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MESIODISTAL CROWN SIZE IN RELATION TO THE RISK AND SEVERITY OF MALOCCLUSION

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ABSTRACT

From among numerous potential causes of dental malocclusion, tooth size has been implicated as one factor. Prior studies show that mesiodistally larger teeth increase the risk of malocclusion. The present report extends our understanding by testing for graded responses between crown size and the extent of dental malocclusion. Maximum mesiodistal crown dimensions of all 14 permanent tooth types (excluding third molars) were measured in 207 American white adolescents (routine orthodontic patients), and 10 measures of malocclusion (*e.g.*, rotations, displacements, spacing) were recorded. Analysis of covariance (controlling for sexual dimorphism in tooth size) disclosed (1) significant positive associations between crown size and measures of crowding and (2) significant negative associations between crown size and measures of spacing. Of note, significant associations are widespread, involving all tooth types, both those emerging early and late. This systemic effect seems due to the intercorrelations among tooth dimensions and to the cumulative effects of crown sizes summed across multiple teeth—and this is borne out by multivariate models. Overall, tooth size probably is not commonly the paramount cause of malocclusion, but it is a readily documented influence, and its importance probably is increasing due to secular increases of crown sizes in response to diminished morbidity and improved nutrition.

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CHAPTER I. INTRODUCTION

Dental malocclusions are commonly the result of a space discrepancy; that is, space available in the dental arch is less than the space required to accommodate the teeth (Nance 1947). This tooth-size arch-size discrepancy (TSASD) may result in malocclusion and represents one factor to be considered when a patient seeks orthodontic treatment. On reflection, it is apparent that TSASD can develop due to: (A) an excess of tooth dimension (notably mesiodistal crown dimensions), (B) a deficit of arch perimeter, or (C) some combination of the two. Most studies have been on arch size and arch development, but some have tested whether crown dimensions are in themselves a risk factor for TSASD. Some of these latter investigations concluded that those with a crowded dentition (*i.e.*, TSASD) have larger teeth (*e.g.*, Fastlicht 1970; Norderval 1975; Keene 1979; Doris *et al*. 1981; Gilmore and Little 1984; Melo 2001), but other studies did not find a significant tooth size differences between those with crowding and those without (*e.g.*, Mills 1964; Howe *et al*. 1983; Radnzic 1988; Laino 2003).

Several studies that have tested for a relationship between dental crowding and tooth size did not consider the effects of sexual dimorphism in tooth crown dimensions when reporting their results (Neff 1949; Horowitz 1958; Sperry 1977). It is well documented that males have larger tooth crown dimensions than females (*e.g.*, Moorrees 1957; Garn *et al*. 1967) as statistical averages. In contemporary America, white male averages exceed those for females by about 3 to 6% depending on the tooth type (with the canines exhibiting the greatest sex difference). An example of this sexual dimorphism is shown in Figure 1, where means of a sample of American whites are plotted. For each of the 14 tooth types the male mean exceeds that for females. Consequently, when searching for an association between tooth size and TSASD, it is critical that the researcher's study design account for sex differences. Otherwise, by manipulating (or not controlling for) the subject's sex, the effect of tooth size in crowding can artificially be accentuated or eliminated simply by altering the male-female ratios in the samples. This failure to control for sexual dimorphism has led to several studies where the conclusions are confounded to unknown extents. That is, the risk of TSASD is confounded with sexual dimorphism, so no definitive interpretation of the hypothesis is possible.

The purpose of the present study is to determine whether mesiodistal crown size differs as a function of the risk and severity of malocclusion. The intent is to test for sex-specific graded dose-responses between crown size and the severity of the dental malocclusion. Prior studies (*e.g.,* Agenter 2008) have

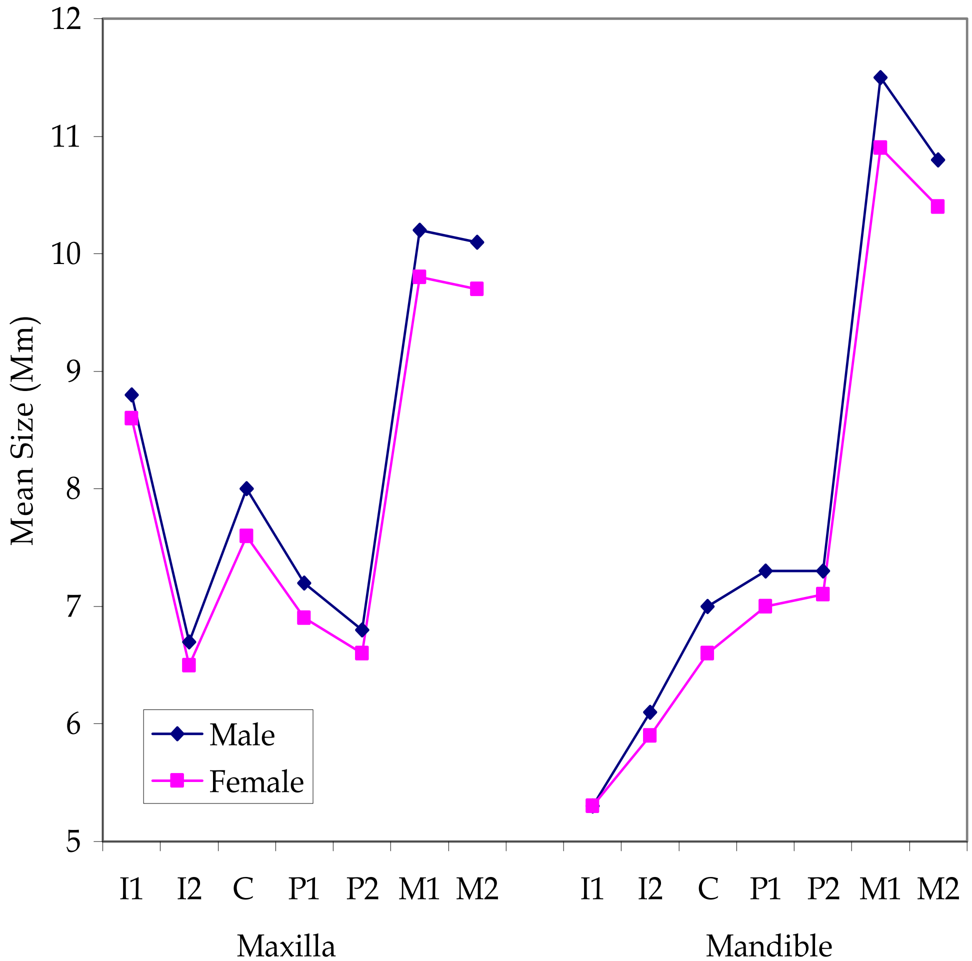

Figure 1. Plot of mean mesiodistal tooth crown diameters by sex, showing the 3 to 6% sexual dimorphism in tooth size of contemporary American whites.

Data from Garn SM, Lewis AB, Swindler DR. Genetic control of sexual dimorphism in tooth size. J Dent Res 1967;46:963-72.

documented smaller tooth sizes in those with naturally occurring good occlusions (compared to a sample with malocclusion that received treatment). It probably is artificial to suppose that the relationship actually is dichotomous–that one either has smaller teeth and no occlusal deviations or larger teeth and occlusal deviations—but what is the nature of the dose-response (where "dose" is tooth size and "response" is severity of the malocclusion). It is necessary to evaluate boys and girls separately, not just because of the confounding issue of sexual dimorphism mentioned above, but also because girls are much more likely to seek orthodontic treatment because of their (and their parents) heightened esthetic concern.

CHAPTER II. REVIEW OF LITERATURE

The causes of malocclusion are multiple and varied. Heredity, ethnicity, bone size and growth, dietary consistency, function, and numerous other factors may contribute to a person's malocclusion. Various researchers have reviewed the common causes of malocclusion (*e.g.,* Proffit 1986; Harris and Johnson 1991; Mossey 1999), though it usually is difficult to identify a single source for any given individual.

Some authors have suggested that the presence of malocclusion in a patient may be related to tooth size. For example, the orthodontic records of 80 patients were examined in the Doris *et al*. 1981 study. There were equal numbers of males and females and all were North American Caucasians between 11 to 18 years of age. This sample was divided into two groups of 40, each based on the amount of dental crowding in the upper and lower arches. Group I was composed of those with 4 mm or less of crowding; those with more than 4 mm of crowding were assigned to Group II. Measurements of the central and lateral incisors, canines, and first and second premolars on each side and in both arches were recorded. The total mean mesiodistal tooth size was larger in the group with crowded arches. These results are graphed in Figure 2. Inspection of this graph suggests that, in the maxilla, the tooth type contributing most to the difference was the lateral incisor. In the mandible, in contrast, the two groupings are most disparate for the canine and the two premolars. These authors concluded that the size of teeth is one factor affecting whether or not a dental arch will be crowded. In their analysis, Doris and coworkers combined the sexes, making it impossible to determine whether the results were due of the effect of sexual dimorphism. It needs to be appreciated here that "balancing" the male-female ratio of subjects does not guarantee that the effect of sexual dimorphism is eliminated.

Melo *et al*. (2001) studied the dental casts of 23 subjects from 3 to 15 years of age at the primary dentition stage and at mixed dentition stage from a sample of 130 pairs of Japanese twins. These longitudinal records were used to compare primary tooth crown size differences in the same subjects in whom, at an older age, they could assess the degree of incisor irregularity in the permanent dentition. Just one set of records was selected from each twin pair for analysis. Those with 4 mm or more of crowding formed one group, and those with less than 4 mm of crowding formed another group. Males and females were combined in the analysis, so sexual dimorphism was not controlled in the study design. The results are graphed in Figure 3. Melo and coworkers concluded that larger primary tooth size is one discernible factor in the development of dental crowding.

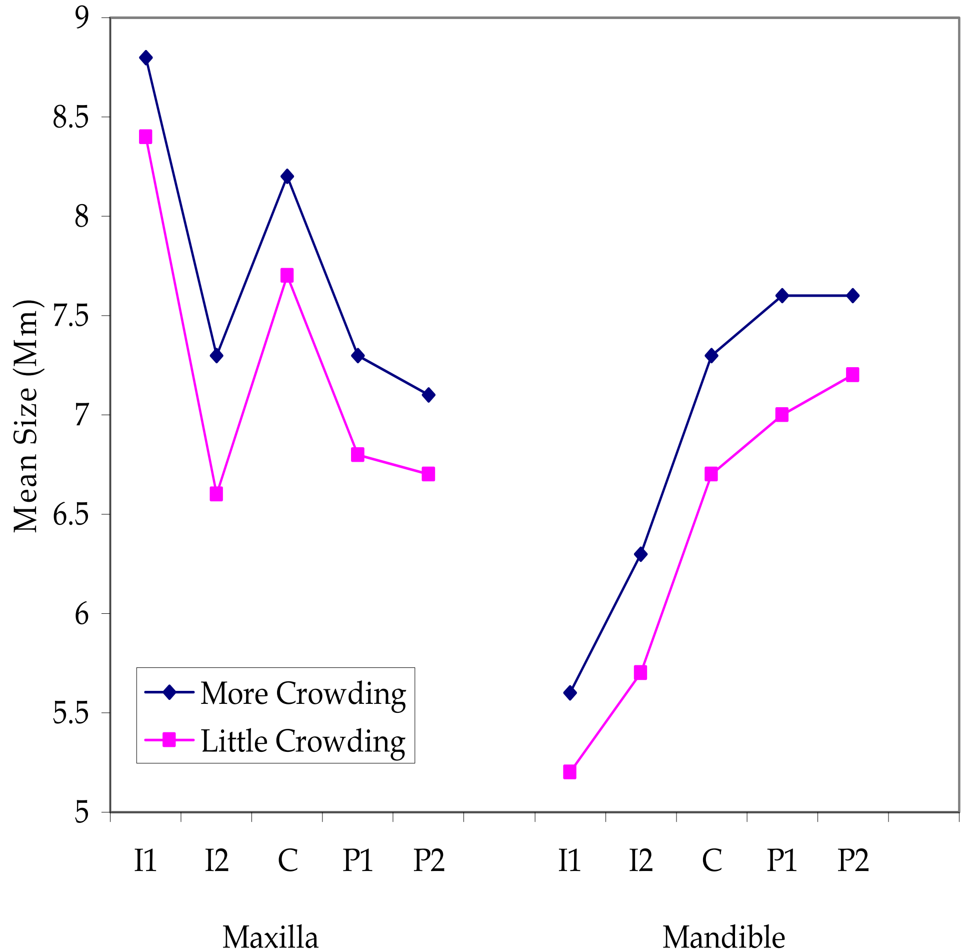

Figure 2. Mesiodistal tooth crown dimensions where their sample of adolescents with little crowding had smaller mesiodistal crown dimensions than their other group with at least 4 millimeters of crowding.

Data from Doris JM, Dernard BW, Kuftinec MM. A biometric study of tooth size and dental crowding. Am J Orthod 1981;79:326-36.

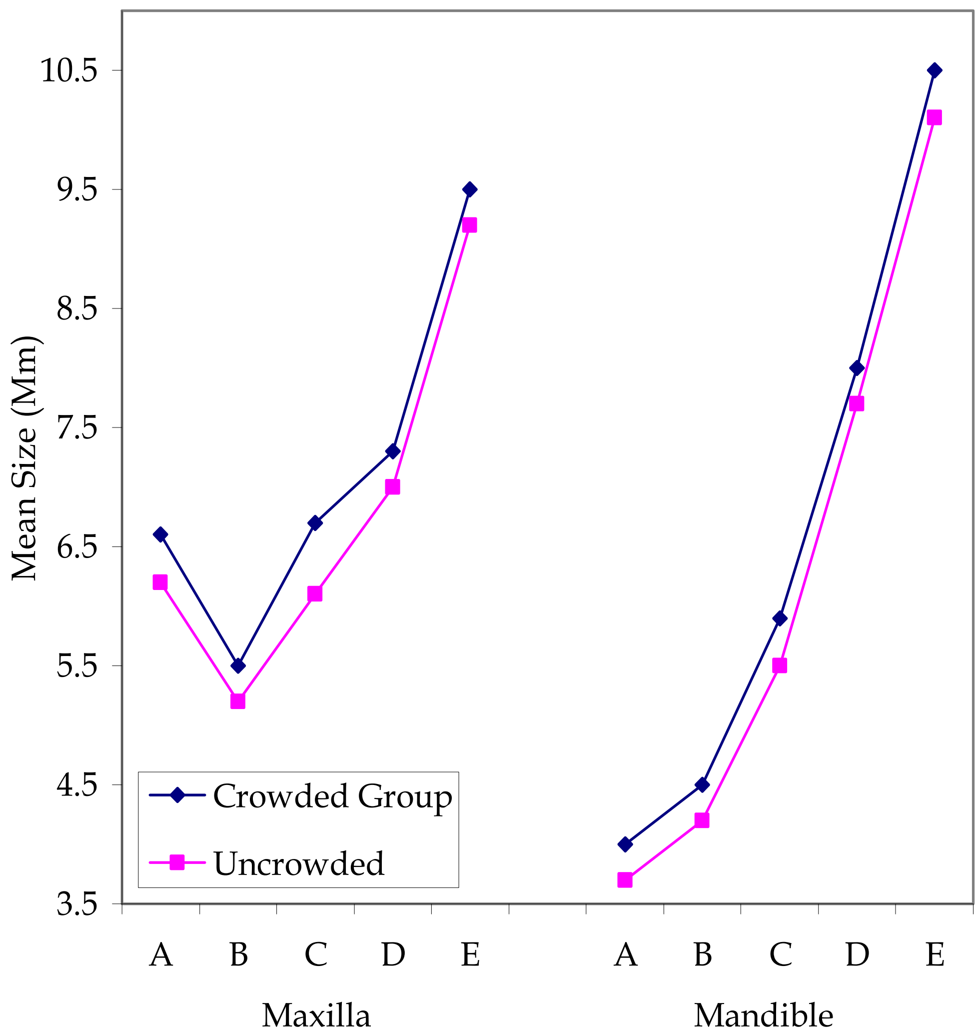

Figure 3. Results showing the mean crown diameters of the six primary teeth were significantly larger in the crowded group than those in the noncrowded group.

Data from Melo L, Ono Y, Takagi Y. Indicators of mandibular dental crowding in mixed dentition. Pediatr Dent 2001;23:118-22.

Al-Khateeb (2006) studied mesiodistal crown dimensions among different malocclusion groups in a Jordanian population. Dental impressions of 140 adolescents, 13 to 15 years of age with a Class I, Class II or Class III malocclusion. There were 34 males and females with Class I malocclusions, 70 males and females with Class II malocclusions, and 36 males and females with Class III malocclusions. They found that those with Class III malocclusions had larger mesiodistal crown dimensions than the other occlusal categories and that the mandibular arch width and arch length for the Class III malocclusion were greater than those of the Class II malocclusions. These tooth size results are graphed in Figure 4. Of note, their analysis pooled boys and girls, so their results, purportedly due to differences among types of malocclusions–were confounded by sexual dimorphism.

Comparing tooth size discrepancies in different malocclusion groups, Nie and Lin (1999) studied the dental casts of 360 patients from the clinic in the Department of Orthodontics, Beijing Medical University, China. The subjects were born and living in China, and were between 13 and 23 years of age. The subjects were grouped by Angle's classification: Class I (30 males and 30 females), Class II (60 males and 60 females), Class III (60 males and 60 females), normal occlusion (30 males and 30 females). The maximum mesiodistal diameters of all the teeth on each cast (except for third molars) were measured using the three dimension measuring machine. The statistical tests disclosed no significant sexual dimorphism of the ratios for any of the six groups. These results suggest that the tooth size discrepancy between maxillary and mandibular teeth may be one of the important factors in the cause of malocclusion.

In another study, Bernabé and Flores-Mir (2006) compared the mesiodistal and buccolingual tooth crown sizes as well as the respective crown proportions in three groups that they labeled: mild (between -0.1 and -5 mm of crowding), moderate (-5.1 mm or more of crowding), and no crowding (zero or no crowding). This study analyzed 200 Peruvian students 12 to 16 years of age. Crowding was defined as the difference in millimeters between the arch perimeter and the MD tooth size sum. The mesiodistal and buccolingual crown sizes were measured, and each dental arch was classified as no crowding (zero or a positive discrepancy), mild crowding (< 5 mm), or moderate crowding (> 5 mm) based on Little's Irregularity Index (Little 1975). When all upper mesiodistal tooth sizes were grouped together and analyzed, a statistically significant average difference was found among moderate, mild, and noncrowded dental arches. When all lower mesiodistal tooth dimensions were summed, a significant average difference was found among moderate, mild, and noncrowded dental arches. Their results showed the mesiodistal crown sizes in the moderate crowded arch were always larger than those in the mildly crowded

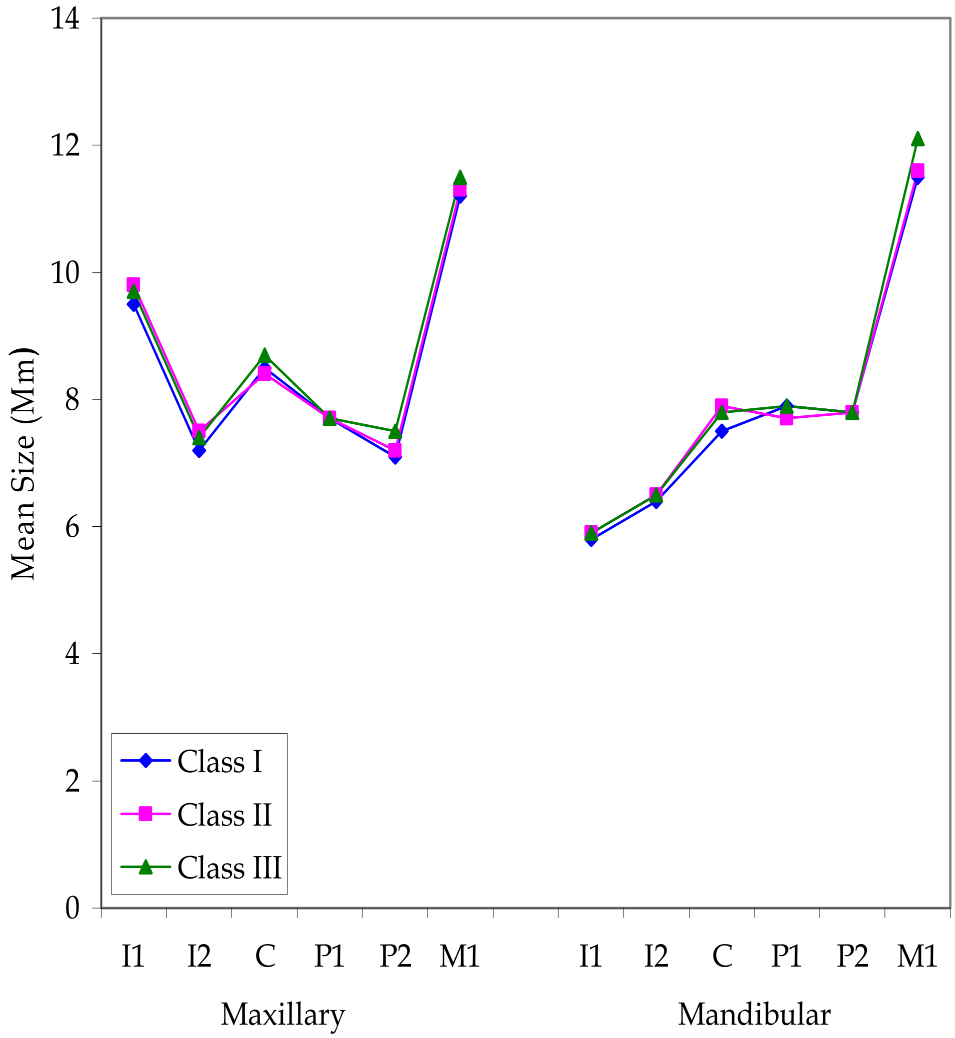

Figure 4. Plot of mean mesiodistal tooth width in the different malocclusion groups.

Data from Al-Khateeb S, Abu Alhaija E. Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. Angle Orthod 2006;76: 459-65.

arch, and these were larger than in the noncrowded arches. The most statistically significant differences were between those with no crowding and those with moderate crowding. The comparison of the combined BL tooth sizes within both dental arches did not indicate significant statistical differences for the upper arch or the lower arch. When considering the mesiodistal tooth sizes, significant differences among crowding groups existed in all upper teeth and in the lower central incisor, second, and first premolar. The evaluation of crown proportions between groups indicated combined differences for both dental arches, though not as significant as that for mesiodistal tooth sizes. In reporting their findings, the authors combined the sexes, which confounds interpretations.

A study that investigated bimaxillary dental protrusion as it relates to tooth size was done by McCann and Burden (1996). They studied the dental casts of 30 white orthodontic patients (14 males and 16 females) between the ages of 9 and 21 years of age, all with an Angle Class I bimaxillary protrusion; and a group of 30 white patients (14 males and 16 females) between 9 and 28 years of age exhibiting a variety of malocclusions without bimaxillary protrusion. Bimaxillary dental protrusion was considered present if the interincisal angle was less than 125 degrees, the maxillary incisors proclined beyond 115º to the maxillary plane and the mandibular incisors proclined beyond 99 degrees to the mandibular plane. Their results (graphed in Figures 5 and 6) showed that, for both males and females, the sum of mesiodistal crown sizes were significantly greater for the bimaxillary group than for the malocclusion group. On average tooth size for the overall maxillary and mandibular dentition was 6% larger in the bimaxillary sample than in the malocclusion group.

The correlation of tooth size and dental crowding as well as face size and shape was considered in a study by Adams (1982). Adams studied the dental casts of 138 boys and girls between 15 and 16 years of age. These were divided into two groups, 47 with excellent occlusion (22 boys and 25 girls), and 91 with incisor crowding (46 boys and 45 girls). The selection of the subjects was visual and crowding was not quantified. Comparisons were made, (1) between boys and girls having excellent occlusion, (2) between boys and girls with crowded dentitions, (3) between boys with excellent occlusions and girls with crowded dentitions, and (4) between girls with excellent occlusions and girls with crowded dentitions. A comparison was also made for all these groups between the total tooth substance dimension in the upper arch and the total tooth substance in the lower arch. For all the comparisons, the mean total mesiodistal diameter of the teeth was larger in crowded dentitions than in excellent occlusions (Figures 7 and 8).

In trying to discern some of the causes of mandibular crowding, Fastlicht (1970) looked at numerous aspects including age, sex, and mesiodistal sizes of

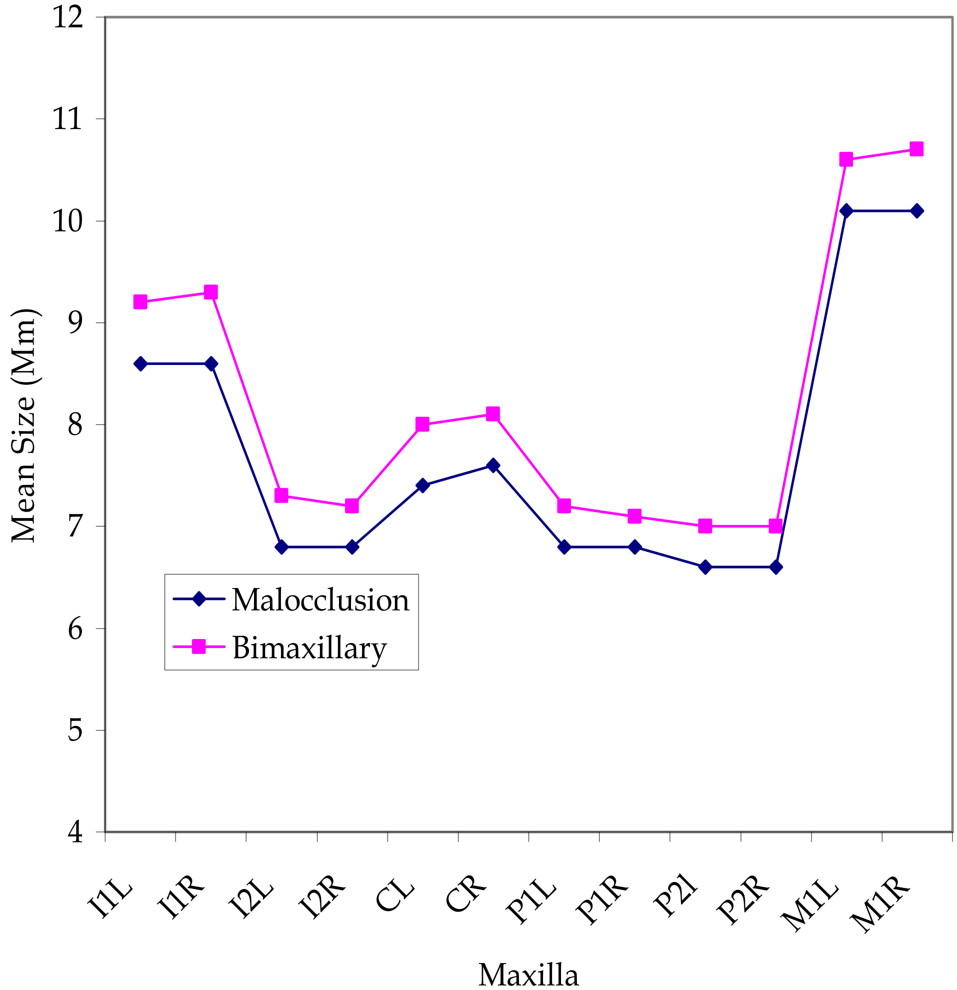

Figure 5. Plot of maxillary mean individual tooth sizes for the malocclusion and bimaxillary groups.

Data from McCann J, Burden DJ. An investigation of tooth size in Northern Irish people with bimaxillary dental protrusion. Eur J Orthod 1996;18:617-21.

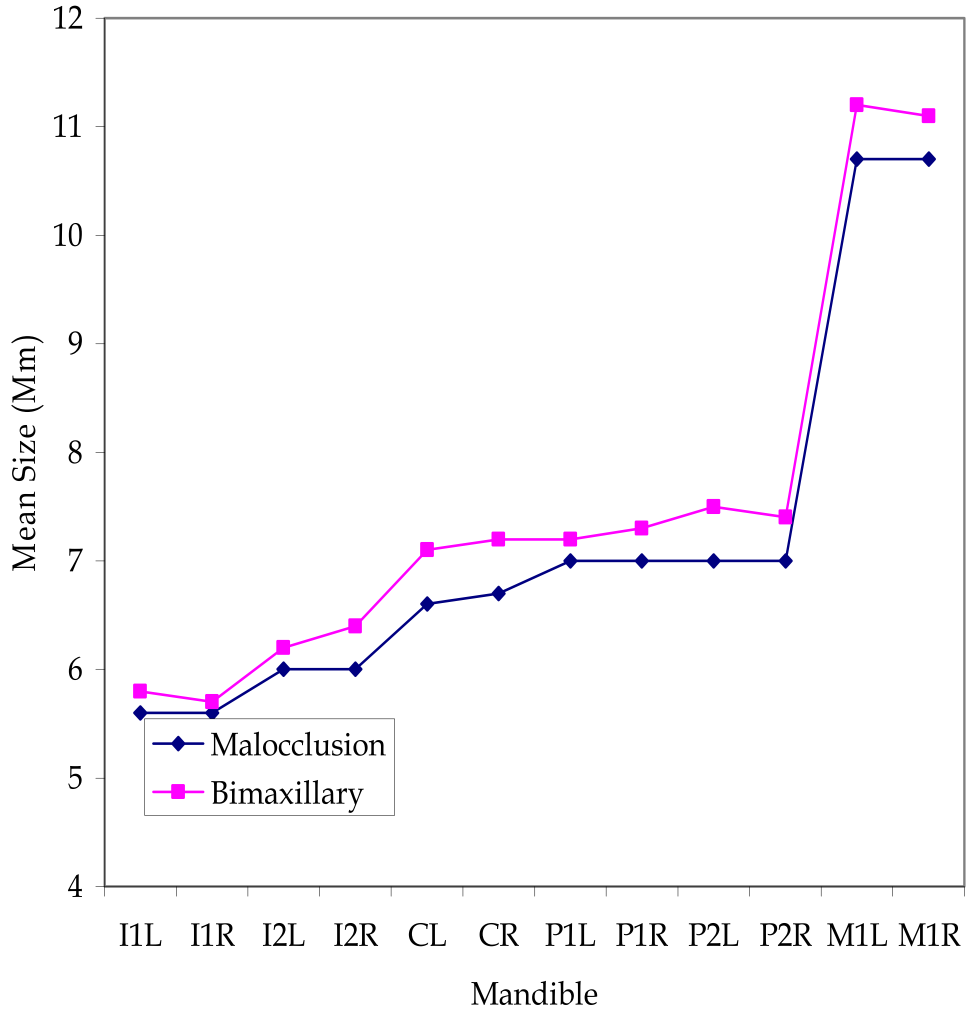

Figure 6. Plot of mandible mean individual tooth sizes for the malocclusion and bimaxillary groups.

Data from McCann J, Burden DJ. An investigation of tooth size in Northern Irish people with bimaxillary dental protrusion. Eur J Orthod 1996;18:617-21.

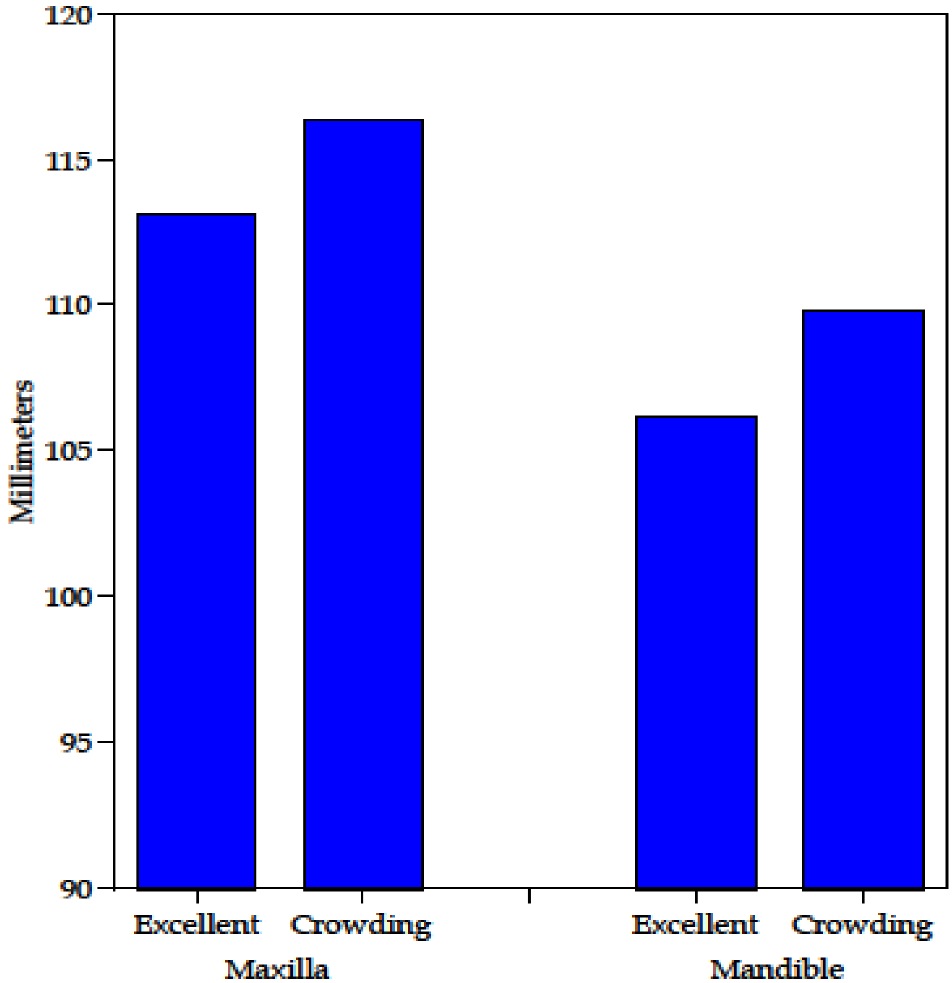

Figure 7. Summation of the 12 mesiodistal crown diameters in the maxilla (M1 through M1) in males depending on whether the person exhibited excellent occlusion or crowding. Differences between groups were significant statistically.

Data from Adams CP. A comparison of 15 year old children with excellent occlusion and with crowding of the teeth, Angle Class I malocclusion, in respect of face size and shape and tooth size. Swed Dent J Suppl 1982;15:11-26.

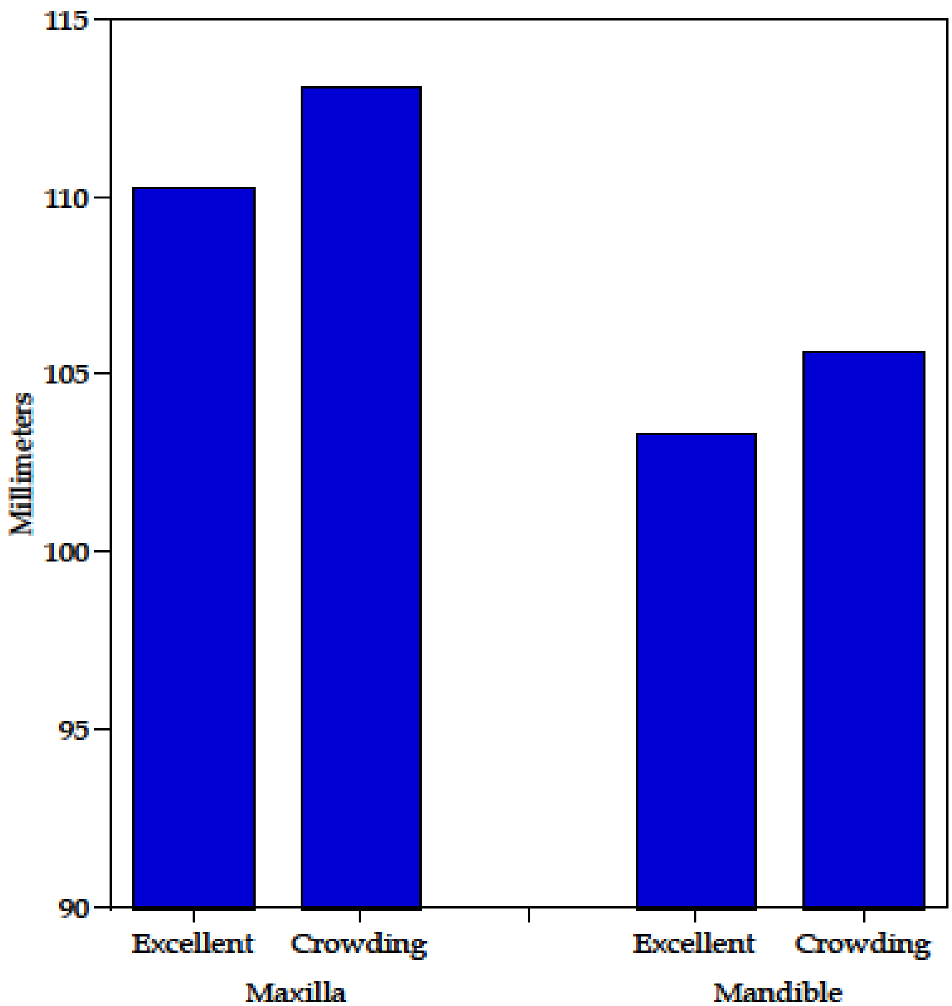

Figure 8. Summation of the 12 mesiodistal crown diameters in the maxilla (M1 through M1) in females depending on whether the person exhibited excellent occlusion or crowding. Differences between groups were significant statistically.

Data from Adams CP. A comparison of 15 year old children with excellent occlusion and with crowding of the teeth, Angle Class I malocclusion, in respect of face size and shape and tooth size. Swed Dent J Suppl 1982;15:11-26 the tooth crowns. He compared two groups. One group of 28 cases (13 males and 15 females) between 14 and 24 years of age had received orthodontic treatment at the University of Michigan. They had been diagnosed as Class II malocclusions. The second group of 28 cases (13 males and 15 females) between 11 and 42 years of age had not received orthodontic treatment and were considered to have esthetically well aligned upper dental arches. Fastlicht found that both the maxillary and mandibular average for crowding was larger in the untreated group. This difference between the mesiodistal widths of the mandibular and the maxillary incisors with crowding was highly significant in both tests.

In order to gather evidence regarding crowding, Lundström (1951) used the dental casts of 139 Swedish males with a mean age of 13 years of age and varying amounts of dental crowding. The connection between the degree of crowding and the arch perimeter was investigated, as well as the sum of the widths of the teeth from M1 through M1 in the upper anterior teeth. He concluded that the larger the tooth-size, the greater risk of tooth crowding, that jaws with small teeth were less likely to be crowded than those with large teeth, and that as the size of the dental arch decreases crowding increases.

Other authors have investigated the relationship of malocclusion and tooth size and reached different conclusions. Howe *et al*. (1983) studied tooth size and jaw size as it contributes to dental crowding. The dental casts of 104 subjects from 9 to 44 years of age obtained from the University of Michigan Elementary and Secondary Growth Study and from private practices were assigned to one of two groups, namely those with normal occlusions and no dental crowding and those with significant dental crowding. Statistical analysis apparently was based on a series of t-tests. Howe *et al*. reported no statistically significant difference between the crowded and non-crowded groups, and this negative finding is in concert with the visual impression of “no difference” supplied by the sex-specific graphs in Figures 9 and 10. Of note, these authors did remove the effects of sexual dimorphism from their data (by performing sex-specific comparisons). We have no interpretation as to why their finding of “no difference” contrasts with the other reports reviewed here.

Tooth size and arch width and length relating to crowding were studied by Mills (1964). His study group was selected from midshipmen at the United States Naval Academy. This sample of males (n = 230), included members from all 50 states and various socioeconomic levels. They were between 17 and 21 years of age, and none had a history of orthodontic treatment. Mills found no significant difference in tooth size or arch length between crowded and uncrowded arches.

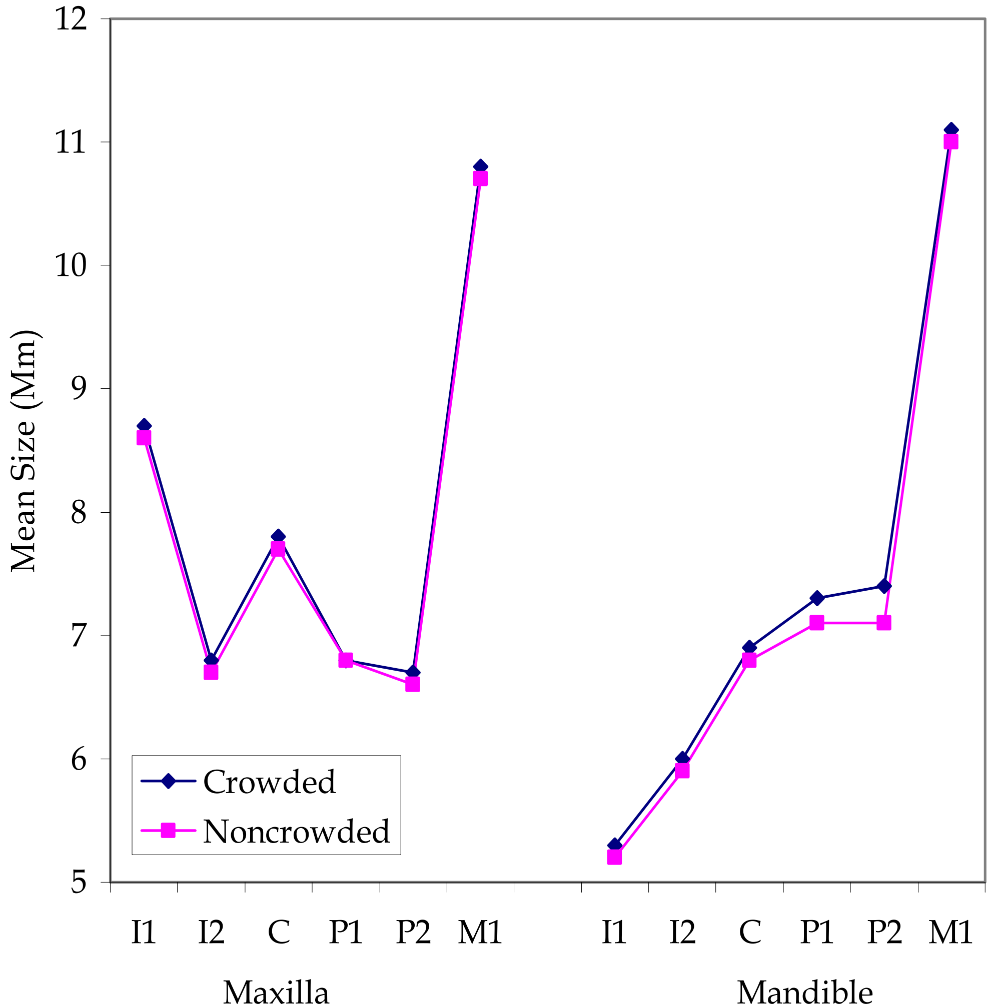

Figure 9. There was no statistically significant difference in tooth size between the crowded and noncrowded samples for boys.

Data from Howe RP, McNamara JA Jr, O'Connor KA. An examination of dental crowding and its relationship to tooth size and arch dimensions. Am J Orthod 1983;83:363-73.

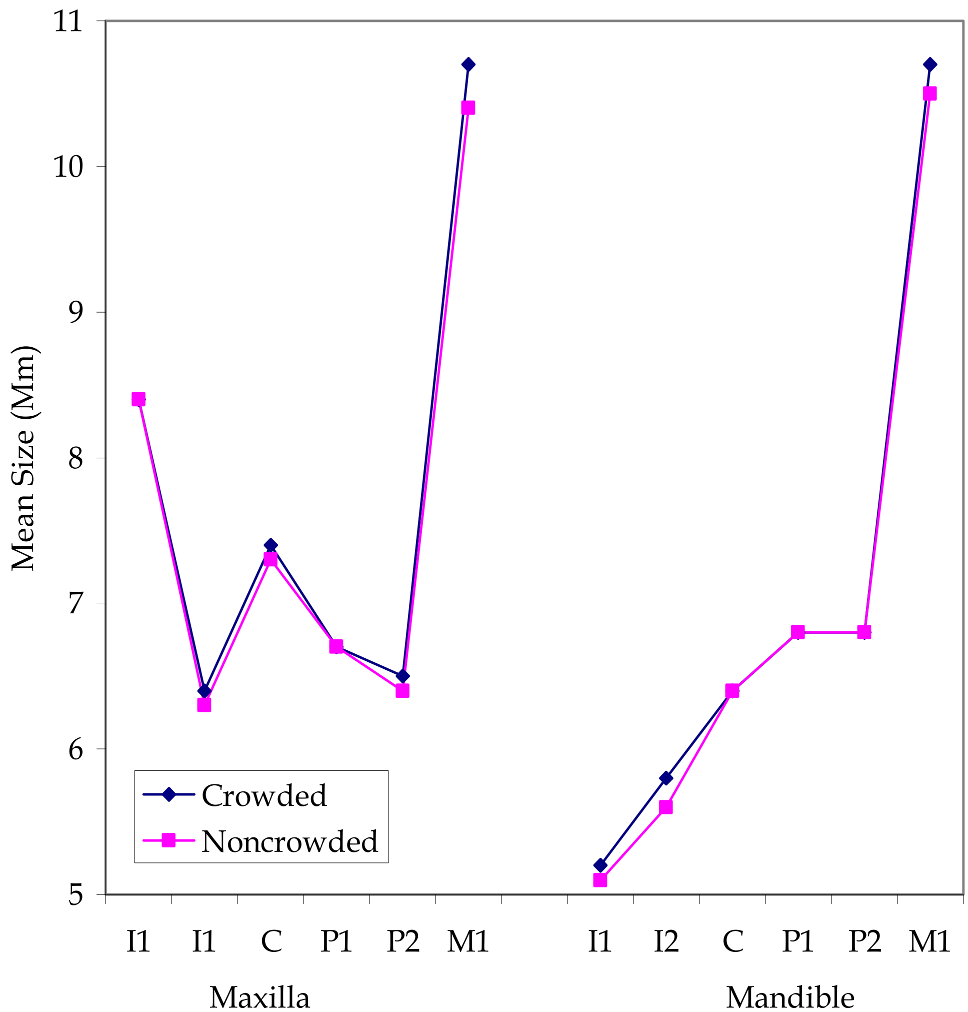

Figure 10. There was no statistically significant difference in tooth size between the crowded and noncrowded samples for girls.

Data from Howe RP, McNamara JA Jr, O'Connor KA. An examination of dental crowding and its relationship to tooth size and arch dimensions. Am J Orthod 1983;83:363-73.

An influential study as regards tooth size and the risk of malocclusion was by Peck and Peck (1972). They contrasted tooth crown diameters of two groups of Caucasian women, (1) a sample (n = 45) with no mandibular incisor irregularity and (2) a sample (n = 70) simply described as "unselected" for incisor irregularity. The key result (Figure 11) was that mean mesiodistal incisor widths were significantly narrower in the good-occlusion sample.

Peck and Peck also measured the mesiodistal and buccolingual incisor diameters of the mandibular incisors and, of interest, these averages were larger in the perfect-alignment sample (Figure 12). This led the authors to infer that the risk of malocclusion is heightened by a difference in incisor crown shape; that the BL/MD index is larger in people with mandibular irregularity.

Though there are numerous studies investigating the causes of crowding in permanent dentition, but the causes of crowding in primary dentition have not been explored in much detail. An investigation into dental crowding in the primary dentition and its relationship to arch and crown dimensions was done by Tsai (2003). His sample consisted of 61 Taiwanese children between 4 and 5 years of age. These were put into two groups, those with anterior crowding in both dental arches (n = 27), and those with anterior spacing in both dental arches (n = 34). Each child had all primary teeth present in each arch, and measurements were made on the dental casts. Tsai reported that the mesiodistal crown widths of all tooth types were larger in the crowded arches, but there was no significant difference in the mean mesiodistal crown width or crown shape of the primary teeth between the two groups. These results are graphed in Figures 13 and 14. Also, there was no significant difference between the groups in terms of arch length, crown width, or crown shape, but arch width of both arches in the crowded group were generally smaller that those in the uncrowded group. This indicated to Tsai that dental crowding of the primary dentition is associated with small dental arch widths rather than large teeth.

Corruccini (1990) reevaluated P. R. Begg's (1954) study that asserted that the disappearance of interproximal attrition and modern man's processed diet have resulted in teeth remaining too large for the arches. Corruccini used the dental casts of modern Australian aborigines, the first generation lacking notable interproximal attrition due to a more refined diet, to analyze primary and permanent tooth size and arch size in the absence of attritional tooth reduction. The casts in this sample were from Aborigines who grew up at a government settlement that provided them food that consisted mostly of flour, sugar and hot stew. The casts were obtained between 1951 and 1971 of 50 subjects (25 boys and 25 girls) between 13 and 15 years of age. From this group, 15 were considered to have malocclusion (7 Class I and 8 Class II or Class III). Analyzing numerous

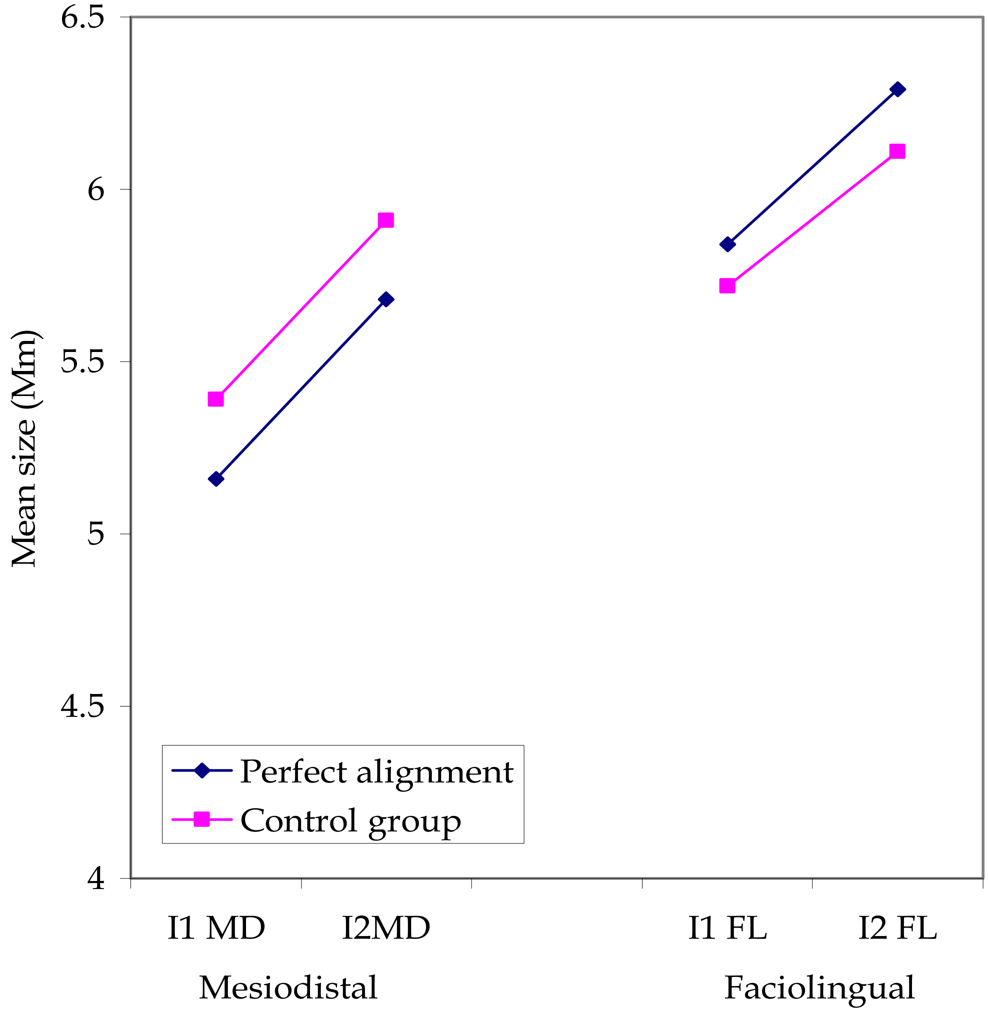

Figure 11. Plot of mean mandibular incisor crown dimensions of females.

Data from Peck S, Peck H. Crown dimensions and mandibular incisor alignment. Angle Orthod 1972;42:148-53.

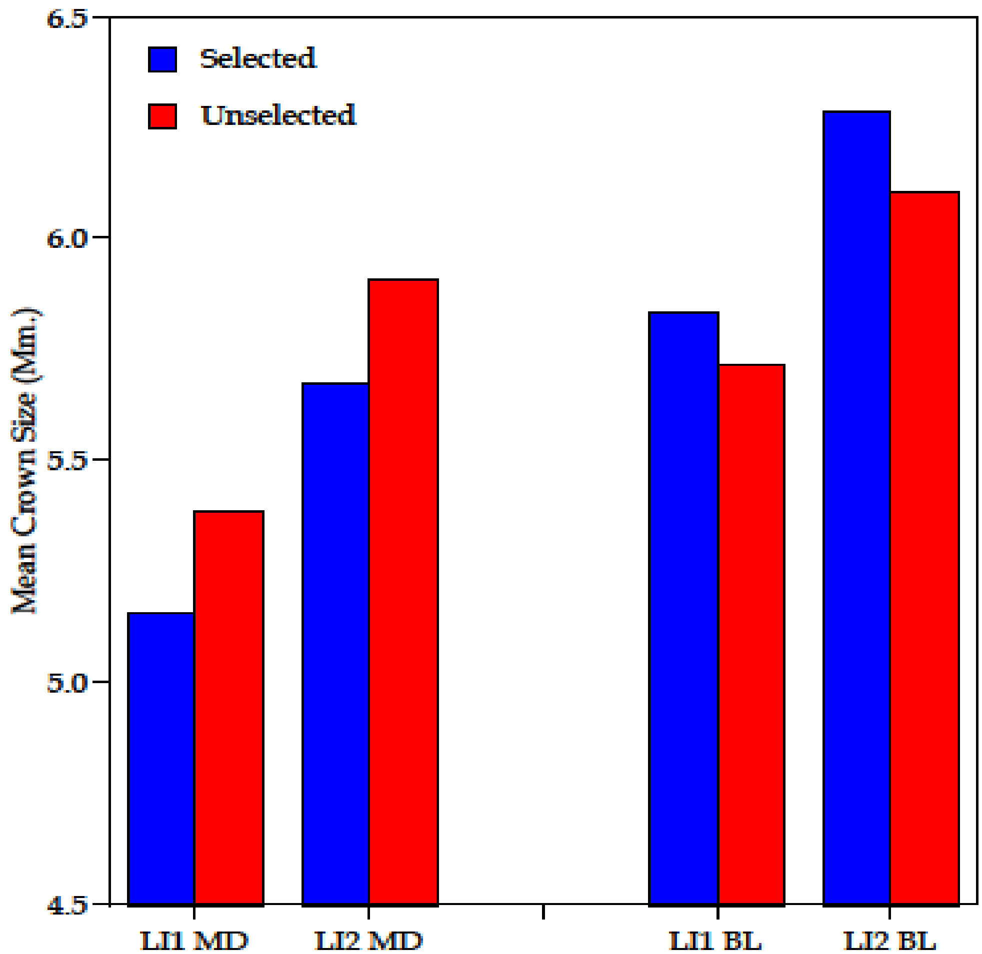

Figure 12. Results showing (A) that mesiodistal incisor diameters were significantly smaller in the perfect-alignment group, (B) buccolingual widths were significantly larger.

Data from Peck S, Peck H. Crown dimensions and mandibular incisor alignment. Angle Orthod 1972;42:148-53.

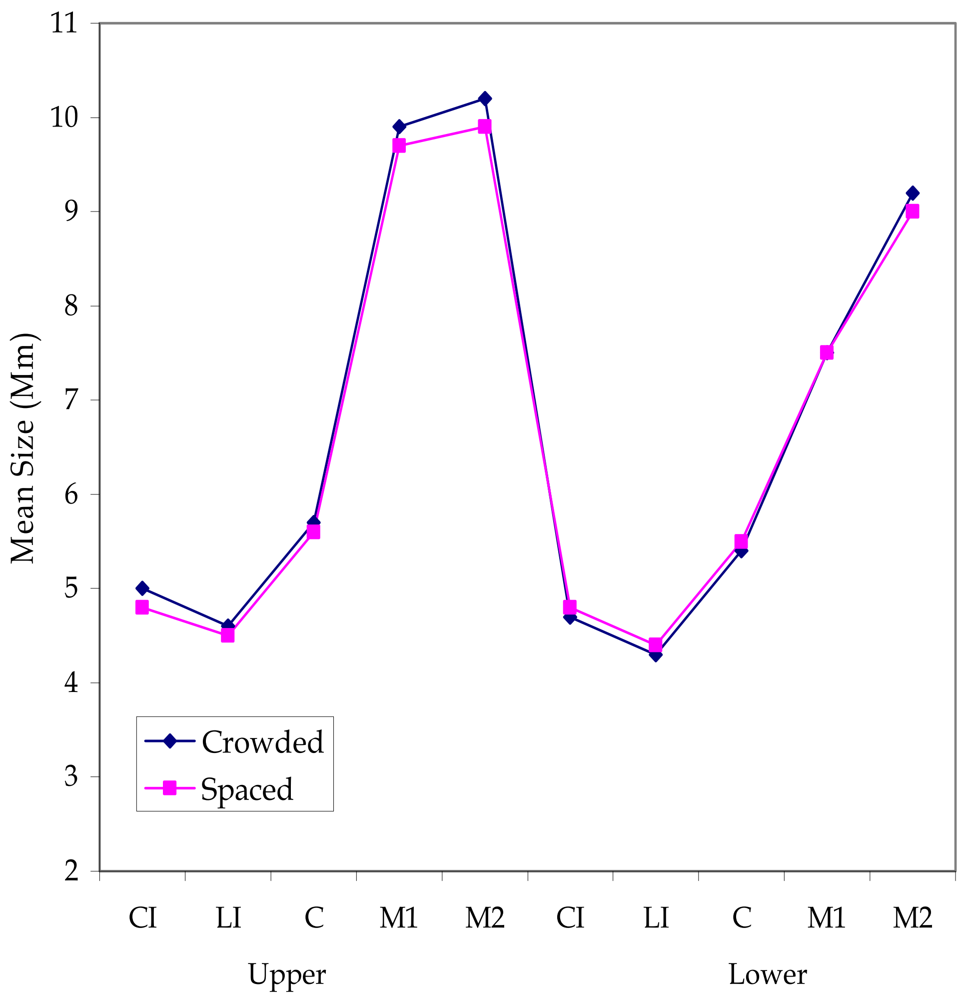

Figure 13. Plot of mean buccolingual crown width of right side primary teeth as shown by those crowded and those with spaced arch.

Data from Tsai HH. Dental crowding in primary dentition and its relationship to arch and crown dimensions. J Dent Child 2003;70:164-9.

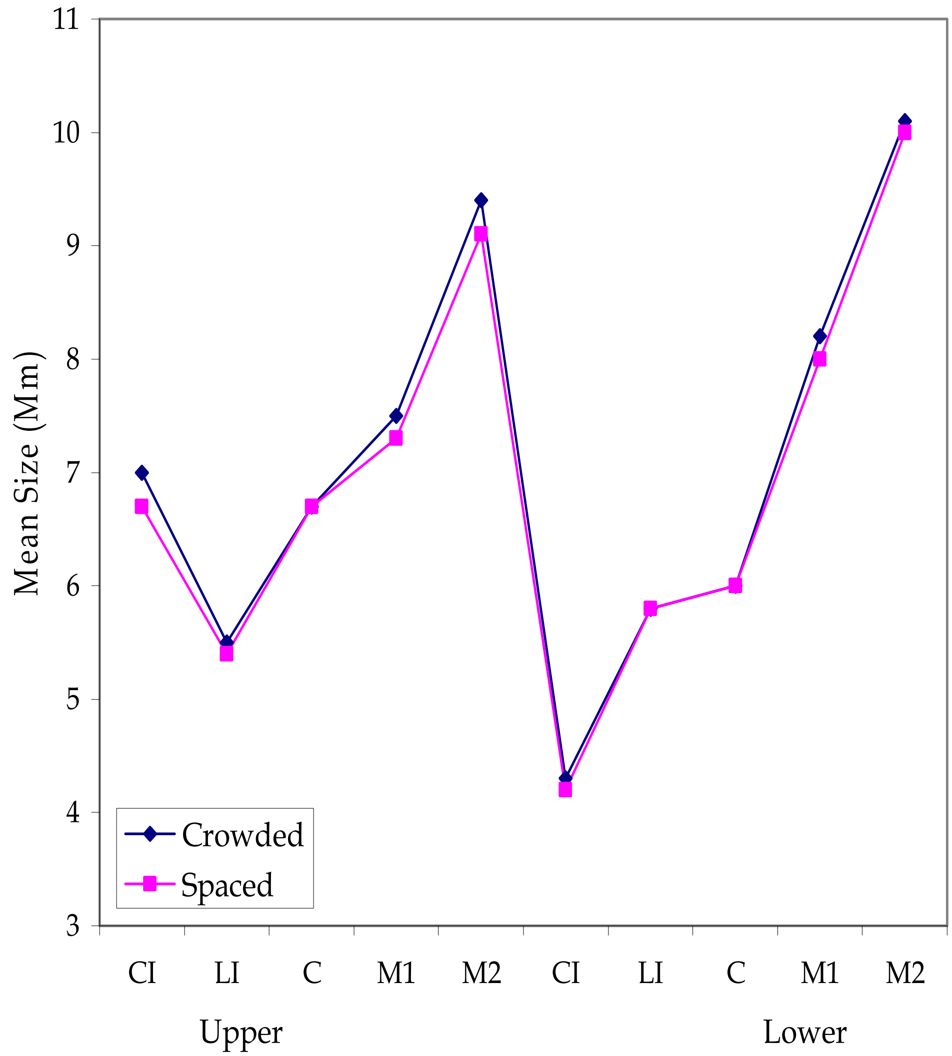

Figure 14. Plot of mean mesiodistal primary crown width of right side teeth as shown by those crowded and those with spaced arch.

