Comparison of tooth size discrepancies among different malocclusion groups

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SUMMARY This retrospective investigation was designed to compare tooth size discrepancies among subjects with different skeletal malocclusions in an orthodontic population. The study employed the pretreatment models of 200 patients (100 males, 100 females, aged from 14 to 20 years) selected from the records of the Orthodontic Department, Shiraz Dental School. The subjects were from four malocclusion groups, Class I, Class II division 1, Class II division 2, and Class III, with the corresponding skeletal characteristics. Each group comprised 50 healthy individuals (25 males, 25 females). The mesio-distal dimensions of teeth were measured using digital electronic callipers (accurate to 0.01 mm) and the Bolton indices were determined. The data were statistically analysed using analysis of variance and Duncan's multiple range test, with the level of significance set at P < 0.05.

The results revealed that the mean anterior ratio (79.01) for the whole sample was statistically significantly different from Bolton's (77.2) but no significant difference was found for the overall ratio. The posterior and overall ratios of the Class III malocclusion group were statistically greater than the other malocclusion groups (P < 0.05). The mean anterior ratio of the Class III group was greater than that of the Class II group. However, there was no difference when compared with the Class I malocclusion group. For the two types of Class II malocclusion, no significant ratio differences were observed.

Introduction

A co-ordinated proportion between the mesio-distal dimensions of the upper and lower teeth is necessary for good intercuspation. The presence of a tooth size discrepancy prevents the achievement of an ideal occlusion. In the posterior region, a high percentage of finishing phase difficulties arise because of tooth size imbalance that could have been detected and considered during initial diagnosis and treatment planning. In some situations, tooth size discrepancy is not observed at the initial examination and could result in poor contacts, spacing, crowding, and an abnormal overjet and overbite (Laino *et al.*, 2003).

Bolton's analysis, based on the ratios between the mesiodistal width of the mandibular and maxillary teeth, is the most popular and best-known method for determining tooth size abnormality, and is also useful in aiding diagnosis in patients with severe tooth size discrepancy (Bolton, 1958, 1962).

As with many other human attributes, there is a variation in tooth size between males and females. Male teeth are generally recognized to be larger than female teeth (Garn *et al.*, 1964; Beresford, 1969; Sanin and Savara, 1971; Potter, 1972; Arya *et al.*, 1974). Gender differences have also been reported between the upper canines and upper central incisors in the primary and permanent dentitions (Doris *et al.*, 1981), whereas the upper lateral incisors and lower incisors are the most homogenous (Richardson and Malhotra, 1975). Although, significant differences in tooth size between males and females have been reported, there is no evidence of a significant difference in upper to lower anterior tooth size proportions (Nie and Lin, 1999; Smith et al., 2000).

The importance of correct tooth size proportions between the upper and lower arches has been demonstrated. Neff (1949) developed an anterior coefficient, which was a proportion for the width dimension of the teeth. A ratio of 1.20–1.22 when the maxillary mesio-distal sum was divided by the mandibular mesio-distal sum would result in an optimal overbite. Lundström (1955) studied the relationship between the mandibular and the maxillary anterior sum and named it 'the anterior index'. The optimal ratio was found to be from 73 to 85 per cent, with a mean of 79 per cent for an ideal overbite.

Gilpatric (1923) showed that the total mesio-distal tooth diameters in the maxillary arch exceeded those in the mandibular arch by 8–12 mm, and a value greater than this resulted in an excessive overbite.

Bolton's (1958, 1962) analysis included comparisons of the total mesio-distal widths of the dental arches including the distal surfaces of the first molars, as well as segments of the arches. He established ideal anterior and overall ratios with mean values of 77.2 and 91.3 per cent, respectively.

Although in recent studies variables such as incisor inclination (Tuverson, 1980), upper incisor thickness (Halazonetis, 1996; Rudolph *et al.*, 1998), and arch form (Braun *et al.*, 1999) have been described as important factors to be considered in achieving an optimal occlusal relationship, and efforts have been made to adapt Bolton's analysis to these variations, the Bolton analysis is still a robust guideline for assessing the relationship of the upper to lower dentition.

