

BOLTON ANALYSIS IN DIFFERENT CLASSES OF MALOCCLUSION IN A SAUDI ARABIAN SAMPLE

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ABSTRACT

Many difficulties encountered during the finishing-phase of orthodontic treatment arise due to lack of intermaxillary tooth-size matching. Bolton ratio is one of the most useful calculations for precise orthodontic diagnosis as it shows if there is a correct ratio between dental proportions. The aim of this study was to compare both the Bolton anterior and overall ratios for a Saudi Arabian sample of different classes of malocclusion and also to find if there is any gender difference. This study involved one hundred sixty subjects divided into three malocclusion groups: Angle's Class I, Angle's Class II, and Angle's Class III. Tooth size measurements, Bolton anterior and overall ratios were performed for the study casts of the patients using the software program Ortho-one. Statistical analysis was done using one-way analysis of variance to check for intergroups differences then independent sample t-test was done to find any sexual dimorphism. The results showed that there is no significant difference between Class I, Class II, and Class III malocclusions. Also no significant gender differences were found in Bolton anterior and overall ratios.

INTRODUCTION :

Specific dimensional relationships must exist between the maxillary and mandibular teeth to ensure proper interdigitation, overbite, and overjet. Discrepancies in tooth size should be known early during the initial diagnosis and treatment planning stages if perfect results in orthodontic finishing are to be achieved.

Many investigators give interest to the harmony between the upper and lower dental arches. Neff¹ developed a proportion for the width dimension of the teeth called the "anterior coefficient". He found that an optimal overbite was represented when maxillary mesiodistal sum divided by the mandibular mesiodistal sum resulted in a ratio of

1.20 to 1.22. Lundstrom² studied the relationship between the mandibular and the maxillary anterior sum and named it the "anterior index". For an ideal overbite, the optimal ratio was found to be from 73% to 85%, with a mean of 79%. Bolton,^{3,4} realized the importance of the harmonious relationship between the teeth in the same arch and between arches. He analyzed the relationship between the mesiodistal tooth width of maxillary and mandibular teeth by studying 55 Caucasian subjects with excellent occlusion. Using the mesiodistal width of 12 teeth, he obtained an overall ratio of $91.3 \pm 1.91\%$; using the six anterior teeth, he obtained an anterior ratio of $77.2 \pm 1.65\%$.

Later on other researchers⁵⁻⁷ proposed new methods to study tooth size discrepancies. Bolton

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method is still the most widely used till now for the diagnosis of tooth size discrepancies.

Many studies reported that the incidence of tooth size discrepancy is high, but relatively little studies in the literature correlated malocclusion with the tooth size discrepancy.

Sperry et al.,⁸ analyzed the Bolton ratios for groups of Class I, Class II, and Class III cases. He found that Class III subjects showed greater mandibular tooth size excess than the Class II and I groups did.

Crosby and Alexander,⁹ analyzed the Bolton ratios for different occlusal categories. They did not differentiate between sexes, and they did not include Class III patients. They did not find a statistically significant difference in the prevalence of tooth size discrepancies among the different malocclusion groups.

Norderval et al.,¹⁰ showed that Bolton anterior ratio was significantly higher in the group with lower incisal crowding compared with the group with good alignment.

Nie and Lin¹¹ found significant differences in the Bolton ratio among several occlusal categories. The study was performed in 360 Chinese subjects, and the data were analyzed according to Angle classifications Classes I, II, and III as well as according to skeletal type. They concluded that the Bolton anterior and overall ratios were greater in Class III patients than in Class II and Class I subjects.

Ta et al.¹² found that the Bolton standards may applied to southern Chinese children with Class I occlusion but not to those with Class II or Class III occlusions. Tooth-size discrepancy was found to be more frequent in the anterior region, especially in the Class III occlusion group.

Lavelle¹³ speculated that Class III individuals had disproportionally smaller maxillary teeth than Class I and Class II subjects did when maxillary

and mandibular dentition sizes were compared.

