Bolton's ratios and tooth-size discrepancies in a Nigerian population

Ajayi EO
Orthodontic Unit, Department of Preventive Dentistry,
Faculty of Dentistry, University of Benin, Nigeria

Correspondence: Ajayi EO
Email: buskyet@yahoo.com

Abstract

Objective: The aim of this study was to determine the Bolton's ratios and tooth size discrepancies in a Nigerian population.
Method: The Bolton tooth size analysis was performed on 54 dental casts of Nigerian subjects comprising 33 (61%) males and 21 (39%) females aged 23 to 31 years (mean 26.6 ± 2.1 years). The overall and anterior tooth size ratios were determined, and gender differences among the sample population was evaluated with t-test. The frequency and magnitude of deviation of the Nigerian subjects outside 2 standard deviations from the Bolton's mean was also determined.
Result: The result revealed no statistically significant gender differences in interarch tooth size ratios ($p > 0.05$) and the measurement for both males and females were therefore combined. The overall ratio was 92.1% ± 2.35 and anterior ratio was 78.9% ± 2.64. The overall tooth size discrepancy was present in 9.3% and the 25.9% of the subjects had anterior tooth size discrepancy in relations to more than 2 standard deviations from the Bolton's mean values.
Conclusion: The study provided data on tooth size ratios among Nigerian subjects whose values were larger than Bolton's data. This study re-emphasized the importance of developing standards for each population.

Key words: Tooth size discrepancy, Bolton's ratios,

Introduction

The coordination between the sizes of the maxillary and mandibular teeth is imperative to ensure proper intercuspation of the teeth, overjet, overbite and achieve optimal occlusion during orthodontic treatment[1,2]. It is important to determine any disproportion among the sizes of individual teeth and interarch tooth size discrepancies during orthodontic evaluation as this could influence treatment planning. A significant variation in maxillary to mandibular tooth size ratios will affect treatment planning which may need to be compensated for during orthodontic treatment by aesthetic bonding, prosthetic recontouring, stripping of enamel, extraction, leaving spaces or changing the desired anterior overjet or overbite [3]. Consequently, many investigators have advocated various methods of measuring tooth-size ratios and detection of interarch tooth size discrepancies[4,5]. The Bolton's method of tooth size analysis is the most widely used method for detecting interarch tooth size discrepancies[6,7].

Bolton[6]developed a method for evaluation of maxillary to mandibular tooth width proportions based on 55 subjects with excellent occlusions by comparing the sums of the mesiodistal widths of the maxillary and mandibular teeth including the first molars to establish two ratios. Bolton established overall ratio which was calculated from the greatest mesiodistal measurements of the teeth in the maxillary and mandibular arches from first molar to first molar and obtained a value of 91.3% with a standard deviation of 1.91. He also calculated anterior ratio from the greatest mesiodistal measurements of the six anterior teeth in the maxillary and mandibular arches from canine to canine and obtained a value of 77.2% with a standard deviation of 1.65. Bolton[7]suggested that a ratio greater than 1 standard deviation from his reported mean values indicated a need for diagnostic consideration. A significant discrepancy was however defined as a value outside of 2 standard deviation from the Bolton's mean by other authors who had applied Bolton's analysis in their studies due to observation that approximately 95% of Bolton's cases were within this range [3,8,9,11]. Bolton analysis has been applied to determine interarch tooth size relationships in various populations and investigation revealed there are differences in tooth width proportions among the ethnic and racial groups[1,3,8-12]. It is therefore important to determine standard values for each ethnic and racial groups since each population has its own characteristics.

Presently, there was no published data on application of Bolton values for Nigerian population which can be used in diagnosis and treatment planning of patients. The purposes of this study were therefore to establish Bolton tooth ratios and frequency of tooth size discrepancies in a Nigerian population and identify any gender differences.

Materials and method

The materials for this study consisted of 54 dental casts of Nigerian subjects who were students of Faculty of Dentistry of the University of Benin, Benin City. The selection criteria included that the subject being a Nigerian and born of Nigerian parents, has a normal occlusion, permanent teeth

present and fully erupted particularly from the first molar to first molar, no crowding, no missing or abnormally sized or shaped teeth, no interproximal caries and or excess tooth materials as a result of restorations and no presence of dental attrition. The sample was made up of 33 (61%) males and 21 (39%) females aged 23 to 31 years (mean 26.6 ± 2.1 years).

The dental casts were measured from the right first molar to left first molar with a digital vernier caliper. The caliper was placed parallel to the occlusal plane of each tooth with its sharp points at the greatest distances between the contact points on the proximal surface of each tooth and measurement taken and rounded to the nearest 0.1mm. The error involved in the measurement of the dental casts was evaluated by repeating the measurement of 20 randomly selected dental casts 4 weeks later. A paired t test was applied to the first and second measurements obtained and the differences were statistically insignificant.

The tooth-size analysis was performed as described by Bolton(6). The Bolton anterior ratio (the ratio between the mesiodistal widths of the 6 anterior mandibular teeth and the mesiodistal widths of the 6 anterior maxillary teeth, from canine to canine) and the Bolton overall ratio (the ratio between the mesiodistal widths of the 12 mandibular teeth and the mesiodistal widths of the 12 maxillary teeth, from right first molar to left first molar) were calculated.

$$\text{Anterior Ratio: } \frac{\text{Sum Mandibular 6}}{\text{Sum Maxillary 6}} \times 100$$

$$\text{Overall Ratio: } \frac{\text{Sum Mandibular 12}}{\text{Sum Maxillary 12}} \times 100$$

The mean, standard deviation, range and coefficient of variation were calculated for both overall ratio and anterior ratio and the gender differences in the values obtained were evaluated with unpaired t-test. Statistical significance was regarded when $p<0.05$. The data obtained was compared to Bolton's mean values and the frequency of the Nigerian subjects who had tooth-size discrepancies which were within one, two or greater than two standard deviations from Bolton' s mean for anterior ratio and overall ratio was also determined.

