ORIGINAL ARTICLE

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Spacing and crowding of the primary dentition in Korean children - relationship to tooth sizes and dental arch dimension

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The aims of this study were to investigate the prevalence of spaced, closed, and crowded primary dentitions by sex and arch in Korean children from Kanghwa, and to determine the frequency of the primate and developmental spaces. The differences in the mesiodistal crown diameters and the arch dimensions between the spaced, closed, and crowded primary dentitions were also evaluated. Dental casts of 102 preschool children (57 males and 45 females, aged 4 ~ 5 years) were studied. The prevalence of spacing in the primary dentition was 63.2% in males and 57.8% in females. The frequency of spacing was greater in males than in females, and greater in the maxillary arch than in the mandibular arch. The crowns were significantly larger and the arches significantly narrower in closed and crowded dentitions than in those with spacing ($p < 0.05$). The results showed that the prevalence of spacing was lower than that found in previous studies and the presence of spacing in the anterior region was related to the mesiodistal crown diameter and the intercanine width.

(**Key words:** Spacing, Crowding, Mesiodistal crown diameter, Arch dimension)

INTRODUCTION

Several authors have described the features of a normal occlusion of the primary dentition at the completion of their eruption.[1-4] These features are spacing between the incisors, a deep overbite, a flush terminal plane, and the primate space mesial to the upper, and distal to the lower canines. Baume[5] suggested that one has either a spaced or a closed dentition. There are two types of spacing in the primary dentition; the primate or anthropoid and the developmental or secondary space. The primate spaces have been described as a genetic characteristic of all primary dentitions. They are particularly prominent in the primary dentitions of *Homo sapiens* .[6]

There are several reports dealing with the prevalence and significance of these spaces in various ethnic groups.[7-12] Kaufman and Koyoumdjisky[7] examined 313 Israeli preschool children aged from 3.5

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to 5.5 years and observed spaced primary dentition in 84.2%. Boyko[8] reported that 78% of the primary dentition had bilateral primate spaces in both arches, 98% of boys had bilateral primate spaces in the maxilla and 86% had spaces in the mandible. Foster *et al.*[3] reported that crowding is rare in the primary dentition, and that the size disproportion between the jaws and the teeth during the primary stage usually presented as an absence of spacing and rarely as crowding. Kim *et al.*[9] reported that 80% of Korean children had primate spaces in the maxilla and 52% in the mandible.

Joshi and Makhija[10] studied the primary dentition of 100 children aged 3 ~ 6 years, from Gujarat, India and reported that a spaced dentition was more common than the closed type. They found that the amount of spacing was greater in males and bilateral primate spaces existed along with other spaces. Otuyemi *et al.*[11] examined 525 3 ~ 4 year-old Nigerian children and observed that 32% had generalized anterior segment spacing, 4% showed exclusively primate spaces, and 18% had either contact between all teeth or anterior crowding. Alexander and Prabhu[12] reported that 75% of South Indian children had both physiologic and primate spaces in both arches and 3% of the population were devoid of spacing and had closed dental arches.

A previous study on the primary dentition of Korean children was limited to the prevalence of the primate space, and the status of the terminal plane.[9] Therefore the characteristics of the primary dentition in Korean children need to be updated in terms of spacing and the relationship to tooth sizes and dental arch dimensions.

The aims of this study were to investigate the prevalence of spaced, closed, and crowded primary dentitions by sex and arch in Korean children from Kanghwa, and to determine the frequency of the primate and developmental spaces. The differences in the mesiodistal crown diameters and the arch dimensions between the spaced, closed, and crowded primary dentitions were also evaluated.

MATERIALS AND METHODS

Materials

Seven hundred and forty seven preschool children from Kanghwa, a city in the western part of Korea were examined to check that all the children had complete primary dentitions free from proximal caries, fractured or deformed teeth, anterior open bite, anterior or posterior crossbite, and no erupted permanent molars. Of these, 102 children were selected; 57 males and 45 females in the range of 4 ~ 5 years of age (male: 4.6 ± 0.6, female: 4.7 ± 0.5 years old). They were of an average socioeconomic status.

Alginate impressions of the maxillary and mandibular arches were obtained and poured into white stone.

Methods

Parameters

Dentition. Spaced dentition was defined as the dentition which had space between teeth, either primate space or developmental space. Closed dentition was defined as the dentition which had zero arch length discrepancy. Crowded dentition was defined as the dentition which had arch length discrepancy less than 0 mm and no space.

Primate space. All casts were inspected for primate spaces mesial to the upper and distal to the lower canine and these were recorded as being present or absent.

