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Comparative Evaluation of Tooth Size Discrepancy In Class I, Class II & Class III Malocclusion: Central India Population

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ABSTRACT

Background: To determine the differences of Bolton's anterior and overall tooth size proportions in Class I, Class II div 1, Class II div 2 and Class III malocclusion groups and to measure the prevalence of tooth size discrepancies in different malocclusion groups as a function of gender.

Materials and methods: The sample for the present study consisted of 120 pretreatment study casts, belonging to the patients who were reported to the People's college of dental sciences for treatment and clinically having full complement of teeth till the second permanent molars. For accurate measurements, standard Digital Caliper Series EC16 with a 0.01mm resolution, ±0.02 mm accuracy and 0.01 mm repeatability (manufacturer specification) was used to measure the mesiodistal width of the teeth. Data was analyzed using IBM SPSS (Statistical Package for the Social Sciences) version 22.0 for the generation of descriptive and inferential statistics.

Results: Mesiodistal dimensions of maxillary teeth compared between male and female population show significant difference in all the tooth except for lateral incisors and 1st premolars. Mesiodistal dimensions of mandibular teeth compared between male and female population shows significant difference in all the tooth except for 1st Molars.

Conclusion: Bolton's anterior and overall tooth material in Class I, Class II div 1, Class II div 2 and Class III malocclusion is significantly different. The highest mean anterior tooth size ratios for male were for Class II division 2 and for Class III compared to Class I and Class II division 1. There was a tendency for mandibular tooth excess in subjects with Class III malocclusions and for maxillary tooth excess in subjects with Class II malocclusions in an orthodontic population. Significant sexual dimorphism for anterior, overall and posterior ratios did not exist when they were compared among whole sample.

Keywords: Bolton's ratios; Tooth size discrepancy.

INTRODUCTION

Attaining harmony is a question of proportion in the size, shape, relationship, and orientation of the dental organs as a whole in their relation to other facial factors.[1] A tooth-size discrepancy (TSD) is defined as a disproportion among the sizes of individual teeth.[2] The best known study of tooth-

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size disharmony in relation to treatment of malocclusion was given by Bolton in 1958. Bolton developed 2 ratios for estimating TSD by measuring the summed mesio-distal (MD) widths of the mandibular to the maxillary anterior teeth. He concluded that these ratios should be used in orthodontic diagnosis allowing the orthodontist to gain insight into the functional and aesthetic outcome of a given case without the use of a diagnostic setup.[3] It was hoped that a method of evaluating tooth size would be found which would be an aid in diagnosis and treatment planning of orthodontic cases and also help in determining the functional and esthetic outcome of the case. A correct maxillary and mandibular mesiodistal tooth size relationship is important for the achievement of proper occlusal interdigitation in the finishing stages of orthodontic treatment. Different angle malocclusions have arch length discrepancy as well as tooth size discrepancy. Bolton's ratio allow the orthodontist to gain insight into the functional and aesthetic outcome of a given case without the use of a diagnostic setup. The ultimate anterior ratio is 77.2% and the total ratio is 91.3% were named as Bolton's Index and served as an aid in the diagnosis and treatment planning of orthodontic cases and in determining the functional and esthetic outcome.[4] Tooth sizes have been analyzed mainly from two aspects, the difference between the genders and the difference between various occlusal categories, although several studies have attempted to show racial and ethnic differences in tooth size. The overall Bolton ratio is the percentage obtained by summing the widths of the 12 mandibular teeth divided by the sum of the widths of the 12 maxillary teeth and should be 91.3 ± 0.26 per cent. Anterior ratio is the percentage obtained by summing the widths of the six mandibular anterior teeth divided by the sum of the widths of the six maxillary anterior teeth and should be 77.2 ± 0.22 per cent. Extrinsic factors such as sexual dimorphism, racial and ethnic variations, type of malocclusion, inclination of anterior teeth, incisor edge thickness and the smile arc can affect this proportionality, usually requiring adjustments in the anterior ratio, as described by Bolton.[5] Need for this study is to get an insight of actual discrepancy in each malocclusion in anterior posterior and overall ratio.

Aims and Objectives

1. To determine the differences of Bolton's anterior and overall tooth size proportions in Class I, Class II div 1, Class II div 2 and Class III malocclusion groups.