The data analysis was carried out with Statistical Package for Social Sciences software version 16 (SPSS, Chicago, IIlinois).

Result

There was no statistically significant difference between the mean anterior and overall ratios for Nigerian males and females even though the males exhibited slightly larger dimensions than females as shown in **Table 1** ($p>0.05$). The measurement for males and females was therefore combined and anterior ratio for the Nigerian subjects was 78.9% with standard deviation of 2.64 while overall ratio was 92.1% with standard deviation of 2.35 as also shown in **Table 2.** The Nigerian measurements were larger when compared to Bolton ratios.

Table 3 shows the frequency of tooth size discrepancy from 1, 2 and more than 2 standard deviations from the Bolton's anterior and overall mean values. The percentages of the Nigerian subjects with tooth size discrepancy outside 2 standard deviation from Bolton overall '12' ratio and anterior '6' ratio were 9.3 % and 25.9% respectively.

Table I: Gender distribution of anterior and overall ratios in Nigerian Subjects

	Males (n=33)		Females (n=21)			Total (n=54)	
Ratio	Mean (%)	S D	Mean (%)	SD	P	Mean (%)	S D
Anterior	79.0	2.55	78.8	2.87	NS	78.9	2.64
Overall	92.4	2.35	91.7	2.30	NS	92.1	2.35

NS, Not significant ***Significant difference at P<0 .05**

Table 2: Comparison of Nigerian values with Bolton's data

	Bolton's data	Nigerian values
Overall Ratio		
Sample size	55	54
Mean	91.3	92.1
Standard deviation	1.91	2.35
Range	87.5 - 94.8	87.7 - 97.9
Coefficient of variation	2.09	2.55
Anterior Ratio		
Sample size	55	54
Mean	77.2	78.9
Standard deviation	1.65	2.64
Range	74.5 - 80.4	73.7 -- 84.4
Coefficient of variation	2.12	3.35

Table 3: The number and percentage distribution of anterior and overall tooth size discrepancies from Bolton's mean in Nigerian Subjects

	Anterior ratio		Overall ratio	
Bolton	Number (n=54)	Percentage (%)	Number (n=54)	Percentage (%)
Bolton ± 1 SD	27	50.0	30	55.6
Bolton ± 2 SD	13	24.1	19	35.2
> 2SD	14	25.9	5	9.3

Discussion

The application of Bolton's interarch tooth ratios in Nigerian subjects revealed no statistically significant gender difference in the anterior and overall ratios as both the Nigerian males and females exhibited similar pattern of interarch tooth size. The mean anterior and overall ratios of the males however slightly larger than females. The report of no sexual dimorphism observed in this study was consistent with findings in Dominican American[9], Spanish[12], Chinese[13], and Jordanian populations[14] and also for anterior ratios only in Turkish[11] and Peruvian populations[15]. However, other studies have found significant gender differences in tooth size ratios especially in the overall ratios[1,11,15].

The anterior and overall ratios established for Nigerian subjects in this study are larger than Bolton's values. This observation is also similar to findings reported in some

populations where Bolton analysis has been applied[1,12-14]. The existence of significant differences in application of Bolton's mean values has necessitated establishment of tooth sizes ratios for different ethnic and racial groups. The anterior ratio of 78.9% established for Nigerian subjects were similar to anterior ratios in Jordanian populations[14] but lower than 79.6% and 79.3 % reported in American whites and Blacks respectively[1]. The overall ratios of 92.1% obtained in the Nigerian subjects was also similar to overall ratios in Jordanian population[12], slightly higher than values reported in Spanish[14] and Dominican Americans [9], but lower than overall ratio of 93.4% in American blacks[1], 93.1% in Hispanics[1], and 93.27% in Chinese populations[13]. The differences observed in application of Bolton's mean values in different populations could be attributed to variation in population sample investigated, since the Bolton's sample had excellent occlusions[6,7] and possibility of ethnic and racial variations in interarch tooth sizes[1,9,12,14,15]. Therefore, this study shows that the Bolton's mean values are also not directly applicable to the Nigerian subjects and the standards established in Nigerian population should be applied for clinical assessment of patients.

The frequency of tooth size discrepancy outside of 2 standard deviations from the Bolton's mean was utilised to determine clinical significance of tooth size disproportion in this study as previously reported in other populations[3,8,12,14]. A little less than 10% of the Nigerian subjects have tooth size discrepancy outside 2 standard deviation from Bolton overall '12' ratio (the total ratio below 87.5 or above 95.1). This percentage was similar to 9.5% reported in Jordanian population but lower than 11% reported in Dominican Americans[9] and 18% in a Turkish population[11]. Also, 25.9% of the Nigerian subjects have tooth size discrepancy outside 2 standard deviation from Bolton anterior '6' ratio (an anterior ratio below 73.9 or above 80.5). This anterior discrepancy was higher than that reported among Spanish and Jordanian populations[12,14] but also lower than 28% reported in Dominican Americans[9]. A higher discrepancy in the anterior rather than the overall ratio was observed in this study as previously reported in other populations. This study therefore re-emphasises the importance of analysis of interarch tooth sizes relationship and application of specific standards of each population in orthodontic evaluation, diagnosis and treatment planning.

Conclusion

The study provided anterior and overall tooth size ratios for a Nigerian population with no significant gender differences observed in tooth size ratios. The anterior and overall ratios were larger than Bolton's and the overall and anterior tooth size discrepancies among Nigerian subjects were 9.3% and 25.9% respectively.

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