Relationship of Dental Crowding to Tooth Size and Arch Width

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The purpose of the present study was to investigate the relationship of dental crowding to tooth size and arch dimension in Korean subjects. Two groups of dental casts with Class I molar relationship, were selected on the basis of crowding. One group, consisting of 82 pairs of study cast (29 males and 53 females), exhibited at least 7 millimeters of crowding in each arch. A second group, consisting of 82 sets of study cast (37 males and 45 females), exhibited normal occlusion with little or no crowding. Mesiodistal tooth diameters, and buccal and lingual dental arch widths were measured and compared between the crowding and normal occlusion groups. Significant differences were observed between the two groups not only in arch widths but also in tooth sizes. The results of the present study suggest that both extraction and expansion can be used as a treatment approach for the crowding cases.

Key words : Crowding, Tooth size, Arch width, Expansion, Extraction

Dental crowding is defined as a discrepancy between tooth size and jaw size. The dental arches may be disposed to crowding due to excessively large teeth, excessively small arch dimensions, and a combination of large teeth and small arches. Selection of an appropriate treatment approach depends upon which factors influence the dental crowding. In cases where the main contributing factor is large teeth, an appropriate treatment strategy would be extraction of some teeth.[1,2] On the other hand, expansion of the dental arch would be a desirable approach in cases where arch dimension is the main causative factor to dental crowding.[3,4]

In order to investigate the relationship of dental crowding to tooth size and arch dimension, a number of

Table 1. Sample description (years-months)

	Crowding group		Normal group	
	Male (n=29)	Female (n=53)	Male (n=37)	Female (n=45)
Mean age	17-2	17-11	18-11	19-0
SD	5-6	5-3	1-7	1-5

studies were undertaken by comparing dental casts of two groups of subjects, one with well-aligned dental arches and one with significant crowding. However, these studies reported dissimilar findings, in terms of the main contributing factor for dental crowding. Lundström,[5,6] Fastlicht,[7] Norderval and colleagues,[8] Doris and co-workers,[9] and Smith[10] reported that tooth size was larger in crowded arches.

On the other hand, Mills,[11] McKeown,[12] Howe and colleagues,[13] Radnzic,[14] and Tsai[15] found greater correlation between arch size and dental crowding than tooth size and dental crowding. Howe and et al.,[13] in a study of 50 dental casts with crowding and 54 pairs of dental casts with no crowding, found that the crowded and noncrowded groups could not be distinguished from each other on the basis of mesiodistal tooth diameters while significant differences were observed in the dental arch dimensions between the two groups. They insisted that consideration be given to those treatment techniques which increase dental arch length rather than reduce tooth mass.

The purpose of the present study was to investigate the relationship of dental crowding to tooth size and arch width. Considering that there has been controversy in the main influencing factor to dental crowding, strict selection criteria were used for both crowding and normal occlusion groups.

MATERIALS AND METHODS

Maxillary and mandibular dental casts were selected from the Chonnam National University Hospital in Gwangju and Yonsei Dental Hospital in Seoul, as the crowding group. Each cast selected met the following criteria: (1) the presence of all permanent teeth with the exception of the third molars. (2) at least 7mm of crowding in the dental casts of both the maxillary and the mandibular arches. (3) Class I molar relationship to match the subjects in the normal group. Twelve subjects were selected from 1,500 consecutive orthodontic patients at Chonnam National University Hospital, and seventy were selected from 5,000 consecutive patients at Yonsei Dental Hospital. The total number was 82. They consisted of 29 males with a mean age of 17 years and 2 months and 53 females with a mean age of 17 years and 11 months.

As the normal group, maxillary and mandibular dental casts were selected from a survey of Chonnam National University students in Gwangju and the data of Korean Adult Occlusion Study Center in Seoul. For the first step of the selection process, a clinical examination was carried out to determine the status of the occlusion; those subjects who were judged to have a normal occlusion were selected. The second step was to obtain a set of study casts. From the examination of study casts, subjects who showed Class I molar and canine relationships with no or minimal crowding were selected. Any subject who presented with crowding greater than 2 mm, spacing greater than 1mm, or a dental midline discrepancy greater than 1mm was excluded from the samples. From a survey of 4,800 subjects, 82 sets of dental cast were selected. They consisted of 37 males with a mean age of 18 years and 11 months and 45 females with a mean age of 19 years (Table 1).

