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An examination of dental crowding and its relationship to tooth size and arch dimension

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This investigation was undertaken to examine the extent to which tooth size and jaw size each contribute to dental crowding. Two groups of dental casts were selected on the basis of dental crowding. One group, consisting of 50 pairs of dental casts (18 males and 32 females), exhibited gross dental crowding. A second group, consisting of 54 pairs of dental casts (24 males and 30 females), exhibited little or no crowding. Means and standard deviations of the following parameters were used to compare the two groups: individual and collective mesiodistal tooth diameters, dental arch perimeters, and buccal and lingual dental arch widths. Statistically, the crowded and noncrowded groups could not be distinguished from each other on the basis of mesiodistal tooth diameters. However, significant differences were observed between the dental arch dimensions of the two groups. The crowded group was found to have smaller dental arch dimensions than the noncrowded group. The results of this study suggest that consideration be given to those treatment techniques which increase dental arch length rather than reduce tooth mass.

Key words: Crowding, tooth size, arch width, arch length, arch perimeter

Dental crowding can be defined as a disparity in the relationship between tooth size and jaw size which results in imbrication and rotation of teeth. Three conditions which may predispose the dental arches to crowding are excessively large teeth, excessively small bony bases of the jaws, and a combination of large teeth and small jaws.

The correction of dental crowding can be accomplished via a variety of orthodontic procedures. For example, the extraction of permanent teeth[1, 2] and the mesiodistal reduction of tooth size[3] are procedures that are designed to fit less total tooth mass into a particular dental arch. Other treatment procedures, including palatal expansion[4, 5] and the use of certain functional appliances,[6] are directed toward expanding the dental arches in order to accommodate the existing teeth. Implicit in the rationale for using any of these approaches is an assumption that dental crowding results from a disparity in the relationship between tooth size and jaw size. Selection of an appropriate treatment approach may depend upon which factors influence the observed crowding.

This investigation was undertaken to examine the extent to which tooth size and jaw size each contribute to dental crowding. By comparing dental casts of two

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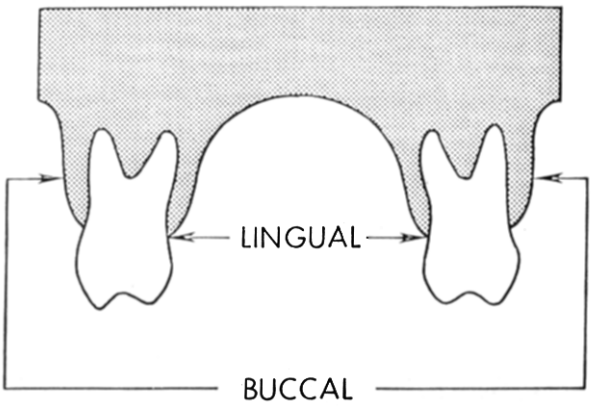

Fig. 1. Diagrammatic representation of arch width measurements.

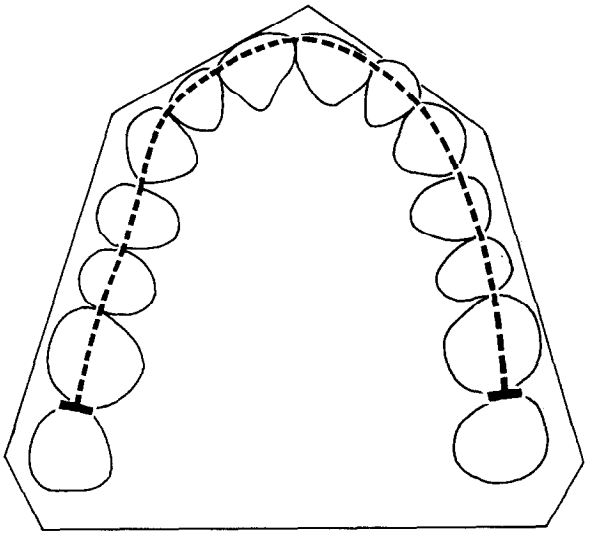

Fig. 2. Arch perimeter and area were determined by tracing the buccolingual or labiolingual centers of each tooth.

groups of subjects, one with well-aligned dental arches and one with significant crowding, we made an effort to answer the following questions: (1) Are there significant individual or collective tooth size differences between the two groups (that is, are the crowded teeth larger than the noncrowded teeth)? (2) Do the two groups differ significantly with respect to dental arch dimensions (that is, are the crowded jaws smaller than the noncrowded jaws)?

