

BOLTON TOOTH SIZE ANALYSIS OF PAKISTANIS OF 13 TO 20 YEARS IN ISLAMABAD CITY

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ABSTRACT

Bolton introduced the anterior and overall ratios that must exist between maxillary and mandibular teeth so as to obtain optimum occlusion. This study was conducted for the purpose of establishing the mean Overall Ratio (OR) and Anterior Ratio (AR) of the Bolton Analysis and the presence of Tooth size discrepancy (TSD) outside 2SD of the Bolton's mean in an orthodontic population, irrespective of the type of malocclusion. The sample comprised 180 pre treatment study casts with fully erupted and complete permanent dentitions from first molar to first molar. Selected randomly from records of the orthodontic patients. The mesiodistal diameters of the teeth were measured at contact points using digital calipers and the Bolton's analysis was carried out. The prevalence of tooth size discrepancies (TSDs) outside of 2 Standard Deviation (SD) from Bolton's mean were 18.8% for the overall ratio and 51% for the anterior ratio. Bolton tooth-size discrepancy is found in large number of Pakistani orthodontic patients which may effect orthodontic treatment goals and outcome. Thus, our results support that Bolton analysis should be mandatory for every orthodontic case before starting the treatment.

Key words: Bolton ratio, Tooth size discrepancy, Orthodontic patients.

INTRODUCTION

In orthodontics, disproportionately sized teeth in either arch can make it difficult to obtain good occlusion, masticatory efficiency, facial esthetics and alignment of the dental arch. Therefore, the maxillary and mandibular teeth must be proportional in size, and research on tooth size is important to predict the post treatment occlusal outcome mathematically.¹⁻³ It is however an overlooked fact since variations in size of teeth could definitely lead to malocclusions.⁴

Interarch tooth size ratio is a reliable diagnostic tool that reduces the need for diagnostic setups to

predict treatment outcomes in complicated orthodontic cases. A high percentage of finishing phase difficulties arise in the posterior region of dental arch because of tooth size discrepancy that could have been detected and considered during initial diagnosis and treatment planning. When the maxillary anterior teeth are too large in relation to the mandibular anterior teeth, clinical manifestations may be one of the several problems, such as: (1) deep overbite (2) greater overjet, or (3) crowded anterior segment. On the other hand, if the mandibular anterior teeth are too large in relation to the maxillary teeth, compensations on tooth positions include, (1) end to end relationship of teeth (2) spacing

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in the maxillary anterior segment (3) mandibular incisor crowding and (4) improper occlusion of posterior teeth.³

Treatment planning should always take into consideration a discrepancy of the tooth size ratios and should include compensating esthetic procedures such as composite bonding, prosthetic reconstruction, stripping and crown recontouring. Similarly, ignoring the tooth sizes can compromise the final results in extraction cases if the chosen extraction pattern leads to a clinically significant mandibulo-maxillary tooth size discrepancy.⁵

Black⁶ in 1902 and Neff⁷ in 1949 were the first to develop methods for measuring tooth size discrepancies. Then in 1952, Dr. Wayne A Bolton provided the widely accepted normative data on the mandibular to maxillary tooth size ratios which is generally referred to as the "Bolton Analysis" and it is still the most widely used for measuring such discrepancies.⁸

Bolton did a study on 55 cases with normal occlusions and calculated the specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from both canine to canine and first molar to first molar so as to obtain optimum occlusion. He concluded that without a proper mesiodistal tooth size ratio between maxillary and mandibular teeth, proper coordination of arches would be difficult. This analysis is based on measurement of the mesiodistal widths of permanent teeth (Figure 2). Bolton compared the sum of the widths of lower teeth to the sum of the widths of upper teeth in a sample of excellent occlusions. From this sample, Bolton determined two clinically significant ratios, which compare the sizes of the upper to the lower permanent teeth. The first ratio, derived from the overall Bolton analysis involves measures from 1st permanent molar on one side of the arch to first permanent molar on the opposite side of the same arch. He found a ratio of $91.3\% \pm 0.26$ when the overall measurement of the 12 lower teeth was divided by the 12 upper teeth. The second ratio, derived from the anterior Bolton analysis, involves width measurements from canine to canine. A ratio of $77.2\% \pm 0.22$ was determined by the comparison of the six lower anterior teeth to the six upper anterior teeth. According to Bolton, an anterior mean ratio of 77.2% provides a satisfactory anterior relationship if the angulations

of the incisors are correct and if the labiolingual thickness of the incisal edges is not excessive. An overall mean ratio of 91.3% results in a good posterior occlusion.⁹⁻¹¹ Studies^{1,5,11,12} to set norms for Bolton ratio have been carried out on different populations.

