

INTER-ARCH TOOTH SIZE DISCREPANCY AMONG DIFFERENT SAGITTAL MALOCCLUSION GROUPS AND ITS CLINICAL IMPLICATIONS

¹NAZIR AHMAD, BDS, FCPS

²MUBASSAR FIDA, BDS, MCPS, FCPS

ABSTRACT

The relationship of the mesiodistal widths of the maxillary and mandibular teeth influences the optimal final occlusion, overbite and overjet. The aim of this study was to compare inter-arch tooth size ratios among different malocclusion groups and to determine the percentage of clinically significant cases (outside two SD from the Bolton's mean) in each malocclusion group. Pretreatment records of 110 patients belonging to different malocclusion groups (Class I = 40, Class II = 40, Class III = 30) were evaluated for Bolton's anterior, overall and posterior ratios. Angle's classification system was used to assign cases into different malocclusion groups. No significant difference was found in anterior, posterior and overall Bolton's ratios among the three malocclusion groups. Forty percent of the entire sample had clinically significant discrepancy in anterior ratio, while 14.54% patients had discrepancy in overall ratios. In Class I malocclusion group, 37.5% patients had anterior ratios and 20% had overall ratios discrepancy outside 2 SD from Bolton's mean. In Class II group, 35% patients had anterior ratios and 12.5% had overall ratios outside this range. In Class III malocclusion group, 50% patients had anterior and 10% patients had overall ratio discrepancies outside 2 SD from Bolton's means. No significant difference was found between males and females when the three ratios were compared between the two genders in individual malocclusion groups as well as in the entire sample.

Key Words: Bolton's discrepancy, Angle's Malocclusion groups.

INTRODUCTION

The relationship of the mesiodistal widths of the maxillary and mandibular teeth influences the optimal final occlusion, overbite and overjet. If teeth are mismatched with unusually large teeth in one arch compared to the other, then an ideal occlusion cannot be attained. The disproportion in the sizes of teeth between the maxillary and mandibular teeth has been defined as a tooth size discrepancy.¹⁻⁴ Inter-arch tooth size discrepancy often influences treatment planning. For example, a congenitally small lateral incisor needs enlargement that may require preserving or regaining space in order to accommodate a restoration or a crown.^{5,6} Extraction decisions may be influenced by the relative tooth size discrepancies between the maxillary and mandibular teeth.^{7,8} In some situations, the tooth size discrepancy is not observed at the initial examination and could result in poor contacts, spacing, crowding and an abnormal overjet and overbite.⁹

Bolton¹ in 1958 analyzed the relationship between the mesiodistal tooth widths of the maxillary and mandibular teeth and described anterior and overall ratios. Various values of inter-arch tooth size discrepancies have been considered clinically significant. Manke and Miethke³ suggested starting corrections at about 2 to 3 mm of discrepancy. Other studies^{2,4} have defined a significant discrepancy as a value outside 2 SD from Bolton's mean. Similarly Thurlow¹⁰ indicated that any tooth size ratio that fell within the 2 SD of the Bolton's mean may be considered normal. Cases with ratios outside 2 SD were considered as having significant discrepancy by Crosby and Alexander.¹¹ More recently, several studies^{2,12} have defined, a clinically significant discrepancy, as a ratio outside 2 SD from the Bolton's mean.

Many studies^{2,3,12} have been carried out on good or excellent occlusions and different ethnicities. However, only a few studies^{9,13} have compared the inter-arch tooth size ratios among different malocclusion groups. The literature is also deficient in studies considering the percentage of clinically significant cases in the different malocclusion groups. The aim of this study was to compare inter-arch tooth size ratios among different malocclusion groups and between the two genders and to determine the percentage of clinically significant

¹ **For Correspondence:** Dr Nazir Ahmad, Assistant Professor Orthodontics, Sardar Begum Dental College, Gandhara University, Canal Road, Academy Town, Peshawar Pakistan. E-mail: nazirahmad_dr@yahoo.com Phone # +92-91-5844429-32 Fax # 091-5844482

² Associate Professor & Program Director Orthodontics, The Aga Khan University Hospital, Karachi

Received for Publication: April 15, 2014

Revision Received: May 6, 2014

Revision Accepted: May 12, 2014

cases (outside two SD from the Bolton's mean) in each malocclusion group in a sample Pakistani population.

