Bolton's standard vs Bolton's ratio of south Indian population

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aims & Objectives: Determination and comparison of the anterior and overall Bolton's ratio among different genders in various malocclusion groups of south Indian population with Bolton's standard. Materials and methods: In this study 800 study models were collected from all over south Indian population which included 325 class I, 325 class II, 150 class III models were measured using digital vernier calliper from Mesiodistal width of right 1st molar to left 1st molar and anterior and overall ratio for each model were calculated using Bolton's formula. The recorded values were tabulated and subjected to statistical analysis.

Results: On comparison of Bolton's mean anterior ratio with Bolton's standard, angles class III malocclusion group was significantly greater than that of class I and class II malocclusion groups. There were no significant differences on comparison of Bolton's standard and no significant sexual dimorphism was seen between anterior and overall ratios of three malocclusion groups. Conclusion: Hence during initial diagnosis, treatment planning and various stages of orthodontic treatment procedures. The Bolton's standard and tooth size discrepancies in relation to malocclusion with respective to the particular population should be considered as an important factor for a successful orthodontic treatment.

Keywords: Tooth material discrepancy, Bolton's Ratio, Anterior Ratio, Overall Ratio

Introduction

The ultimate aim of orthodontic treatment is to achieve ideal occlusion. But it is more complicated as every patient has his or her own variables affecting the treatment outcome. One of those variables is Interarch tooth size discrepancy, which is a disproportion among the sizes of individual teeth. In 1902, Dr. G. V. Black measured the mesio-distal width of a large number of human teeth and measured mean dimensions for eachtooth.[1] Tooth size discrepancy is an important

diagnostic tool and the orthodontist should have a sound knowledge of it to attain excellent post treatment occlusion. Although various authors have proposed various methodologies to detect Interarch tooth discrepancies like Kesling's diagnostic setup, Howe's ratio of canine fossa width to total maxillary tooth width and Neff's anterior co-efficient,[2-4] Bolton's analysis remains the most recognized and most widely used method.

In 1958 W.A. Bolton introduced Bolton's analysis to determine the size of the tooth anomalies and had been used as an aid in diagnosis as well as treatment planning.[5] He conducted a study on models of 55 patients with excellent occlusion to measure the mesio-distal width of all the permanent teeth except second molar and third molars and derived two clinically significant ratios. The first ratio was the overall ratio which involves measurement from first molar to first molar in both jaws inclusively. The second ratio was the anterior ratio involves width measurements from canine to canine inclusively of both jaws.

Even though Bolton's ratio is widely accepted, the shortcomings are:

1. It was done only in Caucasian individuals.

2. The samples were selected with perfect occlusion.

3. The sexual dimorphism and skeletal malrelations were not considered.

After Bolton, many investigators conducted various studies to analyze the variation in Bolton's ratio in different groups of population and racial ethnic groups. Lavelle (1972) carried out a study similar to that of Bolton's in 3 major racial groups - Caucasoid, Mongoloid and Negroid. He suggested that tooth size is more highly correlated between the maxillary and mandibular dental arches in Negroids as compared with Caucasoids, Mongoloids were intermediate.[6] Smith SS

(2000) evaluated Bolton's interarch ratios across populations and genders. He concluded that interarch tooth size relationships were population and gender specific. Bolton ratios can be applied to white females only and the ratios should not be indiscriminately applied to white males, blacks, or Hispanics.[7] studies conducted by sanjaynaduwinmani et al and Prasanna et al in south Indian population showed no statistically significant differences among different malocclusions groups on comparision with Bolton's standard.[8,9] Though, there are various studies conducted regarding Bolton's ratio among various populations in India, the sample size was relatively small. Therefore the present study is to determine with a large number of sample in various malocclusion groups.

Aim and Objectives

To determine and compare the anterior and overall Bolton's ratio among Male and female genders in various malocclusion with Bolton's standard.