Data from Tsai HH. Dental crowding in primary dentition and its relationship to arch and crown dimensions. J Dent Child 2003;70:164-9.

variables, Corruccini reported that mesiodistally longer teeth did not relate to dental crowding and that lack of space did not significantly relate to crowding or other malocclusions. He did report that narrowness of the maxilla related significantly to malocclusion and that it played a major role in tooth size arch size discrepancy.

Though numerous studies have examined contributing causes for dental crowding, no single factor has emerged. Rather, it seems that the causes are multifactoral. Shah *et al*. (2003) investigated the correlation between the shape of mandibular incisor crown and crowding. They studied the dental casts of 50 white adults (25 males and 25 females) between 18 and 29 years of age, who were dental undergraduates and staff members of the Charles Clifford Dental Hospital in Sheffield, United Kingdom. None of the subjects had had orthodontic treatment, and 39 were considered to be Class I, 8 Class II, and 3 Class III. Lower incisor crowding was quantified with Little's irregularity index and anterior tooth size arch length discrepancy (TSASD). No predictor of lower incisor crowding could be established from mandibular incisor crown shape in this study.

Buccal Segment Relationship

Tooth size has been studied as it relates to differences between Angle's various malocclusion classes and as it relates to differences between the sexes. In view of the fact that tooth size in a malocclusion may be influenced by sex, and larger or smaller teeth may influence malocclusion, the interaction of both these areas is an area to consider.

Ayra *et al*. (1974) tested for differences in tooth crown size between occlusion categories. The study used dental records from the University of Oregon Dental School, consisting of 95 boys and girls of Northwest European ancestry between the ages of 4.5 and 14 years. The group of 45 boys and girls had normal occlusion, and the remainder had Angle Class II malocclusions. Mesiodistal crown diameters were measured for all teeth anterior to and including the first permanent molars, and tooth size was considered to be the mean of the tooth sizes from the left and right sides of the arch. The authors found that all tooth types except the mandibular central incisor were significantly different between boys and girls. When the mean tooth sizes were compared between the Angle Class I and Angle Class II groups, no significant difference was observed, regardless of sex.

Bolton Tooth Size Discrepancies

Analysis of the proportionality of the maxillary and mandibular teeth is a useful diagnostic tool for use in treatment planning. Bolton (1958) introduced two indexes. The total Bolton index is obtained by dividing the mesiodistal size of the 12 mandibular teeth (first molar to first molar) by the mesiodistal size of the 12 maxillary teeth. The ratio between the two sums is the percentage relationship of mandibular arch length to maxillary arch length. Bolton also devised an anterior index, obtained by dividing the mesiodistal size of the 6 mandibular anterior teeth (canine to canine) by the mesiodistal size of the 6 maxillary anterior teeth. The ratio between these two sums is the percentage relationship of mandibular anterior width to maxillary anterior width. If the ratio was greater than one standard deviation from his reported mean values, Bolton suggested the possible need for treatment.

Crosby and Alexander (1989) studied the frequency of mesiodistal crown size discrepancies in the malocclusions groups and compared them with Bolton's means and standard deviations. The dental casts of 109 patients with varying malocclusions (Angle Class I, Angle Class II) were obtained from a private orthodontic practice, and Bolton's analysis was performed on each set of casts. The frequency of mesiodistal tooth size discrepancies in the malocclusion groups was compared with Bolton's means and standard deviations. The results, which did not differ between sexes, showed that no specific malocclusion group contained a larger percentage of tooth size discrepancies.

When considering tooth sizes among different malocclusion groups, Basaran *et al.* (2006) found no statistically significant difference in Bolton's tooth size ratios between classes. Another study looked at intermaxillary tooth size discrepancies among different malocclusion groups (Alkofide and Hashim 2002). They analyzed the pretreatment casts of 240 male and female Saudi orthodontic patients 13 to 20 years of age. There was a mixture of Class I, Class II and Class III malocclusions. When tooth size ratios were compared, there was a significant difference between normal occlusion and Class III malocclusion for the anterior ratio, and no significant difference among the other malocclusion groups for the overall ratio and anterior ratio.

Freeman *et al*. (1996) evaluated the percentage of orthodontic patients with an interarch tooth size discrepancy in a study of 157 patients from the U.S. Army Orthodontic Residency program at Fort Meade, Maryland. The sample included 89 females and 68 males (115 white, 27 black, and 15 of other ethnic origins). They evaluated the percentage of patients with a significant tooth size discrepancy, defined as a value outside of 2 standard deviations from Bolton's mean. They defined a "significant" discrepancy as those below 87.5 or above

95.1 for the total ratio, and those below 73.9 or above 80.5 for the anterior ratio. The results for the total ratio showed 21 (13.4%) of the 157 patients with ratios outside the 2 standard deviation from Bolton's mean. Of the anterior ratio 48 (30.6%) of the 157 patients fell outside the 2 standard deviation from Bolton's mean. These results are similar to those found by Crosby and Alexander (1989) who found that 23% of their sample exceeded the total ratio by 2 standard deviations. This suggests that tooth size analysis in orthodontic treatment would be of benefit in outlining treatment goals.

The study by Laino *et al*. (2003) explored the prevalence of tooth size discrepancies as related to skeletal malocclusion in a sample from the Campanian region of Italy. They examined the dental casts of 94 patients who were in treatment in the orthodontic department at the University of Naples. The 38 males and 56 females were assigned to one of three groups based on the values of Steiner cephalometric analysis: Class I (26 males and 31 females), Class II (6 males and 18 females), or Class III (7 males and 6 females). The mesiodistal diameters of teeth were measured with digital electronic calipers. Based on multiple linear regression analysis, they concluded that there is no evidence of a difference in tooth-size discrepancies among the malocclusion groups.

Determining whether tooth size arch size discrepancy and interarch tooth size relationships differ among ethnic populations was the focus of a study by Paredes *et al.* (2006). They looked at whether Bolton's ratios applied to a Spanish population. They used the dental casts of 100 cases (30 females and 70 males) between 11 and 20 years of age, from the Orthodontic Department of the University of Valencia, Spain. Each had optimal occlusion (Class I with no arch discrepancy). The mesiodistal sizes of all of the tooth crowns, excluding the second and third molars, were measured from casts. They found that the anterior ratio values were larger than the Bolton standards, indicting that the relationship between the sizes of the mandibular and maxillary teeth depends of the population. They also found no statistically significant difference between the mean anterior and total tooth width ratios for males and females.

Determining whether there is a discernible difference in intermaxillary tooth crown dimensions among different malocclusion groups in Saudi patients was the focus of a study by Alkofide and Hashim (2002). They examined the pretreatment dental casts of 240 patients from the orthodontic clinic at the dental college of King Saud University. The cases were between 13 and 20 years of age and grouped by Angle's classification; 60 with normal occlusion, 60 Class I, 60 Class II and 60 Class III malocclusion with both sexes evenly distributed in each class. They found (graphed on Figure 15) when mean tooth ratios were compared, there was a significant statistical difference between normal occlusion and Class III malocclusion for the anterior ratio but no significant difference

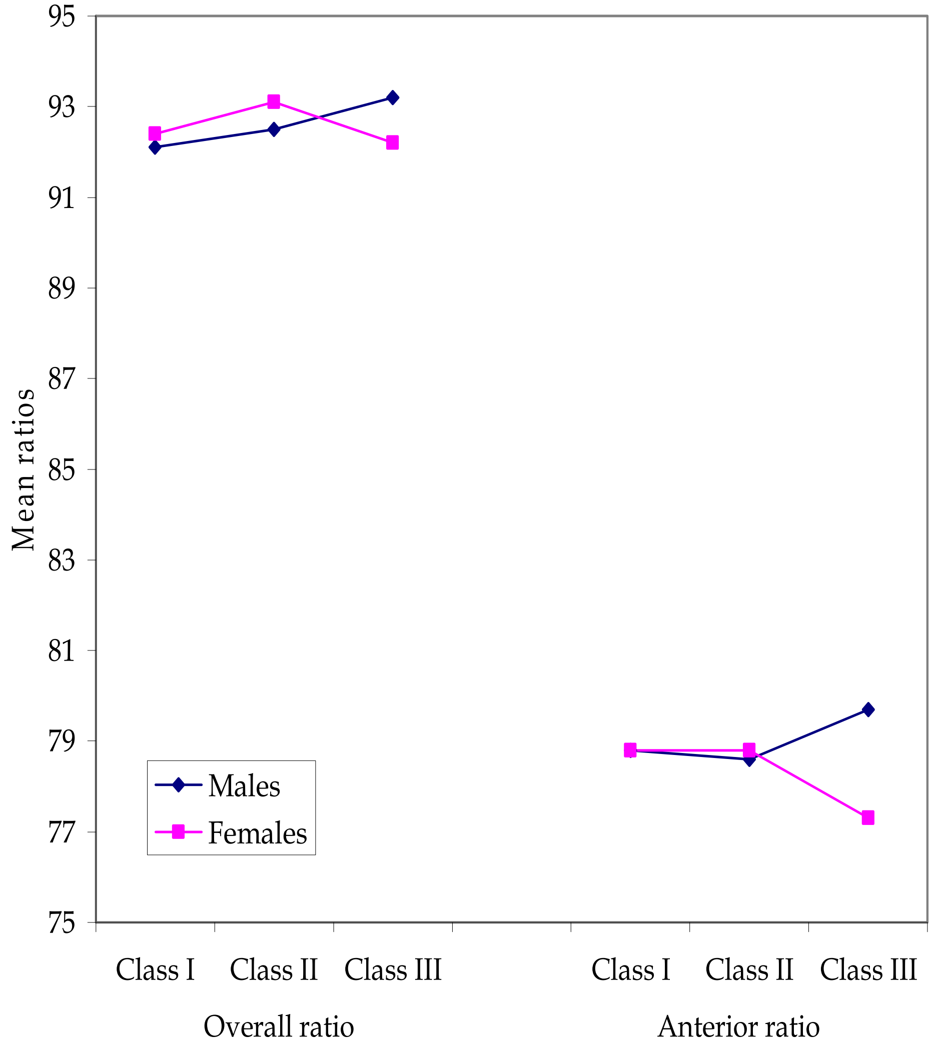

Figure 15. Plot of mean overall and anterior ratios for males and females in Class I, Class II, and Class III.

Data from Alkofide E, Hashim H. Intermaxillary tooth size discrepancies among different malocclusion classes: a comparative study. J Clin Ped Dent 2002;26:383-7.

between the other malocclusion classes for the overall ratio and the anterior ratio. In addition, no statistical significant difference was observed between males and females. When the mean values for the overall and anterior ratios of this study were compared to Bolton's, a significant difference was found in all the malocclusion classes.

An investigation of Bolton's analysis as it applies to tooth size and different ethnic populations (black, Hispanic, and white), was studied by Smith *et al*. (2000). The pre-orthodontic records of 180 cases (30 males and 30 females) from each of 3 populations (black, Hispanic and white) were analyzed. The subjects were between 12 and 38 years of age. The results indicated significant differences in the overall, anterior, and posterior interarch ratios between the black, Hispanic, and white populations and the relationship between the sizes of the mandibular and maxillary teeth are dependent on population, gender, and arch segment length.

Perception of Orthodontic Need

Studies show that girls and their parents have a lower threshold for seeking orthodontic treatment than boys and their parents (O'Brien *et al.* 1996; Sheats *et al.* 1998; Mendall *et al.* 1999; Birkeland *et al*. 2000; Esa *et al*. 2001). This psychosocial sex difference is what explains (1) the 2-to-1 sex difference in orthodontic practices versus (2) the general lack of sex differences in national objective surveys of orthodontic need. Yet the evidence of influence of sex on both normative and perceived need for orthodontic treatment in studies is inconsistent.

For most prospective orthodontic patients, the decision to seek orthodontic treatment reflects a combination of their expectations and those of their dentist or orthodontist. O'Brien *et al*. (1996) investigated factors that influenced the uptake of orthodontic treatment for children referred by their general dentist. Data was collected on 162 referred patients (54% female, 46% male) whose mean age was 12.7 years. Of the children referred, 87 were accepted for treatment (54 girls and 33 boys). Analysis indicated that the sex of the patient and the need for treatment (measured by the IOTN) were the most significant predictors.

Mandall *et al*. (1999) investigated orthodontic esthetic self-perception and the perceived esthetic impact of malocclusion. They matched 434 boys and girls (14 to 15 years of age from Manchester England) for age, sex, social class and ethnicity. Five questions were asked to assess the degree of concern the child perceived because of the arrangement of his or her occlusion. In addition, the children were asked to identify which photograph of the IOTN AC most clearly matched their orthodontic esthetic self-perception of the appearance of their anterior teeth. The scores for all questions and the child's perceived AC score were totaled to give an overall perceived oral aesthetic impact score for each child. They referred to this as the OASIS score (Orthodontic Aesthetic Subjective Impact Score). Most children (94% of 334) perceived their anterior tooth arrangement to be acceptable (IOTN AC scored between 1 and 4), while only 54% of the IOTN AC scores from the children agreed with the examiner's score of the need for treatment. Mandall's data showed that ethnicity and social deprivation did not influence a child's orthodontic esthetic self-perceived AC score or their self-perceived need for orthodontic treatment. The authors reported that Asians and females had a higher orthodontic treatment need based on dental health grounds than Caucasians and males, despite having a lower esthetic need for treatment.

Birkeland *et al.* (2000) studied the relationship in children between occlusion, satisfaction with dental appearance, self-esteem, and their perceived need for treatment at ages 11 and 15 years of age, in a treated and untreated group. They also evaluated the degree of satisfaction of the children and their parents. The study consisted of 359 children (age 11 in 1993) from Bergen, Norway. Then in 1996 the same group of children (now 15 years of age) and their parents were invited for a follow-up study (224 participated). The dental casts were assessed using the Dental Health Component (DHC) and Aesthetic Component (AC) of the IOTN. In addition, questionnaires (regarding satisfaction with dental appearance and desire for orthodontic treatment) were completed separately by the parents and the children. The Global Negative Self-Evaluation Scale (GSE) was used to measure the child's self-esteem. Significantly more girls than boys had been treated with fixed appliances between the two examinations. However, when combining treatment with fixed and removable appliances there was no sex difference (evidently because more boys had been treated with removable devices). The fixed appliance group showed the greatest improvements both for AC and DHC grades. For the untreated group, significant increases in mean AC grades, DHC grades, and PAR scores were found from T1 to T2. Treatment with fixed appliances (as opposed to no treatment or treatment with removable appliances) had the greatest influence on the satisfaction level. At T1, no sex difference was discovered, while at T2, boys showed greater satisfaction with their own dental appearance than girls in the untreated and the removable appliance groups. The sex difference was more evident at 15 than at 11 years of age, as more girls than boys had developed negative self-evaluation. In general, there was a high degree of satisfaction with orthodontic treatment results by both children (95.4%) and by parents (95.6%). About 45% of the children were of the opinion that orthodontic treatment would have a positive influence on their future possibilities in life and that treatment was important for their self-confidence.

Determining the prevalence of malocclusion and orthodontic treatment need in a sample of New Zealand children was the focus of a study by Johnson and Harkness (2000). They examined 294 Caucasian children (153 boys; 141 girls) between 9 and 11 years of age in the mixed dentition. A DAI score was calculated for each child and on the basis of that score they were divided into four orthodontic treatment-need categories. About 20% of the children fell into the little or no treatment need category, 25% in the treatment elective category, 22% in the treatment highly desirable category, and 33% in the treatment mandatory category. A criticism of the DAI has been its inability to assess malocclusion in the mixed dentition, as it was developed for use on subjects in the permanent dentition. Considering this, the high proportion of subjects with handicapping malocclusions in this study may be due to the large number of subjects in the mixed dentition who have temporary occlusal conditions. In this study, the mean DAI scores for the boys and girls differed significantly until the missing teeth component was omitted, then the significant sex difference was lost.

The perception of orthodontic need and if it changes over time was the focus of a study by Stenvik *et al*. (1999). They compared the attitudes to malocclusion and orthodontic treatment in young and middle-aged adults. The sample included a total of 123 individuals, 50 orthodontically untreated young adults (25 males; 25 females) between 17 and 18 years of age, and 73 untreated middle-aged adults (38 females; 35 males) 38 years of age living in Oslo, Norway. Dental casts were used to group subjects according to the IOTN grades. No significant difference between sexes appeared for any of the variables (except for the question about importance of teeth for facial appearance). A high percentage (90% of 18 year olds, and 86% of 35 year olds) felt that well aligned teeth were important for overall facial appearance. Dissatisfaction with their dental arrangement was reported by 20% of the 18 year olds and 15% of the 35 year olds. Desire for treatment was about the same for 18 and 35 year olds. When comparing patients with similarly scored malocclusions the results in the obvious-need category show that 54% of 18 year olds and 21% of 35 year olds were dissatisfied. Results show a decline in concern for borderline malocclusion at midlife compared to the concern in early adulthood.

Evaluating malocclusion and orthodontic treatment need was the focus of a study by Esa *et al*. (2001). They also assessed the relationship between malocclusion and socio-demographic variables, the perceptions of need for orthodontic treatment, esthetic perception and social functioning. The sample consisted of 1,519 Malaysian children (770 males; 742 females) between 12 and 13 years of age. In addition, a self-administered questionnaire covering socio-demographic information, perceived need of treatment and satisfaction with dental appearance was given to each child. The child's sex and regional differences were found to be significantly related to DAI. Girls tended to have lower DAI scores than boys. This study showed a consistent relationship between the DAI score and the subjects' desire for orthodontic treatment, as well as satisfaction with dental appearance and social functioning.

Another study investigated the correlations between the prevalence of malocclusion and the need for orthodontic treatment (Willens *et al.* 2001). In this study the sample included the records from 1,477 (641 males; 836 females) patients from a university orthodontic department in Belgium. From these patients' records, three groups were formed; Group 1 (220 patients) received no treatment, Group 2 (124 patients) stopped their treatment prematurely, and Group 3 (1,133 patients) which completed their orthodontic treatment. In this study, a clear need for orthodontic treatment was found in 63% of the cases according to the DHC component of the IOTN. The mean DHC grade of 3.7 was comparable to other studies of university orthodontic populations, and for non-university orthodontic populations of the same geographical region. In addition, spacing and tooth-size discrepancy (TSD) was investigated. The results reported showed 34.1% of the orthodontic patients, in this study, had a tooth size discrepancy of 1 mm or more indicating that considering tooth size analysis in the treatment plan would be prudent.

The age range of the sample can affect the outcome of the results. In a study by Chi *et al*. (2000) the DAI scores of 150 New Zealand children 13 year old were used to assess the prevalence of orthodontic treatment need. Those results were then compared to the results of a study of those same children at 10 years of age. In the original group, surveyed in 1995, 294 children, 10 years of age were examined, of those, 183 (62.2%) agreed to be re-examined as 13 year olds, in 1998. Methods for patient examination were identical in the two studies. The DAI was administered again in 1998. There was no sex significant difference between the DAI scores for the 13 year old boys and girls. The mean change in the DAI scores for the children examined at both 10 and 13 years of age was -0.7 (sd = 7.1). About half of the 150 children examined at 10 years of age were in the same treatment-need category at 13 years of age; 30 moved into a higher treatment-need category, and the other 47 moved into a lesser treatment-need category. When considering the results by treatment need category the authors reported that fewer 13 year olds (27%) had a mandatory treatment need than when they were 10 years old (33%). This was also true in the desirable treatment category, 20% for 13 year olds compared to 23% for 10 year olds. When the DAI scores, as opposed to the treatment need categories were examined, only 7% of the children were assigned the same score at both 10 and 13 years of age (52% received a higher score; 41% received a lower score). When the four treatment need categories were analyzed, agreement occurred in 49% of the children assessed at both ages, compared with the same children when the DHC component of the IOTN was used. When the individual children's scores were compared, agreement occurred 7% of the time. The authors found the results of malocclusion indices (DAI and IOTN) are affected by the developmental changes with growth.

The idea that some groups are over-represented among patients who receive orthodontic treatment was the focus of a study by Kisely *et al*. (1997). The use of a reliable and valid assessment scale such as the Index of Orthodontic Treatment Need (IOTN) to identify those patients most likely to benefit from treatment was thought to enhance consistency and provide an objective measure. Though the IOTN ranks malocclusions in terms of dental health and esthetic impairment, Kisely *et al*. thought it needed to be supplemented by assessments of the timing and complexity of treatment required because these are areas that the IOTN does not cover. The sample consisted of 400 patients (62% female; 38% male) with a mean age of 12.4 years. All patients were interviewed using the "Pathways Encounter Form" and had a dental assessment that included the IOTN, an assessment of complexity of, treatment and timing of the referral. The authors found no particular socio-demographic or geographic variable associated with a fast or slow pathway, and that severity (measured by an IOTN score greater than 3) was not significantly associated with length of time for obtaining orthodontic treatment. When considering the results, the gender and socio-demographic balance of the sample needs to be noted. Though there is a uniform prevalence of orthodontic anomalies in the population, 62% of the subjects were female and 25% were from social classes I and V (the latter is double the figure expected if the sample reflected the socio-demographic profile of the area). These results in this study showed that orthodontic treatment was not equitably provided and was not based on objective need.

Investigating self-awareness of malocclusion and actual clinical status of orthodontic need was the focus of a study by Sheats *et al.* (1998). The authors conducted orthodontic screening examinations of 861 eighth-grade children (54% female; 46% male) in Florida. Visual examinations were done and wax bite impressions were taken for calculation of the Peer Assessment Rating (PAR) index. In addition, each child was asked four questions (and two follow-up questions when appropriate) regarding self-perception of this occlusion and the need for orthodontic treatment. Those with braces or a history of orthodontic treatment were excluded. The results showed that 64% of the group expressed no self-perceived need for braces while 25% were not satisfied with the way their teeth looked. Results showed that females were significantly more likely than males to perceive a need for non-removable orthodontic devices. In addition, girls were less likely to be satisfied with their dental appearance and were more likely to have a perception of overjet. Girls also expressed more concerns than boys about anterior crowding, but not for increased overjet in those cases where there was a perception of "crooked teeth" or teeth that "stuck out." Race differences were not demonstrated. It was also found that while 57% of the subjects were classified as having no treatment need, 64% of the subjects judged themselves as having no need for braces. With other variables held constant, those who were satisfied with the way their teeth looked, were one-sixth less likely to perceive a need for braces than those who were not happy with they way their teeth looked. The results show a discrepancy between actual clinical findings and a child's demand for orthodontic treatment.

A longitudinal study to examine factors influencing the decision for orthodontic treatment was done by Birkeland *at al.* (1999). They evaluated the attitudes of 11 and 15 year old and their parents which influenced their decisions about orthodontic treatment. The sample consisted of 359 children who were 11 years old in 1993 (T1). Then in 1997 (T2), 293 of those same children (now 15 years old) agreed to participate in a follow-up study. Initially (T1), prevalence of malocclusion was recorded based on assessment of casts using the Dental Health Component (DHC) and Aesthetic Component (AC) grades of the Index of Orthodontic Treatment Need (IOTN). Of that number, 74 (20%) were under orthodontic treatment at that time. Additionally, parents and children separately, completed a questionnaire regarding their orthodontic concerns. The Global Negative Self-Evaluations scale (GSF) was given to each child to measure self-esteem. Then again in 1997 (T2) separate child and parent questionnaires were given, and the children were clinically examined and had dental impressions taken. The results showed that between T1 and T2 the majority (78.9%) changed only one DHC grade. The parents' desire for treatment of their child decreased from 53% at T1 to 24% at T2, with the children's answers showing the same tendency, even though most children (83%) and parents (87%) felt that well-aligned teeth were important for overall facial appearance. Esthetics was the most frequent reason given for treatment by both children (55%) and their parents (37.5%). Of the group 128 children had completed or were undergoing orthodontic treatment. The results for treatment satisfaction were high, with 95% of treated children and 93% of their parent satisfied with their orthodontic results. Neither gender, self-esteem, a negative attitude to public funding or previous orthodontic treatment experience of parent had any influence on treatment uptake in this study. This study did not show an expected increase in the desire for treatment with the general increase in concern about appearance in teens.

Measuring the distribution, prevalence and severity of malocclusion and treatment need in a sample of Nigerian children was the focus of a study by

Otuyemi *et al*. (1999). They used the Dental Aesthetic Index (DAI) to assess whether malocclusion was affected by age, gender, and socio-economic background. In this study sample, there were 703 children (328 males and 375 females) from Nigeria between 12 and 18 years of age. None of the children had a history of orthodontic treatment. Malocclusions were assessed using the DAI and all ten components were measured. The authors found no statistically significant differences in DAI scores between age groups, gender and socio-economic background. Most of the children (77%) had dental appearances indicated as "slight" or "not indicated" orthodontic treatment needed. About 13% were in the "elective" category, 6% were in the "highly desirable category and 4% fell in the mandatory category. When comparing the cumulative percentage frequency of DAI scores of various populations, Nigerian adolescents were found to have better dental aesthetics and less need for orthodontic treatment than American, Japanese, and Australian adolescents.

Kerosuo *et al*. (2004) studied the association between normative and self-perceived orthodontic treatment need in Arab high school students. The authors also evaluated the influence of sex, socioeconomic status, area of living and satisfaction with dental appearance on treatment need. The sample consisted of 139 students (70 girls and 69 boys) between 14 and 18 years of age for urban and rural areas of Kuwait. Data was collected from a questionnaire and clinical examination with treatment need assessed according to the IOTN. The IOTN grade combined the DHC and AC components and was determined for each subject according to the component that had the higher grade in the clinical inspection. The results reported definite need for orthodontic treatment (IOTN 4-5) in 28% of the subjects. Self-reported treatment need among the same subjects was 34%. There was agreement between normative and self-perceived treatment need in 77% of the subjects, showing that IOTN and its components DHC and AC correlated positively for this. In this study normative treatment need (IOTN) did not significantly differ between males and females. Girls tend to pursue treatment more than boys, sex differences regarding normative treatment need might result from and uneven distribution of orthodontic treatment between the sexes.

Orthodontic Indices

Orthodontic indices are used when considering the need for orthodontic treatment. Numerous authors (*e.g*., Helm 1977; Stricker *et al*. 1979; Brook and Shaw 1989) have studied factors involved in defining the need for orthodontic treatment. All emphasize a combination of psychological and dental esthetic factors, when considering the need for orthodontic treatment.

Considering this, there arose a need for an orthodontic index that not only included the biological aspects of malocclusion but the psychological aspects also. The Dental Aesthetic Index (DAI) was developed by Cons *et al*. (1986) to be responsive to not only malocclusion conditions but the psychological harm that may occur if untreated. By linking the physical measurements of the traits associated with malocclusion with the public's perception of dental esthetics using a regression equation, a score is obtained that when placed on a scale gives an indication of the variance from the norm of acceptable dental appearance. The farther the score is from the norm, the more severe the dental appearance and the greater the likelihood that a physical or psychological handicap may occur if not treated.

Adding to this, Jenny *et al*. (1993) established a cut-off score that defined a handicapping malocclusion. In a study involving 1306 study casts of subjects between 15 and 18 years of age, orthodontists were asked to separate those with non-handicapping from those with handicapping occlusal conditions. The orthodontists' decisions were correlated with DAI scores resulting in a score of 36 as the point of the scale separating those handicapping malocclusion from non-handicapping (the greater the score the greater the severity).

Another study (Jenny and Cons, 1996) took the DAI information one step farther by establishing other points on the scale for decision-making purposes. By looking at the frequency distribution of the DAI scores and those from the Jenny *et al*. (1993) study along with data from the National Center for Health Statistics, points of severity along the scale were established along with percent of the NCHS sample encompassed by each interval of the DAI scale. A score of 25 or lower indicates normal or minor malocclusion with no treatment needed. A score of 26 to 30 on the DAI indicates a definite malocclusion with treatment elective. A score of 31 to 36 indicates a severe malocclusion with treatment highly desirable, while a score of 36 or higher indicates a very severe malocclusion with treatment mandatory.

Brook and Shaw (1989) also developed a system for scoring malocclusions, a system that they labeled the Index of Treatment Need (IOTN). The index consists of five grades, (1) no need for treatment, (2) mild or little need for treatment, (3) moderate or borderline need for treatment, (4) severe, meaning a need for treatment and (5) extreme, meaning definite need for treatment. The index includes a dental occlusion and alignment component as well as an esthetic component that evaluates dental appearance against an ordinal scale of ten standard photographs. A consensus of a panel of orthodontists was used to determine the degree of severity of the various malocclusions.

There are various ways to measure malocclusion to classify its severity. The one outlined in this investigation along will the DAI and the IOTN were used to show a continuum of malocclusion severity as it relates to tooth size. The hypothesis is that there will be a discernible statistical correlation between tooth size and severity of malocclusion. The anticipated relationship is that, as tooth size increases so does the severity of the malocclusion within each sex.

CHAPTER III. MATERIALS AND METHODS

The sample for this study consisted of North American white adolescent boys and girls, between 11 and 25 years of age. There were 107 boys and 100 girls in the sample. Mean age was 16.2 years (sd = 4.6 years). Most subjects were selected from orthodontic cases treated in the dental school, but the adults were dental students who had not been treated orthodontically. All cases with a condition known to affect tooth size were excluded. The dental records were selected based on the following criteria: all 24 teeth fully erupted and intact (ignoring second and third molars), and all had good quality pretreatment dental casts.

With the intent of increasing the range (and within-sample variability) of the data, we included 38 casts of males with naturally-occurring good occlusions. These were collected from dental students and have been reported by Agenter (2008). Only two cases of women with naturally-occurring good occlusions were included in the present sample. Consequently, there is an inherent bias in any biological interpretation of sexual dimorphism with regard to the incidence of severity of malocclusion because we have intentionally and knowingly "loaded" the sample with men who have effectively no dentoalveolar malocclusion. The effect of "sex" in the ANCOVA and other models analyzed here should only be viewed as accounting for a "nuisance variable," not as any reliable measure of whether the two sexes differ in the severity of malocclusion.

Teeth on one side of the midline of the upper and lower arches were measured (7 teeth in each arch, the central incisor through the first molar), for a total of 14 measurements per subject. Maximum mesio-distal crown measurements (Seipel 1946) were taken using digital-readout, sliding calipers using the methods described by Moorrees (1959). The beaks of the calipers had been machined to fit well into the embrasures.

Nomenclature and Odontometric Method

Various naming, lettering, and coding systems have been used to refer to specific tooth types (reviewed by Peck and Peck 1993). A combination of letters and numbers was used in the present study corresponding to conventions in the anthropological and genetic literature. The system in the present study was to refer to the four tooth types by their initials, namely incisor (I), canine (C), premolar (P), and molar (M), and to code a tooth's location within each morphogenetic complex by its position, mesial to distal (*e.g.*, Dahlberg 1945, 1951). Arcade and side of the body, where applicable, are written-out for clarity.

It is tedious and space-consuming to constantly write-out the full names of each of the 14 tooth types evaluated here, and it is expedient to use a coding system (Peck and Peck 1993; Harris 2005). Codes used here are (1) to denote the dental arch as maxillary (U for upper) and mandibular (L for lower), (2) to distinguish left (L) and right (R) sides of the arch when necessary, and (3) to use Palmer notation to code the teeth based on their positions and sequence from front to back namely

1. central incisor
2. lateral incisor
3. canine
4. first premolar
5. second premolar
6. first molar
7. second molar

Aspects of the tooth's crown are referred to by using conventional anatomical descriptions, namely mesial, distal, buccal, and lingual (*e.g.,* Zeisz and Nuckolls 1949; Kraus *et al*. 1969; Ash 1993). A tooth's two major occlusal axes are mesiodistal (MD) and buccolingual (BL). These directions are, more specifically, mediolateral and faciolingual for the incisors, but, by convention, the terms MD and BL are used throughout this work. Following conventions (*e.g.,* Moorrees 1957, 1959), mesiodistal crown diameters are termed *lengths* while buccolingual crown diameters are termed *widths*.

Since each tooth crown has a complex three-dimensional morphology, obtaining "maximum" MD and BL dimensions requires experience and systemization (Seipel 1946; Kieser *et al.* 1990). There is some art as well as science in obtaining homologous tooth dimensions within a tooth type among individuals. General statements can be made regarding methodology, but one needs to be cautious when comparing among investigators. The three most-frequently cited descriptions of how to measure maximum MD and BL crown dimensions are those of Lundström (1948), Selmer-Olsen (1949), and Moorrees (1957). Mesiodistal crown length is defined as the maximum distance between a crown's mesial and distal anatomic contact points when a tooth is in its normal position (not rotated or otherwise deviated from its ideal position in the dental arch). The measurement was made with sliding calipers held perpendicular to the tooth's long axis, which should be approximately parallel with the occlusal plane. Adjustments were made to account for tooth rotations and shifts in axial inclinations (Seipel 1946). The measurement should not be influenced by positions of adjacent teeth. Figure 16 illustrates the orientation of maximum MD dimensions on the four maxillary tooth types. Maximum width normally is at the occlusal edge of incisors, but lower, at the height of contour in premolars,

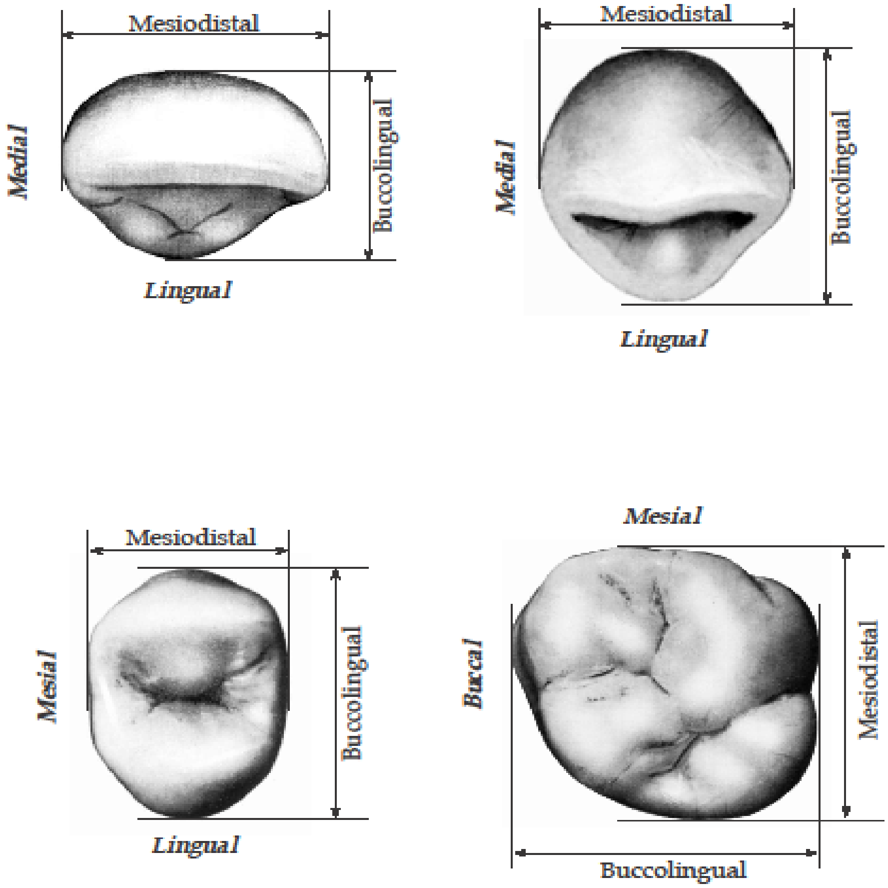

Figure 16. Examples of the four permanent human tooth types showing the axis along which maximum mesiodistal crown diameters were measured using electronic-readout sliding calipers.

Maxillary teeth are illustrated here, incisor (*top left*), canine (*top right*), premolar (*bottom left*), and molar (*bottom right*).

and lower yet, at or near the gingival border (and dentinoenamel junction) on canines and molars.

Measurement Methods

Obtaining dental measurements involves several judgments about landmark locations, and these judgments can affect the acquired dimensions of a sample, both systematically (due to one's measurement style and one's interpretations of dimensions' definitions) and in terms of sample variability (due to interobserver measurement inconsistencies). Kieser and coworkers (1990, 1991) have explored within- and among-observer variations in tooth size determinations, and several other investigators have examined the problem in other areas of human biology (*e.g.*, Houston 1983). Useful articles dealing with non-dental topics are by Gavan (1950), van der Linden *et al*. (1970), Utermohle *et al*. (1983), and Knapp (1992).

Additional concerns occur when one is measuring dental casts rather than real teeth because casting errors in the monochromatic dental material need to be distinguished from actual tooth anatomy. Notably, casting defects that result in blebs of dental stone on a tooth can artificially inflate crown dimensions. Another common problem involves gingival distortions that are incorporated into the dental casts. These are of two sorts, (1) stripping (gingival recession, particularly adjacent to a tooth root's labial and lingual margins) and (2) gingival hyperplasia, where the gingival is inflamed or otherwise hyperplastic, so it covers essential tooth crown landmarks near the cementoenamel junction. Obviously, it is important not to confound measurements of crown size by including artifacts of the gingival morphology that can, variably, increase or decrease the true crown dimensions.

The comments in this section are provided to give the reader a better sense of how the size determinations were obtained in the present study. That is, it is commonplace for researchers in this field to cite published sources, such as Seipel (1946) or Moorrees (1957), as containing definitions of the measurements employed. These definitions are, however, very general. As an example, Moorrees (1957:78) states that a tooth's mesiodistal diameter is "the greatest mesiodistal dimension of the tooth crown, measured parallel to the occlusal and labial surfaces." His operational definition of the BL diameter is equally generic, "the greatest distance between the labial and lingual surfaces of the tooth crown in a plane perpendicular to that in which the mesiodistal diameter was measured" (1957:80).

Mesiodistal Dimensions

Maximum MD diameter of the incisor typically occurs at its occlusal edges so the caliper beaks can be positioned just below the line angles of the tooth, perpendicular to the crown's occlusogingival long axis (which typically is normal to the occlusal plane). On dental casts, this often requires that the sharpened beaks of the calipers be pressed into the embrasures, so the measurements are somewhat less than would be obtained from actual teeth, especially isolated teeth where the beaks can truly span the mesial and distal margin of the tooth's crown.

Maximum MD distances of the canines, premolars, and molars occur at the heights of contour. These heights generally are midway up the crown's facial outline, but may be more gingival in some tooth forms. It is important to hold the calipers parallel with the occlusal plane (specifically, perpendicular to each tooth crown's occlusogingival long axis) and to accommodate to a rotated tooth's mesiodistal occlusal axis. When adjacent teeth have a tight contact, the points of the caliper beaks need to be pressed into the embrasures. One should recognize, though, that such dimensions will be smaller than for isolated teeth (and those cases with interdental spacing). Teeth with mesial and/or distal wear facets due to abrasion against adjacent teeth will yield smaller dimensions. There also is the issue that the measurer should *not* position the calipers to include the actual heel of the terminal molar. This would angulate the calipers relative to the tooth's mesiodistal axis. Instead, beaks need to be positioned so the measurement if made parallel with the tooth row (unless, of course, the molar itself is rotated). Normally, the MD dimension of the terminal molar will be from the buccal side of the embrasure distal to a point on the metacone (distobuccal cusp) such that the calipers' beaks are at right angles to the tooth row (and with the calipers at the height of contour for that tooth and perpendicular to the crown's occlusogingival axis).

Crown Size Dimorphism

Sexual dimorphism in tooth crown dimensions needs to be accounted for in the statistical analysis, but it is not central to this research project. Consequently, it is described here (rather than in Results), largely to confirm that it is a pertinent source of variation. Descriptive statistics are listed in Table 1, along with the results of one-way ANOVA tests.

Most of these mesiodistal dimensions are significantly different between the sexes. Exceptions are (1) the maxillary lateral incisor, (2) the maxillary first

Table 1. Descriptive statistics of mesiodistal crown dimensions, by sex, and tests for sexual dimorphism.

Tooth Type	Males n	Males $\bar{x}$	Males se	Females n	Females $\bar{x}$	Females se	r^2 (Percent)	Percent Dimorph.	F-Ratio	P-Value
					Maxilla					
Central Incisor	107	8.82	0.05	100	8.53	0.05	6.59	3.35	14.47	0.0002
Lateral Incisor	107	6.69	0.06	100	6.57	0.06	1.03	1.84	2.13	0.1462
Canine	107	7.98	0.04	100	7.65	0.04	12.81	4.34	30.13	< 0.0001
First Premolar	107	6.96	0.04	100	6.88	0.04	0.89	1.15	1.84	0.1765
Second Premolar	107	6.75	0.04	100	6.61	0.04	2.93	2.26	6.19	0.0137
First Molar	107	10.48	0.05	100	10.20	0.05	6.60	2.80	14.47	0.0002
Second Molar	107	9.87	0.06	100	9.62	0.06	4.65	2.60	9.99	0.0018
					Mandible					
Central Incisor	107	5.47	0.03	100	5.33	0.04	4.05	2.73	8.65	0.0036
Lateral Incisor	107	5.97	0.04	100	5.84	0.04	2.38	2.16	4.99	0.0265
Canine	107	6.92	0.04	100	6.55	0.04	15.88	5.58	38.70	< 0.0001
First Premolars	107	7.14	0.04	100	7.02	0.04	2.08	1.69	4.36	0.0380
Second Premolar	107	7.24	0.04	100	7.13	0.04	1.52	1.54	3.16	0.0768
First Molar	107	11.23	0.05	100	10.89	0.06	8.35	3.08	18.67	< 0.0001
Second Molar	107	10.35	0.06	100	10.13	0.06	3.19	2.17	6.76	0.0100
					Combined Dimensions					
Maxillary Sum	107	57.55	0.25	100	56.05	0.26	7.83	2.68	17.41	< 0.0001
Mandibular Sum	107	54.31	0.23	100	52.89	0.24	7.97	2.69	17.75	< 0.0001
Grand Sum	107	111.86	0.47	100	108.94	0.48	8.40	2.68	18.79	< 0.0001

premolar, and (3) the mandibular second premolar. Percent of sexual dimorphism ranges from a low of 1% (UI2) up to about 6%.

Overall, sex differences in these American whites average about 3 mm (see "grand sum") for the 14 tooth types, which translates to about 6 mm for the full arch perimeters. The statistical impact of accounting for "sex" in the analytical models r^2 (*i.e.*, how much of the variation in tooth size is accounting for by the subject's sex) can be an important percentage of the totals. Overall, r^2 is over 8% for the sum of all tooth types; individually, it ranges up to 16% for the mandibular canine. In other words, <u>not</u> accounting for subject's sex could emphatically confound interpretations of the statistical results.

Quantifying Crowding

A key issue in this study was how to quantify the severity of malocclusion specifically as regards tooth-size arch-size discrepancies (TSASD). What was desired here was an expedient means of arranging cases, from those with no TSASD along a continuum up to those with severe TSASD. The scoring had to take into account the potential variations in tooth position in all three planes of space (plus axial rotations), but had to be simple enough that a lot of cases could be assessed. On the other hand, skeletal malrelationships should not enter the equation since they have separate etiologies (Harris and Smith 1980; Harris and Johnson 1991) and, while important, skeletal relationships do not pertain to how the teeth *per se* are accommodated into the existing arch space. There are, of course, conventional methods of quantifying occlusal variations (*e.g.,* Little 1976; Harris *et al*. 1987), but they can be insensitive to capturing the degree of dental crowding and, moreover, can be time-consuming, which detracts from elaborating the sample size of a study.

We developed a semi-continuous scale of malocclusion that (1) focuses on the anterior dental segment, where most rotations and displacements occur (Grainger 1967; Kelly and Harvey 1977) and (2) is based on expedient, visual assessments (ordinal grades), while preserving a broad range of inter-individual variation. The methods borrows heavily on the TPI (treatment priority index) developed by the National Center for Health Statistics (Kelly and Harvey 1977). There are three aspects of the index that we collectively label as "crowding," namely (A) tooth displacements, (B) axial tooth rotations, and (C) mesiodistal overlapping of teeth. Just the maxillary six teeth (2 canines and 4 incisors) are scored for these three variables.

Displacements

Each of the six maxillary anterior teeth (I1, I2, C in both quadrants) was scored for its degree of displacement buccolingually out of the idealized arch form. Each displacement was given an ordinal score of 0, 1, or 2, and it was not important whether the displacement involves labioversion or linguoversion (Figure 17):

0. The tooth's buccolingual position is in the idealized arch form.
1. The tooth is displaced (buccally or lingually), but less than 2 mm.
2. The tooth is displaced 2 mm or more, either buccally or lingually.

Scores of the six displacements are summed, with a potential score between 0 and 12.

Rotations

Teeth can be in the desired position labiolingually and mesiodistally, but rotated on their long axis. Typically, additional arch space is required to de-rotate a tooth into its idealized position. The axial rotation of each of the six maxillary anterior teeth was scored (Figure 18):

0. Rotation is normal relative to the idealized arch from, without torsiversion.
1. The tooth is rotated on its long axis, but less than 30 degrees.
2. The tooth is rotated on its long axis more than 30 degrees.

Scores of the six rotations are summed, with a potential range from 0 to 12.

Mediolateral Overlap

The intent here was to quantify the amount of mesiodistal tooth crown size that cannot be accommodated into the arch form without treatment. The mediolateral overlap of a tooth is the extent to which tooth crowns overlap one another in the arch by virtue of their buccolingual displacements. For example, the maxillary lateral incisors often erupt lingual to the central incisors, so the mesial aspect of the lateral tooth overlaps the lateral aspect of the central. The greater the overlap, the more arch space that has to be obtained during treatment

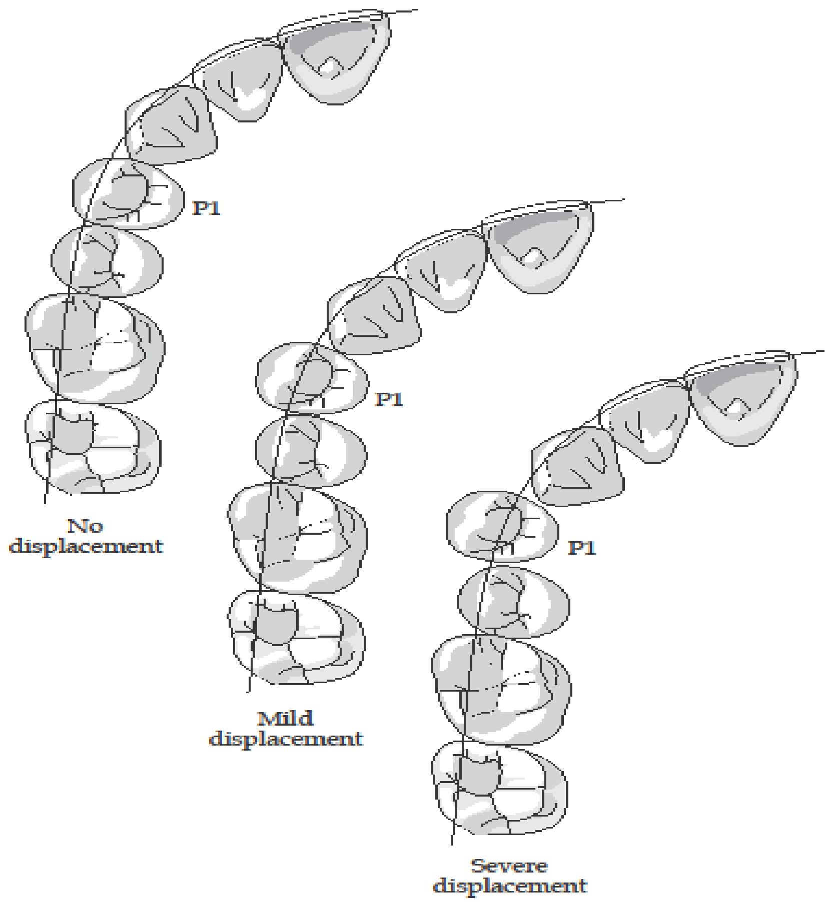

Figure 17. Schematic depictions of the occlusal view of the maxillary right quadrant.

Left: An arch form (heavy line) is shown that approximates the best fit to the buccal cusps of the teeth. None of the teeth is displaced. *Middle*: The first premolar is shown to be slightly (<2mm) displaced from the overall arch form. *Right*: Severely displaced second premolar (>2m).

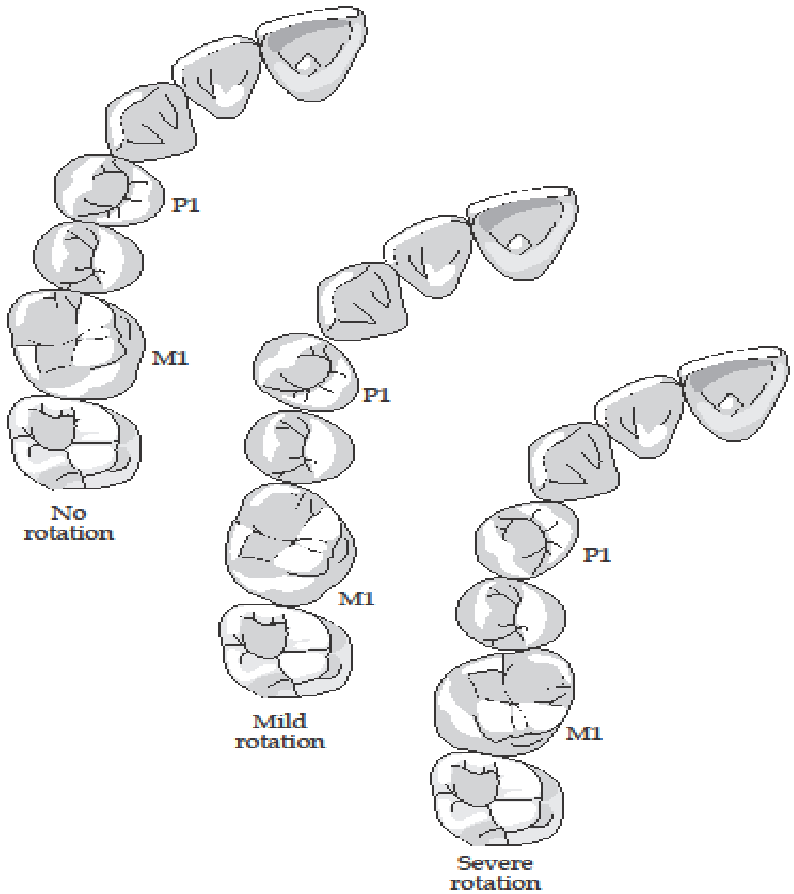

Figure 18. Schematic examples of how tooth rotations were scored.

Left: All teeth in the quadrant are in their idealized positions. *Middle*: First premolar is mildly rotated (clockwise rotation in this figure) and the first molar is mildly rotated (also clockwise). *Right*: First premolar is severely rotated (counterclockwise) as is the first molar, with about 90 degrees of clockwise rotation.

to resolve the TSASD. The mediolateral overlap of each of the six maxillary anterior teeth was scored as:

0. No overlap (though there may be displacement and/or rotation).
1. Up to 2 mm of overlap, from visual assessment of the mediol and lateral aspects of each tooth.
2. Over 2 mm of overlap, assessing both the mediol and lateral aspects.

Summation of displacements, rotations, and dental overlap provides a score from 0 (perfect arch form) to a potential upper limit of 36. This "crowding" provides a semi-quantitative scale of the severity of TSASD that is quick and easy to score (Figure 19). Refinements, not considered here, would be to devise a weighting scheme since there probably is considerable left-right symmetry to the malocclusion that, statistically, involves redundancy of information, as well as redundancy among the three components to the score (displacements, rotations, overlapping). So, too, this score only applies to the maxillary arch.

Dental Aesthetic Index

The Dental Aesthetic Index (DAI) developed by Cons *et. al*. (1996) is aimed at integrating the psychological and physical elements of malocclusion, linking the physical measurements of malocclusion with the public perception of dental esthetics arithmetically. The DAI is formulated as a regression equation with 10 predictive variables (Jenny and Cons 1996). A subject (or his dental casts) is scored for each of 10 variables. These scores are multiplied by their regression coefficients (weights), then added together along with a constant (the intercept of the equation). The sum is the DAI score. After a score had been obtained, it can be placed on a scale that spans a range from most to least esthetic dental appearance. The farther a DAI score is from the norm of acceptable dental appearance the greater the chances that the malocclusion could be socially or physically handicapping if left untreated.

The DAI (dental aesthetic index) was developed by Jenny and Cons (1996) as a means of quantifying the impact of the dentition on facial esthetics. A total of 10 variables are scored, and these can be done with equal precision on subjects themselves, or on their dental casts. A multiple regression coefficient is provided by these authors that yields a value; the lower the value, the more esthetic the dentition is gauged to be. Conversely, the higher the number, the more the dentition is felt to harm a person's facial esthetics. The ten components of the DAI are scored as follows:

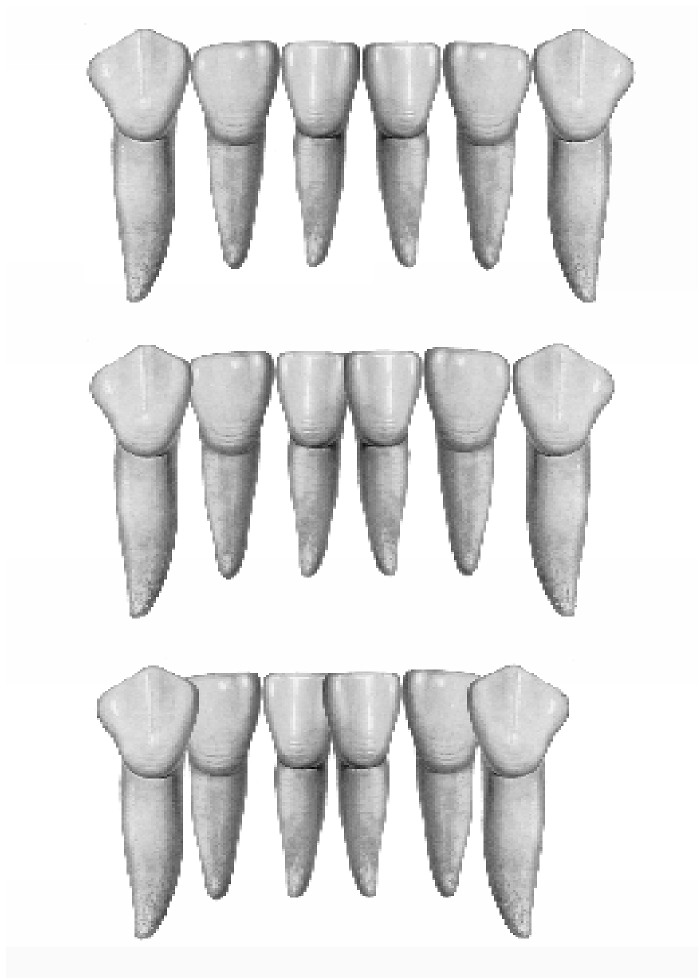

Figure 19. Labial views of the six mandibular anterior teeth. “Overlap” was scored on a three-grade scheme at each of the five contacts shown in this schematic.

Top: All six teeth are correctly approximated (overlap scores of 0). *Middle*: The overlap scores are zero, except for the central incisors with minor overlap (score+1). *Bottom*: There is moderate overlap of at least 2 mm between the canine and lateral incisor in each quadrant, and minor overlap (1 to 2 mm) between the central incisors.

Missing Teeth

Missing teeth can arise from a variety of causes, such as congenital absence, trauma, caries, or periodontal involvement. In the adolescent age group, cases would most commonly result from congenital absence. The Jenny-Cons system counts the number of missing incisors, canines, and premolars in the two arches. In fact, no instance of a missing tooth was encountered in the sample studied in the present investigation.

Incisor Crowding

Crowding is scored using a simple three-grade ordinal scale. Either there was no crowding (score 0), which, predictably, was uncommon in the present study; there was crowding in one jaw (score 1); or there was crowding in both jaws (score 2). An example of severe incisor crowding is illustrated in Figure 20.

Incisor Spacing

Analogous to crowding, interdental spacing among the incisors was scored using a three-grade ordinal scale. Either there was no spacing in either arch (score 0); there was spacing in one arch (score 1); or there was spacing in both arches (score 2).

Midline Diastema

This is the mediolateral width of the diastema that may occur between the maxillary central incisors. Width of the diastema is measured millimetrically with sliding calipers; when a diastema is absent, the score is zero. Figure 21 is a schematic depiction of a diastema between the maxillary central incisors.

Anterior Irregularity Maxilla

The anatomic contacts of the incisors and canines should be closely approximated in an ideal arch. In the Jenny-Cons system, the single largest maxillary discrepancy between the contacts of the adjacent teeth is scored using sliding calipers (Figure 22). This differs from the familiar orthodontic measure of incisor irregularity (Little 1976), where all of the open contacts are considered.

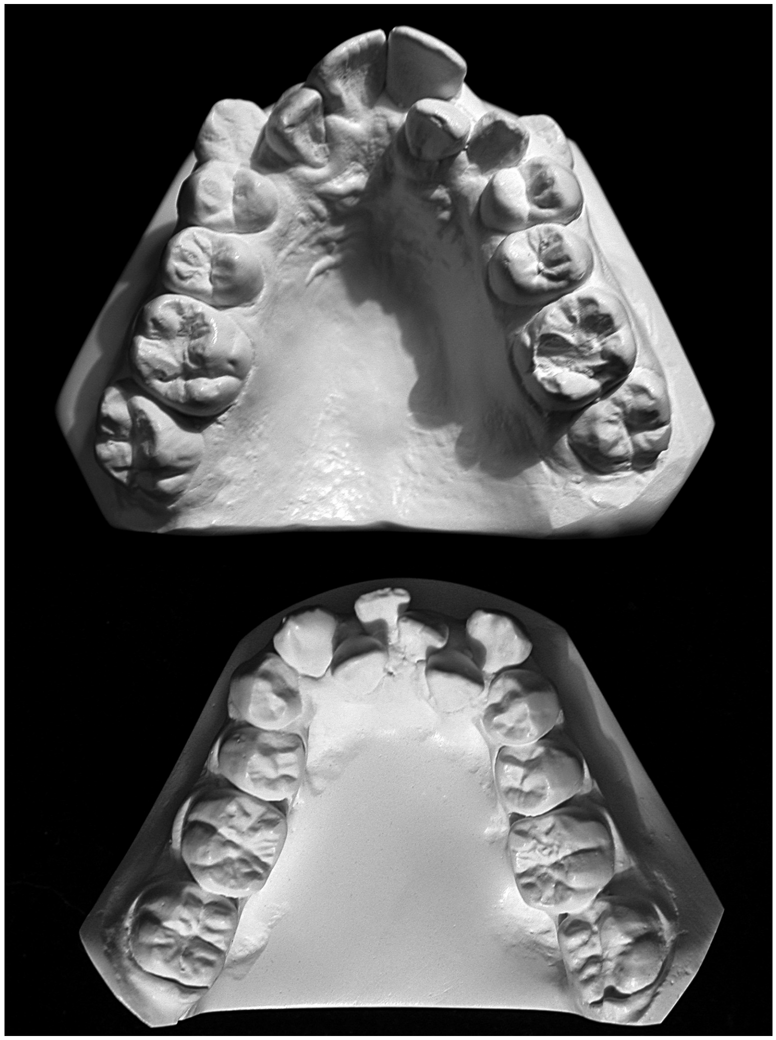

Figure 20. Occlusal views of the dental arches of an orthodontic patient at pretreatment who exhibits severe incisor crowding.

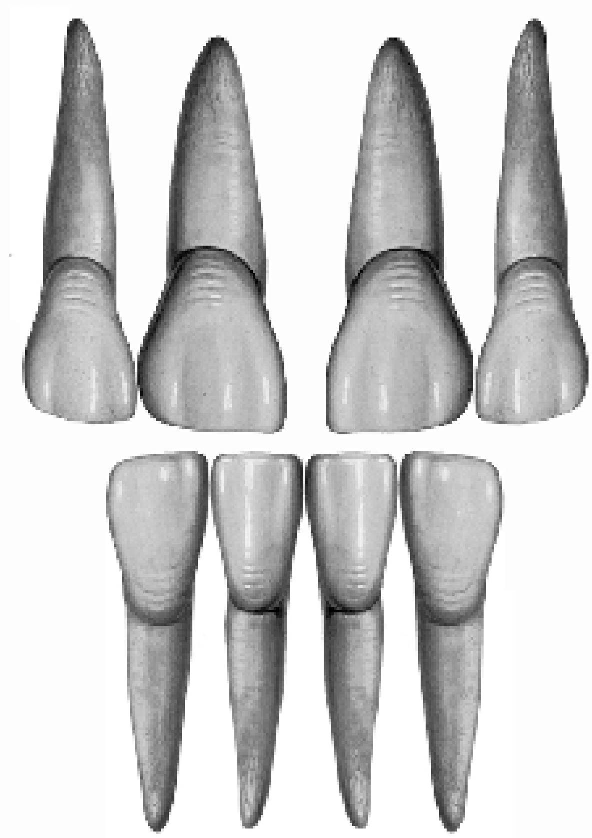

Figure 21. Schematic depiction of a diastema between the maxillary central incisors.

Figure 22. Schematic view of a maxillary dental arch. Heavy lines depict the irregularity between anterior teeth, where the anatomic contacts are not approximated.

In the Jenny-Cons scoring system, only the largest discrepancy in an arch is recorded, in this case the distance between the contacts of the left central and lateral incisors.

Anterior Irregularity Mandible

The single largest mandibular discrepancy among the incisor and canine tooth types is scored. This millimetric value is entered into the DAI equation.

Maxillary Overjet

This is a millimetric value, where the maxillary and mandibular casts are placed in maximum interdigitation, and overjet from the labial of the most prominent maxillary central incisor to the homologous mandibular incisor is measured along the occlusal plane. This is illustrated in Figure 23.

Mandibular Overjet

When there is mandibular prognathism such that the anterior teeth are in crossbite, then this value is measured (and "maxillary overjet" is ignored). Mandibular overjet ("underjet") is measured millimetrically with sliding calipers from the labial surface of the most prominent mandibular incisor to the labial surface of the homologous maxillary incisor (Figure 23).

