Intermaxillary tooth size discrepancies among different malocclusion classes: a comparative study

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The purpose of this study is to determine whether a difference exists in intermaxillary tooth size among different malocclusion groups in Saudi patients. The study consisted of 240 pretreatment orthodontic casts (Sixty cases in each malocclusion class, in addition to normal occlusion). The results of the study shows no significant difference in the incidence of tooth size discrepancies for the overall ratio and anterior ratio between the different malocclusion groups, except for the anterior ratio in class III malocclusion. Further, no statistical significant difference was observed between males and females. When the mean values of the present study were compared to that of Bolton's, a significant difference was found in all the malocclusion classes. We can conclude from this study that Bolton tooth size analysis is an important diagnostic tool, and should be taken into consideration before initiation of orthodontic treatment.
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INTRODUCTION

Tooth size discrepancies have conventionally been described as a relative excess of tooth structure in one arch in relation to the other arch.[1] For proper alignment of the teeth, tooth size must be in harmony with arch size.[2] A significant variation in this harmony will lead to malocclusion and difficulties in obtaining an occlusion with optimal overjet, overbite and Class I canine and molar relation.[3] Although the natural teeth match very well in most dentitions, approximately 5% of the population has some degree of discrepancy among the size of individual teeth.[4]

Heusdens, Dermaut and Verbeeck[5] did an experimental study on the effect of tooth size discrepancies on occlusion. They observed that the effect of severe tooth size discrepancies on occlusion is mild, and that the effect of generalized tooth size discrepancies appears to be limited.

Contrary to this, Sperry, Worms, Isaacson and Speidel[3] investigated the frequency of excess mandibular tooth structure. They found that the frequency of mandibular tooth size excess (overall ratios) was greater in cases of mandibular prognathism than in Angle's Class I and Class II malocclusions.

To assess intermaxillary tooth size discrepancies, a diagnostic setup[6] or a mathematical formula such as the Bolton analysis can be used.[7] If such discrepancies are not detected initially, a delay in the completion of treatment at the finishing stage, or a compromised result may occur. Bolton[7] conducted a study on the relationship of tooth size discrepancy to malocclusion. He studied 55 cases with excellent occlusion, forty-four had been treated orthodontically (non-extraction) and eleven had not received any prior orthodontic treatment. The mesio-distal width measurements of the 12 maxillary teeth (first molar to first molar) were totaled and compared with the sum derived by the same procedure carried out on the 12-madibular teeth. The ratio between the two is the percentage relationship of mandibular arch length to maxillary arch length:

$$\frac{\text{Sum mandibular "12"}}{\text{Sum maxillary "12"}} \times 100 = \text{Overall ratio}$$

The same procedure was carried out to analyze the six anterior teeth (canine to canine):

$$\frac{\text{Sum mandibular "6"}}{\text{Sum maxillary "6"}} \times 100 = \text{Anterior ratio}$$

Bolton concluded that an overall ratio of 91.3 and an anterior ratio of 77.2 were necessary for proper coordi-

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nation of maxillary and mandibular teeth. Until now Bolton analysis is used worldwide and has gained popularity in the field of orthodontics.

Stifter[8] replicated Bolton's study on Class I occlusion and reported similar results. For the overall and anterior ratio, Stifter respectively reported a mean value of 91.04 and 77.55 in comparison to Bolton's values of 91.3 and 77.2. He concluded that the percentage relationship of lower to upper anterior tooth size is a significant factor when attempting to harmonize tooth material. Lavelle[9] conducted a study on tooth dimensions and tooth size ratio. He reported sexual dimorphism between both, in addition to racial dimorphism between Negroid, Mongoloids, and Caucasoid. He also measured the ratio of upper to lower arch tooth Mongoloids, and Caucasoid. He also measured the ratio of upper to lower arch tooth size in different malocclusion groups, as done in the current study. A pattern of contrast was found which was different for the maxillary values, compared with the mandibular values for the different malocclusion groups. Further, Lavelle in his study found that mesiodistal crown dimensions for maxillary teeth were Class I (>) Class II Division I (>) Class II Division 2 (<) Class III, and for mandibular teeth Class III (>) Class I (>) Class II Division 1 (>) Class II Division 2. It can be inferred from this study that as a general trend, the Bolton discrepancy would be greater in Class III cases than other malocclusion groups.

Arya *et al.*[10] demonstrated that there were differences in tooth size between males and females. However, these differences were not observed between Class I and Class II malocclusions.

Crosby and Alexander[11] also analyzed the Bolton ratios for different malocclusion groups. However, in their study Class III patients were not included, and no differentiation between sexes and skeletal pattern was done. They concluded that no significant difference was found in the prevalence of tooth size discrepancies among the different malocclusion groups.

