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Evaluation of the discrepancy of the bolton ratio in three groups of sagittal skeletal relationships

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ABSTRACT

Introduction: The outcome of orthodontic treatment depends on the malocclusion and the ratio of the size of the upper and lower teeth. The aim of this study was to evaluate the discrepancy of tooth crown size in different groups of malocclusions.

Materials & Methods: In this cross-sectional study, 165 patients referred to the Orthodontic Department of Babol School of Dentistry were randomly selected. The samples were divided into three skeletal malocclusion groups (55 in each group) according to the ANB angle. The level of anterior and total Bolton ratio in the cases was calculated, and the deviation from normal value of anterior and posterior Bolton was calculated. The results were analyzed using the ANOVA and chi-square test. The significance level was set at $p < 0.05$.

Results: The sample consists of 80 males and 85 females aged 12 to 25 years. The mean and standard deviation of the anterior tooth ratio were 79.06 ± 2.87 in Cl I, 79.23 ± 3.18 in Cl II, and 80.16 ± 3.71 in Cl III, and there was no significant difference between the mean anterior ratio between the malocclusion groups. The mean and standard deviation of the total Bolton ratio (TBI) were 91.3 ± 2.39 in Cl I, 91.6 ± 2.49 in Cl II, and 92.49 ± 2.64 in Cl III and the difference between the mean total ratio among the groups was statistically significant.

Conclusion: Based on the results of this study between different groups of malocclusion, clinicians should consider the detailed examination of dental proportions in the diagnosis and treatment planning stage.

Keywords: Orthodontics, Malocclusion, Tooth Crown

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Introduction

Cephalometric analysis, which is based on various angular and linear measurements, is an essential part of orthodontic diagnosis and treatment planning, and the analysis of the jaws on the sagittal plane is an essential step in this direction. [1] In orthodontics, the discrepancy is usually described in three dimensions of transverse, sagittal, and vertical. Angular and linear measurements are also included in various cephalometric analyzes to assist the physician in diagnosing anterior-posterior discrepancies. [2, 3] The prevalence of dental malocclusion has been significant in many studies. A high percentage of orthodontic end-stage problems are caused by an imbalance in tooth size that could be detected during initial diagnosis and treatment planning. [4] An excellent outcome of orthodontic treatment with optimal occlusion is often compromised by differences in tooth size or problematic tooth anatomy. [5] If the teeth are disproportionate in size, so that the large teeth are abnormally in one arch relative to the other, ideal occlusion is not achieved, which is defined as the tooth size discrepancy (TSD).[6]

Lack of TSD is the seventh key to ideal occlusion because significant discrepancy inhibits the production of optimal results at the end of orthodontic treatment. [7] The size of the teeth and the size of the arch should be in harmony with each other for proper alignment of the teeth. [8] Also, by determining the size imbalance of the teeth at the initial diagnosis, many orthodontic problems can be prevented during the end stages of treatment. [9] Along with several methods, Bolton's analysis is the most common calculation for defining inter-arch TSD. [10] Some research has shown a correlation between tooth size differences and malocclusion groups. [11-13] Bolton defined an index called the Bolton Anterior Ratio, or ABI (Anterior Bolton's Index), which is calculated by measuring the ratio of the total mesiodistal width of the anterior mandibular teeth to the maxilla. He also defined the TBI index (Bolton's Total Index), which is calculated by measuring the ratio of the total mesiodistal width of the first molar of one side to the first molar of the other side of the mandible to the maxilla. He calculated the anterior Bolton index as 77.2 ± 1.65 % and the total Bolton index as 91.3 ± 1.91 %. Following the Bolton study, many studies were performed, many of which show that these two ratios should be treated according to different races and ethnicities. [14-16]

Previous studies have found an association between deviations of Bolton ratio and Angle Class II and Class III malocclusions. [12] Several studies have found that patients with Class III malocclusion tend larger anterior ratios compared to Class I and II patients. [5, 17] Hussein [10] reported that subjects with Class III malocclusion had smaller maxillary teeth and larger lower arch compared to the subjects with Class II molar relationships. Machado et al., [18] found that anterior Bolton ratios were smaller in Class II patients and larger in Class III patients compared to those with Class I molar relationships. Conversely, Shastri et al. [17] reported that Class II malocclusion was associated with higher anterior ratios in the North Indian population. However, some researchers have not found a difference in Bolton ratios between malocclusion groups [15, 16, 19] Lopatiene et al. [19] did not reveal a statistically significant difference in the anterior Bolton ratio between Angle Class I, II, and III.