Developmental spaces. Spaces between the incisors in the primary dentition were inspected and these were recorded as being present or absent.

Mesiodistal crown diameter. Mesiodistal crown diameter was measured at the widest area of each tooth.

Arch width. Maxillary and mandibular intercanine arch widths were measured between the cusp tips of the right and left primary canines. Maxillary and mandibular intermolar arch widths were measured between the mesiobuccal cusp tips of the right and left second primary molars.

Arch length. Maxillary and mandibular arch lengths were defined as the length of a line running perpendicular from the midpoint between the two

Table 1. Frequency and percentage of spaced, closed, and crowded dentitions

Arch		*Spaced*	*Closed*	*Crowded*
Maxilla				
	Male	39 (68.42%)	7 (12.28%)	11 (19.30%)
	Female	29 (64.44%)	7 (15.60%)	9 (20.00%)
Mandible				
	Male	33 (57.89%)	6 (10.54%)	18 (31.53%)
	Female	23 (51.11%)	4 (8.89%)	18 (40.00%)

Table 2. Frequency of the primate space in the maxillary and mandibular arches

Arch	*Male*				*Female*			
	Spacing left	*Spacing right*	*Bilateral spacing*	*No spacing*	*Spacing left*	*Spacing right*	*Bilateral spacing*	*No spacing*
Maxilla	4	1	36	16	3	1	25	16
Mandible	2	2	30	25	0	2	14	29
Total	4	3	66	41	3	3	39	45

central incisors to a line connecting the most distal points of the right and left second primary molars.

Abbreviations

The following abbreviations were used for tooth types (primary dentition): UA, upper central incisor; UB, upper lateral incisor; UC, upper canine; UD, upper first molar; UE, upper second molar; LA, lower central incisor; LB, lower lateral incisor; LC, lower canine; LD, lower first molar; LE, lower second molar.

Reliability

All measurements were made directly on the casts with digital calipers accurate to 0.01 mm (Mitutoyo Corp., Tokyo, Japan). To minimize the error of the method, the measurements were taken twice and the average reading was recorded. Any measurements that differed by more than 0.5 mm were measured a third time, and the measurement closest to the third measurement was taken as the correct one.

Statistical Analysis

Descriptive analysis was performed on the frequency of the spacing by arch and sex. A Student t-test was used to compare the mesiodistal crown diameters and the arch dimensions of the primary dentition between the spaced, closed, and crowded dentitions by arch and sex. Significance was predetermined at the 0.05 confidence level.

RESULTS

Table 1 shows the frequency of the spaced, closed, and crowded dentitions. Three types of dentition were observed. (1) spaced (2) closed (tight contact between teeth) and (3) crowded. The percentage of spaced dentitions in the maxillary arch was 68.4% in males and 64.4% in females. The percentage of closed and crowded dentitions in the maxillary arch was 12.3% and 19.3% in males, 15.6% and 20.0% for females, respectively.

The percentage of spaced dentitions in the mandibular arch was 57.9% in males and 51.1% in females. The percentage of closed and crowded dentitions was 10.5% and 31.6% in males, and 8.9% and 40.0% in females, respectively.

Table 2 shows the frequency of a primate space in the maxillary and mandibular arches. The frequency of

Table 3. Frequency of developmental space

Arch	*Male*		*Female*	
	Present	*Absent*	*Present*	*Absent*
Maxilla	29	28	17	28
Mandible	31	26	14	31
Total	60	54	31	59

Table 4. Comparison of mesiodistal crown diameters of deciduous teeth between spaced and closed/ crowded dentitions by sex and arch

Tooth	*Male*					*Female*				
	Spaced dentition		*Closed/crowded dentition*		*Significance*	*Spaced dentition*		*Closed/crowded dentition*		*Significance*
	Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
UA	6.65	0.41	7.20	0.42	***	6.63	0..38	6.87	0.53	*NS*
UB	5.39	0.35	5.79	0.26	***	5.42	0.31	5.68	0.40	*
UC	6.62	0.48	7.07	0.16	***	6.62	0.42	6.70	0.23	*NS*
UD	7.28	0.41	7.60	0.41	**	7.29	0.46	7.41	0.51	*NS*
UE	9.19	0.49	9.67	0.46	***	9.21	0.41	9.50	0.47	*
LA	4.10	0.29	4.43	0.21	***	4.15	0.30	4.32	0.26	*
LB	4.66	0.35	5.01	0.30	***	4.62	0.26	5.00	0.36	***
LC	5.77	0.34	6.15	0.27	***	5.82	0.20	5.97	0.29	*
LD	8.20	0.41	8.48	0.39	*	8.22	0.41	8.42	0.41	*NS*
LE	10.50	0.45	10.63	0.31	*NS*	10.34	0.52	10.44	0.49	*NS*

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS*, not significant; *SD*, standard deviation.

the bilateral primate spaces was the greatest in males. However, in females the number of subjects without primate spaces bilaterally was the greatest.

