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Maxillary and mandibular mesiodistal tooth sizes among different malocclusions in a sample of the Turkish population

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SUMMARY The purpose of this study was to establish normative data for mesiodistal tooth crown dimensions with respect to malocclusions and gender differences in Turkish sample. The subjects were randomly selected and assigned to three malocclusion groups according to Angle's classification. Each group consisted of 100 individuals between the ages of 13 and 18 years with the following distribution: Class I, 42 males and 58 females; Class II, 52 males and 48 females; and Class III, 51 males and 49 females. An electronic digital calliper was used to measure the mesiodistal tooth width from the right second permanent molar to the left second permanent molar on both upper and lower study casts. For statistical evaluation, one- and two-way analyses of variance and *post hoc* Tukey's honestly significant difference (HSD) tests were performed.

There were statistically significant differences for the maxillary canine ($P < 0.001$), first premolar ($P < 0.05$), second molar ($P < 0.05$), and mandibular canine ($P < 0.01$) for males, and for all maxillary teeth and the mandibular central ($P < 0.05$), canine ($P < 0.001$), and first premolar ($P < 0.05$) teeth in females among the malocclusion groups. When Angle's classification was evaluated, significant differences were determined, except for the first and second mandibular molars. All mesiodistal widths were also found to be statistically different according to gender dimorphism.

A significant relationship was found between mesiodistal tooth size, Angle's classification, and gender. Therefore, tooth dimensions may play a crucial role in treatment planning and in achieving satisfactory interdigitation of the upper and lower dentition following the completion of orthodontic treatment.

Introduction

The mesiodistal tooth sizes of the maxillary and mandibular arches must have an ideal relationship to obtain an excellent occlusion at the completion of orthodontic treatment (Sanin and Savara, 1971; Heusdens *et al.*, 2000). The precise alignment of teeth and attainment of perfect posterior intercuspation can be difficult when crown size discrepancies are present. Examination of the dentition during treatment planning must include the identification of tooth size, both local and general, final overbite, overjet, and posterior occlusion (Moyers, 1988).

Bolton (1958) studied tooth size disharmonies in relation to treatment of malocclusions in 55 patients with excellent occlusions and produced ratios for the mesiodistal sizes of the maxillary and mandibular teeth. Bolton (1962) presented several clinical cases to determine if his analysis was a viable diagnostic aid and found that by employing the analysis, there is rarely a need for a diagnostic set-up. Formal measurement of at least the labial segment teeth and calculation of Bolton's ratio are thought to enable a more exact and informed choice of occlusal goals for the individual patient (Bolton, 1958, 1962).

Arya *et al.* (1974) demonstrated that there were differences in tooth size between genders. They also attempted to show differences in tooth size between Class I and Class II malocclusions but failed to do so. In their study, the mean size of each tooth for the different groups (i.e. Class I and Class II, boys and girls) was compared. Differences for individuals between different arches were not analysed. Lavelle (1972) showed that there was sexual dimorphism in tooth dimensions and in the ratio of upper to lower arch tooth size. Lavelle (1972) also measured the ratio of upper to lower arch tooth size in different malocclusion types. However, Nie and Lin (1999) found no significant sexual dimorphism for anterior and posterior tooth size ratios in different malocclusion groups.

There is good evidence that populations differ with respect to interarch tooth size relationships because differences in tooth sizes are not systematic (Lavelle, 1972; Arya *et al.*, 1974; Nie and Lin, 1999). Moreover, tooth size differences between males and females are not systematic across all teeth (Lavelle, 1972; Nie and Lin, 1999; Araujo and Souki, 2003; Laino *et al.*, 2003). Because population and gender differences in maxillary tooth size are not the same as those of the mandibular teeth, different interarch relationships might be expected (Lavelle, 1972; Arya *et al.*, 1974; Nie and Lin, 1999; Araujo and Souki, 2003; Laino *et al.*, 2003). The purpose of present study was to evaluate possible gender differences in the individual mesiodistal tooth sizes of males and females according to Angle's Class I, Class II, and Class III malocclusion groups.

