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Clinical Significance of Bolton's Ratio in Crowded and Noncrowded Dentition With Gender Variations

KEYWORDS: Tooth width ratios; Bolton proportion; Clinical significance.

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ABSTRACT

AIM: Discrepancies in tooth width ratios could affect the excellence in the finishing of orthodontic cases. This study compared tooth width ratios in crowded and noncrowded dentitions with gender variation.

METHODOLOGY: Tooth widths were measured from 200 dental casts (50 crowded and 50 spaced in male and 50 crowded and 50 spaced in female) using a digital caliper with a Vernier scale neared 0.1 mm. Bolton analysis was applied to calculate the tooth width ratios (anterior and total). Descriptive statistics, Student's t-test, and chi square test were applied.

RESULTS: There was no statistically significant difference found between the anterior and total tooth width ratios according to gender variation and dentition types (P>.05).A comparison between crowded and noncrowded dentitions irrespective of gender variation showed that there was statistically significant difference (p=0.038 and 0.005 respectively) present. Although both sums were larger in crowded dentitions, all differences were within the normal values proposed by Bolton. Differences between subjects with crowded and noncrowded dentitions were 0.94 and 0.62 mm for the excess of anterior and total upper tooth mass with respect to lower mass excess which can't be considered clinically significant(less than one mm).

CONCLUSION: No difference in the tooth width ratios according to interaction between gender and crowding was found.

INTRODUCTION

A tooth-size discrepancy (TSD) is defined as a disproportion among the sizes of individual teeth[1]. In order to achieve a good occlusion with proper overjet and overbite, the maxillary and mandibular teeth must be proportional in size[2]. Mesiodistal tooth width is considered a primordial etiologic factor in space anomalies, which together with tooth width discrepancy may cause malocclusion[3-5].In the present age of clinical orthodontics, advances in the diagnostic phase of the treatment have been plentiful, especially with regard to the use of cephalometric radiograph and computers. But one of the most important methods often overlooked is tooth size analysis. Analysis of maxillary to mandibular tooth width ratio is an important diagnostic tool for predicting the occlusal results of orthodontic treatment. An appropriate relationship of the mesiodistal width of the maxillary and mandibular teeth favors a good post treatment occlusion[6].

The mesiodistal widths of teeth were first formally investigated by G.V. Black[7] in 1902. He measured a large number of human teeth and set up tables of mean dimensions, which are still used as references today. It was Wayne Bolton who in 1958 proposed the tooth size analysis and tooth width ratio, the purpose was to develop a method of evaluating tooth size discrepancy that would aid in orthodontic diagnosis and treatment planning and also help in determining the functional and esthetic outcome of the case[4]. Bolton's mean ratio is likely to be a good guide permitting a good occlusion, but his standard deviations of this ratio may be a poor indicator of a clinically significant tooth size discrepancy.It is expected that less than ideal occlusal relationships should exist in cases with significant variation in tooth width ratios[5].Thus the Bolton's discrepancy has been added as the seventh key to Andrew's six keys of normal occlusion.

Even though differences between mesiodistal tooth width in crowded and noncrowded dentitions have been reported in several studies[3, 8–14] only few of these studies analyzed mesiodistal tooth width collectively instead of individually. In the literature, only Lu¨ndstrom's3 study previously evaluated the relationship between total tooth width ratio and crowding, but with sample size limitations and Norderval et al9 only for the anterior tooth width ratio. Because dental crowding should be associated to larger tooth width to a certain degree, it is probable that disproportions in the interarch tooth width relationship in the posterior arch area may also influence the presence of dental crowding. Discrepancies in tooth width could affect the excellence in the finishing of orthodontic cases[15].

Proffit and fields1 stated that only when a tooth size discrepancy, compared with Bolton's norm is greater than 1.5 mm or 2 SD, results in difficulties in tooth alignment in the finishing phase of treatment.Therefore, this study was de-

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signed to evaluate tooth width ratios in crowded and non-crowded dentitions and discuss the clinical implications of the possible differences with gender variations.