Some investigations have demonstrated an existing correlation between tooth size discrepancies and malocclusion groups. Lavelle (1972) studied 160 subjects to determine anterior tooth sizes and showed that Bolton's discrepancy would be greater in Class III subjects than other malocclusion groups. Sperry *et al.* (1977) analysed Bolton's ratios for Class I, Class II, and Class III groups. The overall ratios showed that there was excess mandibular tooth size for Class III patients. Crosby and Alexander (1989) also analysed Bolton's ratios for different malocclusion groups. However, they did not differentiate between genders and did not include Class III patients. Their results showed no difference in the incidence of tooth size discrepancy among the different malocclusion groups.

Nie and Lin (1999) and Smith *et al.* (2000) found significant differences in Bolton's ratio among several occlusal categories and concluded that the anterior ratio was greater in Class III than in Class II and Class I subjects.

Araujo and Souki (2003) determined the correlation between anterior tooth size discrepancies and Angle Class I, II, and III malocclusions in a Brazilian population, and showed that subjects with Class I and III malocclusions had a significantly greater prevalence of tooth size discrepancies than individuals with a Class II malocclusion; the mean anterior tooth size discrepancy for Class III subjects was significantly greater than that for Class I and Class II subjects.

In a recent study, conducted to investigate the correlation between the prevalence of tooth size discrepancies and skeletal malocclusion and to determine linear correlations between the posterior, anterior, and total Bolton indices, there was no evidence of any predisposition for a tooth size discrepancy in any of the malocclusion groups (Laino *et al.*, 2003).

The objectives of the current study were to determine whether sexual dimorphism exists for tooth size ratios; to clarify any difference in intermaxillary tooth size discrepancies represented by anterior, overall, and posterior ratios when comparing Class I, Class II division 1, Class II division 2, and Class III cases in an Iranian population; and finally to compare the tooth size ratios of these patients with those of Bolton's study.

Materials and methods

The study models of 200 patients treated at the Orthodontic Department, Shiraz Dental School, were retrospectively selected. The subjects were from four malocclusion groups: Class I, Class II division 1, Class II division 2, and Class III. Each group comprised 50 healthy individuals (25 males, 25 females). The pre-treatment ages ranged from 14 to 20 years. The selection criteria were the equivalent skeletal

and dental classification, good quality study models, all permanent teeth (except third molars) erupted in the upper and lower arches, absence of any dental deformity or severe mesio-distal and occlusal tooth abrasion, no restorations extending to the mesial or distal surfaces, or enamel stripping of the anterior or posterior teeth.

The sagittal relationship was assessed cephalometrically using the ANB angle: skeletal Class I, from 0 to 4 degrees; Class II, greater than 4 degrees; and Class III, less than 0 degrees. The occlusal characteristics of all subjects were classified using Angle's classification and this corresponded to the skeletal relationships.

The teeth on each model, except the second and third molars, were measured at the largest mesio-distal dimension using a digital calliper (Model No. CD6"GS, Mitoyoto Digimatic Calliper No. 500, Tokyo, Japan) with an accuracy of 0.01 mm. The results were recorded at the 0.1 mm level, with the same examiner (HRF) undertaking all the measurements. In order to determine measurement error, the study models of 30 randomly selected individuals were measured again 1 week later by the same examiner and an analysis of error was performed using the non-parametric Wilcoxon statistical test. The results showed no significant difference between the two measurements.

The anterior, posterior, and overall tooth size ratios were computed for each subject as described by Bolton:

 $\frac{\text{Sum mandibular 3-3}}{\text{Sum maxillary 3-3}} \times 100 = \text{anterior ratio},$ $\frac{\text{Sum mandibular 654-456}}{\text{Sum maxillary 654-456}} \times 100 = \text{posterior ratio},$

 $\frac{\text{Sum mandibular 6-6}}{\text{Sum maxillary 6-6}} \times 100 = \text{overall ratio.}$

To compare the prevalence of tooth size discrepancies among the four malocclusion groups and two genders, a chi-square test was performed. In addition, to compare the mean Bolton tooth size ratios as a function of Angle's classification as well as gender, analysis of variance (ANOVA) was undertaken.