Theories proposed to explain the cause of dental crowding vary widely, embracing concepts of evolution, heredity, and environmental effects. Hooten[7] suggested that dental crowding may result from an evolutionary trend toward a reduced facial skeleton size without a corresponding reduction in tooth dimension. However, Brash[8] emphasized the effects of heredity, speculating that dental crowding may result from continued interbreeding between physically dissimilar ethnic groups. Brash also stressed environmental factors, reasoning that the modern, refined diet may have played a role in reducing muscular stimulation, hence the full expression of facial bone growth. Other environmental factors have been suggested by Barber,[9] who speculated that dental crowding may result from abnormal muscle forces, aberrant paths of tooth eruption, occlusal forces resulting in mesial migration of the teeth, and loss of arch length through dental caries.

Table I. Tooth size: Mesiodistal sums of teeth

	Male				*Female*			
Group	*N*	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
Maxillary arch								
Noncrowded	24	94.3	3.9	NS	30	91.7	4.2	NS
Crowded	18	95.0	4.7	NS	32	91.0	3.2	NS
Mandibular arch								
Noncrowded	24	85.5	3.4	NS	30	83.0	4.0	NS
Crowded	18	86.6	4.1	NS	32	82.5	3.1	NS

Numerous investigators have studied various aspects of dental crowding in relation to such variables as race, sex, and age. In an examination of dental crowding, age, and race, LaVelle[10] found that dental crowding increased with age for the Caucasoid and Mongoloid races. However, the dental arches of the blacks did not become more crowded with age. Tooth size was found to be significantly larger in Negroids than it was in Caucasoids or Mongoloids. Sex differences in crowding have been reported by LaVelle and Foster,[11] Fastlicht,[12] and Foster and associates.[13] All found more dental crowding in females than in males. Foster and colleagues,[13] studying the relationship of age and dental crowding, found that crowding increased with age until the thirteenth or fourteenth year and then tended to decrease. Hunter and Smith[14] looked at the degree of dental crowding and its relation to age, examining patients at age 9 and again at age 16. They found that the greater the dental crowding at age 9, the less was the arch perimeter decreased by age 16. Furthermore, crowding at age 9 showed a high correlation with crowding at age 16.

Still other investigators studied the interrelationship of tooth size, arch size, and dental crowding and reported dissimilar findings. Two groups of investigators emerge. The first group found that tooth size correlated with crowding. For example, Fastlicht[12] found a significant correlation between the mesiodistal widths of the maxillary and mandibular incisors and dental crowding. Norderval and colleagues,[15] studying mandibular anterior crowding in a sample of 27 adults with ideal occlusion and a sample of 39 adults with slight

Table II. Tooth size: Individual teeth, right maxillary arch

		Male				*Female*			
Group	*Tooth*	*N*	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
N	Central incisor	24	8.7	0.50	NS	30	8.3	0.51	NS
C		18	8.6	0.71	NS	32	8.3	0.40	NS
N	Lateral incisor	24	6.7	0.52	NS	30	6.3	0.59	NS
C		18	6.8	0.53	NS	32	6.4	0.57	NS
N	Canine	24	7.7	0.74	NS	30	7.4	0.53	NS
C		18	7.8	0.74	NS	32	7.3	0.34	NS
N	First premolar	24	6.8	0.42	NS	30	6.7	0.47	NS
C		18	6.8	0.49	NS	32	6.7	0.37	NS
N	Second premolar	24	6.6	0.49	NS	30	6.5	0.38	NS
C		18	6.7	0.36	NS	32	6.4	0.40	NS
N	First molar	24	10.7	0.46	NS	30	10.6	0.57	NS
C		18	10.8	0.53	NS	32	10.4	0.64	NS

N = Noncrowded.
C = Crowded.

Table III. Tooth size: Individual teeth, right mandibular arch

		Male				*Female*			
Group	*Tooth*	*N*	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
N	Central incisor	24	5.2	0.30	NS	30	5.1	0.31	NS
C		18	5.3	0.38	NS	32	5.2	0.28	NS
N	Lateral incisor	24	5.8	0.32	NS	30	5.5	0.37	NS
C		18	5.9	0.39	NS	32	5.7	0.29	NS
N	Canine	24	6.7	0.31	NS	30	6.3	0.39	NS
C		18	6.8	0.52	NS	32	6.3	0.34	NS
N	First premolar	24	6.9	0.37	NS	30	6.8	0.40	NS
C		18	7.1	0.51	NS	32	6.8	0.40	NS
N	Second premolar	24	6.9	0.34	NS	30	6.8	0.39	NS
C		18	7.2	0.51	NS	32	6.8	0.68	NS
N	First molar	24	11.0	0.56	NS	30	10.6	0.57	NS
C		18	11.1	0.66	NS	32	10.5	0.57	NS

N = Noncrowded.
C = Crowded.

mandibular crowding, stated that in the crowded group the four mandibular incisor teeth had significantly larger mesial-distal diameters. Lundström[16] studied a sample of 139 13-year-old boys and concluded that tooth size increases as crowding increases. He stated also that arch perimeter decreases as crowding increases. In an examination of the variation of tooth size in the etiology of malocclusion, Lundström[17] stated that persons with large teeth are more likely to have crowding than those with small teeth. Doris and co-workers[18] examined orthodontic records of 80 subjects who were divided into two groups according to the amount of dental crowding present. They measured the maxillary and mandibular incisors, canines, and premolars and reported that mesiodistal tooth size was uniformly larger in the group with crowded arches.