Subjects and methods

The data for this study were obtained from the records of the Selçuk University Graduate Program in Orthodontics, Konya, Turkey. Considering that tooth size is not related to chronological age, sample selection was based on dental age with the permanent dentition defined as by the presence of all teeth at least from second molar to second.

The sample consisted of 300 patients allocated to three malocclusion groups according to Angle's classification. The skeletal pattern was determined using Steiner's (1953) cephalometric analysis and by ANB angle. Class I, 0 degrees < ANB < 5 degrees; Class II, ANB >5 degrees; Class III, ANB <0 degrees. Each group comprised 100 individuals with the following distribution: Class I, 42 males and 58 females; Class II, 52 males and 48 females; and Class III, 51 males and 49 females. All were between 13 and 18 years of age. The following selection criteria were used:

1. Turkish with Turkish parents,
2. Equivalent skeletal and dental classifications,
3. A full complement of permanent teeth on both sides of the maxillary and mandibular dental arch (third permanent molars were not included since these teeth tend to vary morphologically),
4. No apparent loss of tooth substance due to attrition, caries, or fillings,
5. Good quality study casts.

The measurements were made directly on unsoaped dental casts. One author (MN) carried out all the measurements under natural and neon light. An electronic digital calliper (Digimatic callipers; Mitutoyo, Southampton, Hampshire, UK) was used. The calliper beaks were inserted from the buccal (labial) and held occlusally parallel to the long axis of the tooth. The beaks were then closed until gentle contact with the points of the tooth was made. The measurements included the mesiodistal width of all 12 maxillary and mandibular teeth from the right second permanent molar to the left second permanent molar. Right and left symmetric teeth were measured and the mean mesiodistal crown size value was calculated. The measurements were made as carefully as possible to avoid any damage to the casts.

The error of the method was determined by the same examiner repeating the measurements for 20 pairs of dental casts for one group, in total 60 casts, after a 1 week interval. The reliability of a single measurement was computed using the formula described by Winner (1971). The reliability of measurements ranged between 0.96 and 0.98.

The test results were entered into an Excel (Microsoft, Seattle, Washington, USA) spreadsheet for calculation of descriptive statistics. One-way analysis of variance (ANOVA) was performed to compare the mesiodistal crown size for males and females separately and then Tukey's honestly significant difference (HSD) tests for comparisons among malocclusion groups at the 0.05 level of significance. Two-way ANOVA (subsequent to confirmation of normal distribution and homogeneity of variance) was used to determine whether mesiodistal tooth size was related to gender and malocclusion classification. All statistical analysis was performed using the Statistical Package for Social Sciences, Version 17.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Table 1 shows the mean and standard deviations of the mesiodistal widths of the maxillary and mandibular teeth in the male and female subgroups with different malocclusions.

Mesiodistal tooth size in males

One-way ANOVA showed statistically significant differences in the width of the maxillary canine ($P < 0.001$), first premolar ($P < 0.05$), second molar ($P < 0.05$), and mandibular canine ($P < 0.01$) among the malocclusion groups. According to Tukey's HSD test, the mesiodistal width of these teeth in the Class II subjects was greater than those in the Class I and III groups. There was no statistical difference ($P > 0.05$) between the Class I and Class III malocclusion groups.

Mesiodistal tooth size in females

Statistically significant differences were found for all maxillary teeth and the mandibular central ($P < 0.05$), canine ($P < 0.001$), and first premolar ($P < 0.05$) among the malocclusion groups. Tukey's HSD test revealed that the mesiodistal widths of the upper central ($P < 0.001$), lateral ($P < 0.001$), canine ($P < 0.001$), first premolar ($P < 0.05$), second molar ($P < 0.01$), lower central ($P < 0.05$), and first premolar ($P < 0.05$) in the Class III sample were smaller than those in the Class I and Class II samples. However, the maxillary second premolar ($P < 0.05$), first molar ($P < 0.01$), and mandibular canine widths in the Class II samples were greater than those in the Class I and Class III groups.

