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Original Research Article

Retrospective Assessment of the Prevalence of Anterior Bolton Tooth-Size Discrepancy in Class I, Class II and Class III Malocclusions

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Abstract:

Background: Anterior tooth-size discrepancy can influence overjet, overbite, anterior intercuspation, and orthodontic treatment outcomes. Bolton analysis provides a standardized method for evaluating the proportional relationship between maxillary and mandibular anterior teeth.

Aim: To retrospectively assess the prevalence of anterior Bolton tooth-size discrepancy and compare anterior Bolton ratios among Class I, Class II, and Class III malocclusions.

Methodology: A retrospective observational study was conducted on 90 orthodontic records and study casts from the Department of Dentistry, Anugrah Narayan Magadh Medical College and Hospital, Gayaji, Bihar. Participants were equally divided into Class I, Class II, and Class III groups (30 each). Mesiodistal widths of the six maxillary and mandibular anterior teeth were measured, and the anterior Bolton ratio was calculated. Data were analyzed using SPSS version 27.0.

Results: The mean anterior Bolton ratio was 76.9 ± 1.9% in Class I, 77.5 ± 2.2% in Class II, and 78.1 ± 2.3% in Class III, showing a significant difference (p=0.046). Overall, 41 (45.6%) participants had tooth-size discrepancy. Prevalence was 40.0%, 50.0%, and 46.7% in Class I, II, and III, respectively. Gender distribution was comparable.

Conclusion: Anterior Bolton discrepancy was common across all malocclusion groups, supporting routine Bolton analysis in orthodontic diagnosis and treatment planning.

Keywords: Bolton ratio; tooth-size discrepancy; malocclusion; Class I; Class II; Class III; orthodontics.

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Introduction

The objective of orthodontic treatment is to provide a proper relationship between the upper and lower teeth and a harmonious face, which would also result in functional occlusion and stability over time [1]. Tooth position, the relative relationship of the maxilla and mandible, arch form and growth directions are important factors in determining occlusion, but the relative size of the upper and lower teeth is also a major factor. The difference in size between the two sets of teeth is known as a tooth-size discrepancy (TSD). When all of the teeth are properly aligned, improper tooth size may result in poor overjet, overbite, intercuspation, and space closure. Thus, evaluation of tooth-size relationships is crucial to the diagnosis and treatment planning process in orthodontics.

The idea of tooth-size discrepancy was a well-planned idea that was introduced by Bolton who studied the correlation between the mesiodistal widths between the maxillary and the mandibular teeth in people with excellent occlusion [2]. Bolton developed the anterior and overall ratios to measure the relationship between the dentitions of the mandibles and maxillae in proportion. Anterior ratio is obtained by multiplying the sum of mesiodistal width of the six mandibular anterior teeth by 100, then dividing by the sum of mesiodistal width of the six maxillary anterior teeth. In his sample, Bolton noted a mean anterior ratio of 77.2% with deviations from this ratio representing relative excess of mandibular or maxillary tooth material. The Bolton analysis is then widely used for the diagnosis of tooth-size discrepancies prior to and during orthodontic treatment.

The anterior tooth-size discrepancy is of special concern because anterior teeth play a direct role in overjet, overbite, incisor inclination, anterior intercuspation and dentition esthetic appearance [3]. Some patients may have excessive anterior tooth material in the mandible which can compromise the ability to

obtain ideal overjet and interdigitation, while excessive anterior tooth material in the maxilla can result in problems with achieving ideal anterior relationships and space closure. Interproximal reduction and/or restorative addition or some other compensating procedure may be required to deal with clinically significant discrepancies, with interproximal reduction being used in cases of small discrepancies.

Malocclusion is often described based on the relationship of the first permanent molars – Class I malocclusion, Class II malocclusion, Class III malocclusion [4]. In most cases, Class I malocclusion is relatively normal molar occlusion, although it can occur with crowding, spacing, dental rotations or other dental irregularities. Class II malocclusion may have a distal relationship of the mandibular dentition to the maxillary dentition and may be associated with increased overjet and variations in the inclination of the incisors [5]. Class III malocclusion is defined as having the lower teeth in the front of the mouth askew and may have anterior crossbite and/or a narrow or negative overjet. The proportional relationship between the size of the teeth of the upper and lower jaws may be different in these malocclusion groups depending on the dental and skeletal features of each group.