Dental casts were measured by one investigator with a digital Vernier caliper (Mitutoyo, Japan) in the following manner.

Tooth size: Mesiodistal tooth diameters of all permanent teeth, exclusive of second and third molars, were

Table 2. Comparison of tooth size in males

	Crowding group		Normal group		P-value
	Mean	SD	Mean	SD	
Maxillary right					
Central incisor	9.2	0.60	8.6	0.46	< 0.001
Lateral incisor	7.8	0.55	7.2	0.51	< 0.001
Canine	8.6	0.45	8.1	0.38	< 0.001
First premolar	8.0	0.46	7.4	0.30	< 0.001
Second premolar	7.7	0.42	7.1	0.41	< 0.001
First molar	11.1	0.92	10.6	0.48	< 0.001
Maxillary left					
Central incisor	9.2	0.49	8.6	0.44	< 0.001
Lateral incisor	7.6	0.53	7.0	0.48	< 0.001
Canine	8.5	0.57	8.0	0.40	< 0.001
First premolar	8.1	0.45	7.5	0.34	< 0.001
Second premolar	7.5	0.47	7.0	0.34	< 0.001
First molar	11.3	0.57	10.6	0.49	< 0.001
Mandibular right					
Central incisor	5.8	0.34	5.4	0.29	< 0.001
Lateral incisor	6.5	0.33	6.0	0.32	< 0.001
Canine	7.5	0.40	7.0	0.34	< 0.001
First premolar	8.1	0.48	7.3	0.34	< 0.001
Second premolar	7.8	0.50	7.4	0.48	< 0.001
First molar	12.1	0.57	11.3	0.50	< 0.001
Mandibular left					
Central incisor	5.8	0.38	5.4	0.33	< 0.001
Lateral incisor	6.5	0.39	6.1	0.34	< 0.001
Canine	7.5	0.34	7.1	0.36	< 0.001
First premolar	8.0	0.49	7.4	0.36	< 0.001
Second premolar	7.9	0.46	7.4	0.41	< 0.001
First molar	12.1	0.60	11.3	0.51	< 0.001

measured. Measurements were taken at the greatest mesiodistal width of each tooth, with the reference to the study by Sim and co-workers,[16] a study of measurement error in tooth size. Because dimensional differences between the sexes exist, all data are presented separately for males and females. Furthermore, comparisons of individual tooth sizes were made without pooling left and right sides.

Arch width: Lingual and buccal arch width measurements were recorded for first molar, first and second premolar, and 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 according to the method previously

described by Howe and co-workers.[13]

Buccal arch width values 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 colleagues[17] and Howe and co-workers.[13] Comparisons of arch widths were made between crowding and normal groups, separately for for males and females.

RESULTS

Tooth size: Comparisons of tooth size differences between crowding and normal groups appear in Tables 2 and 3. In all cases statistically significant differences were

Table 3. Comparison of tooth size in females

	Crowding group		Normal group		P-value
	Mean	SD	Mean	SD	
Maxillary right					
Central incisor	8.9	0.40	8.3	0.41	< 0.001
Lateral incisor	7.5	0.57	6.8	0.59	< 0.001
Canine	8.1	0.49	7.6	0.32	< 0.001
First premolar	7.8	0.48	7.2	0.35	< 0.001
Second premolar	7.4	0.47	6.9	0.37	< 0.001
First molar	11.0	0.53	10.1	0.54	< 0.001
Maxillary left					
Central incisor	8.8	0.50	8.2	0.43	< 0.001
Lateral incisor	7.4	0.55	6.7	0.52	< 0.001
Canine	8.1	0.44	7.6	0.34	< 0.001
First premolar	7.8	0.49	7.2	0.37	< 0.001
Second premolar	7.3	0.49	6.8	0.31	< 0.001
First molar	10.9	0.52	10.0	0.57	< 0.001
Mandibular right					
Central incisor	5.7	0.39	5.3	0.28	< 0.001
Lateral incisor	6.3	0.40	5.8	0.31	< 0.001
Canine	6.9	0.43	6.6	0.37	< 0.001
First premolar	7.8	0.53	7.2	0.35	< 0.001
Second premolar	7.7	0.50	7.0	0.36	< 0.001
First molar	11.7	0.45	10.9	0.45	< 0.001
Mandibular left					
Central incisor	5.7	0.36	5.3	0.29	< 0.001
Lateral incisor	6.4	0.44	5.9	0.31	< 0.001
Canine	7.0	0.42	6.6	0.32	< 0.001
First premolar	7.7	0.50	7.2	0.71	< 0.001
Second premolar	7.7	0.48	7.1	0.39	< 0.001
First molar	11.5	0.47	10.9	0.43	< 0.001

