The Inter-arch anterior tooth size discrepancy in different malocclusion groups

Dr. Jamshaid Ali Imran1,2, Dr. Ambreen Afzal3, Dr. Zeeshan Sheikh4,5,6 Dr. Sahar Jamshaid Ali7

1Resident
Department of Orthodontics
Karachi Medical and Dental College/Altamash Institute of Dental Science, Karachi, PAKISTAN

2Senior Registrar
Ziauddin College of Dentistry
Ziauddin University, Karachi, PAKISTAN

3Professor & Head
Department of Orthodontics
Altamash Institute of Dental Science
Karachi, PAKISTAN

4PhD Scholar
Faculty of Dentistry, Biomedical Sciences
McGill University, Montreal, Quebec, CANADA

5Post-Doctoral Fellow
Faculty of Dentistry, Matrix Dynamics Group,
University of Toronto, Ontario, CANADA

6Associate Professor
Department of Material Sciences & Preclinical Dentistry,
Altamash Institute of Dental Medicine
Karachi, PAKISTAN

7Private Dental Practitioner

Corresponding Author
Dr. Jamshaid Ali Imran
E mail: jamshaid.ali@hotmail.com
Phone: +1 647 4701537

Abstract
Objectives: The present study was aimed to investigate the correlation between anterior tooth size discrepancies and Angle’s class I, II, and III malocclusions and to assess their prevalence in the Pakistani population from the metropolitan city, Karachi.

Study design: A Cross sectional, comparative study.

Place and duration of study: Out-patient department (OPD) of Orthodontics division at Karachi Medical and Dental College. Six months.

Subjects and methodology: Total 90 subjects. (Angle’s class I: 30, Angle’s class II: 30 and Angle’s class III: 30) with an age range of 15-25 years were included in the study. Equal distribution of male and female subjects was maintained. The comparison of male and female subjects was done regardless of body height and weight. Non-probability, purposive type of sampling technique was done for data collection. The mesiodistal tooth width was measured from first molar to first molar on 90 mandibular and 90 maxillary plaster models with a vernier caliper. Analysis of variance was used to compare the mean Bolton anterior tooth size ratios as function of Angle classification and gender. Statistical differences were determined at the 95% Confidence level (P < 0.05).

RESULTS: When Comparing mean anterior ratio of class I (mean=79.8), class II (mean =79.9) and class III (mean =85) in 90 casts, significant difference were found among all three classification (P=0.008). The results showed that significant difference found in mean anterior ratio when comparing different malocclusion groups. Significant difference was found in females when comparing mean anterior ratio among males and females in class III malocclusion group. When multiple comparison was done of anterior ratios between malocclusion groups there was no significant difference found between class I and II while class III malocclusion group was significantly different from class I and class II (P=0.007).

Conclusions: Significant difference found in mean anterior ratio when comparing different malocclusion groups. Subjects with an Angle class III malocclusion had a significant greater probability of tooth size discrepancies than those with class I and class II malocclusions.

Key words: Tooth size discrepancy; Bolton analysis; Bolton ratio; Tooth size analysis; malocclusion.
Introduction
The presence of a tooth size discrepancy [TSD] prevents the achievement of an ideal occlusion. A high percentage of finishing phase difficulties arises because of tooth size imbalance that could have been detected and considered during initial diagnosis and treatment planning. In some situations, tooth size discrepancy is not observed at the initial examination and could result in poor contacts, spacing, crowding, and an abnormal overjet and overbite. The etiology of malocclusion can be broadly categorized under either hereditary, environmental, or a combination of both factors. Exploring the etiology of malocclusion is imperative for selecting the most appropriate treatment approach as well as the most appropriate retention device. Crowding and spacing are considered the most common manifestations of malocclusion and can occur as a result of either a shortage of the space required for tooth alignment or an excess of available space. The tooth size measurements of Wheeler also are frequently used. As significant tooth size discrepancies prevent an ideal occlusion being produced at the end of orthodontic treatment, the absence of a TSD is the seventh “key” for an ideal occlusion.