The orthodontic treatment result depends on the evaluation of crowding and type of skeletal malocclusion and the ratio of the size of the teeth in the maxilla and mandible and since this ratio is variable between different communities and there are no data related to the evaluation of Bolton ratio in this region of the country, the aim of this study was to evaluate the frequency of discrepancy to Bolton ratio in the orthodontic department of Babol School of Dentistry and frequency of tooth size disorders

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in skeletal malocclusions (CI I, CI II and CI III) respectively. The results of this study will be considered basic information for therapeutic considerations in orthodontic patients.

Materials & Methods

This descriptive-analytical cross-sectional study was performed on 165 patients referred to the orthodontic department of Babol Dental School between 2010 to 2018. This study was approved by the Ethics Committee of Babol University of Medical Sciences (IR.MUBABOL.HRI.REC.1398.282). The sample size of 165 cases (55 in each class) was calculated based on a previous study and the below formula. [20]

$$N_1 = \frac{(Z_{1-a/2} + Z_{1-\beta})^2 * [p_1(1-p_1) + R * p_2(1-p_2)]}{(p_1 - p_2)^2} = \frac{(1.96 + 0.84)^2 * [0.28*0.72 + 0.081*0.919]}{(0.28 - 0.081)^2} = 54.65 = 55$$

The samples were selected from patients who had done their orthodontic treatment in Babol dental school and complete preorthodontic records were available, so they entered three skeletal sagittal malocclusions according to the ANB angle. During the admission of patients to Babol Dental School, patients were given written consent in advance, to use their casts and graphs for research projects. In this study, cephalometric radiography and the cast of patients referred to Babol Dental School were studied. In each of the three malocclusion groups, 55 patients were included. The inclusion criteria consisted of the following characteristics: Age between 12 and 25 years, all permanent teeth except the third molars are fully grown, casts are of good quality (no bubbles, fractures, or restorations), and Lateral cephalometrics prepared under standard conditions are available to determine ANB.

Exclusion criteria consisted of these characteristics: Patients with a history of orthodontics, patients with congenital cleft palate and congenital missing anomalies, patients with lateral peg teeth, extracted teeth, deformed teeth, gemination-fusion, broken teeth, with interproximal restoration and caries

With an orthodontic tracing paper, the lateral cephalometrics were manually traced and after determining the cephalometric points, the ANB angle formed between the SNA and SNB lines was measured with the by protractor. Then, samples were divided into three groups of skeletal sagittal malocclusions according to ANB angle as follows: Class I with ANB = 0-4، Class III with ANB<، and Class II with ANB>4. [21]

The mesiodistal width of the right first molars to the left first molars was measured with a digital caliper (Insize Company, Suzhou New District, China) at a distance between two points of contact parallel to the occlusal surface and perpendicular to the buccal surface according to the Moorrees method. [22] To calculate Bolton's anterior ratio, the width of six anterior teeth of the mandible from the canine of one side to the opposite side was divided by the width of six similar anterior teeth in the maxilla. To calculate Bolton's total ratio, the width of 12 mandibular teeth from the first molar of one side to the first molar of the opposite side was divided by the width of 12 teeth similar to the maxilla after calculation of Bolton anterior and total ratio in individuals, deviation from the normal value of anterior and posterior Bolton was reported. The number of subjects with Bolton ratio discrepancy was measured among the three skeletal malocclusion groups and then compared with chi-Square test and one-way analysis of variance. Data were analyzed by SPSS 23 statistical software and the prevalence index and mean were used to report the data and the statistically significant level was considered $P< 0.05$.

