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Original Article

Anterior Tooth Size Discrepancy in Class III Surgical Patients

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Main Points

- Clinically significant anterior tooth size discrepancies were determined in 40.7% of Class III surgical patients.
- No significant correlation was found between anterior Bolton ratios and dentoskeletal measurements.
- Tooth size discrepancy should be considered in the diagnosis and treatment planning of Class III orthognathic surgery patients.

ABSTRACT

Objective: The purpose of the present study was to specify whether there are mesiodistal tooth size discrepancies in the anterior region in patients with dentoskeletal Class III malocclusion who underwent orthognathic surgery and orthodontic treatment and to assess the relationship between anterior Bolton ratio and dentoskeletal cephalometric measurements.

Methods: The diagnostic dental casts and lateral cephalometric radiographs of 113 nongrowing patients (54 females and 59 males; mean age: 19.96 ± 4.42 years) with dentoskeletal Class III malocclusion who underwent orthognathic surgery and orthodontic treatment were included in the study. The mesiodistal widths of the 6 anterior teeth were measured from dental casts using a digital caliper accurate to 0.01 mm and anterior Bolton ratios were calculated. Lateral cephalograms were digitalized and used to measure 4 skeletal and 4 dental parameters.

Results: The mean anterior ratio of Class III surgical patients was 80.1% with a standard deviation of 2.8%. Clinically significant anterior tooth size discrepancies (greater than ±2 standard deviation) were found in 40.7% of the sample, 97.8% of those patients having anterior mandibular tooth excess. No significant correlation was found between the anterior Bolton ratio and cephalometric measurements.

Conclusion: Clinicians should consider the probability of tooth size discrepancy in the diagnosis and treatment planning of Class III surgical patients and should perform interventions to eliminate these discrepancies during presurgical orthodontic treatment.

Keywords: Anterior ratio, tooth size discrepancy, Class III malocclusion, orthognathic surgery

INTRODUCTION

Treatment alternatives for nongrowing patients with skeletal Class III malocclusion are orthodontic camouflage treatment or orthognathic surgery. Appropriate treatment options are determined based on the severity of the malocclusion, the patient's chief complaint, cephalometric analysis, and clinical examinations.[1]

Conventional orthodontic surgical treatment of Class III dentofacial deformities includes presurgical orthodontics, followed by surgical correction and postsurgical orthodontics for detailing and finishing the occlusion.[2] The goals of presurgical orthodontics include decompensation of the incisors to their ideal positions (retroclining proclined maxillary incisors and proclining retroclined mandibular incisors), establishing correct torque, and

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eliminating tooth size discrepancies to ensure Class I canine and molar relationships after surgery.[3] Identifying tooth size imbalances at initial diagnosis and considering these in the treatment plan facilitates optimal occlusion and ideal interdigitation, overbite, and overjet at the finishing stage of treatment.[4]

Several studies have described the significance of an accurate tooth size ratio between both arches.[5,6] Bolton[7,8] analyzed 55 individuals with excellent occlusions and developed the most commonly used method to calculate the ratio between the mesiodistal width of the upper and lower teeth. According to his analysis, the ideal anterior ratio is 77.2% (standard deviation (SD) 1.65%) and the ideal overall ratio is 91.3% (SD 1.91%).

Numerous studies have evaluated tooth size discrepancies in different malocclusion types. Many of these studies indicated that tooth size discrepancies are more common in Class III malocclusions than in Class I and II.[9-12] Araujo and Souki[4] later reported that patients with Class I and Class III malocclusions indicate a significantly greater prevalence of tooth size discrepancies than those with Class II malocclusions, and mean anterior tooth size discrepancies were significantly greater for Class III subjects. In contrast, Uysal et al.[13] and Cançado et al.[14] found no differences in the anterior and overall Bolton ratios between different malocclusion types.

Although there are studies in the literature evaluating tooth size discrepancy in surgical patients,[15,16] to our knowledge, there are no studies that analyzed the relationship between Bolton ratios and dentoskeletal measurements.