MATERIAL AND METHOD

From 350 dental casts between the age of 15 to 35 years with permanent dentition, 200 dental casts were selected according to dental arch discrepancy. All the dental casts had been free of dental caries, restorations, or attrition in proximal surfaces or any anomaly in tooth number, size, or shape. Dental arch discrepancy was considered as the difference between the available and required space in each dental arch. Presence of any negative discrepancy in both arches was considered a crowded case and presence of any positive discrepancy in both arches as a noncrowded case. They were divided into four groups according to crowding and sex (50 male crowding, 50 female crowding and 50 male noncrowding , 50 female noncrowding).

Mesiodistal tooth size of each tooth was measured using a sliding caliper with Vernier scale neared to 0.1 mm according to the technique proposed by Moorrees et al[16] and Moorrees and Reed[17] .To minimize random and systematic errors, all measurements were performed by a single examiner, who was calibrated previously by measuring only eight to ten pairs of models each day to avoid visual fatigue[18] .The primary investigator measured each tooth twice, from the right first molar to the left first molar in each arch. If the difference between both was less than 0.2 mm, the first measurement was registered. If the second measure differed more than 0.2 mm from the first measure, then the tooth was measured again [19-21] and only the new measure was then registered.[21]

Tooth width ratios were calculated in the four groups using formulas proposed by Bolton[3, 4] and then compared using Independent-samples t-test according to gender variation and dentition type. Independent-samples t-test was also used to compare differences between the mean sum of the (anterior and total) maxillary tooth widths and the sum of the (anterior and total) mandibular tooth widths among both types of dental arches. Finally, anterior and overall ratios were grouped according to differences in standard deviations (SD) from Bolton proposed mean values. Chi-square test was used to determine where the differences between types of arches lay.

To check for the the clinical significance of the possible differences the mean sum of anterior and total mesiodistal tooth widths in both arches were calculated and subtracted. As Proffit and fields[1] stated that only when a tooth size discrepancy, compared with Bolton's norm was greater than 1.5 mm or 2 SD it was considered as clinically significant.

RESULTS

The present study was done with 200 pre-treatment models as the sample size to investigate and compare tooth width ratios in crowded and noncrowded dentition with gender variations. Table I exhibit descriptive statistics (mean, SD, mean difference and SE difference) of the tooth width ratios for the groups according to gender and dentition type. Tooth width ratios were compared using an independent Student t-test. There was no statistically significant difference found between the gender (male and female) and dentition type (crowded and noncrowded). Results also found that both the overall and anterior ratios were higher in patients with crowded dentition (p= 0.094 and p=.0.076 respectively).

Table I: Comparison of Tooth width ratios according to crowding and gender variation

	Dentition	Gender	N	Mean	SD	Mean Diff	SE Diff	't'	'p' value
OVERALL RATIO	Crowded	Male	50	91.033	2.003	-0.801	0.474	-1.691	0.094
		Female	50	91.834	2.683				
	Non Crowded	Male	50	92.234	2.322	0.259	0.432	0.599	0.551
		Female	50	91.976	1.984				
	Dentition	Gender	N	Mean	SD	Mean Diff	SE Diff	't'	'p' value
ANTERIOR RATIO	Crowded	Male	50	77.558	2.528	-0.897	0.500	-1.793	0.076
		Female	50	78.455	2.473				
	Non Crowded	Male	50	79.789	2.836	1.106	0.702	1.574	0.119
		Female	50	78.684	4.076				

Table II exhibit a comparison between crowded and noncrowded dentitions of the overall ratios and anterior ratios irrespective of gender using t- test .The results showed that there was statistically significant (p=0.038 and 0.005) difference between two groups.