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Results

Among the 165 patients (consisting of 80 males and 85 females at age 12 to 25 years) studied in terms of malocclusion classification, 55 cases were in class I, 55 cases in class II, and 55 cases in the class III group. The mean and standard deviation of the anterior ratio has been presented in Table 1. Based on ANOVA analysis, no significant difference was observed between the mean anterior ratios of the groups. (p=0.169). The mean and standard deviation of Bolton's total ratio (TBI) in the separation of malocclusion groups has been presented in table 1. Based on ANOVA analysis, there was a significant difference between the mean total ratio of the groups (p-value=0.039). Based on post hoc, there was a significant difference between CL I and CL III in total ratio. (p=0.03). In terms of a discrepancy, the anterior Bolton ratio was 34.5% (57 cases) normal and 65.5% (108 cases) had TSD. According to the chi-square test, the relationship between the malocclusion class and anterior discrepancy was not significant. (p=0.352).

Among 108 patients with TSD, 81.5% had an anterior ratio greater than 2 standard deviations and 18.5% had an anterior ratio less than 2 standard deviations from the mean. These ratios are also given in the different classes in Table 2. According to the chi-square test, there was no significant relationship between the amount of anterior ratio discrepancy in different classes of malocclusion. (p=0.700) In terms of total Bolton discrepancy, 60.6% (100 cases) had normal and 39.4% (65 cases) had TSD. According to the chi-square test, the relationship between the malocclusion class and Bolton's total ratio was not significant (p=0.719), (Table 2). Among patients with a total Bolton ratio discrepancy, 69.2% (45 patients) had a Bolton ratio greater than 2 standard deviations and 30.8% (20 patients) had a Bolton ratio less than 2 standard deviations from the mean. These ratios in different classes are also given in Table 2. According to the chi-square test, there was no significant relationship between the mean difference of Bolton's total ratio in different classes of malocclusion (p=0.435).

Table 1. Mean and standard deviation of anterior and total ratio in patients studied (*P<0.05)

Malocclusion groups	Number	Bolton ratio	Mean ± SD	Min	Max	†P value
Cl I	55	Anterior ratio	79.06 ± 2.87	71.69	86.95	Anterior ratio 0.169
		Total ratio	91.3 ± 2.39	84.9	95	
Cl II	55	Anterior ratio	79.23 ± 3.18	72.72	89.87	
		Total ratio	91.6 ± 2.49	86.15	98.51	
Cl III	55	Anterior ratio	80.16 ± 3.71	73.56	89.43	Total ratio *0.039
		Total ratio	92.49 ± 2.64	88.36	100	
Total	165	Anterior ratio	79.49 ± 3.29	71.69	89.87	
		Total ratio	91.8 ± 2.55	84.9	100	

†: ANOVA

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Table 2. Anterior and total ratio discrepancy status in different classes of malocclusion (*P<0.05)

Malocclusion groups	Bolton ratio	Less than 2 SD	More than 2 SD	TSD	†P value
Cl I	Anterior ratio	5 (15.2%)	28 (84.8%)	33	Anterior ratio 0.700
	Total ratio	7 (33.3%)	14 (66.7%)	21	
Cl II	Anterior ratio	9 (22.5%)	31 (77.5%)	40	
	Total ratio	9 (37.5%)	15 (62.5%)	24	
Cl III	Anterior ratio	6 (17.1%)	29 (82.9%)	35	
	Total ratio	4 (20%)	16 (80%)	20	Total ratio 0.435
Total	Anterior ratio	20 (18.5%)	88 (81.5%)	108	
	Total ratio	20 (30.8%)	45 (69.2%)	65	

†: **Chi-square test**

Discussion

In the present study, the highest mean anterior ratio of Bolton was observed in class III malocclusion and the lowest in class I, and the mean anterior ratio in this study was 79.49%, which was higher than the study of Ebadifar et al. (77.35) [23] and Elyes et al. (78.59) [24], but in our study and the mentioned studies, the mean anterior ratio between different groups of malocclusions was not statistically significant. According to the results obtained in these studies, there was no significant relationship between the type of malocclusion and the anterior ratio of Bolton. [24, 25] However, in the study of Mohammad et al., the relationship between anterior and total ratios in malocclusion groups was significant, which was contrary to the two studies mentioned and the present study. [25] Therefore, the evaluation of this relationship in different societies needs to be examined separately.