observed between the two groups. The tooth sizes were greater in the crowding group. For example, for males the maxillary right central incisors in the crowding group averaged 9.2 mm, while in the normal group its mean value was 8.6 mm. The smallest difference between the means was that for the mandibular central incisors. The mean value in the crowding group was 5.8 mm, while in the normal group its mean value was 5.4 mm. Although the difference was very small, 0.4 mm, it was statistically significant. (Tables 2, 3).

Arch width: Buccal and lingual arch widths were greater in the normal group than in the crowding group, with the exception of lingual width in the canine region. For example, lingual width measurements of the maxilla at the first molar site in males averaged 35.2 mm in the crowding

group. This was 5.3 mm larger than the measurement in the normal group, and the difference was statistically significant. Overall, the differences between the two groups were greater in the maxilla than in the mandible. On the other hand, the only arch width com-parison which was not significantly greater in the normal group was the lingual arch width at the canine site (Tables 4, 5).

Overall, statistically significant differences between the two groups were found not only in the arch widths but also in the tooth size.

DISCUSSION

Although a number of investigators studied the interrelationship of tooth size, arch dimension, and

Table 4. Comparison of arch widths between crowding and normal groups in males

	Crowding group			Normal group		P-value
	Mean	SD		Mean	SD	
Maxillary lingual						
Canine	27.7	3.08		27.2	1.84	0.441
First premolar	25.7	2.52		31.1	1.48	< 0.001
Second premolar	31.4	3.05		37.0	1.81	< 0.001
First molar	35.2	3.15		40.5	3.01	< 0.001
Maxillary buccal						
Canine	36.6	3.53		40.1	3.96	< 0.001
First premolar	45.3	3.88		50.3	4.30	< 0.001
Second premolar	52.4	3.04		57.1	4.59	< 0.001
First molar	59.8	3.33		64.2	5.35	< 0.001
Mandibular lingual						
Canine	20.8	2.76		21.0	1.41	0.641
First premolar	25.9	2.71		28.5	1.49	< 0.001
Second premolar	29.1	2.39		33.6	2.09	< 0.001
First molar	33.3	2.65		37.0	2.19	< 0.001
Mandibular buccal						
Canine	30.8	2.56		31.2	1.32	0.474
First premolar	41.7	1.98		43.0	1.89	0.009
Second premolar	49.3	2.40		51.7	2.38	< 0.001
First molar	58.2	2.54		61.6	2.20	< 0.001

Table 5. Comparison of arch widths between crowding and normal groups in females

	Crowding group			Normal group		P-value
	Mean	SD		Mean	SD	
Maxillary lingual						
Canine	27.0	3.15		26.2	1.99	0.147
First premolar	25.2	1.95		29.5	1.76	< 0.001
Second premolar	30.7	2.48		35.0	1.82	< 0.001
First molar	34.5	2.70		37.8	2.07	< 0.001
Maxillary buccal						
Canine	34.5	2.74		39.0	2.15	< 0.001
First premolar	44.9	2.81		48.8	2.59	< 0.001
Second premolar	51.4	2.73		55.8	2.36	< 0.001
First molar	58.4	2.58		61.7	3.28	< 0.001
Mandibular lingual						
Canine	20.3	2.40		20.6	1.40	0.594
First premolar	24.5	2.28		27.1	1.86	< 0.001
Second premolar	28.9	3.15		31.8	2.12	< 0.001
First molar	32.2	2.89		34.7	1.97	< 0.001
Mandibular buccal						
Canine	28.7	3.64		29.9	1.57	0.030
First premolar	39.5	2.18		41.2	2.01	0.009
Second premolar	47.4	2.52		49.4	1.93	< 0.001
First molar	56.8	2.37		58.9	2.05	< 0.001