On a clinical level, mesiodistal tooth width is correlated to the arch alignment and large teeth are associated with crowded dental arches. Patients with interarch tooth size discrepancies require either removal (e.g., interdental stripping) or addition (e.g., composite buildups or porcelain veneers) of tooth structure to open or close spaces in the opposite arch, it is important to determine the amount and location of a tooth size discrepancy before starting treatment. Bolton developed a method of analyzing the mesiodistal tooth size ratio between maxillary and mandibular teeth. Among patients undergoing orthodontic treatment, the prevalence of an overall TSD has varied from 4% – 11%. Anterior TSDs, however, have prevalence between 17% and 31% among orthodontic patients. The anterior tooth size ratio was higher for Hispanics (80.5%) than for Black people (79.3%). Despite these findings, Othman and Harradine noted that the trend to larger overall tooth size ratios in Black populations is unlikely to be clinically relevant. Significant discrepancies in the overall and anterior tooth size ratios have been found in Japanese, Iranian-Azari, Spanish, and Brazilian subjects. Much work has been done internationally, however no study has been done in our population to set the norms for mesiodistal crown dimension and interarch tooth size ratios. Study of these lines would greatly improve the quality of orthodontic finish in our population and lead to a more sound understanding of one of the most complex variables affecting orthodontic malocclusion. Trends have been identified in the prevalence of TSDs among the malocclusion groups. TSDs are more common in Class II division 1 malocclusions and in Class III malocclusions. The purpose of the study is to set a baseline data to encourage the research of this region to carry out more research on this subject in Pakistani population. The objective of the current study was to determine any difference in intermaxillary tooth size discrepancies represented by anterior ratios when comparing Class I, Class II and Class III cases in a Pakistani population. Study of these lines would greatly improve the quality of orthodontic finish in our population and lead to a more sound understanding of one of the most complex variables affecting orthodontic malocclusion.

Materials and Methods
The data for this study was obtained from the records of the Karachi Medical & Dental College, Dept of Orthodontics. Considering that tooth size is not related to age, the sample selection procedure was based on dental age and the presence of a permanent dentition defined by the presence of all teeth at least from first molar to first molar. The subjects were randomly selected and assigned to three malocclusion groups according to the Angle classification classes I, II, and III. Total 90 subjects (30 pairs of Angle’s Class I, 30 pairs of Class II and 30 pairs of Class III malocclusion). Sampling Technique was Non-Probability, purposive type. The selection criteria adopted were anterior permanent teeth erupted in the upper and lower arches; good-quality study casts; absence of tooth deformity; no record of restoration or stripping of incisor and canine teeth age range of 15 to 25 years of age. Exclusion criteria were: Patients exhibiting incisal or cuspal attrition, fractures of teeth or ectopically erupted teeth, patients with anomalies of tooth size (e.g., microdontia, macrodontia; peg laterals etc), patients with anomalies of tooth number (e.g., hyperdontia, hypodontia, cases of fusion of teeth and gemination), patients with history of previous orthodontic treatment, patients with craniofacial syndrome or anomalies.

A stainless steel Boley Gauge vernier caliper (Odontomed2011, product ref # 16140) was used to measure the mesiodistal width to the nearest 0.1 mm. The width of each tooth was measured from its mesial contact point to its distal contact point at its greatest interproximal distance. Bolton anterior (canine to the canine) ratios were calculated with the following formulae:

Sum mandibular “6” X 100 = anterior ratio (%) 
Sum maxillary “6”

Statistical analysis was performed on data using the software: IBM®SPSS® (v. 20, IBM SPSS Inc., Chicago, IL). For all continuous variables including age and malocclusion, mean (X) and standard deviation (SD), values were calculated for each
measurement. To compare the means of anterior ratio in different malocclusion group's analysis of variance (ANOVA) statistical significance level was taken at 0.05.