The purpose of this study was (1) to determine whether patients with dentoskeletal Class III malocclusion who underwent orthognathic surgery and orthodontic treatment have any mesiodistal tooth size discrepancies in the anterior region that may influence aesthetics and occlusion and (2) to examine the relationship between anterior tooth size ratio and skeletal and dental cephalometric measurements.

METHODS

Ethical approval of this retrospective study was obtained from Bezmialem Vakif University Non-Invasive Ethics Committee (Approval number: 2021/136). One hundred thirteen patients (54 females and 59 males; mean age: 19.96 ± 4.42 years) with dentoskeletal Class III malocclusion who underwent orthognathic surgery and orthodontic treatment were included in the study. Diagnostic casts and lateral cephalometric radiographs of the individuals taken between January 2015 and December 2020 were obtained from the archives of Bezmialem Vakif University and Ankara University, Faculty of Dentistry, Department of Orthodontics.

Inclusion criteria were as follows:

- Nongrowing patients (Ru stage as determined by hand-wrist radiograph);
- Skeletal Class III malocclusion (ANB < 0);
- Anterior crossbite or incisor edge-to-edge relationship;
- Presence of all anterior teeth from canine to canine in both arches; and
- Good-quality study models.

Exclusion criteria were as follows:

- Presence of more than one missing posterior teeth (except third molars) of each quadrant;
- History of previous orthodontic treatment;
- Cleft lip and palate or any craniofacial syndromes; and
- History of procedures that affect tooth mesiodistal width (buildups, crowns, restorations, or enamel stripping).

The largest mesiodistal widths of the upper and lower 6 anterior teeth were measured using a digital caliper (Qingdao Tlead International Co., Ltd.,Qingdao, China) with an accuracy of 0.01 mm. All measurements were performed and recorded by the same examiner (E.S.A.). Anterior Bolton ratio was calculated using the following formula:

$$\text{Anterior ratio } (\%) = \frac{\text{Sum of mandibular } 13-23}{\text{Sum of maxillary } 33-43} \times 100.$$

Anterior Bolton ratios within ±1 SD of the mean (77.2% ± 1.65%) were classified as normal, ratios greater than ±1 SD and less than ±2 SD from the mean as tooth size discrepancy, and ratios greater than ±2 SD from the mean were described as clinically significant tooth size discrepancy.[8]

Cephalometric analysis was done using Dolphin Imaging Software (version 10.0, Chatsworth, Calif, USA) by the same examiner (O.M). Four skeletal (SNA°, SNB°, ANB°, and GoGn-SN°) and 4 dental (PPU1°, IMPA°, overjet (mm), and overbite (mm)) measures were recorded (Figure 1).

Statistical Analysis

Statistical analyses were performed with the Statistical Package for Social Sciences version 22.0 software (IBM Corp., Armonk, NY, USA). Statistical significance was established with a *P* value less than .05.

In order to determine measurement error, the diagnostic casts and cephalometric radiographs of 25 randomly selected subjects were remeasured by the same examiner after an interval of 2 weeks. The paired *t* test was performed to assess the difference between 2 measurements. The results indicated no significant difference between the first and second sets of measurements.

Shapiro–Wilk test was used to test the variables for normal distribution. The mean, SD, maximum, minimum values, and 95% confidence interval for mean were obtained for each variable. The independent *t* test was used to determine whether there were sex differences in the anterior ratio. The Pearson's correlation coefficient (for normally distributed variables) and the Spearman's correlation coefficient (for non-normally distributed variables) were used to analyze the correlation between dentoskeletal measurements and anterior ratio.