1. To compare the anterior and overall ratios in Angle's Class I, Angle's Class II, Angle's Class III malocclusion groups with Bolton standard.

2. To establish whether there is gender differences with regard to the ratios obtained.

Materials and methods

In this study, 800 pre-treatment study models were collected from South Indian population which consisted of both genders between the age group of 15-25 years. The samples were categorized into Class I, Class II and Class III according to the Angle's system of classification which consisted of 325 Angle's class I, 325 Angle's class II and 150 Angle's class III models. Informed consent was taken from the untreated subjects or parents. Samples were chosen based on the following criteria;

Inclusion criteria

1. Subjects of south Indian population.

2. Angle's class I, Angle's class II and Angle's class III molar relation.

3. Fully erupted permanent dentition from first molar to first molar.

4. Good quality of casts.

Exclusion criteria

1. Tooth agenesis.

2. Missing teeth due to caries or periodontal diseases.

3. Any prosthetic replacements.

4. Gross restorations that can change the mesio-distal diameter of tooth.

5. Interproximal or occlusal wear of teeth.

6. Congenital defects and deformed teeth.

7. Previous orthodontic treatment.

Materials and methods

From the pre-treatment models, the mesiodistal dimensions of the teeth of 800 samples were taken. The widest points on the mesiodistal dimension of each tooth were measured from right first molar to left first molar in maxillary and mandibular arches. All measurements were in millimeters. For good access in the interproximal areas, the fine tips were used in the digital Vernier caliper (Aero space) with an accuracy of 0.01mm and the measurements were recorded and tabulated. All measurements were taken under natural light by one examiner. The measurements were done by placing the caliper beak in the buccal aspect and held occlusally parallel to the long axis of the tooth. The beaks were then closed gently until the beak touches the contact points of the tooth (Figure 1 & 2).

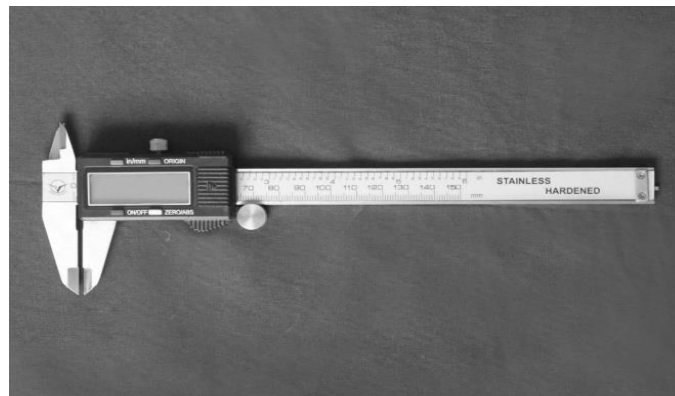Figure 1: Digital Vernier Calliper (Aero space)

Figure 2: Mesio distal Tooth width Measurement

The same examiner evaluated all the models by trial-and-error method. 50 models were randomly selected after 2 weeks of original measurements and the teeth were re-measured on these casts. The 1st and 2nd measurements were compared statistically. Measurements were recorded from right side 1st molar to left side 1st molar and anterior ratio and overall ratio for each model were calculated using Bolton's formula.

The Bolton's anterior ratio and overall ratio was calculated using the formula:

Sum of mandibular 6 teeth / Sum of maxillary 6 teeth × 100 = Anterior ratio (%)

Sum of mandibular 12 teeth / Sum of maxillary 12 teeth × 100 = Overall ratio (%)

The recorded values were tabulated and subjected to statistical analysis.

Statistical analysis

The measured data obtained from study models using digital Vernier caliper were tabulated separately and were evaluated statistically. Statistical calculations were carried out using Statistical Package for Social Sciences 16.0 software the descriptive statistical mean Standard deviation and Coefficient of variation were obtained. The mean overall and anterior Bolton's ratios for each malocclusion groups were compared with Bolton's standard using unpaired Student's t-test. For comparison of the independent set of data, and independent t-test was performed. All the results were evaluated at the $P < 0.05$ significance level. In order to observe the gender differences unpaired Students t-test was conducted and the results were evaluated at the $P < 0.05$ significance level. All these approaches confirmed an acceptable level of measurement error.