Class and gender interactions

When Angle's classification was evaluated, significant differences were determined for all teeth except the first and second mandibular molars according to two-way ANOVA. All mesiodistal widths were also found to be statistically different according to gender dimorphism.

Discussion

The orthodontic literature is replete with studies comparing tooth size proportions in different ethnic and malocclusion

Table 1 Mean and standard deviation (SD) of the mesiodistal crown size of individual teeth for malocclusion groups and the results of one-way and univariate analysis of variance (ANOVA)

	Male				Female					
	Class I, mean ± SD (n = 42)	Class II, mean ± SD (n = 52)	Class III, mean ± SD (n = 51)	P	Class I, mean ± SD (n = 58)	Class II, mean ± SD (n = 48)	Class III, mean ± SD (n = 49)	P	Two-way ANOVA	
Tooth	Maxilla				Maxilla				Class	Gender
Central	8.71 ± 0.55	8.98 ± 0.47	8.91 ± 0.51	ns	8.63 ± 0.51a	8.81 ± 0.47a	8.38 ± 0.62b	***	**	***
Lateral	7.06 ± 0.67	7.10 ± 0.45	6.91 ± 0.63	ns	6.81 ± 0.58a	7.04 ± 0.49a	6.48 ± 0.58b	***	***	***
Canine	7.99 ± 0.54a	8.25 ± 0.41b	7.77 ± 0.46a	***	7.68 ± 0.48a	7.89 ± 0.40b	7.47 ± 0.39c	***	***	***
First premolar	7.04 ± 0.44a	7.24 ± 0.46b	6.96 ± 0.33a	*	6.97 ± 0.47a	7.03 ± 0.42a	6.78 ± 0.42b	*	***	**
Second premolar	6.90 ± 0.48	6.99 ± 0.46	6.87 ± 0.36	ns	6.67 ± 0.50a	6.86 ± 0.42b	6.61 ± 0.46a	*	*	***
First molar	10.40 ± 0.59	10.56 ± 0.60	10.61 ± 0.53	ns	9.90 ± 0.71a	10.22 ± 0.47b	9.93 ± 0.48a	**	*	***
Second solar	9.92 ± 0.56a	10.16 ± 0.66b	9.82 ± 0.43a	*	9.60 ± 0.52a	9.73 ± 0.43a	9.36 ± 0.53b	**	***	***
	Mandible				Mandible					
Central	5.64 ± 0.40	5.73 ± 0.33	5.58 ± 0.31	ns	5.60 ± 0.37a	5.63 ± 0.46a	5.40 ± 0.4b	*	*	*
Lateral	6.19 ± 0.47	6.26 ± 0.32	6.08 ± 0.35	ns	6.09 ± 0.38	6.13 ± 0.32	5.97 ± 0.42	ns	*	*
Canine	7.02 ± 0.58a	7.26 ± 0.42b	6.92 ± 0.37a	**	6.65 ± 0.38a	6.85 ± 0.38b	6.55 ± 0.41a	***	***	***
First premolar	7.18 ± 0.42	7.36 ± 0.46	7.14 ± 0.45	ns	7.13 ± 0.46a	7.18 ± 0.43a	6.91 ± 0.54b	*	**	**
Second premolar	7.29 ± 0.48	7.56 ± 0.73	7.38 ± 0.39	ns	7.12 ± 0.49	7.19 ± 0.47	7.03 ± 0.51	ns	*	***
First molar	11.45 ± 0.63	11.51 ± 0.54	11.57 ± 0.65	ns	10.89 ± 0.62	11.07 ± 0.56	10.82 ± 0.69	ns	ns	***
Second molar	10.69 ± 0.61	10.66 ± 0.80	10.98 ± 0.61	ns	10.13 ± 0.55	10.35 ± 0.65	10.2 ± 0.61	ns	ns	***

ns, no significant. *P < 0.05, **P < 0.01, ***P < 0.001.
Groups with different letters are statistically significantly different according to Tukey's HSD test.

groups. However, there is a lack of knowledge about gender, Angle's classification, and individual mesiodistal tooth size interaction. Additional information is necessary to understand this topic.