The objective of the study was to determine the prevalence of tooth size discrepancy (TSD) in a representative orthodontic population.

METHODOLOGY

Good quality study models were produced from alginate impressions of both maxillary and mandibular arch of one hundred and eighty subjects, hundred male and eighty female ranging from ages thirteen to twenty years. The criteria for selection of the subjects were as follows (1) Presence of all permanent teeth from central incisors to first molars in all four quadrants (2) All teeth fully erupted to the occlusal plane. (3) 2-3mm overjet and overbite, (4) With or without previous orthodontic treatment, none extraction, (5) Absence of prosthetically crowned teeth, extensive caries or extensive tooth fillings (Class II and IV restorations), (6) No apparent congenital craniofacial anomalies. (7) No Transverse discrepancies such as crossbite or scissors bite.

MEASURING TECHNIQUE

Measurements were made directly on the unsoaped plaster dental casts. All the measurements were done by the authors under natural light. An electronic digital vernier caliper (Figure 1) specially designed for dental use, (Mitu-toyo, Kawasaki, Kanakawa, Japan) with sharpened points was used to measure the mesiodistal tooth width. The caliper beaks were inserted from the facial aspect of the teeth and held perpendicular to the long axis of the tooth. The beaks were then closed until gentle contact with the predetermined contact points of the tooth was made. The measurements included the mesiodistal width of all the twelve maxillary and mandibular teeth from the right first permanent molar to the left first permanent molar on two 50 pairs of casts. Bolton anterior and overall ratios were determined by the following formula.

$$\text{Bolton's Anterior Ratio} = \frac{\text{Sum of mandibular 6}}{\text{Sum of maxillary 6}} \times 100 = 77.2\% \pm 1.65 \text{ SD}$$

$$\text{Bolton's Overall Ratio} = \frac{\text{Sum of mandibular 12}}{\text{Sum of maxillary 12}} \times 100 = 91.3\% \pm 1.91 \text{ SD}$$

Inter-examiner and intra examiner reliability is predetermined at 0.2mm as suggested by Bishara et al¹³. The two measurements obtained by the investigator were compared and if less than 0.2 mm variation was found then the values were averaged. In case of more than 0.2 mm variation, the teeth were remeasured and the three measurements were averaged.

SPSS version 16 was used for statistical analysis of collected data. A mean, range, standard deviation (SD), standard error of the mean (SE), and coefficient of variation (CV) were calculated for both the overall and anterior ratios. The percentage of patients who had TSDs within one, two, or greater than two standard deviations from Bolton's mean were determined. The TSDs were considered significant if the overall or anterior ratio values fall outside Bolton's mean by greater than 2 SD. That is, if the overall ratio was below 87.5% or above 95.1%, and/or the anterior ratio was lower than 73.9% or higher than 80.5%.

RESULTS

The prevalence of TSDs in the Pakistani orthodontic patients was 18.8% (17.2% greater than +2 SD and 1.6% less than -2 SD), outside Bolton's mean by greater than 2 SD for the overall ratio (Fig. 2). This shift to the right compared with Bolton's results demonstrates relatively more mandibular tooth width. The mean was 93%, with a standard error (SE) of 0.18. The range falls between 85.9% and 99%, with standard deviation (SD) of 2.4. The coefficient of variation (CV) was 5.8% (Table 2).

For the anterior ratio the percentage was 51% (46% greater than +2 SD and 5% less than -2 SD), outside Bolton's mean by greater than 2 SD (Fig. 3). The mean was 78.8%, with SE of 0.23. The range falls between 69.9% and 87.8%, with SD of 3.18 (Table 3).