Differences in tooth size have been associated with different ethnic backgrounds and malocclusions. Smith et al.,¹⁴ who examined the validity of Bolton ratios for different ethnic groups, recently concluded that Bolton's ratios apply only to white women and should not be applied indiscriminately to white men, blacks, or Hispanics. For this reason, the application of Bolton analysis and the proposed values for a harmonious dentition might not be valid for other populations.

Nourallah et al.,¹⁵ applied Bolton's tooth-size analysis to a sample of 55 harmonious Syrian models, found values similar to the original data of an American population. They concluded that the analysis of and ideal values for a harmonious dentition developed by Bolton can also be used on an Arabian or at least a Syrian population.

Araujo and Souki¹⁶ investigated the correlation between anterior tooth size discrepancies and Angle's Class I, II, and III malocclusions, as well as their prevalence in the Brazilian population. They concluded that individuals with Angle Class I and Class III malocclusions show significantly greater prevalence of tooth size discrepancies than do individuals with Class II malocclusions; and the mean anterior tooth size discrepancy for Angle Class III subjects was significantly greater than for Class I and Class II subjects.

MATERIALS AND METHODS

The samples of this study consisted of 160 pretreatment study casts with varying malocclusions chosen from the records of the Orthodontic Department, Faculty of Dentistry, King Abdul-Aziz University, KSA.

The criteria for selection were as follow:

1. Study casts are of a good quality.
2. All the permanent teeth to be fully erupted except for the third molars.

3. No mesiodistal and occlusal tooth abrasion.
4. No proximal caries or proximal fillings.
5. No crown and bridge restorations.
6. No supernumerary teeth or dental malformations.

The age range was 12 -17 years with a mean age of 13.8 years. The sample consisted of 160 individuals was distributed as follows: Angle's Class I (36 males and 62 females); Angle's Class II, (18 males and 34 females); and Angle's Class III (8 males and 2 females).Table 1.

With the ultimate aim of a 'paperless' orthodontic office and with the already existing possibilities of incorporating digital photos and radiographs into the electronic patient's file, the need for replacement of the plaster casts has emerged. Measurements were done by the digital method us-

Table 1. Sample distribution according to malocclusion and gender.

| Class. | Males | Females | Total |
|-------------------|-------|---------|-------|
| Angle's Class I | 36 | 62 | 98 |
| Angle's Class II | 18 | 34 | 52 |
| Angle's Class III | 8 | 2 | 10 |
| Total | 62 | 98 | 160 |

ing the software program Ortho-1(www.enki-soft.com).The casts were scanned through the program using a reflective scanner. With the aid of the mouse, widest mesiodistal dimensions were obtained by digitizing mesial and distal points for the upper and lower 12 teeth (Right first permanent molar to left first permanent molar). Figure : 1

Bolton anterior ratio (Σ of width of lower six anterior teeth / Σ of width of upper six anterior teeth %) and overall ratio (Σ of width of lower 12 teeth / Σ of width of upper 12 teeth %) were calculated according to Bolton,⁴ using the Ortho-1 software program.

Statistical analysis:

Data were saved on an Excel spreadsheet and then transferred to SPSS software package (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, Ill) for statistical analysis. After the measurements corresponding to the sum of mesiodistal widths for the 6 maxillary and mandibular anterior teeth and the 12 maxillary and mandibular teeth were obtained, their distribution was evaluated using the Kolmogorov-Smirnov test to see whether the sample came from a normally distributed population. The test indicated that the sample came from a normally distributed population. Therefore, parametric tests were used.