METHODOLOGY

The sample for this study consisted of 110 patients with varying malocclusions (Angle's Class I=40, Class II=40 and Class III=30). Patients were selected from those visiting the Department of Orthodontics at the Aga Khan University Hospital for orthodontic treatment. The Angle's classification was used to assign cases into different malocclusion groups. The data were collected from pre-treatment orthodontic casts and files of the patients. Our inclusion criteria included the presence of all permanent teeth, fully erupted, from right to left first permanent molar and age range of 13-30 years. Our exclusion criteria included all those patients who had previous orthodontic treatment, any developmental anomalies/syndromes, restorations and extractions or inter-proximal stripping of teeth.

The greatest mesiodistal widths of all permanent teeth from first molar to first molar were measured from the casts with pointed veneer calipers specifically designed for dental use (Dental Vernier, Munchner Model, Dentaaurum Germany). The data were recorded on a data collection form designed for this study. Anterior and over all tooth size ratios were calculated for each subject according to Bolton's formula.¹ The posterior ratio was also calculated by dividing the sum of the mesiodistal widths of mandibular 1st and 2nd premolars and 1st permanent molar divided by sum of the mesiodistal widths of maxillary 1st and 2nd premolars and 1st permanent molar.⁹ Descriptive statistics including mean, standard deviations and ranges for age, gender, malocclusion groups, overall, anterior and posterior ratios were calculated for each group. One-way ANOVA was used to compare the means of the three ratios among the three malocclusion groups. Independent sample t-test was used when two of the three malocclusion groups were compared in varying combinations. To see gender dimorphism in the entire sample and in individual malocclusion group, independent sample t-test was used.

To determine clinically significant tooth size discrepancies in the entire sample and each malocclusion group, the anterior and overall ratios were categorized according to Bolton's mean and standard deviations for anterior (77.2 ± 1.65) and overall (91.3 ± 1.91) ratios. All those cases outside 2 SD (for the anterior ratio, a ratio below 73.9% or above 80.5%, and for overall ratio any ratio below 87.5% or above 95.1%) from the Bolton's mean

were considered as clinically significant. An analysis of error was performed by randomly selecting 15 pairs of dental casts and recording the same measurements by the same operator at two weeks interval. A paired sample t-test was applied to the measurements to see any difference. No significant difference was found between the two measurements at 95% confidence level ($P > .05$).

RESULTS

The distribution of subjects according to gender and malocclusion is given in Table 1. The mean age was 17 years 5 months (minimum 13 years and maximum 30 years) for the entire sample. The mean age of patients in Class I group was 16 years 9 months, for Class II group it was 17 years 7 months and for Class III group it was 18 years and 1 month. The means and standard deviations of the anterior ratios for the entire sample and Class I, II and III malocclusion groups are given in Table 2. The highest mean Anterior Ratio was found for Class I followed by the Class II group. The highest Overall Ratio was noted for the Class III group followed by the Class I. For the Posterior Ratio, a highest value was recorded for Class III malocclusion followed by Class II. A comparison of the three ratios among the three malocclusion groups showed no statistically significant difference as shown in Table 3.

A comparison of the three ratios between individual malocclusion groups was done in varying combination, but none of the results was statistically significant as shown in Table 4. A comparison of the three ratios between the two genders showed no significant difference as shown in Table 5.