There have been several studies looking at the relationship between Bolton tooth-size discrepancies and various malocclusion groups [6]. Variations in the anterior Bolton ratios have been reported in Class I, Class II and Class III but the results have not been entirely consistent between populations [7]. Other's investigations have found that there is more excessive anterior occlusal relation among Class III subjects, which may be a cause for the prominent anterior relationship seen in this class. The reverse situation, however, also has been documented in Class II malocclusions, specifically in regard to differences in size of the upper and lower incisors. These observations indicate that the Bolton ratio might not be the same for all malocclusion categories.

The relevance of Bolton's original standards for contemporary and ethnically diverse people has also been called into doubt. The dimension of the tooth may differ between different ethnic, sex and age groups and population characteristics [8]. Different populations have been studied, and shown variations in the width of mesiodistal teeth and the Bolton ratio from that of Bolton. Thus, the measurement of the prevalence of the anterior Bolton discrepancy in a clinically defined population can be helpful for diagnosis and treatment planning in orthodontics [9]. This is especially important if one tooth is being evaluated to see if the difference is due to a true tooth-size imbalance or just due to normal biological variation.

A retrospective evaluation enables the comprehensive re-examination of previous orthodontic diagnostic records, dental casts, digital models or other records if any are available to assess tooth-size relationships. Existing records can be used to compare anterior Bolton ratios between malocclusion groups without the need of prospective recruitment. After classification of various cephalometric positions as Class I, Class II and Class III malocclusion, anterior Bolton ratios (ABR) can be calculated and the prevalence and distribution of clinically relevant discrepancies in tooth size can be defined. This method could also be used to determine if specific malocclusion patterns are associated with increased anterior tooth size disproportion.

It is clinically important to know the prevalence of anterior Bolton tooth-size discrepancy in the various malocclusion groups. The discrepancy becomes important before treatment because it can help determine orthodontists if there will be some problems in achieving ideal anterior occlusion, and to choose the proper treatment mechanics. Can also stop unneeded tooth movement done to make up for an unrecognized tooth-size imbalance. Hence, the present study, entitled as "Retrospective Assessment of the Prevalence of Anterior Bolton Tooth-Size Discrepancy in Class I, Class II and Class III Malocclusions," is carried out to evaluate the prevalence of anterior tooth size discrepancy and to see how many tooth size Bolton discrepancies are seen in the three major malocclusions.

Methodology

Study Design: The present study was conducted as a retrospective observational study to assess the prevalence of anterior Bolton tooth-size discrepancy among patients with Class I, Class II, and Class III malocclusions. The study was based on previously recorded orthodontic diagnostic records and study casts of patients who had attended the Department of Dentistry during the specified study period. The records were reviewed to obtain demographic, dental, and orthodontic information relevant to the assessment of anterior tooth-size discrepancy.

Study Area: The study was conducted in the Department of Dentistry, Anugrah Narayan Magadh Medical College and Hospital, Gayaji, Bihar, India.

Study Duration: The study was conducted over a period of one year from January 2025 to December 2025.

Study Participants: The study participants consisted of patients whose orthodontic records and dental casts were available in the department and who had been classified into Class I, Class II, or Class III malocclusion according to the Angle classification. A total of 90 eligible records were included in the study and were categorized into the three malocclusion groups.

Inclusion Criteria

- Records of patients having permanent dentition with erupted maxillary and mandibular anterior teeth from canine to canine.
- Records of patients diagnosed with Class I, Class II, or Class III malocclusion according to Angle's classification.
- Records having adequate-quality and properly preserved maxillary and mandibular study casts.
- Records in which all permanent anterior teeth required for measurement were present.
- Records containing sufficient clinical and orthodontic information for classification of malocclusion.
- Study casts showing clearly identifiable mesiodistal dimensions of the maxillary and mandibular anterior teeth.