2. To measure the prevalence of tooth size discrepancies in different Angle malocclusion groups as a function of gender.

3. Correlation of Bolton's ratio in all malocclusion groups.

MATERIALS AND METHODS

Many authors earned out studies to determine linear regression equations on different population and they concluded that the equation developed for a particular population is not applicable and inaccurate to other population. Therefore, this study is carried out to determine a linear regression equation in Central India population. The sample for the present study consisted of 120 pretreatment study casts, belonging to the patients who were reported to the People's college of dental sciences for treatment and clinically having full complement of teeth till the second permanent molars. The sample of 120 subjects for the study was selected as per the criteria laid down as follows:

1) All the permanent teeth till second permanent molar should be present.
2) No history of any previous orthodontic treatment.
3) All the teeth which are to be measured should be fully erupted and free of interproximal restoration, distortion, fractures and caries
4) There should not be any form, size or number alterations present with the teeth.
5) Class 1 occlusion with mild or no crowding.

Armamentarium used in the study:

1) 120 study models
2) Fine tip marking pen
3) Digital vernier caliper - Aerospace (±0.02 mm accuracy)

METHOD:

1) 120 pretreatment study models obtained from patients reported to the People's College of Dental sciences and Research Centre.

2) The impression of the upper and lower dental arches were obtained by using metallic stainless steel perforated trays with a good quality commercially available irreversible hydrocolloid material. The impression were poured immediately with dental stone type III with a 30ml/100gms water-powder ratio and setting time of approximately 5-7 mins as per the manufacturer's instructions.

3) For accurate measurements, standard Digital Caliper Series EC16 with a 0.01mm resolution, ±0.02 mm accuracy and 0.01 mm repeatability (manufacturer specification) was used to measure the mesiodistal width of the teeth.

MEASUREMENT OF THE TEETH:

1) The mesiodistal width of the teeth was measured with a digital Vernier caliper adjusted to the greatest mesiodistal diameter (contact points) of teeth, parallel to the occlusal surface and perpendicular to the long axis.

2) The measurements included the mesiodistal width of all the twelve mandibular teeth from the right first permanent molar to the left first permanent molar.

3) Mesiodistal width of twelve maxillary teeth, the right first permanent molar through the left first permanent molar, were totaled and compared with sum derived by the same procedure carried out on the mandibular twelve teeth. The ratio between the two is percentage of mandibular arch length to maxillary arch length which is called the "overall ratio".

Sum of mandibular "12" x 100 = Overall ratio

Sum of maxillary "12"

4) The same method was used in setting up a ratio between the maxillary and the mandibular anterior teeth. The ratio between the two is the percentage relationship of mandibular anterior width to maxillary anterior width and this is referred to as the "anterior ratio".

Sum of mandibular "6" x 100 = Anterior ratio

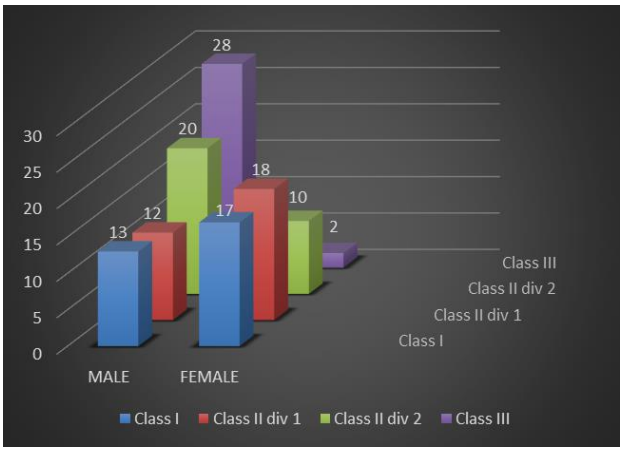
Sum of maxillary "6"

5) For method error evaluation, 20 casts were selected at random, four weeks after the original measurements. The teeth were re-measured on these casts. The first and second measurements were compared statistically.