To statistically compare the anterior and overall tooth size ratios among the malocclusion

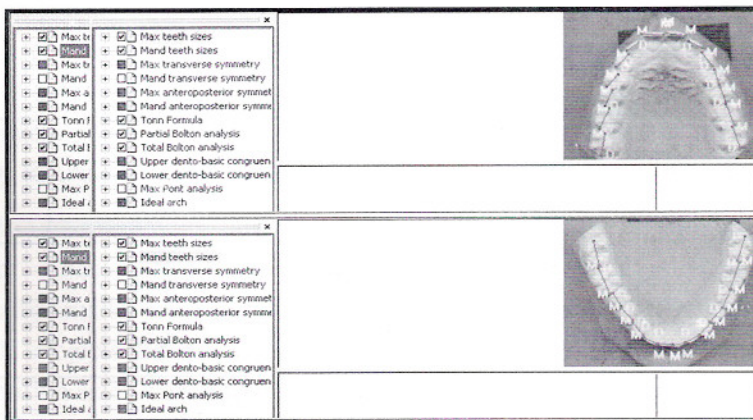


Fig. 1: Determination of the mesiodistal widths and calculation of Bolton ratios.

groups, analysis of variance (ANOVA) was performed. Statistical differences were determined at the 95% confidence level ($P, .05$). To determine if there is any sexual dimorphism in the mean of intermaxillary tooth size ratios, a Student's t-test was performed.

Measurement error assessment:

All measurements were done by the same investigator. For error assessment a total of 20 casts were randomly selected from the original sample, and all the procedures of analysis were repeated after one month. A paired t-test was applied to the first and second measurements. No significant differences between the first and second measurements at the 95% confidence level.

RESULTS

There were no statistically significant differences in Bolton anterior and overall ratios among the different occlusal categories. Table 2 summarizes the means, standard deviations and statistical comparisons of Bolton anterior and overall ratios observed in each group. It shows that there is no statistically significant difference between the three classes of malocclusion for both the anterior and overall ratios. (P -value 0.753 & 0.217 respectively)

Since there were no significant differences between the groups of malocclusion, all the casts were combined and then separated into males and females. Student's t-test was performed to check for sexual dimorphism. Again, there were no statistically significant differences in both ratios between males and females. Table 3 summarizes the means, standard deviations and statistical comparisons of Bolton anterior and overall ratios observed in each sex. It shows that there is no statistically significant difference between the two genders for both the anterior and overall ratios. (P -value 0.102 & 0.353 respectively)

Table 2. Analysis of Variance (ANOVA) of Anterior and Overall Bolton Ratios among Different Malocclusion Groups.

| | Class I | | Class II | | Class III | | P-Value |
|----------------|---------|------|----------|------|-----------|------|---------|
| | Mean | SD | Mean | SD | Mean | SD | |
| Anterior ratio | 81.11 | 5.07 | 81.88 | 4.31 | 80.58 | 3.74 | 0.753 |
| Overall ratio | 93.90 | 4.07 | 93.06 | 3.65 | 96.30 | 1.45 | 0.217 |

* $P \leq .05$

** $P \leq .01$

*** $P \leq .001$

Table 3. Student's t-test of Anterior and Overall Bolton Ratios between two Genders.

| | Males | | Females | | P-Value |
|----------------|-------|------|---------|------|---------|
| | Mean | SD | Mean | SD | |
| Anterior ratio | 80.24 | 4.50 | 82.02 | 4.78 | 0.102 |
| Overall ratio | 93.27 | 4.60 | 94.10 | 3.34 | 0.353 |

* $P \leq .05$

** $P \leq .01$

*** $P \leq .001$

DISCUSSION

Tooth size discrepancies in orthodontic diagnosis has been widely reported in the literature and accepted in the orthodontic field as the relationship between the upper and lower anterior and posterior dentitions is related to proper orthodontic finishing.¹⁶ In this study Bolton anterior and overall ratios in the three classes of malocclusions in a Saudi Arabian sample were studied. The sample size (160 subjects) was relatively small because we restricted the selection upon a young age group to minimize the possibility of alterations in mesiodistal tooth dimensions due to factors such as attrition, proximal restoration or caries.