dental crowding, they reported dissimilar findings. One group[5-10] found that tooth size correlated with crowding while the other group[11-15] found greater correlation between arch size and dental crowding. It is likely that the difference of the results originates from the diff-erence of methodology and sample selection. Howe and colleagues[13] pointed out many drawbacks of previous studies, and selected the samples with selec-tion criteria. The selection procedure was intentionally biased to produce two groups, crowded and noncro-wded groups. The crowded group was selected on the basis of gross dental crowding. The present study used the same methodology as in the study of Howe and colleagues.[13]

In order to investigate if tooth size and arch width influence dental crowding, strict criteria were used in sample selection. The crowding group in the present study had at least 7 mm of crowding in the dental casts of both the maxillary and mandibular arches. Further-more, Class II or Class III subjects were excluded from the sample, to match the subjects in the normal group. From a survey of 6,500 consecutive patients, 82 were selected. Considering that oriental subjects have more crowding than Caucasian, the fact that 82 were selected from 6,500 patients suggests that strict selection criteria were used in the present study.

As the results of the comparison of arch widths between the crowding and normal groups, buccal and lingual arch widths were greater in the normal group than in the crowding group. This finding suggests that an expansion procedure is needed as arch width is responsible for dental crowding. Howe and colleagues[13] also showed that the crowded group had smaller arch dimensions than the noncrowded group. While the crowding group had smaller arch widths than the normal group in the present study, the differences were greater in the maxilla (approximately 5.0 ~ 6.0 mm) than in the mandible (approximately 3.0 ~ 4.0 mm). It indicates that an expansion procedure is needed more in the maxilla than in the mandible.

On the other hand, all arch widths did not show sta-tistically significant differences between the two groups. Lingual arch width at the canine site did not show a statistically significant difference, in both the maxilla and the mandible. This finding suggests that the expansion procedure needs to be applied only to the premolar and molar sites, and not to the canine. It would be desirable not to use canine as an abutment of rapid palatal expander or quad helix appliance. In addition, the fact that intercanine width is similar suggests that incisor crowding might be influenced by large teeth, rather than arch width, at least in the incisor region. Howe and colleagues[13] also reported that lingual width at the canine site did not show a statistically significant difference between the crowded and noncrowded groups in male subjects. The only difference between Howe's and the current study was that this finding occurred only in male in Howe's study.

As for the results of the comparison of tooth sizes, all tooth types showed statistically significant differences between the two groups. The tooth sizes were greater in the crowding group. The findings of this study disagree with those of many previous studies.[11-15] Differences in samples and methods could account for dissimilar findings. Radnzic[14] reported that there was no significant correlation between cumulative mesiodistal crown widths and dental crowding while there were very significant correlations between dental arch dimensions and the degree of crowding. This finding is in direct contrast with the findings of the present study. However, it is found that he did not select crowding individuals as the sam-ples. In his study, space discrepancy was calculated as the difference between the arch perimeter and cumulative mesiodistal crown widths in each arch. Crowded arches were defined as those with a space discrepancy of 3.0 mm or more. It was not the comparison between crowding and normal groups, as in the present study.

It is known that McKeown[12] also found a great correlation between dental arch size and crowding than between tooth size and crowding. He also did not select crowding individuals as the samples. He only divided them into space, no crowding, mild, moderate, and severe crowding groups. For the tooth size, he measured only the incisors. The arch width used in his study was intermolar width. His conclusion was that subjects with

a difference between arch width and anterior tooth widths greater than some extent (4 mm in the upper arch, 10 mm in the lower arch) rarely had crowding. As arch width changes very little from age 7 onwards, measurements at this age might be used as a screening mechanism for future arch crowding. While it was apparent that arch width and crowding are strongly associated in his study, he did not mention the issue of no correlation of the crowding with tooth size.