Result

Table: 1 Comparison of obtained mean anterior and overall ratio with ideal Bolton's ratio

Bolton's Ratio	Sample size(N)	Mean ratio (%)	Standard deviation (SD)	Co-efficient of variation	P -value
Anterior Ratio (77.2%)					
class I	325	77.74%	±2.23	2.87	0.00**
Class II	325	77.95	±2.33	2.99	0.05*
Class III	150	78.12	±2.96	3.79	0.00**
Overall Ratio (91.3%)					
Class I	325	91.27%	±2.52	2.76	0.66*
Class II	325	90.58	±2.30	3.09	0.00**
Class III	150	91.59	±2.81	3.06	0.20*

P – value - >0.05 – not significant (*), <0.05 – significant (**)

Table 1 describes the overall and anterior ratios of class I, class II, and class III with sample size of 325,325,150 respectively. It denotes that the mean Bolton's anterior ratio of all 3 groups were greater than the ideal Bolton's ratio of 77.2%. In mean overall Bolton's ratio class III group was greater than ideal Bolton's overall ratio of 91.3%.

Table: 2 Comparison of obtained mean anterior and overall ratio between genders.

Bolton's Ratio		Sample size(N)	Mean ratio ± SD	Co-efficient of variation	P – value
Anterior ratio					
Class I	Male	161	77.75±2.12	2.73	0.089*
Class II		137	77.27±2.94	3.81	0.214*
Class III		73	77.98± 2.37	3.04	0.580*
Class I	Female	164	77.72±2.34	3.01	0.089*
Class II		188	78.05±2.54	3.25	0.214*
Class III		77	78.25±3.44	4.40	0.580*
Overall ratio					

Class I	Male	161	91.19±2.48	2.72	0.748*
Class II		137	90.57±2.95	3.26	0.949*
Class III		73	91.79±2.79	3.04	0.402*
Class I	Female	164	91.28±2.55	2.80	0.748*
Class II		188	90.59±2.69	2.94	0.949*
Class III		`77	91.40±2.83	3.10	0.402*

P – value - >0.05 – not significant (*), <0.05 – significant (**)

Table 2 describes the gender comparison of Bolton's anterior and overall ratios of class I, class II, class III were greater than the ideal Bolton's anterior and overall ratio of 77.2% and 91.3% respectively

Discussion

An excellent orthodontic finish depends on the analysis of discrepancies in tooth size at the initial diagnosis and treatment planning stages. Tooth size discrepancies may be defined as a disproportion between the size of individual teeth and is considered as an important variable especially in the anterior segment and has even been described as the seventh key of occlusion.[10,11] A good occlusion depends on a correct ratio between the dental masses in the maxillary and mandibular arches. Though many authors like Neff, Ballard, & Lundstrom had attempted to quantify this relationship, it was Bolton in 1958 who computed specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from canine to canine and first molar to first molar so as to obtain optimum occlusion.[3, 5, 12, 13]

Bolton's aim was "to gain insight into the functional and Esthetic outcome of a given cases without the use of Kesling's diagnostic set up for predicting interarch tooth size discrepancy".[2] Though diagnostic set up remains the gold standard, Bolton's analysis is widely used since the measurements are easily and quickly made.