A second group of investigators studying the interrelationship of tooth size, arch size, and dental crowding reported quite different findings. These investigators, including Mills[19] and McKeown,[20] found greater correlation between arch size and dental crowding than between tooth size and dental crowding. Mills,[19] in a study of 230 males between the ages of 17 and 21 years, found a significant association between crowding of teeth and arch width. Furthermore, Mills stated that little variation existed between crown diameters of persons with and without malalignment. McKeown,[20] in a study of 65 dental casts collected from subjects ranging in age from 18 to 25 years, found that arch width and crowding are strongly correlated and that a narrow arch in man predisposes to crowding of the teeth.

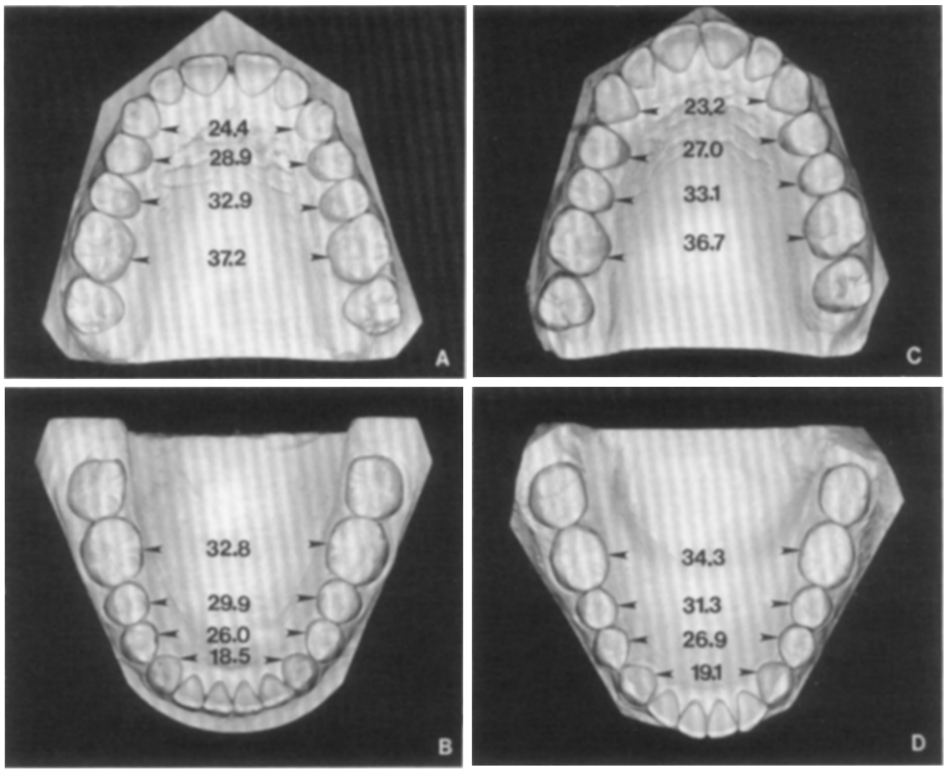

Fig. 3. Dental casts representing the statistical average for the noncrowded group. **A** and **B**, Female averages. **C** and **D**, Male averages.

MATERIALS AND METHODS

Articulated maxillary and mandibular dental casts from 104 subjects were used in this study. Each cast selected met the following criteria: (1) All permanent teeth with the exception of the third molars were present in the dental casts of both the maxillary and the mandibular arches. (2) There had been no previous orthodontic treatment. All records were selected from The University of Michigan Elementary and Secondary School Growth Study and the private practices of three orthodontists (Drs. R. P. Howe, J. A. McNamara, Jr., and R. E. Moyers).

Further, the selection procedure was intentionally biased to produce two groups. The noncrowded group represented Class I normal occlusions with little or no dental crowding. The crowded group was selected on the basis of gross dental crowding. No numerical measurement of arch length or crowding was made in either group until after the selection procedure was completed. Also, no case was selected or assigned to either group without agreement among the three investigators. Disagreements resulted in exclusion of the contested casts. No other criteria were used for the selection of subjects or assignment to either of the two groups.