DISCUSSION

The importance of TSDs in orthodontic diagnosis has been widely reported in the literature and accepted by the orthodontic community because the relationship between the upper and lower dentitions is related to orthodontic finishing excellence. The prevalence of TSDs in this sample was high and serves as an indicator of how important it is to perform a thorough diagnosis before orthodontic treatment the sample was selected with strict selection criteria having subjects of Pakistani origin therefore representative of all malocclusions for our population. In this study, we found that 55% of the total sample presented with anterior TSDs and 32.2% with overall TSDs, greater than ± 1 SD using the Bolton analysis parameter Fig 1 and 2. Originally, Bolton 8 suggested that the ratio greater than ± 1 SD from his reported mean values indicated the need for diagnostic consideration. More recently, clinically significant tooth size ratio discrepancy has generally been defined as ± 2 SD outside Bolton's published mean ratios.^{5,10,14-16} using this definition, an anterior ratio below 73.9% or above 80.5% and the Overall ratio below 87.5% or above 95.1%

TABLE 1: MEAN, STANDARD DEVIATION AND RANGE OF THE AGE OF PAKISTANI POPULATION

Age	N	Range	Minimum	Maximum	Mean	SD
	180	7.0	13.0	20.0	16.07	2.20

SD: Standard deviation

TABLE 2: STATISTICAL COMPARISON BOLTON STUDY, VERSUS ISLAMIC STUDY. OVERALL "12" RATIO

	Bolton	Islamic
Sample size	55 study casts	180 study casts
Mean	91.3 %	93.0%
Minimum	87.5 %	85.9
Maximum	94.8 %	99
Standard deviation	1.91	2.4
Standard error of mean	0.26	0.18
Coefficient of variation	2.09	5.812

TABLE 3: STATISTICAL COMPARISON BOLTON STUDY, VERSUS ISLAMIC STUDY, ANTERIOR "6" RATIO

	Bolton	Islamic
Sample size	55 study casts	180 study cast
Mean	77.2 %	78.8
Minimum	74.5 %	69.9
Maximum	80.4 %	87.8
Standard deviation	1.65	3.18
Standard error of mean	0.22	0.23
Coefficient of variation	2.14	10.138

TABLE 4: SUMMARY OF STUDIES OF THE PREVALENCE OF TOOTH SIZE DISCREPANCY, DEFINED IN TERMS OF BOLTON'S ORIGINAL STANDARD DEVIATIONS

Author	Sample size	Anterior TSD %	Overall TSD%
Crosby and Alexander ¹⁰	109	22.9	—
Freeman et al ¹⁴	157	30.6	13.5
Santoro et al ⁵	54	28	11
Bernabe et al ¹⁵	200	20.5	5.4
Othman and Harradine ¹⁶	150	17.4	5.4
Al-Kawari et al	92	20.6	14.1
Sharma R et al ¹⁹	150	34	10
Quraishi et al ²⁰	150	14.7	9.1
Present study	180	51	18.8

TSD: Tooth size discrepancy

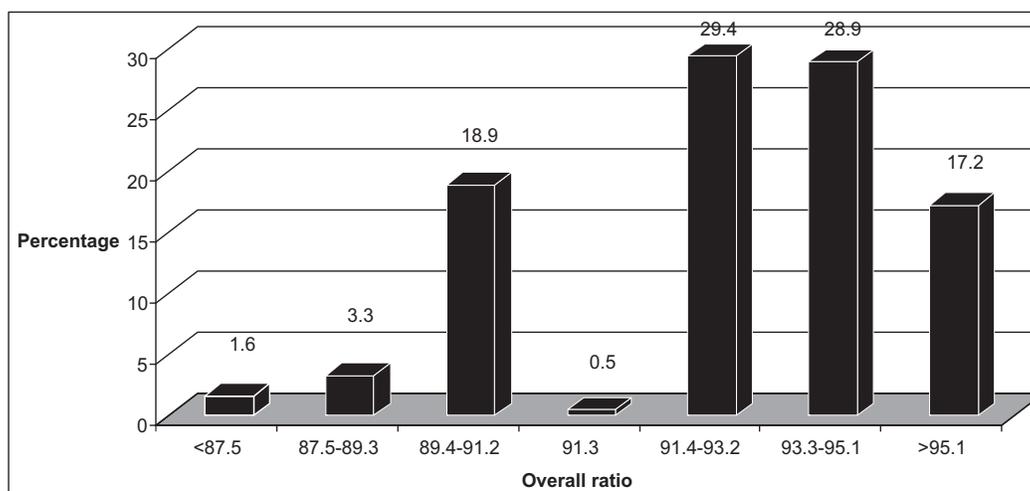


Fig 1: Study sample. (Overall Ratios): 91.3 is Bolton's mean. 89.4-91.2 and 91.4-93.2 are within 1SD. 87.5-89.3 and 93.3-95.1 are outside 1SD, but within 2SD. <87.5 and >95.1 are outside 2SD.