The average total ratio in this study was 91.8 which was close to Ebadifar's study (91.2). [23] There was a significant difference in terms of the total ratio between different groups of malocclusions, which was higher in class III than in other groups and this finding was in line with Machado [18], Fattahi [26], and Greven..'s [27] studies in terms of higher total ratio in class III malocclusion. Rakhshan et al. stated that class II patients might have smaller posterior Bolton ratios compared to class I or III patients. [28] Araujo et al. showed a significant difference in the total ratio between Class II and Class III subjects. [5] Unlike the present study, other studies did not show significant differences in terms of total ratio in different groups of malocclusions. [29-31] The reason for these differences can be genetic and environmental differences and their effect on the growth of tooth-bone tissue, which causes different degrees of malocclusion in populations in different areas.

In this study, 65.5% of patients had anterior discrepancy but in the study of Maamar in Saudi Arabia, the anterior discrepancy ratio was 21.6% and in Othman's study, the anterior discrepancy ratio was 39%. [14, 32] These differences might be due to different ethnic groups, sample size, and inclusion criteria and this discrepancy should be considered in treatment planning. Therefore, the high rate of discrepancy in the anterior ratio in the current study reminds us of the need to evaluate the rate of anterior discrepancy before starting treatment to achieve proper occlusion. In terms of the total Bolton ratio, 60.6% of patients

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had normal and no discrepancy in the total tooth size ratio and 39.4% had total tooth size ratio discrepancy which was even higher than in the study of Maamar et al., where the overall discrepancy ratio was 17.3%. In general, the results show a high degree of a discrepancy, both in the anterior ratio and in the total ratio in this group of Iranians. [32]

In this study, there was no significant relationship between the prevalence of discrepancy in the anterior and total ratio with the type of malocclusion and was in line with the study of Othman, Elyes and Trishala [14,24,29] Unlike our study, in the study of Araujo, the association of anterior discrepancy with malocclusion classes was significant.[5] In our study, 81.5% of the group with anterior discrepancy had an anterior ratio of more than 2 standard deviations from the mean and 69.2% of people with total Bolton discrepancy had a total ratio of more than 2 standard deviations from the mean. In the Study of Strujic [33], the prevalence of the study group with a discrepancy of more than 2 standard deviations from the mean Bolton for the anterior and total ratio was 16.28 and 4.32%, respectively, which in both cases was much lower than our study. In Mohammad MG's study, out of 521 patients, only 5 cases had class II malocclusion with anterior discrepancy greater than 2 standard deviations above the Bolton mean, and one case had class I malocclusion with anterior discrepancy greater than 2 standard deviations above the Bolton mean. [25] The stark difference between these studies and the present study indicates the prevalence of more severe discrepancy in our study population.

Therefore, in different regions, based on the genetic structure and environment of patients, there may or may not be a relationship between the discrepancy in tooth size and the type of malocclusion. The different prevalence of TSD in each population indicates how important it is for the clinician to perform initial planning to determine discrepancy and type of malocclusion class if necessary. Routine check-ups should be done before starting treatment so the difference in the results of alarm studies is for orthodontists to prevent end orthodontic problems by carefully evaluating patients for a malocclusion. Since the cases in the present study were not a proper sample of the Iranian population, so further research should be done with more samples in different regions of the Iranian population.

Conclusion

According to the results of this study, CI III malocclusion might have a larger mean Bolton total ratio, and clinicians would be prepared to diagnose and plan treatment more accurately.

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Conflicts of Interest

We declare no conflict of interest.

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Author's Contribution

R. Ghorbanipour helped with study design and manuscript writing. M. Ahmadi helped with data collection, manuscript writing, and editing. M. Chehrazi helped with data analysis. All authors read and approved the final manuscript.

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