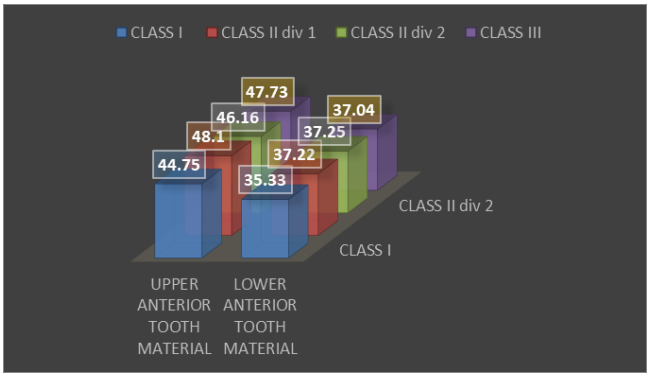
STATISTICAL ANALYSIS

Data was analyzed using IBM SPSS (**Statistical Package for the Social Sciences**) version 22.0 for the generation of descriptive and inferential statistics. The statistical significant difference among groups was determined by the ANOVA. Post-Hoc Tukey Hsd and Chi square test was applied to compare qualitative data and quantitative data. The statistical significance and the level of significance was set at $p < 0.05$.

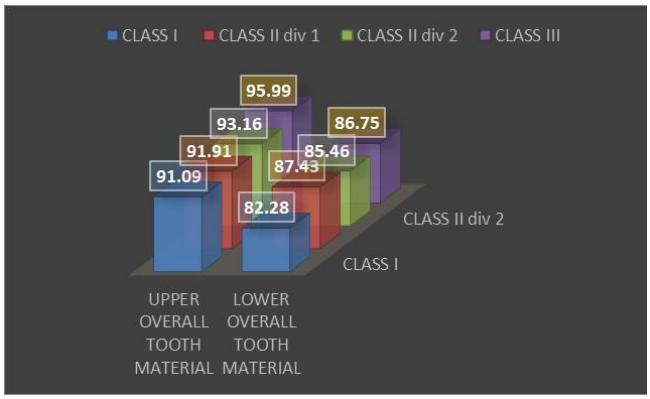
Graph 1: Distribution of study population according to gender and type of malocclusion



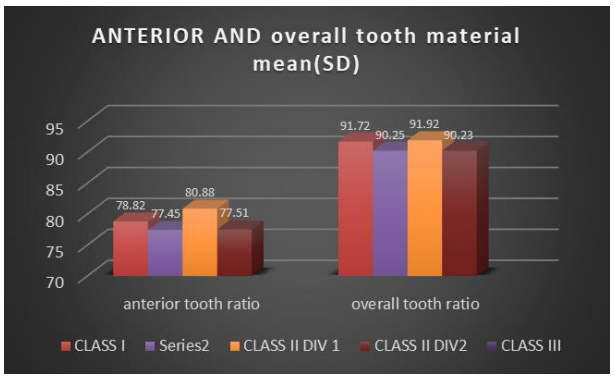
Graph 2: Mean standard deviation (SD) of upper and lower anterior tooth material



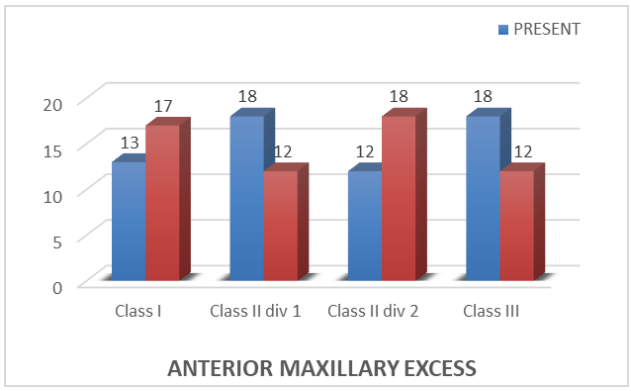
Graph 3: Mean standard deviation (SD) of upper and lower overall tooth material



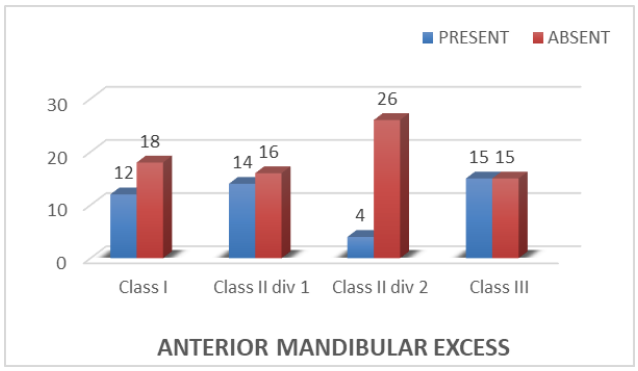
Graph 4: Mean standard deviation (SD) of anterior and overall tooth ratio.