would be considered clinically significant. The present study found 51% (24%) of the sample had anterior TSDs greater than ± 2 SD from Bolton's mean, which is not in agreement with many others. Bolton's SD for the overall ratios than for the anterior ratios. Fig 1 and

2 show that for the anterior discrepancy there was a greater mandibular excess than that of maxillary teeth (2 times), whereas the overall discrepancy had 8 times more mandibular excess. The finding for the anterior ratio is similar to those reported by Freeman et

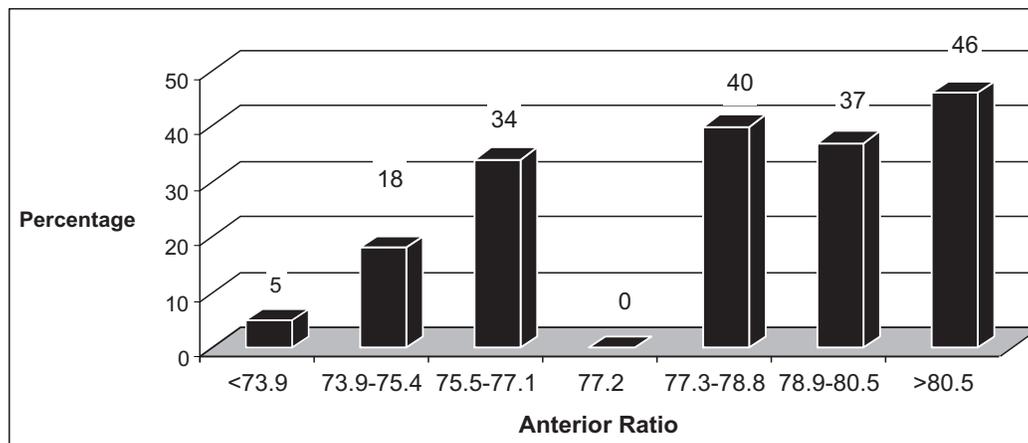


Fig. 2: Study sample. (Anterior Ratios): 77.2 is Bolton's mean. 75.5-77.1 and 77.3-78.8 are within 1SD. 73.9-75.4 and 78.9-80.5 are outside 1SD, but within 2SD. <73.9 and >80.5 are outside 2SD. Study sample. (Anterior Ratios): 77.2 is Bolton's mean. 75.5-77.1 and 77.3-78.8 are within 1SD. 73.9-75.4 and 78.9-80.5 are outside 1SD, but within 2SD. <73.9 and >80.5 are outside 2SD.

al.¹⁴ They stated that the anterior discrepancy was nearly twice more likely to be a mandibular excess than a maxillary excess.

This study showed a higher prevalence of TSDs with more excess in the mandibular teeth than maxillary teeth in patients who had greater overall ratio by 2 SD from Bolton's mean. The patients with overall ratio greater than 2 SD from the Bolton's mean (mandibular excess) were about 17.2% as compared with 1.6% with a maxillary excess, which coincide with a study conducted in a Saudi population¹⁷ while for the anterior ratio the patients with mandibular excess were 46% compared to 5% with maxillary excess. Whereas in Freeman et al¹⁴ study, the overall discrepancy was equally likely to be relative excess in the maxilla or the mandible, whereas the anterior discrepancy was nearly twice as likely to be a relative mandibular excess than a relative maxillary excess. Few other studies also concluded that mandibular teeth are excess in size relatively than the maxillary teeth.^{17,18}

Among the Pakistani population sample this study demonstrated a relatively high percentage of Bolton discrepancy when compared with the established ratios of Bolton. This could be attributed to the fact that Bolton sample was all of ideal occlusion unlike our sample which is all having malocclusion. From this, it could be suggested that Bolton discrepancies may be a cause of or a predisposing factor to malocclusion. This

finding was in agreement with Sharma R et al study.¹⁹ As a result of our findings, it is suggested that Bolton's prediction tables cannot be applicable for all Pakistanis as Quraishi et al have reported in their study.²⁰

CONCLUSION

51% of the sample had anterior and 18.8% had overall ratios greater than 2 SD from Bolton's mean. It seem important to routinely perform the Bolton tooth size analysis and include the finding into orthodontic treatment planning for good interdigitation and results at the end of treatment.