Factors contributing to the variability of permanent tooth size are genetics, environment, race, sex, heredity, secular changes and bilateral asymmetry.[14] Studies of tooth sizes in which various races and ethnic groups have been conducted to show the effect of various gene pools on tooth dimension. More specific genetic studies have used monozygotic and dizygotic twins in an attempt to quantify genetic influence on tooth dimensions.[15]

The same approach has been used to detect the influence of tooth dimensions on occlusion.[16] Bolton's study is based upon heterogeneous Caucasian population sample and hence, provides no information relating to other racial groups.[6]

Tooth sizes have been analyzed mainly from two aspects, the difference between the genders and the difference between various occlusion categories.[17]Sexual dimorphism has been confirmed in various ethnic groups where some teeth were significantly larger in male than in female subjects.[15] Santoro et al performed Bolton tooth size analysis on a sample of Dominican Americans.[18] The overall ratio was found to be equivalent to the Bolton overall ratio, whereas the anterior ratio was larger than the Bolton's ratio.

Studies by Parades et al concluded that both anterior and overall ratios for the Spanish subjects were significantly greater than the Bolton's ratios. They also concluded that the relationship between the sizes of the mandibular and maxillary teeth depends on the population. So, specific standards should be established for the Spanish population.[19] Since various studies performed on tooth sizes on different population had found ethnicity

influences on tooth sizes,[15,16] Keith et al conducted a study on mesiodistal crown diameter of the primary and permanent teeth of 112 models in Hong Kong Southern Chinese population they concluded that tooth sizes in both dentitions were general, larger than those of the Caucasians but comparable with Northern Chinese, but smaller than those of Australian Aboriginals.[20] The current study was conducted to evaluate Bolton's ratio for south Indian population.

The purpose of this study was determined and compared the anterior and overall ratios of different malocclusions with Bolton's standard ratio and to compare the gender differences among the south Indian population. The study consists of 800 samples which include 325 Angle's Class I malocclusions (161 males, 164 females), 325 Angle's Class II malocclusions (137 males, 188 females), 150 Angle's Class III malocclusions (73 males, 77 females) study models.

Bolton's analysis was done by measuring the greatest mesiodistal width of each permanent tooth, including all the teeth from the left fist permanent molar to the right first permanent molar. The standard Bolton's overall and anterior ratios were 91.3%+ 1.91 and 77.2% +1.65 respectively. Above or below 2% of this ideal ratio should be classified as having tooth size discrepancies.[5, 21]All the 800 samples of this study were subjected to Bolton's analysis and statistically analyzed.

But the mean anterior Bolton's ratio was found to be statistically greater for Angle's Class III malocclusion group than Class I and Class II malocclusion groups (p<0.05). These results were in agreement with studies of Lavelle et al, Sperry et al, which concluded that Class III malocclusion patients had greater anterior tooth size discrepancy than Class I and Class II malocclusion patients.[6, 22]

Nie and Lin et al studied tooth size discrepancy in a sample of 360 cases. A significant difference was found in all malocclusion groups, for the anterior and overall ratios which were greatest in Class III and lowest in Class II which coincides with the results of the present study.[17]

Araujo and Souki investigated Bolton's anterior tooth size discrepancies among different malocclusion groups and reported that 56% of the subjects in the study showed Bolton's tooth size discrepancy. They concluded that individuals with Angle Class I and Class III malocclusions have significantly greater frequencies of tooth size discrepancies than individuals with Class II malocclusions and the mean anterior tooth size discrepancy for Angle Class III subjects was much greater than for Class I and Class II subjects which was in accordance with the present study.[23]

Furthermore, when Class I and Class II samples were compared with each other, they showed no significant differences. These results were in agreement with the results of Crosby and Alexander studies where no statistically significant differences when comparing Class I and Class II subjects was found.[24] The suggested reasoning for this anterior discrepancy in Class III malocclusion was that the mesiodistal width of maxillary lateral incisor is smaller in Class III subjects or it may be due to minor discrepancies of individual teeth in the maxilla. The data from the present study also suggests that Class III patients demonstrate mandibular anterior tooth material excess and maxillary tooth material deficiency. These results are in agreement with studies done by Tuverson et al, Redahan and Lager Strom, where mandibular anterior tooth material excess in Class III cases were due to tooth size discrepancy.[25, 26]