Results

Out of 90 cast, 30 pairs of angle class I, 30 pairs of angle class II and 30 pairs of angle class III. The age distribution is 15-25 where 55% are between 15-19 years, 43% in between 20-24 years and rest are above 24 year as shown in fig 1. When comparing mean anterior ratio of class I (mean = 79.8), class II (mean = 79.9) and class III (mean = 85) in 90 casts, significant difference were found among all three classification (p=0.008) as shown in table 1. When multiple comparison was done of anterior ratios between malocclusion groups there was no significant difference found between class I and class II. The class III malocclusion group was significantly different from class I and class II (p = 0.007) as shown in table 2.

Table 1. Comparison of means of anterior ratio in different malocclusion groups (n=90).

<table>
<thead>
<tr>
<th>Classes</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
<th>95% CI</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (n=30)</td>
<td>69 – 89.9</td>
<td>79.8</td>
<td>4.97</td>
<td>77.9 - 81.6</td>
<td>0.008</td>
</tr>
<tr>
<td>II (n=30)</td>
<td>68.5 - 105.19</td>
<td>79.9</td>
<td>7.04</td>
<td>77.2 - 82.5</td>
<td></td>
</tr>
<tr>
<td>III (n=30)</td>
<td>66.6 - 107.7</td>
<td>85</td>
<td>9.1</td>
<td>81.6 - 88.46</td>
<td></td>
</tr>
</tbody>
</table>

*By applying ANOVA (Analysis of Variance).

Table 2. Multiple comparisons of anterior ratio between different malocclusion groups.

<table>
<thead>
<tr>
<th>Classes</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class-I and Class-II</td>
<td>0.977</td>
</tr>
<tr>
<td>Class-III and Class-I</td>
<td>0.007*</td>
</tr>
<tr>
<td>Class-III and Class-II</td>
<td>0.007*</td>
</tr>
</tbody>
</table>

*By LSD test (used t-test to perform all pair wise comparisons)
* Class-III is significantly different from class I and II

Class-I = The triangular ridge of the mesiobuccal cusp of the maxillary first permanent molar articulates in the buccal groove of the mandibular first molar.
Class-II = The mesial groove of the mandibular first permanent molar articulates posteriorly to the mesiobuccal cusp of the maxillary first permanent molar.
CLASS III= The mesial groove of the mandibular first permanent molar articulates anteriorly to the mesiobuccal cusp of the maxillary first permanent molar.

Figure 1.Age distribution of patients (n = 90)

Mean ± SD = 17.32 ± 3.94 (years)
Range = 15 – 25 Years

Figure 2.Boley Gauge Vernier Caliper, stainless steel (Odontomed2011, product ref # 16140)
Discussion

A tooth-size discrepancy is defined as a lack of harmony between the mesiodistal widths of individual teeth or groups of teeth when related to their functional counterparts of the opposing arch. Any discrepancy will result in either spacing in 1 arch or a compromise in functional relationships. To achieve good occlusion with the correct overbite and overjet, the maxillary and mandibular teeth must be proportional in size to each other. 22 Tooth size discrepancies are considered an important variable especially in the anterior segment. Lavelle 23 stated that although tooth size and proportion have an important role in malocclusion. Genetic influences have been considered important in the determination of tooth dimensions, and the first reports were related to clinical observations within families. Studies on twins, however, helped in understanding the genetic contribution of tooth size in that a greater tooth size correlation was found in monozygotic twins. 24 Other investigators de-emphasized the genetic contribution and described the determination of tooth size as multifactorial, with the environment playing an important role. 26

Teratogenic and nutritional factors have been associated with the mechanism of tooth formation. Space limitations and nutrition have been described as important in the development of a healthy tooth germ and have been related to alterations in number, shape and form of permanent teeth. 26 Although it is widely accepted that both genetic and environmental variables affect tooth development, it is virtually impossible to identify and describe the role each of these variables play in the determination of tooth size.