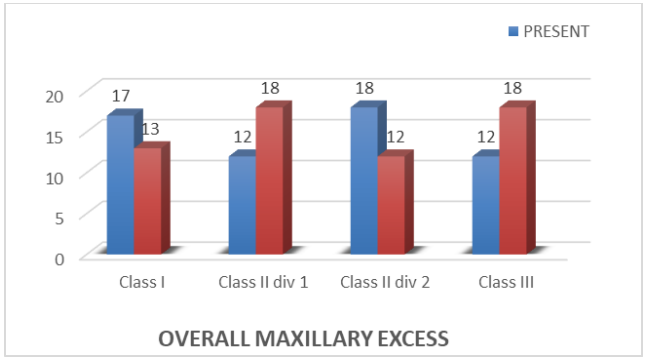
Graph 5: Shows distribution of the presence or absence of anterior maxillary excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions



Graph 6: Shows distribution of the presence or absence of anterior mandibular excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions



Graph 7: Shows distribution of the presence or absence of overall maxillary excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions



Graph 8: Shows distribution of the presence or absence of overall mandibular excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions

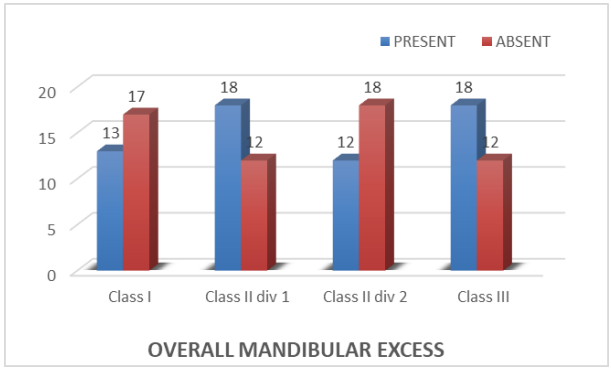


Table 7: Comparison of male and female for anterior ratio and overall tooth ratio.

Gender	mean	Standard Deviation	Standard Error	p value
Anterior ratio Male Female	78.80 78.46	4.22 4.17	0.49 0.61	0.67 0.67
Overall	90.95	3.68	0.43	0.77

ratio Male Female	91.15	3.43	0.50	0.77

Fig 1: Digital Vernier Calliper

Fig 2: Mesiodistal diameter of maxillary incisors.

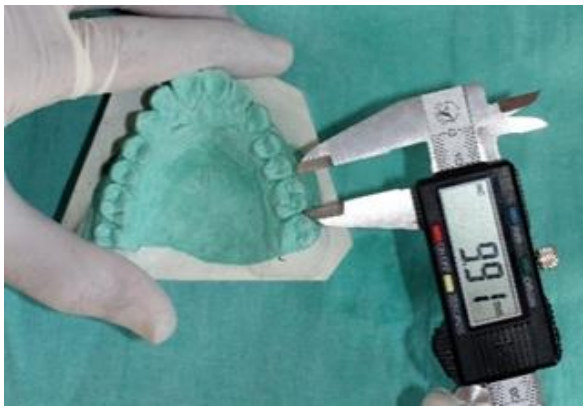


Fig 3: Mesiodistal diameter of maxillary molar.

Fig 4: Mesiodistal diameter of mandibular incisors.

Fig 5: Mesiodistal diameter of mandibular molar

Graph 1 shows the distribution of study population.

Among the Angles Class I malocclusion 13(43.3%) were males and 17(56.7%) were females. In Angles Class II div 1 malocclusion group 12 were (40%) males and 18(60%) were females, whereas in Angles Class II div 2 malocclusion 20(66.7%) males and 10(33.3%) were females. Angles Class III malocclusion group were comprised of 28(93.3%) males and 2(6.7%) females.

Graphs 2, 3, 4 shows distribution of mean standard deviation of different malocclusion groups.

ANOVA was performed to compare the mean value of upper anterior tooth material, lower anterior tooth material, upper overall tooth material, lower overall tooth material, anterior tooth ratio and for the overall tooth ratio. All the parameters shows a statistical significant difference between Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions except for the overall tooth ratio.