Tsai[15] reported that there were little significant differences between crowded and spaced arches in mesiodistal crown width, while crowded arches had statistically significantly smaller arch widths than did the spaced arches. However, his study was carried out in the primary dentition, and cannot be compared to the results of the present study which used the individuals with permanent dentition as the subjects.

Unlike those studies stated above, Howe and collea-gues[13] used the same method as the present study. The results of the comparison of tooth size in their study contradict the findings of the present study while the results of the comparison of arch widths do not. They reported no significant differences of tooth size bet−ween crowded and noncrowded groups while the present study showed statistically significant differences in all tooth types, in both males and females. The possible differences between Howe's and the present study are as follows: (1) In the current study more strict criteria were applied to sample selection. For an example, the crowding group in the present study had at least 7 mm of crowding in the dental casts of both the maxillary and the mandibular arches whereas no numerical measurement of crowding was made in Howe's study. For this reason, it is likely that the degree of crowding was higher in the samples of the current study than in Howe's study. (2) Another possible reason of differences is a racial difference. Howe's study used Caucasian while the present study used Korean subjects. It is well−known that Caucasians have narrower arch forms than oriental subjects. For the same reason, the arch width might be more responsible for crowding than the tooth size in Caucasian samples. The impact of tooth

size on the crowding could be attenuated although it was really responsible for crowding. Further investigation into the difference of the interrelationship of dental crowding to tooth size between races may be productive.

As stated earlier, Howe and colleagues[13] carried out a comprehensive study on the issue of the relationship of dental crowding to tooth size and arch dimension, using the crowded and noncrowded groups. They found that the two groups could not be distinguished in terms of tooth size, but that arch dimensions in the crowded group were generally smaller than in the noncrowded group. They concluded that dental crowding was associated with smaller dental arches, rather than large teeth, and suggested that consideration be given to those treatment techniques which increase dental arch length rather than reduce tooth mass. In order to increase arch length, they proposed to use an expansion appliance, such as a rapid palatal expander. [3,4,18] The findings of their study have been used as a good reference to support an expansion approach in many clinical cases, and to avoid extraction approach, over the years. However, as this current study reports, dental crowding is associated with large teeth as well as smaller dental arches. According to the findings of the current study, extraction can be used as an approach to relieve dental crowding in addition to expansion. This would be particularly true in gross crowding cases in Korean subjects. On the other hand, it should be kept in mind that many other factors, such as position of incisors, patient co−operation, age, and growth pattern, should be considered in a decision of extraction or expansion to relieve dental crowding, in addition to tooth sizes and arch dimensions.

CONCLUSION

In the comparison of mesiodistal tooth diameters and buccal and lingual arch widths between the crowding and normal groups, significant differences were observed between the two groups not only in arch widths but also in tooth sizes. The results of the present study suggest that both extraction and expansion can be used

as a treatment approach for the crowding cases.

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국문초록 ···

치아 크기와 치열궁 폭경이 치아밀집에 미치는 영향

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　본 연구는 치아밀집이 과도한 치아크기에 의해 나타나는지 아니면 좁은 치열궁으로 인해 초래되는지 그 원인을 규명하기 위하여 시행되었다. 앵글씨 1급 구치관계를 가지면서 상악 하악 모두 7mm이상의 치아밀집을 나타내는 경우와 정상교합자를 각각 실험군과 대조군으로 설정하였다. 82조(남29, 여53)의 치아밀집 석고모형과 82조(남37, 여45)의 정상교합 석고모형에서 각 치아의 치관근원심폭경과 협측 및 설측 치열궁 폭경을 측정하고 치아밀집군과 정상교합군 간에 비교한 결과 치관근원심폭경과 치열궁 폭경 모두에서 두 군간의 유의한 차이가 나타났다. 치아밀집의 기여요인을 살펴본 본 연구 결과 치아밀집은 치열궁과 치아크기, 모두에 의해 초래됨으로 치열궁 확장 및 치아 발치, 모두가 치료방법으로 사용될 수 있음을 알 수 있었다.

주요 단어 : 치아밀집, 치아 크기, 치열궁 폭경, 확장, 발치

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