Several studies were published describing the importance of a correct tooth size proportion between the upper and lower arches. Lundström 27 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 10,28 evaluated 55 cases with “excellent” occlusion. After considering tooth sizes from canine to canine in the maxillary and mandibular arches, Bolton established an ideal anterior ratio with a mean value of 77.2% and standard deviation (SD) of 1.65%. It would be very difficult to obtain an excellent occlusion in the finishing phase of treatment without a correct mesiodistal tooth size ratio. Orthodontists should be concerned with tooth size discrepancies because of the high incidence in orthodontic patient populations. Bolton 10,28 reported tooth size discrepancies greater than ±1 SD in 29% of the patients studied in his private practice, and Richardson and Malhotra 29 reported similar discrepancies in 33.7% of their patients. Crosby and Alexander 30 stated that a tooth size discrepancy had to be greater than ±2 SD, e.g., two to three mm of deviation, to influence the course of orthodontic treatment. In studies involving 109 individuals, 22.9% showed anterior ratios that significantly deviated from the Bolton analysis mean (greater than ±2 SD).

Sassouni 31 was the first to report that individuals with a Class III facial type and deficient maxillary growth showed a greater prevalence of alterations in shape of the anterior teeth as well as a greater incidence of agenesis. In more recent articles, other variables such as incisor inclinations, upper-incisor thickness, 33,34 and arch form 35,36 have been described as important to consider in achieving optimal occlusion relationships. Efforts have been made to adapt the Bolton analysis to these variations. Cua-Benward et al. 37 studied the prevalence of missing teeth in different malocclusion groups, relating their findings to Moss’s functional matrix concept. They found a greater prevalence of tooth deformities in the maxilla in Class III individuals, whereas they found more tooth deformities in the mandible in Class II individuals. Hashim HA 38 evaluated mesiodistal crown width in different malocclusion groups (Class I, Class II and Class III) and found no statistical difference between them. Discrepancies in tooth size should be known at the initial diagnosis and treatment planning stages if perfect results in orthodontic finishing are to be achieved.

Tooth size discrepancies are considered an important variable, especially in the anterior segment. Araujo and Souki 39 reported that the mean anterior tooth size discrepancy for Angle Class III subjects was significantly greater than that for Class I and Class II Subjects.

A comparative study between Jordanians, Iraqi, Yemenites, and Caucasians reported that Jordanians and Iraqi had larger teeth than the other populations. 39 The later study, however, did not discuss the differences in tooth size between different malocclusions. Correct tooth size relationship between maxillary and mandibular teeth is an important factor to achieve a proper occlusal interdigitation during the final stages of orthodontic treatment. 10,40 The importance of correct tooth size proportions between the upper and lower arches has been demonstrated. Neff 40 developed an anterior coefficient, which was a proportion for the width dimension of the teeth. A ratio of 1.20 – 1.22 when the maxillary mesio-distal sum was divided by the mandibular mesio-distal sum would result in an optimal overbite. Several methods have been described to evaluate interarch tooth size relationship such as Neff’s anterior coefficient 40,41 and Bolton’s ratios for the six anterior teeth and the overall ratio for the 12 teeth. 10,28

Many factors such as heredity, growth of the bone, eruption and inclination of the teeth, external influences, function, and ethnic background would
affect the size and shape of the dental arches. However, Gilmore and Little found that, although there was a tendency for incisors with a greater mesiodistal dimension to be associated with crowding, the association was so weak that reduction of the widths of incisors to fit a specific range cannot be expected to produce a stable alignment. Theories proposed to explain the cause of dental crowding vary widely, embracing concepts of evolution, heredity, and environmental effects.

In a more recent study, Santoro et al. reinforced the findings of Crosby and Alexander observing that 28% of 54 Dominican Americans presented a discrepancy greater than ±2 SD. Lavelle studied 160 subjects for anterior tooth sizes and showed a tendency for Angle Class III individuals to present smaller upper teeth compared with subjects classified as Class II or I. Moreover, Lavelle stated that teeth in the lower arch are larger in Class III than in Classes II and I, with the inference that a Bolton discrepancy is greater in Class III cases than in the other malocclusion groups. In this study, the mesiodistal tooth size and Bolton ratio were compared in Class I, Class II and Class III in a Pakistani sample.