The frequency of the developmental spaces is presented in Table 3. In males, there were similar numbers of subjects with developmental spaces as without. In contrast, subjects without developmental spaces were more common in females.

To compare the mesiodistal crown diameter and arch dimension, the closed dentition group and crowded dentition group were made into one group because the samples of the closed dentition group were too small to analyze statistically.

The differences in the mesiodistal crown diameters of the primary teeth between the spaced, closed, and crowded dentitions are presented in Table 4. In males, the teeth in the spaced dentitions were statistically smaller than those in the closed and crowded dentitions ($p < 0.001$) except for LE. In females, UB, UE, LA, LB, and LC in the spaced dentitions were significantly smaller than those in the closed and crowded dentitions ($p < 0.05$).

Table 5 shows the means and standard deviations (SDs) of the sum of the mesiodistal crown diameters of 6 anterior teeth and 4 posterior molars in relation to the spacing of the arch. In males, these teeth in the spaced dentitions were smaller than those in the other groups ($p < 0.001$). However, in females, there were statistically significant differences in the sum of the 6 anterior teeth ($p < 0.01$).

Table 5. Sum of mesiodistal crown diameters of the six anterior teeth and four molars between spaced and closed/crowded dentitions by sex and arch

Tooth		*Male*					*Female*				
		Spaced dentition		*Closed/crowded dentition*		*Significance*	*Spaced dentition*		*Closed/crowded dentition*		*Significance*
		Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
Maxilla											
	Sum of six anterior teeth	37.32	2.20	40.11	1.46	***	37.33	1.86	38.48	1.95	*NS*
	Sum of four molars	32.95	1.76	34.54	1.61	**	33.01	1.58	33.82	1.87	*NS*
Mandible											
	Sum of six anterior teeth	29.06	1.80	31.20	1.34	***	29.18	1.35	30.58	1.58	**
	Sum of four molars	37.39	1.65	38.22	1.13	*	37.13	1.76	37.71	1.55	*NS*

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS,* not significant; *SD,* standard deviation.

Table 6. Intercanine width, intermolar width, and arch length between spaced and closed/crowded dentitions by sex and arch

Tooth		*Male*					*Female*				
		Spaced dentition		*Closed/crowded dentition*		*Significance*	*Spaced dentition*		*Closed/crowded dentition*		*Significance*
		Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
Maxilla											
	Intercanine width	30.40	1.03	28.90	1.32	***	29.38	1.63	28.15	1.39	*
	Intermolar width	45.18	1.47	44.15	2.00	*	43.31	1.70	43.20	1.92	*NS*
	Arch length	28.62	1.66	28.39	0.82	*NS*	28.00	1.66	27.21	1.09	*NS*
Mandible											
	Intercanine width	24.03	1.22	22.25	1.12	***	22.92	1.24	21.62	1.13	*
	Intermolar width	37.95	1.29	36.53	1.90	**	36.48	1.76	35.57	1.41	*NS*
	Arch length	25.67	1.36	25.35	1.03	*NS*	25.37	1.73	24.89	0.70	*NS*

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS,* not significant; *SD,* standard deviation.

The inter-relations of arch spacing, intercanine and intermolar widths, and arch length by arch and sex are shown in Table 6. In males, the intercanine and intermolar widths in both arches were wider in the spaced dentitions ($p < 0.01$). In females, the intercanine width in the spaced dentitions was wider than those of the other groups in both arches ($p < 0.05$). Arch length did not appear to be significantly related to spacing of the arches.

DISCUSSION

The presence of spacing or crowding in the primary dentition and its significance for the development of the permanent dentition has long been a subject of discussion. There have been many epidemiological studies of the primary dentition in preschool children in several ethnic groups.[2,3,7-12] However, the ages of children examined ranged from 2.5 to 5 years. Bishara *et al.*[13] reported that the maxillary and mandibular intercanine and intermolar widths significantly increase between 3 and 5 years of age. Therefore, the subjects in this study were limited to those between 4 and 5 years of age in order to exclude the growth effect.