Since the p value was greater than 0.05 (P>0.05), it was concluded that there was no significant difference in the

overall ratio and anterior ratio of the male and female in Class I, class II and Class III malocclusion group. These results were in accordance with the studies reported by Al Tamimi and Hashim where no gender difference was found in Bolton's ratio.[27]Basaran et al also found that there were no sexual differences in Bolton's Ratio.[28]

Studies of Lavelle showed that the male teeth on the average were larger than female teeth predominantly the permanent canines, while incisors showed a minimum difference and premolars showed an intermediate difference.[6] Richardson and Malhotra found that the teeth of black North American males were larger than those of females for each type of tooth in both arches, but there were no differences in anterior or posterior interarch tooth size proportions.[29] Smith et al found that males had larger Bolton's ratios than females.[7]

These studies were controversial to the results of the present study where there was no significant difference between the genders in the mean anterior and overall ratios of Class I, Class II, and Class III malocclusion group. The suggested reasoning for this difference in the results was due to the comparison of gender difference within the malocclusion groups and not within the overall samples. Studies shows that a sex difference in the tooth size ratio may be population specific.[7, 30] These results were in accordance with the study done by Johe, et al.[31]

Conclusion

The present study evaluated and compared the mean anterior and overall ratios of Angle's Class I, Angle's Class II and Angle's Class III malocclusion samples on south Indian population to the standard Bolton's ratio. The results showed that the mean anterior ratio for Angle's Class III malocclusion is greater than Angle's Class II and Angle's Class I malocclusion. On comparison of the mean anterior and overall Bolton's

ratio among the genders on Angle's Class I, Angle's Class II and Angle's Class III malocclusion samples there was no statistically significant differences. Hence during initial diagnosis, treatment planning and various stages of orthodontic treatment procedures the tooth size discrepancies in relation to malocclusion with respective to the particular population should be considered as an important factor for a successful orthodontic treatment. No other studies are present in literature that discuss these results for south Indian population on such a large sample size.

In the current study, measurements and mathematical calculations were made manually which sometimes may not be accurate and reliable. So, in future accurate and reliable measurements and calculations can be made using virtual models obtained by three-dimensional scanning software rather than using conventional digital caliper.

References

1. Black GV. Descriptive Anatomy of the Human Teeth,4th edition Philadelphia: S.S. White Dental Mfg. Co.; 1902.

2. Kesling HD. The philosophy of the tooth positioning appliance. American Journal of Orthodontics & oral surgery 1945; 31(6):297-340

3. Howes AE. Case analysis and treatment planning based upon the relationship of the tooth material to its supporting bone. Am J Orthod 1947; 33:499-533.

4. Neff CW. Tailored occlusion with anterior coefficient. Am J Orthod 1949; 35:309-13.

5. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusions. Angle Orthod 1958; 28 Issue-3 :113-130.

6. Lavelle CLB. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. Am J Orthod 1972; 61:29-37.

7. Smith SS, Buschang PH, Watanabe E. Interarch tooth size relationships of 3 populations: "Does Bolton's analysis apply?" Am J Orthod Dentofacial Orthop 2000;117(2):169-74.

8. Sanjay Laxman Naduwinmani, Jyosna Preet ham Naduwinmani, Krishna U.S Nayak. Evaluation of Bolton's Tooth Width Ratios in Crowded and Non-Crowded Dentitions Among the South Indian Population: Int. Journal of Contemporary Dentistry, December, 2010 • 1(3)

9. A Lakshmi Prasanna, V Venkatramana, A Srikanth Aryasri, Anil Kumar Katta, K Santhanakrishnan, Uma Maheshwari, Evaluation and Comparison of Intermaxillary Tooth Size Discrepancy among Class I, Class II Division 1, and Class III Subjects Using Bolton's Analysis: An in vitro Study, J Int Oral Health 2015; Sep:7(9):58-64

10. Profit WR. Contemporary Orthodontics, 3rd Edition, Mosby, St louis, p170.

11. McLaughlin RP, Bennett JC, Trevisi HJ. Systemized Orthodontic treatment mechanics. London: Mosby; 2001. p. 4, 6, 281.