Hashim and Murshid[12] did a study among Saudi patients presenting with different malocclusions. No significant difference in tooth size ratios was observed between sexes, and between their results and that of Bolton's. Nie and Lin[13] analyzed the Bolton ratio for different malocclusion groups in 360 Chinese patients (120 for each Class). The results showed no significant sexual dimorphism, and no significant difference between subcategories of malocclusion. However, a significant difference was found for both ratios between all the groups. The results showed that the ratio in Class III malocclusion was greater than in Class I and Class II. They concluded that the Bolton analysis should be taken into consideration during orthodontic diagnosis and therapy.

Recently Tamimi[14] performed an odontometric study on tooth size among Saudi military officers with normal occlusion. He compared his results (anterior and overall ratios) with that reported by Bolton**.** No significant difference was noted between the two studies.

Thus, the present study was undertaken in an effort to determine if a difference does exist in tooth size ratios between the different malocclusion classes and normal occlusion, and to determine if in fact sexual dimorphism occurs.

MATERIALS AND METHODS

Materials

The pretreatment casts were selected from the records of patients attending the orthodontic clinic at the dental college of King Saud University. The sample consisted of 240 pretreatment casts with both sexes evenly distributed in each class (60 cases with normal occlusion, 60 cases Class I, 60 cases Class II and 60 cases were Class III malocclusions). The sample was selected according to Angle's classification. All patients were Saudi national, between the ages of 13 to 20 years old. The following selection criteria were used:

1. Good quality pre-treatment models.
2. All permanent teeth erupted and present from right first molar to left first molar.
3. No extraction or interproximal stripping performed.
4. No severe mesiodistal and occlusal tooth abrasion.
5. No restorative treatment other than Class I restorations.
6. No history of orthodontic treatment.
7. No residual crown or crown-bridge restoration.
8. Subjects with congenitally missing teeth, extracted teeth, questionable articulation, malformed teeth, broken or chipped teeth or carious lesion that could affect the mesiodistal crown width were not included in the sample.

Methods

The measurements were made directly on the unsoaped dental casts. Electronic digital calipers (Digimatic caliper, Mitutoyo, U.K) accurate to 0.01mm with fine tips to improve the access interproximally were used for measurements. All measurements were taken under natural and neon light by one examiner.

The procedure of measuring the mesiodistal tooth width was performed as described by Hunter and Priest[15]. The caliper beaks were inserted from the buccal (labial), and held occlusally parallel to the long axis of the tooth. The beaks were then closed until gentle contact with the contact points of the tooth was felt. The measurements included the maximum mesiodistal width of all the twelve maxillary and mandibular teeth from the right first permanent molar to the left first permanent molar. The measurements were made as carefully as possible to avoid any damage on beaks contact. Tooth size ratios were analyzed as described by Bolton.

Error of the method

In order to determine the measurement error, 5 sets of models randomly selected from the whole sample were measured, and then measured again 10 days later by the same examiner. Pearson correlation coefficient and Dahlberg's method were used for testing the error of the method.

The results exhibited a high correlation between the first and second measurements. The Dahlberg's method showed that the upper left canine showed the highest value, while the lower left canine the lowest.

Statistical Analysis

Descriptive statistics as well as one-way analysis of variances were used for statistical analysis of the data. If a significant F-value was found, Tukey's test was used to check the difference between the four classes. Furthermore, the t-test was used for comparison between the present study and Bolton's results at the level of significance $P < 0.05$.

RESULTS

The sample consisted of 240 orthodontic models: normal occlusion, Class I, Class II, and Class III malocclusion, evenly distributed. The average overall ratio for all classes combined was 92.61 and for the anterior ratio 78.86 (Table 1).

Table 2 shows that the mean overall ratio for the Class II malocclusion group was greater than that of Class I and Class III malocclusions, when both sexes were combined. While the mean anterior ratio was greater for the Class I malocclusion group than the two other malocclusal groups.

When the three malocclusion groups were compared in males and females, the results shows that the mean overall and anterior ratio of Class III > Class I and Class II malocclusion in both males and females (Table 3).

The one-way analysis of variance indicates there was a significant difference between the different malocclusion classes. The difference was found between normal occlusion and Class I malocclusion (Table 4).

When the overall ratio was compared between males and females, no significant difference was detected between either sexes (Table 5). But when the anterior ratio was compared between both sexes, a significant difference was noted in females with Class III malocclusions $p<0.001$ (Table 6). Comparisons of the overall and anterior ratios between normal occlusion and other malocclusion classes (with no sex difference) indicate that there was no statistical significant difference between them.