Results

The means, standard deviations, and standard error of the tooth size ratios were obtained for each group (Table 1).

Anterior dental proportions

The mean anterior ratio of male subjects (79.57 ± 2.7) was significantly larger than that of female subjects (78.45 ± 2.81) . ANOVA demonstrated that there were significant differences between all groups (Table 2).

Groups $(n = 50)$	Anterior ratio, mean \pm SD (range)	Posterior ratio, mean ± SD (range)	Overall ratio, mean ± SD (range)
Class I	79.44 ± 3.14 (14.99)	$104.00 \pm 3.48 (18.93)$	91.85 ± 2.21 (11.48)
Class II division 1	$77.73 \pm 2.17(7.77)$	$103.21 \pm 3.42(16.31)$	$90.65 \pm 1.78(6.37)$
Class II division 2	$78.72 \pm 2.38(10.62)$	$103.45 \pm 3.21(14.76)$	$91.09 \pm 2.05(9.11)$
Class III	$80.16 \pm 2.88(13.27)$	$105.82 \pm 2.94(14.91)$	$93.14 \pm 1.86(8.25)$
Total sample ($n = 200$)	$79.01 \pm 2.80(17.75)$	$104.12 \pm 3.40(20.66)$	$91.68 \pm 2.18(11.95)$
Bolton's study	77.20 ± 1.65 (5.9)		91.30 ± 1.91 (7.3)

 Table 1
 Mean, standard deviation, and range of ratios in each malocclusion group.

Table 2 Mean (X), standard deviation (SD), and standard error (SE) of the ratios in males and females.

		Males		Females			P value
	X	SE	SD	X	SE	SD	
Class I							
AR	80.12	0.45	2.27	78.76	0.75	3.75	0.127
PR	103.61	0.67	3.34	104.39	0.73	3.63	0.433
OR	92.17	0.36	1.78	91.54	0.51	2.57	0.318
Class II division 1							
AR	78.51	0.47	2.37	76.94	0.33	1.65	0.009
PR	102.22	0.64	3.78	104.10	0.69	3.47	0.089
OR	90.47	0.35	1.74	90.56	0.37	1.84	0.72
Class II division 2							
AR	79.04	0.47	2.36	78.40	0.48	2.41	0.34
PR	102.82	0.67	3.35	104.08	0.60	3.01	0.16
OR	90.98	0.40	2.02	91.20	0.42	2.12	0.7
Class III							
AR	80.61	0.66	3.28	79.72	0.48	2.40	0.27
PR	106.42	0.68	3.40	105.23	0.46	2.30	0.15
OR	93.61	0.39	1.96	92.67	0.33	1.66	0.07
Malocclusion groups (total)							
AR	79.57	0.27	2.70	78.45	0.28	2.81	0.004
PR	103.80	0.36	3.64	104.45	0.31	3.13	0.177
OR	91.87	0.22	2.18	91.49	0.22	2.19	0.22

AR, anterior ratio; PR, posterior ratio; OR, overall ratio.

Using Duncan's multiple range test, it was found that the differences were between subjects with a Class II division 1 and Class I malocclusion, and also between Class III and Class II malocclusion subjects. The mean ratio for the Class III sample was significantly greater than that for the Class II subjects (P < 0.05) but the Class I and Class III sample showed no significant differences when compared with each other (Table 3).

Posterior dental proportions

The mean posterior ratio for different malocclusions as a single group was found to be 104.12, with a standard deviation of 3.40. Although the absolute value of the tooth size ratio of male patients (103.8 ± 3.64) was smaller than that of female patients (104.45 ± 3.13), the difference was not statistically significant (P = 0.177).

Comparing the different malocclusion groups, the Class III group was found to have a statistically larger posterior ratio (P < 0.05).