Exclusion Criteria

- Records of patients with missing maxillary or mandibular anterior teeth.
- Study casts with fractures, distortion, poor preservation, or inadequate quality for accurate measurement.
- Patients with congenital absence or developmental anomalies affecting the anterior teeth.
- Teeth showing marked morphological abnormalities or significant deformity.
- Records of patients who had undergone restoration, interproximal reduction, stripping, or other procedures that could have altered the original mesiodistal tooth dimensions.
- Records with incomplete or insufficient information for assigning the patient to a malocclusion group.

Sample Size: A total sample of 90 patients was included in the study. The selected records were distributed among three malocclusion groups, namely Class I, Class II, and Class III, for assessment and comparison of the prevalence and magnitude of anterior Bolton tooth-size discrepancy.

Procedure: The eligible orthodontic records and study casts were retrieved from the departmental archives. Each selected record was reviewed for demographic details and classification of malocclusion. Patients were categorized into Class I, Class II, and Class III groups according to the documented Angle classification. The maxillary and mandibular anterior permanent teeth, from canine to canine, were examined on the study casts. The greatest mesiodistal width of each maxillary and mandibular incisor and canine was measured using a calibrated digital vernier caliper with an accuracy of 0.01 mm. Measurements were recorded to the nearest 0.1 mm. The measurements of the six maxillary anterior teeth and six mandibular anterior teeth were summed separately for each participant. The anterior Bolton tooth-size ratio was calculated using Bolton's formula: Anterior Bolton ratio = (sum of mesiodistal widths of mandibular six anterior teeth / sum of mesiodistal widths of maxillary six anterior teeth) × 100. The calculated ratio was compared with Bolton's established anterior ratio of approximately 77.2% to identify anterior tooth-size discrepancy. The discrepancy was categorized according to whether the calculated ratio indicated a clinically relevant excess in mandibular or maxillary anterior tooth material. The prevalence of anterior Bolton tooth-size discrepancy was subsequently determined within each malocclusion group. All measurements were performed by the same examiner to minimize inter-examiner variability. A proportion of randomly selected casts was remeasured to assess the reliability of the measurements.

Statistical Analysis: The collected data were entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics version 27.0. Descriptive statistics were used to summarize the demographic characteristics, malocclusion groups, anterior Bolton ratios, and prevalence of tooth-size discrepancy. The mean and standard deviation were calculated for continuous variables, while frequencies and percentages were calculated for categorical variables. The prevalence of anterior Bolton tooth-size discrepancy was compared among Class I, Class II, and Class III malocclusion groups using the Chi-square test. One-way ANOVA was used to compare the mean anterior Bolton ratios among the three malocclusion groups, where applicable. Appropriate post-hoc analysis was performed for significant ANOVA results. The level of statistical significance was set at $p < 0.05$, and a 95% confidence level was considered for statistical interpretation."

Result

Table 1 presents the distribution of study participants according to their demographic characteristics among the 90 participants included in the study. The mean age of the participants was 17.2 ± 3.1 years. The largest proportion of participants belonged to the 16–19 years age group, comprising 38 (42.2%) participants, followed by those aged 12–15 years, with 32 (35.6%) participants. Participants in the 20–25 years age group constituted the smallest proportion, accounting for 20 (22.2%) participants. Regarding gender, the study population was equally distributed, with 45 (50.0%) male and 45 (50.0%) female participants. Thus, the study included a balanced representation of both genders, while participants aged 16–19 years constituted the predominant age group. Overall, the demographic profile indicates that the study population primarily consisted of adolescents and young adults, with a relatively even distribution across the two genders.