To determine the number of clinically significant cases, the percentage of cases outside 2 SD from Bolton's mean were calculated. Forty percent of the patients in the entire sample had anterior ratios and 14.5% of the patients had overall ratios outside 2 SD from Bolton's means as shown in Tables 6 and 7. Similarly 37.5% patients in the Class I malocclusion group had anterior ratios and 20% had overall ratios outside 2 SD from Bolton's mean. In the Class II group, 35% patients had anterior ratios and 12.5% had overall ratios outside 2 SD from the Bolton mean. In the Class III malocclusion group, 50% of the patients had anterior and 10% patients had overall ratio outside 2 SD from Bolton's mean. This shows a greater prevalence of clinically significant tooth size discrepancy in the Class III malocclusion group, when only anterior ratios were considered. However for the overall ratios, a greater prevalence of clinically significant tooth size discrepancy was found in the Class I malocclusion group.

TABLE 1: DISTRIBUTION OF SUBJECTS ACCORDING TO GENDER AND MALOCCLUSION GROUPS

Malocclusion groups	Males	Females	Total
Class I	19	21	40
Class II	18	22	40
Class III	16	14	30
Total	53	57	110

TABLE 2: MEAN AND STANDARD DEVIATIONS OF ANTERIOR, OVERALL AND POSTERIOR RATIOS IN THREE MALOCCLUSION GROUPS

Malocclusion group	Anterior ratio (mean $\pm$ SD)	Overall ratio (mean $\pm$ SD)	Posterior ratio (mean $\pm$ SD)
Class I	79.80 $\pm$ 4.54	91.49 $\pm$ 3.12	102.88 $\pm$ 5.46
Class II	79.17 $\pm$ 3.35	91.46 $\pm$ 2.64	103.47 $\pm$ 3.23
Class III	79.00 $\pm$ 3.43	91.83 $\pm$ 2.23	104.79 $\pm$ 3.99
Total sample	79.35 $\pm$ 3.83	91.57 $\pm$ 2.70	103.62 $\pm$ 4.38

TABLE 3: COMPARISON OF ANTERIOR, OVERALL AND POSTERIOR RATIOS AMONG THE THREE MALOCCLUSION GROUPS

Ratios	Class I	Class II	Class III	P value
Anterior Ratio	79.80 $\pm$ 4.54	79.17 $\pm$ 3.35	79.00 $\pm$ 3.43	0.647
Overall Ratio	91.49 $\pm$ 3.12	91.46 $\pm$ 2.64	91.83 $\pm$ 2.23	0.826
Posterior Ratio	102.88 $\pm$ 5.46	103.47 $\pm$ 3.23	104.79 $\pm$ 3.99	0.193

Test of significance: ANOVA
Level of significance: $p \leq 0.05$

TABLE 4: COMPARISON OF ANTERIOR, OVERALL AND POSTERIOR RATIOS BETWEEN INDIVIDUAL MALOCCLUSION GROUPS

Ratios	Class I vs II (p value)	Class I vs III (p value)	Class II vs III (p value)
Anterior Ratio	0.487	0.423	0.532
Overall Ratio	0.962	0.609	0.829
Posterior Ratio	0.563	0.112	0.131

Test of significance: independent sample t-test
Level of significance: $p \leq 0.05$

TABLE 5: COMPARISON BETWEEN MALES AND FEMALES IN INDIVIDUAL MALOCCLUSION GROUPS AND ENTIRE SAMPLE

Ratios	Class I males vs females (p value)	Class II males vs females (p value)	Class III males vs females (p value)	Entire sample males vs females (p value)
Anterior Ratio	0.491	0.425	0.539	0.809
Overall Ratio	0.539	0.668	0.831	0.809
Posterior Ratio	0.805	0.904	0.531	0.973

Test of significance: independent sample t-test
Level of significance: $p \leq 0.05$