Sex and age distributions for the groups were as follows: The noncrowded group consisted of 30 females and 24 males ranging in age from 11 years 6 months to 28 years 7 months, with a mean age of 15 years 7 months; the crowded group consisted of 32 females and 18 males ranging in age from 9 years to 44 years with a mean age of 19 years 7 months. Plaster casts were measured by one investigator with helios calipers calibrated to 0.1 mm. Measurements were repeated on ten sets of dental casts by the same investigator. The mean difference of 0.15 mm. between the values of the first and second readings was not significant. Measurements for comparison were made in the following manner:

Tooth size. Mesiodistal tooth diameters of all permanent teeth, exclusive of second and third molars, were recorded. Even though second molars were present, they were not always fully erupted and measurement was deemed impractical. Third molars were rarely present in the dental casts and were excluded. Measurements were taken at the greatest mesiodistal width of each tooth, with the caliper tips held perpendicular to the long axis of each tooth.

Because dimensional differences between the sexes exist with respect to tooth size and arch size, all data

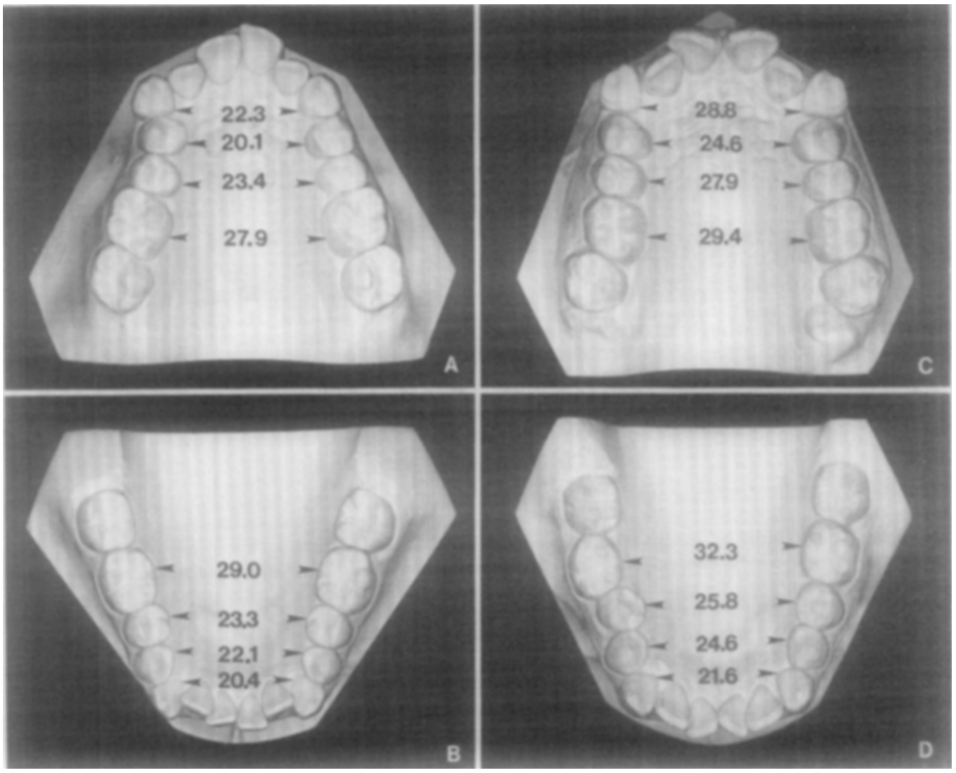

Fig. 4. Dental casts representing the statistical average for the crowded group. **A** and **B**, Female averages. **C** and **D**, Male averages.

are presented separately for males and females. Furthermore, comparisons of individual tooh sizes were made without pooling left and right sides. For example, the maxillary right canines of the crowded group were compared to the maxillary right canines of the noncrowded group. Individual tooth size measurements presented in tabular form represent right-side measurements only. Left-side measurements were recorded and were not found to be dissimilar. Measurements reported for sums of mesiodistal tooth diameters for each arch included all teeth of the arch (that is, both left and right sides).

Arch width. Lingual and buccal arch width measurements were recorded for first permanent molar, first and second premolar, and permanent canine regions of each arch. Lingual arch widths were measured at the cervical region of each designated mesiodistal tooth from the midpoint of the lingual surface of the tooth to a corresponding point on its antimere (Fig. 1). Buccal arch width values[6] were measured from a point on the buccal gingiva, 5 mm. apical to the mesiodistal center of each designated tooth, to a corresponding point across the dental arch according to the method previously described by McDougall and co-workers.[6]

Arch perimeter and area measurements. Arch perimeter measurements were obtained by first placing a 2½-inch rigid acetate sheet directly over the occlusal surface of each cast. A line was then traced from the buccolingual center of the distal surface of the first permanent molar around the dental arch through the buccolingual centers of the posterior teeth and over the incisal edges of the anterior teeth, terminating at the corresponding distal surface of the opposite first permanent molar (Fig. 2). The acetate sheet was then placed on a Summagraphics digitizing tablet and the dental arch was traced in stream mode, making possible estimates of its perimeter and area. The Michigan Terminal System (MTS) at The University of Michigan was used for data analysis.