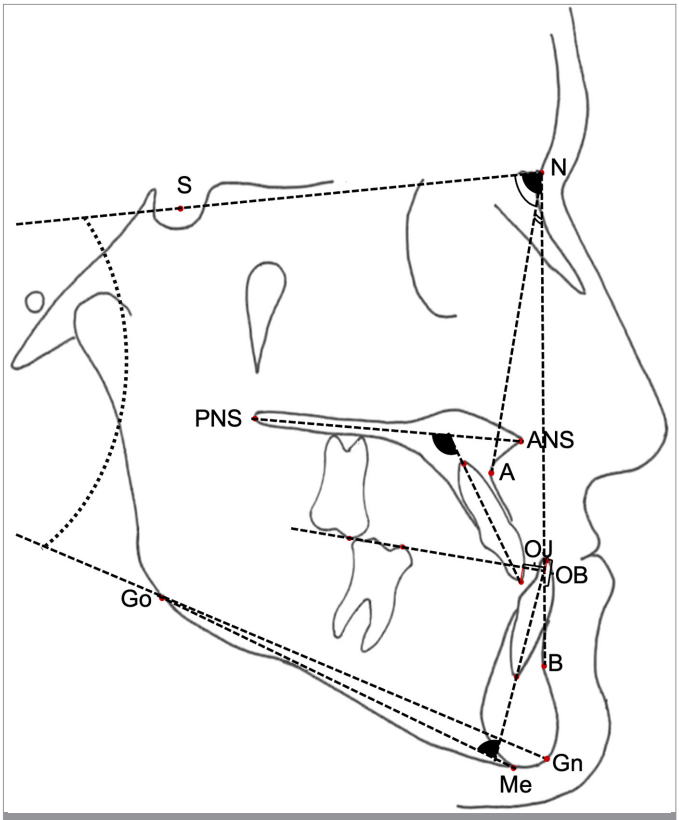

Figure 1. Skeletal and dental lateral cephalometric variables used in the study. SNA°, angle between anterior cranial base (Sella-Nasion) to the A point; SNB°, angle between anterior cranial base to the B point; ANB°, difference between SNB° and SNA°; GoGn-SN°, angle between mandibular plane (Go-Gn) to the anterior cranial base; PPU1°, angle between the upper incisor long axis and the palatal plane (ANS-PNS); IMPA°, angle between the mandibular incisor long axis and the mandibular plane (GoMe); Overjet (OJ), horizontal distance between upper and lower central incisors with reference to the occlusal plane; Overbite (OB), vertical distance between the incisal edges of the upper and lower central incisors.

RESULTS

The descriptive statistics of the subjects' ages and skeletal and dental measurements (mean, SD, minimum and maximum, and 95% confidence interval) are given in Table 1.

Descriptive statistics and comparison of sex differences in the anterior tooth size ratio were given in Table 2. The anterior ratios of males and females were combined because there were no significant sex differences ($P < 0.05$).

The distribution and descriptive statistics of anterior tooth size discrepancies according to Bolton norms are given in Figure 2 and Table 3. Anterior ratio was more than 1 SD above the mean in a total of 75 patients (63.9%) and more than 1 SD below the mean in 5 patients (4.4%). Clinically significant anterior tooth size discrepancies (greater than ±2 SD) were found in 40.7% of the sample (n = 46), 97.8% of those patients (n = 45) having anterior mandibular tooth excess (anterior ratio more than 2 SD above the mean). There was no significant correlation between the anterior Bolton ratio and cephalometric measurements (Table 4).

DISCUSSION

This study was based on observations that when presurgical dental casts of Class III orthognathic surgical patients were manipulated into positive overjet, the canines were in Class II relationship in most cases, leading us to wonder about the prevalence of tooth size discrepancies in these patients. We evaluated anterior tooth size discrepancies due to the fact that most patients were missing posterior teeth and differences in anterior tooth size, in particular, could affect treatment stability and the finishing quality of orthodontic treatment.[4,17]

The study included young adults with a mean age of 19.91 ± 4.16 years. In order to investigate the correlation between dentoskeletal measurements and Bolton anterior ratio, we analyzed only nongrowing skeletal and dental Class III individuals. In this study, sex difference has been found to have no significant effect on the anterior ratio. Although there are contradictory results reported in the literature, our results are in harmony with the findings of many previous studies.[4,13,18]

