

Evaluation of Tooth Size Discrepancy in Orthodontic Patients with Various Skeletal Patterns

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ABSTRACT

Objective: To determine the frequency of various skeletal patterns in orthodontic patients with malocclusion and evaluate mean tooth size discrepancy ratios in various skeletal patterns.

Methodology: It was a cross-sectional study with consecutive sampling conducted at 28 Military Dental Centre, Lahore. After approval from the ethical committee and written informed consent from patients, the ANB angle of 150 orthodontic patients was derived from corresponding lateral cephalograms to determine the skeletal pattern (Class I, II, III). Their impressions were taken with alginate and poured with hard plaster to form pre-treatment study casts. The mesiodistal widths of all maxillary and mandibular teeth from right first molar to left first molar were measured on the casts using a digital caliper, to calculate the anterior and overall ratios via Bolton analysis.

Results: The frequency of skeletal patterns was such that there were 34.7% patients with Class I skeletal pattern, 51.3% of patients with Class II skeletal pattern and 14% of patients with Class III skeletal pattern. No significant difference in the overall and anterior Bolton ratios in different skeletal patterns ($p>0.05$) was observed upon the application of ANOVA and Tukey's test. However, the anterior ratios for all skeletal patterns showed higher values than the norm, owing to the diversity of skeletal patterns selected. The frequency of individuals with significant tooth size discrepancy i.e. outside $\pm 2SD$ of Bolton's norms was 12.6% for overall ratio and 36.0% for anterior ratio. No sexual dimorphism was observed.

Conclusion: Class II skeletal pattern showed the highest frequency in this study. No significant difference was found in the tooth size discrepancy ratios in different skeletal patterns and both genders. However, a common trend was noted towards excess tooth material in the mandibular anterior region of all skeletal patterns.

Keywords: *Tooth size discrepancy. Bolton's norms. Bolton analysis. Overall ratio. Anterior ratio.*

INTRODUCTION

Tooth size discrepancy (TSD) is the term used for a relative excess of tooth material in one arch compared to the other arch, or, the disproportion in the size of individual teeth.¹ For occlusal harmony, certain norms must be there for the dimensions of maxillary and mandibular teeth. An appropriate relationship will favor orthodontic treatment results.^{2,3} In 1958, Bolton devised two ratios for calculating tooth size discrepancy.⁴ He measured the total mesiodistal widths of mandibular anterior teeth and found its ratio to the maxillary anterior teeth (anterior ratio) to be 77.2. Similarly, he calculated the overall ratio to be 91.3 by dividing the total width of all mandibular teeth by maxillary teeth, including first molars and all teeth anterior to them. Any variation from these norms signifies the presence of tooth size discrepancy in either jaw of a particular individual.⁵

Although the size of most natural dentitions is well proportioned, almost 5% of people have a discrepancy among the size of individual teeth.⁶ The most common cause is anomalous maxillary lateral incisor(s),

followed by premolars and other teeth.⁷ One of the first investigators to become interested in the subject of tooth size was G.V. Black. In 1902, he researched the size of innumerable human teeth and established tables of mean values, including the mesiodistal widths of teeth, which are used as important references till date.³ Tooth size analysis, developed by Bolton, constitutes an integral segment of diagnosis and treatment planning in orthodontics, which otherwise comprises of history and examination, photographic, radiographic and cast analysis.⁶ It determines certain space management issues during the course of treatment.⁷ The ratios calculated for each patient are compared with Bolton's norms (overall ratio 91.3, anterior ratio 77.2) to determine whether or not there is a tooth size discrepancy.³ If the computed ratios are greater than the norms, it signifies a relative excess of tooth material in the mandible. Similarly, a relative excess of tooth material will occur in the maxilla if the computed ratios are less than the norms. A variation greater than 2 standard deviation of the normal ratios and TSD greater than 2 mm is considered clinically significant.⁵ The prevalence of significant TSD varies in different populations since it is affected by variables such as skeletal pattern, gender, race and ethnicity.⁷ Several studies have been dedicated worldwide to shed light on it but few relate it to skeletal pattern, which is the relative anteroposterior position of the jaws with reference to the cranial base.⁶ This study will broaden our knowledge by providing a database about tooth size discrepancy in a segment of the Pakistani population.