TABLE 6: THE PERCENTAGE DISTRIBUTION OF ANTERIOR TOOTH SIZE DISCREPANCIES OUTSIDE 2 SD FROM BOLTON'S MEAN

Malocclusion group	Outside -2 SD (<73.9)	-2 SD (73.90-75.54)	-1 SD (75.55-77.19)	Mean 77.20	+1SD (77.21-78.85)	+2SD (78.86-80.50)	Outside +2 SD (>80.50)
Class I	2.5%	5.0%	12.5%	2.5%	17.5%	25.0%	35.0%
Class II	7.5%	5.0%	12.5%	2.5%	22.5%	22.5%	27.5%
Class III	6.67%	3.33%	23.33%	0.0%	13.33%	10.0%	43.33%
Entire sample	5.45%	4.55%	15.45%	1.82%	18.185	20%	34.55%

TABLE 7: THE PERCENTAGE DISTRIBUTION OF OVERALL RATIO DISCREPANCIES OUTSIDE 2 SD FROM BOLTON'S MEAN

Malocclusion group	Outside -2 SD (<87.50)	-2 SD (87.50-89.39)	-1 SD (89.40-91.29)	Mean 91.30	+1SD (91.31-93.29)	+2SD (93.21-95.10)	Outside +2 SD (>95.10)
Class I	10.0%	7.5%	22.5%	0.0%	37.5%	12.5%	10.0%
Class II	2.5%	17.5%	27.5%	0.0%	35.0%	7.5%	10.0%
Class III	6.67%	6.67%	23.33%	3.33%	36.67%	20.0%	3.33%
Entire sample	6.365	10.91%	24.55%	0.91%	36.36%	12.73%	8.18%

DISCUSSION

The importance of tooth size discrepancies in orthodontic diagnosis has been widely reported in the literature because the relationship between the upper and the lower anterior dentitions is related to orthodontic finishing excellence.¹³ In the present study a comparison of tooth size ratios was made among different malocclusion groups. Subjects in the younger age group were chosen to minimize the alteration in mesiodistal tooth dimensions because of factors such as attrition or caries.

The result of present study showed no significant differences in the Anterior, Overall and Posterior ratios among the three malocclusion groups. This is in agreement with some earlier studies in different populations. Crosby and Alexander¹¹ and Xia and Wu¹⁴ found no significant difference for tooth size ratios between the malocclusion groups and the normal occlusion group. Similar results were shown by Basaran et al¹⁵, Al-Khatteeb and Abu-Alhaija,¹⁶ Akyalcin et al¹⁷ and Uysal et al.¹⁸ However some other studies by Nie and Lin¹⁹ and Fattahi et al²⁰ have shown significant differences in anterior and overall ratios among different malocclusion groups. Alkofide and Hashim²¹ concluded that no significant difference was found among the three groups for overall ratios, but a significant difference was found in the anterior ratios of the three groups. Ta et al²² found no significant differences in anterior ratios among the three malocclusion groups. This difference in the result of our study with other studies can be due to a number of reasons e.g. difference in sample selection criteria and sample sizes, racial and ethnic differences among different populations studied and allocation of subjects into various malocclusion groups on dental or skeletal basis.

A comparison of anterior, overall and posterior ratios between male and female subjects in the entire sample and individual malocclusion groups showed no significant difference between the two genders. Similar results were shown by Nie and Lin¹⁹, Ta et al²², Gaidyte et al²³, Nourallah et al²⁴ and Bernabe et al²⁵. However some other studies by Uysal and Sari¹⁸, Fattahi et al²⁰, Smith et al²⁶ and Bernabe et al²⁵ have shown gender dimorphism in anterior, overall and posterior ratios, with most studies showing larger anterior and overall ratios in males than females.