Individuals with Class III malocclusion treated with orthognathic surgery and orthodontic treatment had a mean anterior Bolton ratio of 80.09% (SD 2.84%). Anterior discrepancies of ±1 SD were

Table 1. Descriptive statistics (Mean, SD, Minimum, Maximum, and 95% CI) of cephalometric measurements

						95% CI	
	n	Mean	SD	Minimum	Maximum	Lower	Upper
Age (years)	113	19.91	4.16	15.83	31		
SNA (°)	113	78.54	3.84	70.50	87.40	77.76	79.23
SNB (°)	113	82.90	4.04	72.00	93.10	82.09	83.73
ANB (°)	113	−4.40	2.66	−11.60	−0.30	−4.90	−3.90
GoGnSN (°)	113	34.07	6.39	17.70	48.00	32.88	35.26
IMPA (°)	113	79.83	7.27	61.60	105.00	78.48	81.19
PPU1 (°)	113	115.94	6.63	94.00	129.90	111.33	117.05
Overjet (mm)	113	−3.14	2.42	−11.00	0.00	−3.58	−2.67
Overbite (mm)	113	−0.08	2.57	−8.20	7.90	−0.58	0.40

SD, standard deviation.

Table 2. Descriptive statistics and comparison of sex differences in the anterior tooth size ratio

		Female (n = 54)	Male (n = 59)	*P*
Mean		80.35	79.86	.358
SD		2.90	2.78	
Minimum		73.96	73.34	
Maximum		89.42	86.26	
95% CI	Lower	79.56	79.13	
	Upper	81.14	80.58	

SD, standard deviation.

present in 68.3% and clinically significant anterior discrepancy (>±2 SD) was present in 40.7% of the patients. It is noteworthy that the majority of discrepancies were caused by mandibular tooth excess.

Sperry et al.[11] showed that tooth size excess in the mandibular arch was more frequent among Class III patients with mandibular prognathism than in Class I and Class II groups. Strujić et al.[12] evaluated Bolton ratios for groups including both dentoskeletal Class I, II, and III cases. They reported that subjects with Class II malocclusion tend to have maxillary tooth size excess, while those with Class III malocclusion tend to have mandibular tooth size excess. Similarly, Lavelle[9] and Nie and Lin[10] reported that among different malocclusion groups, the mesiodistal dimensions of lower teeth were larger and those of the upper teeth were smaller in Class III subjects.

Fattahi et al.[19] compared Bolton discrepancies in 4 different malocclusion groups categorized using Angle's classification with corresponding skeletal relationships. It was reported that all ratios except the anterior ratios were significantly greater in the individuals with Class III malocclusion than in the others. While the Bolton ratio in the anterior region was greater in the Class III group compared to the Class II division 1 and division 2 groups, no significant difference was found when compared with the Class I group.

Similarly, Uysal et al.[13] compared the overall and anterior tooth size ratios of different malocclusion groups with those of untreated individuals with normal occlusion. Although no significant difference in both ratios was found between the malocclusion groups, they reported that the overall ratio was statistically significantly higher in all malocclusion groups compared to the normal occlusion group. The anterior ratio was 78.83 ± 3.46 in the Class III malocclusion group, and no significant difference was observed between the normal occlusion group. Although the present study was conducted in individuals with the same ethnic background as those studied by Uysal et al.[13] their relatively higher anterior ratio in our study may be due to the fact that the Class III patients in our study had more severe skeletal deficiencies to correct with orthognathic surgery. Similarly, McSwiney et al.[16] reported that the prevalence of clinically significant tooth size discrepancy was higher in the surgical patients compared to the non-surgical patients with Class III malocclusion.