When the results of the present study were compared to Bolton's results, statistical significant differences were noted for both overall and anterior ratios in normal occlusion and the other malocclusion classes (Table 7).

Table 1. Sample size, means, standard deviation and range for the overall and the anterior ratios when both sexes and all groups were combined.

Ratio	n	Mean	S.D.	Range
Overall ratio	240	92.61	2.04	86.68- 97.48
Anterior ratio	240	78.86	2.55	72.51- 85.08

n=Sample Size *S.D.=Standard Deviation*

Table 2. Mean, standard deviation of anterior and overall ratios in all classes (both sexes are combined).

	Overall Ratio		Anterior Ratio	
Angle classification	**Mean**	**S.D.**	**Mean**	**S.D.**
Class I	92.24	2.04	78.77	2.74
Class II	92.80	2.20	78.70	2.45
Class III	92.71	2.12	78.50	2.53

S.D. = Standard Deviation

Table 3. Mean and standard deviation of the overall and anterior ratios in all classes for males and females

	Ratio	Males		Females	
Occlusion & Malocclusion	**Overall ratio**	**Mean**	**S.D**	**Mean**	**S.D.**
Class I		92.10	1.60	92.40	2.30
Class II		92.50	2.20	93.10	2.20
Class III		93.20	2.20	92.20	2.00
	Anterior Ratio	**Mean**	**S.D**	**Mean**	**S.D.**
Class I		78.80	2.30	78.80	3.20
Class II		78.60	2.70	78.80	2.20
Class III		79.70	2.50	77.30	2.00

S.D. = Standard Deviation

Table 4. ANOVA test for anterior and overall ratios between the classes in males and females.

Gender	Ratio	Sum of Squares	df	Mean Squares	F-value	Significance Level
Female	**Overall Ratio**	13.861	3	4.62	1.109	0.34
	Anterior Ratio	67.76	3	22.578	3.689	*0.01
Male	**Overall Ratio**	19.689	3	6.563	1.567	0.20
	Anterior Ratio	28.39	3	9.463	1.499	0.21

Table 5. Mean, standard deviation, t-value and level of significance for the overall ratio between males and females.

Classification	Males n	Males Mean	Males S.D.	Females n	Females Mean	Females S.D.	t-value	P
Class I	30	92.12	1.67	30	92.36	2.37	0.45	NS
Class II	30	92.50	2.17	30	93.10	2.23	1.061	NS
Class III	30	93.20	2.15	30	92.21	2.02	1.827	NS

n=Sample size S.D.=Standard Deviation NS=Not significant (p>0.05)

Table 6. Mean, standard deviation, t-value and level of significance for the anterior ratio between males and females.

Classification	Males n	Males Mean	Males S.D.	Females n	Females Mean	Females S.D.	t-value	P
Class I	30	78.75	2.27	30	78.79	3.19	0.06	NS
Class II	30	78.56	2.73	30	78.84	2.17	0.434	NS
Class III	30	79.66	2.52	30	77.34	1.98	3.954	***

n=Sample size S.D.=Standard Deviation NS=Not significant (p>0.05)
****=p<0.001*

Table 7. Comparison of the overall and anterior ratios between the present study and Bolton's

Malocclusion	Study Type	Overall Ratio n	Overall Ratio Mean	Overall Ratio S.D.	Anterior Ratio n	Anterior Ratio Mean	Anterior Ratio S.D.
	Bolton	55	91.30	1.91	55	77.20	1.65
Normal	***Present Study***	60	93.58	2.12	60	78.86	2.55
	t-value		4.20			7.27	
	P		***			***	
Class I	***Present Study***	60	92.24	2.04	60	78.77	2.74
	t-value		2.50			4.44	
	P		*			***	
Class II	***Present Study***	60	92.80	2.20	60	78.70	2.45
	t-value	4.05	4.74				
	P		***			***	
Class III	***Present Study***	60	92.71	2.12	60	78.50	2.53
	t-value	3.80	3.98				
	P		***			***	

n=Sample size S.D.=Standard Deviation p=Level of significance
**=p<0.05 ***=p<0.001*

DISCUSSION

The importance of obtaining an adequate relationship between the maxillary and mandibular teeth has drawn the attention of many investigators over the years. One of the causative factors leading to an inadequate relationship between both has been attributed to a discrepancy in tooth size.[5] This discrepancy may manifest as an anomaly in the size of the upper lateral incisors, but variation in premolars or other teeth may be present.[16] These anomalies are sometimes difficult to detect by inspection alone. However, comparing clinically the size of upper and lower lateral incisors can be a quick method to check for this discrepancy. Unless the upper lateral incisor is 12 to 14% wider than the lower lateral incisor, a discrepancy almost surely exists.[16]