RESULTS

Overall, no significant differences were found in tooth sizes between the noncrowded and crowded groups, regardless of whether tooth size was compared individually or whether the mesiodistal sums of entire arches were compared. However, significant differences were observed when the arch dimensions of the crowded and the noncrowded groups were compared. These dimensions included lingual arch width, buccal arch width, dental arch perimeter, and dental arch area.

Table IV. Maxillary arch widths

Group	Region	Male				Female			
		N	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
Lingual									
N	Canine	24	26.4	1.38	NS	30	25.1	2.07	<0.05
C		18	24.6	3.83		32	23.5	3.27	
N	First premolar	24	28.9	1.26	<0.01	30	27.7	1.73	<0.01
C		18	23.5	2.91		32	22.8	1.79	
N	Second premolar	24	34.1	1.80	<0.01	30	32.9	1.48	<0.01
C		18	27.7	3.22		32	27.0	2.63	
N	First molar	24	37.4	1.67	<0.01	30	36.2	1.92	<0.01
C		18	31.1	4.11		32	30.8	2.40	
Buccal									
N	Canine	24	37.9	1.86	<0.01	30	36.0	2.09	<0.01
C		18	33.6	2.81		32	32.0	2.46	
N	First premolar	24	47.4	1.81	<0.01	30	45.0	2.51	<0.01
C		18	43.1	3.40		32	40.5	2.62	
N	Second premolar	24	53.8	1.84	<0.01	30	51.6	2.44	<0.01
C		18	48.1	3.59		32	46.1	2.72	
N	First molar	24	60.9	2.14	<0.01	30	59.1	2.66	<0.01
C		18	55.0	3.86		32	53.2	2.49	

N = Noncrowded.
C = Crowded.

Table V. Mandibular arch widths

Group	Region	Male				Female			
		N	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
Lingual									
N	Canine	24	20.1	1.45	NS	30	19.3	1.39	<0.01
C		18	19.4	2.24		32	18.2	1.87	
N	First premolar	24	26.7	1.43	<0.01	30	25.6	1.54	<0.01
C		18	23.3	1.82		32	22.4	1.96	
N	Second premolar	24	30.6	1.57	<0.01	30	29.6	1.63	<0.01
C		18	26.8	2.22		32	25.5	2.46	
N	First molar	24	34.1	1.78	<0.01	30	32.8	1.58	<0.01
C		18	31.8	2.67		32	29.1	2.75	
Buccal									
N	Canine	24	29.8	1.38	<0.01	30	28.1	1.49	<0.01
C		18	28.2	2.33		32	26.4	2.21	
N	First premolar	24	39.3	1.26	<0.01	30	37.6	2.05	<0.01
C		18	37.8	1.94		32	35.5	1.98	
N	Second premolar	24	47.5	1.80	<0.01	30	45.7	2.09	<0.01
C		18	45.0	2.04		32	42.2	2.04	
N	First molar	24	56.7	1.67	<0.01	30	55.0	1.90	<0.01
C		18	54.5	2.29		32	51.5	2.38	

N = Noncrowded.
C = Crowded.

Tooth size

The difference in the mean values of maxillary mesiodistal tooth diameters between the crowded and noncrowded groups for males was found to be 0.7 mm. (Table I). The difference between the mean values for the corresponding comparison in the mandibular arch was 0.1 mm. The difference in mean values for females was 0.7 mm. and 0.5 mm. for the maxillary and mandibular arches, respectively. In all cases these differences were not statistically significant (Table I). When mesiodistal sums of teeth for males and females were compared arch by arch, males had uniformly larger values.

Comparisons of individual tooth size differences

Table VI. Maxillary arch dimensions

		Male				*Female*			
Group	*Measure*	*N*	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
N	Arch perimeter	24	99.3	4.30	<0.05	30	95.6	4.2	<0.01
C	Arch perimeter	18	94.7	7.70		32	90.4	6.4	
N	Area	24	1408.0	102.80	<0.01	30	1317.0	108.3	<0.01
C	Area	18	1194.0	159.15		32	1113.0	129.8	

N = Noncrowded.
C = Crowded.

Table VII. Mandibular arch dimensions

		Male				*Female*			
Group	*Measure*	*N*	*Mean*	*S.D.*	*P*	*N*	*Mean*	*S.D.*	*P*
N	Arch perimeter	24	88.1	5.9	NS	30	84.6	3.7	<0.01
C	Arch perimeter	18	83.7	5.9		32	79.6	5.1	
N	Area	24	1116.0	131.1	<0.01	30	1037.0	83.6	<0.01
C	Area	18	980.0	116.8		32	884.0	84.9	

N = Noncrowded.
C = Crowded.

between the noncrowded and the crowded groups appear in Tables II and III. In all cases no significant differences were observed when tooth size was compared. For example, for males the maxillary right central incisors in the noncrowded group averaged 8.7 mm., while in the crowded group its mean value was 8.6 mm. (Table II). The difference between these two measurements was not significant. Similar findings are observed for the remaining maxillary teeth of both males and females. Also, no significant differences were observed for individual tooth size measurements in the mandibular arch (Table III). The largest difference between the means was that for the mandibular right second premolars. The mean value in the noncrowded group was 6.9 mm. and was not significantly different from the mean value in the crowded group, which was 7.2 mm. Differences in tooth sizes were observed between males and females, with males having slightly larger mesiodistal dimensions. These differences were more pronounced for the maxillary incisors and canines.