Mean standard deviation (SD) of upper anterior tooth material of Class 1, Class II div 1, Class II div 2

and Class 3 malocclusions are 44.75 (+/-2.47), 48.10(+/-2.48), 46.16(+/-3.82) and 47.73(+/-3.39) respectively. P<0.05 f=7.44.Mean standard deviation (SD) of lower anterior tooth material of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 35.35 (+/-2.45), 37.22 (+/-1.84), 37.25 (+/-2.63) and 37.04 (+/-2.66) respectively. P<0.05 f=4.4.Mean standard deviation (SD) of upper overall tooth material of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 91.09 (+/-4.71), 96.91 (+/-4.15), 93.16 (+/-7.18) and 95.99 (+/-5.52) respectively. P<0.05 f=7.02.Mean standard deviation (SD) of lower overall tooth material of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 82.28 (+/-10.71), 87.43 (+/-3.93), 85.46 (+/-5.38) and 86.75 (+/-5.74). P<0.05 f=3.26.Mean standard deviation (SD) of anterior tooth ratio of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 78.82 (+/-4.59), 77.45 (+/-3.06), 80.88 (+/-4.38) and 77.51 (+/-3.77). P<0.05 f=4.84.Mean standard deviation (SD) of overall tooth ratio of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 91.72 (+/-3.39), 90.25 (+/-2.67), 91.92 (+/-4.0) and 90.23 (+/-3.39). P>0.05 f=2.02.

Graph 5-8. Distribution of the presence or absence of tooth material excess.

It shows distribution of the presence or absence of anterior maxillary excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 18, 16, 26 and 15 respectively ($p < 0.05$); distribution of the presence or absence of anterior mandibular excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 12,14,4 and 15 respectively ($p < 0.05$); distribution of the presence or absence of overall maxillary excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 17, 12, 18 and 12 respectively ($p > 0.05$) and distribution of the presence or absence of overall mandibular excess of Class 1, Class II div 1, Class II div 2 and Class 3 malocclusions are 13, 18, 12 and 18 respectively ($p > 0.05$).

Results of Chi-square testing demonstrating significant difference ($p > 0.05$) in overall maxillary and mandibular excess. But showing no significant difference in anterior maxillary and mandibular excess.

Table 7. Comparison of male and female for anterior ratio and overall tooth ratio.

Results show that there was no significant difference found between the genders.

DISCUSSION

Wayn Bolton[5] in 1958 computed the specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from both canine-canine and first molar-first molar so as to obtain optimum occlusion. The intended purpose of tooth size discrepancy ratio as a diagnostic aid as said by Bolton "To gain insight into the functional and esthetic outcome of a given case without the use of diagnostic set up."

Significant higher overall ratios of malocclusion groups could be explained by a relatively larger mandibular arch or smaller maxillary arch segments than normal occlusion groups. As in many other human attributes, teeth vary in size between males and females. Gender differences have been reported in the literature and may have clinical relevance. There is also a lack of agreement regarding gender differences in relation to the tooth size proportion between upper and lower anteriors.[6]

Studies of Arya et al[7] and Lavelle[8] shows , male teeth on the average larger than female teeth and sexual dimorphism was evident predominantly in permanent canines, while incisors showed a minimum difference and premolars showed an intermediate difference. However these differences were small being much less than one standard deviation from Bolton's sample.

Proffit stated that Tooth Size Discrepancies less than 1.5 mm are rarely significant. He also suggested that a quick check for anterior TSD can be done by comparing the size of upper and lower lateral incisors. For posterior TSD, he recommends that a quick visual check be done by comparing the size of upper and lower second premolars, which should be of approximately equal size. The prevalence of significant TSD is different for different populations.[9]

As tooth size discrepancies tend to be population specific, this study was taken up in Central India population to assess the Bolton's tooth size

discrepancy of this population. The main objective of this study was to determine the tooth-size ratios for the maxillary and mandibular dentitions in central India population, and to compare the figures obtained with those of the Bolton values. My study includes 120 pretreatment patient maxillary and mandibular study models, 30 numbers each from Class I, Class II div 1, Class II div 2 and Class III.