In the present study, the results of comparison among the three malocclusion groups showed that the mean ratio of Class II was greater than that in Class I and Class III for the overall ratio. This is in disagreement with Nie and Lin,[13] who found that the mean ratio in Class III was greater than that in Class I and Class II among Chinese. This result supports the findings of Lavelle,[10] who reported that there was racial dimorphism between Negroid, Mongoloids and Caucasoid. The statistical analysis of the present study showed no significant difference in the incidence of tooth size dis-

crepancies among the different malocclusion classes for the overall and the anterior ratio.

However, a significant difference in the anterior ratio was observed between males and females in Class III malocclusion. When the overall ratio was evaluated, no significant difference was observed between both sexes in all malocclusion classes. This is in partial agreement with Crosby and Alexander[11] who found no significant difference among the different malocclusion classes for the overall and the anterior ratios, but they did not include Class III cases. Furthermore, the results of the present study is in disagreement with Nie and Lin,[13] who found a significant difference between Class I, Class II and Class III malocclusion, but no significant difference was found between subcategories of malocclusion which was not investigated in the present study.

When the overall and anterior ratios of normal occlusion were compared to those of Bolton's study, a statistically significant difference was apparent. This disagreed with the results obtained by Tamimi[14] in his study among Saudi military officers with normal occlusion and Hashim and Murshid[12] in a Saudi sample with all malocclusion classes combined.

The findings of the present study indicate that the Bolton tooth size analysis should be used initially in the diagnostic phase of orthodontic treatment in order to avoid problems that may be encountered either during or at the finishing stages of therapy.

CONCLUSIONS

1. When tooth size ratios were compared, there was a statistical significant difference between normal occlusion and Class III malocclusion for the anterior ratio, whereas, no significant difference was found between the other malocclusion classes for the overall ratio and anterior ratio.
2. Significant sexual dimorphism existed only for the anterior ratio in Class III malocclusion.
3. The means for anterior and overall ratios for the normal occlusion and other malocclusion classes in the present study were statistically significant compared to those of Bolton.
4. Bolton tooth size analysis is an important diagnostic tool and should be taken into consideration before initiation of orthodontic treatment.

REFERENCES

1. Fields HW. Orthodontic restorative treatment for relative mandibular anterior excess tooth size problems. Am J Orthod Dentofacial Orthop 79: 176-183, 1981.
2. Moorrees CFA, Reed RB. Biometric of crowding and spacing of the teeth in the mandible. Am J Phys Antrhop 12: 77-88, 1954.
3. Sperry TP, Worms FW, Isaacson RJ, Speidel TM. Tooth size discrepancy in mandibular prognathism. Am J Orthod Dentofacial Orthop 72: 183-90, 1977.
4. Proffit W. R. Contemporary orthodontics. 2nd edn. St Louis: Mosby, 1993.
5. Heusdens M, Dermaut L, Verbeeck R. The effect of tooth size discrepancy on occlusion: An experimental study. Am J Orthod Dentofacial Orthop 77: 189-91, 2000.
6. Kesling, HD. Philosophy of tooth positioning appliance. Am J Orthod Dentofacial Orthop 31: 297-340, 1954.
7. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 28: 113-130, 1958.
8. Stifter J. A study of Pont's, Howes', Rees', Neff's and Bolton analysis on Class I adult dentitions. Angle Orthod 28: 215-225, 1958.
9. Lavelle CL. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. Am J Orthod Dentofacial Orthop 61: 29-37, 1972.
10. Arya BS, Savara BS, Thomas D. Relation of sex and occlusion to mesiodistal tooth size. Am J Orthod Dentofacial Orthop 66: 479-86, 1974.
11. Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 95: 457-61, 1989.
12. Hashim HA, Murshid Z. Intermaxillary tooth width ratio in a Saudi sample with different malocclusions. Alex Den J 19: 45-52, 1994.
13. Nie Q, Lin J. Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 116: 539-544, 1999.
14. Tamimi TS. An odontometric study of tooth size ratio and arch dimensions in a Saudi population with normal occlusion. Master Thesis, 2000. College of Dentistry, King Saud University. Saudi Arabia.
15. Hunter WS, Priest WR. Error and discrepancies in measurements of tooth size. J Dent Res 39: 405-14, 1960.
16. Binder RE, Cohen SM. Clinical evaluation of tooth size discrepancy. J Clin Orthod 9: 544-546, 1998.