Sassouni[20] was the first to notice that patients with Class III dentofacial deformities and retrognathic maxilla demonstrated a higher incidence of shape variation and agenesis in the anterior teeth. Fattahi et al.[19] reported that mandibular prognathism may be an etiological factor in the greater mesiodistal width of the lower teeth in individuals with Class III malocclusion compared to other malocclusion groups. The authors also stated that further studies are needed to clarify this theory. The relationship between anterior ratio and selected skeletal parameters was analyzed to check whether there was a correlation between them in the present study. Although no significant correlations were detected, we found that a substantial proportion of Class III orthognathic surgery patients (a total of 39.8% of the patients) who had tooth size discrepancy in the anterior region greater

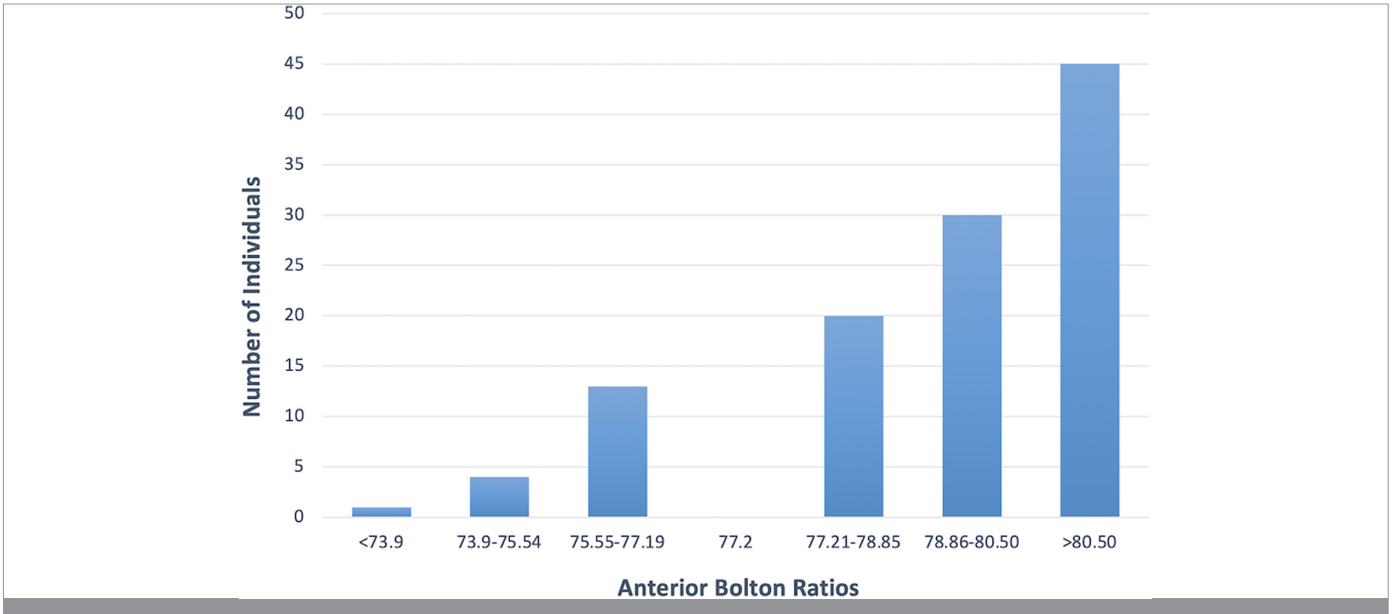

Figure 2. Distribution of patients' anterior tooth size ratios categorized by the standard deviations of Bolton norms.

Table 3. Percentage of subjects and descriptive statistics of anterior tooth size discrepancy according to Bolton norms

							95% CI	
	n	%	Mean	SD	Minimum	Maximum	Lower	Upper
<2 SD	1	0.9	73.34	-	-	-	-	-
−2 SD to 1 SD	4	3.5	75.02	0.70	73.96	75.41	73.89	76.14
−1 SD to mean	13	11.5	76.52	0.40	75.85	77.19	75.83	76.23
Mean to 1 SD	20	17.7	78.14	0.49	77.22	78.82	77.20	77.47
1 SD to 2 SD	30	26.5	79.74	0.47	78.86	80.50	78.75	79.16
>2 SD	45	39.8	82.83	1.87	80.57	89.42	80.47	80.93
Total	113	100	80.09	2.84	73.34	89.42	79.56	80.62

SD, standard deviation.