Mean anterior ratio in the present study for Class I, Class II div 1, Class II div 2 and Class III was found to be 78.82 ± 4.59, 77.45 ± 3.06, 80.88 ± 4.38, 77.51 ± 3.77 respectively. The new anterior ratio calculated will be 78.67 ± 3.95. The mean anterior ratio closely resembles Bolton[5,10] mean of 77.2 and Crosby and Alexander 77.5. The present study anterior ratio is not in agreement with Smith[11] (79.6%) in White Americans, Smith et al (79.3%) in blacks, Santoro et al[12] (78.1%) in Dominician Americans. The Central India samples anterior ratio mean value resembles these values closely. The prevalence of clinically significant anterior TSDs in the Irish sample (37.9%) is higher than the recorded 17.4% in a British orthodontic population. The prevalence, however, falls between that reported in a US population by Freeman et al.[13]

Mean overall ratio in the present study for Class I, Class II div 1, Class II div 2 and Class III was found to be 91.72 ± 3.39, 90.25 ± 2.67, 91.92 ± 4.01, 90.23 ± 3.39 respectively. New overall ratio calculated was 91.03 ± 3.37. Mean overall ratio as found in various studies Bolton (91.3%), Crosby and Alexander[45] (91.4%), Smith[51] (92.3 %) in White Americans, Smith et al[11] (93.4%) in blacks. In general, the central India samples in this study resembles with these values closely.

Bolton's ratio were compared in males and females, the results showed there is no statistically significant difference in the mean Bolton's anterior and overall ratio between males and females. These results are agreement with studies of Richardson and Malhotra[14], Nic and Lin[15], Paredes et al[16] and in disagreement with studies of Arya et al[7], Keene[17].

Mesiodistal widths of males in present study showed 99.0 mm in upper arch and 90.7 mm in lower arch; females it showed 88.0 mm in upper arch and 81.7 mm in lower arch showing mesiodistal dimension of males are larger than females in Central India population. According to Seipel there are fewer sex differences in the deciduous dentition than in the permanent dentition.

Lavelle[18] studied subjects for anterior tooth sizes and showed a tendency for Angle Class III patients to have smaller maxillary teeth compared with those classified as Class I or Class II. Moreover, the study indicated that mandibular teeth were larger in Class III than in Class I and Class II subjects, with the inference that a Bolton discrepancy is greater in Class III patients than in the other malocclusion groups.

For both overall and anterior ratios in the present study, means were nearly identical with those of Bolton's study although the ranges and SDs were significantly larger. This finding is consistent with the results of Crosby and Alexander[19], Freeman et al[20], and Santoro et al[12].

Lastly, evaluating tooth-size discrepancies is only part of the diagnostic orthodontic treatment-planning process. Other factors, including soft tissue, skeletal, and other dental evaluation factors, also significantly contribute to developing a logical and cogent treatment plan. Tooth-size discrepancies should be evaluated and addressed while simultaneously considering other treatment issues. The final treatment plan and outcome are best evaluated as the sum of the constituent parts, not the individual parts themselves.

CONCLUSION

In 1958 Wayne Bolton computed the specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from canine-canine and first molar-first molar so as to obtain optimum occlusion using 55 models with ideal Class I occlusion. From that study Bolton concluded that an overall ratio of 91.3% and an anterior ratio of 77.2% were necessary for proper coordination of maxillary and mandibular teeth. Until now Bolton's analysis is used worldwide and has gained popularity in the field of orthodontics.

Various studies have investigated ethnic and sex differences in the intermaxillary tooth ratios. As in other physical properties of human beings, teeth vary in the size between the two sexes and among individuals from different geographical region.

Thus the aim of the present study was to evaluate and compare mean and prevalence of anterior and overall Bolton's ratio from the values given by Bolton as a function of gender.

The pretreatment casts were selected from the records of patients reporting to People's college of dental sciences, Bhopal. The sample consisted of 120 subjects with all the permanent teeth till second permanent molar present. The sample was selected 30 numbers each according to Angles Class 1, Class II div 1, Class II div 2 and Class III occlusion.

Bolton's anterior and overall ratios computed using Electronic Digital Vernier Caliper and the values are subjected to statistical analysis.