Anterior Openbite

This vertical measurement is included when the incisors do not overlap vertically (Figure 24). Openbite is the maximum millimetric distance between the opposing incisal edges measured perpendicular to the occlusal plane.

Buccal Molar Relationship

This is scored along a three-grade ordinal scale. The more-deviant side of the arch is recorded, and if there is a Class I molar relationship, the score is 0. This occurs when the mesiobuccal cusp of the maxillary first molar is located against the buccal groove of the mandibular first molar when viewed in *norma lateralis*. When, instead, the cusp-to-groove relationship is off by up to ½ -cusp either mesially or distally, the score is 1. As the third option, if the deviation exceeds one-half cusp, the score is 2. Buccal molar relationships of the permanent first molars are illustrated in Figure 25.

In the present study, we used each of these ten constituent variables individually as measures of dental malocclusions (excepting "missing teeth" that

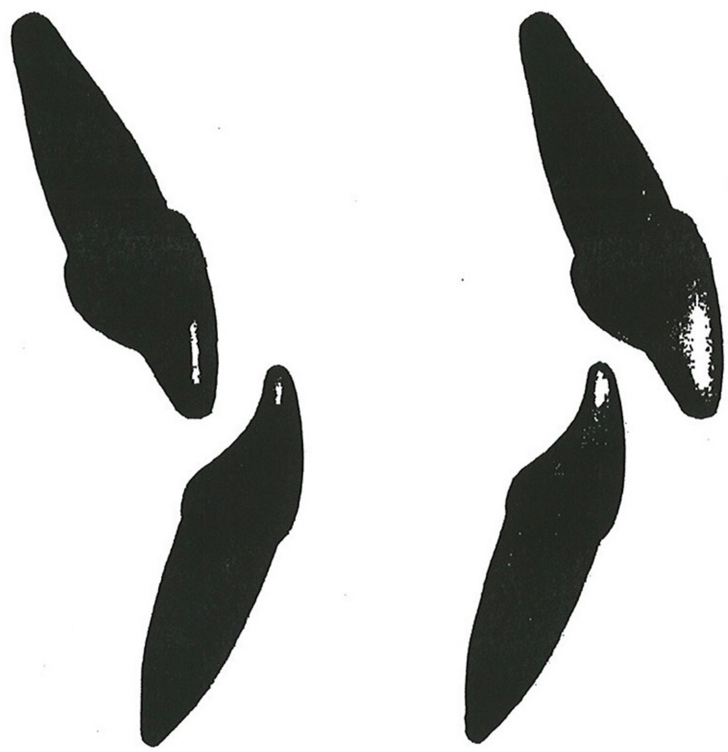

Figure 23. Depictions of horizontal incisor relationships between the arches.

Left: An anterior crossbite termed here a negative overjet. *Right*: The incisor overjet is the horizontal distance between the labial incisal surfaces of the upper and lower incisors parallel with the occlusal plane.

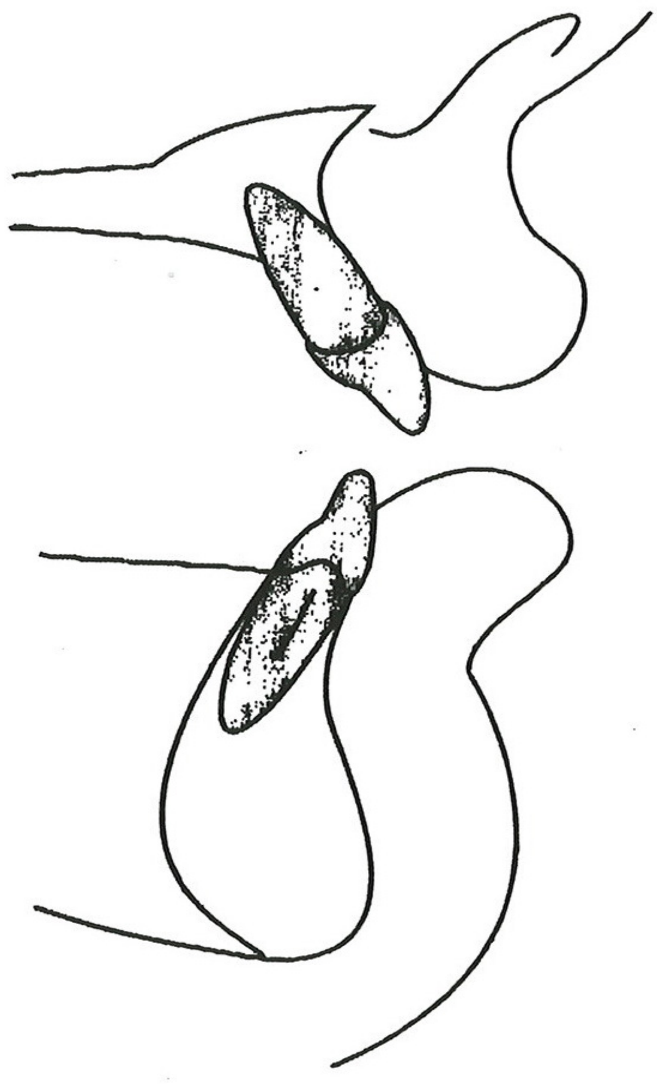

Figure 24. Depiction of the lateral view of the lower face showing an anterior openbite, where the incisal edges of the central incisors do not overlap vertically.

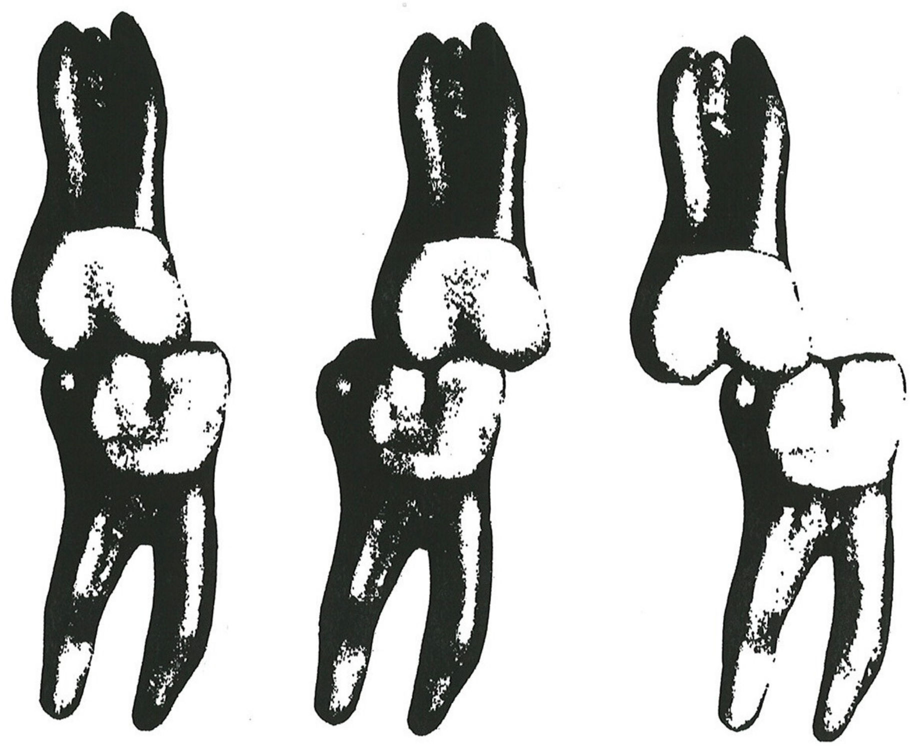

Figure 25. Buccal segment relationship refers to the parasagittal relationship of the permanent first molars.

Left: normal (Class 1) molar relationship has the mesiobuccal cusp of the maxillary molar aligned with the buccal groove of the mandibular molar. *Middle*: Full-step distoclusion (Class II) has the mesiobuccal cusp of the maxillary molar a full cusp mesial of the buccal groove of the lower molar. *Right*: Illustration of full-step mesioclusion (Class III). Most deviations from a Class I relationship involve less than the full-cusp divergences shown here.

did not occur). The DAI score, weighted by the coefficients listed in Table 2 also was tested as a predictor of tooth size.

Statistical Analysis

The questions asked of these data are fairly straightforward; one batch of issues is purely descriptive, namely, by Angle's classification and/or sex, what are the normative dimensions of the teeth? What are the size differences between the incisor tooth types? How much left-right asymmetry is there? A second battery of questions involves understanding and partitioning the variation in the sample. As examples: How much sexual dimorphism is there, and does this differ between crown and root dimensions?

Once the tooth sizes were obtained, the measurements were collated in Excel and statistical analysis was performed using the JMP statistical package. Distances calculated in Photoshop® 6.0 were transcribed onto data forms and then entered into a Microsoft® Excel® spreadsheet (Microsoft, Seattle, WA), where the ratios were calculated. The Excel® document was then loaded into JMP (SAS Corporation, Cary, NC) where statistical analysis was performed.

Descriptive statistics were calculated as defined by Sokal and Rohlf (1995), namely sample size (n), arithmetic mean ($\bar{x}$), standard deviation (sd), sample variance (s^2), standard error of the mean (se), skewness (g_1), and kurtosis (g_2). Regarding skewness and kurtosis, statistical packages commonly fail to provide inferential tests of whether g_1 or g_2 differ significantly from normality. Inspection of these raw statistics themselves is not particularly informative. Following Sokal and Rohlf (1995, p 138), the standard error for skewness is

$$se_{g_1} = \sqrt{\frac{6n(n-1)}{(n-2)(n+1)(n+3)}}$$

where n is the sample sizes, and the standard error for kurtosis is

$$se_{g_2} = \sqrt{\frac{24n(n-1)^2}{(n-3)(n-2)(n+3)(n+5)}}$$

an interesting feature of the tests of whether skewness or kurtosis departs from normality is that they are each evaluated at infinite degrees of freedom regardless of the actual size of the samples.

Table 2. Listing of the variables scored in the Dental Aesthetic Index.[1]

Variable	Weight
1. Number of missing teeth	5.76
2. Incisor crowding	1.15
3. Incisor spacing	1.31
4. Midline diastema	3.13
5. Largest anterior irregularity, maxilla	1.34
6. Largest anterior irregularity, mandible	0.75
7. Anterior maxillary overjet (mm)	1.62
8. Anterior mandibular overject (mm)	3.68
9. Anterior openbite (mm)	3.69
10. Buccal molar relationship	2.69

[1]Numbers in right column are the regression weighting coefficients. Along with the Y-intercept of 13.36, these weights yield the DAI.

Exploratory data methods (Tukey 1977) were used to identify statistical outliers. Percentage sexual dimorphism was calculated from this formula:

$$\left(\frac{(\bar{x}_M - \bar{x}_F)}{\bar{x}_F}\right)100$$

so the percentage is read as the degree to which the male average exceeds the mean size of females.

Statistics were generated using JMP version 7.0.02 (SAS Institute Inc., Cary, NC). Tests were two-tail, and the conventional level of statistical significance (alpha = 0.05) was used throughout.

Statistical Models

ANCOVA models are useful in the present study because they can be used to test for an association between two variables, while controlling for extraneous variables (*e.g.*, patient's sex, measurements of homologous left-right traits), thus (1) greatly reducing the number of tests that have to be performed (and interpreted), (2) preserving degrees of freedom, and (3) testing for statistical interactions among the variables evaluated in combination. Essentially two ANCOVA models are used, both search for an association between mesiodistal crown size and some measure of dentoalveolar malocclusion. Tests were run using the JMP statistical package (SAS Institute Inc., Cary, NC), which used a generalized linear model approach for calculation. One, simple model uses patient's sex as a covariate, so (1) males and females can be combined in the same test while (2) testing for heterogeneity of slopes—whether the association is significantly different in the two sexes. The form of the table is this (Winer *et al*. 1991):

Intercept
Tooth size
Sex
    Tooth size-by-Sex Interaction

where Intercept is the Y-intercept, Tooth size is mesiodistal crown size of one of the 14 tooth types, Sex is whether the patient is male or female, and the Interaction term tests whether the association (slope of the regression line) is statistically different between the two sexes. If the interaction term is significant, then the main effects of the model are biased, and the analysis should be run on a sex-specific basis.

The other common model used here is a mixed-effect design where some measure of malocclusion is measured on both the right and left quadrants, so they need to be viewed as repeated measures:

Among Subjects
- Intercept
- Tooth Size
- Sex
- Tooth size-by-Sex Interaction

Within Subjects
- Side
- Side-x-Tooth size Interaction
- Side-x-Sex
- Side-x-Tooth size-x-Sex

Here—as with the other mixed models (*e.g.*, Winer *et al*. 1991)—there are two separate error terms (one among subjects and one within subjects). The Intercept is the Y-intercept of the regression line. Tooth size is the mesiodistal crown size of one of the 14 tooth types. "Sex" is a test of significant sexual dimorphism in average tooth size between males and females. The tooth size-by-sex interaction term assesses whether the slopes differ significantly by sex. Within subjects, Side is used when a trait (*e.g*., BSR, rotations, displacements) measured in each quadrant is systematically different on one side (*i.e*., directional asymmetry). Importantly, Side also extracts the variance due to systematic left-right differences from the error term, which enhances the chance of finding a difference in the other effects if they occur. The two first-order interaction terms and the one second-order term provide tests of the additivity of the model. Additivity is an assumption of the covariance model; when it is violated, individual tests should be run on each category of that covariate.

At their simplest, analysis of covariance (ANCOVA) models test for a linear relationship between the predictor and the outcome variables. Unless noted, a more complex (curvilinear) model did not provide a significantly better fit than a straight line. When indicated, a curvilinear model of the form ($X + X^2$) was tested to see whether extreme values of tooth size were associated with exaggerated (nonlinear) levels of malocclusion. The following section builds on the comments just provided.

Analysis of Covariance

A central question in the present study is whether there is an association between tooth crown size and the severity of the malocclusion (where "malocclusion" is some measure of crowding, displacement, overlap, and/or irregularity). A simple example is shown in Figure 26, where (hypothetherally) there is a positive statistical association between mesiodistal width of the maxillary central incisor and incisor irregularity. Such a statistical association can be a test for using linear regression (*e.g*., Freund and Littell 1991).

Since, however, tooth size is sexually dimorphic, it is necessary to account for "sex" of the subject, and this can be done by analyzing males and females separately (which is inefficient), or, preferably, including "sex" in the regression model using analysis of covariance (ANCOVA). "Sex" in the analysis is used here as "indicator variable" (Freund and Littell 1991); it is a dichotomous qualitative variable that accounts in these tests for the offset in tooth size (males > female) between the two sexes. An indicator variable is identical to what previously was termed a dummy variable. There are a couple of concerns here, the main one being whether the relationships of incisor irregularity on tooth size are the same in both sexes. Statistically, the concern here is whether the slopes of the regression coefficients are the same in the two sexes. For example, one possibility is that the slope is significantly steeper in one sex than the other, as illustrated in Figure 27. It is possible (A) that the two slopes differ significantly in their steepness, (B) that they are of opposite signs, or (C) that the slope differs significantly from zero (either positively or negatively) for one sex, but is flat ($r = 0$) for the other sex. These three possibilities—that is whether there is significant heterogeneity of slopes—can be assessed from inspection of the size-by-malocclusion interaction term in the ANCOVA model. When the interaction term is significant statistically, then the main effects are biased and other regression models need to be applied instead.

In the ANCOVA design used here, there are three inferential tests, namely (1) whether the interaction term is significant, (2) whether "sex" significantly affects the best-fit regression lines Y-intercept, and (3) whether the association between the predictor variable (tooth crown dimension) and the outcome variable (a measure of malocclusion) is significant statistically. The second of these tests (a "sex" effect) assesses whether there is a statistically significant vertical offset (*i.e*., the Y-intercept of the regression line) between the two sexes.

The ANCOVA model used here can, usefully, be made a bit more complex since homologous measures of malocclusion of the right and left teeth were measured in this study, but there is no systematic side difference in the extent of the malocclusions. Instead, malocclusions in the left and right hemispheres can

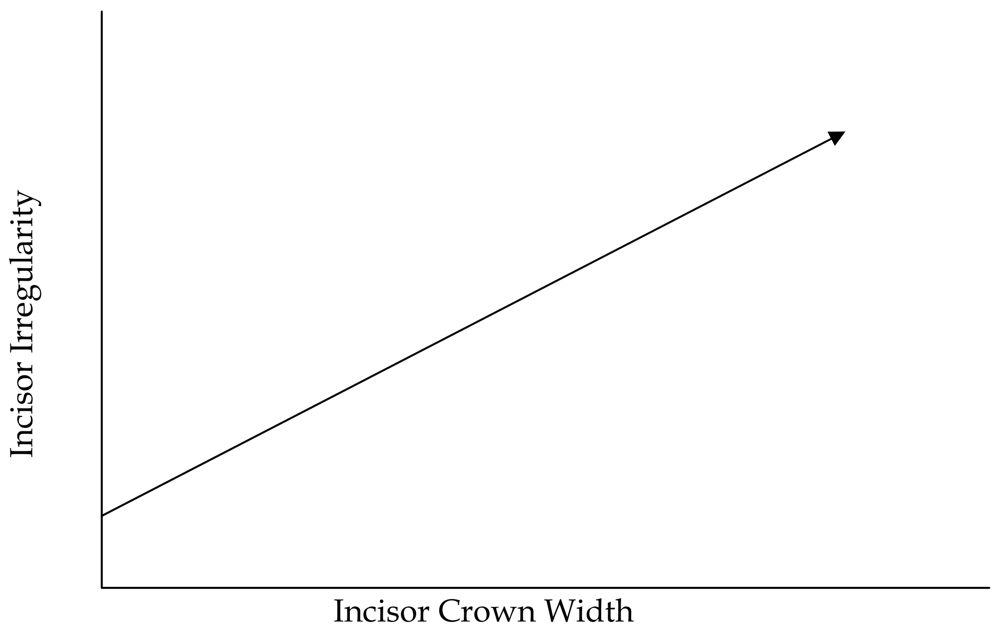

Figure 26. Hypothetical plot of a positive linear association between tooth size and irregularity.

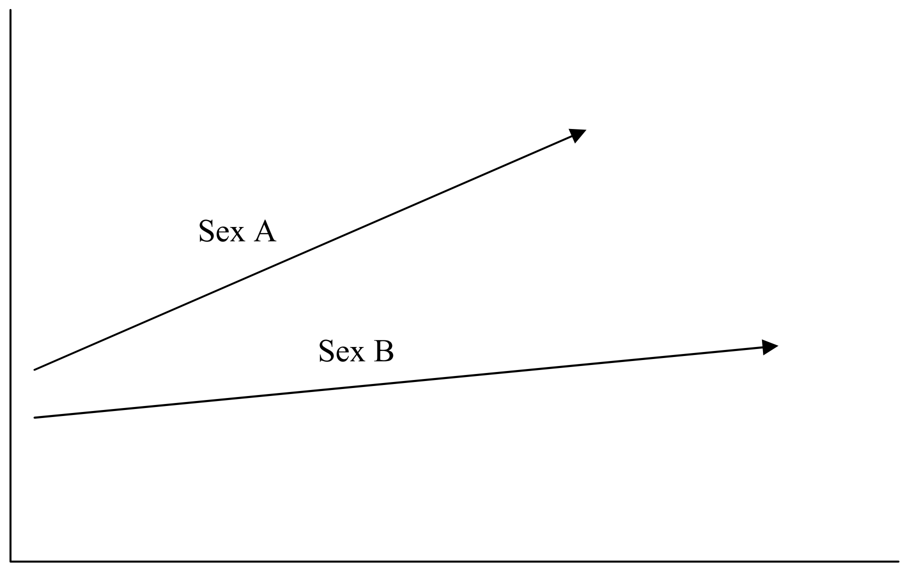

Figure 27. Hypothetical plot showing a steeper slope for one sex than the other.

best be viewed as duplicates. The number of tests is cut in half when both sides of the dentition are used in an ANCOVA model, with measures on the left and sides viewed as repeated measures. Not only does this reduce the number of tests by half (thus reducing the risk of type II statistical errors), it also provides internal tests for directional asymmetry in severity of dentoavleolar malocclusions (*e.g*., Harris and Bodford 2007). This model can be handled in the JMP statistical package, though, of course, there is a different error mean squares for testing the repeated measure term.

As with ANCOVA designs in general, there are various assumptions of the model (Sokal and Rohlf 1995). Perhaps foremost is the assumption of homogeneity of the slopes of the regression lines (*i.e*., that they are parallel), but, as noted, this can be tested explicitly by the interaction term. Second is linearity of the response. We did not overtly test for the fit of other, nonlinear models, but the computer-generated plots were perused, looking for systematic regions of poor fit, where a curvilinear model might provide a better fit.

Another assumption of the analysis of covariance is that the covariate is measured without error and is under the researcher's control. The covariate in these tests is tooth size, so this assumption (as is common) is not strictly met. There doubtlessly, is some error in the tooth size measurements (*e.g*., Kieser and Groeneveld 1990, 1991), and they are not under the control of the investigator.

CHAPTER IV. RESULTS

A total of 33 measures of malocclusion are described in the Methods section. Several of these are of little interest in themselves but were measured with the intent of combining them into more comprehensive assessments. For example, tooth displacements out of the idealized dental arch (*i.e.*, ectopia) was quantified for 12 teeth (the anterior six teeth in each arch). Each of these was measured on an ordinal scale (0, 1, or 2). However, the sum of these scores provides a quasi-continuous variable termed "total displacements." Similarly, total rotations and total overlapping also were derived. Eleven other variables suggested by Jenny and Cons (1996) also provide generalized measures of malocclusion. Altogether, there are 14 measures that collectively quantify several aspects of malocclusion in the sense of greater-or-lesser failures of teeth to erupt into occlusion as gauged within and between the arches. These 14 are listed in Table 3.

The driving question in this thesis was whether there is a graded response between mesiodistal size of a tooth and the extent of the malocclusion. As described previously, maximum mesiodistal crown dimensions were obtained for each of the 14 tooth types in the two arches, central incisor through second molar. Is there a statistical association between tooth size and the extent of a subject's malocclusion? This was tested in a series of ANCOVA tests, where prime interest was on whether the regression of a measure of malocclusion on tooth size was statistically significant while controlling for ancillary variables such as sex and, for bilaterally symmetric variables, side of the dental arch. Testing for graded "dose-responses" between MD crown size and the extent (severity) of the malocclusion extends prior research (*e.g.,* Peck and Peck 1972; Agenter 2008) that tooth size is larger in samples of people with malocclusions. In other words, the goal here was to move beyond artificially dichotomous comparisons between "no malocclusion" versus "malocclusion" to look, more realistically, at severity of malocclusion as a continuum that ranges from mild to handicapping.

For completeness, the ANCOVA tests (14 tooth dimensions and 32 measures of malocclusion) all are listed in the Appendix. Here we discuss the key results of associations between tooth sizes and what we deem are the 14 pertinent measures of malocclusion.

The ANCOVA statistical models (Appendix) are more or less complex, each with multiple F-ratios, but the purpose of these elaborations was to remove potential sources of extraneous variation from the residual mean squares in order to improve chances of finding significant tooth size malocclusion

Table 3. Occlusal variables considered.

	Feature	Scoring Method
1.	Total displacements	Sum of Ordinal Scores (3grades)
2.	Total rotations	Sum of Ordinal Scores (3grades)
3.	Total overlapping	Sum of Ordinal Scores (3grades)
4.	Total displacements, rotations, and overlapping	Sum of Ordinal Scores (3grades)
5.	Crowding	Ordinal Scores (3grades)
6.	Spacing	Ordinal Scores (3grades)
7.	Diastema	Ratio (millimeter)
8.	Maxillary irregularity	Ratio (millimeter)
9.	Mandibular irregularity	Ratio (millimeter)
10.	Maxillary overjet	Ratio (millimeter)
11.	Mandibular overjet	Ratio (millimeter)
12.	Openbite	Ratio (millimeter)
13.	AP relationship	Ordinal Scores (3grades)
14.	DAI score	Weighted Sum

relationships if they exist. Consequently—and with some degree of simplification—we only focus here on the F-ratios for the regression aspect of the ANCOVA tests, and these are summarized for the maxillary tooth types (Table 4) and the mandibular tooth types (Table 5). Again, the ANCOVA models are described in the Methods chapter, and full details of all tests are provided in the Appendix.

Maxillary Tooth Types

The P-values and the F-tests between each of the seven maxillary tooth types are collected in Table 4. Full results of the ANOVA results are provided in the Appendix. This one page table involves much less effect than searching through the full results. What is shown here is the P-value of the F-ratio testing whether the association (linear regression) between tooth size and a measure of malocclusion.

This situation is readily illustrated using the first test in Table 4, between the maximum mesiodistal size of the maxillary central incisor (U1) and severity of the total displacement score. Regression of total displacements on U1 size is highly significant, which is the P-value listed in the table. Significance does not disclose the nature of the association, but Figure 28 makes it evident that broader U1 teeth are associated with greater displacements. The full ANOVA table in the Appendix shows that, additionally, there is a significant sex difference (*i.e.,* larger dimensions in males than females), but there is no tooth-size by displacement interaction.

A few generalities can be drawn from the results in Table 4: One, many of the statistical associations are significant (alpha = 0.05), and many are highly significant ($P < 0.01$), indicating that tooth sizes commonly are reflected in the severity of tooth-based malocclusions. Two, the significant associations are more common in the anterior segment of the arch, but some variables (*e.g.*, overlapping and the combination of displacements, rotations, and overlapping) have significant associations with most maxillary tooth types. One interpretation here is simply that, indeed, crown dimensions throughout the arch affect severity of the malocclusion.

A second, seemingly more parsimonious interpretation is that crown dimensions among all tooth types are positively intercorrelated (*e.g.*, Harris and Bailit 1988) and that some of the associations in Table 4 developed indirectly from these intertooth correlations. It depends on multivariate approaches (later in this chapter) to distinguish between these two scenarios. Three, some of

Table 4. P-Values associated with test (F-Ratios) of the regression of crowding on tooth size in the maxilla.

Variable	U1	U2	U3	U4	U5	U6	U7
Total displacements	< 0.0001	0.0030	0.0006	0.1517	0.7024	0.0390	0.0702
Total rotations	0.0016	0.0464	0.0132	0.0459	0.0254	0.3356	0.5983
Total overlapping	0.0001	< 0.0001	< 0.0001	0.0054	0.0186	0.0139	0.0518
Total displacements, rotations, and overlapping	< 0.0001	0.0002	< 0.0001	0.0167	0.0666	0.0272	0.0807
Crowding	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0009	0.0087	0.0353
Spacing	0.0002	< 0.0001	0.0001	< 0.0001	0.0013	0.0169	0.0060
Diastema	0.0037	0.0080	0.0065	0.0235	0.0174	0.3552	0.0511
Maxillary irregularity	0.0033	0.0006	0.0023	0.1863	0.3834	0.0294	0.2129
Mandibular irregularity	< 0.0001	0.0043	0.0072	0.0333	0.5911	0.0221	0.0854
Maxillary overjet	0.0005	0.3360	0.0207	0.0544	0.0441	0.5124	0.7633
Mandibular overjet	0.1151	0.4743	0.1280	0.3615	0.5897	0.8752	0.2853
Openbite	0.5755	0.2432	0.2555	0.5366	0.4407	0.4833	0.3663
AP relationship	0.7609	0.0695	0.2957	0.1799	0.6431	0.7499	0.8244
DAI score	0.0100	0.2194	0.0247	0.4172	0.5363	0.4091	0.9515

Full results of the ANCOVA models are provided in the Appendix.

Table 5. P-Values associated with test (F-Ratios) of the regression of crowding on tooth size in the mandible.

Variable	L1	L2	L3	L4	L5	L6	L7
Total displacements	0.0004	< 0.0001	0.0273	0.1177	0.2808	0.1386	0.4212
Total rotations	< 0.0001	< 0.0001	0.0189	0.0143	0.0715	0.2488	0.5299
Total overlapping	< 0.0001	< 0.0001	0.0048	0.0037	0.3720	0.0799	0.2378
Total displacements, rotations, and overlapping	< 0.0001	< 0.0001	0.0042	0.0081	0.0581	0.0840	0.5347
Crowding	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0158	0.0746	0.0582
Spacing	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0024	0.0078
Diastema	0.0056	0.0062	0.0017	0.0015	0.0585	0.0764	0.0214
Maxillary irregularity	0.0122	0.0006	0.1688	0.2977	0.1490	0.1487	0.8936
Mandibular irregularity	< 0.0001	< 0.0001	0.0413	0.0476	0.1670	0.0513	0.0261
Maxillary overjet	0.0380	0.0274	0.0654	0.3181	0.1974	0.6994	0.3142
Mandibular overjet	0.0766	0.0024	0.3148	0.8549	0.8705	0.2549	0.0432
Openbite	0.7494	0.7100	0.6068	0.7931	0.6946	0.9967	0.1595
AP relationship	0.2861	0.4115	0.6296	0.2836	0.4599	0.7056	0.0836
DAI score	0.0409	0.0090	0.2906	0.9854	0.5230	0.7082	0.1219

Full results of the ANCOVA models are provided in the Appendix.

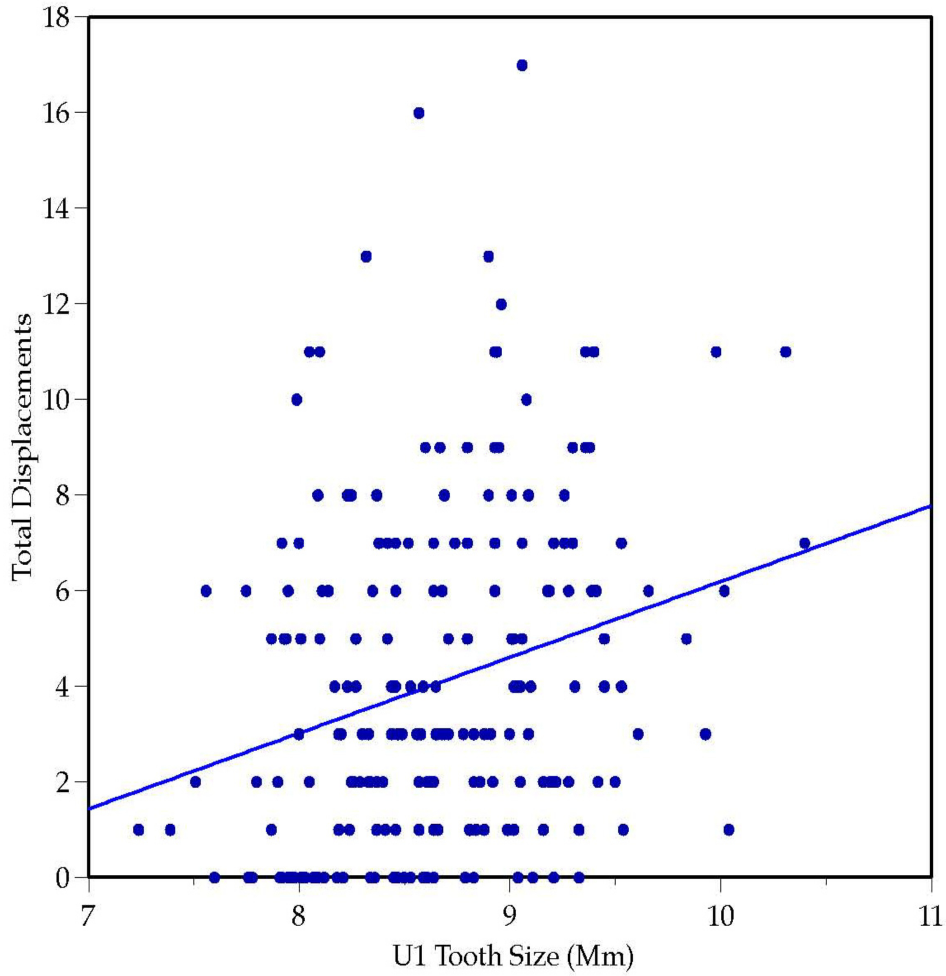

Figure 28. Plot between mesiodistal tooth size of U1 and total displacement scores.

the 14 variables tested are consistently independent of tooth size, notably mandibular overjet, openbite, and AP relationships. Of the 14 variables tested, these three are distinguished in that they depend on skeletal relationships rather than tooth relationships *per se* (see Harris and Johnson 1991, and Harris 2008).

The following presentation of results is organized by occlusal trait.

Total Displacements

There are highly significant, positive associations between displacement scores and mesiodistal crown dimensions for U1 (Figure 28), U2 (Figure 29), and U3 (Figure 30). Distal to the canine, the associations are weak and not significant statistically.

Total Rotations

Statistically significant, positive associations occur throughout much of the arch. Somewhat erratically, the associations are statistically significant ($P < 0.05$) from a high at the central incisor (Figure 31) through the second premolar. In each case, the associations are positive, meaning that larger teeth size tend to occur with more rotations. In contrast, the molars have no relationship to rotation scores.

Total Overlapping

As with the rotation scores just examined, overlapping is significantly associated with MD crown lengths. Here, the positive associations achieve statistical significance throughout the whole arcade (though U7, the terminal tooth is only marginally significant, $P = 0.05$). Strengths of the associations are strongest for U1 (Figure 32) and U2 (Figure 33). The nature of the associations is that mesiodistally larger teeth are associated with greater scores for dental overlapping.

In all of the results presented in this chapter, tooth size is a fixed entity so the necessary scenario is that large tooth size is the etiological cause of the dental malocclusion, In other words, the malocclusion— variously expressed as ectopic, rotated, and overlapping teeth—is the consequence of mesiodistally large crown sizes. It also is noteworthy that all of the significant results described here show a graded response; it is not just that large teeth are a risk

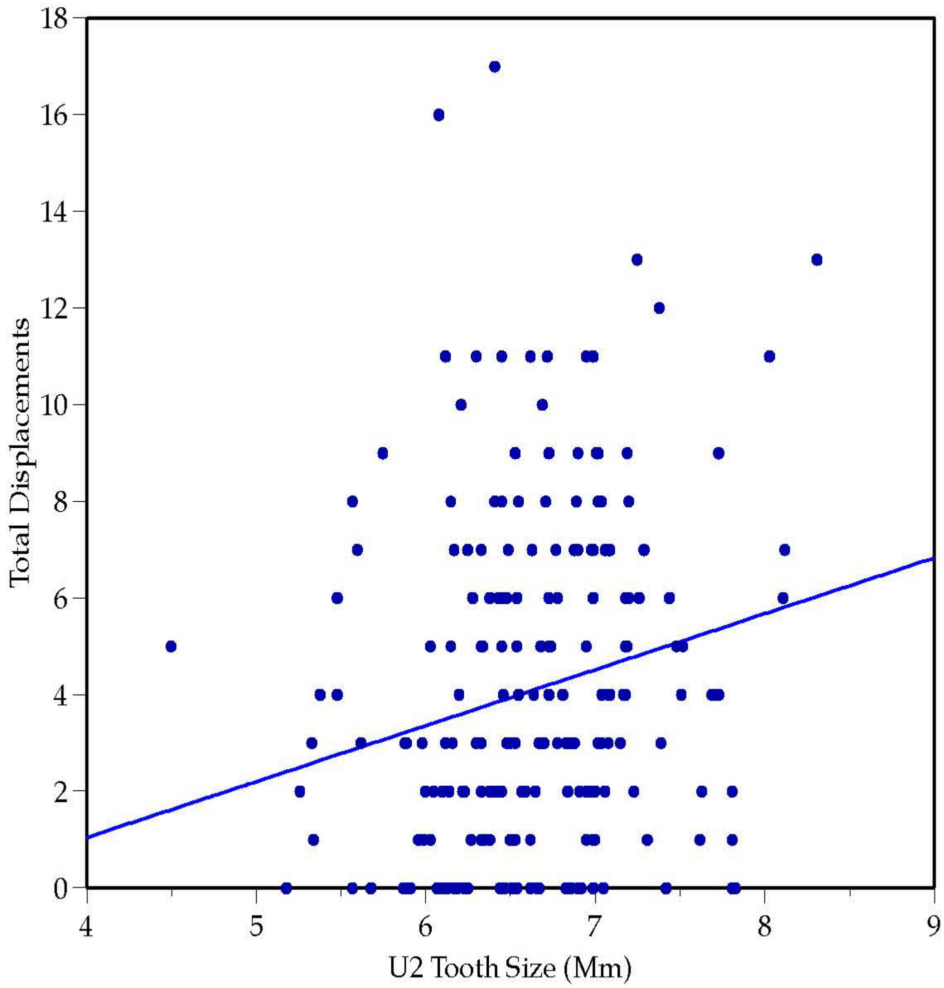

Figure 29. Plot between mesiodistal tooth size of U2 and total displacement scores.

As tooth size increases, so does the average total displacement score.

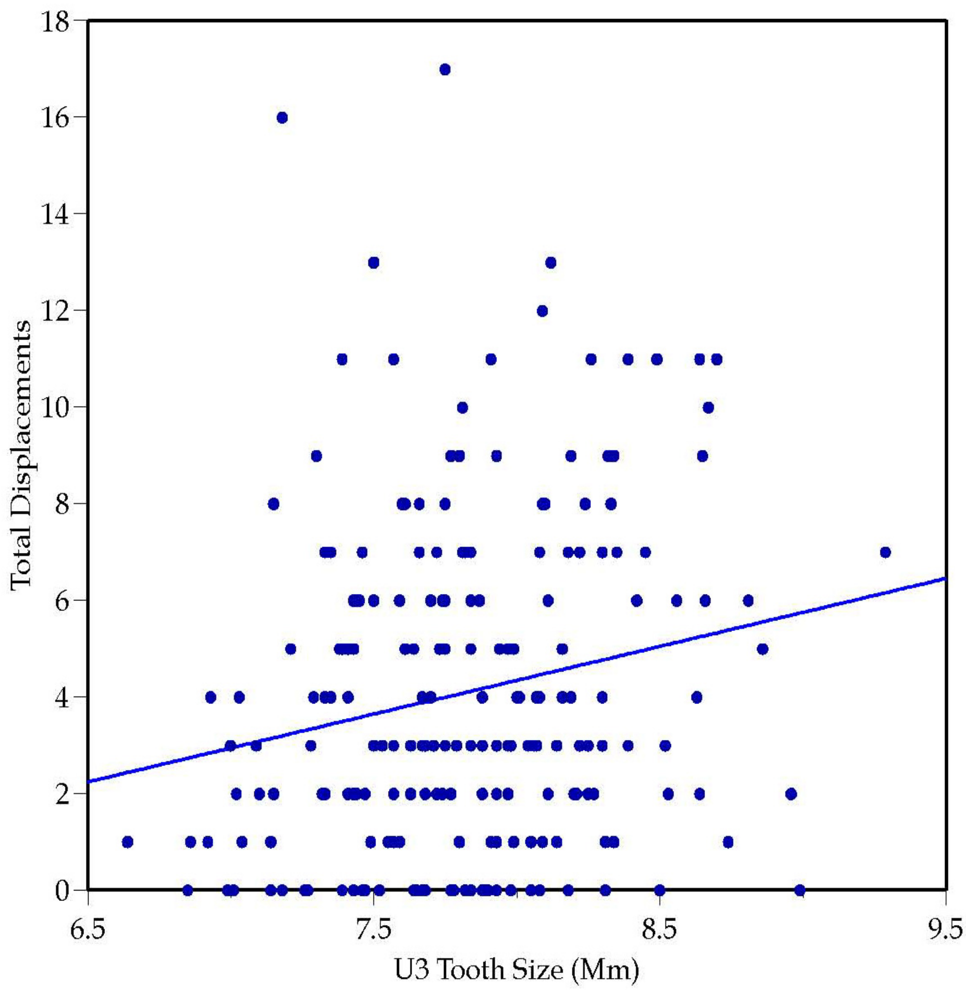

Figure 30. Plot between mesiodistal tooth size of U3 and total displacement scores.

As tooth size increases, so does the average total displacement score.

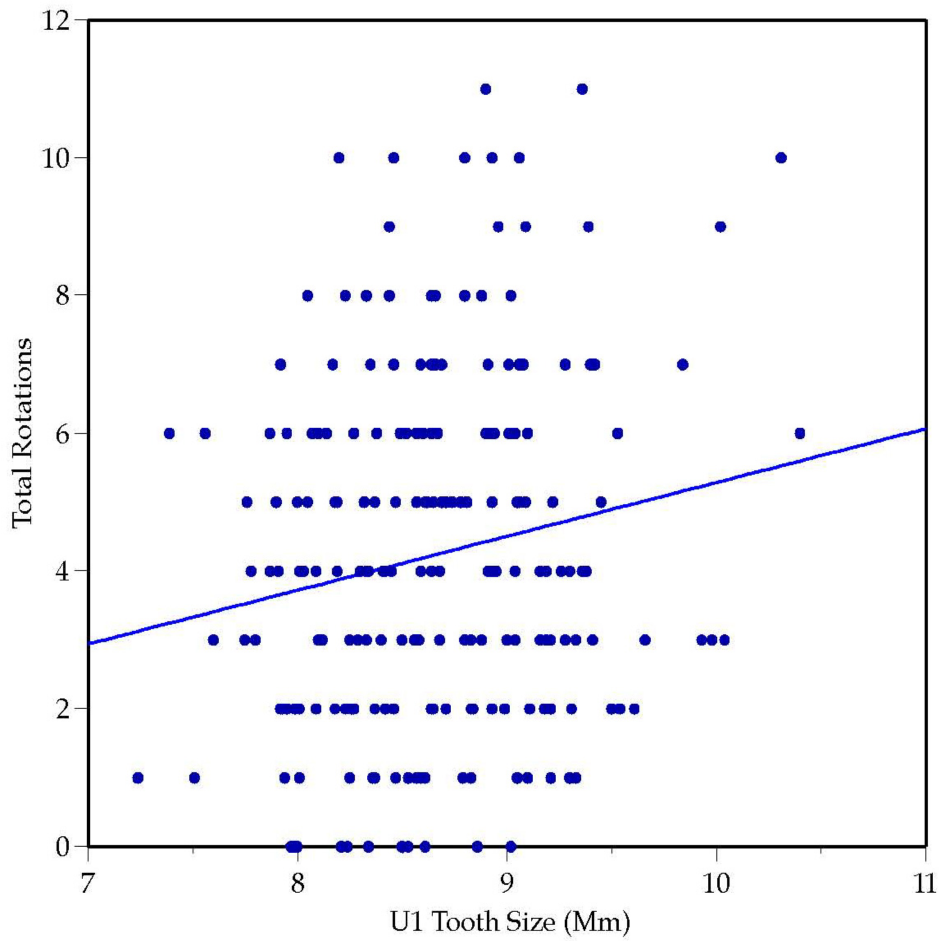

Figure 31. Plot between mesiodistal tooth size of U1 and total rotations.

As tooth size increases, so does the average total rotations.

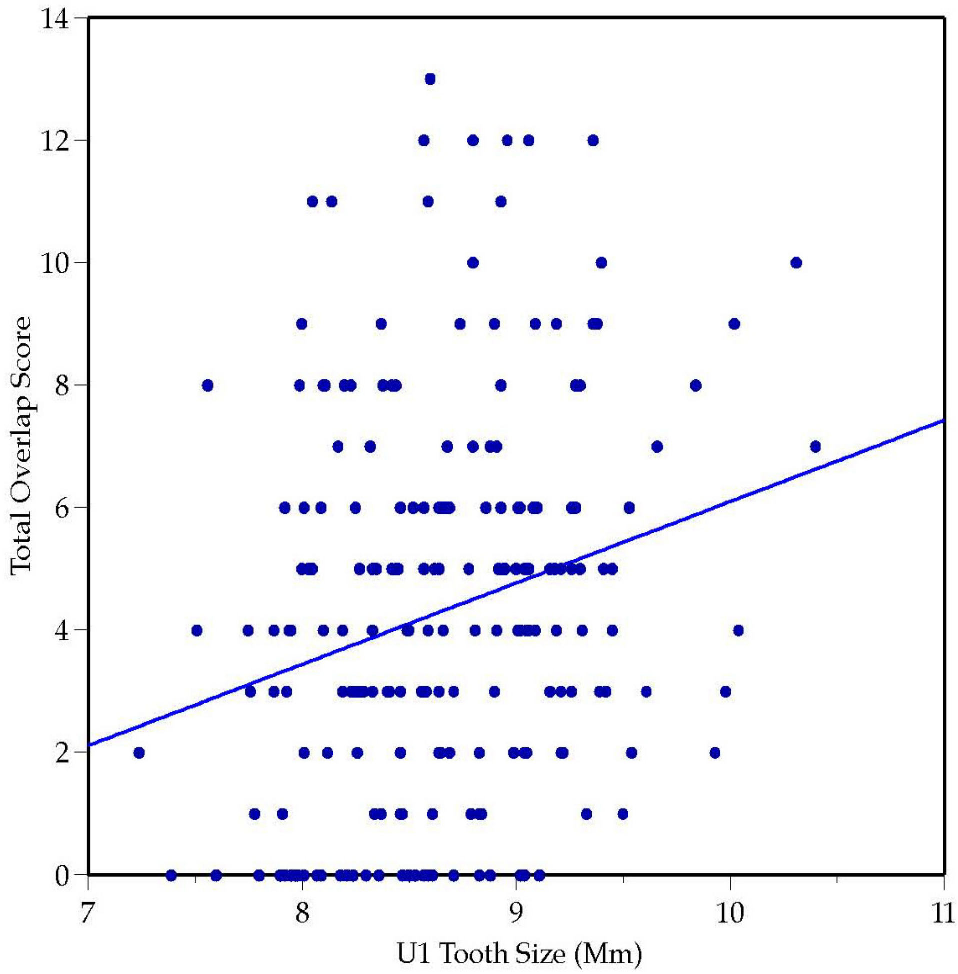

Figure 32. Plot between mesiodistal tooth size of U1 and total overlap.

As tooth size increases, so does the average total overlap score.

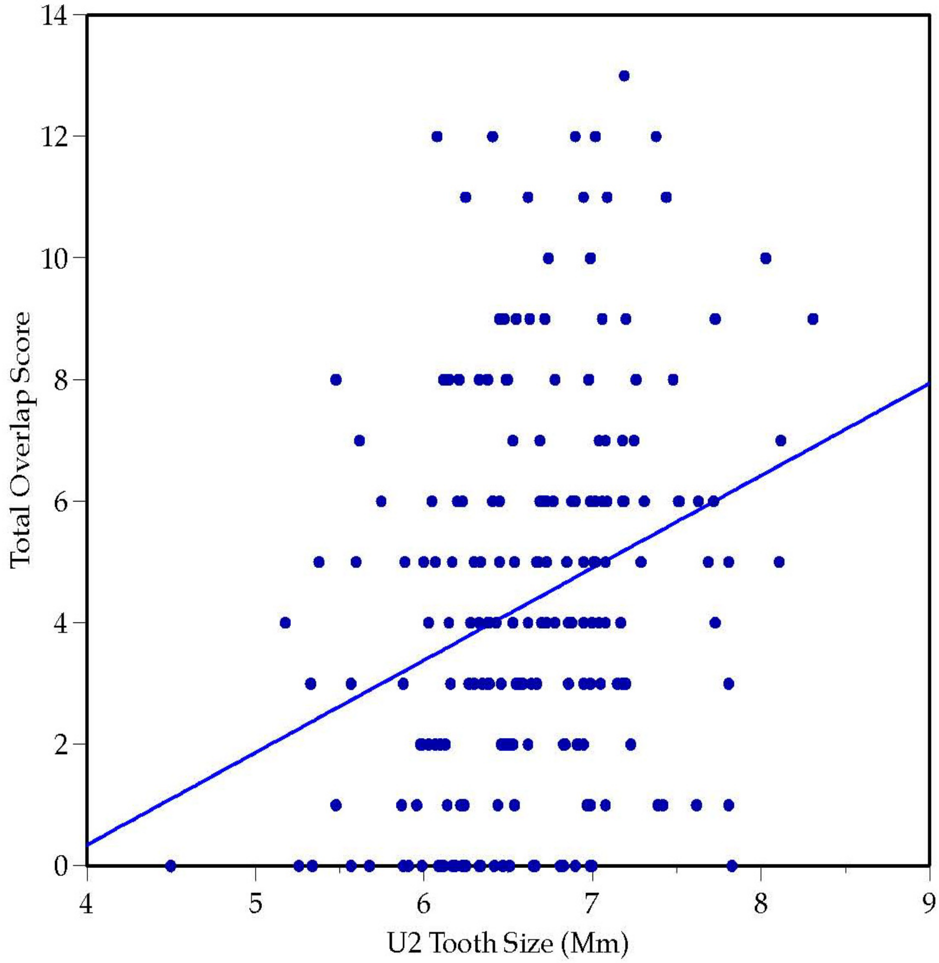

Figure 33. Plot between mediodistal tooth size of U2 and total overlap.

As tooth size increases, so does the average total overlap score.

factor for malpositional teeth but that the greater the crown size the greater the extent of the malpositions.

Total Displacements, Rotations, and Overlapping

This composite measure of three sorts of dental malocclusions is significantly associated with MD crown dimensions throughout most of the tooth row; of the seven teeth tested, only U5 and U7 have non-significant P-values; and these are suggestive (0.10 > P > 0.05). The stronger associations occur among the anterior tooth types, and the data are plotted for U1 (Figure 34), U2 (Figure 35), and U3 (Figure 36).

Crowding

Mesiodistal crown sizes are highly significantly predictive of crowding; the P-values are highly significant through all tooth types (excepting U7, where P = 0.03). The associations all are positive, meaning that larger crown sizes are associated with greater crowding. Examples are illustrated for U1 (Figure 37), U2 (Figure 38), U3 (Figure 39), and U4 (Figure 40).

Interdental Spacing

Interdental spacing is of particular interest here because it is the antithesis of the crowding just reviewed. With crowding, tooth sizes exceed the available arch size. With spacing, the opposite relationship occurs, where there is a deficiency of tooth size. Here, (1) the significant associations are widespread, involving all seven tooth types, and (2) the associations are negative. The negative associations are illustrated in Figure 41 (for U1), Figure 42 (for U2), Figure 43 (for U3), and Figure 44 (for U4). With smaller crown sizes there is greater spacing, so the associations are negative.

Midline Diastema

Both the typical width and the incidence of this feature diminish as mesiodistal crown width increases. Moreover, several tooth types (U1 through U5) are significantly predictive of diastema width. As examples, the relationship is evident for U1 (Figure 45), and for the canine (Figure 46), but also in the mid-arch such as the second premolar (Figure 47). The indication here is that small

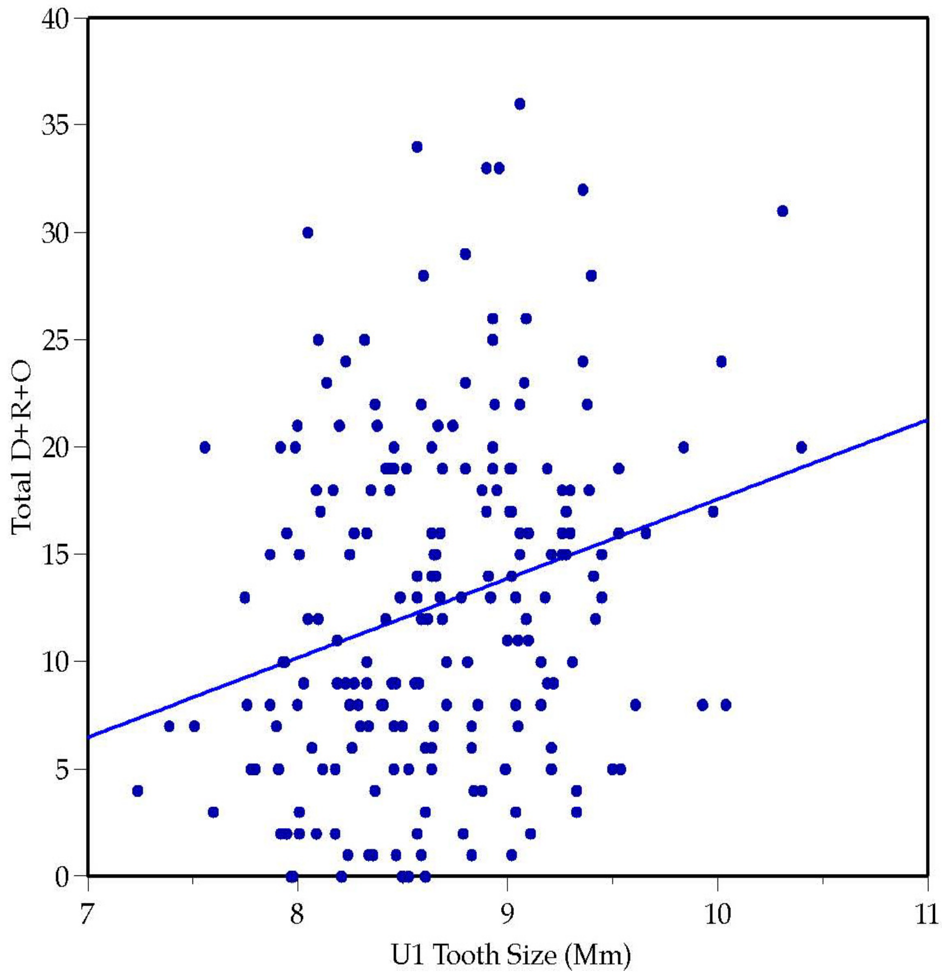

Figure 34. Plot between mesiodistal tooth size of U1 and total displacements plus rotations plus overlap.

As tooth size increases, so does the average total D+R+O score.

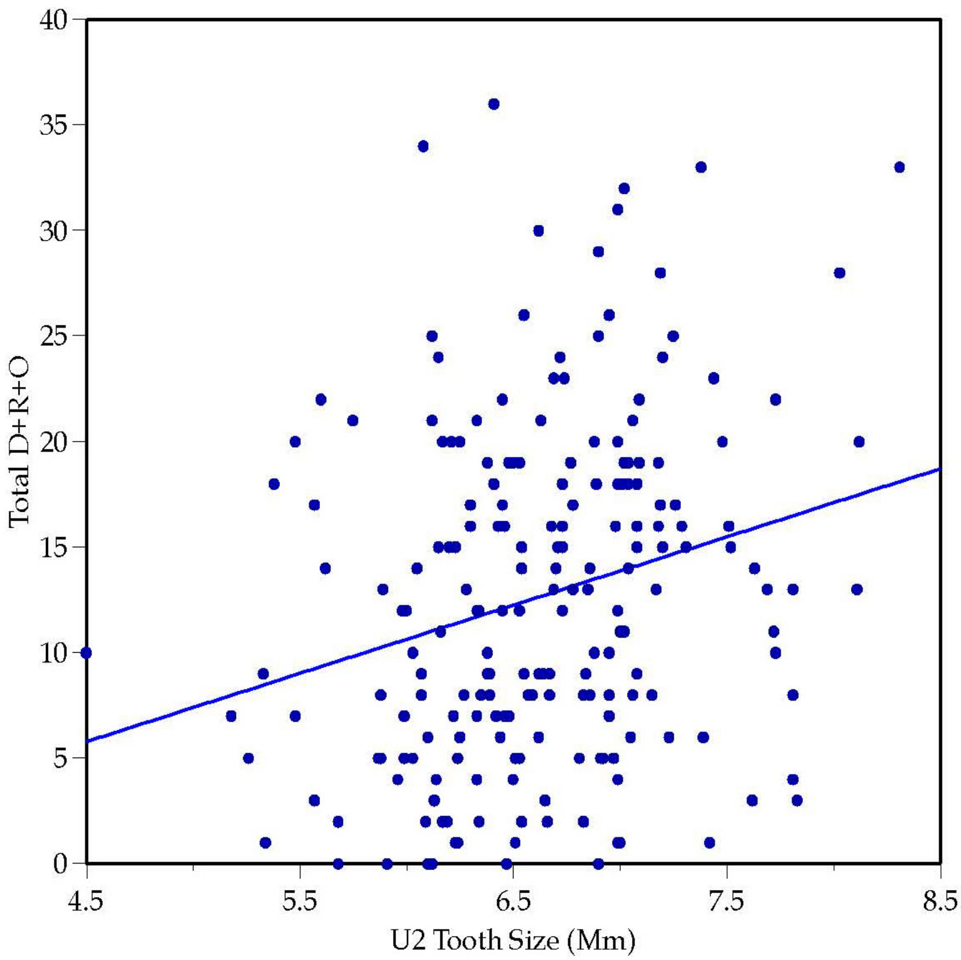

Figure 35. Plot between mesiodistal tooth size of U2 and total D+R+O scores.

As tooth size increases, so does the average total D+R+O score.

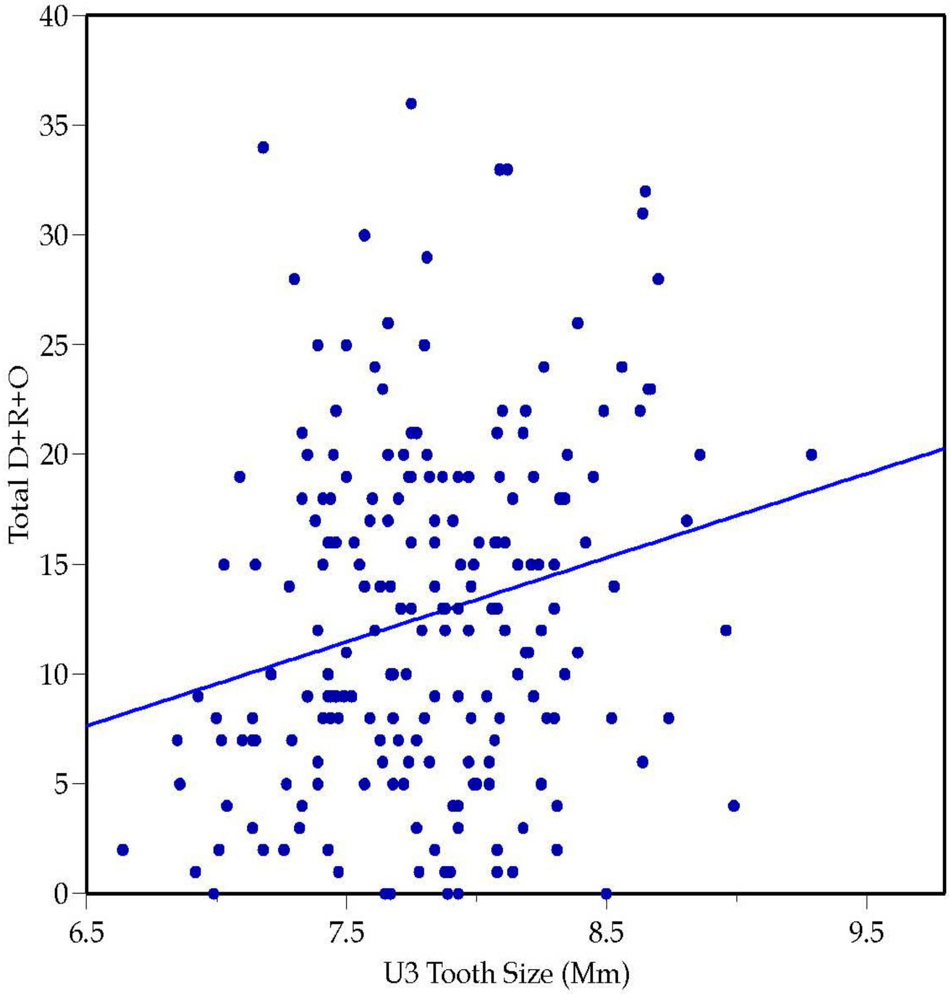

Figure 36. Plot between mesiodistal tooth size of U1 and total D+R+O scores.

As tooth size increases, so does the average total D+R+O

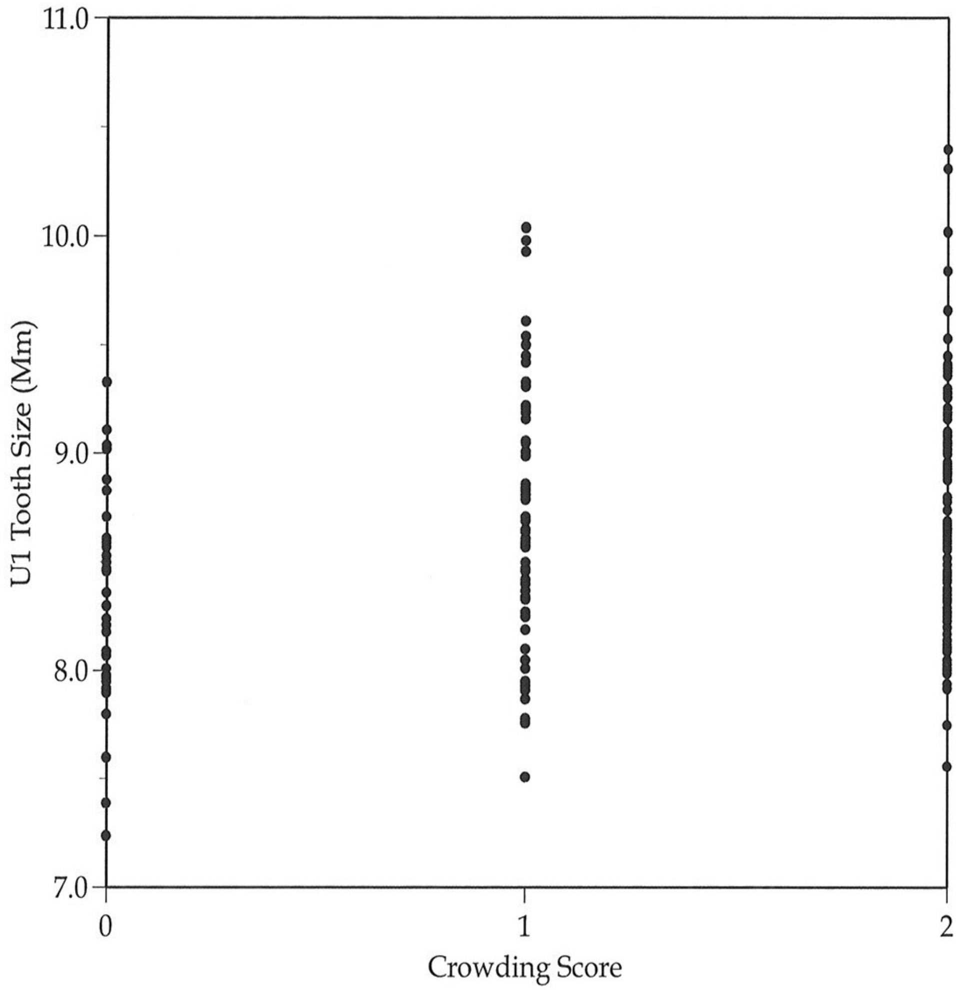

Figure 37. Plot between mesiodistal tooth size of U1 and crowding score.