12. Murray L. Ballard: Asymmetry in tooth size: A factor in the etiology, diagnosis and treatment of malocclusion, Angle Orthod. 1944 (July-oct)14: 67-70.

13. Lundstrom AS, Intermaxillary tooth-width ratio analysis, Eur, J. Orthod 1981-3(4), 285-287

14. Bishara SE, Jakobsen JR, Abdallah EM, Garcia AF. Comparisons of mesiodistal and buccolingual crown dimensions of the permanent teeth in three populations from Egypt, Mexico, and the United States. Am J Orthod Dentofacial Orthop 1989; 96:416-22.

15. Brookh. A.H, A Unifying Aetiological Explanation for Anomalies of Human Tooth Number and Size, Arrhs Oral Bid. 1984, Vol. 29. No. 5, pp. 373-378,

16. Arya BS, Savara BS, Thomas D, et al. Relation of sex and occlusion to mesiodistal tooth size. Am J Orthod 1974; 66:479-86.

17. Nie, Qiong, Jiuxiang Lin. Comparison of Inter maxillary tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofac Orthop 1999; 116: 539-544.

18. Santoro M, Ayoub ME, Pardi VA, Thomas J C. Mesiodistal Crown Dimensions and Tooth Size Discrepancy of the Permanent Dentition of Dominican Americans. The Angle Orthod 2000; 70:303-307.

19. Paredes V, Gandia JL, Cibrian R. Do Bolton's ratios apply to a Spanish population? Am J Orthod Dentofacial Orthop 2006;129: 428–30.

20. KEITH KWOK-WAH YUEN, ENDARRA LAI-KING TANG and LISA LAI-YING SO, Relations Between the Mesiodistal Crown Diameters of The Primary and Permanent Teeth of Hong Kong Chinese, Arch oral Biol.1996 Vol. 41, No. I, pp. 1-7,

21. Bolton WA. The clinical application of a tooth size analysis, Am. J Orthod, 1962, 48: 504-529.

22. Sperry TP, Worms FW, Isaacson RJ, et al. Tooth-size discrepancy in mandibular prognathism. Am J Orthod 1977; 72:183-90.

23. Eustaquio Araujo, Marcelo Souki, Bolton Anterior Tooth Size Discrepancies Among Different Malocclusion Groups Angle Orthod 2003; vol – 73(3) :307–313.

24. Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 1989;95(6):457-61.

25. Tuverson DL. Anterior interocclusal relations. Part I. Am J Orthod 1980;78(4):361-70.

26. Redahan S, Lager Strom L. Orthodontic treatment outcome: The relationship between anterior dental

relations and anterior inter-arch tooth size discrepancy. J Orthod 2003;30(3):237-44.

27. Al-Tamimi T, Hashim HA. Bolton tooth-size ratio revisited. World J Orthod 2005;6(3):289-95.

28. Basa ran G, Selek M, Hamamci O, Akkus Z. Intermaxillary Bolton tooth size discrepancies among different malocclusion groups. Angle Orthod 2006;76(1):26-30

29. Richardson ER, Malhotra SK. Mesiodistal crown dimension of the permanent dentition of American Negroes. Am J Orthod. 1975; 68:157–164.

30. Uysal T, Sari Z. Intermaxillary tooth size discrepancy and mesiodistal crown dimensions for a Turkish population. Am J Orthod Dentofacial Orthop 2005;128(2):226-30.

31. Rene S. Johe, Todd Steinhart, Nina sado, Barbara Greenberg and Shuying Jing, intermaxillary tooth-size discrepancies in different sexes, malocclusion groups, and ethnicities, Am J Orthod Dentofacial Orthop 2010; 138: 599-607