Arch dimensions

Arch dimension comparisons yielded significant differences between the noncrowded and crowded groups. Noncrowded arches tended to be larger.

Arch widths. Buccal and lingual arch widths were greater in the noncrowded group than in the crowded group (Figs. 3 and 4, Tables IV and V). For example, transverse lingual measurements of maxillary arch width at the first molar site in males averaged 37.4 mm. in the noncrowded group. This was 6.1 mm. larger than the measurement in the crowded group. For females, the corresponding lingual measurement averaged 36.2 mm. in the noncrowded group and 30.8 mm. in the crowded group. In both comparisons, the differences were significant ($p < 0.01$). Similar values were observed for transverse buccal arch widths in the maxillary arch. The only maxillary arch width comparison which was not significantly larger in the noncrowded group was the transverse lingual arch width for males at the maxillary canine. The mean value for the maxillary lingual canine measurement in the noncrowded males was 26.4 mm., which was not significantly different from the crowded males' arch width measurement of 24.6 mm. Similarly, comparison of the transverse lingual measurements at the mandibular canine for males yielded values which were not significantly different from one another. All other differences in mandibular arch width presented in Table V were significant.

Arch perimeter. Significant differences were found in dental arch perimeter measurements for the maxilla between the noncrowded and crowded groups (Table VI). For example, dental arch perimeter for the 24 males in the noncrowded group averaged 99.3 mm. and was significantly larger than the average value of 94.7 mm. for the 18 males in the crowded group. The 30 females in the noncrowded group had a mean value of 95.6 mm. for dental arch perimeter, which was once again significantly larger than the 90.4 mm. mean value for the 32 females with crowded maxillary arches. Similar findings were observed for the mandibular

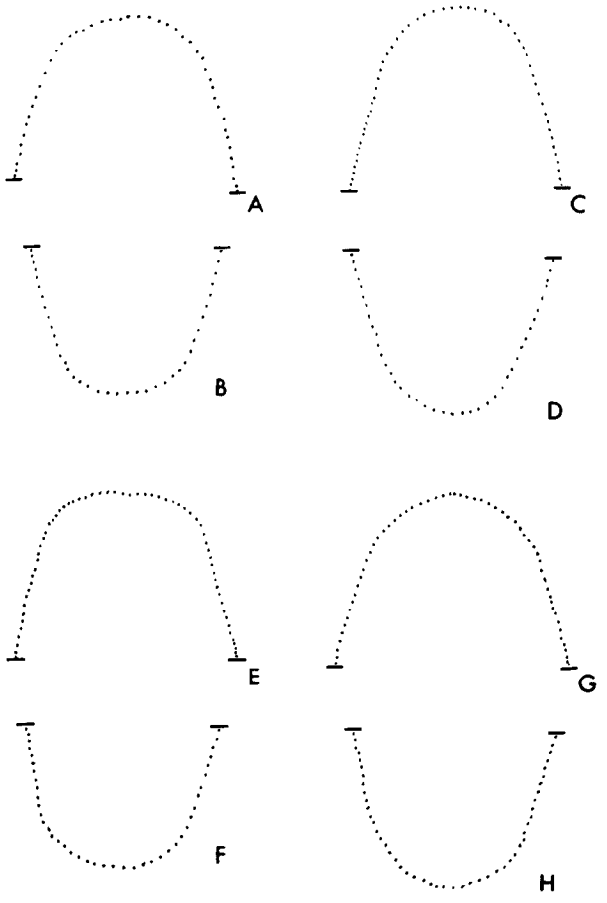

Fig. 5. Arch-perimeter drawings from the noncrowded group. **A** to **D** correspond with the dental casts shown in Fig. 3 and represent average values. **E** to **H** represent extreme variants.