REFERENCES

- 1 Paredes V, Gandia JL, Cibrian R. Do Bolton's ratios apply to a Spanish population? *Am J Orthod Dentofacial Orthop* 2006; 129: 428-30.
- 2 Shellhart WC, Lang DW, Kluemper GT, Hicks EP, Kaplan AL. Reliability of the Bolton tooth size analysis when applied to crowded dentitions. *Angle Othod* 1995; 65: 327-34.
- 3 Bolton WA. The clinical application of the tooth size analysis. *Am J Orthod* 1962; 48: 504-29.
- 4 Lombardi VA. The Adaptive Value of Dental Crowding: A Consideration of the Biologic Basis of Malocclusion. *Am J Orthod* 1982; 81: 38-42.
- 5 Santoro M, Ayoub ME, Pardi VA, Cangialosi TJ. Mesiodistal crown dimensions and tooth size discrepancy of permanent dentition of Dominican Americans. *Angle Orthod* 2000; 70: 303-7.
- 6 Black GV. *Descriptive anatomy of the human teeth*. 4th ed. Philadelphia, PA: SS White Dental Mfg Co; 1902.

7. Neff CW. Tailored occlusion with the anterior coefficient. *Am J Orthod* 1949; 35: 309-13.
8. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthod* 1958; 28: 113-30.
9. Puri N, Pradhan KL, Chandna A, Sehgal V, Gupta R. Biometric study of tooth size in normal, crowded, and spaced permanent dentitions. *Am J Orthod Dentofacial Orthop* 2007; 132: 279.
10. Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. *Am J Orthod Dentofacial Orthop* 1989; 95: 457-61.
11. 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.
12. Endo T, Shundo I, Abe R, Ishida K, Yoshino S, Shimooka S. Applicability of Bolton's tooth size ratios to a Japanese orthodontic population. *Odontology* 2007; 95: 57-60.
13. Bishara SE, Jacobsen JR, Abdullah EM, Garcia AF. Comparisons of mesiodistal and buccolingual crown dimensions of the permanent teeth in 3 populations from Egypt, Mexico, and the United states. *Am J Orthod Dentofacial Orthop* 1989; 96: 416-22.
14. Freeman JE, Maskeroni AJ, Lorton L. Frequency of Bolton tooth size discrepancies among orthodontic patients. *Am J Orthod Dentofacial Orthop* 1996; 110: 24-7.
15. Bernab E, Major PW, Flores-Mir C. Tooth-width ratio discrepancies in a sample of Peruvian adolescents. *Am J Orthod Dentofacial Orthop* 2004; 125: 361-5.
16. Othman SA, Harradine NW. Tooth size discrepancies in an orthodontic population. *Angle Orthod* 2007; 77: 668-74.
17. Al-Kawari H, Al-Balbeesi HO, Al-Mazyad N, Al-Mutairi B. Bolton tooth-size discrepancies in a sample of Saudi female orthodontic patients at college of dentistry, King Saud University. *J Pak Dent Assoc* 2012; 21(01): 31-34.
18. Araujo E, Souki M. Bolton anterior tooth size discrepancies among different malocclusion groups. *Angle Orthod* 2003; 73: 307-313.
19. Rekha S, Hussain S, Ansari F, Zeeshan F. Prevalance of tooth size discrepancy among North Indian orthodontic patients. *Contemp Clin Dent* 2011; 2(3): 170-75.
20. Quraishi BA, Hussain S, Ansari F, Zeeshan F. Frequency of Bolton tooth size discrepancies outside 2 Standard deviation of the Bolton's mean among orthodontic patients. *J Pak Dent Assoc* 2011; 4: 250-53.