Overall dental proportions

For posterior ratio, the overall ratio was significantly larger for the Class III malocclusion subjects than the other groups, but with no significance for either gender. Regarding absolute values, the mean overall ratio for the different groups was in the order of Class III > Class I > Class II division 2 > Class II division 1. In addition, there was a statistically significant difference between the Class I and Class II division 1 groups.

Discussion

The findings of the present study demonstrate statistically significant differences in the anterior ratio between males and females among the four malocclusion groups, but not for overall and posterior ratios. When comparing the mean to interpret the overall ratio, the results of the present study are similar to those of Bolton (1958) and Stifter (1958). For anterior ratio, which was 79.01 ± 2.8 when all

 Table 3
 Significant mean ratios between the different malocclusion groups using Duncan's multiple range test.

Intergroups comparison	Anterior ratio	Posterior ratio	Overall ratio
Class I and Class II division 1	*	NS	*
Class I and Class II division 2	NS	NS	NS
Class I and Class III	NS	*	*
Class II division 1 and division 2	NS	NS	NS
Class II division 1 and Class III	*	*	*
Class II division 2 and Class III	*	*	*

NS, not significant; *P < 0.05.

malocclusion subjects (i.e. 200 patients) were combined, no similarity was found. The subjects in the present investigation all had malocclusions sufficiently severe to warrant treatment and it is possible that this is contributed to the larger percentage of tooth size discrepancies, especially in the anterior region. This could be explained by the fact that anterior teeth, especially the incisors, have a much greater incidence of tooth size deviations, that is, the greatest variables in mesio-distal tooth width occur in the anterior region.

The findings that individuals with a Class III malocclusion have a significantly greater mean anterior ratio than the other groups may confirm the results of Lavelle (1972) that Class III individuals have disproportionately smaller maxillary teeth than Class I and Class II subjects. However, a small size of the maxillary teeth was not found in the present study. Therefore, the Bolton discrepancy in the Class III sample must either be attributed to an increase in the width of the anterior mandibular teeth or the accumulation of minor discrepancies of individual teeth.

The results obtained by Nie and Lin (1999) using Angle's classification as a variable in analysing 360 Chinese individuals for tooth size discrepancies are in agreement with the present findings that Class III patients demonstrate a greater tooth size discrepancy when compared with Class II and I patients. These findings also confirm the initial investigations by Sperry *et al.* (1977).

Crosby and Alexander (1989) tried to verify the presence of a tooth size discrepancy in 109 patients divided into four malocclusion groups, but not including Class III subjects. They compared the average of the anterior and overall Bolton indices but did not find any statistical difference in the incidence of the tooth size discrepancy among the groups (Class I, Class II divisions 1 and 2, and surgical Class II). Some of the findings in the present investigation were similar to their results with respect to the absence of statistically significant differences when comparing Class I and Class II malocclusion groups. Since they did not include subjects with a Class III malocclusion in their investigation, they could not find any difference between normal occlusion and malocclusion groups coinciding with the Bolton indices, while in the present study, a large part of the differences in the Bolton indices were attributed to the presence of a Class III malocclusion.

Regarding studies reporting the mesio-distal dimensions of lower teeth to be larger in Class III malocclusion subjects when compared with Classes I and II (divisions 1 and 2) (Lavelle, 1972; Sperry *et al.*, 1977), it seems that the greater mean of Bolton's ratio in these Classes might be due to aetiological factors that lead to mandibular prognathism. Further studies are needed to clarify whether a correlation exists between increased mandibular growth (as in Class III malocclusions) with increased mesio-distal dimensions of lower anterior teeth. The possible interaction of genetic factors could determine mandibular size while affecting the mesio-distal dimensions of lower mandibular teeth in the same way.

