), and bases were made using dental plaster type II (Kaldent, Kalabhai Karson Pvt. Ltd, India). All measurements were carried out by a single operator. Measurements on the casts were made using digital calipers (Liaoning MEC Group Co., Ltd. China) to the nearest 0.01mm. Individual mesiodistal widths measurement was taken from the first molar to the first molar in each arch. Measurements were made from the mesial contact point to the distal contact point of each tooth as suggested by Moorrees et al.[9] The summed mesiodistal width of 12 mandibular teeth was divided by summed mesiodistal width of 12 maxillary teeth for the overall ratio. The summed mesiodistal width of 6 mandibular anterior teeth was divided by summed mesiodistal width of 6 maxillary anterior teeth for the anterior ratio.[4]

Measurements were recorded in an Excel worksheet and analyzed using Statistical Package for the Social Sciences (SPSS) version 20.

RESULTS

Out of the total sample, 25% of the sample was remeasured by the same examiner at the interval of two weeks. For intraobserver reliability, Cohen's kappa analysis was performed. All the parameters showed near-perfect agreement with the value of 0.871 for the sum of mesiodistal width of 12 maxillary teeth, sum of mesiodistal width of 12 mandibular teeth, sum of mesiodistal width of 6 maxillary teeth; and 0.867 for sum of mesiodistal width of 6 mandibular teeth. Data normality was checked using Kolmogorov - Smirnov test. The test showed that variables such as the sum of mesiodistal width of twelve maxillary teeth, the sum of mesiodistal width of twelve mandibular teeth, the sum of mesiodistal width of six maxillary anterior teeth, and the sum of mesiodistal width of six mandibular anterior teeth were normally distributed. Out of 125 samples, 50 (40%) were males and 75 (60%) were females. Table 1 shows descriptive data i.e., mean, standard deviation, maximum value, and minimum value of all the parameters.

Table 1: Mean, Standard deviation, Maximum value, and Minimum value of all the parameters

SN	Parameter	Mean	SD	Maximum value	Minimum value
1.	Sum of mesiodistal width of 12 maxillary teeth (mm)	89.37	4.16	98.34	77.63
2.	Sum of mesiodistal width of 12 mandibular teeth (mm)	81.97	3.58	89.95	71.89
3.	Sum of mesiodistal width of 6 maxillary teeth (mm)	44.62	2.45	50.37	37.98
4.	Sum of mesiodistal width of 6 mandibular teeth (mm)	34.46	1.83	38.79	29.66
5.	Overall ratio (%)	91.75	1.32	95.13	90.02
6.	Anterior ratio (%)	77.21	1.65	80.77	74.27

Table 2 shows the gender distribution of study variables. Independent sample t-test was used to assess gender differences in all parameters. The result showed a statistically significant difference between the mean value of the sum of mesiodistal width of 12 maxillary teeth, the sum of mesiodistal width of 12 mandibular teeth, the sum of mesiodistal width of 6 maxillary teeth, and the sum of mesiodistal width of 6 mandibular teeth between males and females. The mean values of significant parameters were greater in males than in females. There was no significant difference between the overall ratio and anterior ratio between males and females.

Table 2: Gender – wise comparison of all the parameters

Parameter	Total Population (N = 125)		Sex				p- Value	95% C.I. of mean difference	
			Male (n = 50)		Female (n =7 5)				
	Mean	SD	Mean	SD	Mean	SD		Lower	Upper
Sum of mesiodistal width of 12 maxillary teeth (mm)	89.37	4.16	90.34	3.85	88.73	4.26	0.033*	0.13	3.09
Sum of mesiodistal width of 12 mandibular teeth (mm)	81.97	3.58	82.81	3.25	81.4	3.7	0.031*	0.13	2.68
Sum of mesiodistal width of 6 maxillary teeth (mm)	44.62	2.45	45.55	2.41	44.01	2.3	<0.001**	0.69	2.38
Sum of mesiodistal width of 6 mandibular teeth (mm)	34.46	1.83	35.1	1.7	34.03	1.81	0.001*	0.42	1.70
Overall ratio (%)	91.75	1.32	91.70	1.28	91.79	1.34	0.710	-0.57	0.39
Anterior Ratio (%)	77.21	1.65	77.09	1.57	77.29	1.71	0.497	-0.81	0.39

* Statistically significant at p <0.05
** Statistically highly significant at p <0.001

Table 3 shows the Independent sample t-test to compare parameters obtained in the present study with that of Bolton's Values and a statistically significant difference was noted between the two samples regarding the overall ratio.

Table 3: Statistical parameters obtained in the present study compared to the Bolton's Value

Parameter	Nepalese		Bolton's Values		p- Value	95% C.I. of the mean difference	
	Mean	SD	Mean	SD		Lower	Upper
Overall ratio	91.75	1.32	91.3	1.91	0.034*	0.22	0.69
Anterior Ratio	77.21	1.65	77.2	1.65	0.488	-0.27	0.31

* Statistically significant at p <0.05

Pearson correlation test was done between the overall ratio and all other parameters. Overall ratio showed a highly significant weak positive correlation with anterior ratio (r=0.449, p <0.001), highly significant weak negative correlation with the sum of mesiodistal width of 12 maxillary teeth (r= -0.342, p <0.001), and highly significant weak negative correlation with the sum of mesiodistal width of 6 maxillary teeth (r= -0.342, p <0.001). Overall ratio showed no significant correlation with the sum of mesiodistal width of 12 mandibular teeth (r = -0.033, p = 0.716) and the sum of mesiodistal width of 6 mandibular teeth (r = -0.172, p = 0.055).