Space limitations and nutrition have been described as important in the development of a healthy tooth germ and have been related to alterations in the number, shape, and form of permanent teeth (Stewart and Prescott, 1979). Although it is widely accepted that both genetic and environmental variables affect tooth development, it is almost impossible to identify and describe the role each of these in the determination of tooth size (Araujo and Souki, 2003).

The intended purpose of a tooth size discrepancy ratio as a diagnostic aid is to gain insight into the functional and aesthetic outcome of a given case without the use of a diagnostic set-up; in particular, they are frequently employed in individuals who appear to have a tooth size discrepancy between the dental arches (Bolton, 1958).

Mesiodistal crown size relationships are decisive variables in the search for factors associated with the development of occlusal irregularities, the possible effects of discrepancies in interdigitation, and the isolation of discrepant teeth with minor malocclusion that may be treated in part by selective mesiodistal grinding and minor tooth movement (Sanin and Savara, 1971). To accomplish this, the clinician should be able to analyse the largest possible number of crown size relationships; that is, the relative size differences between a single tooth and groups of teeth, regardless of their location in the dental arch (Sanin and Savara, 1971).

Although Bolton's analysis has proven to be useful in the clinical setting to guide the orthodontist in subjects with extreme tooth size discrepancies, it is not without limitations. Firstly, Bolton's estimates of variation were underestimated because his sample was derived from subjects with a perfect Class I occlusion (Bolton, 1958, 1962). Secondly, the population and gender composition of Bolton's sample were not specified, which implies potential selection bias. Bolton's index is not universally applicable across all population groups (Stephanie *et al.*, 2000). Thirdly, Bolton's analysis implies anterior or overall ratio, so Bolton's analysis does not identify individual mesiodistal tooth size, such as 'excessiveness' or 'smallness'.

The presence of a tooth size discrepancy prevents the achievement of a correct occlusion. The size mismatch between the maxillary and mandibular dentition can lead to generalized spacing or crowding or deviations from a Class I occlusion in the posterior region. Methods to correct a tooth size discrepancy are usually limited to the affected arch (Laino *et al.*, 2003). For example, with an increased Bolton's ratio (lower excess or upper deficit), one might choose to strip the lower teeth, re-contour the upper teeth, increase the angulation of the upper incisors, or compromise the overjet and overbite if this does not affect function. Similarly, if there is a decrease in Bolton's ratio (lower deficit or upper excess), the upper teeth can be stripped, the lower incisors flared, or the overjet or overbite moderately increased. For example, if the maxillary laterals are small, it is not always necessary to undertake restorative procedures when stripping of the lower teeth would do (Basciftci *et al.*, 2000; Laino *et al.*, 2003; Bayram and Ozer, 2007). This view is commonly accepted.

Sanin and Savara (1971) devised a simple procedure to identify individual and group tooth size disharmonies, but their analyses have limitations as the study was performed on treated and untreated subjects with good or excellent occlusion. However, for the study of tooth size in subjects with malocclusion, especially for comparison of intermaxillary tooth size relationships among different malocclusions, there are a limited number of published studies and the results are controversial. Within gender groups, teeth larger or smaller than the optimum may be one cause of malocclusion. The size of the teeth may be associated with malocclusion in one gender more than in the other. If there is a standard to determine whether a crown is too large or too small or whether the other 27 crowns are too large or too small, the number of discrepancies may be approximately 22 000 billion (Sanin and Savara, 1971).