As tooth size increases, average crowding also increases.

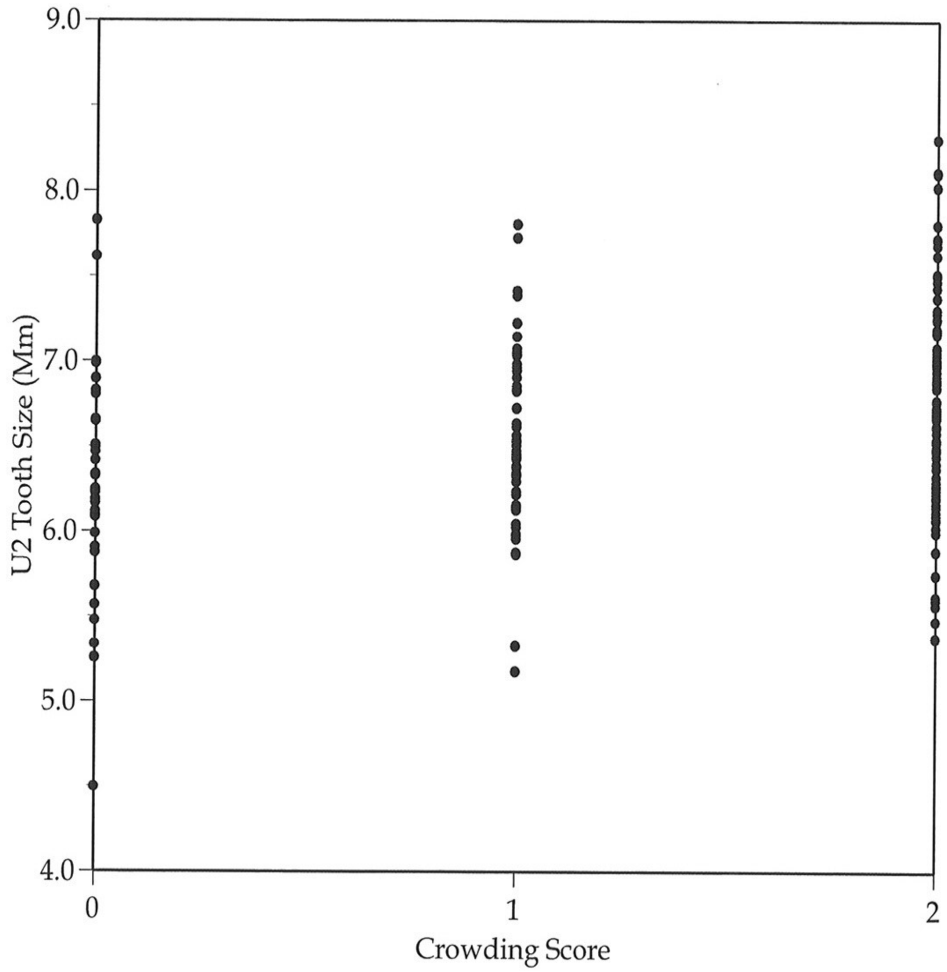

Figure 38. Plot between mesiodistal tooth size of U2 and crowding score.

As tooth size increases, average crowding also increases.

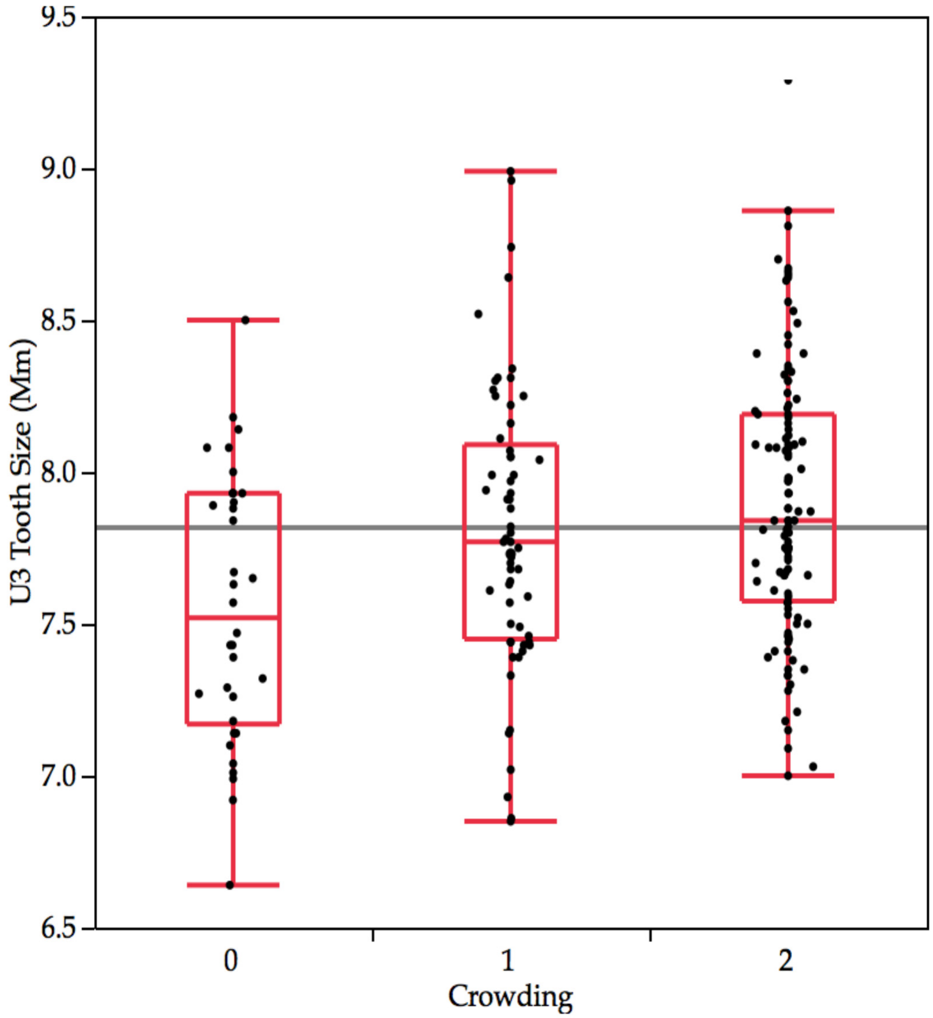

Figure 39. Plot between mesiodistal tooth size of U3 and crowding score.

As tooth size increases, average crowding also increases.

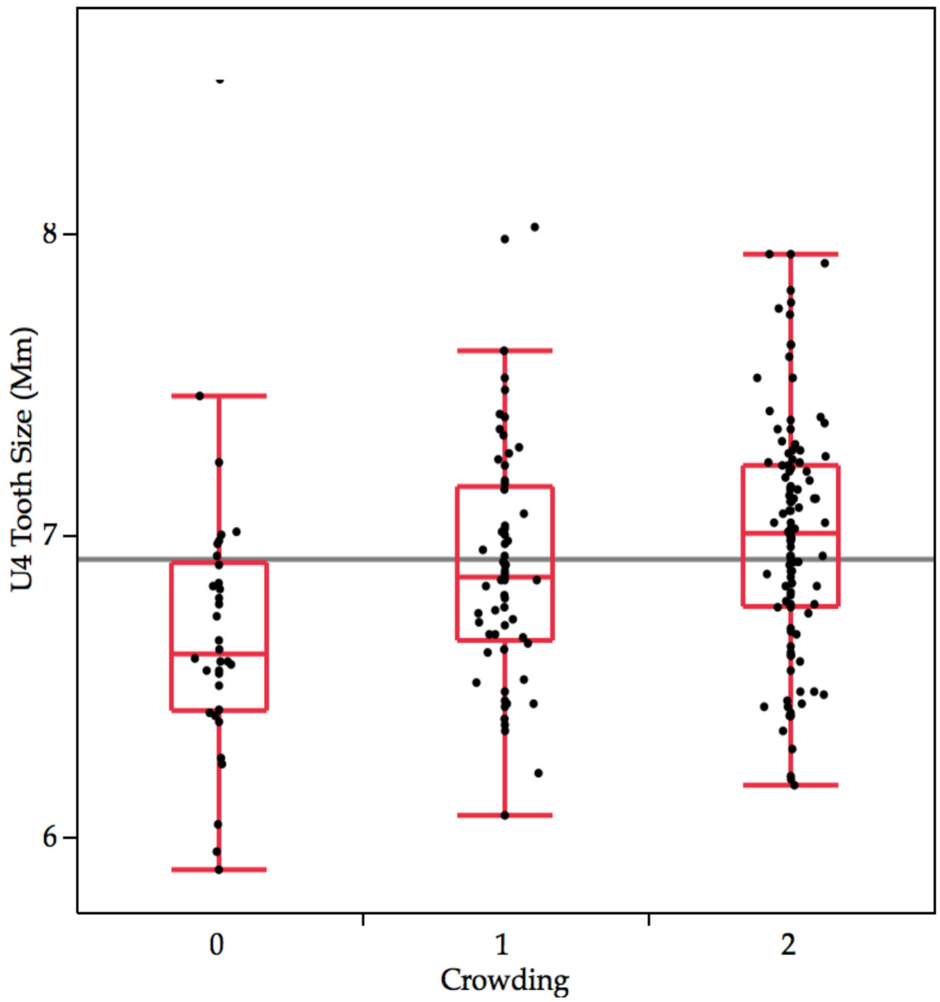

Figure 40. Plot between mesiodistal tooth size of U4 and crowding score.

As tooth size increases, average crowding also increases.

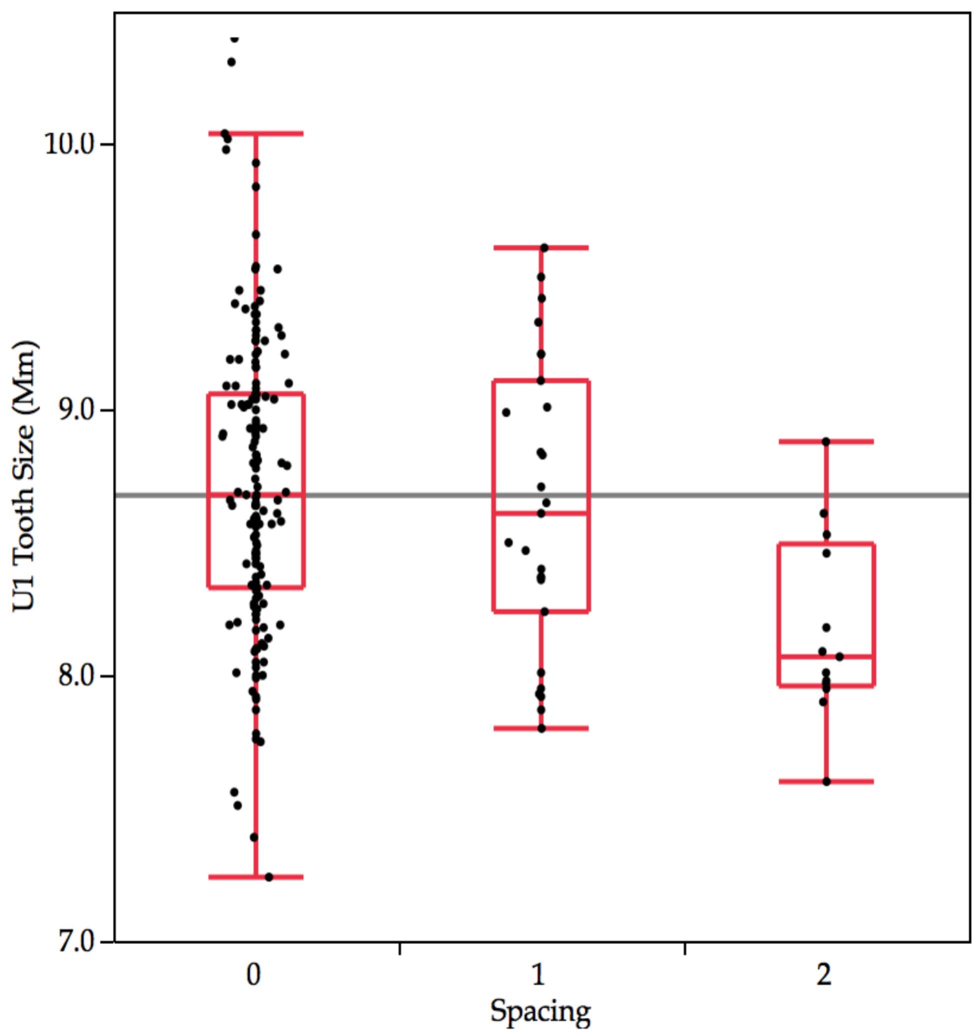

Figure 41. Plot between mesiodistal tooth size of U1 and spacing score.

As tooth size increases, average spacing decreases.

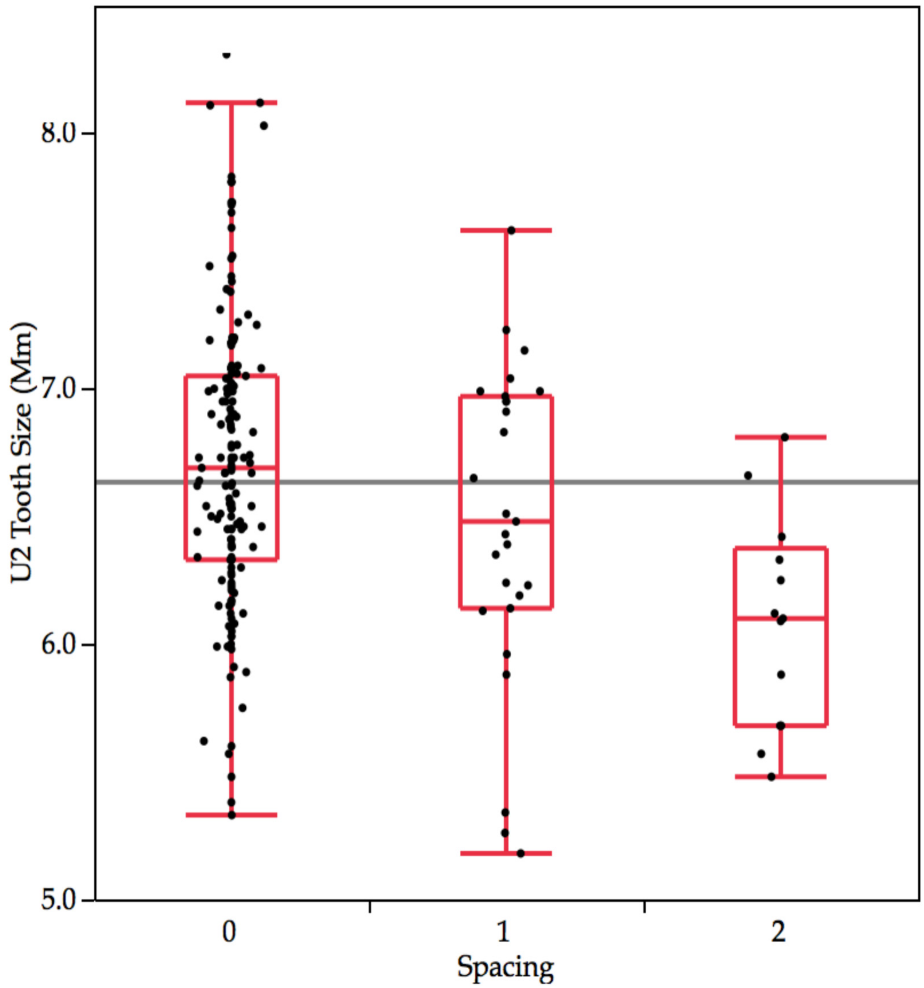

Figure 42. Plot between mesiodistal tooth size of U2 and spacing score.

As tooth size increases, average spacing decreases.

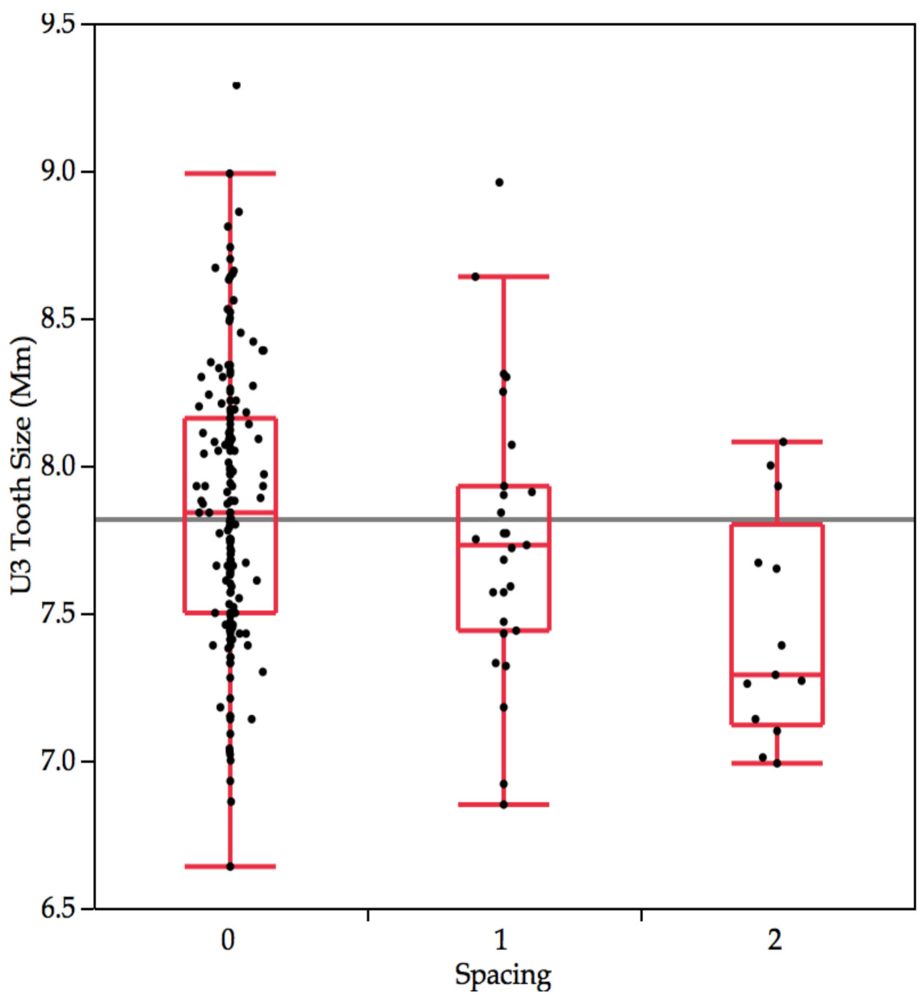

Figure 43. Plot between mesiodistal tooth size of U3 and spacing score.

As tooth size increases, average spacing decreases.

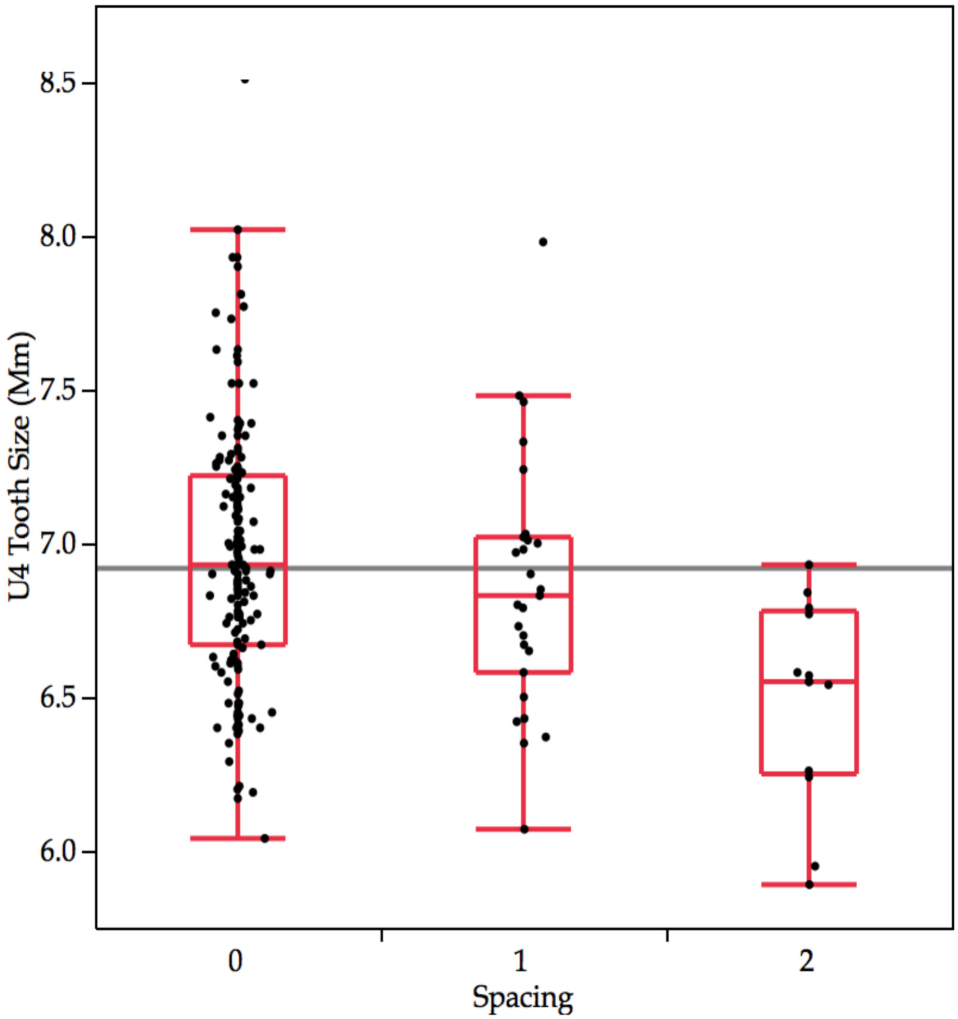

Figure 44. Plot between mesiodistal tooth size of U4 and spacing score.

As tooth size increases, average spacing decreases.

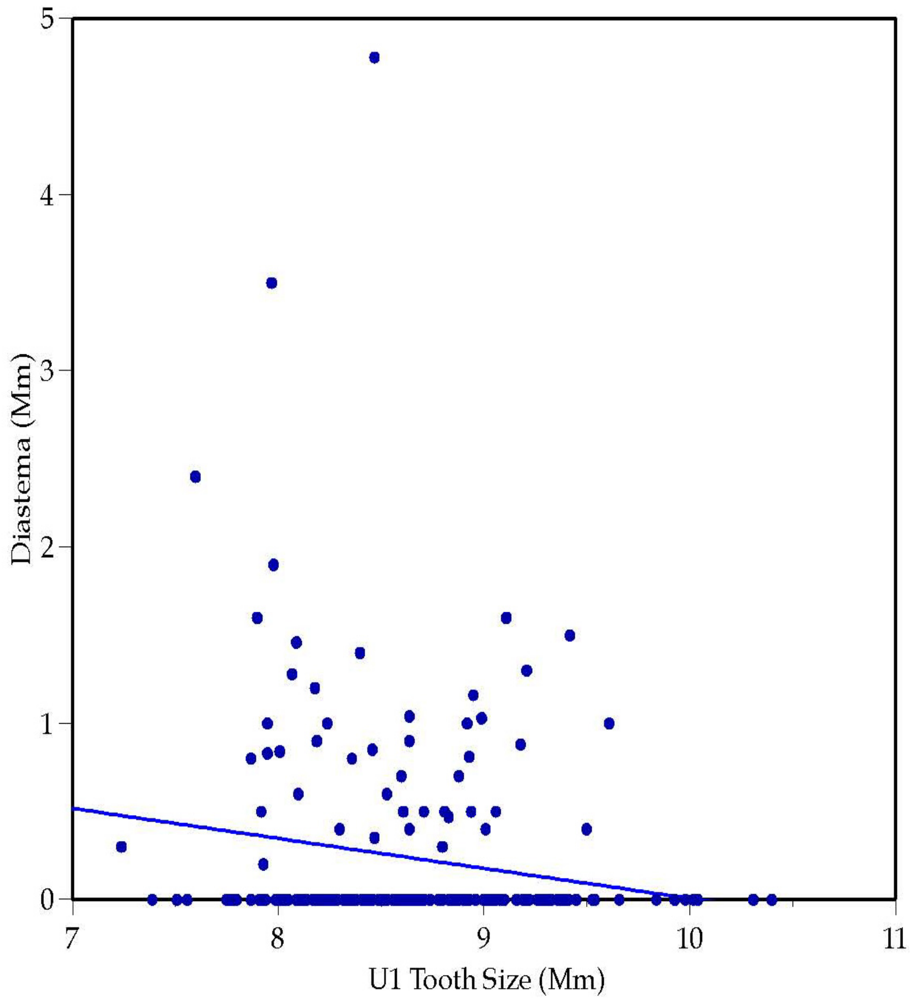

Figure 45. Plot between mesiodistal tooth size of U1 and diastema.

As tooth size increases, diastema spaces diminish.

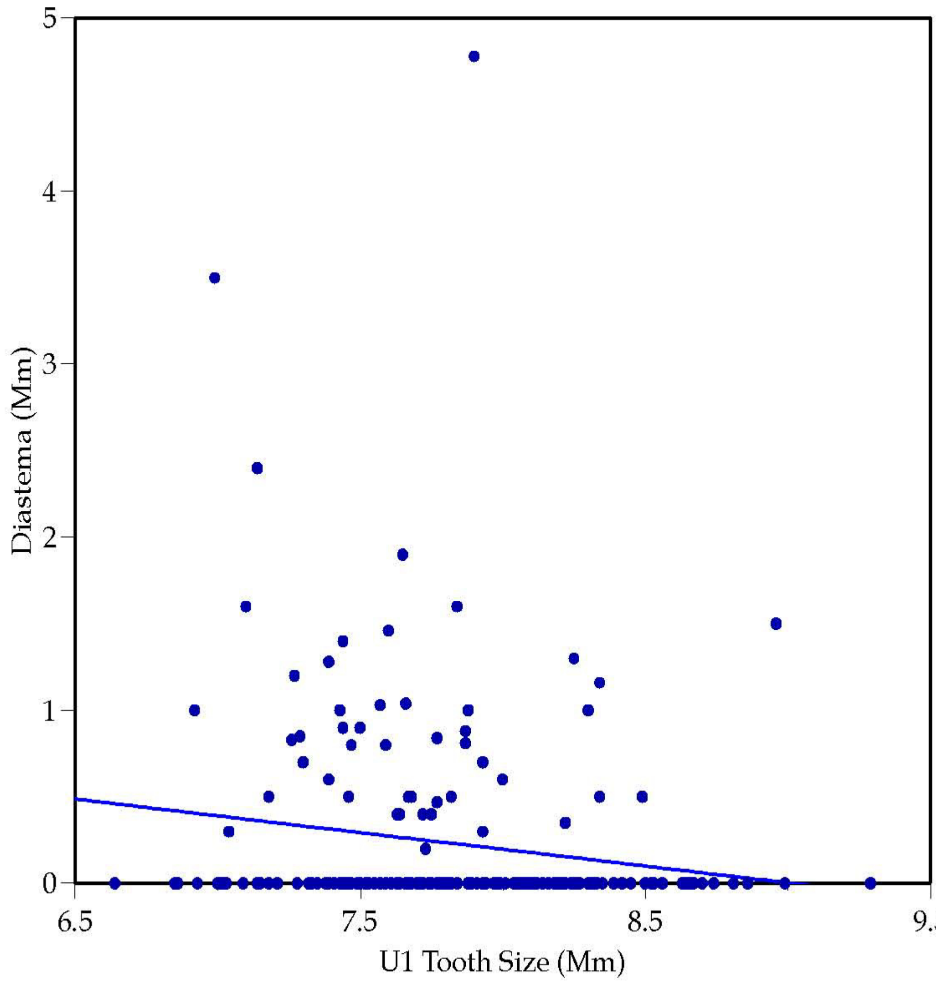

Figure 46. Plot between mesiodistal tooth size of U3 and diastema.

As tooth size increases, diastema spaces diminish.

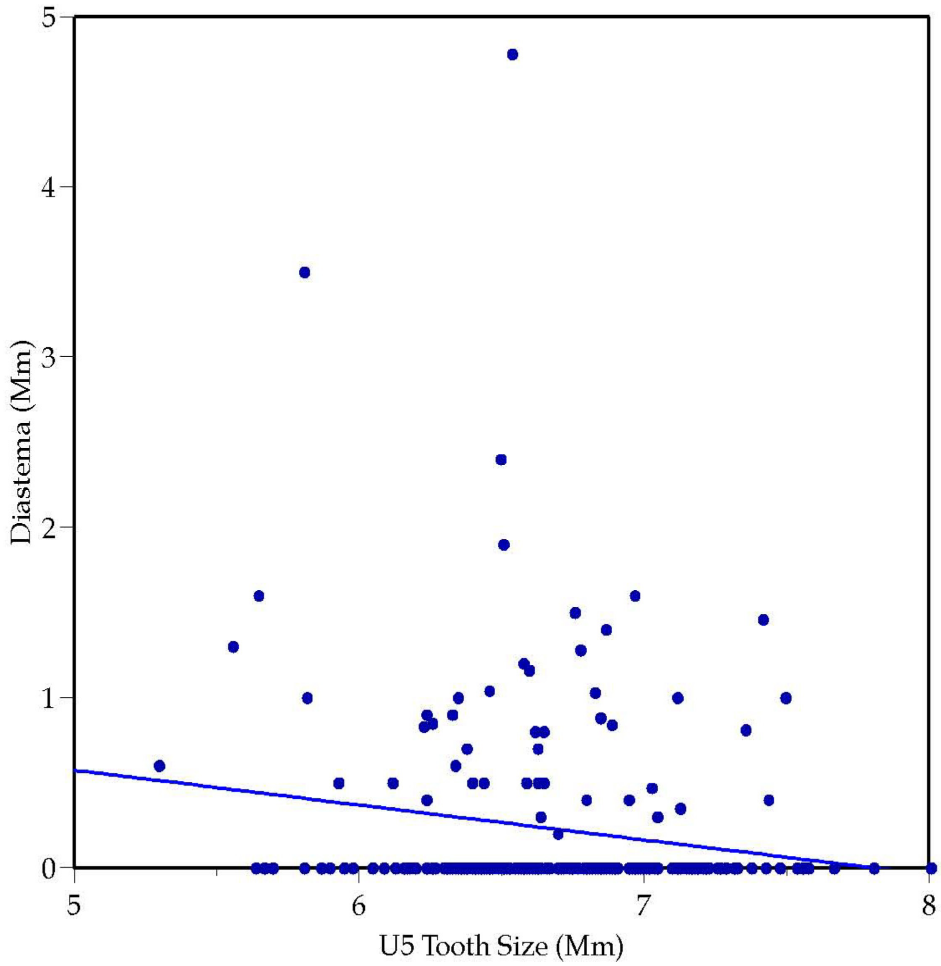

Figure 47. Plot between mesiodistal tooth size of U5 and diastema. As tooth size increases, diastema spaces diminish.

crowns “lend themselves” to arch length excesses, but as crowns get larger across the population distribution, arch length is at a premium and the size and incidence of diastemas decrease.

Maxillary Irregularity

There are several tooth types showing significant, positive associations between crown size and maxillary irregularity (Table 4), and the strongest relationships are for the anterior teeth. The relationship is graphed for U1 (Figure 48), U2 (Figure 49), U3 (Figure 50). Associations are weak or non-significant for the premolars and molars. Indeed, we suspect that the marginally significant situations (U6) may be indirect effects, where U6 size is positively correlated with U1 size, so both dimensions show a simple association with irregularity.

Mandibular Irregularity

Of the seven maxillary tooth types tested (Table 4), only U1 is strongly associated with incisor irregularity in the lower arch (Figure 51). The mode of operation between the arches may be that mesiodistally broad U1 also tend to be big faciolingually, which may tend to push the lower incisors out of alignment. Too, the scenario may be that large U1 tend to occur with large L1, which in turn increases the risk of lower incisor irregularity.

DAI Score

One might anticipate that this composite measure of esthetic dental problems (Jenny and Cons 1996) would be strongly and broadly intercorrelated with tooth crown dimensions, but it is not (Table 4). Indeed, only the central incisor (of the seven maxillary teeth) exhibits a significant association (Figure 52). The apparent reasons for the weak associations are twofold. One, the DAI is explicitly an esthetic index, so features are included that do not involve dental malocclusions. Mandibular overjet (*i.e.,* mandibular prognathism), anterior overbite, and AP (anterior-posterior) relationship are obvious cases in point since they are shown to be uncorrelated with crown size. Two, the DAI is a weighted index, and the weighting coefficients are based on a person’s esthetic conditions, not on dental malocclusions *per se*.

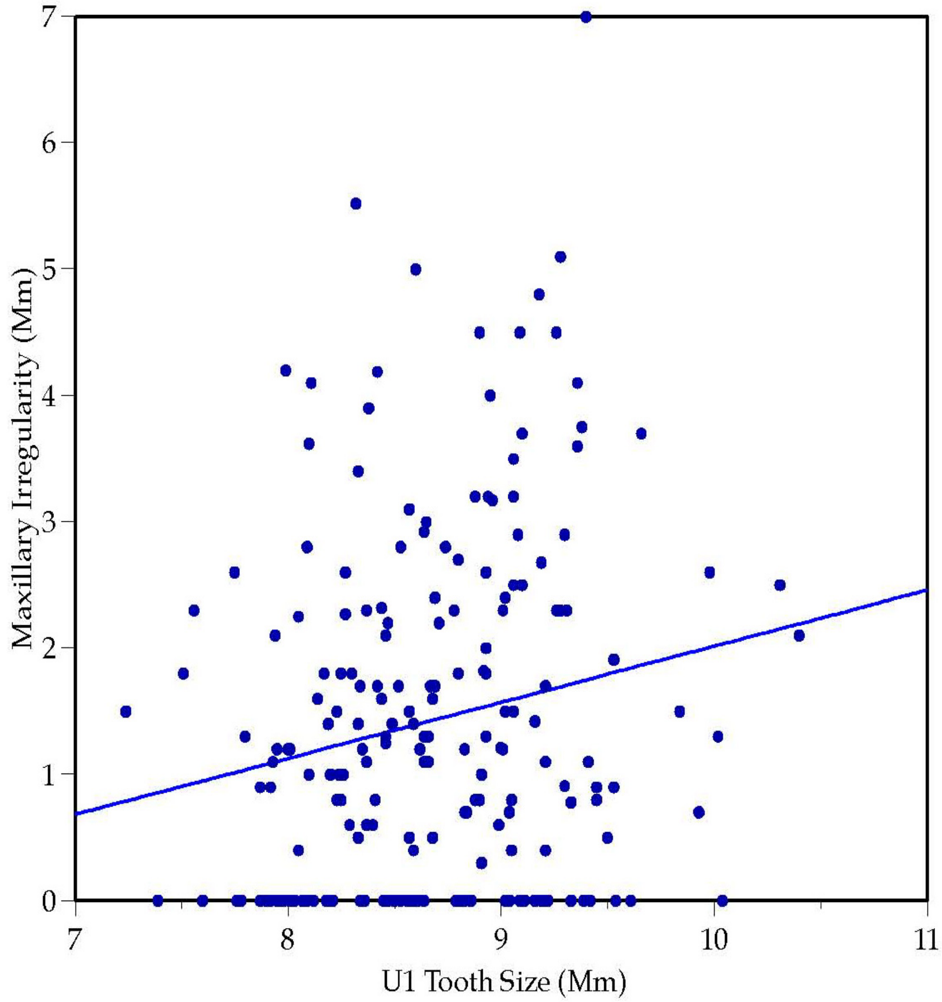

Figure 48. Plot between mesiodistal tooth size of U1 and maxillary irregularity.

As tooth size increases, so does maxillary irregularity.

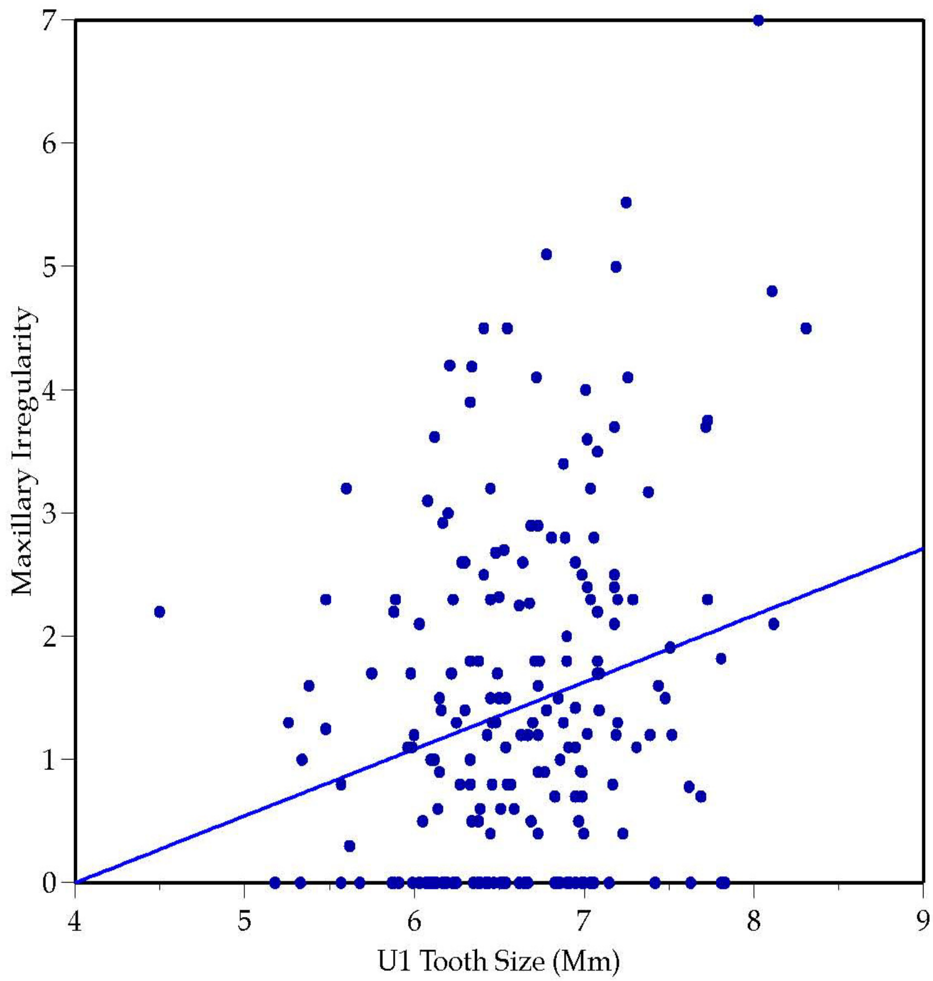

Figure 49. Plot between mesiodistal tooth size of U2 and maxillary irregularity.

As tooth size increases, so does maxillary irregularity.

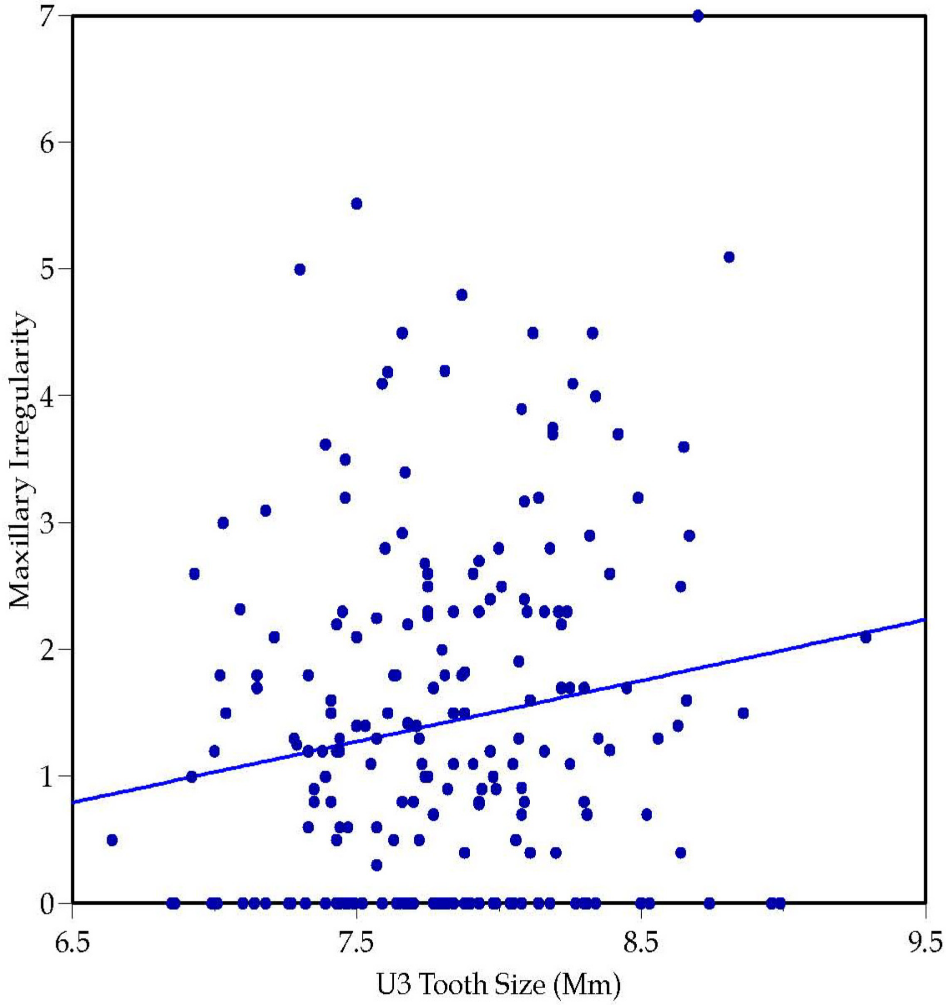

Figure 50. Plot between mesiodistal tooth size of U3 and maxillary irregularity.

As tooth size increases, so does maxillary irregulalrity.

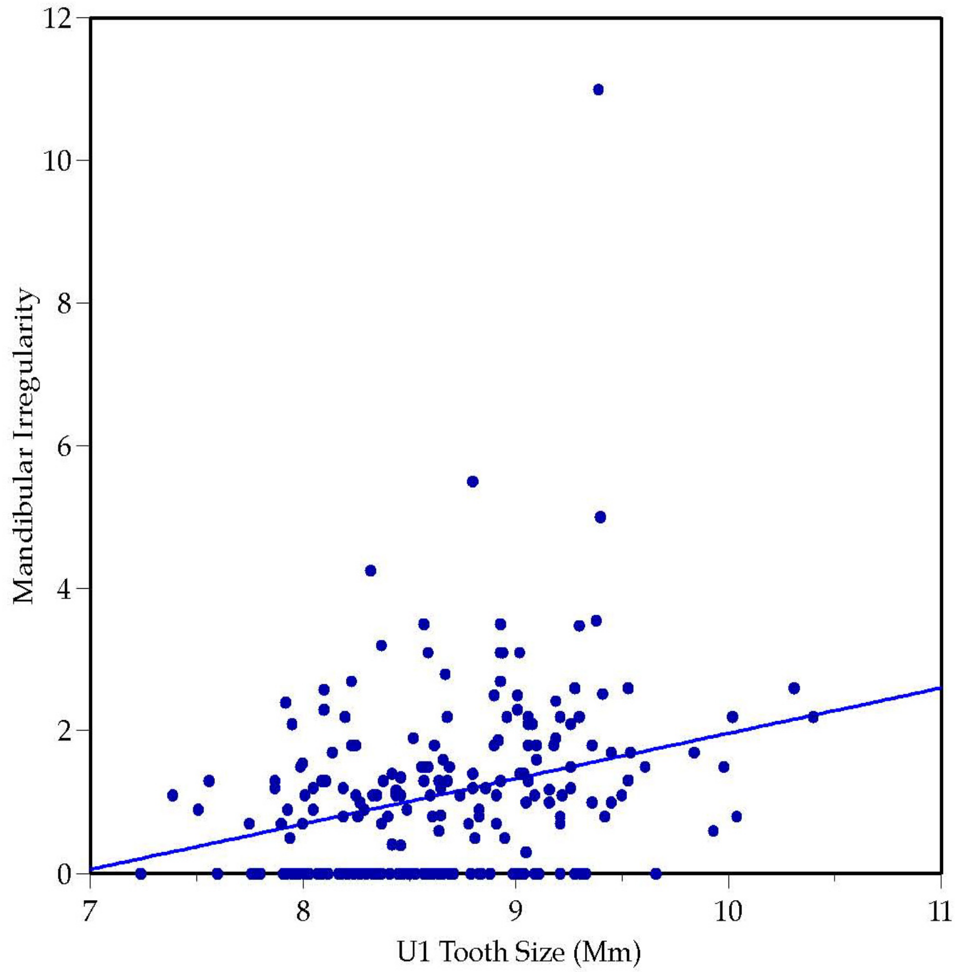

Figure 51. Plot between mesiodistal tooth size of U1 and mandibular irregularity.

As tooth size increases, so does irregularity of the lower arch.

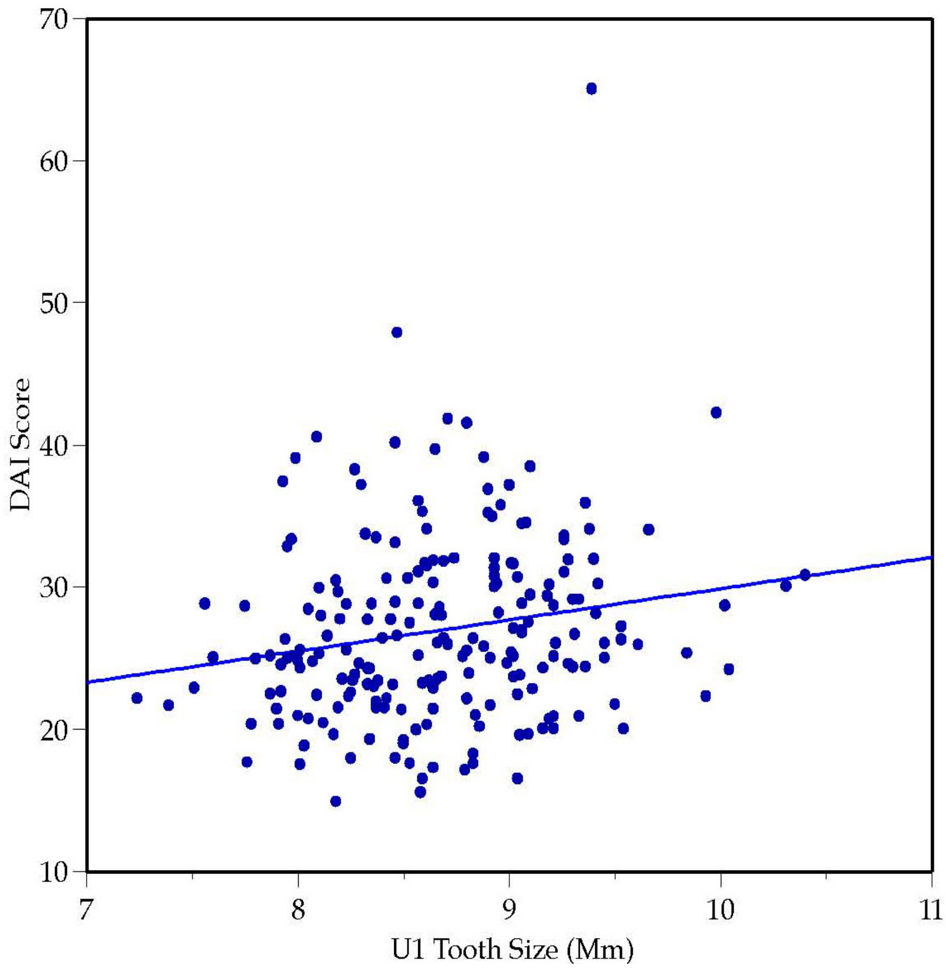

Figure 52. Plot between mesiodistal tooth size of U1 and DAI score.

As tooth size increases, so does the average DAI score.

Mandibular Tooth Types

A table of P-Values associated with the F-Ratios of the regression of occlusal status on mandibular mesiodistal tooth size is in Table 5. This parallels the findings for the maxillary teeth and, again, some generalities can be drawn. One, there are a fewer statistically significant associations here than for the maxillary variables, and the difference is primarily due to the lack of associations with the posterior teeth. Unlike the table of maxillary associations, significant relationships between crown size and occlusal variations are clustered in the anterior region of the arch. Two, the sources of malocculsions that depend primarily on relationships of the supporting bony structures (mandibular overjet, openbite, AP relationship) are seldom significantly correlated with crown size.

Total Displacements

There are highly significant, positive associations between anterior crown sizes and total displacement. This is evident for L1 (Figure 53) and L2 (Figure 54). Mesiodistally broader teeth are associated with greater displacement scores.

Total Rotations

Four of the seven associations are significant statistically, and the stronger associations are with L1 (Figure 55) and L2 (Figure 56). Also of the associations are positive: Broader tooth crowns are associated with greater rotation scores.

Total Overlapping

Significant, positive associations occur between tooth size and the extent of overlapping, particularly in the teeth of the anterior and mid-arch segments. The relationships are illustrated here for L1 (Figure 57) and L2 (Figure 58) where the associations are strongest.

Total Displacements, Rotations, and Overlapping

This composite of different sorts of malocclusions is positively associated with mesiodistal crown sizes in the mandible, especially for the incisors and canine. The strongest associations are for L1 (Figure 59) and L2 (Figure 60).

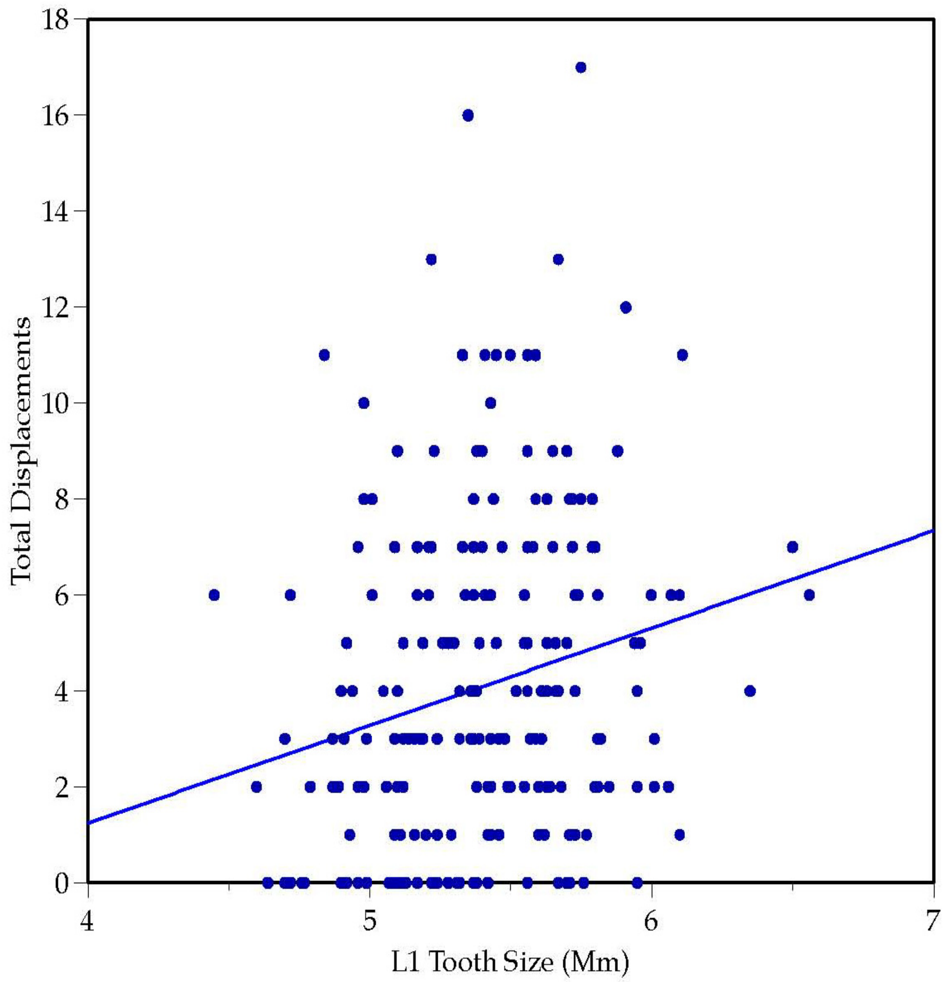

Figure 53. Plot between mesiodistal tooth size of L1 and total displacement score.

As tooth size increases, so does the average total displacement score.

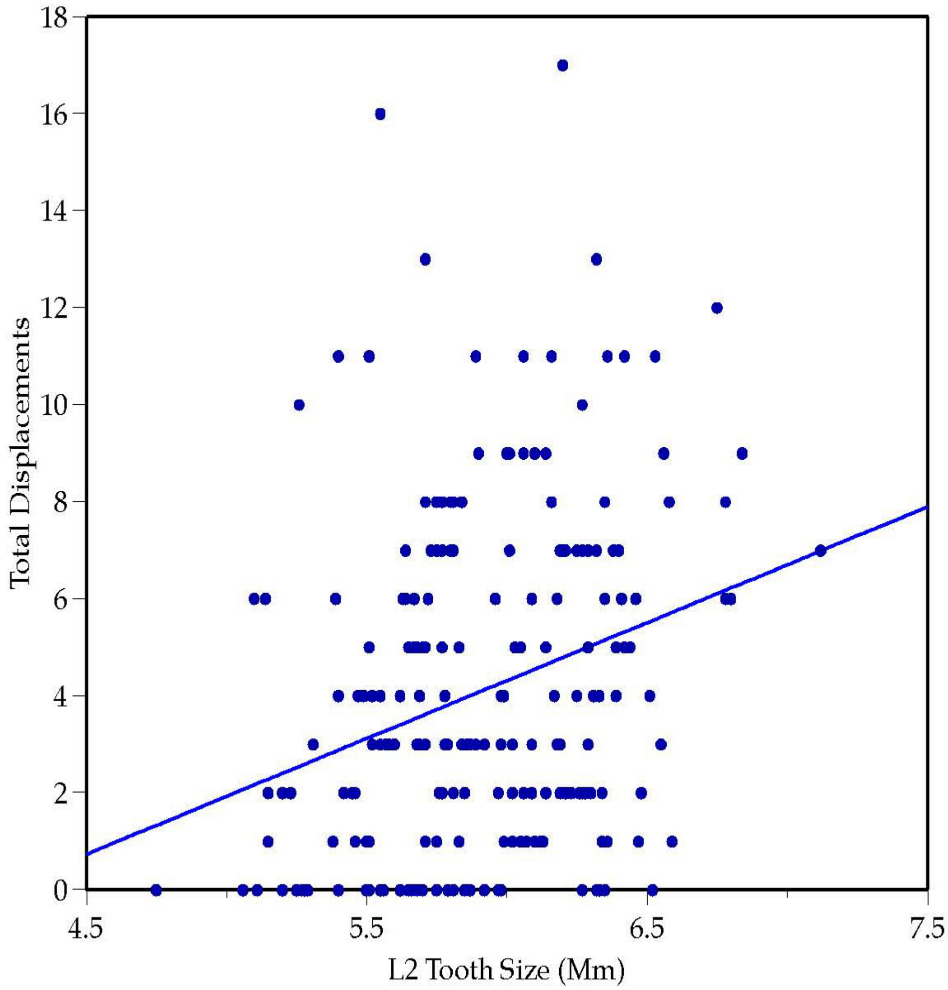

Figure 54. Plot between mesiodistal tooth size of L2 and total displacement score.

As tooth size increases, so does the average total displacement score.

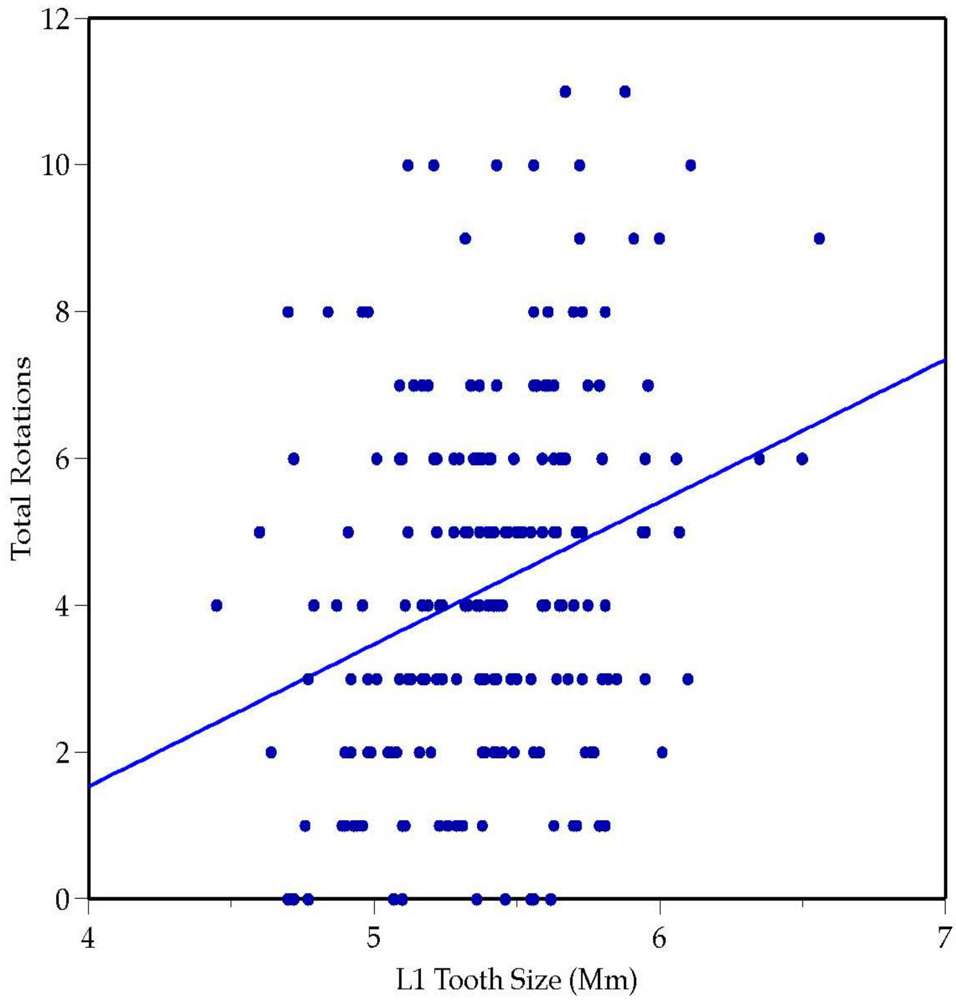

Figure 55. Plot between mesiodistal tooth size of L1 and total rotations.

As tooth size increases, so does the average total rotations.

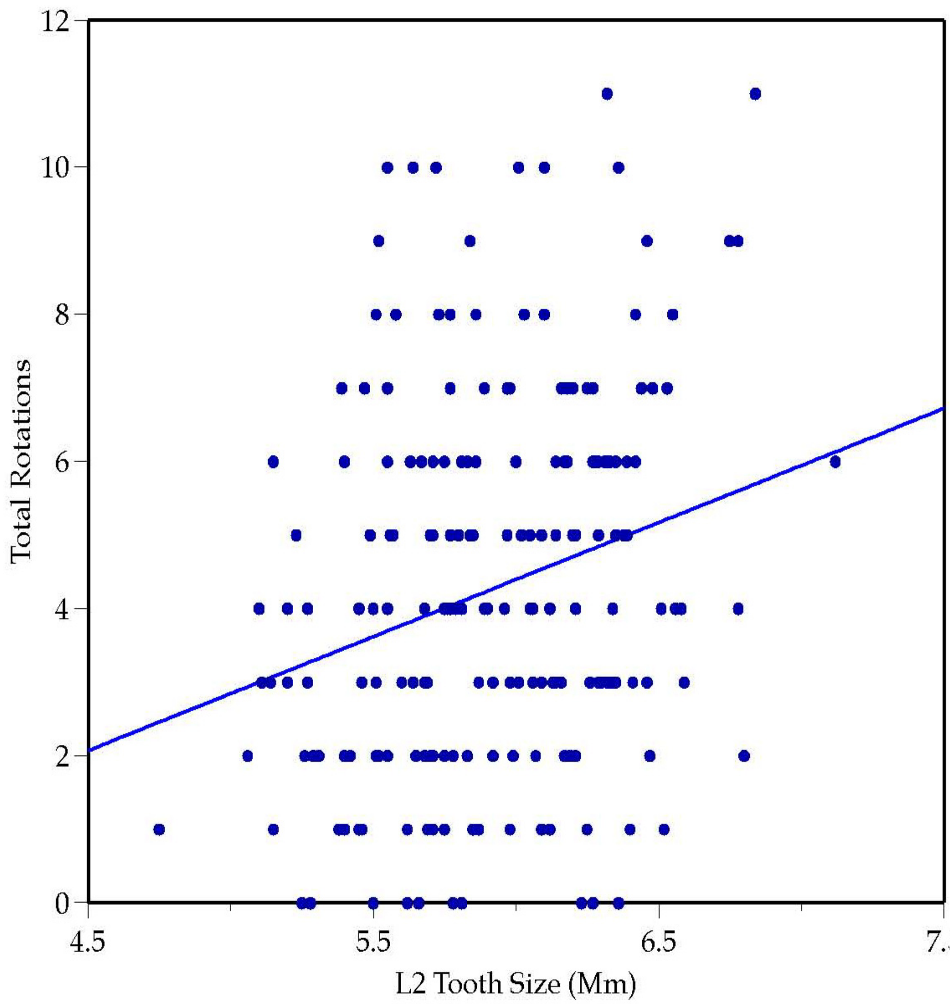

Figure 56. Plot between mesiodistal tooth size of L2 and total rotations.