Table 1: Distribution of study participants according to demographic characteristics (N=90)			
Variable	**Category**	**n**	**%**
Age (years)	12–15	32	35.6
	16–19	38	42.2
	20–25	20	22.2
Mean age ± SD		**17.2 ± 3.1**	
Gender	Male	45	50
	Female	45	50
Total		**90**	**100**

Table 2 presents the distribution of participants according to the type of malocclusion and gender within each malocclusion group. The study population of 90 participants was equally divided among Class I, Class II, and Class III malocclusion groups, with 30 (33.3%) participants in each group. Regarding gender distribution, the Class I group comprised 14 (46.7%) males and 16 (53.3%) females, indicating a slight female predominance. In the Class II group, 16 (53.3%) participants were male and 14 (46.7%) were female, showing a slightly higher representation of males. The Class III group demonstrated an equal gender distribution, with 15 (50.0%) males and 15 (50.0%) females. Overall, the complete study population consisted of 45 (50.0%) males and 45 (50.0%) females. Thus, the three malocclusion groups were equally represented, while gender distribution within the groups remained relatively balanced.

Table 2: Distribution of participants according to type of malocclusion (N=90)			
Malocclusion group	**n**	**%**	
Class I	30	33.3	
Class II	30	33.3	
Class III	30	33.3	
Total	**90**	**100**	
Gender distribution within malocclusion groups			
Malocclusion	**Male, n (%)**	**Female, n (%)**	**Total**
Class I	14 (46.7)	16 (53.3)	30
Class II	16 (53.3)	14 (46.7)	30
Class III	15 (50.0)	15 (50.0)	30
Total	**45 (50.0)**	**45 (50.0)**	**90**

Table 3 compares the maxillary and mandibular anterior tooth dimensions and anterior Bolton ratio among the Class I, Class II, and Class III malocclusion groups. The mean sum of maxillary anterior tooth dimensions was 47.8 ± 2.4 mm in Class I, 47.5 ± 2.6 mm in Class II, and 47.1 ± 2.5 mm in Class III, with no statistically significant difference among the groups (p=0.564). Similarly, the mean sum of mandibular anterior tooth dimensions was 36.7 ± 2.0 mm, 36.9 ± 2.1 mm, and 37.0 ± 2.2 mm in Class I, Class II, and Class III groups, respectively, and the difference was not statistically significant (p=0.841). However, the anterior Bolton ratio demonstrated a statistically significant difference among the three groups (p=0.046). The ratio increased progressively from 76.9 ± 1.9% in Class I to 77.5 ± 2.2% in Class II and 78.1 ± 2.3% in Class III, indicating variation in anterior tooth-size relationships across malocclusion patterns."

Table 3: Comparison of maxillary and mandibular anterior tooth dimensions and Bolton anterior ratio among different malocclusion groups				
Parameter	**Class I (n=30) Mean ± SD**	**Class II (n=30) Mean ± SD**	**Class III (n=30) Mean ± SD**	**p-value**
Sum of maxillary anterior teeth (mm)	47.8 ± 2.4	47.5 ± 2.6	47.1 ± 2.5	0.564
Sum of mandibular anterior teeth (mm)	36.7 ± 2.0	36.9 ± 2.1	37.0 ± 2.2	0.841
Anterior Bolton ratio (%)	76.9 ± 1.9	77.5 ± 2.2	78.1 ± 2.3	0.046*

"Table 4 presents the prevalence of anterior Bolton tooth-size discrepancy according to the malocclusion group among the 90 study participants. In the Class I group, 18 (60.0%) participants had no tooth-size discrepancy, whereas 12 (40.0%) demonstrated a discrepancy. In the Class II group, an equal distribution was observed, with 15 (50.0%) participants showing no discrepancy and 15 (50.0%) having a tooth-size discrepancy. In the Class III group, 16 (53.3%) participants had no discrepancy, while 14 (46.7%) demonstrated a discrepancy. Overall, 49 (54.4%) participants had no anterior Bolton tooth-

size discrepancy, whereas 41 (45.6%) participants exhibited a discrepancy. The prevalence of discrepancy was therefore highest in the Class II group (50.0%), followed by Class III (46.7%) and Class I (40.0%). These findings indicate that anterior Bolton tooth-size discrepancy was relatively common across all three malocclusion groups.