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METHODOLOGY

It was a cross-sectional study with consecutive sampling conducted at 28 Military Dental Centre, Lahore. After approval from the ethical committee, written informed consent was obtained from 150 orthodontic patients of Pakistani ethnicity aged 13 years and above, presenting with malocclusion. Patients included in the study had fully erupted permanent dentition from the first molar to first molar, good quality casts, and absence of caries, extensive restorations or wear of teeth. Patients who were excluded from the study had retained deciduous teeth, morphological dental anomaly, congenitally missing, impacted or extracted teeth and history of previous orthodontic treatment.

Lateral cephalograms of the orthodontic patients were traced and ANB angle was derived to determine the skeletal pattern, such that 0° to 4° was Class I, more than 4° was Class II and less than 0° was Class III. Their intraoral impressions were taken with alginate and pre-treatment study casts were made with hard plaster. The mesiodistal widths of all maxillary and mandibular teeth from the right first molar to the left first molar were measured on the casts using a digital caliper to the nearest 0.01 mm. Bolton analysis was done to calculate the anterior and overall ratios.⁴ All measurements were recorded on a specially designed proforma.

STATISTICAL ANALYSIS

All acquired data was entered into the Statistical Package for the Social Sciences (SPSS) version 24 for statistical analysis. Frequency and percentages were calculated for gender and different skeletal patterns. Mean and standard deviation were calculated for overall and anterior ratios in all subjects and also for the three skeletal patterns individually. ANOVA was applied to compare the TSD among three skeletal patterns, followed by Tukey's Test for post HOC analysis. A p-value of ≤ 0.05 was considered to be significant. The frequency of clinically significant tooth size discrepancy was also observed which occurs if Bolton's ratios are computed to be beyond $\pm 2SD$ of the norms.

RESULTS

The sample selected had a mean age of 14.8 ± 2.77 years. The gender distribution was such that there were 67

males (44.7%) and 83 females (55.3%) among a total of 150 patients. The frequency of skeletal patterns was such that there were 52 class I patients, 77 class II patients and 21 class III patients, as shown in table 1. Class II patients constituted 51.3% of the total sample size, reflecting the fact that class II skeletal pattern is the most prevalent type of malocclusion in this part of the world for which patients seek orthodontic treatment.

The results for the overall ratio (91.35) computed in the present study showed no difference from Bolton's mean of 91.3 (Table 1). The mean anterior ratio was 78.61 which also lies within $\pm 2SD$ of the normal anterior ratio of 77.2.

The overall ratio was also calculated for individual skeletal patterns and found no meaningful differences from the mean value for the entire sample. The anterior ratios computed for the individual skeletal patterns showed higher values than the norm (Table 1), with class I displaying the highest mean anterior ratio of 79.1, secondly class II with 78.6 and thirdly class III with 77.4. Higher values signify a trend towards excessive tooth material in the mandibular anterior region. No significant difference in the overall and anterior Bolton ratios in different skeletal patterns ($p > 0.05$) was observed upon the application of ANOVA and Tukey's test (Table 2).

The current study found no meaningful gender differences in TSD. Both the gender groups had mean overall and anterior ratios close to the means for the entire sample. The mean values for overall and anterior ratios in males were 91.58 ± 2.37 and 78.44 ± 3.02 respectively, while the same for females were found to be 91.16 ± 2.86 and 78.75 ± 3.02 respectively. Both genders displayed a greater range of values for anterior ratio as compared to the overall ratio.

In the current research, 12.6% of the sample displayed a significant overall ratio while 36% of the sample had a significant anterior ratio (Table 3). Among the 12.6% patients with significant overall TSD, 8.6% of individuals showed a trend towards overall maxillary excess while the remainder 4% of individuals had an overall mandibular excess. Among the 36% of patients with significant anterior TSD, 3.3% of individuals displayed anterior maxillary excess, while a very high percentage of 32.6% individuals displayed anterior mandibular excess.