As tooth size increases, so does the average total rotations.

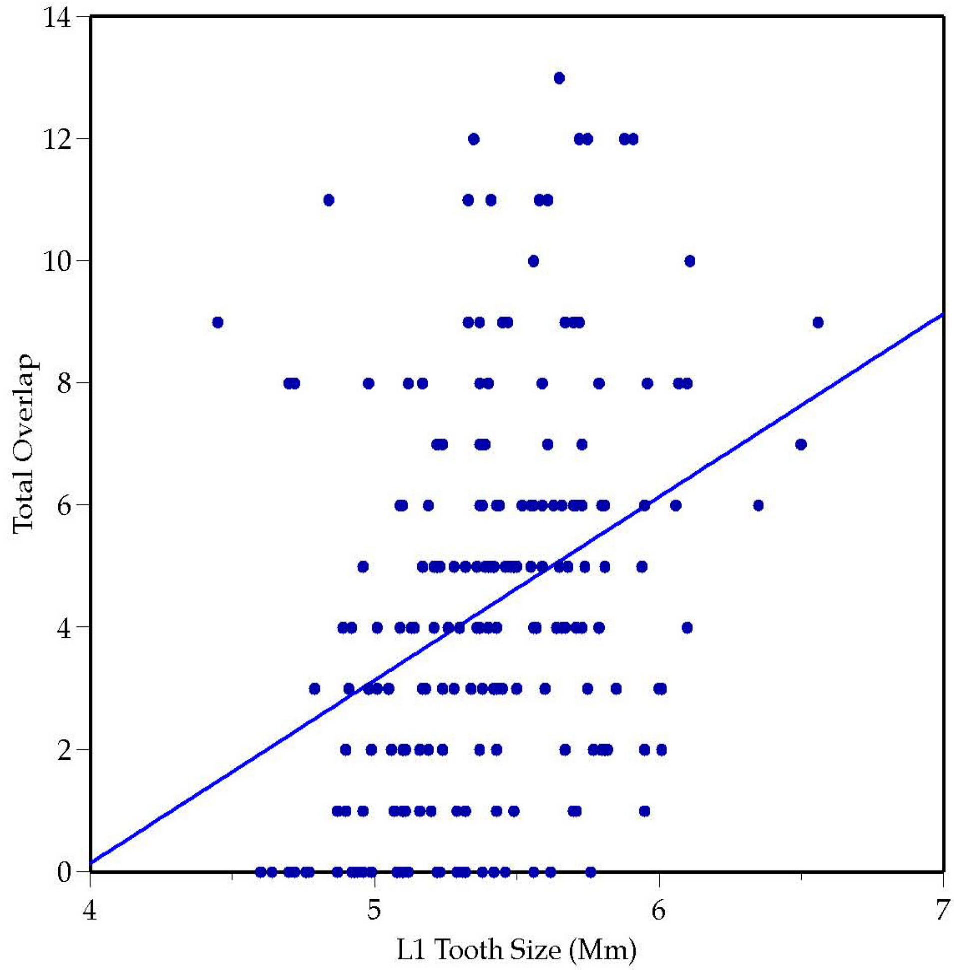

Figure 57. Plot between mesiodistal tooth size of L1 and total overlap.

As tooth size increases, so does the average total overlap score.

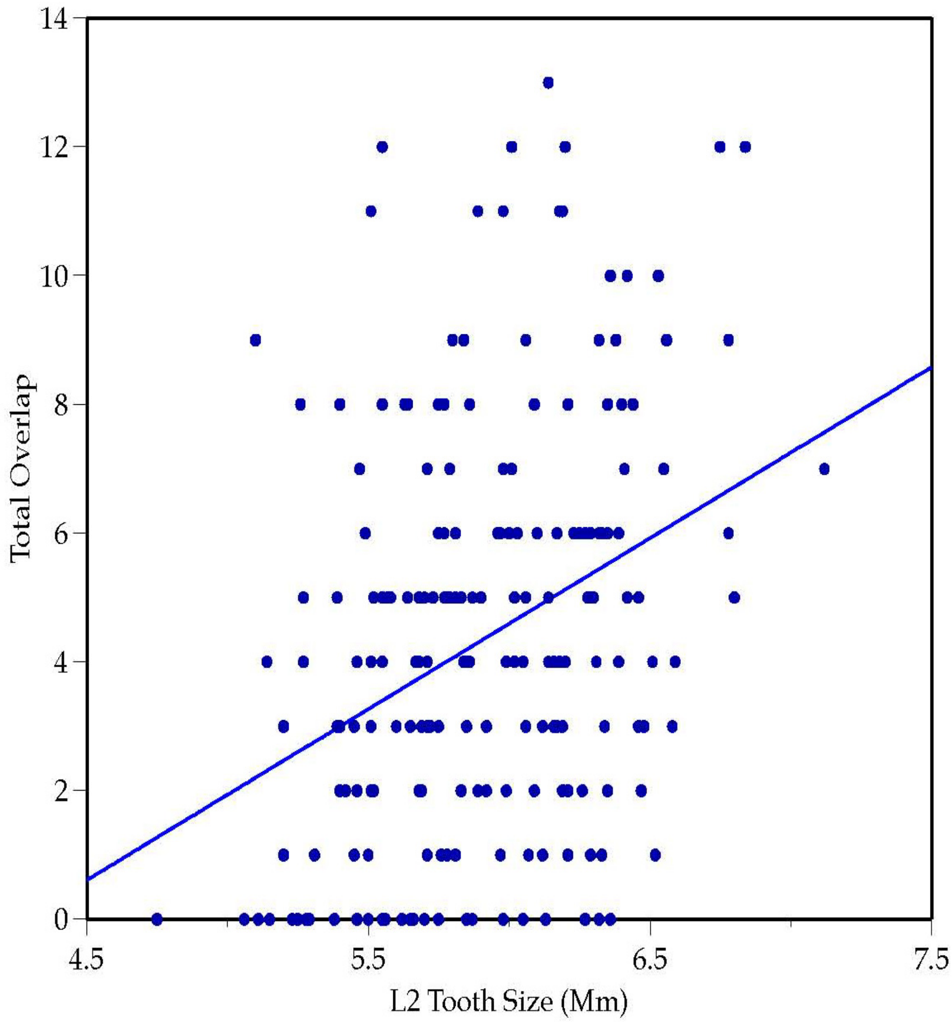

Figure 58. Plot between mesiodistal tooth size of L2 and total overlap.

As tooth size increases, so does the average total overlap score.

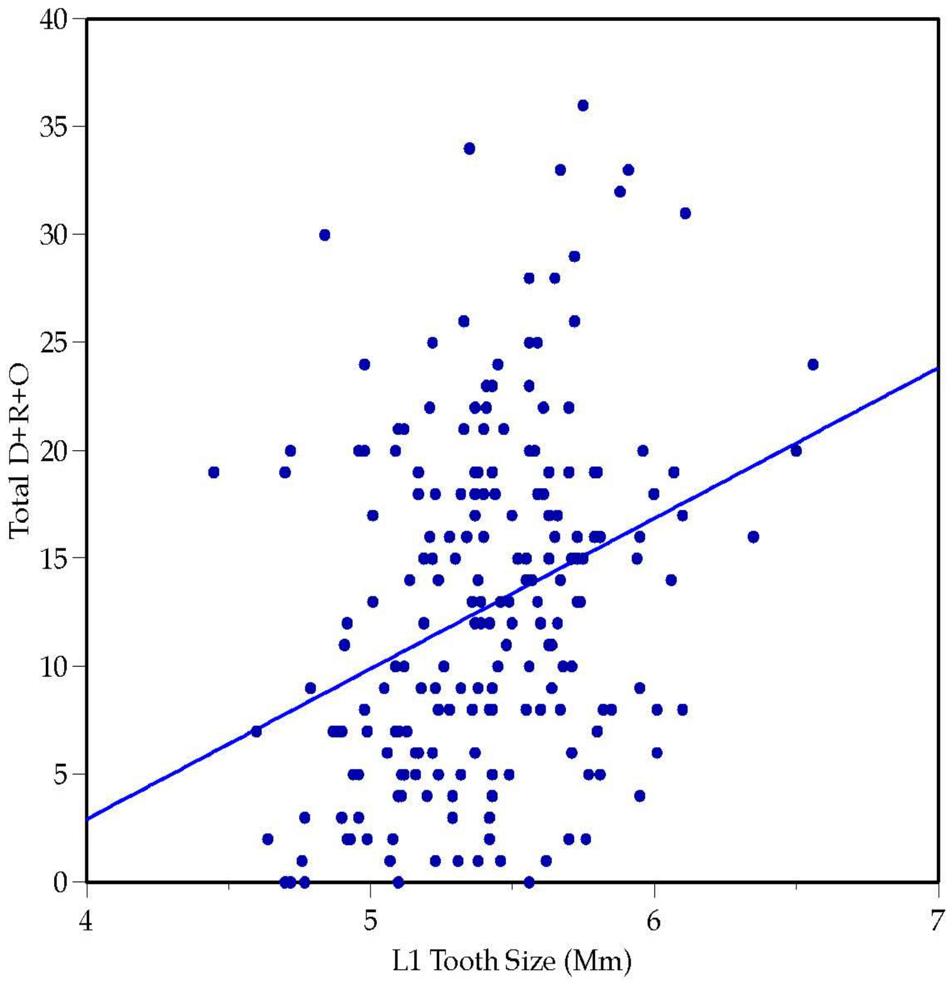

Figure 59. Plot between mesiodistal tooth size of L1 and total displacements plus rotations plus overlapping.

As tooth size increases so does the average total D+R+O score.

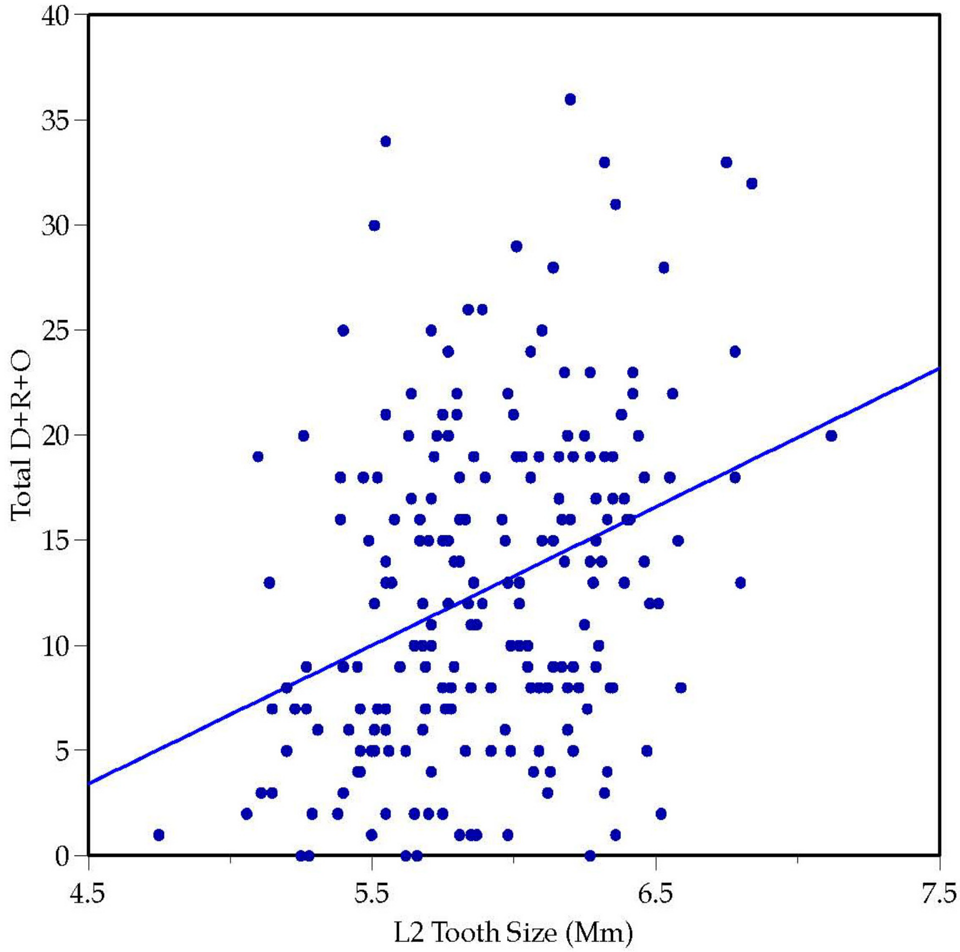

Figure 60. Plot between mesiodistal tooth size of L2 and total displacements plus rotations plus overlapping.

As tooth size increases, so does the average total D+R+O score.

Crowding

Highly significant, positive associations ($P < 0.0001$) occur between the extent of crowding and (1) L1 (Figure 61), (2) L2 (Figure 62), (3) L3 (Figure 63), and (4) L4 (Figure 64). Just as elsewhere, broader mesiodistal tooth crowns are associated with greater crowding. The three distal tooth types (L5, L6, L7) are comparatively weakly associated with this measure of crowding.

Spacing

Interdental spacing is unique among the mandibular variables tested in that (1) the associations with tooth size are negative and (2) all seven tooth types are highly significantly correlated with spacing. The relationships are negative (Figure 65 and 66) because the smaller the crown widths the greater the spacing tends to be.

It is fairly commonplace to find all seven tooth types significantly correlated with a measure of malocclusion in the maxillary (Table 4). The trend in the mandible (Table 5) is that the two molar tooth types are unrelated.

Diastema

The relationship for the diastema parallel that for interdental spacing: smaller crown sizes are associated with diastemas; larger teeth significantly deduce the likelihood of a diastema. In other words, the relationships are negative, and this is illustrated in Figure 67 (L1) and Figure 68 (L2).Comparable to the situation for spacing most of the seven tooth types exhibit a significant association with diastema. Perhaps this is due to the interrelationships across crown sizes (*e.g.*, Moorrees and Reed 1964), so some of the statistical associations may be indirect.

Maxillary Irregularity

There are highly significant, positive associations between mandibular incisor width, but teeth distal of the incisors are independent of irregularity. The association for L1 and irregularity is shown in Figure 69; that for L2 is shown in Figure 70.

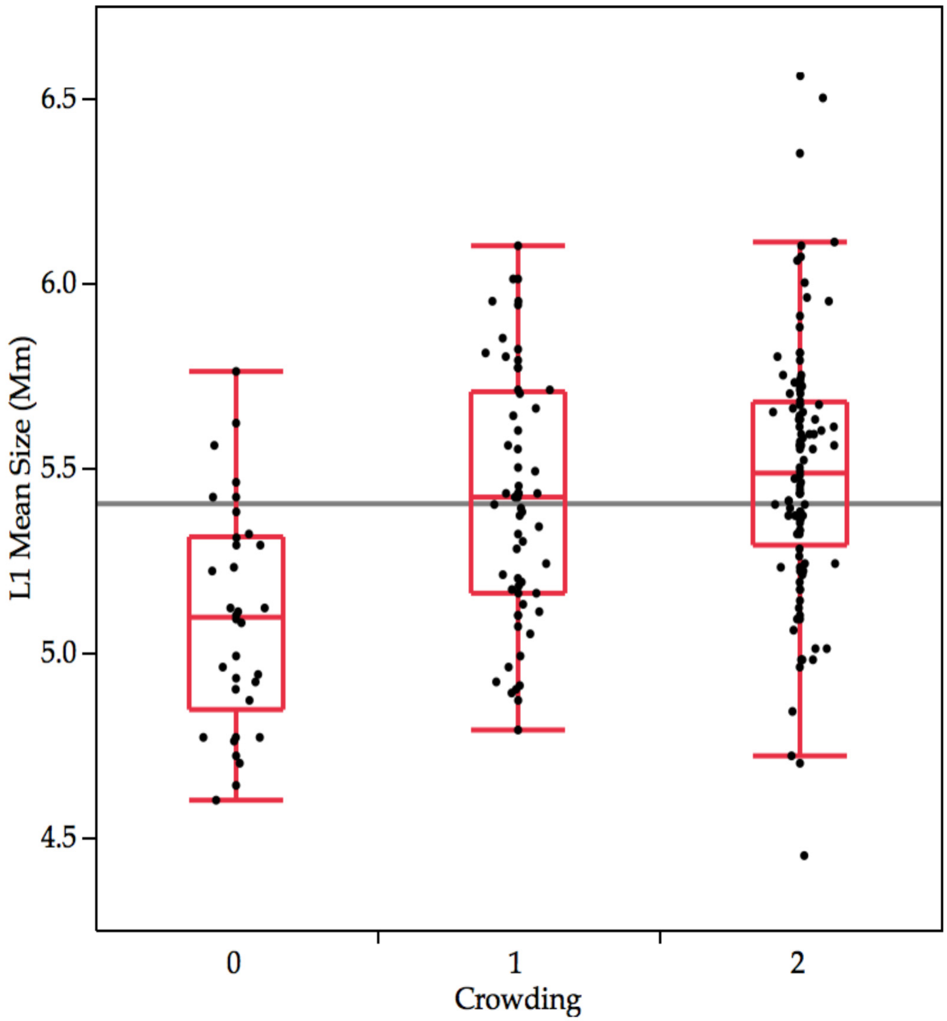

Figure 61. Plot between mesiodistal tooth size of L1 and crowding score.

As tooth size increases, average crowding also increases.

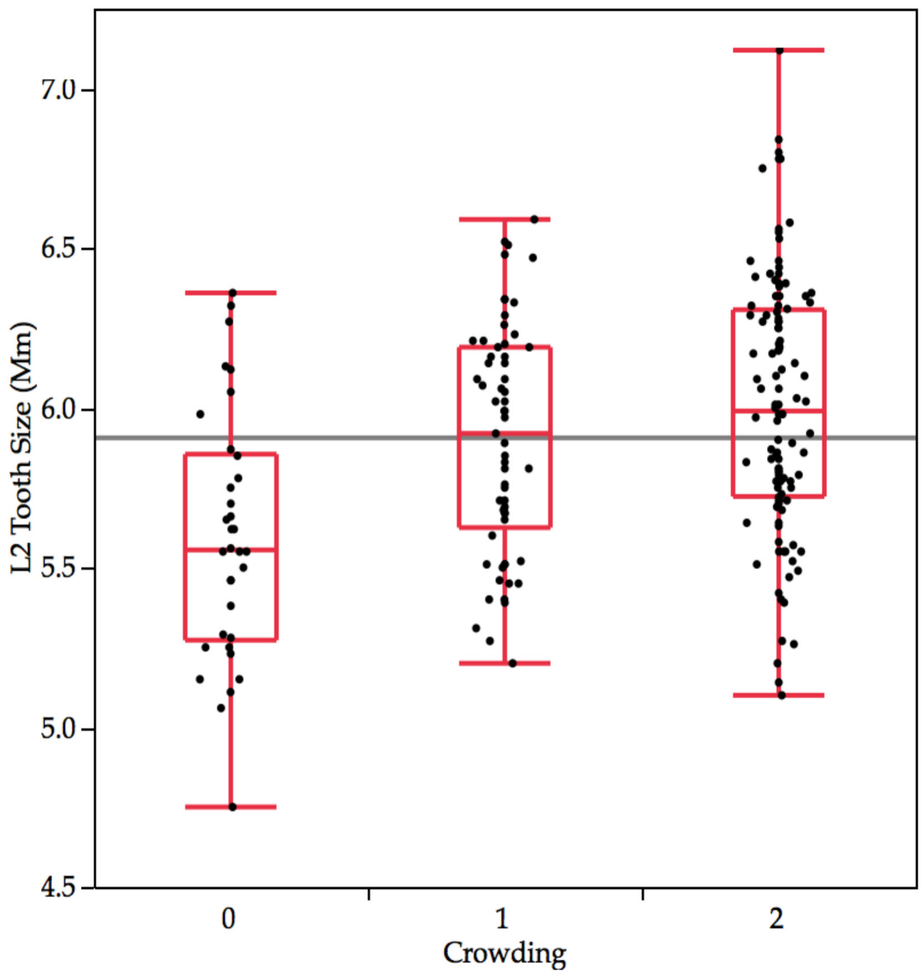

Figure 62. Plot between mesiodistal tooth size of L2 and crowding score.

As tooth size increases, average crowding also increases.

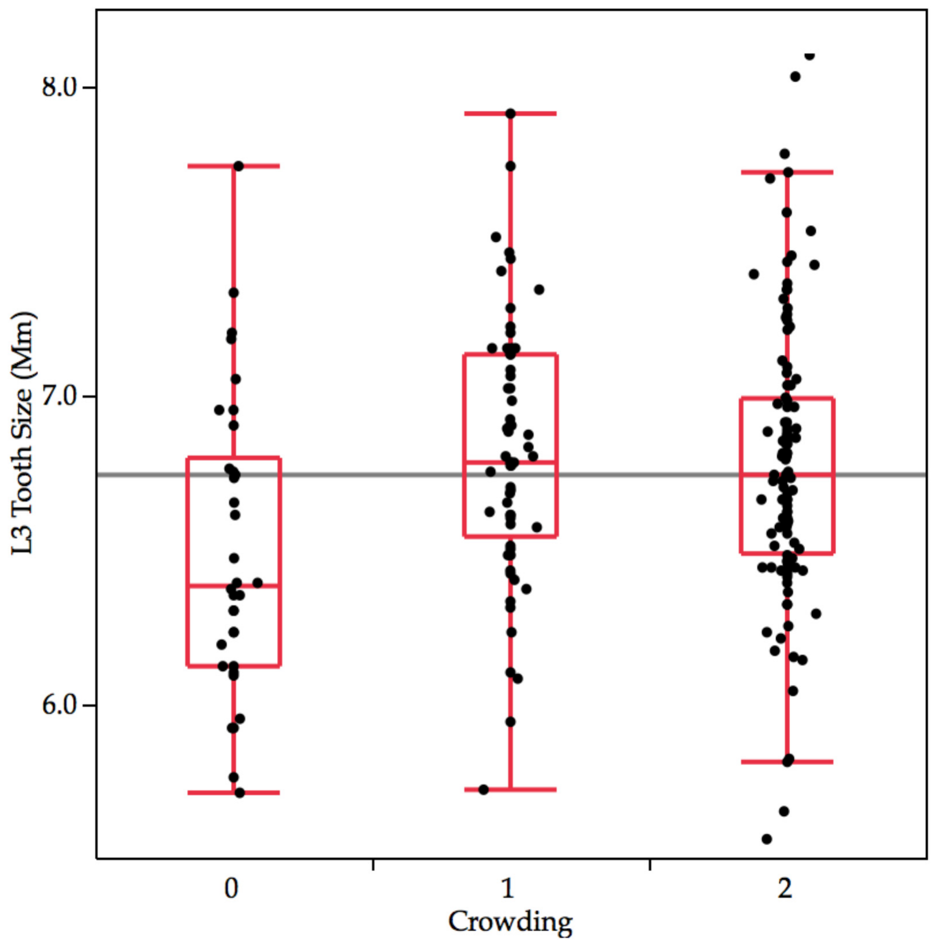

Figure 63. Plot between mesiodistal tooth size of L3 and crowding score.

As tooth size increases, average crowding also increases.

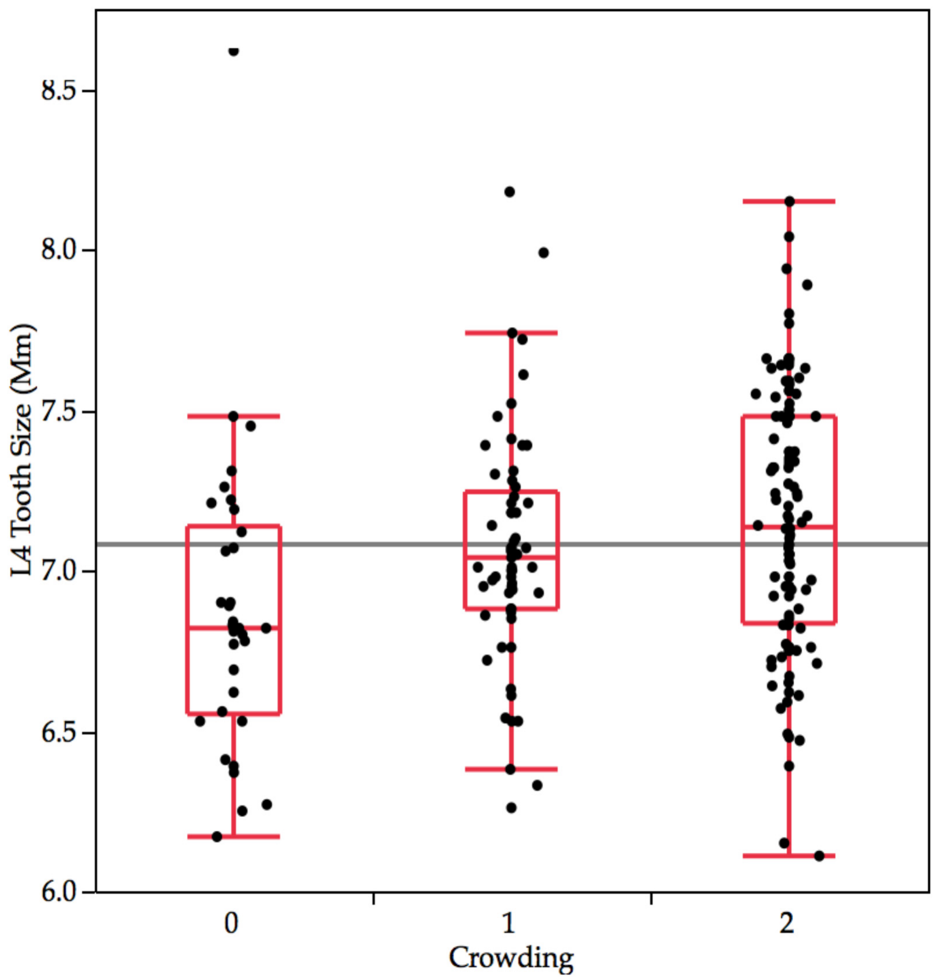

Figure 64. Plot between mesiodistal tooth size of L4 and crowding score.

As tooth size increases, average crowding also increases.

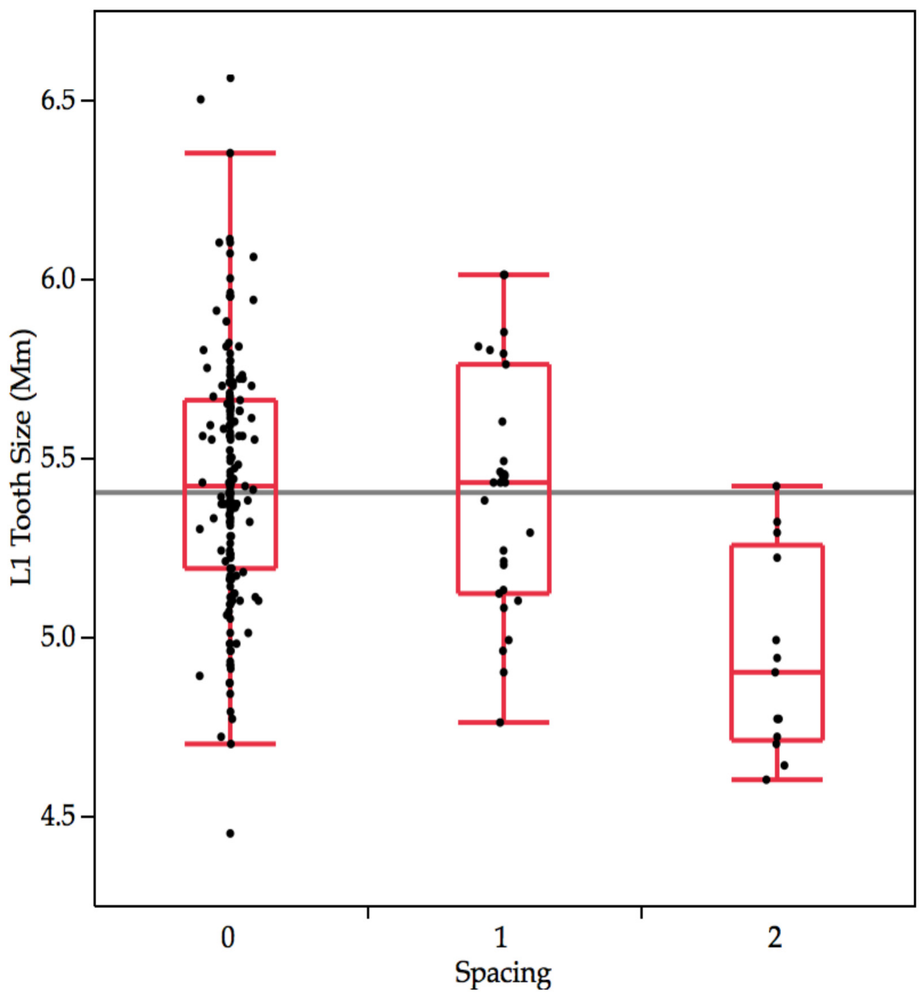

Figure 65. Plot between mesiodistal tooth size of L1 and spacing score.

As tooth size increases, average spacing decreases.

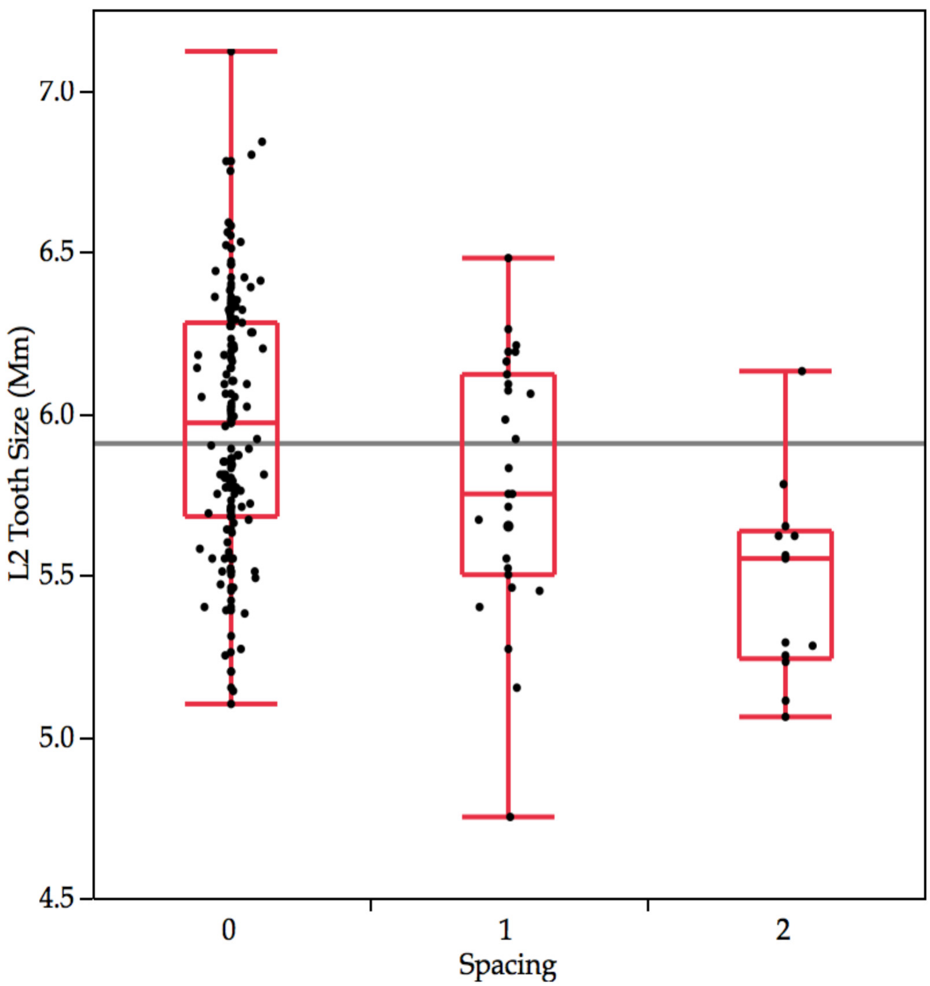

Figure 66. Plot between mesiodistal tooth size of L2 and spacing score.

As tooth size increases, average spacing decreases.

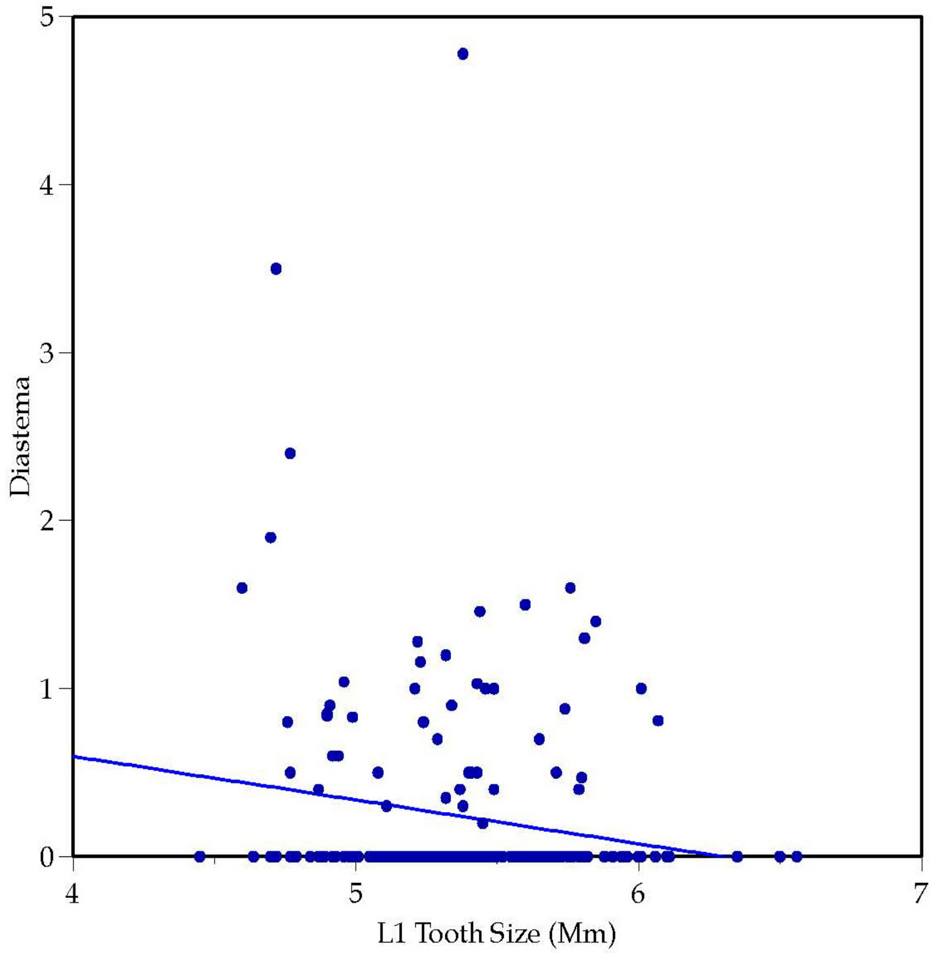

Figure 67. Plot between mesiodistal tooth size of L1 and diastema.

As tooth size increases, average diastema diminishes.

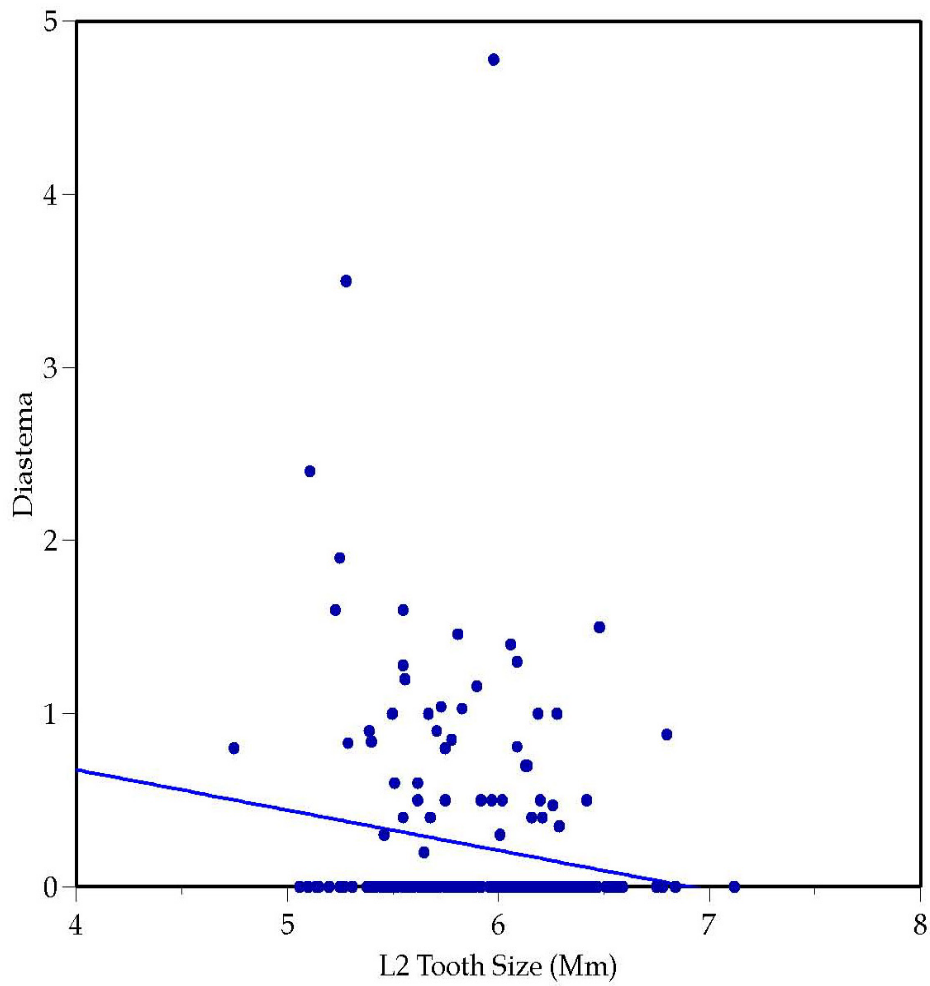

Figure 68. Plot between mesiodistal tooth size of L2 and diastema.

As tooth size increases, average diastema diminishes.

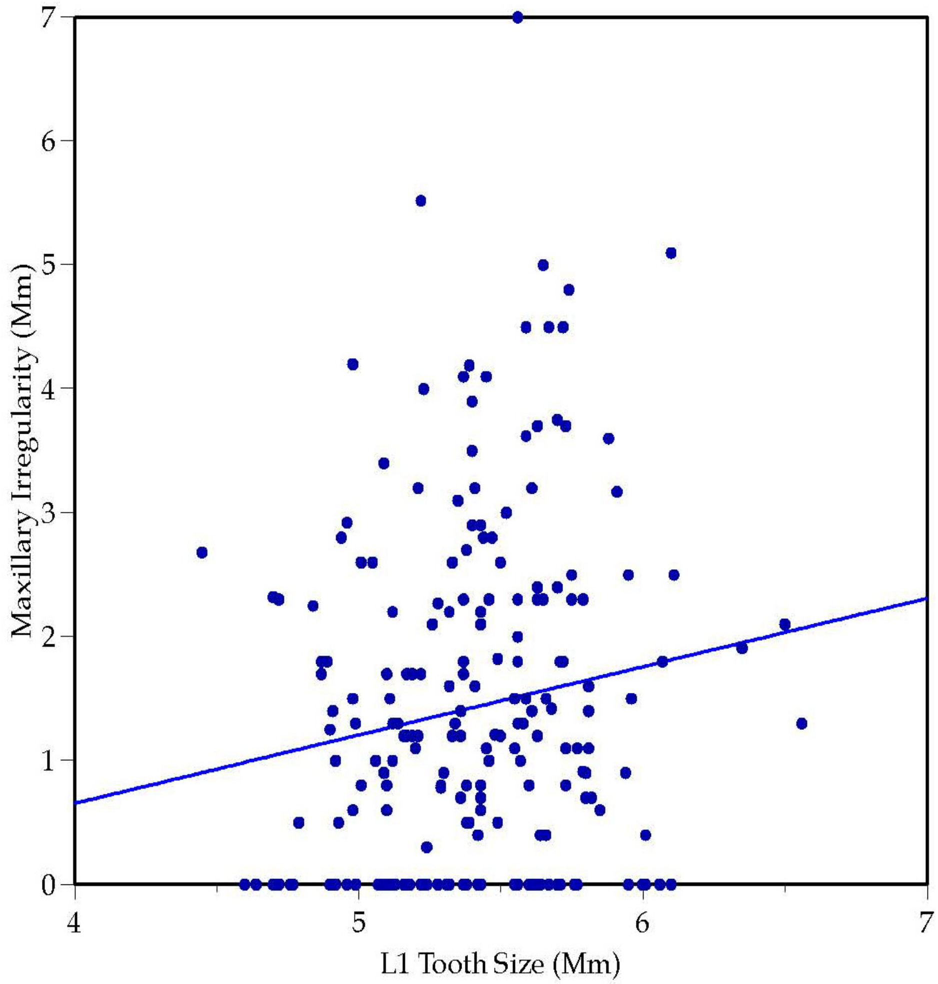

Figure 69. Plot between mesiodistal tooth size of L1 and maxillary irregularity.

As tooth size increases, so does the typical irregularity.

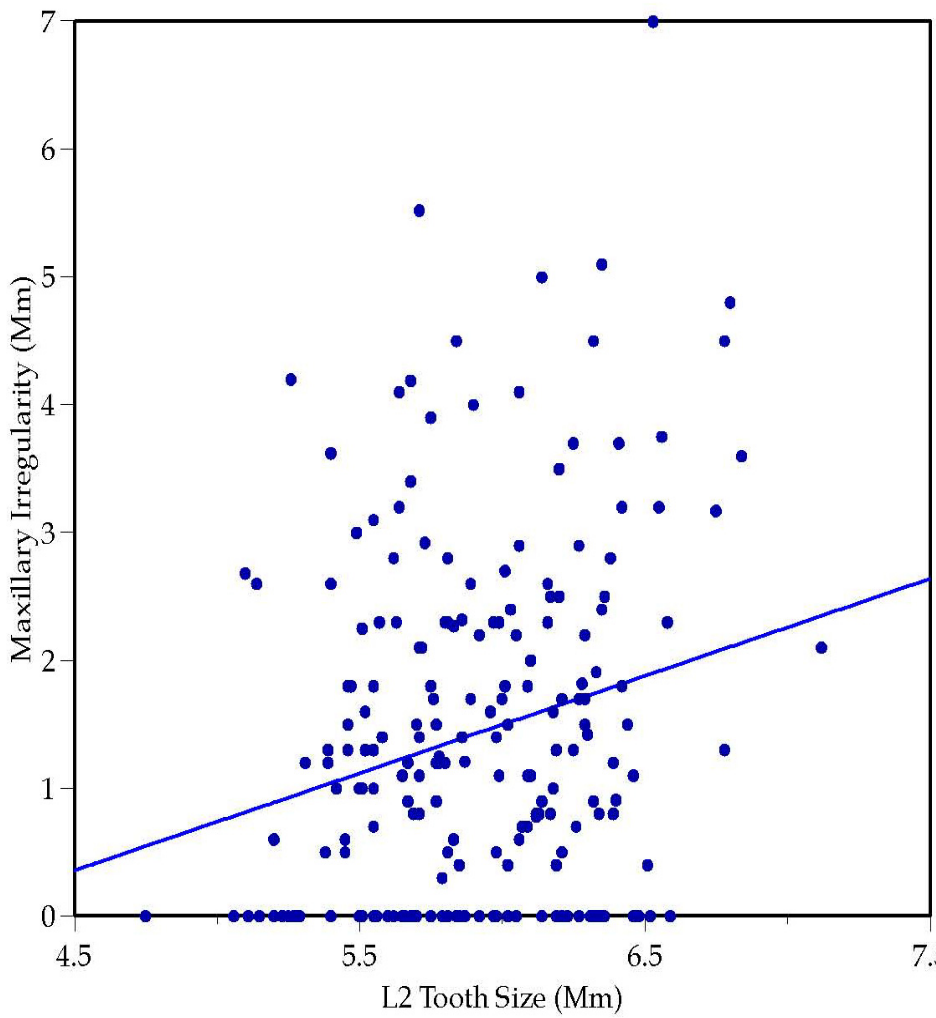

Figure 70. Plot between mesiodistal tooth size of L2 and maxillary irregularity.

As tooth size increases, so does the typical irregularity.

Mandibular Irregularity

The pattern of associations for the lower arch parallel those in the maxillary: there are highly significant, positive associations between incisor width and mandibular irregularity. These are graphed for L1 (Figure 71) and L2 (Figure 72). Interestingly, the relationships are much weaker for the teeth distal to the incisors.

Maxillary Overjet

Extent of the overjet is mildly correlated with mandibular incisor widths ($0.05 > P > 0.01$), but not with any tooth types from the canine back. The associations are positive as shown for L1 (Figure 73) and L2 (Figure 74), but the causes of the association is unclear. Perhaps it is an indirect association brought about by the pervasive intertooth size correlations (*e.g.*, Harris and Bailit 1988).

DAI Score

Associations between DAI and maxillary crown sizes are modest at best, and the same holds for these mandibular crown sizes (Table 5). Just the two incisor tooth types are significantly associated (Figure 75 and 76). As before, we attribute these modest associations to the fact that the DAI was not specifically intended as a measure of occlusal variations but, rather, as an instrument for quantifying facial esthetics.

Predicting Crown Size from Malocclusion

Prior sections in this chapter examined the bivariate associations among crown sizes and measures of malocclusions. While informative, there is considerable redundancy in the outcomes, primarily because (1) tooth crown dimensions are statistically intercorrelated (*e.g.*, Moorrees and Reed 1964; Potter *et al*. 1968) and (2) the measures of malocclusion are themselves statistically interdependent. For example, Table 6 lists the correlation matrix for all 14 tooth types taken pair wise. With the sample size of 207 individuals (sexes pooled), the Pearson correlation coefficient only needs to be at least $r \geq 0.14$ to be significant at alpha of 0.05, which means that all 91 correlations are significantly different from zero. This means, for example, that there are far more tooth dimensions than independent axes of variation.

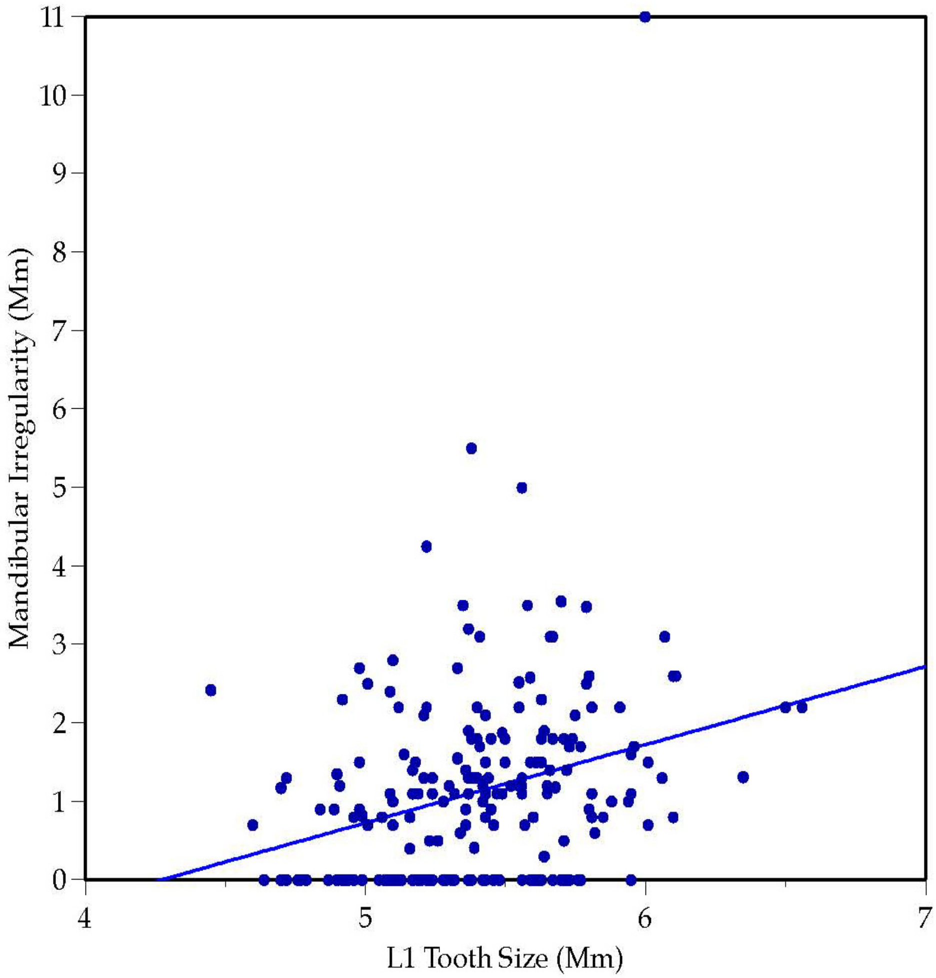

Figure 71. Plot between mesiodistal tooth size of L1 and mandibular irregularity.

As tooth size increases, so does the typical irregularity.

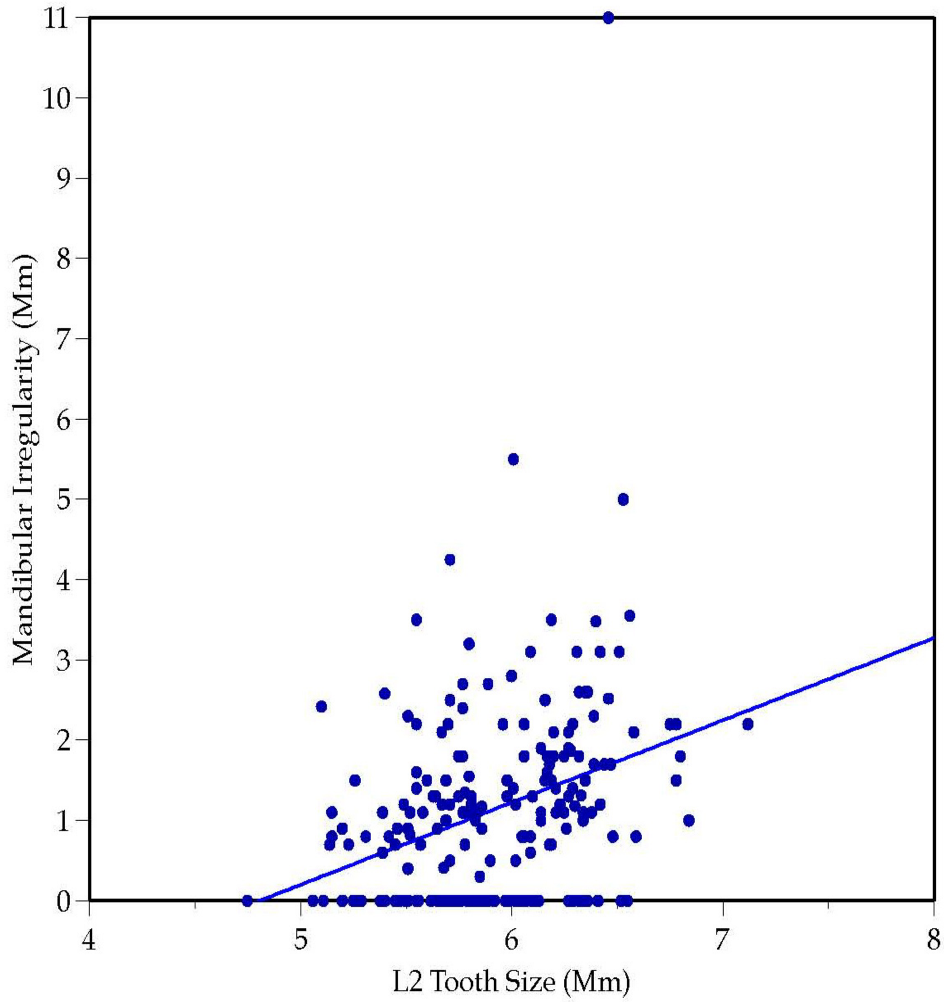

Figure 72. Plot between mesiodistal tooth size of L2 and mandibular irregularity.

As tooth size increases, so does the typical irregularity.

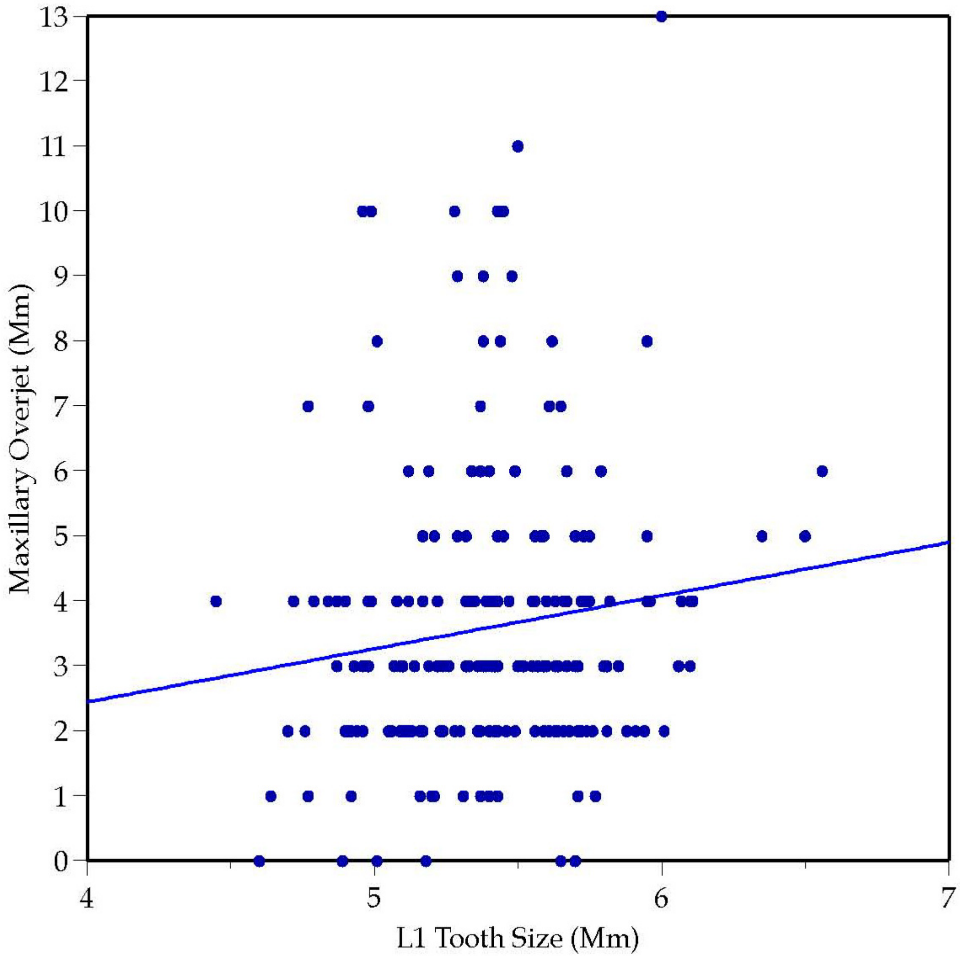

Figure 73. Plot between mesiodistal tooth size of L1 and maxillary overjet.

As tooth size increases, so does the typical size of the overjet.

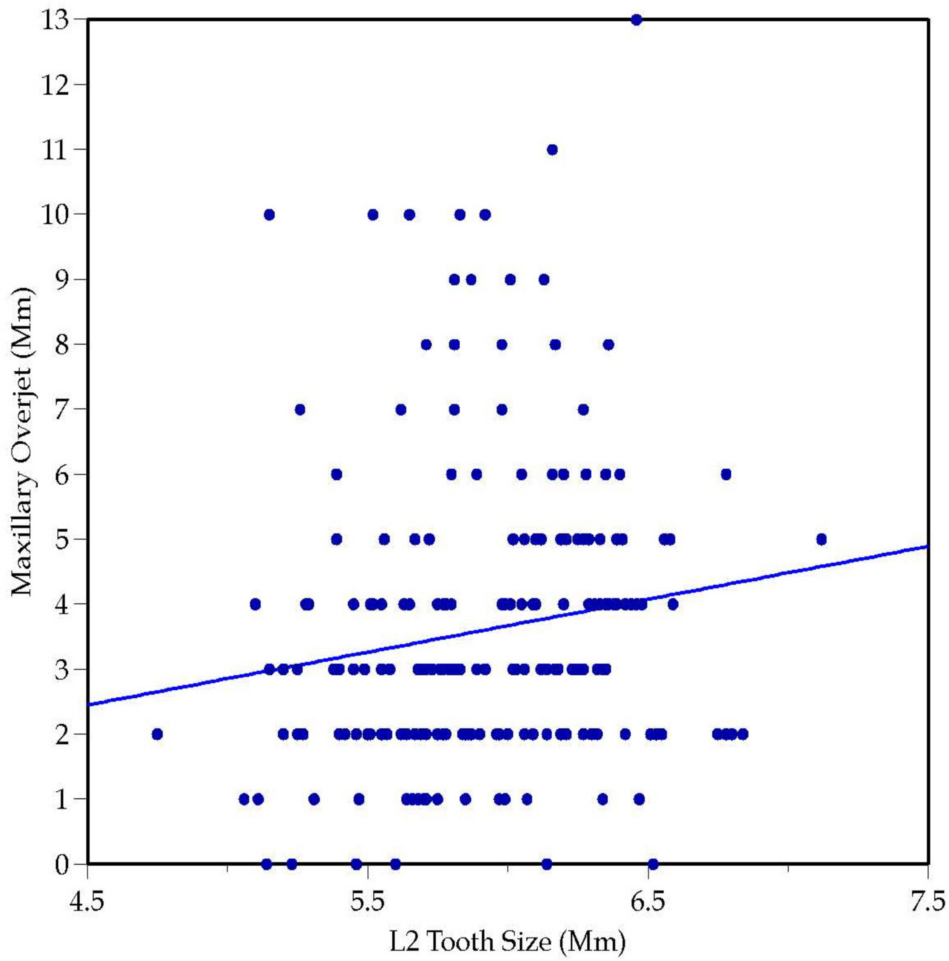

Figure 74. Plot between mesiodistal tooth size of L2 and maxillary overjet.

As tooth size increases, so does the typical size of the overjet.

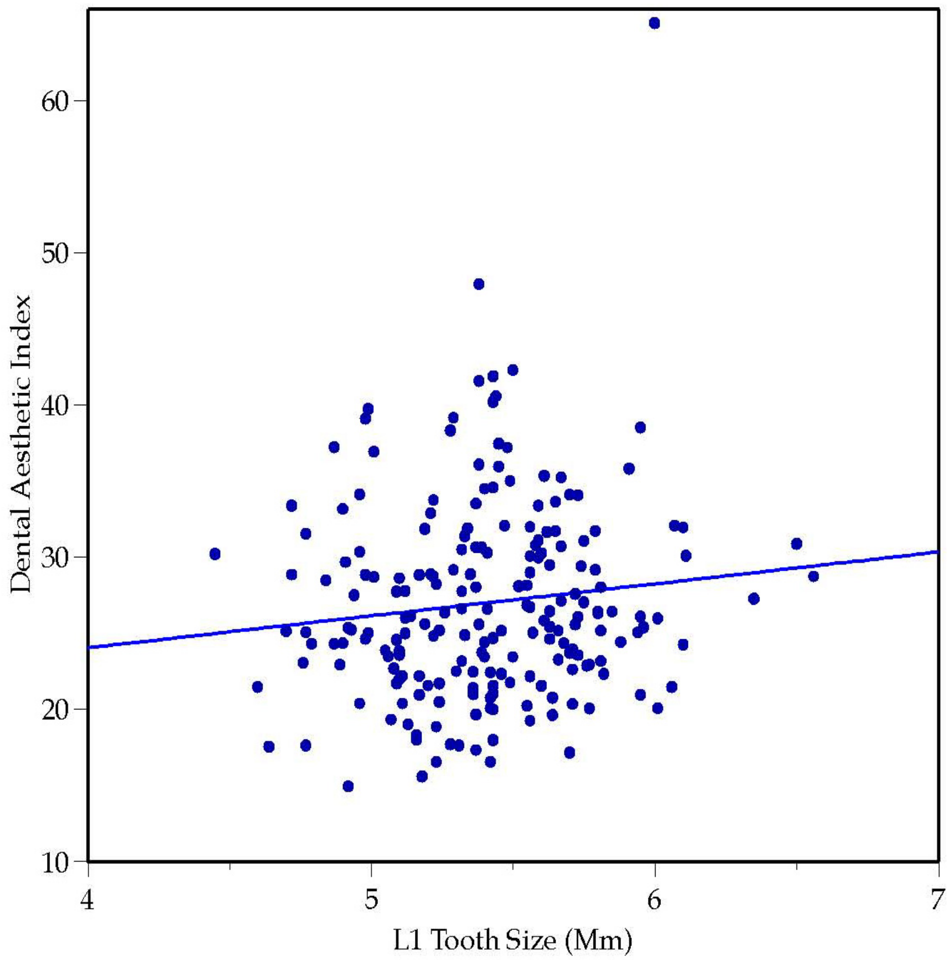

Figure 75. Plot between mesiodistal tooth size of L1 and DAI score.

As tooth size increases, so does the typical DAI score.