Table 4: Prevalence of anterior Bolton tooth-size discrepancy according to malocclusion group (N=90)			
Malocclusion group	**No discrepancy, n (%)**	**Tooth-size discrepancy, n (%)**	**Total**
Class I	18 (60.0)	12 (40.0)	30
Class II	15 (50.0)	15 (50.0)	30
Class III	16 (53.3)	14 (46.7)	30
Total	**49 (54.4)**	**41 (45.6)**	**90**

Table 5 presents the distribution of anterior Bolton tooth-size discrepancy according to gender among the 90 study participants. Among the 45 male participants, 24 (53.3%) had no tooth-size discrepancy, whereas 21 (46.7%) demonstrated an anterior Bolton discrepancy. Similarly, among the 45 female participants, 25 (55.6%) had no discrepancy, while 20 (44.4%) showed a tooth-size discrepancy. Overall, 49 (54.4%) participants had no anterior Bolton tooth-size discrepancy, whereas 41 (45.6%) exhibited a discrepancy. The prevalence of discrepancy was slightly higher among males (46.7%) than females (44.4%), with a difference of only 2.3 percentage points. Conversely, the proportion without discrepancy was marginally higher among females (55.6%) compared with males (53.3%). Thus, anterior Bolton tooth-size discrepancy was observed in nearly half of the participants, with a relatively similar distribution between male and female participants.

Table 5: Distribution of anterior Bolton tooth-size discrepancy according to gender (N=90)			
Gender	**No discrepancy, n (%)**	**Tooth-size discrepancy, n (%)**	**Total**
Male	24 (53.3)	21 (46.7)	45
Female	25 (55.6)	20 (44.4)	45
Total	**49 (54.4)**	**41 45.6)**	**90**

Discussion

This present retrospective study evaluated anterior Bolton tooth-size discrepancy among 90 patients in equal numbers in Class I, Class II and Class III malocclusion. The mean age of the participants was 17.2 ± 3.1 years, with the majority (68%) were between the ages of 16 and 19. The 3 groups of malocclusion were evenly distributed so that a suitable comparison could be made of the anterior tooth-size relationships for the 3 groups. Harmonious proportional relationships between anterior teeth of the maxilla and mandible are essential for optimal occlusion and desirable orthodontic finishing (Bolton, 1958) [10]."

"In the present study, the mean sum of the widths of the maxillary anterior teeth was found to be 47.8 ± 2.4 mm, 47.5 ± 2.6 mm and 47.1 ± 2.5 mm in Class I, Class II and Class III, respectively. The corresponding mandibular anterior tooth sums were 36.7 ± 2.0 mm, 36.9 ± 2.1 mm, and 37.0 ± 2.2 mm, respectively. No significant difference was found between the absolute dimensions of anterior teeth in the three malocclusion groups, showing that there was a fair degree of similarity in the absolute dimensions of anterior teeth. The results are consistent with those of Crosby and Alexander (1989) [11] who reported no significant differences among the various malocclusions when analysing tooth-size discrepancies. Likewise, Basaran et al. (2006) [12] found differences in interarch size relationships of malocclusion groups, but showed that interarch size relationships can vary based on the population studied.

However, the anterior Bolton ratio was different among the present study groups. The ratio increased progressively from 76.9 ± 1.9% in Class I to 77.5 ± 2.2% in Class II and 78.1 ± 2.3% in Class III. The Class I was not far removed from Bolton's original anterior ratio of around 77.2% (Bolton, 1958). Class III reflects a relatively greater contribution from the mandibular anterior teeth to the anterior maxilla. This is consistent with the findings of Nie and Lin (1999) [13] which showed that the intermaxillary tooth-size discrepancy was larger in the Class III subjects than in the Class I and Class II subjects. Likewise, in individuals with mandibular prognathism, Sperry et al. (1977) [14] noted an excess in the size proportions of mandibular teeth, implying that there may be a relationship between mandibular tooth-size excess and anterior tooth-size imbalance in Class III malocclusion.