In this study, the statistical analysis of Bolton anterior and overall ratios calculated in the three classes of malocclusion studied showed no significant differences. This finding was in agreement with earlier studies done by other researchers. Crosby and Alexander⁹ found that there was no significant difference among Class I; Class II, division 1; Class II, division 2; and Class II surgery groups. However, they did not include Class III patients.

Also Qiong and Jiuxiang¹⁷ compared five different malocclusion groups and reported that there were no statistically significant differences between these groups.

The results obtained here in this study confirm also those of Laino et al.,¹⁹ when they used three malocclusion groups based on the values of Steiner cephalometric analysis. Bolton's anterior and total indices were calculated. They concluded that there is no evidence of any predisposition for a tooth-size discrepancy in any of the malocclusion groups.

In a disagreement with our results Lavelle¹³ found that Class III individuals had disproportionately smaller maxillary teeth than Class I and Class II subjects did when maxillary and mandibular dentition sizes were compared. Also Araujo and Souki¹⁶ concluded that individuals with An-

gle Class I and Class III malocclusions show significantly greater prevalence of tooth size discrepancies than do individuals with Class II malocclusions; and the mean anterior tooth size discrepancy for Angle Class III subjects was significantly greater than for Class I and Class II subjects. Again Nie and Lin¹¹ found a significant difference for all the anterior and overall ratios between the groups, the ratios showing that Class III the highest followed by Class I and then Class II. He further added that intermaxillary tooth size discrepancy may be one of the important factors in the cause of malocclusions, especially in Class II and Class III malocclusions and that Bolton analysis should be taken into consideration during orthodontic diagnosis and therapy.

This study demonstrated that there were no sex differences in both anterior and overall Bolton ratios, a finding which is in agreement with other investigators. Nie and Lin¹¹ found no statistically significant sex differences in his Chinese sample. Nourallah et al.,¹⁵ also obtained the same results concerning the gender difference when he applied the Bolton standards upon the Syrian population. Crosby and Alexander⁹ did not differentiate between sexes for any gender differences.

Lavelle¹³ demonstrated sexual dimorphism in the ratio of upper to lower arch tooth size, this is in a disagreement with the conclusions of this current study. Also in the study done by Bernabe et al.,¹⁹ when they studied the tooth-width ratio in a sample of Peruvian adolescents mean total tooth-width ratios between male and female samples were statistically different but the anterior tooth-width ratios between male and female samples were not statistically significantly different.

Again in conflict with the results obtained by Ta et al.,¹² Then they found a statistically significant difference between the Bolton standard and the Class III occlusion group. For the overall ratio, a statistically significant differences were found between the Bolton standard and the Class II

occlusion group, and between the Class II and the Class III occlusion groups.

As regard to the method of measuring the tooth size for the analysis it could be performed with the aid of either Vernier calipers, needle pointed dividers, Boley gauge, Digital caliper or computerized models. Zilberman et al.,²⁰ tested the accuracy of measuring casts with the aid of digital calipers and OrthoCAD. They concluded that the OrthoCAD measurement tool showed high accuracy and reproducibility but was inferior to measurements done on plaster models with digital calipers.

This study demonstrated a high percentage of Bolton discrepancy among the three malocclusion groups studied when compared with the established ratios of Bolton 3,4. The cause of this could be attributed to the fact that Bolton sample was all of ideal occlusion meanwhile our sample here are all having malocclusion. From this it could be suggested that Bolton discrepancies may be a cause of or a predisposing factor to malocclusion.

If these discrepancies are diagnosed early, the orthodontist will be able to plan proper solutions like composite buildups or mesiodistal stripping when required and finishing orthodontics can be better predicted. Another solution suggested by Ramos et al,²¹ is to make changes in inclinations of anterior teeth to resolve anterior Bolton discrepancies and achieve an ideal relationship of incisors.

CONCLUSIONS

From this study it was concluded that:

1- There were no significant differences between Angle's Class I, Class II, and Class III malocclusions.

2- There was no sexual dimorphism in Bolton anterior and overall ratios for the combined three classes of malocclusion.

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