Pearson correlation test was also done between the anterior ratio and all other parameters. Anterior ratio showed a highly significant weak positive correlation with overall ratio (r=0.449, p<0.001), and statistically significant weak negative correlation with the sum of mesiodistal width of six maxillary teeth (r = - 0.276, p = 0.002). Anterior ratio showed no significant correlation with the sum of mesiodistal width of 12 maxillary teeth (r= -0.130, p = 0.148), the sum of mesiodistal width of 12 mandibular teeth (r= 0.015, p = 0.869), and the sum of mesiodistal width of 6 mandibular teeth (r = 0.122, p = 0.177).

DISCUSSION

The age range of the samples was from 14 years to 24 years. This young age group was selected to minimize the alteration of the mesiodistal tooth dimensions due to the attrition, restoration, or caries. All the subjects had nearly ideal esthetic profile with normal occlusion.

Moorrees et al[9] conducted a study on 184 Northern American children and concluded that the tooth crowns of the males were invariably broader than those of the females and the sex difference was larger for the permanent than for the deciduous teeth. Bishara et al.[10] compared boys and girls within and between 3 populations from Iowa, Egypt, and Mexico. Canines and molars were significantly larger in boys than in girls. A study by Lavelle[5] also showed that the tooth dimensions were greater in males than in females. Similar findings were supported by our study as well as mesiodistal parameters were greater in males than females.

There was no significant difference in the overall ratio and anterior ratio between males and females in the present study. These findings of no sexual dimorphism among anterior ratio and overall ratio were also reported by Alkofide and Hashim.[11] Al-Tamimi and Hashim[12] also found no sexual dichotomy in Bolton ratios in a relatively small sample of 65 Saudi subjects. Similar findings were reported by Uysal et al.,[13] Basaran et al.,[14] and Paredes et al.[15]

Lavelle[5] reported relatively larger overall ratios in males compared to females in white, black, and Mongoloid populations. Smith et al.[7] also reported that males had larger ratios than females. However, these differences (0.7% for overall ratio and 0.6% for the anterior ratio) were small, being much less than 1 standard deviation from Bolton's sample.

In the present study, the overall ratio for Nepalese obtained was 91.70 ± 1.28 for males and 91.79 ± 1.34 for females and the anterior ratio for males was 77.09 ± 1.57 and 77.29 ± 1.71 for females with no significant difference between them. The result was comparable to the study in the Nepalese subjects by Hong et al.[8] who reported no significant difference between males and females Class I samples for either anterior ratio or overall ratio with the findings of the overall ratio of 91.26 ± 1.90 for males and 91.18 ± 2.09 for females and the anterior ratio of 78.28 ± 2.55 for males and 77.81 ± 2.89 for females.

In the present study, the overall ratio obtained was 91.75 ± 1.32 and the anterior ratio obtained was 77.21 ± 1.65. The overall ratio was statistically significantly different from that of Bolton's value whereas the anterior ratio showed no statistical difference. Similar findings have been reported by Lavelle[11] who showed that the overall ratio of Caucasoid males to be 91.7 and anterior ratio to be 76.8. Similarly, Richardson and Malhotra[16] found significant differences between blacks and whites using an interarch ratio that included the second molars. Their overall ratio for blacks was 94, which was very different from Bolton's value of 91.3. In contrast, their anterior ratio of 77 was similar to Bolton's value, suggesting that blacks differ markedly in the posterior arch segment relationship.

Mishra R et al.[17] conducted a study to determine the anterior and overall Bolton's ratio in Nepalese population, to compare Bolton's ratio between subjects with normal occlusion, Class I malocclusion, and Class II malocclusion, to compare the results with Bolton's original value, and to determine the frequency of clinically significant (beyond 2 SD) tooth size discrepancy compared to Bolton's value. The differences in the tooth size ratio were not significant Review of Literature Page 21 statistically when the groups were compared based on malocclusion or gender. Anterior ratio showed a statistically significant difference when compared to Bolton's original value. The frequency of the clinically significant tooth size ratio discrepancy was lower for the overall ratio (9.1%) compared to the anterior ratio (22.5%)

In our study, maxillary teeth determined the discrepancy in overall ratio mostly and maxillary anterior teeth determined the discrepancy in anterior ratio mostly.

Smith et al.[7] conducted a study to evaluate Bolton's interarch ratio among various populations and genders and concluded that the mandibular second premolars, the maxillary lateral incisors, the maxillary second premolars, the mandibular central incisors, and the first molars explain most of the variation in the interarch discrepancy and these teeth should be examined and dealt with first when an interarch tooth size discrepancy is suspected.

Large sample size could have been gathered and a better picture of this sort of investigation could have been achieved. Tip, torque, interincisal angle, and tooth thickness which influence the ideal tooth size relationship have not been taken into account.

CONCLUSIONS

In our study, we found that there was no sexual dimorphism in Bolton ratio though mesiodistal parameters were greater in males and we found statistically significantly different overall ratio than the original ratio by Bolton. Thus, Population-specific standards of anterior ratio and overall ratio are necessary for clinical assessment to make treatment planning more accurate and predictable.

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