Conclusion

The results show that subjects with an Angle Class III malocclusion had a significantly greater prevalence of tooth size discrepancies than those with Class I and Class II malocclusions. The mean anterior tooth size discrepancy for Angle Class III individuals was significantly greater than that in Class II subjects but not Class I patients. No statistically significant difference was found between the two types of Class II malocclusion for anterior, posterior, and overall ratios. The anterior and overall ratios of the Class I group were significantly greater than those in the Class II division 1 subjects but not in those with a Class II division 2 malocclusion.

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References

- Araujo E, Souki M 2003 Bolton anterior tooth size discrepancies among different malocclusion groups. Angle Orthodontist 73: 307–313
- Arya B S, Savara B S, Thomas D, Clarkson Q 1974 Relation of sex and occlusion to mesiodistal tooth size. American Journal of Orthodontics 66: 479–486
- Beresford J S 1969 Tooth size and class distinction. Dental Practice 20: 113–120
- Bolton W A 1958 Disharmony in tooth size and its relations to the analysis and treatment of malocclusion. Angle Orthodontist 28: 113–130
- Bolton W A 1962 The clinical application of a tooth-size analysis. American Journal of Orthodontics 48: 504–529
- Braun S, Hnat W P, Kusnoto B, Hnat T W 1999 A new accurate approach to the anterior ratio with clinical applications. Part 1: a computer program. American Journal of Orthodontics and Dentofacial Orthopedics 115: 368–372
- Crosby D R, Alexander C G 1989 The occurrence of tooth size discrepancies among different malocclusion groups. American Journal of Orthodontics and Dentofacial Orthopedics 95: 457–461
- Doris J M, Bernard B W, Kuftinec M M 1981 A biometric study of tooth size and dental crowding. American Journal of Orthodontics 79: 326–336
- Garn S M, Lewis A B, Kerewsky R S 1964 Sex difference in tooth size. Journal of Dental Research 43: 306–307
- Gilpatric W H 1923 Arch predetermination—is it practical? Journal of the American Dental Association 10: 553–572
- Halazonetis D J 1996 The Bolton ratio studied with the use of spreadsheets. American Journal of Orthodontics and Dentofacial Orthopedics 109: 215–219
- Laino A, Quaremba G, Paduano S, Stanzione S 2003 Prevalence of toothsize discrepancy among different malocclusion groups. Progress in Orthodontics 4: 437–444

- Lavelle C L B 1972 Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. American Journal of Orthodontics 61: 29–37
- Lundström A 1955 Intermaxillary tooth width ratio and tooth alignment and occlusion. Acta Odontologica Scandinavica 34: 265–292
- Neff C W 1949 Tailored occlusion with the anterior coefficient. American Journal of Orthodontics 35: 309–313
- Nie Q, Lin J 1999 Comparison of the intermaxillary tooth size discrepancies among different malocclusion groups. American Journal of Orthodontics and Dentofacial Orthopedics 116: 539–544
- Potter R H 1972 Univariate versus multivariate differences in tooth size according to sex. Journal of Dental Research 51: 716–722
- Richardson E R, Malhotra S K 1975 Mesiodistal crown dimension of the permanent dentition of American Negroes. American Journal of Orthodontics 68: 157–164
- Rudolph D J, Dominguez P D, Ahn K, Thinh T 1998 The use of tooth thickness in predicting intermaxillary tooth-size discrepancies. Angle Orthodontist 68: 133–140
- Sanin C, Savara B S 1971 An analysis of permanent mesiodistal crown size. American Journal of Orthodontics 59: 488–500
- Smith S S, Buschang P M, Watanabe E 2000 Interarch tooth size relationship of 3 populations. "Does Bolton's analysis apply?" American Journal of Orthodontics and Dentofacial Orthopedics 117: 169–174
- Sperry T P, Worms F W, Isaacson R J, Speidel T M 1977 Tooth-size discrepancy in mandibular prognathism. American Journal of Orthodontics 72: 183–190
- Stifter J 1958 A study of Pont's, Howes', Rees', Neff's and Bolton's analyses on Class I adult dentitions. Angle Orthodontist 28: 215–225
- Tuverson D L 1980 Anterior interocclusal relations. Part I. American Journal of Orthodontics 78: 361–370

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