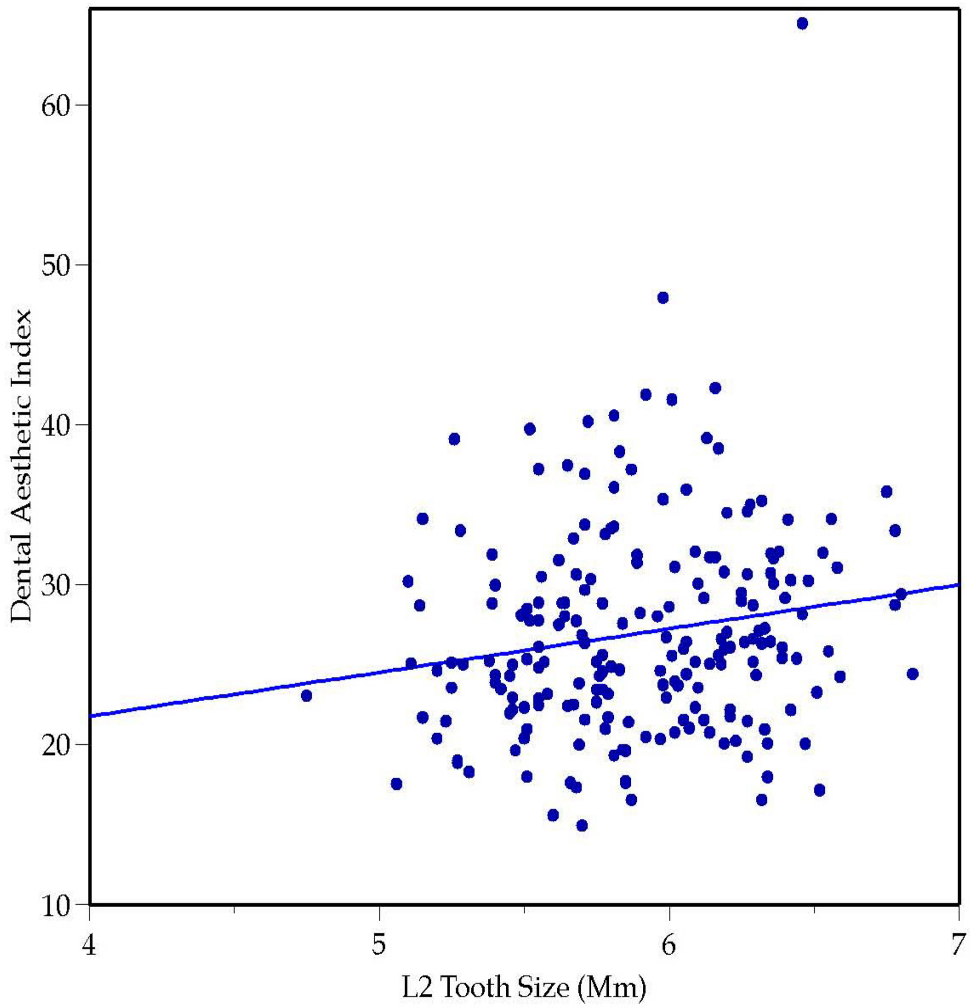

Figure 76. Plot between mesiodistal tooth size of L2 and DAI score.

As tooth size increases, so does the typical DAI score.

Table 6. Matrix of Pearson correlation coefficients for all 14 mesiodistal crown dimensions taken pairwise.

	Maxilla							Mandible						
	I1	I2	C	P1	P2	M1	M2	I1	I2	C	P1	P2	M1	M2
								Maxilla						
I1	1.00	0.46	0.60	0.47	0.43	0.48	0.43	0.66	0.67	0.59	0.48	0.36	0.46	0.39
I1	0.46	1.00	0.51	0.49	0.40	0.35	0.32	0.50	0.54	0.40	0.52	0.38	0.39	0.32
C	0.60	0.51	1.00	0.54	0.46	0.44	0.44	0.53	0.62	0.72	0.58	0.46	0.46	0.41
P1	0.46	0.49	0.54	1.00	0.68	0.47	0.47	0.52	0.53	0.48	0.76	0.62	0.43	0.43
P2	0.43	0.40	0.46	0.68	1.00	0.48	0.53	0.49	0.43	0.44	0.61	0.66	0.43	0.43
M1	0.48	0.35	0.44	0.47	0.48	1.00	0.70	0.49	0.48	0.46	0.44	0.49	0.71	0.57
M2	0.43	0.32	0.44	0.47	0.53	0.70	1.00	0.43	0.39	0.39	0.50	0.55	0.62	0.68
								Mandible						
I1	0.66	0.50	0.53	0.52	0.49	0.49	0.43	1.00	0.75	0.58	0.53	0.51	0.52	0.42
I2	0.67	0.54	0.62	0.53	0.43	0.48	0.39	0.75	1.00	0.65	0.53	0.44	0.53	0.37
C	0.59	0.40	0.72	0.48	0.44	0.46	0.39	0.58	0.65	1.00	0.56	0.48	0.52	0.39
P1	0.48	0.52	0.58	0.76	0.61	0.44	0.50	0.53	0.53	0.56	1.00	0.64	0.46	0.47
P2	0.36	0.38	0.46	0.62	0.66	0.49	0.55	0.51	0.44	0.48	0.64	1.00	0.51	0.49
M1	0.46	0.39	0.46	0.43	0.43	0.71	0.62	0.52	0.53	0.52	0.46	0.51	1.00	0.63
M2	0.39	0.32	0.41	0.43	0.43	0.57	0.68	0.42	0.37	0.39	0.47	0.49	0.63	1.00

There are several multivariate statistical methods that reduce this statistical redundancy. We pursued a stepwire linear regression approach to predict crown size from the compilation of 14 measures of malocclusion. (Cohen and Cohen 1975; Freund and Littell 1991).

The method can be illustrated using the composite variable of the sum of the 14 mesiodistal crown dimensions. This addresses the interesting question of whether a person's "tooth size" taken globally (as the sum of 14 tooth types) is statistically dependent on one or more measures of dental malocclusion.

Results for summed crown sizes are listed in Table 7. These values show the "final solution" of the stepwise procedure. At step 0 the univariate F–ratio for all 14 measures of malocclusion with tooth size was determined. Step 1 selected the variable with the largest F–ratio, which in this case was interdental spacing and the 13 other F–ratios were recalculated on the basis of spacing, being in the predictive model. At step 2, there was one statistically significantly F–ratio contingent on having accounted for spacing; this was mandibular irregularity. Again, the program recalculates all of the other F–ratios, now contingent on having spacing and mandibular irregularity in the model. The new "contingent" F–ratios take into account the covariance of the variables already entered into the model, so redundant statistical interdependencies among the predictor variables are accounted for. Each variable, then, has to contribute significant independent covariance to the model in order to be entered in the stepwise procedure. The stepwise procedure progresses until none of the remaining variables contributes significant additional information. Typically this stepwise procedure consists of only a few "steps" because most variables have very little unique information to contribute to the variation in the dependent (tooth size) variable. In this example, only two measures of malocclusion, (1) spacing and (2) mandibular irregularity, are predictive of summed tooth size. The other 12 measures of malocclusion contain trivial statistical information about summed tooth size that is not already accounted for by the two variables in the model, and the stepwise procedure ceases. In other words, two variables (spacing and mandibular irregularity) are conjointly the "best" predictors of summed tooth size from among those tested.

In fact, the forward and backward stepping procedure used here does <u>not</u> ensure that the optimal combination of predictors is discovered— though it generally is. There is a "brute force" procedure incorporated in the JMP software that will (as a selectable option) test every possible combination of predictor variables (Freund and Littell 1991). This "brute force" procedure was tested in many instances, and as commonly found — the stepping procedure arrives at the same solution.

Table 7. Results of stepwise multiple regression analysis predicting summed mesiodistal widths of all 14 tooth types from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	110.313	0.0000	0.00	1.0000
Total displacements	0	0.5513	0.02	0.8773.
Total rotations	0	0.8599	0.04	0.8471
Total overlapping	0	18.0653	0.79	0.3762
Total D+R+O	0	3.2099	0.14	0.7094
Crowding	0	22.8180	0.99	0.3198
Spacing	-2.259	309.1153	13.47	0.0003
Diastema	0	2.8633	0.12	0.7248
Maxillary irregularity	0	3.1213	0.14	0.7132
Mandibular irregularity	0.632	121.4144	5.29	0.0224
Maxillaryt overjet	0	28.0018	1.22	0.2703
Mandibular overjet	0	2.2794	0.10	0.7535
Openbite	0	45.9624	2.01	0.1575
AP relationship	0	35.2387	1.54	0.2161
DAI score	0	0.0417	0.00	0.9661

With reference to the results in Table 7, the two predictor variables collectively account for 11% of the variation in tooth size. While far from the majority of the variance in tooth size, the statistical association is highly significant statistically. Moreover, one would not expect "much" of the variation in tooth size to be explained by dental malocclusion.

The "Estimate" column is Table 7 lists additional information: One, the signs of the estimates show that (1) there is a negative association between spacing and tooth size and (2) the association between tooth size and mandibular irregularity is positive. This simply reinforces the bivariate findings described previously. Two, regression coefficient for spacing (-2.3) is much larger than for mandibular irregularity (0.6), meaning that, of these two variables, spacing plays the larger role in accounting for the variance in tooth size. Other information from the procedure, namely, the individual R^2, further interpret this. Spacing by itself accounts for 9% of the variance summed tooth size; the addition of mandibular irregularity to the model only added another 2%, for a total of 11%.

Maxillary Crown Dimensions

Table 8 lists the final stepwise results for the central incisor. Of the 14 potential predictors, three were entered into the prediction model. Of these, spacing has the largest coefficient, which is, of course, negative. The recurrent statistical impact of interdental spacing as seen, for example, among the bivariate tests described in an earlier section, suggest that the small mesiodistal crown diameters may define a distinctive subset of the patients studied here. That is, our focus was to evaluate the effect of large crown diameters on raising the risk of malocclusions. Yet, the recurrent, statistically imposing associations between small crown sizes and spacing suggest that these patients constitute an influential subset of the tooth size distributions.

The predictive model developed in Table 8 shows that (1) interdental spacing has an important negative association with crown size but, secondarily, (2) mandibular irregularity and, to a lesser extent, the severity of maxillary overjet also is predictive of U1 size. Collectively, the three measures of malocclusion explain 12.5% of the variance in U1 width in the statistical sense, though, again, spacing accounts for most of this variance ($R^2 = 8\%$).

Just one measure of malocclusion has a significant association with U2 size (Table 9), namely crowding. That is, once crowding has been entered in the stepwise procedure, no other measure of malocclusion has significant covariation with U2 size that is not already explained by the variation due to

Table 8. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary central incisor from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	8.486	0.0000	0.00	1.0000
Total displacements	0	0.2534	0.92	0.3387
Total rotations	0	0.1025	0.37	0.5432
Total overlapping	0	0.2139	0.78	0.3796
Total D+R+O	0	0.2895	1.05	0.3064
Crowding	0	0.3978	1.45	0.2304
Spacing	-0.173	1.7953	6.52	0.0114
Diastema	0	0.1497	0.54	0.4624
Maxillary irregularity	0	0.2948	1.07	0.3021
Mandibular irregularity	0.082	1.8622	6.76	0.0100
Maxillary overjet	0.040	1.5292	5.55	0.0194
Mandibular overjet	0	0.1354	0.49	0.4846
Openbite	0	0.4377	1.59	0.2083
AP relationship	0	1.3889	1.42	0.2357
DAI score	0	0.0848	0.31	0.5803

Table 9. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary lateral incisor from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	6.300	0.0000	0.00	1.0000
Total displacements	0	0.0382	0.12	0.7332
Total rotations	0	0.1305	0.40	0.5388
Total overlapping	0	0.4424	1.36	0.2456
Total D+R+O	0	0.0443	0.14	0.7137
Crowding	0.242	6.8426	20.94	0.0000
Spacing	0	0.7205	2.22	0.1380
Diastema	0	0.2067	0.63	0.4278
Maxillary irregularity	0	0.6858	2.11	0.1479
Mandibular irregularity	0	0.2805	0.86	0.3555
Maxillary overjet	0	0.1594	0.49	0.4863
Mandibular overjet	0	0.0040	0.01	0.9119
Openbite	0	0.5906	1.81	0.1795
AP relationship	0	1.3692	4.26	0.0404
DAI score	0	0.0240	0.07	0.7873

crowding. By itself, crowding accounts for a quarter (24%) of the variance in U2 size, which seems striking. On the other hand, this strong association probably is tied to the unusually high variability in U2 size among whites (Polder *et al*. 2004, Albashaireh and Khader 2006). We would predict much lower associations among other social groups where U2 is not so prone to size reduction, pegging, microdonty, congenital absence, and the like. It should not go unnoticed that the high variability in U2 width is a common source of Bolton discrepancies, leading to failure of proper intercuspation but also, evidently, to enhanced risk of anterior crowding.

Mesiodistal width of the upper canine (Table 10) is significantly predicted by just one variable of those tested, namely crowding. This association accounts for 16% in MD variation in canine width, which suggests that canine size—its placement in the arch—merits more critical attention. There seem to be several impinging issues here. One, the permanent canine is much larger mesiodistally than the primary canine it replaces. Two, it erupts late – during the second transition (van der Linden and Duterloo 1976) and has to erupt into a confined space. Data (Moorrees 1959) suggest that canine eruption pushes the earlier-erupting incisors medially, thereby instigating their irregularity and crowding (if not already underway).

Predictors of first premolar size (Table 11) are few, just interdental spacing. On the other hand, this association accounts for a fifth of the variation in premolar crown size (R^2 = 19%). At face value, these results suggest that mesiodistal crown length of U4 has an appreciable influence on crowding — spacing in the anterior region. Its negative association here with anterior spacing suggests that, when U4 is short mediodistally, this raises the likelihood of interdental spacing in the anterior segment. Conversely, a mediodistally elongated first premolar would reduce spacing. Since U4 emerges late (10 to 12 years of age; van der Linden and Duterloo 1976), the effect on the anterior segment likewise should be late in childhood, which coincides with the pre-teen changes documented by Moorrees (1959).

Stepwise results for the second premolar, likewise implicate spacing as the prime associate (Table 12). Again the relationship is negative, which sensibly means that mesiodistally longer U5 diminish the likelihood of spacing. A couple of the interesting developmental features here are (1) that later-erupting teeth in the midarch effect occlusion in the anterior segment and (2) that the supposed mesial forces act around the "corner" of the arch (Southard *et al*. 1989). This latter feature implies more than just the linear vectors of pressure, and may well implicate the complexes of supragingivel interdental fibers.

Table 10. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary canine from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	7.60	0.0000	0.00	1.0000
Total displacements	0	0.0907	0.45	0.5046
Total rotations	0	0.0078	0.04	0.8452
Total overlapping	0	0.3293	1.63	0.2029
Total D+R+O	0	0.1177	0.58	0.4471
Crowding	0.157	2.8606	14.13	0.0002
Spacing	0	0.2326	1.15	0.2848
Diastema	0	0.1657	0.82	0.3669
Maxillary irregularity	0	0.0717	0.35	0.5530
Mandibular irregularity	0	0.1302	0.64	0.4239
Maxillary overjet	0	0.5896	2.94	0.0879
Mandibular overjet	0	0.0010	0.01	0.9434
Openbite	0	0.2215	1.10	0.2967
AP relationship	0	0.2280	1.13	0.2897
DAI score	0	0.1838	0.91	0.3420

Table 11. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary first premolar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	6.968	0.0000	0.00	1.0000
Total displacements	0	0.0001	0.00	0.9836
Total rotations	0	0.0821	0.50	0.4811
Total overlapping	0	0.1726	1.05	0.3066
Total D+R+O	0	0.0707	0.43	0.5133
Crowding	0	0.5492	3.38	0.0674
Spacing	-0.193	2.4334	14.81	0.0002
Diastema	0	0.0251	0.15	0.6971
Maxillary irregularity	0	0.0011	0.01	0.9337
Mandibular irregularity	0	0.2711	1.65	0.1998
Maxillary overjet	0	0.6111	3.77	0.0536
Mandibular overjet	0	0.0199	0.12	0.7289
Openbite	0	0.1557	0.95	0.3317
AP relationship	0	0.4446	2.73	0.1001
DAI score	0	0.1303	0.79	0.3745

Table 12. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary second premolar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	6.927	0.0000	0.00	1.0000
Total displacements	0	0.4105	2.29	0.1322
Total rotations	0	0.1345	0.74	0.3898
Total overlapping	0	0.0503	0.28	0.5991
Total D+R+O	0	0.0058	0.03	0.8584
Crowding	0	0.2397	1.33	0.2506
Spacing	-0.164	1.7511	9.69	0.0021
Diastema	0	0.0966	0.53	0.4662
Maxillary irregularity	0	0.0310	0.17	0.6798
Mandibular irregularity	0	0.1893	1.05	0.3074
Maxillary overjet	0.027	0.7653	4.23	0.0409
Mandibular overjet	0	0.0112	0.06	0.8041
Openbite	0	0.3408	1.89	0.1704
AP relationship	0	0.3587	1.99	0.1595
DAI score	0	0.4441	2.47	0.1173

Moving distally to the molar region (Table 13), effects on malocclusions in this anterior segment are, not surprisingly, weak. For U6 (Table 13) mandibular irregularity is the only statistically significant predictor, and the explained variance (R^2 = 2%) is trivial.

This theme—that distally positioned teeth have little influence on anterior malocclusion—is reflected as well in the U7 model (Table 14). Here, there is the negative association with spacing that is seen several times previously. The association is weak (R^2 = 3%). The noteworthy feature is, perhaps, that there is any statistically discernable effect at all this far back in the arch. Alternatively, these stepwise models do not preclude the associations being indirect. For example, this association with U7 (Table 14) may be due to U7's positive size covariation with anterior teeth.

Mandibular Crown Dimensions

Two measures of malocclusion were significantly associated with L1 size, namely crowding and mandibular irregularity (Table 15), but of these crowding clearly is the more strongly associated. The relatively weak association between L1 size and mandibular irregularity may be due to the method of quantifying irregularity (Jenny and Cons 1996), where it is merely scored as present or absent in each arcade.

Mesiodistal crown size of L2 has significant associations with three measures of malocclusion (Table 16), namely overlapping, spacing and mandibular irregularity. The associations with overlapping and malocclusion are positive, so broader L2 incisors increase the risk of anterior overlapping and of mandibular irregularity. Conversely, the negative regression coefficient with interdental spacing (Table 17) denotes a negative relationship, where narrower L2 widths are associated with greater spacing. Mesiodistal width of L3 is significantly associated with just one of the 14 measures of malocclusion. This is a negative association.

Because "spacing" commonly occurs as a significant variable in these analyses, it merits evaluating the relationship in a bit more detail. "Spacing" is scored in a course fashion (Jenny and Cons 1996), with only three ordinal grades namely none (score of 0), one jaw with spacing (score of 1), or both jaws with spacing (score of 2). Still, cases with the largest canine diameters tend to have no spacing, canine size is intermediate when one arch exhibits spacing, and crown size is smallest where there is spacing in both arches. Mean canine widths associated with these three grades of spacing are 6.8 mm, 6.7 mm, and 6.3 mm,

Table 13. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary first molar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	10.270	0.0000	0.00	1.0000
Total displacements	0	0.0792	0.26	0.6108
Total rotations	0	0.0001	0.00	0.9861
Total overlapping	0	0.3706	1.22	0.2705
Total D+R+O	0	0.1393	0.46	0.4997
Crowding	0	0.3919	1.29	0.2571
Spacing	0	0.7319	2.43	0.1209
Diastema	0	0.0390	0.13	0.7210
Maxillary irregularity	0	0.4357	1.44	0.2320
Mandibular irregularity	0.066	1.4309	4.71	0.0312
Maxillary overjet	0	0.0031	0.01	0.9194
Mandibular overjet	0	0.1913	0.63	0.4288
Openbite	0	0.5227	1.73	0.1904
AP relationship	0	0.0315	0.10	0.7483
DAI score	0	0.0680	0.22	0.6374

Table 14. Results of stepwise multiple regression analysis predicting mesiodistal width of the maxillary second molar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	9.794	0.0000	0.00	1.0000
Total displacements	0	0.1373	0.41	0.5208
Total rotations	0	0.1105	0.33	0.5645
Total overlapping	0	0.0609	1.18	0.6690
Total D+R+O	0	0.0239	0.07	0.7890
Crowding	0	0.0006	0.00	0.9651
Spacing	-0.174	1.9729	5.96	0.0154
Diastema	0	0.0766	0.23	0.6315
Maxillary irregularity	0	0.0071	0.02	0.8836
Mandibular irregularity	0	0.3481	1.05	0.3062
Maxillary overjet	0	0.0191	0.06	0.8106
Mandibular overjet	0	0.0452	0.14	0.7127
Openbite	0	0.3543	1.07	0.3018
AP relationship	0	0.0163	0.05	0.8252
DAI score	0	0.0013	0.00	0.9500

Table 15. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular central incisor from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	5.159	0.0000	0.00	1.0000
Total displacements	0	0.1427	1.27	0.2610
Total rotations	0	0.1813	1.62	0.2048
Total overlapping	0	0.1105	0.98	0.3228
Total D+R+O	0	0.0159	0.14	0.7075
Crowding	0.141	1.8179	16.17	0.0001
Spacing	0	0.1864	1.66	0.1986
Diastema	0	0.0174	0.15	0.6952
Maxillary irregularity	0	0.0872	0.77	0.3799
Mandibular irregularity	0.042	0.4627	4.12	0.0438
Maxillary overjet	0	0.1369	1.22	0.2709
Mandibular overjet	0	0.0319	0.28	0.5956
Openbite	0	0.0215	0.19	0.6632
AP relationship	0	0.1853	1.65	0.2000
DAI score	0	0.0078	0.07	0.7925

Table 16. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular lateral incisor from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	5.776	0.0000	0.00	1.0000
Total displacements	0	0.0332	0.24	0.6282
Total rotations	0	0.0769	0.55	0.4612
Total overlapping	0.020	0.5056	3.59	0.0595
Total D+R+O	0	0.0038	0.03	0.8703
Crowding	0	0.0172	0.12	0.7279
Spacing	-0.127	0.8029	5.71	0.0178
Diastema	0	0.0124	0.09	0.7678
Maxillary irregularity	0	0.0150	0.11	0.7452
Mandibular irregularity	0.068	1.1637	8.27	0.0045
Maxillary overjet	0	0.2745	1.96	0.1631
Mandibular overjet	0	0.3432	2.46	0.1186
Openbite	0	0.0796	0.56	0.4534
AP relationship	0	0.2067	1.47	0.2264
DAI score	0	0.0738	0.52	0.4703

Table 17. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular canine from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	6.782	0.0000	0.00	1.0000
Total displacements	0	0.0775	0.38	0.5382
Total rotations	0	0.0359	0.18	0.6751
Total overlapping	0	0.1533	0.75	0.3864
Total D+R+O	0	0.1208	0.59	0.4419
Crowding	0	0.1589	0.78	0.3777
Spacing	-0.165	1.7793	8.76	0.0034
Diastema	0	0.0556	0.27	0.6022
Maxillary irregularity	0	0.0015	0.01	0.9326
Mandibular irregularity	0	0.3144	1.55	0.2143
Maxillary overjet	0	0.5769	2.87	0.0920
Mandibular overjet	0	0.0376	0.18	0.6682
Openbite	0	0.1739	0.86	0.3562
AP relationship	0	0.0002	0.00	0.9769
DAI score	0	0.1314	0.65	0.4226

respectively, which supports the visual impression from Figure 74 that the principal difference is the small crown sizes of those with interdental spacing in both arches.

The stepwise analysis for L4 (Table 18) identifies just one significant association with malocclusion, namely a positive association between the degree of crowding and L4 diameter.

Interdental spacing surfaces again is the only predictor here for L5 size (Table 19). It is perhaps noteworthy that tooth size in the midarch plays any detectable role in dental malocclusion. Mean mesiodistal diameters of the second premolars (L5) are 7.2 mm in those without spacing and, likewise, 7.2 mm in those with spacing in one arch. When, however, there is spacing in both arches, mean L5 size drops to 6.7 mm, which is the main source of the significant association.

Notably, this same measure of interdental spacing is the one and only significant predictor of L6 size (Table 20) and of L7 size (Table 21). So too, it is the smaller crown dimensions in subjects with spacing in both jaws that produce the statistically significant associations. The three mesiodistal crown means for L6 are 11.1 mm (spacing 0), 11.1 mm (spacing 1), and 10.6 mm (spacing 2). The means for L7 are 10.3 mm (spacing 0); 10.3 mm (spacing 1), and 9.7 mm (spacing 2).

These several comparisons show that the effect of spacing is widespread. Indeed, "spacing" entered 10 of the 14 stepwise models, making it the most pervasive predictor of tooth size in these analyses. But, what we are looking at is almost certainly the recurrence of the same effect: Because tooth crown diameters all are significantly and positively intercorrelated (Harris and Bailit 1988); people with one small tooth type tend to be the same people with other small tooth types. "Tooth size" should be viewed as an over-arching generic feature of an individual, not a collection of independent crown dimensions. One measure of this is to assess the relationship between (1) the three grades of "spacing" against (2) summed mesiodistal sizes of all 14 tooth types (Figure 77). Most subjects in the sample have no spacing (mean = 111.1 mm), and most of the rest have crowding in just one arch (means = 110.0 mm). Indeed, just 13 of the 207 people in the study have spacing in both arches, and they also have significantly smaller crown sizes (mean = 104.3 mm).

Concern might be raised here that we have not controlled for sexual dimorphism. Conceivably, subjects with very small teeth might just be females. Table 22 lists the results of a two-way Ancova, where the sex of the subject is

Table 18. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular first premolar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	6.90	0.0000	0.00	1.0000
Total displacements	0	0.0819	0.51	0.4775
Total rotations	0	0.0337	0.21	0.6488
Total overlapping	0	0.0038	0.02	0.8777
Total D+R+O	0	0.0028	0.02	0.8948
Crowding	0.129	1.9307	11.98	0.0007
Spacing	0	0.3305	2.06	0.1527
Diastema	0	0.1685	1.05	0.3077
Maxillary irregularity	0	0.0933	0.58	0.4482
Mandibular irregularity	0	0.0781	0.48	0.4877
Maxillary overjet	0	0.0648	0.40	0.5275
Mandibular overjet	0	0.0546	0.34	0.5619
Openbite	0	0.0811	0.50	0.4794
AP relationship	0	0.2100	1.30	0.2547
DAI score	0	0.0911	0.56	0.4537

Table 19. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular second premolar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	7.236	0.0000	0.00	1.0000
Total displacements	0	0.0362	0.19	0.6628
Total rotations	0	0.0250	0.13	0.7169
Total overlapping	0	0.0016	0.01	0.9265
Total D+R+O	0	0.0003	0.00	0.9677
Crowding	0	0.0002	0.00	0.9724
Spacing	-0.190	2.3572	12.46	0.0005
Diastema	0	0.0041	0.02	0.8831
Maxillary irregularity	0	0.0139	0.07	0.7869
Mandibular irregularity	0	0.0145	0.08	0.7824
Maxillary overjet	0	0.4172	2.22	0.1379
Mandibular overjet	0	0.0177	0.09	0.7605
Openbite	0	0.0065	0.03	0.8534
AP relationship	0	0.0917	0.48	0.4876
DAI score	0	0.1162	0.61	0.4346

Table 20. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular first molar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	11.113	0.0000	0.00	1.0000
Total displacements	0	0.0010	0.00	0.9564
Total rotations	0	0.0070	0.02	0.8842
Total overlapping	0	0.0041	0.01	0.9114
Total D+R+O	0	0.0016	0.01	0.9453
Crowding	0	0.1451	0.44	0.5074
Spacing	-0.189	2.3454	7.156	0.0081
Diastema	0	0.0001	0.00	0.9845
Maxillary irregularity	0	0.0137	0.04	0.8384
Mandibular irregularity	0	0.3718	1.13	0.2882
Maxillary overjet	0	0.0414	0.13	0.7233
Mandibular overjet	0	0.0285	0.09	0.7688
Openbite	0	0.0049	0.02	0.9028
AP relationship	0	0.0321	0.10	0.7554
DAI score	0	0.0210	0.06	0.8010

Table 21. Results of stepwise multiple regression analysis predicting mesiodistal width of the mandibular second molar from measures of malocclusion.

Variable	Estimate	SSQ	F-Ratio	P-Value
Intercept	10.291	0.0000	0.00	1.0000
Total displacements	0	0.0583	0.16	0.6931
Total rotations	0	1.2175	3.31	0.0703
Total overlapping	0	0.0618	0.17	0.6846
Total D+R+O	0	0.3441	0.93	0.3373
Crowding	0	0.0063	0.02	0.8966
Spacing	-0.186	2.2559	6.07	0.0146
Diastema	0	0.3684	0.99	0.3207
Maxillary irregularity	0	0.5828	1.57	0.2114
Mandibular irregularity	0	0.8663	2.35	0.1272
Maxillary overjet	0	0.4774	1.29	0.2582
Mandibular overjet	0	0.6160	1.66	0.1988
Openbite	0	0.9992	2.71	0.1013
AP relationship	0	1.2499	3.40	0.0666
DAI score	0	1.1537	3.14	0.0781

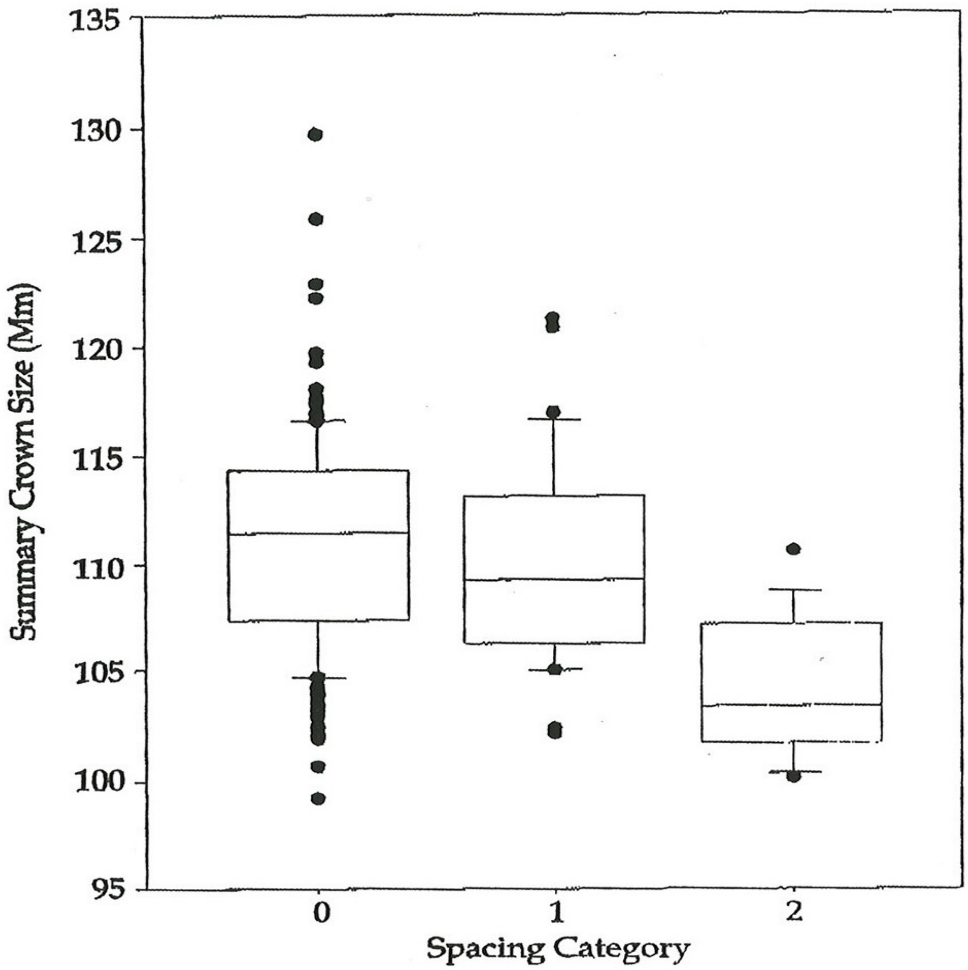

Figure 77. Plot showing the relationship between the three grades of "spacing" against the summed mesiodistal sizes of all 14 tooth types.

Table 22. Analysis of variance testing for a difference in summed tooth size among grades of spacing while controlling for sexual dimprohism.

Source	df	SSQ	F-Ratio	P-Value
Sex	1	288.703	13.7771	0.0003
Spacing	2	582.455	13.892	< 0.0001
Sex-x-Spacing	2	41.096.	0.980	0.3770

taken out of the comparison among grades of spacing. Sexual dimorphism is highly significant for the sum of 14 mesiodistal crown diameters; however, this effect is independent of the fact disclosed above that those with interdental spacing tend to have smaller tooth crowns ($P < 0.0001$).

CHAPTER V. DISCUSSION

Malocclusions are quite common in the United States and other industrialized countries (*e.g.*, Kelly and Harvey 1977; Brunelle *et al*. 1996). Indeed, only about one teenager in ten has a naturally-occurring good occlusion. Such high frequencies naturally raise the question of what factors are responsible for malocclusion—and for their high prevalence in modern populations. Corruccini and Potter (1980) and Harris and Smith (1980) showed that the common tooth-based sorts of malocclusion (*e.g.*, crowding, rotations, overlapping) have no discernible genetic basis and, instead, are the result of environmental issues (Corruccini 1999). Harris and Johnson (1991), among others, suggest that malocclusions should be viewed as developing from some combination of two broad sources; one is skeletal, which has a familial (genetic) basis (*e.g*., Nakata *et al*. 1974 a,b; Harris 1975), and the other is dental, which seems to be controlled predominately by the environment (Beecher and Corruccini 1983).

Added to this mix is the issue of tooth size. Mesiodistal crown diameters can affect the risk of dental malocclusions, as mesiodistally broader teeth obviously require greater arch size for proper arrangements. Due to several converging issues the effects of crown size are probably of increasing relevance. Townsend and others (Dempsey *et al*. 1995; Hughes *et al*. 2007) document that tooth sizes are under appreciable genetic control. Begg's classic argument (1954) is that, in the past, interproximal attrition due to substantial grit in the diet was accommodative in that it reduced mesiodistal crown dimensions such that TSASDs were uncommon. The grit introduced by the stone-milling of grains led to substantive attrition into the 20th century in many industrialized societies (Brothwell 1981; Brook *et al*. 2006).

Nowadays, several trends seem to conspire towards high frequencies of dental malrelationships. Improved childhood health (decreased morbidity) and enhanced nutrition have led to secular trends of increasing tooth size (Garn *et al*. 1968; Ebeling *et al*. 1973; Harris *et al*. 2001), while, conversely, diminished chewing stress during tooth eruption phases of childhood fails to stimulate tooth alignment and, thereby, fails to stimulate alveolar bone growth (*e.g*., Watt and Williams 1952; Beecher and Corruccini 1981, 1983; Ciochon *et al*. 1997; Mavropoulos *et al*. 2005). Thirdly, the absence of interproximal attrition exacerbates the risk of dental malocclusions.

Discussions of dental malocclusions in the orthodontic literature often are couched as developmental competitions between tooth crown dimensions and alveolar bone support. The issue commonly is described as an "either-or" question—whether crowding is a tooth-size or an arch-size problem. This "competition" seems to us to misconstrue the developmental events. The erupting tooth, specifically the dental follicle, produces the molecular signals that stimulate alveolar bone growth as the tooth erupts (Wise *et al*. 2002). At later ages, alveolar remodeling occurs along with tooth movement, but its capacity to proliferate is greatly restricted (*e.g.,* Reitan and Rygh 1994; Krishnan and Davidovitch 2006; Masella and Meister 2006). Alveolar bone proliferates to surround and support the teeth. However, when teeth erupt into crowded, overlapping positions, the alveolus does not need to grow more than supports their crowded, constrained locations. Alveolar growth is sufficient to this step. The problem occurs when the clinician wants to move the teeth into alignment, which characteristically requires additional arch perimeter and, thereby, more bony support. At present, we do no know how to engineer bone growth (guided tissue generation) to harmonize the occlusion. The alternative is that extractions and/or IPR (interproximal reduction) are the viable alternatives. The point, however, is that the "fault" of malocclusion seldom is inadequate bone growth; bone growth is almost invariably sufficient to support the teeth in their maloccluded positions. Research studies that conclude that there is less alveolar support when teeth erupt in crowded overlapping positions compared to naturally occurring good occlusions seem to overlook this developmental consideration. In our opinion, inadequate alveolar bone growth is rarely the cause of a TSASD but, rather the consequence.

It is not readily apparent how the mesiodistal sizes of late-emerging teeth in the buccal segment can influence the crowding already existing among the early-emerging anterior teeth. One explanation is that the various tooth types show the same sorts of positive associations because tooth sizes are highly intercorrelated (Moorrees and Reed 1964; Potter *et al*. 1968) and are congruent within an individual (Bolton 1962).

Numerous studies have looked at the relationship between tooth size and dental crowding. Some studies conclude that mesiodistal tooth size is larger in subjects with dental crowding (Lundström 1969; Fastlicht 1970; Norderval *et al*. 1975; Doris *et al*. 1981; Smith *et al*. 1982; Gilmore and Little 1984). Almost all of the studies that have tested for an effect of crown size have compared just two samples, one with crowding and the other without (Lindström 1949; Doris *et al.* 1981; Melo *et al.* 2001). Those with crowding tended to have larger crowns requiring more arch space for alignment. The present study extended this design to test whether there are graded responses between increasing tooth size and increasing severity of malocclusion. That is, (1) can an association be documented between a subject's tooth size and his extent of tooth-based malocclusion (rotations, displacements, crowding) and (2) what is the nature of the association? The test design takes the sexual dimorphism of tooth dimensions into account, so that tooth sizes between the sexes do not confound interpretations.

Fastlicht (1970) tested whether orthodontic treatment influenced the crowding of the mandibular incisors. He found a strong statistical correlation between mesiodistal widths of the mandibular and the maxillary incisors with crowding. He showed that where there were larger mesiodistal widths, there was more crowding. The present study found similar results, showing that the displacement of the maxillary canines was significantly related to the size of the maxillary lateral incisor and canine. This is anticipated as the maxillary canine is the last tooth anterior to the maxillary first molar to erupt and may have insufficient space to erupt into its proper position in the dental arch.

Norderval *et al*. (1975) compared a group with well aligned mandibular front teeth with a group exhibiting mandibular anterior crowding. The group with crowding had significantly broader mesiodistal diameters ($P < 0.05$) of the incisors.

Bernabé and Flores-Mir (2006) compared the mediodistal and buccolingual crown dimensions among samples grouped as mild crowding, moderate crowding, and no crowding. Statistically significant average difference was found between each of these three groups. This agrees with the present study where crowding is significantly related to mesiodistal size of both maxillary and mandibular central incisors.

The fundamental issue in this study was to search for statistical associations between tooth size and the extent of the malocclusion; a positive "dose-response" relationship between increasing crown size and each measure of crowding. Each of the 10 measures of occlusal variation was tested against each of the mesiodistal crown dimensions of the 14 tooth types. All the regressive coefficients between tooth size and the extent of malocclusion are positive, showing that larger crown dimensions are significantly predictive of crowding; this includes displacements, rotations, and dental overlapping. There were two exceptions where the coefficients were negative, spacing and diastema. In these cases the smaller the teeth the greater the risk of interdental spacing. The common theme is that broader teeth require more space, which increases the risk and degree of dental malocclusion. Our speculation is that tooth-size arch-size discrepancies are on the increase because of secular trends toward larger crown sizes, with little enhancement of the supporting jaw structure.

CHAPTER VI. SUMMARY AND CONCLUSIONS

Malocclusion has been demonstrated to be multifactorial in origin. Most of the studies that have tested for an effect of crown size have compared just two samples, one with crowding and the other without. Those groups with crowding tend to have larger crowns requiring more space for alignment. Our study examined mesiodistal tooth size as a contributing factor to malocclusion and the nature of that association.

We mesasured the mesiodistal width of both maxillary and mandibular teeth from central incisor to second molar on pretreatment orthodontic casts. The casts used were from the University of Tennessee department of orthodontics. The subjects were from 11 to 25 years of age. Data was collected by one observer. Major findings include:

1. Generally, the association between crowding and malocclusion does have a dose response relationship. Subjects with malocclusion have a tendency toward greater tooth size.
2. The relationship is based on a continuum of relative tooth size and degree of malocclusion, rather than the distinct groupings, "crowded" and "not crowded."
3. Specifically, the association between mesiodistal tooth size and malocclusion becomes stronger as the teeth exhibiting larger mesiodistal dimensions are located nearer the midline of the dental arch.

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APPENDIX.

ANCOVA RESULTS

Statistical results, by measure of malocclusion and tooth type

Table A-1. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	3.5376	0.0614
Sex	2.5180	0.1141
U1-Size-x-Sex	0.9087	0.3416
	Within Subjects	
Side	2.4263	0.1209
Side-x-U1-Size	2.2353	0.1364
Side-x-Sex	0.0382	0.8453
Side-x-U1-Size-x-Sex	1.9612	0.1629

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L3 dis	0.38
U_R3 dis	0.41

Means, by Sex

	U_R3 dis	U_L3 dis
Boys	0.33 0.30	
Girls	0.48 0.42	

Table A-2. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	2.3262	0.1288
Sex	6.1700	0.0138
U1-Size-x-Sex	0.0194	0.8894
	Within Subjects	
Side	0.4254	0.5150
Side-x-U1-Size	0.3861	0.5350
Side-x-Sex	0.0622	0.8033
Side-x-U1-Size-x-Sex	2.6798	0.1032

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L2 dis	0.41
U_R2 dis	0.37

Means, by Sex

	U_R2 dis	U_L2 dis
Boys	0.28	0.32
Girls	0.48	0.49

Table A-3. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	5.8228	0.0167
Sex	0.2423	0.6231
U1-Size-x-Sex	0.0102	0.9197
	Within Subjects	
Side	2.1556	0.1436
Side-x-U1-Size	2.2360	0.1364
Side-x-Sex	1.4661	0.2274
Side-x-U1-Size-x-Sex	0.2071	0.6495

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L1 dis	0.36
U_R1 dis	0.34

Means, by Sex

	U_R1 dis	U_L1 dis
Boys	0.35	0.32
Girls	0.33	0.40

Table A-4. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	4.8653	0.0285
Sex	3.8462	0.0512
U1-Size-x-Sex	0.0878	0.7673
	Within Subjects	
Side	0.1763	0.6750
Side-x-U1-Size	0.1842	0.6682
Side-x-Sex	2.5029	0.1152
Side-x-U1-Size-x-Sex	0.1918	0.6619

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L3 dis	0.23
L_R3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boys	0.14 0.20	
Girls	0.33 0.26	

Table A-5. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	18.9529	<0.0001
Sex	4.0880	0.0445
U1-Size-x-Sex	1.2794	0.2593
	Within Subjects	
Side	1.1504	0.2847
Side-x-U1-Size	1.3060	0.2545
Side-x-Sex	0.6421	0.4239
Side-x-U1-Size-x-Sex	0.7807	0.3780

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L2 dis	0.47
L_R2 dis	0.51

Means, by Sex

	L_R2 dis	L_L2 dis
Boys	0.43	0.42
Girls	0.63	0.55

Table A-6. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	2.3891	0.1237
Sex	0.1088	0.7419
U1-Size-x-Sex	3.4616	0.0643
	Within Subjects	
Side	4.0198	0.0463
Side-x-U1-Size	4.2766	0.0399
Side-x-Sex	0.0934	0.7602
Side-x-U1-Size-x-Sex	1.1379	0.2874

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L1 dis	0.17
L_R1 dis	0.22

Means, by Sex

	L_R1 dis	L_L1 dis
Boys	0.22	0.17
Girls	0.19	0.16

Table A-7. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	0.0212	0.8844
Sex	3.8477	0.0512
U1-Size-x-Sex	0.6381	0.4253
	Within Subjects	
Side	0.0015	0.9693
Side-x-U1-Size	0.0025	0.9605
Side-x-Sex	0.3108	0.5778
Side-x-U1-Size-x-Sex	1.4019	0.2378

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L3 rot	0.22
U_R3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boys	0.18	0.15
Girls	0.26	0.28

Table A-8. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	0.5083	0.4767
Sex	0.4839	0.4875
U1-Size-x-Sex	0.2001	0.6551
	Within Subjects	
Side	0.0137	0.9069
Side-x-U1-Size	0.0051	0.9432
Side-x-Sex	0.0000	0.9953
Side-x-U1-Size-x-Sex	0.2304	0.6317

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L2 rot	0.42
U_R2 rot	0.39

Means, by Sex

	U_R2 rot	U_L2 rot
Boys	0.37 0.40	
Girls	0.42 0.45	

Table A-9. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	1.6355	0.2024
Sex	0.2025	0.6532
U1-Size-x-Sex	0.5015	0.4796
	Within Subjects	
Side	2.2066	0.1390
Side-x-U1-Size	2.2706	0.1334
Side-x-Sex	0.4808	0.4889
Side-x-U1-Size-x-Sex	0.1641	0.6858

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L1 rot	0.49
U_R1 rot	0.47

Means, by Sex

	U_R1 rot	U_L1 rot
Boys	0.48 0.46	
Girls	0.48 0.54	

Table A-10. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	8.8001	0.0034
Sex	6.9989	0.0088
U1-Size-x-Sex	0.7419	0.3901
	Within Subjects	
Side	4.4052	0.0371
Side-x-U1-Size	4.6327	0.0325
Side-x-Sex	4.0172	0.0464
Side-x-U1-Size-x-Sex	0.2542	0.6147

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L3 rot	0.35
L_R3 rot	0.39

Means, by Sex

	L_R3 rot	L_L3 rot
Boys	0.26 0.31	
Girls	0.54 0.41	

Table A-11. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	5.3262	0.0220
Sex	1.4471	0.2304
U1-Size-x-Sex	3.8289	0.0517
	Within Subjects	
Side	0.7305	0.3937
Side-x-U1-Size	0.4932	0.4833
Side-x-Sex	0.3355	0.5631
Side-x-U1-Size-x-Sex	0.0316	0.8591

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L2 rot	0.23
L_R2 rot	0.35

Means, by Sex

	L_R2 rot	L_L2 rot
Boys	0.32	0.23
Girls	0.42	0.27

Table A-12. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	1.6622	0.1988
Sex	2.1361	0.1454
U1-Size-x-Sex	0.2453	0.6209
	Within Subjects	
Side	0.3982	0.5287
Side-x-U1-Size	0.3542	0.5524
Side-x-Sex	0.6124	0.4348
Side-x-U1-Size-x-Sex	1.1534	0.2841

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L1 rot	0.34
L_R1 rot	0.38

Means, by Sex

	L_R1 rot	L_L1 rot
Boys	0.43	0.37
Girls	0.31	0.32

Table A-13. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	2.8172	0.0948
Sex	6.7772	0.0099
U1-Size-x-Sex	0.0506	0.8222
	Within Subjects	
Side	1.7119	0.1922
Side-x-U1-Size	1.6323	0.2028
Side-x-Sex	0.0993	0.7529
Side-x-U1-Size-x-Sex	0.3271	0.5680

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L2-3 lapping	0.37
U_R3-2 lapping	0.38

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boys	0.27	0.27
Girls	0.50	0.46

Table A-14. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	0.3522	0.5535
Sex	8.0703	0.0050
U1-Size-x-Sex	0.6330	0.4272
	Within Subjects	
Side	4.8037	0.0295
Side-x-U1-Size	4.6935	0.0314
Side-x-Sex	0.0534	0.8175
Side-x-U1-Size-x-Sex	3.0083	0.0844

*df for each test is 1 and 203.

Means, Sexes Pooled

U_L1-2 lapping	0.31
U_R2-1 lapping	0.35

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boys	0.24	0.22
Girls	0.42	0.42

Table A-15. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	23.2040	<0.0001
Sex	4.1925	0.0419
U1-Size-x-Sex	0.1444	0.7044
	Within Subjects	
Side	0.5212	0.4712
Side-x-U1-Size	0.6281	0.4290
Side-x-Sex	0.0227	0.8804
Side-x-U1-Size-x-Sex	0.1959	0.6585

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L2-3 lapping	0.65
L_R3-2 lapping	0.71

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boys	0.61	0.56
Girls	0.81	0.74

Table A-16. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U1-Size	4.0805	0.0447
Sex	1.1278	0.2895
U1-Size-x-Sex	0.1453	0.7034
	Within Subjects	
Side	1.7706	0.1848
Side-x-U1-Size	1.7178	0.1915
Side-x-Sex	0.2503	0.6174
Side-x-U1-Size-x-Sex	0.0174	0.8952

*df for each test is 1 and 203.

Means, Sexes Pooled

L_L1-2 lapping	0.46
L_R2-1 lapping	0.47

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boys	0.44	0.45
Girls	0.52	0.49

Table A-17. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-12.079	3.841	-3.14	0.0019
U1-Size	1.865	0.444	4.20	< 0.0001
Sex	-0.632	0.239	-2.64	0.0089
Interaction	0.055	0.444	0.12	0.9017

Table A-18. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-4.927	2.886	-1.71	0.0893
U1-Size	1.067	0.334	3.20	0.0016
Sex	-0.376	0.180	-2.09	0.0378
Interaction	-0.473	0.334	-1.42	0.1577

Table A-19. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.148	0.540	-2.13	0.0346
U1-Size	0.162	0.062	2.60	0.0100
Sex	-0.032	0.034	-0.95	0.3441
Interaction	-0.117	0.062	-1.87	0.0632

Table A-20. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.154	0.567	-0.27	0.7861
U1-Size	0.062	0.066	0.94	0.3470
Sex	0.094	0.035	2.67	0.0083
Interaction	0.011	0.066	0.16	0.8722

Table A-21. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-9.439	3.550	-2.66	0.0085
U1-Size	1.590	0.410	3.87	0.0001
Sex	-0.591	0.221	-2.67	0.0081
Interaction	0.049	0.410	0.12	0.9053

Table A-22. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-26.445	8.731	-3.03	0.0028
U1-Size	4.522	1.009	4.48	<0.0001
Sex	-1.599	0.544	-2.94	0.0037
Interaction	-0.369	1.009	-0.37	0.7148

Table A-23. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.549	0.825	-3.09	0.0023
U1-Size	0.455	0.095	4.77	<0.0001
Sex	-0.165	0.051	-3.21	0.0015
Interaction	-0.094	0.095	-0.99	0.3253

Table A-24. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.628	0.635	4.14	<0.0001
U1-Size	-0.275	0.073	-3.75	0.0002
Sex	0.074	0.040	1.88	0.0612
Interaction	0.074	0.073	1.01	0.3142

Table A-25. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.143	0.656	3.27	0.0013
U1-Size	-0.222	0.076	-2.93	0.0037
Sex	0.056	0.041	1.37	0.1724
Interaction	0.111	0.076	1.47	0.1428

Table A-26. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.190	1.551	-2.06	0.0410
U1-Size	0.533	0.179	2.97	0.0033
Sex	-0.202	0.097	-2.09	0.0377
Interaction	0.022	0.179	0.12	0.9037

Table A-27. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-5.346	1.399	-3.82	0.0002
U1-Size	0.749	0.162	4.64	<0.0001
Sex	-0.152	0.087	-1.75	0.0821
Interaction	-0.181	0.162	-1.12	0.2637

Table A-28. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-5.447	2.566	-2.12	0.0350
U1-Size	1.049	0.297	3.54	0.0005
Sex	-0.215	0.160	-1.35	0.1794
Interaction	-0.403	0.297	-1.36	0.1756

Table A-29. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.452	0.315	-1.43	0.1533
U1-Size	0.058	0.036	1.58	0.1151
Sex	-0.049	0.020	-2.47	0.0144
Interaction	-0.058	0.036	-1.58	0.1151

Table A-30. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.214	0.533	-0.40	0.6888
U1-Size	0.035	0.062	0.56	0.5755
Sex	0.005	0.033	0.16	0.8756
Interaction	-0.107	0.062	-1.73	0.0852

Table A-31. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.514	0.821	0.63	0.5321
U1-Size	0.029	0.095	0.30	0.7609
Sex	0.033	0.051	0.64	0.5214
Interaction	-0.116	0.095	-1.22	0.2228

Table A-32. ANCOVA results testing for associations between mesiodistal width of the maxillary central incisor and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.491	7.395	0.34	0.7366
U1-Size	2.852	0.855	3.34	0.0010
Sex	-0.743	0.462	-1.61	0.1091
Interaction	-1.331	0.855	-1.56	0.1209

Table A-33. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	4.2803	0.0398
Sex	1.7976	0.1815
U2-Size-x-Sex	0.4548	0.5008
	Within Subjects	
Side	0.2040	0.6520
Side-x-U2-Size	0.2848	0.5941
Side-x-Sex	0.4447	0.5056
Side-x-U2-Size-x-Sex	8.8045	0.0034

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.34 0.33	
Girl	0.49 0.41	

Table A-34. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	3.7261	0.0550
Sex	5.5283	0.0197
U2-Size-x-Sex	0.0628	0.8024
	Within Subjects	
Side	6.7906	0.0098
Side-x-U2-Size	6.5428	0.0113
Side-x-Sex	0.1214	0.7279
Side-x-U2-Size-x-Sex	11.5546	0.0008

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29 0.33	
Girl	0.47 0.48	

Table A-35. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	1.6922	0.1948
Sex	0.0003	0.9855
U2-Size-x-Sex	0.0287	0.8657
	Within Subjects	
Side	0.3784	0.5391
Side-x-U2-Size	0.3498	0.5549
Side-x-Sex	0.5941	0.4417
Side-x-U2-Size-x-Sex	0.8796	0.3494

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.34
Girl	0.33	0.37

Table A-36. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	0.2222	0.6379
Sex	2.1213	0.1468
U2-Size-x-Sex	3.1223	0.0787
	Within Subjects	
Side	0.1621	0.6877
Side-x-U2-Size	0.1767	0.6746
Side-x-Sex	2.4492	0.1191
Side-x-U2-Size-x-Sex	1.7712	0.1847

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.15	0.21
Girl	0.30	0.23

Table A-37. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	5.1285	0.0246
Sex	1.1895	0.2767
U2-Size-x-Sex	0.0006	0.9809
	Within Subjects	
Side	0.1934	0.6606
Side-x-U2-Size	0.2710	0.6032
Side-x-Sex	0.3097	0.5785
Side-x-U2-Size-x-Sex	0.4707	0.4935

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.46	0.44
Girl	0.57	0.51

Table A-38. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	5.0822	0.0252
Sex	0.2588	0.6115
U2-Size-x-Sex	0.1481	0.7007
	Within Subjects	
Side	1.5819	0.2099
Side-x-U2-Size	1.9143	0.1680
Side-x-Sex	0.5183	0.4724
Side-x-U2-Size-x-Sex	0.0603	0.8062

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.25 0.17	
Girl	0.20 0.17	

Table A-39. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	0.2508	0.6171
Sex	4.0719	0.0449
U2-Size-x-Sex	0.1278	0.7211
	Within Subjects	
Side	0.0001	0.9915
Side-x-U2-Size	0.0000	0.9979
Side-x-Sex	0.3582	0.5502
Side-x-U2-Size-x-Sex	0.0104	0.9189

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.18	0.16
Girl	0.26	0.29

Table A-40. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	2.9121	0.0894
Sex	0.4837	0.4875
U2-Size-x-Sex	0.3622	0.5479
	Within Subjects	
Side	0.2990	0.5851
Side-x-U2-Size	0.2532	0.6154
Side-x-Sex	0.0012	0.9726
Side-x-U2-Size-x-Sex	1.4010	0.2379

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.37	0.39
Girl	0.42	0.44

Table A-41. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	3.0330	0.0831
Sex	0.0818	0.7751
U2-Size-x-Sex	0.0725	0.7880
	Within Subjects	
Side	0.5484	0.4598
Side-x-U2-Size	0.5297	0.4676
Side-x-Sex	0.0488	0.8254
Side-x-U2-Size-x-Sex	1.7366	0.1891

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.47
Girl	0.48	0.50

Table A-42. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	1.0472	0.3074
Sex	3.9270	0.0489
U2-Size-x-Sex	0.0056	0.9406
	Within Subjects	
Side	1.6899	0.1951
Side-x-U2-Size	1.9180	0.1676
Side-x-Sex	2.6005	0.1084
Side-x-U2-Size-x-Sex	0.7431	0.3897

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.29	0.32
Girl	0.50	0.39

Table A-43. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	0.7958	0.3734
Sex	0.4635	0.4968
U2-Size-x-Sex	1.4732	0.2263
	Within Subjects	
Side	0.0209	0.8852
Side-x-U2-Size	0.1397	0.7090
Side-x-Sex	0.6885	0.4076
Side-x-U2-Size-x-Sex	0.0413	0.8393

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.32 0.23	
Girl	0.40 0.24	

Table A-44. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	0.0007	0.9797
Sex	3.4614	0.0643
U2-Size-x-Sex	0.0000	0.9977
	Within Subjects	
Side	0.0011	0.9741
Side-x-U2-Size	0.0110	0.9165
Side-x-Sex	0.3902	0.5329
Side-x-U2-Size-x-Sex	0.2524	0.6160

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.44	0.38
Girl	0.31	0.30

Table A-45. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	6.4025	0.0122
Sex	6.2854	0.0130
U2-Size-x-Sex	0.0088	0.9253
	Within Subjects	
Side	0.1837	0.6687
Side-x-U2-Size	0.2224	0.6377
Side-x-Sex	0.5232	0.4703
Side-x-U2-Size-x-Sex	2.5816	0.1097

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.27 0.29	
Girl	0.51 0.45	

Table A-46. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	4.8170	0.0293
Sex	9.1870	0.0028
U2-Size-x-Sex	0.7472	0.3884
	Within Subjects	
Side	0.1775	0.6739
Side-x-U2-Size	0.2555	0.6138
Side-x-Sex	0.1779	0.6736
Side-x-U2-Size-x-Sex	1.5613	0.2129

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25	0.23
Girl	0.46	0.41

Table A-47. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	7.6456	0.0062
Sex	1.1035	0.2947
U2-Size-x-Sex	0.3883	0.5339
	Within Subjects	
Side	0.0137	0.9070
Side-x-U2-Size	0.0528	0.8185
Side-x-Sex	0.0013	0.9718
Side-x-U2-Size-x-Sex	0.3115	0.5774

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.67	0.60
Girl	0.76	0.70

Table A-48. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U2-Size	10.2793	0.0016
Sex	0.7761	0.3794
U2-Size-x-Sex	1.1748	0.2797
	Within Subjects	
Side	1.3443	0.2476
Side-x-U2-Size	1.2992	0.2557
Side-x-Sex	0.5713	0.4506
Side-x-U2-Size-x-Sex	0.0083	0.9273

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.44	0.46
Girl	0.52	0.48

Table A-49. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.8710	2.6614	-1.45	0.1474
U2	1.2004	0.4002	3.00	0.0030
Sex	-0.4381	0.2368	-1.85	0.0658
Interaction	0.2287	0.4002	0.57	0.5683

Table A-50. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.2842	1.9888	0.14	0.8865
U2	0.5992	0.2991	2.00	0.0464
Sex	-0.2576	0.1770	-1.46	0.1471
Interaction	0.0088	0.2991	0.03	0.9766

Table A-51. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.7290	0.3672	-1.99	0.0485
U2	0.1467	0.0552	2.66	0.0085
Sex	-0.0171	0.0327	-0.52	0.6003
Interaction	-0.0399	0.0552	-0.72	0.4709

Table A-52. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.6707	0.3784	-1.77	0.0778
U2	0.1590	0.0569	2.79	0.0057
Sex	0.0933	0.0337	2.77	0.0061
Interaction	-0.0125	0.0569	-0.22	0.8259

Table A-53. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.3852	2.3866	-2.68	0.0081
U2	1.6211	0.3589	4.52	< 0.0001
Sex	-0.4632	0.2124	-2.18	0.0303
Interaction	-0.1691	0.3589	-0.47	0.6381

Table A-54. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-9.9720	6.0047	-1.66	0.0983
U2	3.4207	0.9030	3.79	0.0002
Sex	-1.1588	0.5343	-2.17	0.0312
Interaction	0.0685	0.9030	0.08	0.9396

Table A-55. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and crowding.