Table 4. Correlations between anterior Bolton discrepancy and skeletal and dental measurements

		SNA (°)	SNB (°)	ANB (°)	GoGnSN (°)	IMPA (°)	PPU1 (°)	Overjet (mm)	Overbite (mm)
Anterior Bolton discrepancy (%)	*r*	−0.046[a]	0.032[b]	−0.089[b]	−0.081[a]	−0.013[b]	−0.077[a]	−0.051[a]	0.124[a]
	P	.629	.736	.348	.391	.891	.420	.591	.189

r, correlation coefficient.
[a]Pearson's correlation coefficient; [b]Spearman's correlation coefficient.

than 2 SD above the mean, which indicates clinically significant mandibular tooth size excess.

The findings of our study indicate that tooth size discrepancy should be considered in the diagnosis and treatment planning of Class III orthognathic surgery patients. Tooth size discrepancies between the upper and lower teeth in the anterior region can prevent achieving ideal occlusion with satisfactory interdigitation and intercuspation of the teeth and a correct overbite and overjet. These discrepancies not only adversely affect the quality of orthodontic treatment but also impact treatment stability, leading to relapse during the retention period (post-treatment crowding).[4,21]

During presurgical orthodontic treatment, reduction of tooth excess by interproximal stripping or extraction or creating space for the addition of tooth tissue by restorations should be performed to eliminate tooth size discrepancies. In addition, changes in incisors inclination and angulation can be performed to manage tooth size discrepancy. Tuverson[22] reported that diastemas in the upper anterior region can be compensated by adding distal root tip and palatal root torque to the maxillary incisors. Besides, Bolton[8] indicated that the inclinations of the incisors and their labiolingual thickness could affect the anterior tooth size discrepancy. In light of this information, whether there is a relationship between incisor inclinations and anterior tooth size discrepancy in patients with dentoskeletal Class III malocclusion was the subject of interest in the present study. However, no correlation was observed between incisor inclinations (IMPA°, U1-PP°) and anterior ratio. Lack of correlation between anterior ratio and incisor inclination might be explained by the fact that patients had skeletal discrepancies in addition to the dental malocclusion. Moreover, the fact that dental compensation did not occur as expected in all the patients and that the incisors' inclinations showed a wide standard deviation may also explain the lack of correlation.

As mentioned above, anterior tooth size discrepancy can negatively affect the relationship between overjet and overbite in an ideal occlusion.[4,21] In the presence of dentoskeletal Class III malocclusion, overjet and overbite showed no correlation with the anterior ratio. In the present study, individuals were classified only according to the sagittal pattern. The fact that patients with different vertical patterns were included and that the expected dental compensation was not observed in all patients may explain the lack of correlation. Apart from tooth size discrepancy, many dental and skeletal parameters can also affect the overjet and overbite (incisor inclination, vertical patterns, etc.).[23,24]

The main limitation of the current study is that Bolton discrepancy was evaluated only in the anterior region. It would be beneficial to carry out further studies with more Class III surgical patients who do not have missing teeth from the first molar to the first molar in order to evaluate the overall ratio.

CONCLUSION

Based on the findings of the present study:

- Clinically significant anterior tooth size discrepancies were found in 40.7% of the sample.
- No significant correlation was found between anterior Bolton ratios and dentoskeletal measurements.

Ethics Committee Approval: Ethics committee approval was received for this study from the Non-Invasive Ethics Committee of Bezmialem Vakif University (Approval number: 2021/136).

Informed Consent: The study was retrospective, so (in accordance with the ethical approval) no written informed consent was obtained.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - E.S.A.; Design - E.S.A.; Supervision - T.U.T.M.; Materials - Ö.M.; Data Collection and/or Processing - E.S.A., Ö.M.; Analysis and/or Interpretation - E.S.A., Ö.M.; Literature Review - E.S.A., Ö.M., T.U.T.M.; Writing - E.S.A.; Critical Review - Ö.M., T.U.T.M.

Declaration of Interests: The authors have no conflicts of interest to declare.

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