Table II: Comparison of Crowded and noncrowded dentition in general

		N	Mean	SD	Mean Diff	SE Diff	't'	'p' value
OVERALL RATIO	Crowded	100	91.434	2.390	-0.671	0.322	-2.087	0.038
	Non Crowded	100	92.105	2.153				
		N	Mean	SD	Mean Diff	SE Diff	't'	'p' value
ANTERIOR RATIO	Crowded	100	78.006	2.529	-1.230	0.435	-2.829	0.005
	Non Crowded	100	79.237	3.537				

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Table III exhibits the comparison of the mean sum of the mesiodistal tooth sizes in crowded and noncrowded dentitions. The mean sum of the six maxillary anterior tooth widths exceeded the sum of the six mandibular anterior tooth widths by 10.59 mm for crowded and by 9.66 mm for noncrowded dentitions. Independent sample t-test demonstrated that the difference between both the groups was significant (p=0.003).Similarly the sum of the 12 maxillary tooth widths exceeded the sum of the 12 mandibular tooth widths by 8.09 mm for crowded dentitions and by 7.47 mm for noncrowded dentitions. Independent sample t-test demonstrated that this difference was not statistically significant (p=0.156).

Table III: Mean sum of mesiodistal tooth size in crowded and noncrowded dentition

	Dental Arch	Maxilla		Mandible		Difference		'p' value
		Mean	SD	Mean	SD	Mean	SD	
Anterior	Crowded	47.835	3.111	37.237	2.374	10.597	1.580	0.003
	Non Crowded	45.449	3.617	35.786	2.373	9.662	2.654	
Overall	Crowded	96.624	5.630	88.532	4.954	8.091	2.549	0.156
	Non Crowded	91.868	6.664	84.396	5.630	7.472	3.526	

Table IV exhibit a comparison between crowded and noncrowded dentitions according to the number of SDs from the mean proposed by Bolton using chi square test. The results showed both overall and anterior ratios were statistically significant between Bolton mean and -1SD.

Table IV: Comparison Tooth Size Discrepancies Grouped According to Standard Deviations from Bolton Proposed Mean Values in Crowded and Noncrowded Dentitions

Overall ratio		Between -1SD and -2SD	Between Bolton mean and -1SD	Between Bolton mean and +1SD	Between +1SD and +2SD	More than +2SD			Total	'p' value
Crowded		15		39	30	14	2	100	0.954	
		15.0%	39.0%	30.0%	14.0%	2.0%	100.0%			
Non Crowded		17		37	33	11	2	100		
		17.0%	37.0%	33.0%	11.0%	2.0%	100.0%			
Anterior ratio		Between -1SD and -2SD	Between Bolton mean and -1SD	Between Bolton mean and +1SD	Between +1SD and +2SD	More than +2SD	Total		'p value'	
	Crowded	11	**38**	**34**	11	3			0.298	
	11.0%	38.0%	34.0%	11.0%	3.0%	100				
	Non Crowded	10	**34**	**34**	20	0	100.0%			
	10.0%	34.0%	34.0%	20.0%	.0%	100		100.0%		

DISCUSSION

In order to achieve excellence in orthodontic finishing, clinician should be familiar with the discrepancies in tooth size at the initial stages of diagnosis and treatment planning. Tooth size discrepancies are considered an important factor for an ideal finishing. A good occlusion depends on a correct ratio between the dental masses in the maxillary and mandibular arches [4]. If the patient has significant tooth size discrepancy, orthodontic alignment into optimal occlusion with proper overjet and overbite may not be possible.

Several studies have reported differences between mesiodistal tooth width in crowded and noncrowded dentitions by considering tooth width of the individual tooth rather than considering whole arch. There is good evidence that populations differ with respect to interarch tooth size relationships.[22] Previously Bolton[4], Crosby and Alexander[23] did a study on tooth size discrepancies but in their studies they did not consider gender and racial differences while analyzing these tooth-size discrepancies. Therefore this study was designed to evaluate and compare tooth width ratios in crowded and noncrowded dentitions along with gender variations and to discuss the clinical significance of the same. This study compared tooth width ratios in 200 subjects with simultaneously crowded or spaced arches selected from records in the Department of Orthodontics and Dentofacial Orthopedics at M S Ramaiah Dental College and hospital, Bangalore.