Term	Estimate	SE	t-Test	P-value
Intercept	-1.3905	0.5565	-2.50	0.0133
U2	0.4188	0.0837	5.00	<0.0001
Sex	-0.1254	0.0495	-2.53	0.0121
Interaction	-0.1070	0.0837	-1.28	0.2026

Table A-56. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.0586	0.4257	4.84	<0.0001
U2	-0.2729	0.0640	-4.26	<0.0001
Sex	0.0516	0.0379	1.36	0.1746
Interaction	0.1001	0.0640	1.56	0.1195

Table A-57. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.4089	0.4464	3.16	0.0018
U2	-0.1782	0.0671	-2.66	0.0086
Sex	0.0346	0.0397	0.87	0.3844
Interaction	0.0773	0.0671	1.15	0.2508

Table A-58. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.1855	1.0397	-2.10	0.0368
U2	0.5438	0.1564	3.48	0.0006
Sex	-0.1588	0.0925	-1.72	0.0876
Interaction	0.1794	0.1564	1.15	0.2525

Table A-59. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.6873	0.9774	-1.73	0.0858
U2	0.4243	0.1470	2.89	0.0043
Sex	-0.0701	0.0870	-0.81	0.4213
Interaction	0.0197	0.1470	0.13	0.8936

Table A-60. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.8715	1.7902	1.05	0.2971
U2	0.2596	0.2692	0.96	0.3360
Sex	-0.0793	0.1593	-0.50	0.6193
Interaction	0.0503	0.2692	0.19	0.8520

Table A-61. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.1128	0.2157	-0.52	0.6016
U2	0.0233	0.0324	0.72	0.4743
Sex	-0.0415	0.0192	-2.16	0.0319
Interaction	-0.0233	0.0324	-0.72	0.4743

Table A-62. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.3544	0.3625	-0.98	0.3295
U2	0.0638	0.0545	1.17	0.2432
Sex	0.0068	0.0322	0.21	0.8320
Interaction	0.0309	0.0545	0.57	0.5712

Table A-63. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.7536	0.5473	3.20	0.0016
U2	-0.1502	0.0823	-1.82	0.0695
Sex	0.0463	0.0487	0.95	0.3431
Interaction	-0.1649	0.0823	-2.00	0.0465

Table A-64. ANCOVA results testing for associations between mesiodistal width of the maxillary lateral incisor and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	20.7000	5.1314	4.03	<0.0001
U2	0.9506	0.7717	1.23	0.2194
Sex	-0.3648	0.4566	-0.80	0.4253
Interaction	0.1717	0.7717	0.22	0.8241

Table A-65. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	7.9819	0.0052
Sex	4.3359	0.0386
U3-Size-x-Sex	0.1031	0.7485
	Within Subjects	
Side	0.1688	0.6816
Side-x-U3-Size	0.1287	0.7201
Side-x-Sex	0.1895	0.6638
Side-x-U3-Size-x-Sex	0.8033	0.3712

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.31	0.29
Girl	0.52	0.45

Table A-66. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	2.0287	0.1559
Sex	6.3508	0.0125
U3-Size-x-Sex	0.0702	0.7914
	Within Subjects	
Side	3.2939	0.0710
Side-x-U3-Size	3.2631	0.0723
Side-x-Sex	0.5557	0.4569
Side-x-U3-Size-x-Sex	4.5645	0.0338

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.27 0.31	
Girl	0.50 0.47	

Table A-67. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	0.6983	0.4043
Sex	0.0268	0.8702
U3-Size-x-Sex	0.0819	0.7751
	Within Subjects	
Side	0.0219	0.8824
Side-x-U3-Size	0.0279	0.8675
Side-x-Sex	0.7044	0.4023
Side-x-U3-Size-x-Sex	0.0071	0.9330

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.36 0.34	
Girl	0.33 0.39	

Table A-68. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	1.7836	0.1832
Sex	3.2118	0.0746
U3-Size-x-Sex	4.9983	0.0265
	Within Subjects	
Side	0.1706	0.6800
Side-x-U3-Size	0.1604	0.6892
Side-x-Sex	1.6335	0.2027
Side-x-U3-Size-x-Sex	0.1933	0.6607

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.13 0.17	
Girl	0.29 0.23	

Table A-69. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	11.1600	0.0010
Sex	4.0868	0.0445
U3-Size-x-Sex	0.0192	0.8899
	Within Subjects	
Side	0.0002	0.9885
Side-x-U3-Size	0.0021	0.9635
Side-x-Sex	0.2285	0.6331
Side-x-U3-Size-x-Sex	1.0581	0.3049

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.41 0.41	
Girl	0.61 0.57	

Table A-70. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	2.5939	0.1088
Sex	0.0129	0.9096
U3-Size-x-Sex	0.0778	0.7806
	Within Subjects	
Side	1.0523	0.3062
Side-x-U3-Size	1.2591	0.2631
Side-x-Sex	0.1524	0.6966
Side-x-U3-Size-x-Sex	0.8978	0.3445

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.24 0.16	
Girl	0.22 0.17	

Table A-71. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	0.0241	0.8768
Sex	3.5415	0.0613
U3-Size-x-Sex	0.0064	0.9361
	Within Subjects	
Side	0.0001	0.9925
Side-x-U3-Size	0.0000	0.9959
Side-x-Sex	0.3088	0.5790
Side-x-U3-Size-x-Sex	0.3146	0.5755

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.18 0.16	
Girl	0.26 0.28	

Table A-72. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	8.3544	0.0043
Sex	2.3672	0.1255
U3-Size-x-Sex	0.0170	0.8964
	Within Subjects	
Side	0.0639	0.8007
Side-x-U3-Size	0.0489	0.8252
Side-x-Sex	0.0038	0.9509
Side-x-U3-Size-x-Sex	0.0208	0.8854

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.34 0.37	
Girl	0.46 0.48	

Table A-73. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	0.2027	0.6530
Sex	0.0692	0.7928
U3-Size-x-Sex	0.0005	0.9814
	Within Subjects	
Side	0.0442	0.8337
Side-x-U3-Size	0.0490	0.8250
Side-x-Sex	0.1272	0.7218
Side-x-U3-Size-x-Sex	0.0574	0.8110

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.47 0.47	
Girl	0.48 0.51	

Table A-74. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	7.3094	0.0074
Sex	7.6915	0.0061
U3-Size-x-Sex	0.9795	0.3235
	Within Subjects	
Side	0.0304	0.8617
Side-x-U3-Size	0.0503	0.8227
Side-x-Sex	2.1070	0.1482
Side-x-U3-Size-x-Sex	0.0523	0.8194

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.27 0.29	
Girl	0.55 0.44	

Table A-75. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	1.9423	0.1649
Sex	1.1354	0.2879
U3-Size-x-Sex	1.2857	0.2582
	Within Subjects	
Side	0.1218	0.7274
Side-x-U3-Size	0.2416	0.6236
Side-x-Sex	0.8458	0.3588
Side-x-U3-Size-x-Sex	0.0117	0.9138

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.31 0.23	
Girl	0.43 0.25	

Table A-76. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	1.3966	0.2387
Sex	4.8038	0.0295
U3-Size-x-Sex	1.3850	0.2406
	Within Subjects	
Side	0.0842	0.7719
Side-x-U3-Size	0.0607	0.8056
Side-x-Sex	0.4687	0.4944
Side-x-U3-Size-x-Sex	0.0356	0.8506

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.44 0.37	
Girl	0.28 0.28	

Table A-77. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	6.7177	0.0102
Sex	9.2401	0.0027
U3-Size-x-Sex	0.0981	0.7544
	Within Subjects	
Side	0.0572	0.8112
Side-x-U3-Size	0.0359	0.8500
Side-x-Sex	0.3339	0.5640
Side-x-U3-Size-x-Sex	2.3874	0.1239

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.25	0.24
Girl	0.54	0.46

Table A-78. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	6.7976	0.0098
Sex	12.7908	0.0004
U3-Size-x-Sex	0.0330	0.8561
	Within Subjects	
Side	0.2953	0.5874
Side-x-U3-Size	0.2447	0.6214
Side-x-Sex	0.0275	0.8685
Side-x-U3-Size-x-Sex	0.0375	0.8466

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.22	0.19
Girl	0.48	0.43

Table A-79. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	20.7044	<0.0001
Sex	5.6409	0.0185
U3-Size-x-Sex	0.4657	0.4958
	Within Subjects	
Side	0.1816	0.6705
Side-x-U3-Size	0.2640	0.6079
Side-x-Sex	0.0197	0.8884
Side-x-U3-Size-x-Sex	0.5200	0.4717

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.60	0.53
Girl	0.83	0.75

Table A-80. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U3-Size	4.0556	0.0453
Sex	1.5371	0.2165
U3-Size-x-Sex	0.3862	0.5350
	Within Subjects	
Side 1.0086	0.3164	
Side-x-U3-Size	1.0131	0.3153
Side-x-Sex	0.1983	0.6565
Side-x-U3-Size-x-Sex	0.6239	0.4305

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.43 0.45	
Girl	0.52 0.51	

Table A-81. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-10.7012	4.2522	-2.52	0.0126
U3-Size	1.8877	0.5449	3.46	0.0006
Sex	-0.6768	0.2508	-2.70	0.0075
Interaction	0.3633	0.5449	0.67	0.5057

Table A-82. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.6868	3.1851	-1.16	0.2484
U3-Size	1.0210	0.4082	2.50	0.0132
Sex	-0.3916	0.1879	-2.08	0.0384
Interaction	-0.1769	0.4082	-0.43	0.6652

Table A-83. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.5514	0.5988	-0.92	0.3582
U3-Size	0.1013	0.0767	1.32	0.1881
Sex	-0.0249	0.0353	-0.71	0.4812
Interaction	0.0102	0.0767	0.13	0.8949

Table A-84. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4704	0.6166	-0.76	0.4464
U3-Size	0.1080	0.0790	1.37	0.1733
Sex	0.0854	0.0364	2.35	0.0198
Interaction	0.0598	0.0790	0.76	0.4503

Table A-85. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-13.4738	3.8228	-3.52	0.0005
U3-Size	2.2781	0.4899	4.65	<0.0001
Sex	-0.7412	0.2255	-3.29	0.0012
Interaction	0.2095	0.4899	0.43	0.6693

Table A-86. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-27.8618	9.5820	-2.91	0.0040
U3-Size	5.1868	1.2279	4.22	<0.0001
Sex	-1.8096	0.5651	-3.20	0.0016
Interaction	0.3960	1.2279	0.32	0.7474

Table A-87. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.1551	0.8924	-3.54	0.0005
U3-Size	0.5846	0.1144	5.11	<0.0001
Sex	-0.1978	0.0526	-3.76	0.0002
Interaction	-0.1893	0.1144	-1.66	0.0994

Table A-88. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.9298	0.6897	4.25	<0.0001
U3-Size	-0.3452	0.0884	-3.91	0.0001
Sex	0.0928	0.0407	2.28	0.0235
Interaction	0.1299	0.0884	1.47	0.1431

Table A-89. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.1951	0.7183	3.06	0.0025
U3-Size	-0.2532	0.0921	-2.75	0.0065
Sex	0.0661	0.0424	1.56	0.1202
Interaction	0.0832	0.0921	0.90	0.3669

Table A-90. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.7915	1.6945	-2.24	0.0263
U3-Size	0.6697	0.2171	3.08	0.0023
Sex	-0.2375	0.0999	-2.38	0.0184
Interaction	-0.0463	0.2171	-0.21	0.8313

Table A-91. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.1678	1.5759	-2.01	0.0457
U3-Size	0.5480	0.2019	2.71	0.0072
Sex	-0.1348	0.0929	-1.45	0.1485
Interaction	0.0898	0.2019	0.44	0.6569

Table A-92. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.9772	2.8462	-1.05	0.2968
U3-Size	0.8505	0.3647	2.33	0.0207
Sex	-0.2070	0.1679	-1.23	0.2189
Interaction	-0.4223	0.3647	-1.16	0.2483

Table A-93. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4757	0.3445	-1.38	0.1688
U3-Size	0.0675	0.0441	1.53	0.1280
Sex	-0.0516	0.0203	-2.54	0.0119
Interaction	-0.0675	0.0441	-1.53	0.1280

Table A-94. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.7424	0.5841	1.27	0.2052
U3-Size	-0.0854	0.0748	-1.14	0.2555
Sex	0.0246	0.0344	0.72	0.4753
Interaction	-0.0302	0.0748	-0.40	0.6868

Table A-95. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.1402	0.8869	-0.16	0.8746
U3-Size	0.1191	0.1137	1.05	0.2957
Sex	0.0163	0.0523	0.31	0.7555
Interaction	-0.2593	0.1137	-2.28	0.0236

Table A-96. ANCOVA results testing for associations between mesiodistal width of the maxillary canine and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	8.7728	8.1649	1.07	0.2839
U3-Size	2.3678	1.0463	2.26	0.0247
Sex	-0.7087	0.4816	-1.47	0.1427
Interaction	-1.5229	1.0463	-1.46	0.1471

Table A-97. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.0323	0.8576
Sex	1.2886	0.2576
U4-Size-x-Sex	0.0015	0.969
	Within Subjects	
Side 0.0288	0.8654	
Side-x-U4-Size	0.0433	0.8355
Side-x-Sex	0.374	0.5415
Side-x-U4-Size-x-Sex	0.2555	0.6138

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29 0.34	
Girl	0.46 0.49	

Table A-98. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.0323	0.8576
Sex	4.6426	0.0324
U4-Size-x-Sex	0.2225	0.6376
	Within Subjects	
Side	1.6437	0.2013
Side-x-U4-Size	1.5222	0.2187
Side-x-Sex	0.0376	0.8464
Side-x-U4-Size-x-Sex	1.2473	0.2654

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.35	0.34
Girl	0.47	0.41

Table A-99. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.8903	0.3465
Sex	0.0036	0.9525
U4-Size-x-Sex	0.0616	0.8042
	Within Subjects	
Side	0.0001	0.9933
Side-x-U4-Size	0.0003	0.9873
Side-x-Sex	0.6982	0.4044
Side-x-U4-Size-x-Sex	0.0925	0.7614

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.34
Girl	0.32	0.37

Table A-100. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.7676	0.3820
Sex	2.2233	0.1375
U4-Size-x-Sex	1.2563	0.2637
	Within Subjects	
Side	0.3693	0.5441
Side-x-U4-Size	0.3668	0.5454
Side-x-Sex	2.1165	0.1473
Side-x-U4-Size-x-Sex	0.0084	0.9271

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.15	0.21
Girl	0.30	0.24

Table A-101. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	5.0154	0.0262
Sex	1.1508	0.2847
U4-Size-x-Sex	0.2410	0.6240
	Within Subjects	
Side	0.0384	0.8448
Side-x-U4-Size	0.0209	0.8853
Side-x-Sex	0.2392	0.6253
Side-x-U4-Size-x-Sex	1.0024	0.3179

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.46	0.44
Girl	0.56	0.51

Table A-102. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L1 displacements.

Source	F-Ratio*	P-Ralue
	Among Subjects	
U4-Size	0.1468	0.7020
Sex	0.4854	0.4868
U4-Size-x-Sex	0.0409	0.8399
	Within Subjects	
Side	0.8265	0.3644
Side-x-U4-Size	0.9926	0.3203
Side-x-Sex	0.5812	0.4467
Side-x-U4-Size-x-Sex	0.2940	0.5883

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.25	0.17
Girl	0.19	0.17

Table A-103. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.3104	0.5781
Sex	4.5206	0.0347
U4-Size-x-Sex	0.5716	0.4505
	Within Subjects	
Side	0.2872	0.5926
Side-x-U4-Size	0.2984	0.5855
Side-x-Sex	0.4249	0.5153
Side-x-U4-Size-x-Sex	0.0787	0.7794

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.16
Girl	0.26	0.29

Table A-104. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.2566	0.6130
Sex	0.2205	0.6392
U4-Size-x-Sex	0.1245	0.7246
	Within Subjects	
Side	0.0850	0.7709
Side-x-U4-Size	0.1138	0.7362
Side-x-Sex	0.0034	0.9538
Side-x-U4-Size-x-Sex	1.9843	0.1605

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.37	0.40
Girl	0.40	0.44

Table A-105. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	1.7269	0.1903
Sex	0.0545	0.8157
U4-Size-x-Sex	0.0336	0.8548
	Within Subjects	
Side	0.4199	0.5177
Side-x-U4-Size	0.4008	0.5274
Side-x-Sex	0.0563	0.8127
Side-x-U4-Size-x-Sex	0.1788	0.6729

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.47
Girl	0.48	0.50

Table A-106. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	2.5757	0.1101
Sex	4.1790	0.0422
U4-Size-x-Sex	1.0385	0.3094
	Within Subjects	
Side	0.0509	0.8218
Side-x-U4-Size	0.0332	0.8556
Side-x-Sex	2.0831	0.1505
Side-x-U4-Size-x-Sex	0.9753	0.3245

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.29	0.32
Girl	0.50	0.40

Table A-107. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	2.7094	0.1013
Sex 0.5625	0.4541	
U4-Size-x-Sex	1.8345	0.1771
	Within Subjects	
Side 0.7860	0.3764	
Side-x-U4-Size	1.0994	0.2956
Side-x-Sex	0.8124	0.3685
Side-x-U4-Size-x-Sex	2.1242	0.1465

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.32 0.23	
Girl	0.40 0.23	

Table A-108. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.8362	0.3616
Sex 3.1939	0.0754	
U4-Size-x-Sex	1.3145	0.2529
	Within Subjects	
Side 0.1836	0.6687	
Side-x-U4-Size	0.2357	0.6279
Side-x-Sex	0.3432	0.5586
Side-x-U4-Size-x-Sex	0.7831	0.3772

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43 0.37	
Girl	0.31 0.30	

Table A-109. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.2016	0.6539
Sex	5.1005	0.0250
U4-Size-x-Sex	0.0034	0.9538
	Within Subjects	
Side	0.0896	0.7650
Side-x-U4-Size	0.1040	0.7474
Side-x-Sex	0.4904	0.4845
Side-x-U4-Size-x-Sex	0.6847	0.4089

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28 0.30	
Girl	0.49 0.44	

Table A-110. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	0.0143	0.9050
Sex	7.7425	0.0059
U4-Size-x-Sex	0.3132	0.5763
	Within Subjects	
Side	0.4202	0.5176
Side-x-U4-Size	0.3641	0.5469
Side-x-Sex	0.0936	0.7600
Side-x-U4-Size-x-Sex	0.1852	0.6674

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.23	
Girl	0.45 0.40	

Table A-111. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	9.4220	0.0024
Sex	1.1374	0.2875
U4-Size-x-Sex	1.8102	0.1800
	Within Subjects	
Side	1.2552	0.2639
Side-x-U4-Size	1.4426	0.2311
Side-x-Sex	0.0034	0.9538
Side-x-U4-Size-x-Sex	0.0201	0.8875

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.66	0.60
Girl	0.76	0.69

Table A-112. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U4-Size	10.3587	0.0015
Sex	0.7370	0.3916
U4-Size-x-Sex	0.4192	0.5181
	Within Subjects	
Side	0.6691	0.4143
Side-x-U4-Size	0.6331	0.4271
Side-x-Sex	0.6486	0.4215
Side-x-U4-Size-x-Sex	2.1003	0.1488

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.44 0.46	
Girl	0.52 0.47	

Table A-113. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.4039	4.1240	-0.83	0.4101
U4-Size	0.7697	0.4228	1.82	0.1517
Sex	-1.0569	4.1240	-0.26	0.7980
Interaction	0.0610	0.4228	0.14	0.8854

Table A-114. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.692	2.966	-0.57	0.5690
U4-Size	0.860	0.428	2.01	0.0459
Sex	-0.255	0.177	-1.44	0.1504
Interaction	-0.029	0.428	-0.07	0.9460

Table A-115. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.451	0.554	-0.81	0.4172
U4-Size	0.101	0.080	1.26	0.2108
Sex	-0.012	0.033	-0.37	0.7116
Interaction	-0.073	0.080	-0.91	0.3616

Table A-116. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.8642	0.5870	1.47	0.1425
U4-Size	-0.0491	0.0602	-0.82	0.4155
Sex	0.3251	0.5870	0.55	0.5803
Interaction	-0.0222	0.0602	-0.37	0.7131

Table A-117. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.3852	2.3866	-2.68	0.0081
U4-Size	1.6211	0.3589	4.52	0.0054
Sex	-0.4632	0.2124	-2.18	0.0303
Interaction	-0.1691	0.3589	-0.47	0.6381

Table A-118. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.714	4.043	-0.42	0.6721
U4-Size	0.840	0.584	1.44	0.0167
Sex	-0.399	0.241	-1.65	0.0996
Interaction	0.147	0.584	0.25	0.8010

Table A-119. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.203	0.842	-2.62	0.0095
U4-Size	0.519	0.122	4.27	<0.0001
Sex	-0.121	0.050	-2.40	0.0172
Interaction	-0.189	0.122	-1.56	0.1213

Table A-120. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.934	0.634	4.63	<0.0001
U4-Size	-0.388	0.092	-4.24	<0.0001
Sex	0.050	0.038	1.33	0.1840
Interaction	0.177	0.092	1.93	0.0553

Table A-121. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.731	0.662	2.61	0.0096
U4-Size	-0.218	0.096	-2.28	0.0235
Sex	0.033	0.039	0.83	0.4099
Interaction	0.243	0.096	2.54	0.0118

Table A-122. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.687	1.599	-0.43	0.6678
U4-Size	0.306	0.231	1.33	0.1863
Sex	-0.138	0.095	-1.45	0.1484
Interaction	0.008	0.231	0.03	0.9740

Table A-123. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.022	1.468	-1.38	0.1699
U4-Size	0.454	0.212	2.14	0.0333
Sex	-0.062	0.088	-0.71	0.4785
Interaction	0.150	0.212	0.71	0.4797

Table A-124. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.507	2.648	-0.57	0.5700
U4-Size	0.740	0.383	1.94	0.0544
Sex	-0.093	0.158	-0.59	0.5549
Interaction	-0.420	0.383	-1.10	0.2739

Table A-125. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.252	0.321	-0.78	0.4339
U4-Size	0.042	0.046	0.91	0.3615
Sex	-0.042	0.019	-2.18	0.0305
Interaction	-0.042	0.046	-0.91	0.3615

Table A-126. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.406	0.542	0.75	0.4549
U4-Size	-0.048	0.078	-0.62	0.5386
Sex	0.013	0.032	0.39	0.6994
Interaction	-0.041	0.078	-0.53	0.5995

Table A-127. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.864	0.828	2.25	0.0255
U4-Size	-0.161	0.120	-1.35	0.1799
Sex	0.044	0.049	0.89	0.3764
Interaction	-0.069	0.120	-0.58	0.5650

Table A-128. ANCOVA results testing for associations between mesiodistal width of the maxillary first premolar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	20.795	7.671	2.71	0.0073
U4-Size	0.901	1.108	0.81	0.4172
Sex	-0.343	0.457	-0.75	0.4536
Interaction	-0.276	1.108	-0.25	0.8033

Table A-129. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.1629	0.6869
Sex	1.3915	0.2395
U5-Size-x-Sex	0.2709	0.6033
	Within Subjects	
Side	0.9803	0.3233
Side-x-U5-Size	0.8776	0.3500
Side-x-Sex	0.1905	0.6630
Side-x-U5-Size-x-Sex	2.2355	0.1364

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.36	0.34
Girl	0.48	0.41

Table A-130. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.1422	0.7065
Sex	4.7473	0.0305
U5-Size-x-Sex	0.0097	0.9216
	Within Subjects	
Side	1.1513	0.2846
Side-x-U5-Size	1.0528	0.3061
Side-x-Sex	0.0642	0.8003
Side-x-U5-Size-x-Sex	1.0513	0.3064

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29	0.33
Girl	0.46	0.48

Table A-131. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.1557	0.6936
Sex	0.0065	0.9358
U5-Size-x-Sex	0.0088	0.9252
	Within Subjects	
Side	0.7907	0.3749
Side-x-U5-Size	0.8649	0.3535
Side-x-Sex	0.9923	0.3204
Side-x-U5-Size-x-Sex	1.6773	0.1968

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36 0.35	
Girl	0.31 0.38	

Table A-132. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.5778	0.4480
Sex	1.5821	0.2099
U5-Size-x-Sex	1.2727	0.2606
	Within Subjects	
Side	1.1339	0.2882
Side-x-U5-Size	1.1075	0.2939
Side-x-Sex	1.7677	0.1852
Side-x-U5-Size-x-Sex	0.9828	0.3227

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.16 0.21	
Girl	0.29 0.23	

Table A-133. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	1.0815	0.2996
Sex	1.0351	0.3102
U5-Size-x-Sex	4.5387	0.0343
	Within Subjects	
Side	0.3656	0.5461
Side-x-U5-Size	0.2930	0.5889
Side-x-Sex	0.1669	0.6833
Side-x-U5-Size-x-Sex	0.0397	0.8422

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.45	0.42
Girl	0.55	0.49

Table A-134. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.8520	0.3571
Sex	0.7836	0.3771
U5-Size-x-Sex	0.0224	0.8813
	Within Subjects	
Side	0.3236	0.5701
Side-x-U5-Size	0.4473	0.5044
Side-x-Sex	0.5346	0.4655
Side-x-U5-Size-x-Sex	0.6174	0.4329

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.26	0.17
Girl	0.19	0.16

Table A-135. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	1.8728	0.1727
Sex	5.2575	0.0229
U5-Size-x-Sex	0.0016	0.9679
	Within Subjects	
Side	0.6017	0.4388
Side-x-U5-Size	0.6357	0.4262
Side-x-Sex	0.5428	0.4621
Side-x-U5-Size-x-Sex	0.9970	0.3192

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.15
Girl	0.26	0.30

Table A-136. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.0204	0.8865
Sex	0.2344	0.6288
U5-Size-x-Sex	1.1634	0.2820
	Within Subjects	
Side	0.1077	0.7432
Side-x-U5-Size	0.0757	0.7834
Side-x-Sex	0.0004	0.9845
Side-x-U5-Size-x-Sex	1.3527	0.2462

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.40
Girl	0.40	0.44

Table A-137. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.8313	0.3630
Sex	0.0660	0.7975
U5-Size-x-Sex	1.3203	0.2519
	Within Subjects	
Side	0.0025	0.9603
Side-x-U5-Size	0.0050	0.9435
Side-x-Sex	0.0953	0.7579
Side-x-U5-Size-x-Sex	0.0237	0.8777

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.46	0.46
Girl	0.47	0.50

Table A-138. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	7.6866	0.0061
Sex	5.5999	0.0189
U5-Size-x-Sex	0.1755	0.6758
	Within Subjects	
Side	0.0265	0.8709
Side-x-U5-Size	0.0135	0.9077
Side-x-Sex	2.0263	0.1561
Side-x-U5-Size-x-Sex	0.3011	0.5838

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.27	0.31
Girl	0.51	0.41

Table A-139. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.8376	0.3612
Sex	0.5439	0.4617
U5-Size-x-Sex	0.1883	0.6648
	Within Subjects	
Side	0.0002	0.9891
Side-x-U5-Size	0.0231	0.8794
Side-x-Sex	0.6555	0.4191
Side-x-U5-Size-x-Sex	0.0111	0.9161

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.32	0.23
Girl	0.40	0.24

Table A-140. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.0689	0.7932
Sex	3.2808	0.0716
U5-Size-x-Sex	1.7729	0.1845
	Within Subjects	
Side	0.8188	0.3666
Side-x-U5-Size	0.9481	0.3314
Side-x-Sex	0.2093	0.6478
Side-x-U5-Size-x-Sex	1.0183	0.3141

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43	0.37
Girl	0.31	0.29

Table A-141. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.8459	0.3588
Sex	5.5489	0.0194
U5-Size-x-Sex	0.0780	0.7804
	Within Subjects	
Side	0.0166	0.8978
Side-x-U5-Size	0.0242	0.8764
Side-x-Sex	0.4760	0.4910
Side-x-U5-Size-x-Sex	0.4122	0.5216

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28	0.29
Girl	0.50	0.44

Table A-142. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	1.0051	0.3173
Sex	8.5520	0.0038
U5-Size-x-Sex	1.5640	0.2125
	Within Subjects	
Side	1.0112	0.3158
Side-x-U5-Size	0.9297	0.3361
Side-x-Sex	0.0370	0.8476
Side-x-U5-Size-x-Sex	0.6007	0.4392

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.24	0.22
Girl	0.44	0.41

Table A-143. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	11.1290	0.0010
Sex	1.7797	0.1837
U5-Size-x-Sex	1.3146	0.2529
	Within Subjects	
Side	0.0000	0.9974
Side-x-U5-Size	0.0104	0.9188
Side-x-Sex	0.0010	0.9744
Side-x-U5-Size-x-Sex	1.4393	0.2317

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.65	0.58
Girl	0.77	0.70

Table A-144. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U5-Size	0.1644	0.6855
Sex	0.3578	0.5504
U5-Size-x-Sex	0.0815	0.7755
	Within Subjects	
Side	1.2682	0.2614
Side-x-U5-Size	1.1852	0.2776
Side-x-Sex	0.4884	0.4855
Side-x-U5-Size-x-Sex	4.4202	0.0367

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.45	0.45
Girl	0.51	0.46

Table A-145. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.639	3.752	0.70	0.4827
U5-Size	0.214	0.561	0.38	0.7027
Sex	-0.381	0.244	-1.56	0.1209
Interaction	0.449	0.561	0.80	0.4243

Table A-146. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.907	2.729	-0.70	0.4854
U5-Size	0.918	0.408	2.25	0.0254
Sex	-0.289	0.178	-1.62	0.1057
Interaction	0.418	0.408	1.03	0.3060

Table A-147. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.355	0.513	-0.69	0.4904
U5-Size	0.089	0.077	1.16	0.2474
Sex	-0.015	0.033	-0.44	0.6596
Interaction	0.027	0.077	0.35	0.7235

Table A-148. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.123	0.531	0.23	0.8175
U5-Size	0.039	0.079	0.50	0.6196
Sex	0.100	0.035	2.89	0.0043
Interaction	-0.044	0.079	-0.56	0.5780

Table A-149. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.724	3.400	-1.10	0.2747
U5-Size	1.205	0.508	2.37	0.0186
Sex	-0.454	0.221	-2.05	0.0418
Interaction	0.401	0.508	0.79	0.4308

Table A-150. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.992	8.482	-0.35	0.7246
U5-Size	2.338	1.268	1.84	0.0666
Sex	-1.123	0.553	-2.03	0.0434
Interaction	1.268	1.268	1.00	0.3182

Table A-151. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.276	0.792	-1.61	0.1087
U5-Size	0.398	0.118	3.36	0.0009
Sex	-0.130	0.052	-2.51	0.0127
Interaction	-0.052	0.118	-0.44	0.6638

Table A-152. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.191	0.597	3.67	0.0003
U5-Size	-0.291	0.089	-3.26	0.0013
Sex	0.057	0.039	1.46	0.1454
Interaction	0.101	0.089	1.14	0.2566

Table A-153. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.708	0.618	2.76	0.0063
U5-Size	-0.222	0.092	-2.40	0.0174
Sex	0.040	0.040	1.00	0.3180
Interaction	0.044	0.092	0.48	0.6346

Table A-154. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.141	1.483	0.09	0.9245
U5-Size	0.194	0.222	0.87	0.3834
Sex	-0.141	0.097	-1.46	0.1466
Interaction	-0.022	0.222	-0.10	0.9222

Table A-155. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.370	1.367	0.27	0.7870
U5-Size	0.110	0.204	0.54	0.5911
Sex	-0.052	0.089	-0.58	0.5613
Interaction	0.319	0.204	1.56	0.1194

Table A-156. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.329	2.447	-0.54	0.5876
U5-Size	0.741	0.366	2.03	0.0441
Sex	-0.120	0.159	-0.75	0.4534
Interaction	-0.313	0.366	-0.85	0.3937

Table A-157. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.119	0.298	-0.40	0.6905
U5-Size	0.024	0.044	0.54	0.5897
Sex	-0.042	0.019	-2.16	0.0321
Interaction	-0.024	0.044	-0.54	0.5897

Table A-158. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.459	0.502	0.91	0.3614
U5-Size	-0.058	0.075	-0.77	0.4407
Sex	0.015	0.033	0.46	0.6482
Interaction	-0.018	0.075	-0.25	0.8055

Table A-159. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.112	0.768	1.45	0.1492
U5-Size	-0.053	0.115	-0.46	0.6431
Sex	0.041	0.050	0.82	0.4112
Interaction	-0.118	0.115	-1.03	0.3038

Table A-160. ANCOVA results testing for associations between mesiodistal width of the maxillary second premolar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	22.670	7.095	3.20	0.0016
U5-Size	0.657	1.060	0.62	0.5363
Sex	-0.358	0.462	-0.77	0.4395
Interaction	-0.559	1.060	-0.53	0.5984

Table A-161. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	2.0189	0.1569
Sex	2.1074	0.1481
U6-Size-x-Sex	0.5362	0.4648
	Within Subjects	
Side	0.1420	0.7067
Side-x-U6-Size	0.1153	0.7346
Side-x-Sex	0.2398	0.6249
Side-x-U6-Size-x-Sex	0.2391	0.6254

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.33	0.32
Girl	0.48	0.42

Table A-162. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	3.2430	0.0732
Sex	6.5656	0.0111
U6-Size-x-Sex	0.7544	0.3861
	Within Subjects	
Side	0.6467	0.4222
Side-x-U6-Size	0.5862	0.4448
Side-x-Sex	0.0747	0.7848
Side-x-U6-Size-x-Sex	0.4856	0.4867

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.28	0.33
Girl	0.49	0.51

Table A-163. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.0833	0.7732
Sex	0.0073	0.9319
U6-Size-x-Sex	2.2739	0.1331
	Within Subjects	
Side	0.7665	0.3823
Side-x-U6-Size	0.7610	0.3841
Side-x-Sex	0.3334	0.5643
Side-x-U6-Size-x-Sex	1.4109	0.2363

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.35	0.33
Girl	0.32	0.35

Table A-164. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.0164	0.8983
Sex	1.9309	0.1662
U6-Size-x-Sex	0.6970	0.4048
	Within Subjects	
Side	0.0115	0.9148
Side-x-U6-Size	0.0063	0.9367
Side-x-Sex	2.1736	0.1419
Side-x-U6-Size-x-Sex	3.2756	0.0718

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.16	0.20
Girl	0.30	0.23

Table A-165. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	5.8871	0.0161
Sex	2.1144	0.1475
U6-Size-x-Sex	1.1724	0.2802
	Within Subjects	
Side	0.8497	0.3577
Side-x-U6-Size	0.9301	0.3360
Side-x-Sex	0.5403	0.4632
Side-x-U6-Size-x-Sex	0.3207	0.5718

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.42	0.42
Girl	0.58	0.51

Table A-166. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.1654	0.6846
Sex	0.3874	0.5344
U6-Size-x-Sex	2.0393	0.1548
	Within Subjects	
Side	2.1840	0.1410
Side-x-U6-Size	2.4252	0.1210
Side-x-Sex	0.1864	0.6663
Side-x-U6-Size-x-Sex	0.2044	0.6517

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.24	0.16
Girl	0.19	0.15

Table A-167. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.0667	0.7965
Sex	4.3015	0.0393
U6-Size-x-Sex	0.0740	0.7859
	Within Subjects	
Side	0.0285	0.8660
Side-x-U6-Size	0.0342	0.8534
Side-x-Sex	0.4024	0.5265
Side-x-U6-Size-x-Sex	0.4035	0.5260

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.16
Girl	0.26	0.29

Table A-168. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.0106	0.9181
Sex	0.2832	0.5952
U6-Size-x-Sex	0.0653	0.7985
	Within Subjects	
Side	2.1700	0.1423
Side-x-U6-Size	2.0459	0.1542
Side-x-Sex	0.1163	0.7334
Side-x-U6-Size-x-Sex	0.5870	0.4445

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.42
Girl	0.42	0.44

Table A-169. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.1359	0.7128
Sex	0.0379	0.8459
U6-Size-x-Sex	0.3589	0.5498
	Within Subjects	
Side	0.0029	0.9570
Side-x-U6-Size	0.0023	0.9616
Side-x-Sex	0.0738	0.7862
Side-x-U6-Size-x-Sex	0.5009	0.4799

*df for each test is 1 and 203.

Means, Sexes Pooled

Overall Means

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.46
Girl	0.47	0.49

Table A-170. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	1.8032	0.1808
Sex	4.7036	0.0313
U6-Size-x-Sex	1.2560	0.2637
	Within Subjects	
Side	0.7170	0.3981
Side-x-U6-Size	0.8081	0.3698
Side-x-Sex	2.7511	0.0987
Side-x-U6-Size-x-Sex	0.4396	0.5080

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.27	0.30
Girl	0.50	0.38

Table A-171. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	1.7601	0.1861
Sex	0.8482	0.3582
U6-Size-x-Sex	1.2613	0.2627
	Within Subjects	
Side	0.0870	0.7683
Side-x-U6-Size	0.1907	0.6628
Side-x-Sex	0.7869	0.3761
Side-x-U6-Size-x-Sex	0.4406	0.5076

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.32	0.23
Girl	0.42	0.24

Table A-172. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.9051	0.3425
Sex	4.2482	0.0406
U6-Size-x-Sex	0.4796	0.4894
	Within Subjects	
Side	0.6085	0.4363
Side-x-U6-Size	0.6604	0.4174
Side-x-Sex	0.1731	0.6778
Side-x-U6-Size-x-Sex	0.8374	0.3612

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43	0.39
Girl	0.30	0.29

Table A-173. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	3.0070	0.0844
Sex	6.8074	0.0098
U6-Size-x-Sex	0.5517	0.4585
	Within Subjects	
Side	0.0851	0.7708
Side-x-U6-Size	0.0957	0.7573
Side-x-Sex	0.5286	0.4680
Side-x-U6-Size-x-Sex	0.0168	0.8969

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.25	0.28
Girl	0.50	0.45

Table A-174. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.0252	0.8740
Sex	7.4486	0.0069
U6-Size-x-Sex	0.0077	0.9303
	Within Subjects	
Side	0.2013	0.6541
Side-x-U6-Size	0.2299	0.6321
Side-x-Sex	0.2220	0.6381
Side-x-U6-Size-x-Sex	0.6301	0.4282

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.24	0.24
Girl	0.45	0.40

Table A-175. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	10.3054	0.0015
Sex	2.4681	0.1177
U6-Size-x-Sex	1.0436	0.3082
	Within Subjects	
Side	3.7039	0.0557
Side-x-U6-Size	4.0455	0.0456
Side-x-Sex	0.2234	0.6370
Side-x-U6-Size-x-Sex	1.4900	0.2236

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.63 0.57	
Girl	0.80 0.70	

Table A-176. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U6_Size	0.6176	0.4328
Sex	0.5113	0.4754
U6-Size-x-Sex	1.2284	0.2690
	Within Subjects	
Side	1.2206	0.2705
Side-x-U6-Size	1.1881	0.2770
Side-x-Sex	0.3223	0.5709
Side-x-U6-Size-x-Sex	0.0303	0.8619

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.43 0.45	
Girl	0.50 0.46	

Table A-177. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-5.522	4.595	-1.20	0.2309
U6-Size	0.923	0.444	2.08	0.0390
Sex	-0.495	0.246	-2.01	0.0456
Interaction	0.554	0.444	1.25	0.2140

Table A-178. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.926	3.428	0.27	0.7873
U6-Size	0.320	0.331	0.97	0.3356
Sex	-0.266	0.183	-1.45	0.1485
Interaction	0.177	0.331	0.53	0.5942

Table A-179. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.972	0.633	-1.54	0.1261
U6-Size	0.118	0.061	1.93	0.0546
Sex	-0.025	0.034	-0.75	0.4553
Interaction	-0.062	0.061	-1.01	0.3128

Table A-180. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.480	0.660	0.73	0.4675
U6-Size	-0.010	0.064	-0.15	0.8811
Sex	0.104	0.035	2.96	0.0035
Interaction	0.010	0.064	0.15	0.8817

Table A-181. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.139	4.210	-1.46	0.1463
U6-Size	1.010	0.407	2.48	0.0139
Sex	-0.507	0.225	-2.25	0.0256
Interaction	0.361	0.407	0.89	0.3762

Table A-182. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-10.735	10.477	-1.02	0.3068
U6-Size	2.253	1.013	2.22	0.0272
Sex	-1.268	0.561	-2.26	0.0248
Interaction	1.092	1.013	1.08	0.2824

Table A-183. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.244	0.993	-1.25	0.2117
U6-Size	0.254	0.096	2.65	0.0087
Sex	-0.136	0.053	-2.56	0.0111
Interaction	-0.036	0.096	-0.38	0.7057

Table A-184. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.061	0.751	2.74	0.0066
U6-Size	-0.175	0.073	-2.41	0.0169
Sex	0.060	0.040	1.49	0.1380
Interaction	0.019	0.073	0.26	0.7936

Table A-185. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.946	0.777	1.22	0.2246
U6-Size	-0.070	0.075	-0.93	0.3552
Sex	0.034	0.042	0.81	0.4176
Interaction	0.035	0.075	0.46	0.6445

Table A-186. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.571	1.821	-1.41	0.1596
U6-Size	0.386	0.176	2.19	0.0294
Sex	-0.181	0.097	-1.86	0.0647
Interaction	0.061	0.176	0.35	0.7296

Table A-187. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.769	1.682	-1.65	0.1012
U6-Size	0.375	0.163	2.31	0.0221
Sex	-0.097	0.090	-1.08	0.2814
Interaction	0.135	0.163	0.83	0.4081

Table A-188. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.591	3.069	0.52	0.6046
U6-Size	0.195	0.297	0.66	0.5124
Sex	0.508	3.069	0.17	0.8687
Interaction	-0.058	0.297	-0.20	0.8453

Table A-189. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.097	0.370	0.26	0.7928
U6-Size	-0.006	0.036	-0.16	0.8753
Sex	-0.097	0.370	-0.26	0.7928
Interaction	0.006	0.036	0.16	0.8753

Table A-190. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.515	0.621	0.83	0.4081
U6-Size	-0.042	0.060	-0.70	0.4833
Sex	0.606	0.621	0.98	0.3301
Interaction	-0.057	0.060	-0.95	0.3433

Table A-191. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.057	0.956	1.11	0.2701
U6-Size	-0.030	0.092	-0.32	0.7499
Sex	0.369	0.956	0.39	0.6999
Interaction	-0.032	0.092	-0.34	0.7323

Table A-192. ANCOVA results testing for associations between mesiodistal width of the maxillary first molar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	19.747	8.805	2.24	0.0260
U6-Size	0.704	0.851	0.83	0.4091
Sex	0.567	8.805	0.06	0.9487
Interaction	-0.094	0.851	-0.11	0.9119

Table A-193. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.1514	0.6976
Sex	0.0182	0.8929
U7-Size-x-Sex	0.0421	0.8376
	Within Subjects	
Side	0.0444	0.8333
Side-x-U7-Size	0.0227	0.8804
Side-x-Sex	3.8286	0.0518
Side-x-U7-Size-x-Sex	3.9650	0.0478

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.36	0.33
Girl	0.49	0.41

Table A-194. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	4.0255	0.0461
Sex	2.5542	0.1116
U7-Size-x-Sex	3.0693	0.0813
	Within Subjects	
Side	0.5267	0.4688
Side-x-U7-Size	0.4653	0.4959
Side-x-Sex	0.5997	0.4396
Side-x-U7-Size-x-Sex	0.6211	0.4316

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29	0.33
Girl	0.49	0.51

Table A-195. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.0000	0.9946
Sex	0.5763	0.4486
U7-Size-x-Sex	0.5906	0.4431
	Within Subjects	
Side	0.2563	0.6132
Side-x-U7-Size	0.2338	0.6292
Side-x-Sex	0.0013	0.9712
Side-x-U7-Size-x-Sex	0.0062	0.9374

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.34
Girl	0.32	0.36

Table A-196. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.8968	0.3448
Sex	0.1064	0.7447
U7-Size-x-Sex	0.0539	0.8166
	Within Subjects	
Side	0.8343	0.3621
Side-x-U7-Size	0.7998	0.3722
Side-x-Sex	1.5257	0.2182
Side-x-U7-Size-x-Sex	1.7255	0.1905

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.16	0.20
Girl	0.31	0.24

Table A-197. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	4.3200	0.0389
Sex	1.0126	0.3155
U7-Size-x-Sex	0.8654	0.3533
	Within Subjects	
Side	0.0287	0.8656
Side-x-U7-Size	0.0163	0.8985
Side-x-Sex	1.3223	0.2515
Side-x-U7-Size-x-Sex	1.2611	0.2628

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.44	0.43
Girl	0.57	0.52

Table A-198. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.4996	0.4805
Sex	0.6732	0.4129
U7-Size-x-Sex	0.7310	0.3936
	Within Subjects	
Side	1.3025	0.2551
Side-x-U7-Size	1.4951	0.2228
Side-x-Sex	0.0021	0.9638
Side-x-U7-Size-x-Sex	0.0064	0.9364

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.24	0.17
Girl	0.19	0.16

Table A-199. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.5376	0.4643
Sex	0.0523	0.8194
U7-Size-x-Sex	0.0097	0.9217
	Within Subjects	
Side	0.0047	0.9452
Side-x-U7-Size	0.0039	0.9505
Side-x-Sex	0.0217	0.8829
Side-x-U7-Size-x-Sex	0.0129	0.9098

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.15
Girl	0.26	0.29

Table A-200. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.4441	0.5059
Sex	0.6154	0.4337
U7-Size-x-Sex	0.6512	0.4206
	Within Subjects	
Side	0.0124	0.9113
Side-x-U7-Size	0.0326	0.8570
Side-x-Sex	6.1110	0.0143
Side-x-U7-Size-x-Sex	6.1394	0.0140

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.37	0.42
Girl	0.40	0.46

Table A-201. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.0272	0.8691
Sex	0.2623	0.6091
U7-Size-x-Sex	0.2542	0.6147
	Within Subjects	
Side	1.6016	0.2071
Side-x-U7-Size	1.5659	0.2122
Side-x-Sex	0.0288	0.8655
Side-x-U7-Size-x-Sex	0.0283	0.8665

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.48
Girl	0.48	0.49

Table A-202. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	1.0257	0.3124
Sex	0.4619	0.4975
U7-Size-x-Sex	0.3109	0.5777
	Within Subjects	
Side	1.3456	0.2474
Side-x-U7-Size	1.5114	0.2203
Side-x-Sex	2.1234	0.1466
Side-x-U7-Size-x-Sex	2.4344	0.1203

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.28	0.30
Girl	0.51	0.38

Table A-203. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.2863	0.5932
Sex	1.3208	0.2518
U7-Size-x-Sex	1.4192	0.2349
	Within Subjects	
Side	2.1248	0.1465
Side-x-U7-Size	2.5923	0.1089
Side-x-Sex	0.0042	0.9484
Side-x-U7-Size-x-Sex	0.0174	0.8951

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.31	0.25
Girl	0.41	0.23

Table A-204. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.0622	0.8033
Sex	1.9524	0.1639
U7-Size-x-Sex	2.2825	0.1324
	Within Subjects	
Side	1.8821	0.1716
Side-x-U7-Size	2.0296	0.1558
Side-x-Sex	0.0092	0.9236
Side-x-U7-Size-x-Sex	0.0060	0.9385

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43	0.37
Girl	0.31	0.28

Table A-205. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.9633	0.3275
Sex	0.0462	0.8299
U7-Size-x-Sex	0.1277	0.7212
	Within Subjects	
Side	0.1199	0.7295
Side-x-U7-Size	0.1455	0.7033
Side-x-Sex	1.6441	0.2012
Side-x-U7-Size-x-Sex	1.7616	0.1859

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28	0.29
Girl	0.51	0.44

Table A-206. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.0276	0.8681
Sex	0.1637	0.6862
U7-Size-x-Sex	0.0602	0.8064
	Within Subjects	
Side	0.3457	0.5572
Side-x-U7-Size	0.3209	0.5717
Side-x-Sex	3.8482	0.0512
Side-x-U7-Size-x-Sex	3.7994	0.0526

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.24	
Girl	0.43 0.41	

Table A-207. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	10.4266	0.0014
Sex	1.0558	0.3054
U7-Size-x-Sex	0.8867	0.3475
	Within Subjects	
Side	2.7926	0.0962
Side-x-U7-Size	3.1184	0.0789
Side-x-Sex	1.4311	0.2330
Side-x-U7-Size-x-Sex	1.4803	0.2251

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.64 0.58	
Girl	0.79 0.70	

Table A-208. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
U7-Size	0.8461	0.3587
Sex	0.0619	0.8038
U7-Size-x-Sex	0.0424	0.8372
	Within Subjects	
Side	0.8045	0.3708
Side-x-U7-Size	0.7678	0.3819
Side-x-Sex	0.2667	0.6061
Side-x-U7-Size-x-Sex	0.3097	0.5785

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.44 0.45	
Girl	0.51 0.47	

Table A-209. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.4039	4.1240	-0.83	0.4101
U7-Size	0.7697	0.4228	1.82	0.0702
Sex	-1.0569	4.1240	-0.26	0.7980
Interaction	0.0610	0.4228	0.14	0.8854

Table A-210. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.6359	3.0615	0.86	0.3903
U7-Size	0.1656	0.3139	0.53	0.5983
Sex	-0.9125	3.0615	-0.30	0.7660
Interaction	0.0688	0.3139	0.22	0.8267

Table A-211. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.5211	0.5654	-0.92	0.3578
U7-Size	0.0793	0.0580	1.37	0.1730
Sex	0.7150	0.5654	1.26	0.2074
Interaction	-0.0752	0.0580	-1.30	0.1958

Table A-212. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.8642	0.5870	1.47	0.1425
U7-Size	-0.0491	0.0602	-0.82	0.4155
Sex	0.3251	0.5870	0.55	0.5803
Interaction	-0.0222	0.0602	-0.37	0.7131

Table A-213. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.0454	3.7829	-0.81	0.4217
U7-Size	0.7587	0.3878	1.96	0.0518
Sex	-0.9779	3.7829	-0.26	0.7963
Interaction	0.0532	0.3878	0.14	0.8911

Table A-214. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.8134	9.4122	-0.41	0.6858
U7-Size	1.6941	0.9650	1.76	0.0807
Sex	-2.9472	9.4122	-0.31	0.7545
Interaction	0.1830	0.9650	0.19	0.8498

Table A-215. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4792	0.8863	-0.54	0.5893
U7-Size	0.1926	0.0909	2.12	0.0353
Sex	1.2458	0.8863	1.41	0.1614
Interaction	-0.1406	0.0909	-1.55	0.1235

Table A-216. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.0927	0.6652	3.15	0.0019
U7-Size	-0.1896	0.0682	-2.78	0.0060
Sex	-0.6851	0.6652	-1.03	0.3043
Interaction	0.0763	0.0682	1.12	0.2645

Table A-217. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.5752	0.6871	2.29	0.0229
U7-Size	-0.1382	0.0704	-1.96	0.0511
Sex	-0.2116	0.6871	-0.31	0.7584
Interaction	0.0259	0.0704	0.37	0.7133

Table A-218. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.5902	1.6341	-0.36	0.7183
U7-Size	0.2094	0.1675	1.25	0.2129
Sex	1.2608	1.6341	0.77	0.4413
Interaction]	-0.1450	0.1675	-0.87	0.3877

Table A-219. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.4923	1.5081	-0.99	0.3236
U7-Size	0.2673	0.1546	1.73	0.0854
Sex	-1.2815	1.5081	-0.85	0.3965
Interaction	0.1235	0.1546	0.80	0.4253

Table A-220. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.8039	2.7321	1.03	0.3060
U7-Size	0.0845	0.2801	0.30	0.7633
Sex	2.3066	2.7321	0.84	0.3995
Interaction	-0.2443	0.2801	-0.87	0.3841

Table A-221. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.3065	0.3280	-0.93	0.3510
U7-Size	0.0360	0.0336	1.07	0.2853
Sex	0.3065	0.3280	0.93	0.3510
Interaction	-0.0360	0.0336	-1.07	0.2853

Table A-222. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.5753	0.5541	1.04	0.3004
U7-Size	-0.0514	0.0568	-0.91	0.3663
Sex	0.2765	0.5541	0.50	0.6183
Interaction]	-0.0266	0.0568	-0.47	0.6399

Table A-223. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.9409	0.8518	1.10	0.2706
U7-Size	-0.0194	0.0873	-0.22	0.8244
Sex	0.3751	0.8518	0.44	0.6601
Interaction	-0.0344	0.0873	-0.39	0.6941

Table A-224. ANCOVA results testing for associations between mesiodistal width of the maxillary second molar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	26.6387	7.8401	3.40	0.0008
U7-Size	0.0489	0.8038	0.06	0.9515
Sex	7.4953	7.8401	0.96	0.3402
Interaction	-0.8013	0.8038	-1.00	0.3200

Table A-225. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	1.7098	0.1925
Sex	0.5932	0.4421
L1-Size-x-Sex	0.7422	0.3900
	Within Subjects	
Side	3.1878	0.0757
Side-x-L1-Size	2.9904	0.0853
Side-x-Sex	1.7609	0.1860
Side-x-L1-Size-x-Sex	1.8048	0.1806

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.36	0.33
Girl	0.49	0.43

Table A-226. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	3.3149	0.0701
Sex	0.9079	0.3418
L1-Size-x-Sex	1.2513	0.2646
	Within Subjects	
Side	0.9273	0.3367
Side-x-L1-Size	0.8707	0.3519
Side-x-Sex	5.2797	0.0226
Side-x-L1-Size-x-Sex	5.3651	0.0215

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29	0.33
Girl	0.49	0.50

Table A-227. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	2.2326	0.1367
Sex	0.2344	0.6288
L1-Size-x-Sex	0.2248	0.6359
	Within Subjects	
Side	0.7399	0.3907
Side-x-L1-Size	0.7935	0.3741
Side-x-Sex	0.1070	0.7439
Side-x-L1-Size-x-Sex	0.1550	0.6942

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.35	0.33
Girl	0.32	0.38

Table A-228. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	3.5484	0.0610
Sex	0.1841	0.6684
L1-Size-x-Sex	0.2992	0.5850
	Within Subjects	
Side	2.0682	0.1519
Side-x-L1-Size	2.1437	0.1447
Side-x-Sex	2.2724	0.1333
Side-x-L1-Size-x-Sex	2.6492	0.1052

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.15	0.21
Girl	0.33	0.24

Table A-229. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	17.8539	<0.0001
Sex	0.2766	0.5995
L1-Size-x-Sex	0.4107	0.5223
	Within Subjects	
Side	0.1777	0.6738
Side-x-L1-Size	0.1398	0.7089
Side-x-Sex	1.3292	0.2503
Side-x-L1-Size-x-Sex	1.2667	0.2617

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.44	0.42
Girl	0.60	0.55

Table A-230. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	1.2995	0.2557
Sex	0.6198	0.4321
L1-Size-x-Sex	0.6730	0.4130
	Within Subjects	
Side	4.9063	0.0279
Side-x-L1-Size	5.3167	0.0221
Side-x-Sex	0.0240	0.8770
Side-x-L1-Size-x-Sex	0.0327	0.8568

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.24	0.17
Girl	0.20	0.16

Table A-231. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	0.0251	0.8743
Sex	0.0029	0.9573
L1-Size-x-Sex	0.0070	0.9334
	Within Subjects	
Side	0.0026	0.9593
Side-x-L1-Size	0.0019	0.9650
Side-x-Sex	1.5681	0.2119
Side-x-L1-Size-x-Sex	1.4716	0.2265

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.18	0.15
Girl	0.27	0.29

Table A-232. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	2.2336	0.1366
Sex	0.1782	0.6733
L1-Size-x-Sex	0.2271	0.6342
	Within Subjects	
Side	4.4288	0.0366
Side-x-L1-Size	4.2864	0.0397
Side-x-Sex	0.1749	0.6762
Side-x-L1-Size-x-Sex	0.1980	0.6569

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.40
Girl	0.44	0.44

Table A-233. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	4.7790	0.0300
Sex	0.4198	0.5178
L1-Size-x-Sex	0.3742	0.5414
	Within Subjects	
Side	0.0226	0.8808
Side-x-L1-Size	0.0179	0.8937
Side-x-Sex	0.0567	0.8120
Side-x-L1-Size-x-Sex	0.0486	0.8257

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.46 0.45	
Girl	0.48 0.51	

Table A-234. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	5.7607	0.0173
Sex	0.0530	0.8182
L1-Size-x-Sex	0.1495	0.6994
	Within Subjects	
Side	16.8348	<0.0001
Side-x-L1-Size	17.5465	<0.0001
Side-x-Sex	3.5783	0.0600
Side-x-L1-Size-x-Sex	4.1979	0.0418

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.27	0.31
Girl	0.54	0.38

Table A-235. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	11.7520	0.0007
Sex	0.5784	0.4478
L1-Size-x-Sex	0.7161	0.3984
	Within Subjects	
Side	0.0362	0.8492
Side-x-L1-Size	0.0011	0.9733
Side-x-Sex	0.5571	0.4563
Side-x-L1-Size-x-Sex	0.4838	0.4875

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.30	0.22
Girl	0.41	0.26

Table A-236. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	3.8540	0.0510
Sex	2.2842	0.1322
L1-Size-x-Sex	2.5898	0.1091
	Within Subjects	
Side	0.6027	0.4385
Side-x-L1-Size	0.7023	0.4030
Side-x-Sex	0.1552	0.6940
Side-x-L1-Size-x-Sex	0.1325	0.7162

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.42 0.36	
Girl	0.32 0.30	

Table A-237. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	5.8401	0.0165
Sex	2.2224	0.1376
L1-Size-x-Sex	2.7934	0.0962
	Within Subjects	
Side	1.7994	0.1813
Side-x-L1-Size	1.7322	0.1896
Side-x-Sex	0.1805	0.6714
Side-x-L1-Size-x-Sex	0.2034	0.6525

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28	0.28
Girl	0.52	0.48

Table A-238. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	3.0197	0.0838
Sex	1.8515	0.1751
L1-Size-x-Sex	1.3339	0.2495
	Within Subjects	
Side	0.0000	0.9998
Side-x-L1-Size	0.0031	0.9560
Side-x-Sex	0.0344	0.8531
Side-x-L1-Size-x-Sex	0.0441	0.8338

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.23 0.21	
Girl	0.46 0.40	

Table A-239. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	33.4639	<0.0001
Sex	0.6692	0.4143
L1-Size-x-Sex	0.4723	0.4927
	Within Subjects	
Side	11.1283	0.0010
Side-x-L1-Size	11.7642	0.0007
Side-x-Sex	0.0573	0.8111
Side-x-L1-Size-x-Sex	0.0794	0.7784

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.61 0.58	
Girl	0.82 0.72	

Table A-240. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L1-Size	15.1042	0.0001
Sex	0.2059	0.6505
L1-Size-x-Sex	0.2943	0.5881
	Within Subjects	
Side	0.0010	0.9754
Side-x-L1-Size	0.0037	0.9515
Side-x-Sex	0.9580	0.3289
Side-x-L1-Size-x-Sex	1.0754	0.3010

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.42	0.44
Girl	0.54	0.48

Table A-241. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-8.7843	3.6016	-2.44	0.0156
L1	2.3935	0.6667	3.59	0.0004
Sex	2.1005	3.6016	0.58	0.5604
Interaction	-0.4890	0.6667	-0.73	0.4641

Table A-242. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-7.3144	2.6112	-2.80	0.0056
L1	2.1426	0.4833	4.43	<0.0001
Sex	-0.6636	2.6112	-0.25	0.7996
Interaction	0.0531	0.4833	0.11	0.9127

Table A-243. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.6916	0.5049	-1.37	0.1722
L1	0.1735	0.0935	1.86	0.0649
Sex	0.2208	0.5049	0.44	0.6624
Interaction	-0.0447	0.0935	-0.48	0.6327

Table A-244. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.0618	0.5117	-2.08	0.0392
L1	0.2658	0.0947	2.81	0.0055
Sex	-0.6414	0.5117	-1.25	0.2115
Interaction	0.1343	0.0947	1.42	0.1578

Table A-245. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-13.6621	3.1643	-4.32	<0.0001
L1	3.3366	0.5857	5.70	<0.0001
Sex	-0.6826	3.1643	-0.22	0.8294
Interaction	0.0140	0.5857	0.02	0.9810

Table A-246. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-29.7607	7.9280	-3.75	0.0002
L1	7.8728	1.4675	5.36	<0.0001
Sex	0.7544	7.9280	0.10	0.9243
Interaction	-0.4219	1.4675	-0.29	0.7740

Table A-247. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.2503	0.7354	-4.42	<0.0001
L1	0.8590	0.1361	6.31	<0.0001
Sex	0.4132	0.7354	0.56	0.5749
Interaction	-0.1066	0.1361	-0.78	0.4346

Table A-248. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.9875	0.5738	5.21	<0.0001
L1	-0.5084	0.1062	-4.79	<0.0001
Sex	-0.8559	0.5738	-1.49	0.1374
Interaction	0.1718	0.1062	1.62	0.1073

Table A-249. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.9073	0.6041	3.16	0.0018
L1	-0.3134	0.1118	-2.80	0.0056
Sex	-1.1627	0.6041	-1.92	0.0557
Interaction	0.2239	0.1118	2.00	0.0466

Table A-250. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.2031	1.4441	-1.53	0.1287
L1	0.6762	0.2673	2.53	0.0122
Sex	1.0209	1.4441	0.71	0.4804
Interaction	-0.2216	0.2673	-0.83	0.4082

Table A-251. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-4.7615	1.2947	-3.68	0.0003
L1	1.0938	0.2397	4.56	<0.0001
Sex	1.1092	1.2947	0.86	0.3926
Interaction	-0.2284	0.2397	-0.95	0.3418

Table A-252. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.4257	2.4180	-0.59	0.5561
L1	0.9350	0.4476	2.09	0.0380
Sex	1.8411	2.4180	0.76	0.4473
Interaction	-0.3653	0.4476	-0.82	0.4153

Table A-253. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4699	0.2905	-1.62	0.1074
L1	0.0957	0.0538	1.78	0.0766
Sex	0.4699	0.2905	1.62	0.1074
Interaction	-0.0957	0.0538	-1.78	0.0766

Table A-254. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.0772	0.4936	-0.16	0.8759
L1	0.0292	0.0914	0.32	0.7494
Sex	0.7478	0.4936	1.51	0.1314
Interaction	-0.1369	0.0914	-1.50	0.1356

Table A-255. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.5684	0.7553	2.08	0.0391
L1	-0.1495	0.1398	-1.07	0.2861
Sex	1.0469	0.7553	1.39	0.1672
Interaction	-0.1849	0.1398	-1.32	0.1874

Table A-256. ANCOVA results testing for associations between mesiodistal width of the mandibular central incisor and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	12.8777	6.9323	1.86	0.0647
L1	2.6399	1.2832	2.06	0.0409
Sex	8.2019	6.9323	1.18	0.2381
Interaction	-1.6115	1.2832	-1.26	0.2106

Table A-257. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	2.3615	0.1259
Sex	1.2715	0.2608
L2-Size-x-Sex	1.0715	0.3018
	Within Subjects	
Side	2.0535	0.1534
Side-x-L2-Size	1.8918	0.1705
Side-x-Sex	2.6725	0.1036
Side-x-L2-Size-x-Sex	2.7606	0.0982

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.34	0.32
Girl	0.47	0.41

Table A-258. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	6.1262	0.0141
Sex	0.2168	0.6420
L2-Size-x-Sex	0.4089	0.5233
	Within Subjects	
Side	3.8872	0.0500
Side-x-L2-Size	3.7535	0.0541
Side-x-Sex	7.3560	0.0073
Side-x-L2-Size-x-Sex	7.5043	0.0067

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.28	0.32
Girl	0.49	0.49

Table A-259. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	1.0635	0.3036
Sex	0.2798	0.5974
L2-Size-x-Sex	0.2793	0.5978
	Within Subjects	
Side	0.5008	0.4799
Side-x-L2-Size	0.5263	0.4690
Side-x-Sex	0.7309	0.3936
Side-x-L2-Size-x-Sex	0.6255	0.4299

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.33
Girl	0.32	0.37

Table A-260. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	8.1833	0.0047
Sex	1.0472	0.3074
L2-Size-x-Sex	0.8023	0.3715
	Within Subjects	
Side	0.2017	0.6538
Side-x-L2-Size	0.1944	0.6598
Side-x-Sex	0.1357	0.7130
Side-x-L2-Size-x-Sex	0.2177	0.6413

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.14	0.20
Girl	0.31	0.25

Table A-261. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	25.1451	<0.0001
Sex	0.0376	0.8465
L2-Size-x-Sex	0.0953	0.7579
	Within Subjects	
Side	0.3564	0.5512
Side-x-L2-Size	0.4239	0.5158
Side-x-Sex	1.3222	0.2515
Side-x-L2-Size-x-Sex	1.2301	0.2687