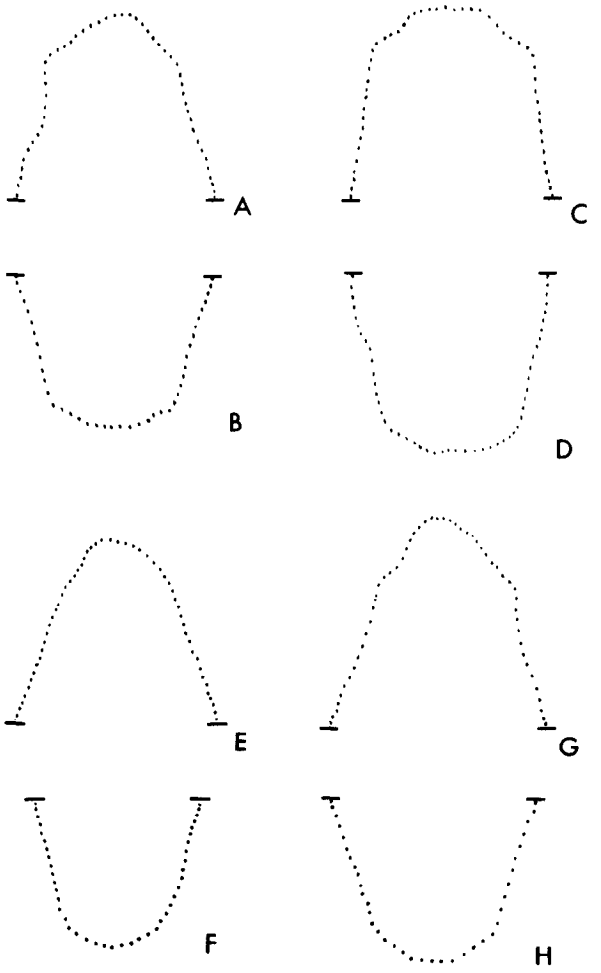

Fig. 6. Arch-perimeter drawings from the crowded group. **A** to **D** correspond with the dental casts shown in Fig. 4 and represent average values. **E** to **H** represent extreme variants.

arches (Table VII) with one exception. The mean value of 88.1 for the arch perimeter of males in the noncrowded group was not significantly larger than the mean value of 83.7 for the dental arch length of males in the crowded group. Significant differences in dental arch perimeter of the noncrowded and crowded groups were observed for females in both the maxillary and mandibular arches (Tables VI and VII). The noncrowded arches tended to be wider and more broadly contoured than did the crowded arches (Figs. 5 and 6).

Arch area. Values for maxillary arch area were significantly larger in the noncrowded group for both males and females (Table VI). For example, the average maxillary arch area for males in the noncrowded group was 1,408 mm.^{2} and for the males in the crowded group it was 1,194 mm.^{2}. Females in the noncrowded group had an average maxillary arch area of 1,317 mm.^{2} compared to that of 1,113 mm.^{2} for females in the crowded group. The same relationship was observed for the mandibular arch (Table VII). Once again, dental arch area for the noncrowded arches was significantly larger than the area for crowded arches among both males and females.

DISCUSSION

The primary finding of this study is that, for the sample examined, subjects with dental crowding were more likely to have smaller dental arch measurements than subjects with little or no dental crowding. Furthermore, subjects with crowded dental arches could not be distinguished statistically from subjects with normal occlusions on the basis of tooth size.

When interpreting the findings of this study, the following limitations should be kept in mind: The sampling procedure used in this study was not random. The selection procedure was intentionally biased to produce two dissimilar groups—one with dental crowding and

one with well-aligned teeth. All cases of mild to moderate crowding, as well as cases of crowding in only one of the two dental arches, were excluded from the study. While this procedure made comparisons of the two groups convenient, it is possible that the nonrandom-selection procedure affected the results.

The findings of this study, which are in agreement with those of Mills[19] and McKeown,[20] disagree with the findings presented by Fastlicht,[12] Norderval and associates,[15] and Doris and co-workers.[18] While differences in samples and methods of the various studies could account for dissimilar findings, an adequate explanation for the disparate results was not found.

The stated purpose of Fastlicht's study[12] was to determine whether or not orthodontic treatment influenced the crowding of the mandibular incisors and to clarify the causes of mandibular crowding. To accomplish this, two groups of 28 subjects, with equal sex distribution, were compared. One group consisted of orthodontically treated patients, while subjects in the second group had undergone no orthodontic treatment. Because cases were chosen at random, it can be assumed that no attempt was made to group them according to the presence or absence of crowding. While Fastlicht's findings that the relationship of crowding and mesiodistal width of incisors in either the maxillary or the mandibular arches of untreated males is not significant ($P = 0.3$), he did find a significant relationship between crowding and mesiodistal widths of incisors in untreated females. Fastlicht did not report findings for either males or females in the treated group with regard to crowding and its relationship to mesiodistal widths of incisors. The principal differences between Fastlicht's and the current study are as follows: (1) In the former study the groups were composed of either orthodontically treated or nontreated arches, whereas in the current study the groups were composed of either crowded or noncrowded arches. (2) In Fastlicht's study sums of incisor measurements were reported, whereas in the current study measurements for incisors, canines, premolars, and first permanent molars were reported, both individually and collectively. (3) In Fastlicht's study one group (namely, untreated females) had mesiodistal incisor dimensions which correlated with dental crowding. A second group (untreated males) showed no significant relationship, and two groups (treated males and females) were unreported. In the current study, no significant differences in tooth size were observed for any of the four groups: males with noncrowded arches, females with noncrowded arches, males with crowded arches, and females with crowded arches.