The number of patients with clinically significant tooth size discrepancy was also calculated. For the entire group, 40% of the patients had anterior and 14.54% of the patients had overall ratio discrepancy. It was found that a high percentage of patients had an anterior ratio outside 2 SD from Bolton's mean. In the majority of these patients, the discrepancy was more towards the higher range than lower. This can be interpreted as an anterior mandibular excess or maxillary deficiency. Uysal and Sari¹⁸ found overall ratio discrepancy in 18% and anterior discrepancy in 21.3% of the subjects. In other studies the percentage of patients reported with a clinically significant overall discrepancy are 13.4% by Crosby and Alexander¹¹, 5% by Bernabe et al²⁵, 8% by Ta et al²² and 18.5% by Gaidyte et al²³. The percentages of patients with clinically significant anterior ratio discrepancy as reported in different studies are 30.6% by Crosby and Alexander¹¹, 20.5% by Bernabe et al²⁵, 26% by Ta et al²² and 5.5% by Gaidyte et al.²³ The percentage of patients with a clinically significant anterior ratio was highest in our study as compared to other studies. This can be explained by the fact that maxillary and mandibular incisors have more predispositions to variability in crown size and morphology.

Also some of the above studies were done on subjects with normal occlusion while all the subjects in our study had malocclusions severe enough to warrant treatment. It is possible that this contributed to the larger percentage of tooth size discrepancies found in this sample.

When considered in individual malocclusion groups, individuals in the Class III group had the highest percentage of clinically significant anterior ratio discrepancies. It has been suggested²⁷ that the smaller mesiodistal widths of maxillary lateral incisors in Class III subjects can be the possible cause of anterior ratio discrepancy in this group. Similarly the Class I group had the maximum number of cases with clinically significant overall ratio discrepancy. When compared with other studies, Uysal et al²⁸ reported the highest number of Class III patients showing both anterior and overall ratios outside 2 SD from Bolton's mean. Similar results were reported by Ta et al²², who found out that majority of class III patients had significant anterior discrepancy.

The finding that a large number of individuals presented with proportionately discrepant maxillary dental arches is important to the clinician. When aware of the possible discrepancies, the orthodontist should consider increasing the maxillary tooth size mass in Class III patients with the objective of achieving optimal incisor inclination and occlusal relationship. Also changes in incisors inclination and angulations may be used as a strategy to resolve anterior Bolton discrepancy and achieve normal incisor relationships. Inter-proximal reduction of mandibular incisors may sometime be required to achieve normal occlusion at the end of treatment. In this case early discussion with the patients will be required to educate them and get their consent for inter-proximal stripping at treatment planning stage.

CONCLUSION

No significant difference was found in tooth size ratios among three malocclusion groups. Class III malocclusion group had highest percentage (50%) of patients with clinically significant anterior tooth size discrepancy. Clinically significant anterior ratio discrepancy was found in 40% cases in the entire sample, while overall ratio discrepancy was found only in 14.5 % patients. No significant difference was found between males and females when the three ratios were compared between the two genders.