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.43	0.43
Girl	0.59	0.54

Table A-262. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	2.8685	0.0919
Sex	0.8057	0.3704
L2-Size-x-Sex	0.8653	0.3534
	Within Subjects	
Side	4.1360	0.0433
Side-x-L2-Size	4.5452	0.0342
Side-x-Sex	0.0350	0.8518
Side-x-L2-Size-x-Sex	0.0228	0.8800

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.24 0.17	
Girl	0.20 0.17	

Table A-263. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	0.0027	0.9587
Sex	0.0820	0.7749
L2-Size-x-Sex	0.0215	0.8837
	Within Subjects	
Side	0.0312	0.8600
Side-x-L2-Size	0.0309	0.8606
Side-x-Sex	1.0241	0.3128
Side-x-L2-Size-x-Sex	0.9408	0.3332

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.18	0.15
Girl	0.26	0.29

Table A-264. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	3.2601	0.0725
Sex	0.2225	0.6377
L2-Size-x-Sex	0.2775	0.5989
	Within Subjects	
Side	1.1080	0.2938
Side-x-L2-Size	1.0219	0.3133
Side-x-Sex	0.0002	0.9899
Side-x-L2-Size-x-Sex	0.0005	0.9825

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.40
Girl	0.43	0.45

Table A-265. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	4.0381	0.0458
Sex	0.3688	0.5443
L2-Size-x-Sex	0.4051	0.5252
	Within Subjects	
Side	0.3167	0.5742
Side-x-L2-Size	0.3321	0.5650
Side-x-Sex	0.4671	0.4951
Side-x-L2-Size-x-Sex	0.4321	0.5117

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.46
Girl	0.49	0.52

Table A-266. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	11.7829	0.0007
Sex	1.6299	0.2032
L2-Size-x-Sex	2.0883	0.1500
	Within Subjects	
Side	1.8783	0.1720
Side-x-L2-Size	2.0642	0.1523
Side-x-Sex	0.5881	0.4440
Side-x-L2-Size-x-Sex	0.7786	0.3786

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.28	0.31
Girl	0.53	0.41

Table A-267. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	9.3500	0.0025
Sex	2.4267	0.1208
L2-Size-x-Sex	2.6631	0.1042
	Within Subjects	
Side	0.7128	0.3995
Side-x-L2-Size	1.0601	0.3044
Side-x-Sex	1.0002	0.3184
Side-x-L2-Size-x-Sex	1.1355	0.2879

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.31	0.23
Girl	0.42	0.24

Table A-268. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	0.0711	0.7901
Sex	0.1445	0.7042
L2-Size-x-Sex	0.2538	0.6149
	Within Subjects	
Side	0.5405	0.4631
Side-x-L2-Size	0.6396	0.4248
Side-x-Sex	0.3035	0.5823
Side-x-L2-Size-x-Sex	0.2669	0.6060

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.44	0.37
Girl	0.31	0.29

Table A-269. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	3.1740	0.0763
Sex	0.7905	0.3750
L2-Size-x-Sex	0.5165	0.4732
	Within Subjects	
Side	1.1038	0.2947
Side-x-L2-Size	1.0302	0.3113
Side-x-Sex	1.9755	0.1614
Side-x-L2-Size-x-Sex	2.0765	0.1511

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28	0.27
Girl	0.50	0.45

Table A-270. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	3.2929	0.0711
Sex	0.1679	0.6825
L2-Size-x-Sex	0.0403	0.8410
	Within Subjects	
Side	0.0296	0.8637
Side-x-L2-Size	0.0121	0.9126
Side-x-Sex	0.4900	0.4847
Side-x-L2-Size-x-Sex	0.5241	0.4699

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.22	
Girl	0.46 0.41	

Table A-271. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	35.9868	<0.0001
Sex	0.8300	0.3634
L2-Size-x-Sex	0.6264	0.4296
	Within Subjects	
Side	8.0521	0.0050
Side-x-L2-Size	8.6347	0.0037
Side-x-Sex	0.5163	0.4732
Side-x-L2-Size-x-Sex	0.5572	0.4563

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.63 0.58	
Girl	0.80 0.71	

Table A-272. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L2-Size	17.3411	<0.0001
Sex	0.0197	0.8885
L2-Size-x-Sex	0.0497	0.8239
	Within Subjects	
Side	0.0156	0.9008
Side-x-L2-Size	0.0241	0.8768
Side-x-Sex	1.4727	0.2263
Side-x-L2-Size-x-Sex	1.6259	0.2037

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.43	0.45
Girl	0.54	0.48

Table A-273. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-10.8407	3.4006	-3.19	0.0017
L2-Size	2.5275	0.5757	4.39	<0.0001
Sex	-2.5989	3.4006	-0.76	0.4456
Interaction	0.3512	0.5757	0.61	0.5425

Table A-274. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.1933	2.5244	-2.45	0.0150
L2-Size	1.7769	0.4273	4.16	<0.0001
Sex	3.3032	2.5244	1.31	0.1922
Interaction	-0.6160	0.4273	-1.44	0.1510

Table A-275. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.5323	0.4864	-1.09	0.2751
L2-Size	0.1318	0.0823	1.60	0.1110
Sex	0.3614	0.4864	0.74	0.4583
Interaction	-0.0640	0.0823	-0.78	0.4378

Table A-276. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.5842	0.4994	-1.17	0.2434
L2-Size	0.1631	0.0845	1.93	0.0551
Sex	-0.2898	0.4994	-0.58	0.5623
Interaction	0.0648	0.0845	0.77	0.4443

Table A-277. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-12.2492	3.0505	-4.02	<0.0001
L2-Size	2.8091	0.5164	5.44	<0.0001
Sex	-2.3795	3.0505	-0.78	0.4363
Interaction	0.3112	0.5164	0.60	0.5474

Table A-278. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-29.2831	7.5810	-3.86	0.0002
L2-Size	7.1135	1.2833	5.54	<0.0001
Sex	-1.6752	7.5810	-0.22	0.8253
Interaction	0.0464	1.2833	0.04	0.9712

Table A-279. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.6704	0.7192	-3.71	0.0003
L2-Size	0.6869	0.1217	5.64	<0.0001
Sex	0.3154	0.7192	0.44	0.6614
Interaction	-0.0777	0.1217	-0.64	0.5242

Table A-280. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	3.0331	0.5488	5.53	<0.0001
L2-Size	-0.4723	0.0929	-5.08	<0.0001
Sex	-0.8741	0.5488	-1.59	0.1127
Interaction	0.1590	0.0929	1.71	0.0885

Table A-281. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.8348	0.5835	3.14	0.0019
L2-Size	-0.2732	0.0988	-2.77	0.0062
Sex	-0.8592	0.5835	-1.47	0.1425
Interaction	0.1525	0.0988	1.54	0.1243

Table A-282. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.3096	1.3664	-2.42	0.0163
L2-Size	0.8013	0.2313	3.46	0.0006
Sex	-1.1294	1.3664	-0.83	0.4095
Interaction	0.1613	0.2313	0.70	0.4863

Table A-283. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-5.1494	1.2287	-4.19	<0.0001
L2-Size	1.0630	0.2080	5.11	<0.0001
Sex	-0.2570	1.2287	-0.21	0.8345
Interaction	0.0246	0.2080	0.12	0.9058

Table A-284. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.5587	2.3243	-0.67	0.5032
L2-Size	0.8742	0.3935	2.22	0.0274
Sex	0.4432	2.3243	0.19	0.8490
Interaction	-0.0952	0.3935	-0.24	0.8091

Table A-285. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.7901	0.2726	-2.90	0.0042
L2-Size	0.1421	0.0461	3.08	0.0024
Sex	0.7901	0.2726	2.90	0.0042
Interaction	-0.1421	0.0461	-3.08	0.0024

Table A-286. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.0998	0.4755	-0.21	0.8340
L2-Size	0.0300	0.0805	0.37	0.7100
Sex	0.6219	0.4755	1.31	0.1923
Interaction	-0.1039	0.0805	-1.29	0.1984

Table A-287. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.3493	0.7311	1.85	0.0664
L2-Size	-0.1019	0.1238	-0.82	0.4115
Sex	0.0860	0.7311	0.12	0.9064
Interaction	-0.0071	0.1238	-0.06	0.9541

Table A-288. ANCOVA results testing for associations between mesiodistal width of the mandibular lateral incisor and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	9.5372	6.6403	1.44	0.1525
L2-Size	2.9629	1.1241	2.64	0.0090
Sex	0.9743	6.6403	0.15	0.8835
Interaction	-0.2488	1.1241	-0.22	0.8250

Table A-289. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	4.0087	0.0466
Sex	0.0968	0.7560
L3-Size-x-Sex	0.1825	0.6697
	Within Subjects	
Side	1.4804	0.2251
Side-L3-Size	1.3448	0.2476
Side-Sex	0.1978	0.6569
Side-L3-Size-x-Sex	0.1965	0.6581

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.33	0.30
Girl	0.51	0.47

Table A-290. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.9436	0.3325
Sex	0.0013	0.9714
L3-Size-x-Sex	0.0340	0.8539
	Within Subjects	
Side	1.8516	0.1751
Side-L3-Size	1.7741	0.1844
Side-Sex	1.8017	0.1810
Side-L3-Size-x-Sex	1.8778	0.1721

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.28	0.32
Girl	0.50	0.48

Table A-291. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.0821	0.7747
Sex	0.1577	0.6917
L3-Size-x-Sex	0.1422	0.7065
	Within Subjects	
Side	0.5593	0.4554
Side-L3-Size	0.6483	0.4217
Side-Sex	2.2540	0.1348
Side-L3-Size-x-Sex	2.4256	0.1209

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.37	0.36
Girl	0.30	0.40

Table A-292. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	2.7615	0.0981
Sex	1.1265	0.2898
L3-Size-x-Sex	0.8559	0.3560
	Within Subjects	
Side	0.0522	0.8195
Side-L3-Size	0.0601	0.8066
Side-Sex	0.2473	0.6195
Side-L3-Size-x-Sex	0.3434	0.5585

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.13	0.18
Girl	0.32	0.24

Table A-293. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	4.1846	0.0421
Sex	0.0297	0.8633
L3-Size-x-Sex	0.0044	0.9473
	Within Subjects	
Side	0.2733	0.6017
Side-L3-Size	0.2749	0.6006
Side-Sex	5.4134	0.0210
Side-L3-Size-x-Sex	5.2459	0.0230

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.41	0.42
Girl	0.57	0.57

Table A-294. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	1.1207	0.2910
Sex	0.1177	0.7319
L3-Size-x-Sex	0.1248	0.7242
	Within Subjects	
Side	0.1479	0.7009
Side-L3-Size	0.2102	0.6471
Side-Sex	0.0027	0.9585
Side-L3-Size-x-Sex	0.0078	0.9298

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.23 0.16	
Girl	0.20 0.17	

Table A-295. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.1479	0.7010
Sex	0.0513	0.8211
L3-Size-x-Sex	0.1106	0.7398
	Within Subjects	
Side	0.0660	0.7975
Side-L3-Size	0.0808	0.7764
Side-Sex	2.0496	0.1538
Side-L3-Size-x-Sex	1.9374	0.1655

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.20	0.16
Girl	0.28	0.27

Table A-296. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	2.9597	0.0869
Sex	0.0194	0.8894
L3-Size-x-Sex	0.0460	0.8304
	Within Subjects	
Side	2.3521	0.1267
Side-L3-Size	2.1930	0.1402
Side-Sex	0.0206	0.8861
Side-L3-Size-x-Sex	0.0106	0.9180

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.33	0.39
Girl	0.46	0.46

Table A-297. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.8113	0.3688
Sex	0.9180	0.3391
L3-Size-x-Sex	0.9604	0.3283
	Within Subjects	
Side	0.0078	0.9297
Side-L3-Size	0.0007	0.9787
Side-Sex	2.5733	0.1102
Side-L3-Size-x-Sex	2.5793	0.1098

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.46	0.50
Girl	0.49	0.55

Table A-298. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	3.4185	0.0659
Sex	1.9156	0.1679
L3-Size-x-Sex	2.3406	0.1276
	Within Subjects	
Side	0.0411	0.8395
Side-L3-Size	0.0665	0.7968
Side-Sex	0.0743	0.7854
Side-L3-Size-x-Sex	0.1302	0.7186

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.29	0.31
Girl	0.56	0.44

Table A-299. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	4.7080	0.0312
Sex	0.5310	0.4670
L3-Size-x-Sex	0.6637	0.4162
	Within Subjects	
Side	0.1037	0.7478
Side-L3-Size	0.0357	0.8504
Side-Sex	0.3850	0.5356
Side-L3-Size-x-Sex	0.3302	0.5662

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.30	0.22
Girl	0.42	0.28

Table A-300. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.0711	0.7900
Sex	0.6170	0.4331
L3-Size-x-Sex	0.7960	0.3733
	Within Subjects	
Side	0.3484	0.5557
Side-L3-Size	0.4054	0.5250
Side-Sex	0.0119	0.9132
Side-L3-Size-x-Sex	0.0079	0.9291

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43	0.37
Girl	0.30	0.28

Table A-301. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	1.0382	0.3094
Sex	0.0540	0.8165
L3-Size-x-Sex	0.0057	0.9399
	Within Subjects	
Side	0.1466	0.7022
Side-L3-Size	0.1893	0.6639
Side-Sex	1.8816	0.1717
Side-L3-Size-x-Sex	1.9861	0.1603

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.27	0.27
Girl	0.53	0.44

Table A-302. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	0.0132	0.9086
Sex	0.2855	0.5937
L3-Size-x-Sex	0.1351	0.7135
	Within Subjects	
Side	1.1450	0.2859
Side-L3-Size	1.0735	0.3014
Side-Sex	0.6413	0.4242
Side-L3-Size-x-Sex	0.6411	0.4242

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.22	
Girl	0.43 0.42	

Table A-303. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	12.0329	0.0006
Sex	0.1492	0.6997
L3-Size-x-Sex	0.0595	0.8075
	Within Subjects	
Side	0.6786	0.4111
Side-L3-Size	0.8465	0.3586
Side-Sex	1.0524	0.3062
Side-L3-Size-x-Sex	1.0779	0.3004

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.61 0.54	
Girl	0.84 0.74	

Table A-304. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L3-Size	4.6412	0.0324
Sex	0.6360	0.4261
L3-Size-x-Sex	0.7738	0.3801
	Within Subjects	
Side	0.5164	0.4732
Side-L3-Size	0.4798	0.4893
Side-Sex	0.0273	0.8690
Side-L3-Size-x-Sex	0.0379	0.8458

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.43	0.44
Girl	0.55	0.51

Table A-305. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-5.1731	4.1359	-1.25	0.2125
L3-Size	1.3778	0.6199	2.22	0.0273
Sex	-0.6092	4.1359	-0.15	0.8830
Interaction	-0.0012	0.6199	0.00	0.9984

Table A-306. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.9207	3.0494	-0.96	0.3393
L3-Size	1.0815	0.4570	2.37	0.0189
Sex	3.3723	3.0494	1.11	0.2701
Interaction	-0.5630	0.4570	-1.23	0.2194

Table A-307. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.1571	0.5742	-0.27	0.7847
L3-Size	0.0590	0.0861	0.69	0.4940
Sex	-0.0888	0.5742	-0.15	0.8772
Interaction	0.0104	0.0861	0.12	0.9041

Table A-308. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.8494	0.5852	-1.45	0.1482
L3-Size	0.1824	0.0877	2.08	0.0388
Sex	-0.0856	0.5852	-0.15	0.8839
Interaction	0.0231	0.0877	0.26	0.7929

Table A-309. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.4766	3.7626	-1.72	0.0867
L3-Size	1.6077	0.5639	2.85	0.0048
Sex	-0.8929	3.7626	-0.24	0.8127
Interaction	0.0348	0.5639	0.06	0.9508

Table A-310. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-14.5704	9.3619	-1.56	0.1212
L3-Size	4.0669	1.4031	2.90	0.0042
Sex	1.8702	9.3619	0.20	0.8419
Interaction	-0.5294	1.4031	-0.38	0.7063

Table A-311. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.1935	0.8729	-2.51	0.0127
L3-Size	0.5372	0.1308	4.11	<0.0001
Sex	1.4135	0.8729	1.62	0.1069
Interaction	-0.2393	0.1308	-1.83	0.0688

Table A-312. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	3.1443	0.6529	4.82	<0.0001
L3-Size	-0.4361	0.0979	-4.46	<0.0001
Sex	-1.6111	0.6529	-2.47	0.0144
Interaction	0.2563	0.0979	2.62	0.0095

Table A-313. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.3868	0.6819	3.50	0.0006
L3-Size	-0.3258	0.1022	-3.19	0.0017
Sex	-1.3399	0.6819	-1.96	0.0508
Interaction	0.2113	0.1022	2.07	0.0399

Table A-314. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.8756	1.6465	-0.53	0.5955
L3-Size	0.3408	0.2468	1.38	0.1688
Sex	-0.6526	1.6465	-0.40	0.6922
Interaction	0.0689	0.2468	0.28	0.7803

Table A-315. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.0228	1.5147	-1.34	0.1832
L3-Size	0.4661	0.2270	2.05	0.0413
Sex	-0.5800	1.5147	-0.38	0.7022
Interaction	0.0669	0.2270	0.29	0.7685

Table A-316. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.4952	2.7380	-0.55	0.5856
L3-Size	0.7602	0.4104	1.85	0.0654
Sex	0.7999	2.7380	0.29	0.7705
Interaction	-0.1489	0.4104	-0.36	0.7172

Table A-317. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.2879	0.3315	-0.87	0.3861
L3-Size	0.0501	0.0497	1.01	0.3148
Sex	0.2879	0.3315	0.87	0.3861
Interaction	-0.0501	0.0497	-1.01	0.3148

Table A-318. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.3730	0.5587	0.67	0.5052
L3-Size	-0.0432	0.0837	-0.52	0.6068
Sex	0.4488	0.5587	0.80	0.4228
Interaction	-0.0639	0.0837	-0.76	0.4463

Table A-319. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.3682	0.8546	0.43	0.6671
L3-Size	0.0619	0.1281	0.48	0.6296
Sex	1.3973	0.8546	1.64	0.1036
Interaction	-0.2036	0.1281	-1.59	0.1135

Table A-320. ANCOVA results testing for associations between mesiodistal width of the mandibular canine and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	18.6217	7.9080	2.35	0.0195
L3-Size	1.2558	1.1852	1.06	0.2906
Sex	1.7817	7.9080	0.23	0.8220
Interaction	-0.3443	1.1852	-0.29	0.7717

Table A-321. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.9420	0.3329
Sex	0.0662	0.7972
L4-Size-x-Sex	0.1067	0.7443
	Within Subjects	
Side	0.0216	0.8832
Side-x-L4-Size	0.0343	0.8532
Side-x-Sex	0.4704	0.4936
Side-x-L4-Size-x-Sex	0.5170	0.4729

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.34	0.34
Girl	0.48	0.41

Table A-322. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.1605	0.6891
Sex	0.0296	0.8635
L4-Size-x-Sex	0.0026	0.9591
	Within Subjects	
Side	2.9386	0.0880
Side-x-L4-Size	2.8055	0.0955
Side-x-Sex	2.7743	0.0973
Side-x-L4-Size-x-Sex	2.8286	0.0941

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29	0.33
Girl	0.46	0.48

Table A-323. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.0130	0.9092
Sex	0.1348	0.7139
L4-Size-x-Sex	0.1279	0.7210
	Within Subjects	
Side	0.5513	0.4587
Side-x-L4-Size	0.5059	0.4777
Side-x-Sex	1.1767	0.2793
Side-x-L4-Size-x-Sex	1.2624	0.2625

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.35
Girl	0.32	0.37

Table A-324. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	2.7370	0.0996
Sex	1.4101	0.2364
L4-Size-x-Sex	1.1975	0.2751
	Within Subjects	
Side	1.5562	0.2137
Side-x-L4-Size	1.5238	0.2185
Side-x-Sex	0.9644	0.3272
Side-x-L4-Size-x-Sex	1.1116	0.2930

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.15	0.20
Girl	0.30	0.24

Table A-325. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	3.1644	0.0768
Sex	0.4480	0.5040
L4-Size-x-Sex	0.3680	0.5448
	Within Subjects	
Side	0.6805	0.4104
Side-x-L4-Size	0.6080	0.4365
Side-x-Sex	1.1098	0.2934
Side-x-L4-Size-x-Sex	1.0631	0.3037

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.45	0.43
Girl	0.56	0.51

Table A-326. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.4870	0.4861
Sex	0.5840	0.4457
L4-Size-x-Sex	0.5313	0.4669
	Within Subjects	
Side	0.0004	0.9834
Side-x-L4-Size	0.0109	0.9170
Side-x-Sex	0.7907	0.3749
Side-x-L4-Size-x-Sex	0.7090	0.4008

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.25	0.17
Girl	0.20	0.17

Table A-327. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.5304	0.4673
Sex	1.3100	0.2537
L4-Size-x-Sex	1.0465	0.3075
	Within Subjects	
Side	0.6127	0.4347
Side-x-L4-Size	0.6058	0.4373
Side-x-Sex	0.2650	0.6073
Side-x-L4-Size-x-Sex	0.2380	0.6262

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.15
Girl	0.26	0.28

Table A-328. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	1.1426	0.2864
Sex	1.6858	0.1956
L4-Size-x-Sex	1.6316	0.2029
	Within Subjects	
Side	0.2608	0.6101
Side-x-L4-Size	0.2226	0.6376
Side-x-Sex	0.2403	0.6245
Side-x-L4-Size-x-Sex	0.2370	0.6269

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.37	0.40
Girl	0.40	0.43

Table A-329. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	5.1382	0.0245
Sex	0.9833	0.3226
L4-Size-x-Sex	1.0313	0.3111
	Within Subjects	
Side	2.3478	0.1270
Side-x-L4-Size	2.3045	0.1306
Side-x-Sex	0.2250	0.6357
Side-x-L4-Size-x-Sex	0.2210	0.6388

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.47
Girl	0.50	0.51

Table A-330. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	2.7757	0.0972
Sex	0.3377	0.5618
L4-Size-x-Sex	0.4871	0.4860
	Within Subjects	
Side	0.5535	0.4577
Side-x-L4-Size	0.6275	0.4292
Side-x-Sex	0.1415	0.7072
Side-x-L4-Size-x-Sex	0.2140	0.6441

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.28	0.31
Girl	0.51	0.40

Table A-331. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	7.1857	0.0080
Sex	3.8393	0.0514
L4-Size-x-Sex	4.0498	0.0455
	Within Subjects	
Side	0.4555	0.5005
Side-x-L4-Size	0.6721	0.4133
Side-x-Sex	0.3983	0.5287
Side-x-L4-Size-x-Sex	0.4635	0.4968

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.31	0.23
Girl	0.42	0.25

Table A-332. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.2131	0.6448
Sex	0.0547	0.8153
L4-Size-x-Sex	0.1102	0.7403
	Within Subjects	
Side	0.2072	0.6495
Side-x-L4-Size	0.2527	0.6157
Side-x-Sex	0.0120	0.9127
Side-x-L4-Size-x-Sex	0.0063	0.9371

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.43	0.37
Girl	0.31	0.30

Table A-333. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	1.3824	0.2411
Sex	0.0534	0.8176
L4-Size-x-Sex	0.1314	0.7174
	Within Subjects	
Side	1.3412	0.2482
Side-x-L4-Size	1.4042	0.2374
Side-x-Sex	1.7409	0.1885
Side-x-L4-Size-x-Sex	1.8623	0.1739

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.28 0.29	
Girl	0.51 0.44	

Table A-334. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	0.1405	0.7082
Sex	2.6676	0.1040
L4-Size-x-Sex	2.1958	0.1399
	Within Subjects	
Side	0.0093	0.9231
Side-x-L4-Size	0.0033	0.9545
Side-x-Sex	0.3064	0.5805
Side-x-L4-Size-x-Sex	0.2845	0.5943

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25	0.23
Girl	0.44	0.39

Table A-335. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	11.1701	0.0010
Sex	0.4036	0.5259
L4-Size-x-Sex	0.3179	0.5735
	Within Subjects	
Side	1.7702	0.1848
Side-x-L4-Size	1.9888	0.1600
Side-x-Sex	1.0082	0.3165
Side-x-L4-Size-x-Sex	1.0235	0.3129

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.65 0.59	
Girl	0.78 0.70	

Table A-336. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L4-Size	7.6361	0.0062
Sex	2.0863	0.1502
L4-Size-x-Sex	2.2378	0.1362
	Within Subjects	
Side	0.3486	0.5556
Side-x-L4-Size	0.3182	0.5733
Side-x-Sex	1.9567	0.1634
Side-x-L4-Size-x-Sex	2.0755	0.1512

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.44 0.46	
Girl	0.53 0.48	

Table A-337. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.7943	4.3819	-0.64	0.5244
L4-Size	0.9737	0.6197	1.57	0.1177
Sex	-1.0974	4.3819	-0.25	0.8025
Interaction	0.0952	0.6197	0.15	0.8781

Table A-338. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.6507	3.2036	-1.14	0.2558
L4-Size	1.1191	0.4530	2.47	0.0143
Sex	1.2157	3.2036	0.38	0.7047
Interaction	-0.2124	0.4530	-0.47	0.6397

Table A-339. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.8912	0.5995	-1.49	0.1387
L4-Size	0.1607	0.0848	1.90	0.0595
Sex	0.5051	0.5995	0.84	0.4005
Interaction	-0.0739	0.0848	-0.87	0.3847

Table A-340. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4529	0.6212	-0.73	0.4668
L4-Size	0.1187	0.0878	1.35	0.1781
Sex	0.6159	0.6212	0.99	0.3227
Interaction	-0.0734	0.0878	-0.84	0.4041

Table A-341. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-7.2940	3.9632	-1.84	0.0672
L4-Size	1.6462	0.5605	2.94	0.0037
Sex	-0.0076	3.9632	0.00	0.9985
Interaction	-0.0642	0.5605	-0.11	0.9089

Table A-342. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-13.7391	9.8816	-1.39	0.1659
L4-Size	3.7390	1.3975	2.68	0.0081
Sex	0.1106	9.8816	0.01	0.9911
Interaction	-0.1814	1.3975	-0.13	0.8968

Table A-343. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.5143	0.9145	-2.75	0.0065
L4-Size	0.5522	0.1293	4.27	<0.0001
Sex	1.6420	0.9145	1.80	0.0741
Interaction	-0.2507	0.1293	-1.94	0.0540

Table A-344. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	3.1134	0.6881	4.52	<0.0001
L4-Size	-0.4061	0.0973	-4.17	<0.0001
Sex	-1.8434	0.6881	-2.68	0.0080
Interaction	0.2687	0.0973	2.76	0.0063

Table A-345. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.5006	0.7115	3.51	0.0005
L4-Size	-0.3230	0.1006	-3.21	0.0015
Sex	-2.0401	0.7115	-2.87	0.0046
Interaction	0.2942	0.1006	2.92	0.0038

Table A-346. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.3898	1.7354	-0.22	0.8225
L4-Size	0.2562	0.2454	1.04	0.2977
Sex	-1.0861	1.7354	-0.63	0.5321
Interaction	0.1334	0.2454	0.54	0.5872

Table A-347. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.0604	1.5939	-1.29	0.1976
L4-Size	0.4493	0.2254	1.99	0.0476
Sex	-1.0034	1.5939	-0.63	0.5297
Interaction	0.1317	0.2254	0.58	0.5597

Table A-348. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.7036	2.8983	0.24	0.8084
L4-Size	0.4102	0.4099	1.00	0.3181
Sex	1.2049	2.8983	0.42	0.6780
Interaction	-0.1826	0.4099	-0.45	0.6564

Table A-349. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.0236	0.3499	-0.07	0.9463
L4-Size	0.0091	0.0495	0.18	0.8549
Sex	0.0236	0.3499	0.07	0.9463
Interaction	-0.0091	0.0495	-0.18	0.8549

Table A-350. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.2317	0.5861	0.40	0.6930
L4-Size	-0.0218	0.0829	-0.26	0.7931
Sex	0.8352	0.5861	1.43	0.1557
Interaction	-0.1163	0.0829	-1.40	0.1621

Table A-351. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.7201	0.9005	1.91	0.0575
L4-Size	-0.1369	0.1274	-1.08	0.2836
Sex	0.4424	0.9005	0.49	0.6237
Interaction	-0.0561	0.1274	-0.44	0.6603

Table A-352. ANCOVA results testing for associations between mesiodistal width of the mandibular first premolar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	26.8413	8.3394	3.22	0.0015
L4-Size	0.0216	1.1794	0.02	0.9854
Sex	-2.8090	8.3394	-0.34	0.7366
Interaction	0.3532	1.1794	0.30	0.7649

Table A-353. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.2594	0.6111
Sex	0.1822	0.6699
L5-Size-x-Size	0.2508	0.6171
	Within Subjects	
Side	0.0199	0.8878
Side-x-L5-Size	0.0101	0.9201
Side-x-Sex	0.3449	0.5577
Side-x-L5-Size-Sex	0.3899	0.5331

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.35	0.34
Girl	0.48	0.41

Table A-354. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.1898	0.6636
Sex	0.1490	0.6999
L5-Size-x-Size	0.0637	0.8011
	Within Subjects	
Side	1.5357	0.2167
Side-x-L5-Size	1.4082	0.2367
Side-x-Sex	0.0325	0.8571
Side-x-L5-Size-Sex	0.0377	0.8462

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.36
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.28	0.33
Girl	0.45	0.48

Table A-355. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.1445	0.7043
Sex	0.4902	0.4847
L5-Size-x-Size	0.4839	0.4874
	Within Subjects	
Side	0.0440	0.8340
Side-x-L5-Size	0.0315	0.8593
Side-x-Sex	1.3841	0.2408
Side-x-L5-Size-Sex	1.5123	0.2202

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.35

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.35
Girl	0.32	0.37

Table A-356. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.9123	0.3406
Sex	1.8031	0.1808
L5-Size-x-Size	1.5683	0.2119
	Within Subjects	
Side	0.6172	0.4330
Side-x-L5-Size	0.5925	0.4424
Side-x-Sex	3.4034	0.0665
Side-x-L5-Size-Sex	3.7555	0.0540

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.22
L_L3 dis	0.22

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.15	0.20
Girl	0.30	0.23

Table A-357. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.7652	0.3827
Sex	3.4914	0.0631
L5-Size-x-Size	3.2913	0.0711
	Within Subjects	
Side	0.2835	0.5950
Side-x-L5-Size	0.2259	0.6351
Side-x-Sex	0.0117	0.9139
Side-x-L5-Size-Sex	0.0066	0.9354

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.45	0.43
Girl	0.55	0.49

Table A-358. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.5587	0.4556
Sex	0.0038	0.9510
L5-Size-x-Size	0.0005	0.9823
	Within Subjects	
Side	0.0563	0.8127
Side-x-L5-Size	0.1163	0.7335
Side-x-Sex	4.7646	0.0302
Side-x-L5-Size-Sex	4.5708	0.0337

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.16

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.25 0.16	
Girl	0.19 0.16	

Table A-359. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.8025	0.3714
Sex	0.8659	0.3532
L5-Size-x-Size	0.6375	0.4256
	Within Subjects	
Side	0.1237	0.7255
Side-x-L5-Size	0.1353	0.7134
Side-x-Sex	0.6896	0.4073
Side-x-L5-Size-Sex	0.7610	0.3840

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.21
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.15
Girl	0.25	0.29

Table A-360. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.1203	0.7290
Sex	0.5807	0.4469
L5-Size-x-Size	0.5399	0.4633
	Within Subjects	
Side	2.6645	0.1042
Side-x-L5-Size	2.5262	0.1135
Side-x-Sex	1.2761	0.2600
Side-x-L5-Size-Sex	1.2585	0.2633

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.40
Girl	0.40	0.43

Table A-361. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.7841	0.3769
Sex	0.4413	0.5072
L5-Size-x-Size	0.4260	0.5147
	Within Subjects	
Side	0.6158	0.4335
Side-x-L5-Size	0.5912	0.4428
Side-x-Sex	0.0050	0.9436
Side-x-L5-Size-Sex	0.0034	0.9534

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.48

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.46	0.47
Girl	0.47	0.49

Table A-362. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	2.7262	0.1003
Sex	0.0546	0.8155
L5-Size-x-Size	0.1318	0.7169
	Within Subjects	
Side	1.8662	0.1734
Side-x-L5-Size	2.0151	0.1573
Side-x-Sex	0.0533	0.8176
Side-x-L5-Size-Sex	0.0170	0.8964

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.38
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.28	0.31
Girl	0.50	0.39

Table A-363. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	1.6627	0.1987
Sex	0.2000	0.6552
L5-Size-x-Size	0.1620	0.6877
	Within Subjects	
Side	0.6211	0.4316
Side-x-L5-Size	0.4140	0.5207
Side-x-Sex	2.1031	0.1485
Side-x-L5-Size-Sex	1.9883	0.1600

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.30 0.22	
Girl	0.38 0.23	

Table A-364. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.4260	0.5147
Sex	5.5147	0.0198
L5-Size-x-Size	6.0805	0.0145
	Within Subjects	
Side	0.6398	0.4247
Side-x-L5-Size	0.7410	0.3904
Side-x-Sex	0.5578	0.4560
Side-x-L5-Size-Sex	0.5131	0.4746

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.37
L_L1 rot	0.33

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.42	0.36
Girl	0.30	0.28

Table A-365. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.3513	0.5540
Sex	0.1506	0.6984
L5-Size-x-Size	0.2811	0.5966
	Within Subjects	
Side	0.8300	0.3634
Side-x-L5-Size	0.8751	0.3507
Side-x-Sex	0.1397	0.7090
Side-x-L5-Size-Sex	0.1789	0.6727

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.36

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.27 0.30	
Girl	0.50 0.44	

Table A-366. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	0.0329	0.8563
Sex	0.5949	0.4414
L5-Size-x-Size	0.3616	0.5483
	Within Subjects	
Side	0.6167	0.4332
Side-x-L5-Size	0.6894	0.4073
Side-x-Sex	0.7592	0.3846
Side-x-L5-Size-Sex	0.7138	0.3992

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.34
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.244	0.23
Girl	0.448	0.39

Table A-367. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	10.8117	0.0012
Sex	2.6739	0.1036
L5-Size-x-Size	2.4544	0.1188
	Within Subjects	
Side	3.3416	0.0690
Side-x-L5-Size	3.7076	0.0556
Side-x-Sex	1.7523	0.1871
Side-x-L5-Size-Sex	1.7916	0.1822

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.65 0.59	
Girl	0.76 0.69	

Table A-368. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L5-Size	1.5438	0.2155
Sex	0.4098	0.5228
L5-Size-x-Size	0.3592	0.5496
	Within Subjects	
Side	0.5473	0.4603
Side-x-L5-Size	0.4998	0.4804
Side-x-Sex	6.2455	0.0132
Side-x-L5-Size-Sex	6.5274	0.0114

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.44 0.45	
Girl	0.51 0.45	

Table A-369. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.15911	3.935166	-0.04	0.9678
L5	0.59065	0.546191	1.08	0.2808
Sex	-2.91699	3.935166	-0.74	0.4594
Interaction	0.350531	0.546191	0.64	0.5217

Table A-370. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.968	2.873752	-0.34	0.7366
L5	0.722673	0.398869	1.81	0.0715
Sex	-4.71371	2.873752	-1.64	0.1025
Interaction	0.619692	0.398869	1.55	0.1218

Table A-371. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.0651	0.540644	-0.12	0.9043
L5	0.04244	0.07504	0.57	0.5723
Sex	-0.26972	0.540644	-0.5	0.6184
Interaction	0.036075	0.07504	0.48	0.6312

Table A-372. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.182247	0.557551	0.33	0.7441
L5	0.027445	0.077387	0.35	0.7232
Sex	-0.36158	0.557551	-0.65	0.5174
Interaction	0.064446	0.077387	0.83	0.4059

Table A-373. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.16644	3.583089	-0.88	0.3779
L5	1.043029	0.497323	2.1	0.0372
Sex	-3.98874	3.583089	-1.11	0.2669
Interaction	0.496391	0.497323	1	0.3194

Table A-374. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-4.29354	8.907965	-0.48	0.6303
L5	2.356352	1.236402	1.91	0.0581
Sex	-11.6194	8.907965	-1.3	0.1936
Interaction	1.466614	1.236402	1.19	0.2369

Table A-375. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.66655	0.842755	-0.79	0.4299
L5	0.284796	0.116972	2.43	0.0158
Sex	-0.167	0.842755	-0.2	0.8431
Interaction	0.007171	0.116972	0.06	0.9512

Table A-376. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.521934	0.624594	4.04	<0.0001
L5	-0.31557	0.086692	-3.64	0.0003
Sex	0.000402	0.624594	0	0.9995
Interaction	0.007211	0.086692	0.08	0.9338

Table A-377. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.469757	0.652851	2.25	0.0254
L5	-0.17242	0.090614	-1.9	0.0585
Sex	-0.04669	0.652851	-0.07	0.9431
Interaction	0.011112	0.090614	0.12	0.9025

Table A-378. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.80751	1.551687	-0.52	0.6033
L5	0.312004	0.21537	1.45	0.149
Sex	0.193186	1.551687	0.12	0.901
Interaction	-0.04684	0.21537	-0.22	0.828

Table A-379. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.87026	1.435008	-0.61	0.5449
L5	0.276261	0.199175	1.39	0.167
Sex	-1.77407	1.435008	-1.24	0.2178
Interaction	0.238606	0.199175	1.2	0.2323

Table A-380. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.277668	2.58432	0.11	0.9145
L5	0.463918	0.358697	1.29	0.1974
Sex	1.831259	2.58432	0.71	0.4794
Interaction	-0.26727	0.358697	-0.75	0.4571

Table A-381. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.01058	0.313061	-0.03	0.9731
L5	0.007093	0.043452	0.16	0.8705
Sex	0.010575	0.313061	0.03	0.9731
Interaction	-0.00709	0.043452	-0.16	0.8705

Table A-382. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.13667	0.527446	-0.26	0.7958
L5	0.02878	0.073208	0.39	0.6946
Sex	-0.06029	0.527446	-0.11	0.9091
Interaction	0.009654	0.073208	0.13	0.8952

Table A-383. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.350807	0.80394	1.68	0.0944
L5	-0.08263	0.111585	-0.74	0.4599
Sex	1.293278	0.80394	1.61	0.1092
Interaction	-0.17414	0.111585	-1.56	0.1202

Table A-384. ANCOVA results testing for associations between mesiodistal width of the mandibular second premolar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	22.30307	7.445733	3	0.0031
L5	0.661295	1.033448	0.64	0.523
Sex	4.852641	7.445733	0.65	0.5153
Interaction	-0.72322	1.033448	-0.7	0.4848

Table A-385. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.1732	0.6777
Sex	0.9253	0.3372
L6-Size-x-Sex	0.8102	0.3691
	Within Subjects	
Side	0.0659	0.7977
Side-x-L6-Size	0.0430	0.8360
Side-x-Sex	1.6221	0.2043
Side-x-L6-Size-Sex	1.6944	0.1945

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.34	0.32
Girl	0.47	0.40

Table A-386. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	3.3982	0.0667
Sex	2.9444	0.0877
L6-Size-x-Sex	3.4416	0.0650
	Within Subjects	
Side	1.3277	0.2506
Side-x-L6-Size	1.2625	0.2625
Side-x-Sex	1.2455	0.2657
Side-x-L6-Size-Sex	1.2948	0.2565

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.29	0.34
Girl	0.51	0.52

Table A-387. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.0187	0.8912
Sex	0.6673	0.4150
L6-Size-x-Sex	0.6778	0.4113
	Within Subjects	
Side	0.0040	0.9495
Side-x-L6-Size	0.0023	0.9616
Side-x-Sex	0.0889	0.7659
Side-x-L6-Size-Sex	0.0661	0.7973

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.36	0.34
Girl	0.31	0.36

Table A-388. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.7528	0.3866
Sex	0.0973	0.7554
L6-Size-x-Sex	0.0521	0.8197
	Within Subjects	
Side	0.4510	0.5026
Side-x-L6-Size	0.3955	0.5301
Side-x-Sex	6.8470	0.0095
Side-x-L6-Size-Sex	7.2233	0.0078

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.17	0.19
Girl	0.32	0.23

Table A-389. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.8586	0.3552
Sex	0.0150	0.9025
L6-Size-x-Sex	0.0043	0.9476
	Within Subjects	
Side	0.0046	0.9461
Side-x-L6-Size	0.0074	0.9314
Side-x-Sex	4.1641	0.0426
Side-x-L6-Size-Sex	4.0633	0.0451

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.44	0.45
Girl	0.56	0.52

Table A-390. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	1.5608	0.2130
Sex	3.3512	0.0686
L6-Size-x-Sex	3.4263	0.0656
	Within Subjects	
Side	1.8425	0.1762
Side-x-L6-Size	2.0608	0.1527
Side-x-Sex	0.1831	0.6692
Side-x-L6-Size-Sex	0.1654	0.6847

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.23	0.16
Girl	0.20	0.16

Table A-391. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.0011	0.9737
Sex	1.6585	0.1993
L6-Size-x-Sex	1.4040	0.2374
	Within Subjects	
Side	0.0328	0.8565
Side-x-L6-Size	0.0346	0.8526
Side-x-Sex	0.0326	0.8568
Side-x-L6-Size-Sex	0.0219	0.8826

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.17	0.15
Girl	0.25	0.28

Table A-392. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.3926	0.5317
Sex	0.5707	0.4508
L6-Size-x-Sex	0.6273	0.4293
	Within Subjects	
Side	1.6035	0.2069
Side-x-L6-Size	1.5135	0.2200
Side-x-Sex	0.1578	0.6916
Side-x-L6-Size-Sex	0.1445	0.7042

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.36	0.41
Girl	0.43	0.45

Table A-393. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.3309	0.5658
Sex	0.1210	0.7283
L6-Size-x-Sex	0.1313	0.7175
	Within Subjects	
Side	1.3621	0.2445
Side-x-L6-Size	1.3460	0.2473
Side-x-Sex	0.2102	0.6471
Side-x-L6-Size-Sex	0.2129	0.6450

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.47	0.48
Girl	0.49	0.50

Table A-394. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.0960	0.7570
Sex	0.0072	0.9324
L6-Size-x-Sex	0.0340	0.8540
	Within Subjects	
Side	1.0116	0.3157
Side-x-L6-Size	1.1261	0.2899
Side-x-Sex	0.5638	0.4536
Side-x-L6-Size-Sex	0.7085	0.4009

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.29	0.32
Girl	0.51	0.38

Table A-395. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	2.7644	0.0979
Sex	3.2528	0.0728
L6-Size-x-Sex	3.4615	0.0643
	Within Subjects	
Side	0.0180	0.8933
Side-x-L6-Size	0.0674	0.7954
Side-x-Sex	0.0661	0.7974
Side-x-L6-Size-Sex	0.0456	0.8312

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.32	0.24
Girl	0.42	0.26

Table A-396. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.0002	0.9902
Sex	2.1642	0.1428
L6-Size-x-Sex	2.4562	0.1186
	Within Subjects	
Side	2.9284	0.0886
Side-x-L6-Size	3.0370	0.0829
Side-x-Sex	0.8764	0.3503
Side-x-L6-Size-Sex	0.8893	0.3468

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.41	0.38
Girl	0.30	0.28

Table A-397. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.3108	0.5778
Sex	0.2384	0.6259
L6-Size-x-Sex	0.1358	0.7129
	Within Subjects	
Side	0.8695	0.3522
Side-x-L6-Size	0.9303	0.3359
Side-x-Sex	0.9689	0.3261
Side-x-L6-Size-Sex	1.0686	0.3025

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.27 0.29	
Girl	0.51 0.43	

Table A-398. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	0.0000	0.9963
Sex	0.2310	0.6313
L6-Size-x-Sex	0.3856	0.5353
	Within Subjects	
Side	0.0358	0.8502
Side-x-L6-Size	0.0488	0.8253
Side-x-Sex	0.3576	0.5505
Side-x-L6-Size-Sex	0.3328	0.5647

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.24	
Girl	0.45 0.41	

Table A-399. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	6.3981	0.0122
Sex	0.0304	0.8618
L6-Size-x-Sex	0.0095	0.9224
	Within Subjects	
Side	2.1288	0.1461
Side-x-L6-Size	2.3966	0.1232
Side-x-Sex	1.7428	0.1883
Side-x-L6-Size-Sex	1.8013	0.1811

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.65 0.58	
Girl	0.81 0.70	

Table A-400. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L6-Size	1.5699	0.2117
Sex	0.0003	0.9854
L6-Size-x-Sex	0.0041	0.9487
	Within Subjects	
Side	0.2263	0.6348
Side-x-L6-Size	0.2158	0.6428
Side-x-Sex	0.0064	0.9361
Side-x-L6-Size-Sex	0.0019	0.9654

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.43 0.45	
Girl	0.52 0.48	

Table A-401. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.0271	4.7823	-0.63	0.5275
L6	0.6424	0.4320	1.49	0.1386
Sex	-2.2902	4.7823	-0.48	0.6325
Interaction	0.1643	0.4320	0.38	0.7041

Table A-402. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.1957	3.5321	0.06	0.9559
L6	0.3690	0.3191	1.16	0.2488
Sex	0.9048	3.5321	0.26	0.7981
Interaction	-0.1074	0.3191	-0.34	0.7367

Table A-403. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.2435	0.6569	-0.37	0.7113
L6	0.0448	0.0593	0.75	0.4513
Sex	0.6380	0.6569	0.97	0.3325
Interaction	-0.0591	0.0593	-1.00	0.3203

Table A-404. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.1128	0.6799	0.17	0.8684
L6	0.0241	0.0614	0.39	0.6952
Sex	-0.1491	0.6799	-0.22	0.8266
Interaction	0.0224	0.0614	0.37	0.7153

Table A-405. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-3.3446	4.3844	-0.76	0.4464
L6	0.6970	0.3961	1.76	0.0799
Sex	0.0521	4.3844	0.01	0.9905
Interaction	-0.0483	0.3961	-0.12	0.9032

Table A-406. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-6.1761	10.8922	-0.57	0.5713
L6	1.7084	0.9839	1.74	0.0840
Sex	-1.3333	10.8922	-0.12	0.9027
Interaction	0.0086	0.9839	0.01	0.9930

Table A-407. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4386	1.0285	-0.43	0.6702
L6	0.1665	0.0929	1.79	0.0746
Sex	1.3492	1.0285	1.31	0.1910
Interaction	-0.1336	0.0929	-1.44	0.1521

Table A-408. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.6117	0.7679	3.40	0.0008
L6	-0.2130	0.0694	-3.07	0.0024
Sex	0.1594	0.7679	0.21	0.8358
Interaction	-0.0080	0.0694	-0.12	0.9079

Table A-409. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.6356	0.7950	2.06	0.0409
L6	-0.1279	0.0718	-1.78	0.0764
Sex	-0.6380	0.7950	-0.80	0.4231
Interaction	0.0618	0.0718	0.86	0.3907

Table A-410. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-1.2999	1.8905	-0.69	0.4925
L6	0.2476	0.1708	1.45	0.1487
Sex	0.2311	1.8905	0.12	0.9028
Interaction	-0.0361	0.1708	-0.21	0.8330

Table A-411. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.2898	1.7445	-1.31	0.1908
L6	0.3090	0.1576	1.96	0.0513
Sex	-0.1449	1.7445	-0.08	0.9339
Interaction	0.0044	0.1576	0.03	0.9777

Table A-412. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.3768	3.1656	0.75	0.4536
L6	0.1106	0.2860	0.39	0.6994
Sex	0.1339	3.1656	0.04	0.9663
Interaction	-0.0195	0.2860	-0.07	0.9456

Table A-413. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.3857	0.3790	-1.02	0.3100
L6	0.0391	0.0342	1.14	0.2549
Sex	0.3857	0.3790	1.02	0.3100
Interaction	-0.0391	0.0342	-1.14	0.2549

Table A-414. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.0866	0.6397	0.14	0.8925
L6	-0.0002	0.0578	0.00	0.9967
Sex	0.8892	0.6397	1.39	0.1660
Interaction	-0.0794	0.0578	-1.37	0.1707

Table A-415. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.1299	0.9843	1.15	0.2524
L6	-0.0336	0.0889	-0.38	0.7056
Sex	0.7299	0.9843	0.74	0.4592
Interaction	-0.0621	0.0889	-0.70	0.4857

Table A-416. ANCOVA results testing for associations between mesiodistal width of the mandibular first molar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	23.7271	9.0746	2.61	0.0096
L6	0.3072	0.8197	0.37	0.7082
Sex	6.8454	9.0746	0.75	0.4515
Interaction	-0.6515	0.8197	-0.79	0.4277

Table A-417. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.8974	0.3446
Sex	0.0901	0.7643
L7-Size-x-Sex	0.0597	0.8072
	Within Subjects	
Side	0.0611	0.8051
Side-x-L7-Size	0.0397	0.8423
Side-x-Sex	1.3997	0.2382
Side-x-L7-Size-x-Sex	1.4812	0.2250

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 dis	0.41
U_L3 dis	0.38

Means, by Sex

	U_R3 dis	U_L3 dis
Boy	0.36	0.34
Girl	0.47	0.40

Table A-418. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.1543	0.6948
Sex	1.5815	0.2100
L7-Size-x-Sex	1.9089	0.1686
	Within Subjects	
Side	0.8133	0.3682
Side-x-L7-Size	0.7307	0.3936
Side-x-Sex	0.4582	0.4992
Side-x-L7-Size-x-Sex	0.4775	0.4904

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 dis	0.37
U_L2 dis	0.41

Means, by Sex

	U_R2 dis	U_L2 dis
Boy	0.30	0.35
Girl	0.46	0.49

Table A-419. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.1425	0.7062
Sex	0.3069	0.5802
L7-Size-x-Sex	0.3021	0.5832
	Within Subjects	
Side	1.1331	0.2884
Side-x-L7-Size	1.1981	0.2750
Side-x-Sex	0.3022	0.5831
Side-x-L7-Size-x-Sex	0.3739	0.5415

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 dis	0.34
U_L1 dis	0.36

Means, by Sex

	U_R1 dis	U_L1 dis
Boy	0.37	0.35
Girl	0.32	0.38

Table A-420. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L3 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.0013	0.9712
Sex	0.0173	0.8955
L7-Size-x-Sex	0.0024	0.9610
	Within Subjects	
Side	0.0703	0.7911
Side-x-L7-Size	0.0641	0.8004
Side-x-Sex	0.5976	0.4404
Side-x-L7-Size-x-Sex	0.7409	0.3904

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 dis	0.23
L_L3 dis	0.23

Means, by Sex

	L_R3 dis	L_L3 dis
Boy	0.16	0.21
Girl	0.30	0.24

Table A-421. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L2 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	5.3667	0.0215
Sex	0.0393	0.8430
L7-Size-x-Sex	0.0150	0.9025
	Within Subjects	
Side	0.1519	0.6971
Side-x-L7-Size	0.1870	0.6659
Side-x-Sex	2.0358	0.1552
Side-x-L7-Size-x-Sex	1.9414	0.1650

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 dis	0.51
L_L2 dis	0.47

Means, by Sex

	L_R2 dis	L_L2 dis
Boy	0.44	0.44
Girl	0.57	0.52

Table A-422. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L1 displacements.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	4.4361	0.0364
Sex	0.5327	0.4663
L7-Size-x-Sex	0.5653	0.4530
	Within Subjects	
Side	1.0540	0.3058
Side-x-L7-Size	1.2618	0.2626
Side-x-Sex	1.5165	0.2196
Side-x-L7-Size-x-Sex	1.4245	0.2341

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 dis	0.22
L_L1 dis	0.17

Means, by Sex

	L_R1 dis	L_L1 dis
Boy	0.24	0.16
Girl	0.20	0.17

Table A-423. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.1016	0.7502
Sex	0.0579	0.8100
L7-Size-x-Sex	0.0132	0.9087
	Within Subjects	
Side	1.2823	0.2588
Side-x-L7-Size	1.2880	0.2577
Side-x-Sex	0.4526	0.5019
Side-x-L7-Size-x-Sex	0.3913	0.5323

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3 rot	0.22
U_L3 rot	0.22

Means, by Sex

	U_R3 rot	U_L3 rot
Boy	0.18	0.15
Girl	0.26	0.29

Table A-424. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.9184	0.3390
Sex	0.8889	0.3469
L7-Size-x-Sex	0.9297	0.3361
	Within Subjects	
Side	0.0062	0.9373
Side-x-L7-Size	0.0199	0.8879
Side-x-Sex	5.3052	0.0223
Side-x-L7-Size-x-Sex	5.3273	0.0220

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2 rot	0.39
U_L2 rot	0.42

Means, by Sex

	U_R2 rot	U_L2 rot
Boy	0.38	0.42
Girl	0.40	0.45

Table A-425. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.0663	0.7971
Sex	0.4933	0.4833
L7-Size-x-Sex	0.4993	0.4806
	Within Subjects	
Side	0.5919	0.4426
Side-x-L7-Size	0.5686	0.4517
Side-x-Sex	0.0293	0.8643
Side-x-L7-Size-x-Sex	0.0261	0.8717

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R1 rot	0.47
U_L1 rot	0.49

Means, by Sex

	U_R1 rot	U_L1 rot
Boy	0.48	0.49
Girl	0.48	0.50

Table A-426. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L3 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	1.4928	0.2232
Sex	0.0926	0.7612
L7-Size-x-Sex	0.1624	0.6874
	Within Subjects	
Side	0.8713	0.3517
Side-x-L7-Size	0.9871	0.3216
Side-x-Sex	0.7661	0.3825
Side-x-L7-Size-x-Sex	0.9479	0.3314

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3 rot	0.39
L_L3 rot	0.35

Means, by Sex

	L_R3 rot	L_L3 rot
Boy	0.30	0.33
Girl	0.49	0.38

Table A-427. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L2 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.9037	0.3429
Sex	0.2211	0.6387
L7-Size-x-Sex	0.2657	0.6068
	Within Subjects	
Side	0.8431	0.3596
Side-x-L7-Size	1.1171	0.2918
Side-x-Sex	1.8538	0.1749
Side-x-L7-Size-x-Sex	1.7008	0.1937

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2 rot	0.35
L_L2 rot	0.23

Means, by Sex

	L_R2 rot	L_L2 rot
Boy	0.31	0.24
Girl	0.40	0.24

Table A-428. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L1 rotations.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.0323	0.8575
Sex	5.6281	0.0186
L7-Size-x-Sex	6.1911	0.0136
	Within Subjects	
Side	3.5347	0.0615
Side-x-L7-Size	3.7259	0.0550
Side-x-Sex	0.0713	0.7898
Side-x-L7-Size-x-Sex	0.0808	0.7765

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R1 rot	0.38
L_L1 rot	0.34

Means, by Sex

	L_R1 rot	L_L1 rot
Boy	0.42	0.37
Girl	0.30	0.28

Table A-429. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U2-U3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.6373	0.4256
Sex	0.9993	0.3187
L7-Size-x-Sex	1.2629	0.2624
	Within Subjects	
Side	0.4556	0.5004
Side-x-L7-Size	0.4986	0.4809
Side-x-Sex	1.2394	0.2669
Side-x-L7-Size-x-Sex	1.3490	0.2468

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R3-2 lapping	0.38
U_L2-3 lapping	0.37

Means, by Sex

	U_R3-2 lapping	U_L2-3 lapping
Boy	0.30	0.31
Girl	0.50	0.43

Table A-430. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and U1-U2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	0.1531	0.6960
Sex	0.0009	0.9761
L7-Size-x-Sex	0.0361	0.8494
	Within Subjects	
Side	1.0244	0.3127
Side-x-L7-Size	0.9750	0.3246
Side-x-Sex	4.3634	0.0380
Side-x-L7-Size-x-Sex	4.3241	0.0388

*df for each test is 1 and 203.

Means, Sexes Pooled

U_R2-1 lapping	0.35
U_L1-2 lapping	0.31

Means, by Sex

	U_R2-1 lapping	U_L1-2 lapping
Boy	0.25 0.24	
Girl	0.44 0.41	

Table A-431. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L2-L3 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	5.5270	0.0197
Sex	0.1410	0.7077
L7-Size-x-Sex	0.0932	0.7605
	Within Subjects	
Side	6.4824	0.0116
Side-x-L7-Size	6.9739	0.0089
Side-x-Sex	1.3869	0.2403
Side-x-L7-Size-x-Sex	1.4487	0.2301

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R3-2 lapping	0.71
L_L2-3 lapping	0.65

Means, by Sex

	L_R3-2 lapping	L_L2-3 lapping
Boy	0.65 0.60	
Girl	0.78 0.69	

Table A-432. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and L1-L2 overlap.

Source	F-Ratio*	P-Value
	Among Subjects	
L7-Size	1.7323	0.1896
Sex	0.1915	0.6622
L7-Size-x-Sex	0.1536	0.6955
	Within Subjects	
Side	0.0906	0.7637
Side-x-L7-Size	0.1068	0.7441
Side-x-Sex	0.9245	0.3374
Side-x-L7-Size-x-Sex	1.0354	0.3101

*df for each test is 1 and 203.

Means, Sexes Pooled

L_R2-1 lapping	0.47
L_L1-2 lapping	0.46

Means, by Sex

	L_R2-1 lapping	L_L1-2 lapping
Boy	0.43	0.46
Girl	0.52	0.46

Table A-433. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and total displacements.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.8261	4.0872	0.20	0.8400
L7-Size	0.3214	0.3988	0.81	0.4212
Sex	0.8419	4.0872	0.21	0.8370
Interaction	-0.1214	0.3988	-0.30	0.7611

Table A-434. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and total rotations.

Term	Estimate	SE	t-Test	P-Value
Intercept	6.1932	3.0133	2.06	0.0411
L7-Size	-0.1882	0.2940	-0.64	0.5229
Sex	0.5258	3.0133	0.17	0.8617
Interaction	-0.0709	0.2940	-0.24	0.8096

Table A-435. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and maxillary R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.4326	0.5572	-0.78	0.4385
L7-Size	0.0666	0.0544	1.23	0.2220
Sex	0.6971	0.5572	1.25	0.2124
Interaction	-0.0696	0.0544	-1.28	0.2020

Table A-436. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and mandibular R1-L1 overlap.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.1005	0.5785	0.17	0.8622
L7-Size	0.0274	0.0565	0.48	0.6285
Sex	-0.1149	0.5785	-0.20	0.8427
Interaction	0.0210	0.0565	0.37	0.7104

Table A-437. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and total overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.0628	3.7468	-0.02	0.9866
L7-Size	0.4329	0.3656	1.18	0.2378
Sex	0.9251	3.7468	0.25	0.8052
Interaction	-0.1306	0.3656	-0.36	0.7213

Table A-438. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and total displacements, rotations, and overlapping.

Term	Estimate	SE	t-Test	P-Value
Intercept	6.9565	9.3287	0.75	0.4567
L7-Size	0.5662	0.9102	0.62	0.5347
Sex	2.2928	9.3287	0.25	0.8061
Interaction	-0.3230	0.9102	-0.35	0.7231

Table A-439. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and crowding.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.2738	0.8757	-0.31	0.7549
L7-Size	0.1628	0.0854	1.90	0.0582
Sex	1.0578	0.8757	1.21	0.2285
Interaction	-0.1148	0.0854	-1.34	0.1806

Table A-440. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and spacing.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.0175	0.6571	3.07	0.0024
L7-Size	-0.1724	0.0641	-2.69	0.0078
Sex	-0.1921	0.6571	-0.29	0.7703
Interaction	0.0240	0.0641	0.37	0.7083

Table A-441. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and diastema.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.7946	0.6738	2.66	0.0084
L7-Size	-0.1525	0.0657	-2.32	0.0214
Sex	0.2292	0.6738	0.34	0.7341
Interaction	-0.0184	0.0657	-0.28	0.7794

Table A-442. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and maxillary incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	1.6609	1.6151	1.03	0.3050
L7-Size	-0.0211	0.1576	-0.13	0.8936
Sex	1.0990	1.6151	0.68	0.4970
Interaction	-0.1194	0.1576	-0.76	0.4494

Table A-443. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and mandibular incisor irregularity.

Term	Estimate	SE	t-Test	P-Value
Intercept	-2.1873	1.4805	-1.48	0.1411
L7-Size	0.3237	0.1445	2.24	0.0261
Sex	-0.1374	1.4805	-0.09	0.9262
Interaction	0.0056	0.1445	0.04	0.9691

Table A-444. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and maxillary overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	6.3345	2.6685	2.37	0.0185
L7-Size	-0.2627	0.2604	-1.01	0.3142
Sex	4.4119	2.6685	1.65	0.0998
Interaction	-0.4343	0.2604	-1.67	0.0969

Table A-445. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and mandibular overjet.

Term	Estimate	SE	t-Test	P-Value
Intercept	-0.6007	0.3187	-1.88	0.0609
L7-Size	0.0633	0.0311	2.03	0.0432
Sex	0.6007	0.3187	1.88	0.0609
Interaction	-0.0633	0.0311	-2.03	0.0432

Table A-446. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and openbite.

Term	Estimate	SE	t-Test	P-Value
Intercept	0.8423	0.5415	1.56	0.1214
L7-Size	-0.0746	0.0528	-1.41	0.1595
Sex	0.7451	0.5415	1.38	0.1704
Interaction	-0.0709	0.0528	-1.34	0.1810

Table A-447. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and anteroposterior relationship.

Term	Estimate	SE	t-Test	P-Value
Intercept	2.1991	0.8295	2.65	0.0087
L7-Size	-0.1407	0.0809	-1.74	0.0836
Sex	1.0161	0.8295	1.22	0.2220
Interaction	-0.0941	0.0809	-1.16	0.2466

Table A-448. ANCOVA results testing for associations between mesiodistal width of the mandibular second molar and DAI score.

Term	Estimate	SE	t-Test	P-Value
Intercept	38.9652	7.5756	5.14	<0.0001
L7-Size	-1.1481	0.7392	-1.55	0.1219
Sex	17.8924	7.5756	2.36	0.0191
Interaction	-1.7651	0.7392	-2.39	0.0179

VITA

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