The present study showed that there was no statistically significant difference found in mesiodistal tooth width ratios between the gender (male and female) and dentition type (crowded and noncrowded). This has been previously reported by other authors. Eduardo Bernabe et al [15] in his study on Peruvian adolescents concluded that there was no significant difference between the anterior and total tooth width ratios according to sex. Also Al-Tamimi T et[24] al in their study on Saudi population found that there were no statistically significant differences between the mean values of the anterior ratio and the overall ratio between genders and the mean values reported by Bolton. Doris[10] in his study concluded that teeth in males were uniformly larger than in females, but not to a statistically significant level. Frequency for occurrences of crowding and non-

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crowding showed no predilection for particular sex.

In contrast to this, Uysal et al [25] in their study compared interarch tooth size discrepancy in orthodotically untreated subjects and found significant gender dimorphism. All malocclusion groups showed significantly higher overall ratios than normal occlusion groups. Also Susan N et al [26] in their study on Jordanian found significant tooth size differences between male and female. Their study also showed differences in tooth width among different types of malocclusion .

It is interesting to note that if differences among mesiodistal tooth width in subjects with crowding and spacing exist, these would not be of the same magnitude for all teeth in both arches. When all these small differences are considered together, different values for tooth width ratios are obtained.[15] Previously, Lu¨ndstrom[3] found that cases with large upper teeth in relation with the lower teeth presented a tendency to greater crowding in the upper arch. Cases of relatively larger teeth in one jaw than in the other should be more likely to produce greater crowding in the former than in the latter jaw. In all above mention studies [3, 10, 15, 24, 26] dental casts were selected irrespective of their posterior occlusion along with variability in crowding or spacing either in the maxillary or mandibular arch but not in both.

It must be noted that, in this study only those subjects were selected who presented crowding in both maxillary and mandibular arch with Angle class I molar relationship. Also the subjects for spacing were selected in a similar way. When a comparison was done between crowded and noncrowded dentitions of the overall ratios and anterior ratios irrespective of gender variation the results showed that there was statistically significant (p=0.038 and 0.005) difference between two groups. Results also showed that both the means of the tooth width ratios overall and anterior were higher (p= 0.094 and p=.0.076 respectively) in crowded cases suggesting greater tendency for crowding in mandibular dentition. Previously only Norderval et al[9] evaluated tooth width ratios in crowded and noncrowded dentitions with posterior class I occlusion with slight crowding. But they only considered anterior tooth width ratio in their study and found a higher anterior ratio in crowded cases. Their study did not evaluate the total ratio. So no comparison in this regard can be made. Rees [27] in his study found that mesiodistal width of the maxillary teeth from right second premolar to left second premolar exceeded those of the mandible by an average of 7.5mm with a range of 5 to 10mm. He believed that the discrepancy could be reduced by stripping, extraction or placing crowns.

With the purpose of finding clinical significance for these results, the mean sum of anterior and total mesiodistal tooth widths in both arches were calculated and subtracted. Although both sums were larger in crowded dentitions, all differences were within the normal values proposed by Bolton. Differences between subjects with crowded and noncrowded dentitions were 0.94 and 0.62 mm for the excess of anterior and total upper tooth mass with respect to lower mass excess. Neither can be considered clinically significant. Proffit and Fields[1] stated that tooth width discrepancies less than 1.5 mm are rarely significant. Only larger discrepancies could create problems that need to be considered in treatment planning. This has been previously reported by Eduardo Bernabe´ at el [15] in their study.

Also, Adams[11] made a comparison of the sum of tooth widths for each arch according to sex but also considered second molars. He found that the differences were significant for male individuals in both arches and for female individuals in the upper arch. The samples used in this study represented common cases seen in orthodontic practice with Angle's class I molar relationship having crowding or spacing. Although dental arches with and without crowding present significant statistical differences in tooth width ratios, these differences are too small to be considered of clinical significance (less than one mm).

CONCLUSION

In the present study the following conclusions may be drawn:

1. Statistical but no clinical differences (less than one mm) were found between tooth width ratios in crowded and noncrowded dentitions. (p=0.03 for overall and p=0.01 for Anterior)
2. No difference in the tooth width ratios according to interaction between gender and crowding was found.

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