REFERENCES

- Bolton WA. The clinical application of a tooth-size analysis. *Am J Orthod.* 1962; 48: 504-29.
- Freeman JE, Maskeroni AJ, Lorton L. Frequency of Bolton tooth-size discrepancies among orthodontic patients. *Am J Orthod Dentofacial Orthop.* 1996; 110: 24-7.
- Manke M, Miethke RR. Size of the anterior Bolton's Index and frequency of the Bolton's discrepancy in the anterior tooth segment in untreated orthodontic patients. [German translation] *Fortschritte der Kieferorthopädie.* 1983; 44: 59-65.
- Endo T, Uchikura K, Ishida K, Shundo I, Sakaeda K, Shimooka S. Thresholds for Clinically Significant Tooth-Size Discrepancy. *Angle Orthod.* 2009; 79: 740-6.
- Jones ML, Richmond T. An assessment of the fit of a parabolic curve to pre- and post-treatment dental arches. *Br J Orthod.* 1989; 16: 85-93.
- Braun S, Hnat WP. Dynamic relationships of the mandibular anterior segment. *Am J Orthod Dentofacial Orthop.* 1997; 111: 518-24.
- Shellhart WC, Lange DW, Kluerner GT, Hicks EP, Kaplan AL. Reliability of the Bolton tooth-size analysis when applied to crowded dentitions. *Angle Orthod.* 1995; 65: 327-34.
- Rudge SJ. Dental arch analysis: Arch form: a review of the literature. *Eur J Orthod.* 1981; 3: 279-84.
- Othman S, Harradine H. Tooth Size Discrepancies in an Orthodontic Population. *Angle Orthod.* 2007; 77: 668-74.
- Thurlow RC. *Atlas of orthodontic principles.* Second Edition, St. Louis: C.V. Mosby, 1977. Pages 88-91.
- Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. *Am J Orthod Dentofacial Orthop.* 1989; 95: 457-61.
- Johe RS, Steinhart T, Sado N, Greenberg B, Jing S. Intermaxillary tooth-size discrepancies in different sexes, malocclusion groups, and ethnicities. *Am J Orthod Dentofacial Orthop.* 2010; 138: 599-607.
- O'Mahony G, Millett DT, Barry MK, McIntyre GT, Cronin MS. Tooth size discrepancies in Irish orthodontic patients among different malocclusion groups. *Angle Orthod.* 2011; 81: 130-3.
- Xia Z, Wu XY. The application of dentocclusal measurement in malocclusion. *Stomatol.* 1983; 3: 126-7.
- Basaran G, Selek M, Hamamcı O, Akkus Z. Intermaxillary Bolton tooth size discrepancies among different malocclusion groups. *Angle Orthod.* 2006; 76: 26-30.
- Al-Khateeb SN, Abu-Alhaja ESJ. Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. *Angle Orthod.* 2006; 76: 459-65.
- Akyalcın S, Dogan S, Dincer B, Erdinc AME, Oncag G. Bolton tooth size discrepancies in skeletal Class I individuals presenting with different dental Angle's classifications. *Angle Orthod.* 2006; 76: 637-41.
- Uysal T, Sari Z. Intermaxillary tooth size discrepancy and mesiodistal crown dimensions for a Turkish population. *Am J Orthod Dentofacial Orthop.* 2005; 128: 226-30.
- Nie Q, Lin J. Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. *Am J Orthod Dentofacial Orthop.* 1999; 116: 539-44.
- Fattahi HR, Pakshir HR, Hedayati Z. Comparison of tooth size discrepancies among different malocclusion groups. *Eur J Orthod.* 2006; 28: 491-5.
- Alkofide E, Hashim H. Intermaxillary tooth size discrepancies among different malocclusion classes: a comparative study. *J Clin Pediatr Dent.* 2002; 26: 383-7.
- Ta TA, Ling JY, Hagg U. Tooth-size discrepancies among different occlusion groups of southern Chinese children. *Am J Orthod Dentofacial Orthop.* 2001; 120: 556-8.
- Gaidyte A, Latkauskienė D, Baubiniene D, Leskauskas V. Analysis of tooth size discrepancy (Bolton index) among patients of orthodontic clinic at Kaunas Medical University. *Stomatol.* 2003; 5: 27-30.
- Nourallah AW, Splieth CH, Schwahn C, Khurdaji M. Standardizing interarch tooth-size harmony in a Syrian population. *Angle Orthod.* 2005; 75: 996-9.
- Bernabe E, Villanueva KM, Flores-Mir C. Tooth width ratios in crowded and noncrowded dentitions. *Angle Orthod.* 2004; 74: 765-8.
- 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: 169-74.
- Lavelle CL. Maxillary and mandibular tooth size in different racial groups and in different occlusion categories. *Am J Orthod.* 1972; 61: 29-37.
- Uysal T, Sari Z, Basciftci FA, Memili B. Intermaxillary tooth size discrepancy and malocclusion: Is there a relation? *Angle Orthod.* 2005; 75: 204-09.