Norderval and colleagues[15] have reported that subjects with slight mandibular crowding were found to have larger mesiodistal widths of the four lower incisor teeth than subjects without lower incisor crowding. As in the current study, their subjects were divided into two groups based on the presence or absence of crowding. However, other differences in methods appear. First, in the study by Norderval's group measurements were made of lower incisors only, rather than of all teeth mesial to second molars. Second, Norderval and his co-workers selected subjects with slight anterior crowding, whereas subjects in the current study were selected for gross crowding. Furthermore, Norderval and associates describe the overall sample with regard to sex (48 males and 18 females), yet they do not state the number of males and females in the noncrowded and crowded groups. This may be an important consideration, since males were found to have larger mesiodistal tooth widths than females.[12, 21]

Findings of the current study contradict the findings of Doris and co-workers.[18] In the latter study, two groups of 40 each were selected according to the amount of crowding present. Group 1 had up to 4 mm. of crowding and Group 2 had more than 4 mm. of crowding. Means and standard deviations for each tooth in the maxilla and mandible, exclusive of the molars, were presented. In each case, significant differences were found in mesiodistal tooth dimensions between the noncrowded and crowded groups, with the crowded group having uniformly larger teeth. This finding is in direct contrast with the findings of the present study, in which mesiodistal tooth diameters were not found to be significantly different between the crowded and noncrowded groups. Examination of mean tooth measurements indicates that tooth sizes were found to be similar in the noncrowded groups in both studies. However, for the crowded groups, mesiodistal tooth dimensions in the study by Doris and associates appear to be larger than those reported in the current study. No explanation for the difference in these findings is apparent.

In discussing their findings, Doris and colleagues state that "when the sum of the twenty teeth is 140 mm. or greater, the clinician can label the case as one having larger than normal tooth mass, and thus consider the need for extraction therapy." Because of the findings of this study, namely, that mesiodistal tooth size is not significantly different between crowded and noncrowded subjects, it may be prudent to consider the need for nonextraction therapy for patients with dental crowding.

Observations were made during the course of this study which suggest further investigation. For example, the findings presented could be interpreted to sug-

gest that dental arch dimension is associated with dental crowding, while tooth size may have little association with dental crowding. However, important differences between the two groups may have been overlooked. Visual inspection of the two groups of casts which had been set out for measurement was revealing. The noncrowded arches were easily identifiable, with broad symmetrical arch forms that were uniform in shape. In contrast, the crowded arches were sometimes asymmetrical, frequently narrow or tapered, and strikingly irregular in arch form. If excessive tooth size alone were responsible for dental crowding, then one might have expected to see crowded arches with broad symmetrical and uniform arch shapes that differed from noncrowded arches only in the amount of overlap and rotation of the teeth. Or, if arch dimension alone were responsible for dental crowding, one might have expected to see dental crowding in symmetrical, uniform arches that were significantly smaller than the noncrowded arches. Because these conditions were not observed in the crowded arches, further investigation into the relationship of dental crowding to arch shape and arch symmetry may be productive.

Clinical implications

These findings may have clinical relevance in the treatment of malocclusion. Once a discrepancy between tooth size and jaw size has been established (that is, the patient has been diagnosed as having dental crowding), treatment planning can be directed toward (1) reducing the tooth mass, (2) increasing the dental arch dimension, or (3) a combination of both. The selection of an appropriate course of treatment would likely include a consideration of the patient's present condition (i.e., that crowding is due to excessively large teeth or to excessively small dental arches) as well as the effectiveness of the proposed treatment. For example, if a patient is diagnosed as having dental crowding resulting from excessively small dental arches, the extraction of permanent teeth may be an effective treatment measure. However, it may be inappropriate for correcting that particular patient's malocclusion. A more appropriate treatment measure may be the expansion of the dental arches.

Obviously, this reasoning cannot be followed without limitation. With present treatment practices, it seems unlikely that small dental arches of a mature patient can be expanded to accommodate gross crowding. In such cases, there is little doubt that the extraction of permanent teeth is appropriate. Also, there is little question that treatment practices which strive to maintain intercanine width in an effort to avoid a posttreatment relapse, are not without merit.[21]

However, if, as this study suggests, dental crowding is associated with small dental arches rather than with large teeth, greater consideration may be given to those treatment techniques which increase dental arch length. This may be especially relevant in younger patients whose dentitions are in the deciduous and mixed stages of development. If such a patient is diagnosed as having dental crowding and small dental arches, then treatment measures may include efforts to further jaw development in order to accommodate the existing tooth mass. This might be accomplished by early expansion procedures using such appliances as the rapid palatal expander, the quad helix appliance, or the Fränkel appliance,[6] alone or in combination.

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