This study showed that in both sexes spacing in the primary dentition was more frequent in the maxilla than in the mandible (Tables 1-3). Even though primate and developmental spacings appear to be a common feature of the primary dentition in the Korean children from Kanghwa (63.2% in males and 57.8% in females), the prevalence of spacing was lower than that found in previous studies. Baume[5] reported that there was either contact between the teeth or crowding in the mandible in 14.9% of children. Boyko[8] observed 2% of his study as having no spaces and Foster and Hamilton[2] reported that only 1% of British children had no spaces. Joshi and Makhija[10] reported that 12.5% of Indian children had dentition without spaces. Otuyemi *et al.*[11] showed a higher prevalence of crowding or contact between all primary teeth of 24.4% and 26.3% in the maxilla and the mandible, respectively.

This study indicates that the frequency of closed or crowded dentition was higher than that reported in other investigations in both arches. Leighton's hypothesis[14] suggests that there should be a 6 mm or more space between the mandibular teeth in order for there to be no chance of developing incisor crowding in the permanent dentition. If this is correct, then the children in this study have a high chance of developing incisor crowding later in life.

El-Nofely *et al.*[15] reported that children with spaced dentitions have small mesiodistal crown diameters and wide intercanine widths. The findings of this study are in agreement with the study reported by El-Nofely *et al.* The crowns were significantly larger and the arches were significantly narrower in the subjects with no spacing (Tables 4-6).

Warren and Bishara[16] compared the intercanine and intermolar widths and arch length in the primary dentition between contemporary and historic samples. They found that the maxillary and mandibular arch lengths in both sexes were significantly shorter in the contemporary sample. All the arch widths were significantly smaller in contemporary males, but not in females. They suggested that the decrease in the arch dimensions might be associated with more crowding in the permanent dentition.

There may be several possible explanations for the results found in this study. First, genetic differences among various ethnic groups might explain the high prevalence of the closed and crowded deciduous dentition in Korean children. In a recent study, Yonezu *et al.*[17] reported that Japanese children of both sexes had larger mesiodistal tooth sizes and larger intermolar widths than did American children. Yuen *et al.*[18] in a study of Hong Kong children reported that all the primary and permanent teeth were significantly larger than those of the American children. Therefore, racial differences may exist in tooth sizes and arch dimensions.

Second, the consistency of food items may influence dental health. Hard and tough food requires a greater horizontal movement of the lower jaw, and soft and tender food mainly requires more vertical movement.[19] A change in food texture can also affect the development of the dental arches.[20]

Third, the adaptation of the human cranium to an upright position may have resulted in a change of the arch dimension and tooth size/jaw size discrepancy. As the human nasomaxillary complex has become rotated downward and backward into an upright rather than a horizontal position, dental arch length has been significantly reduced.[21] Therefore, this evolutionary change in the human face may explain the decrease in the arch dimension and the decreased prevalence of the spaced primary dentition.

The etiology of crowding is multifactorial. These include a physiologic mesial drift, the anterior component of force on the mesially inclined teeth, and an increase in the greater mandibular forward growth. The leeway space in both arches, due to the difference in the size of the primary molars and permanent premolars, may be another contributing factor.[22]

CONCLUSION

This study provides information on the prevalence of spacing and crowding in the primary dentitions of Korean children from Kanghwa. Although spaced dentitions were more frequent than closed or crowded dentitions, the prevalence of spacing was lower than that found in other studies. The crowns were significantly larger and the arches were significantly narrower in the subjects with no spacing. Further studies are needed to confirm whether or not the prevalence of a spaced dentition is decreasing and the arch dimensions are narrowing.

- 국문초록 -

한국인 아동의 유치열기의 특성 - 치아 치열궁의 관계

임동혁 · 김태우 · 남동석 · 장영일

이 연구의 목적은 강화지역의 한국인 아동의 유치열기에서의 공극과 총생의 빈도를 조사하고, 치아 크기와 치열궁간의 관계를 조사하는 것이다. 102개의 취학전 아동(남자 57명, 여자 45명, 4 ~ 5세)의 석고모형을 조사하여 치아의 크기, 견치간 폭경, 구치부 폭영, 치열궁 장경을 측정하였다. 유치열기의 공극 빈도는 남자에서 63.2%, 여자에서 57.8%로 나타났다. 공극의 빈도는 남자에서, 하악보다는 상악에서 더 높게 나타났다. 공극이 있는 경우보다 총생을 보이는 치열에서 치아 크기는 크고 치열궁 폭경은 더 작게 나타났다 ($p < 0.05$). 전치부 공극의 존재 여부는 치아의 크기, 견치간 폭경과 관련이 있었다.

(**주요 단어**: 공극, 총생, 치아 크기, 치열궁 크기)

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