Table 1: Mean Overall and Anterior Ratios

Skeletal Pattern	Frequency (n)	Percentage	Mean Overall Ratio	Mean Anterior Ratio
Class I	52	34.7%	91.43 ± 2.48	79.10 ± 4.01
Class II	77	51.3%	91.33 ± 2.85	78.61 ± 3.63
Class III	21	14.0%	91.22 ± 2.40	77.40 ± 2.98
Total	150	100.0%	91.35 ± 2.65	78.61 ± 3.70

Table 2: Results for ANOVA and Tukey's Test

Skeletal Pattern	Overall Ratio	p-value	Anterior Ratio	p-value
Class I	Class II	0.974	Class II	0.739
	Class III	0.951	Class III	0.179
Class II	Class I	0.974	Class I	0.739
	Class III	0.986	Class III	0.379
Class III	Class I	0.951	Class I	0.179
	Class II	0.986	Class II	0.379

p-value ≤ 0.05 is significant

Table 3: Frequency of Significant Overall and Anterior TSD

Standard Deviation	Overall Ratio (91.3)		Anterior Ratio (77.2)		Interpretation
	Frequency (n)	Percentage	Frequency (n)	Percentage	
< - 2SD	13	8.6%	5	3.3%	Maxillary excess
> + 2SD	6	4.0%	49	32.6%	Mandibular excess
Total	19	12.6%	54	36.0%	

DISCUSSION

Tooth size discrepancy prevails in 5% of the general population. Regional and ethnic variations are grossly reported in the available literature.^{6,8} A significant TSD may present intraorally in the form of rotations, spacing, crowding and improper interdilatation.² If diagnosed during the initial phase of treatment planning, difficulties during the finishing stage can be avoided. Also, the extraction pattern, anchorage requirements, treatment mechanics and need for later restoration or prosthesis can be planned ahead.⁹

In the present research, the average overall ratio for 150 subjects was 91.35 ± 2.65 . However, the ranges and standard deviations recorded were higher in contrast to Bolton's original study. This can be attributed to the fact that a variety of skeletal patterns were selected in this study, whereas Bolton's original study only included subjects with excellent occlusion. These results are supported by other studies. Al-Omari et al. found the overall ratio to be 92.2 among Jordanian children.¹⁰ Another study conducted by Jaiswal and Paudel in Nepal found the mean overall ratio to be 92.42 ± 1.80 which is slightly greater than the mean calculated in this study for the Pakistani population.¹¹

Quraishi et al. carried out a study in Karachi, Pakistan, in which the mean overall and anterior ratios were 91.54 and 78.85 respectively, regardless of the type of occlusion.¹² These values are very close to those of the present study, probably due to similar race and ethnicity of the subjects selected. The anterior ratio calculated in the present research was found to be 78.61 ± 3.70 , which lies within $\pm 2SD$ of Bolton's norm of 77.2.

The minimum and maximum anterior ratios recorded in the current research were 71.90 and 88.70, both in class I skeletal patterns. Another local research by Batool et

al. reported a minimum anterior ratio of 66.0 in a class I patient and a maximum anterior ratio of 97.3 in a class III patient.¹³ The range is quite large compared to the present study, however, the average anterior ratio of the entire sample is quite comparable at 79.34 ± 5.19 .

Bolton's TSD ratios were also calculated for individual skeletal patterns, of which class II was the most prevalent. No significant difference was seen between the overall ratio computed for individual skeletal patterns and the mean overall ratio for the entire sample, as concluded by ANOVA and Tukey's test. These findings are supported by Basaran et al.,⁹ O'Mahony et al.,¹⁴ Uysal et al.¹⁵ and Endo et al.¹⁶

The anterior ratios were also computed for individual skeletal patterns, whereby the mean for each group was higher than the norm. Higher values signify a trend towards excessive tooth material in the anterior mandibular segment. A similar quantitative study conducted by Batool et al. in Rawalpindi, Pakistan, resulted in very high anterior ratios in class II malocclusion, signifying the presence of excess tooth material in the anterior mandibular segment.¹³ Such findings suggest that for a clinical orthodontic evaluation, there is a need to set population-specific standards and norms.