Araujo and Souki (2003) in a study of 300 subjects also found that the frequency of anterior tooth size discrepancy in Class III subjects was higher than that of Class II subjects, and was higher than that of Class I subjects. They reported, however, that the highest prevalence was in Class III (49.9%), Class II (26.3%) and Class I (20.0%), findings that differ from the present study. Crosby and Alexander (1989) also did not find any significant variation in discrepancy incidence between malocclusion

groups. This conflicting evidence suggests the association between malocclusion pattern and Bolton discrepancy may differ among population groups depending on population characteristics, sample size, diagnostic criteria, and the discrepancy definition.

In general, 41 (45.6%) of the participants in the present study exhibited anterior Bolton tooth-size discrepancy, while 49 (54.4%) did not. Therefore, almost half of the orthodontic sample exhibited some degree of anterior tooth-size imbalance. Bolton discrepancies have also been reported in orthodontic patients and were found by Freeman et al. 1996 [15] indicating the clinical significance of periodic measurement of tooth size. Crosby and Alexander (1989) reported nearly 22.9% anterior discrepancy when they used a more stringent criterion, of ±2 standard deviations. This may account for the greater rate of discrepancy seen in the current study, in relation to the operational definition and threshold applied for the identification of discrepancy.

A few notes are also due on the difference between the continuous Bolton ratio and the categorical discrepancy prevalence. Class III had the highest mean ratio value (78.1 ± 2.3%), however, Class II had the highest percentage of discrepancies (50.0%). This shows that different aspects of tooth-size imbalance can be represented by group mean ratios and proportions of people who have surpassed a set discrepancy threshold. Thus, the highest mean ratio does not necessarily lead to the maximum incidence of classified discrepancy.

The prevalence was virtually the same for males and females. There was a slight difference of only 2.3 per cent between the anterior Bolton discrepancies of the males and the females, with 21 (46.7%) males and 20 (44.4%) females having this discrepancy. The present result is consistent with Nie and Lin's (1999) report of no association of tooth-size discrepancy with gender. But interarch tooth-size relationships are not the same across populations, and cannot be determined from just sex" (Smith et al. 2000 [16]). Males might show greater absolute tooth size, but there might be similar proportions in the anterior segment of the teeth in both sexes (Garn et al., 1964) [17].

An anterior Bolton discrepancy is more prevalent in the present study than in most other studies, highlighting the importance of making a tooth-size analysis to individualize the treatment of each case prior to orthodontic intervention. Any undetected discrepancies can impact overjet, overbite, anterior interdigitation, and final occlusal relationships. Recognition of Bolton discrepancy may aid in predicting treatment needs such as interproximal reduction, restorative augmentation and/or modification of anterior tooth inclination, as suggested by Ramos et al. [18]. In general, these results indicate that while the absolute size of the anterior teeth was similar among the 3 groups, the anterior Bolton ratio was significantly different and greater in the Class III group than in the Class I and Class II groups. Another finding found in all three malocclusion groups reinforces the importance of routine Bolton analysis in orthodontic diagnosis and treatment planning.

Conclusion

The present retrospective study demonstrated that anterior Bolton tooth-size discrepancy was a relatively common finding among patients with Class I, Class II, and Class III malocclusions. Among the 90 participants, 41 (45.6%) exhibited an anterior tooth-size discrepancy, while 49 (54.4%) showed no discrepancy. Although the mean maxillary and mandibular anterior tooth dimensions did not differ significantly among the three malocclusion groups, the mean anterior Bolton ratio showed a statistically significant difference, increasing from 76.9 ± 1.9% in Class I to 77.5 ± 2.2% in Class II and 78.1 ± 2.3% in Class III. The prevalence of discrepancy was highest in Class II (50.0%), followed by Class III (46.7%) and Class I (40.0%). Gender-wise, the prevalence was comparable between males and females. These findings emphasize the importance of routine Bolton analysis for individualized orthodontic diagnosis, treatment planning, and achievement of optimal anterior occlusion.

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