Identifying tooth size discrepancy before final tooth alignment should be beneficial in defining the final expectations of both the clinician and the patient. Although such an analysis may be time-consuming, the benefits of interproximal stripping to correct any discrepancies would seem to outweigh the minor inconvenience of performing the analysis, which should allow more efficient diagnosis of problems (Rossouw and Tortorella, 2003).

In previous studies, gender differences have been reported and these may have clinical relevance. According to Seipel (1949), there are fewer gender differences in the primary than in the permanent dentition. Male teeth are generally recognized to be larger than female teeth (Lavelle, 1972; Arya *et al.*, 1974; Doris *et al.*, 1981; Araujo and Souki, 2003). In both the primary and the permanent dentitions, the upper canines and upper central incisors show the greatest gender differences (Doris *et al.*, 1981), whereas the upper lateral incisor and lower central incisor are the most homogenous (Potter, 1972; Araujo and Souki, 2003). In the present study, the mesiodistal dimensions of the maxillary teeth showed a higher variability than the mandibular teeth. Since they can be responsible for occlusal disharmony, this should be determined at the beginning of treatment to detect any major size and shape variation. It is interesting to note that the first and second maxillary and mandibular premolars in the present sample were approximately the same size in both genders. The mesiodistal width of the mandibular teeth followed a similar distribution pattern in the male and female samples, with dental measurements in males being slightly larger than those in females. In general, higher variability was found in the female group. Lavelle (1972) studied anterior tooth size in 160 subjects and showed a tendency for Angle Class III individuals to present with smaller upper teeth compared with those classified as Class I or II. Moreover, Lavelle (1972) stated that teeth in the lower arch are larger in Class III than in Class I and II subjects, with the inference that the Bolton's discrepancy was greater in Class III cases than in the other malocclusion groups. Sperry *et al.* (1977) studied the prevalence of tooth size discrepancy in malocclusion groups and found that Class III subjects showed a greater mandibular tooth size excess than Class I and Class II subjects. The findings of the present study are partly in accordance with the findings of Lavelle (1972) and Sperry *et al.* (1977). The results are in agreement with those of Nie and Lin (1999) who analysed 360 Chinese individuals for tooth size discrepancies using Angle's classification. Data from the current study showed that Class III patients had smaller mesiodistal tooth sizes when compared with Class I and Class II patients. In addition, all mesiodistal widths were statistically different according to gender dimorphism. These findings are in agreement with those reported by other investigators (Nie and Lin, 1999; Stephanie *et al.*, 2000; Araujo and Souki, 2003).

Accurate diagnosis and treatment planning is important in Class II and Class III malocclusion subjects, especially females, with proportionately discrepant maxillary dental arches. In the event of discrepancies, the appropriate treatment such as composite build-ups or mesiodistal reduction and orthodontics can be predicted more effectively (Araujo and Souki, 2003). Anterior crown torque changes may be used as an orthodontic solution to correct the anterior occlusion and achieve an ideal incisor relationship. Increasing or decreasing the maxillary tooth size mass in Class III or II patients, respectively, should be considered with the objective of achieving an optimal anterior and posterior relationship of the dentition.

Conclusions

On the basis of the limitations of this investigation, the following conclusions can be drawn:

1. The mesiodistal maxillary tooth widths in Class II subjects were greater than that in the Class I and Class III groups, whereas mesiodistal widths in the Class III group were smaller than those in the Class I and Class II samples,
2. Maxillary canine, first premolar, second molar, and mandibular canine mesiodistal widths in the Class II male subjects were greater than those in the Class I and III males,

3. The upper central, lateral, first premolar, second molar, lower central, and first premolar mesiodistal widths in the Class III group were smaller than those in the Class I and Class II samples. However, the maxillary second premolar, first molar, and mandibular canine widths in the Class II females were greater than those in the Class I and Class III females,
4. All mesiodistal widths were found to be statistically different according to gender dimorphism,
5. The maxillary teeth showed a higher variability than the mandibular teeth,
6. A higher variability was found for females.

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