In another local research by Asad et al., the difference in Bolton's ratios was statistically insignificant in three skeletal classes.¹⁷ Contrary to the present research, the incidence of significant Bolton's ratios was more in skeletal class III. A Brazilian study by Cancado et al. also showed no significant differences in the overall and anterior ratios of tooth size discrepancies among different Angle malocclusion groups.¹⁸

To determine the frequency of significant TSD in the current research, values of ratios beyond 2 standard

deviations of Bolton's norms were considered significant.⁵ The results displayed 12.6% individuals with an overall ratio beyond $\pm 2SD$ of 91.3 and 36% individuals with anterior ratio beyond $\pm 2SD$ of 77.2. These results very closely relate with Freeman's study in which the percentage of significantly different overall and anterior ratios was found to be 13.5% and 30.6% respectively. Freeman's study also concluded that the overall discrepancy could equally be either an excess in the mandible or maxilla. However, the chances for excess tooth material in the anterior mandible (19.7%) were double than that in anterior maxilla (10.8%).¹⁹

Another important aspect related to tooth size discrepancy is sexual dimorphism. The current study found no meaningful differences in TSD between males and females. The mean overall ratio for males was 91.58 ± 2.37 and for females was 91.16 ± 2.86 . Both values are very close to the overall mean of 91.35 and Bolton's norm of 91.3. However, it can be concluded that males showed a trend towards overall mandibular excess while females followed a trend towards overall maxillary excess. As far as the anterior ratio is concerned, males reported a mean value of 78.4 ± 3.02 , while females displayed a mean value of 78.75 ± 3.02 , both signifying a trend towards excess tooth material in the mandibular anterior region.

A Jordanian study by Al-Omari et al. showed no significant differences in the TSD between males and females.¹⁰ In another study on the Turkish population by Basaran et al., no sexual dimorphism was found among various malocclusions.⁹ Endo et al. found no statistically significant sexual difference in anterior and overall ratios in Japanese population.¹⁶ Paredes et al. investigated TSD in a Spanish population and concluded no significant gender differences in tooth-width ratios.²⁰ Among the local literature available, a notable study by Quraishi et al. in Karachi, Pakistan, reported no sexual differences in tooth size discrepancy.¹² On the contrary, a Nepalese study by Jaiswal and Paudel displayed a significant difference in mean overall ratios between male and female subjects.¹¹ In another study by Uysal et al. in Turkey, a significantly different overall ratio was found among males and females with normal occlusions.¹⁵

The clinical implication of Bolton's ratios has been demonstrated time and time again. TSD is a principal factor in space analysis. The ultimate goal of orthodontic treatment is to achieve the best esthetics, function and stability. Management will of course depend on the particular situation of Bolton's discrepancy.²¹ This study has explored a segment of Pakistani population presenting for orthodontic treatment in an area of Lahore. During the review of the literature, very few local studies were found on this important subject. The relevant studies were notably

from Rawalpindi, Karachi and Lahore. Although these are the three largest metropolitan cities of the country, representing two of Pakistan's most densely populated provinces, more pertinent data is required from the northern and western territories in order to depict a complete picture of the prevalence of TSD among the entire nation.

CONCLUSION

Class II skeletal pattern showed the highest frequency in this study. No significant difference was found in the tooth size discrepancy ratios in different skeletal patterns and both genders. However, a common trend was noted towards excess tooth material in the mandibular anterior region of all skeletal patterns. Further investigations are required to ascertain the racial, ethnic and sexual differences in tooth size discrepancy, and determine its relationship with various types of dental and skeletal malocclusions.

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