In our study anterior ratio showed tendency towards large Bolton ratio in class III malocclusion group which is most similar to the studies done in Chinese population. The difference in the results between this study and the other investigations might be attributed to the sample size, method of analysis and large standard deviation found in this study. Crosby and Alexander also compared the tooth size ratios among different malocclusion groups, as in this study. They found that there were no significant differences among Class I, Class II division 1, Class II division 2, and Class II surgery groups. This study also found no significant difference between these groups. In this study we compared the tooth size ratios among Angle’s class I, class II and class III malocclusion groups and found significant difference in mean anterior ratios of class III malocclusion group.

Crosby and Alexander also compared the tooth size ratios among different malocclusion groups but did not included class III malocclusion group, as in the current study. They found that there was no significant difference among Class I, Class II, division 1; Class II, division 2; and Class II surgery groups. In the present study, three malocclusion groups were compared, and no statistically significant difference was found among them in overall ratio and statistical difference in anterior ratio. For patients with Class III malocclusion, the present findings were in accordance with Nie and Lin and Lavelle.

The subjects in the present investigation all had malocclusions sufficiently severe to warrant treatment and it is possible that this is contributed to the larger percentage of tooth size discrepancies, especially in the anterior region. This could be explained by the fact that anterior teeth, especially the incisors, have a much greater incidence of tooth size deviations, that is, the greatest variables in mesiodistal tooth width occur in the anterior region. The findings that individuals with a Class III malocclusion have a significantly greater mean anterior ratio than the other groups may confirm the results of Lavelle that Class III individuals have disproportionately smaller maxillary teeth than Class I and Class II subjects. However, a small size of the maxillary teeth was not found in the present study. Therefore, the Bolton discrepancy in the Class III sample must either be attributed to an increase in the width of the anterior mandibular teeth or the accumulation of minor discrepancies of individual teeth.

The results obtained by Nie and Lin using Angle’s classification as a variable in analyzing 360 Chinese individuals for tooth size discrepancies are in agreement with the present findings that Class III patients demonstrate a greater tooth size discrepancy when compared with Class II and I patients. Crosby and Alexander tried to verify the presence of a tooth size discrepancy in 109 patients divided into four malocclusion groups, but not including Class III subjects. They compared the average of the anterior and overall Bolton indices but did not find any statistical difference in the incidence of the tooth size discrepancy among the groups (Class I, Class II divisions 1 and 2, and surgical Class II). Some of the findings in the present investigation were similar to their results with respect to the absence of statistically significant differences when comparing Class I and Class II malocclusion groups. Since they did not include subjects with a Class III malocclusion in their investigation, they could not find any difference between normal occlusion and malocclusion groups coinciding with the Bolton indices, while in the present study, a large part of the differences in the Bolton indices were attributed to the presence of a Class III malocclusion.

Several authors proposed new methods to study tooth size discrepancies. However, these proposals need to be tested in clinical studies and, for now, the Bolton analysis prevails as an efficacious clinical tool for appraising various relationships of upper to lower dentitions. The high prevalence of anterior TSDs in Irish orthodontic population suggests that a tooth size analysis should be conducted at the treatment planning stage. Where significant TSDs are detected, this is normally accommodated by the reduction or augmentation of tooth tissue.

Further studies are needed to clarify whether a correlation exists between increased mandibular growths (as in Class III malocclusions) with
increased mesiodistal dimensions of lower anterior teeth. The possible interaction of genetic factors could determine mandibular size while affecting the mesiodistal dimensions of lower mandibular teeth in the same way.

**Conclusion**

Subjects with an Angle Class III malocclusion had a significantly greater probability of tooth size discrepancies than those with Class I and Class II malocclusions. The mean anterior tooth size discrepancy for Angle Class III individuals was significantly greater than that in Class II and Class I malocclusion. The Orthodontist who is aware of these possible discrepancies will be better prepared to diagnose and plan treatment with a more accurate certainty for patients of varied population mix. These conclusions could greatly influence clinical decision making and further studies should be undertaken in this field.

**References**

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