Mean anterior ratio in the present study for Class I, Class II div 1, Class II div 2 and Class III was found to be 78.82 ± 4.59, 77.45 ± 3.06, 80.88 ± 4.38, 77.51 ± 3.77 respectively. The new anterior ratio calculated will be 78.67 ± 3.95.Mean overall ratio in the present study for Class I, Class II div 1, Class II div 2 and Class III was found to be 91.72 ± 3.39, 90.25 ± 2.67, 91.92 ± 4.01, 90.23 ± 3.39 respectively. New overall ratio calculated was 91.03 ± 3.37.

Bolton's ratio were compared in males and females, the results showed there is no statistically significant difference ($p > 0.05$) in the mean Bolton s anterior and overall ratio between males and females.

CONCLUSION

Bolton's anterior and overall tooth material in Class I, Class II div 1, Class II div 2 and Class III malocclusion is significantly different. The highest mean anterior tooth size ratios for male were for Class II division 2 and for Class III compared to Class I and Class II division 1. There was a tendency for mandibular tooth excess in subjects with Class III malocclusions and for maxillary tooth excess in subjects with Class II malocclusions in an orthodontic population.

Significant sexual dimorphism for anterior, overall and posterior ratios did not exist when they were compared among whole sample. It is important to note that the possibility of gender differences in tooth size discrepancies is different from differences in absolute tooth size. In general, male crown measurement were slightly larger and showed a higher variability than the female measurements. A higher variability was found in the maxillary teeth as compared to the mandibular teeth. Maxillary lateral incisor, maxillary first premolar and mandibular first molars are shown to be quite variable in size and are frequently the reason for the tooth size discrepancy between arches.

Bolton's ratio is correlated with different types of malocclusion. In clinical practice, attention should be paid to tooth size discrepancies between the maxillary and mandibular teeth and that Bolton's analysis is important for orthodontic diagnosis and treatment planning that would improve achieving optimal occlusion, overbite, and overjet. It should also be borne in mind that Bolton tooth size analysis might be of assistance in the finishing phase of orthodontic treatment, especially in increasing the stability of the treatment result. Although such an analysis in some instances may appear to be time consuming, the benefits would seem to be significant.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Balit HL. Dental variation among populations: an anthropologic view. Dent Clin North America 1975; 19(1): 125-139.

2. Othman SA, Harradine NWT. Tooth size discrepancy and Bolton's ratios: a literature review. J Orthod. 2006;33:45–51.

3. Moyers RE. Craniofacial Morphology In: McNamara JA ed Evolution of concepts of the face. Craniofacial Growth Series Ann Arbor, Mich.: Center for human growth and development. The University of Michigan 1993: 27- 39.

4. Neff CW. Tailored occlusion with the anterior coefficient. Am J Orthod 1949; 35:309-333.

5. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 1958; 28: 113-30.

6. 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.

7. Arya BS, Savara BS, Thomas D and Clarkson Q. Relation of sex and occlusion to mesiodistal tooth size. Am J Orthod 1974; 66; 479 - 486.

8. Moorrees CFA. The Aleut Dentition. Harvard University Press, Cambridge, Massachusetts 1957.

9. Othman S and Harradine N. Tooth Size discrepancies in an orthodontic population. Angle Orthod 2007; 77: 668-674.

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

11. Ballard ML. A fifth column within normal dental occlusion. Am J Orthod 1956; 42: 116-24.

12. Santoro M, Ayoub ME, PardiVA , Cangialosi TJ. Mesiodistal crown dimensions and tooth-size discrepancy of the permanent dentition of Dominician Americans .Angle Orthod 2000; 70; 303-7.

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

14. Richardson ER, Malhotra SK. Mesiodistal crown dimension of permanent dentition of American Negroes. Am J Orthod 1975; 15: 368-72.

15. Nie 0 and Lin J. Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 1999; 116:539-44.

16. Pardes, Gandia JL, and Cibrianc R. Do Bolton's ratios apply to a Spanish population. Am J Orthod Dentofacial Orthop 2006; 129:428-30.

17. Keene HJ. Mesiodistal crown diameter of permanent teeth in male American Negroes. Am J Orthod 1979; 76: 95-99.

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

19. Crosby DR and Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 1989;95; 457-61.

20. Freeman JE, Maskeroni AJ, Lorton L. Frequency of Bolton tooth-size discrepancies among orthodontic patients. Am J Orthod Dentofacial Orthop 1996; 110:24-7.