Indicators of mandibular dental crowding in the mixed dentition

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Abstract

Purpose: Dental crowding occurring in the anterior part of the mandible in the early mixed dentition has been a subject of increasing concern for child patients, their parents, and the pediatric dentist. The aim of this study was to evaluate indicators of crowding found at the primary dentition, which may lead to the future manifestation of crowding at the anterior part of the mandibular arch in the early mixed dentition.

Methods: Skeletal and dental morphological characteristics at the stage of primary dentition were compared between two groups, using dental casts and cephalograms of 23 subjects. These two groups had been formed by evaluating the degree of crowding at 9 years of age (12 normal and 11 crowded cases).

Results: The size of several teeth in the crowding group was significantly greater than that found in the normal group. For the cephalometric measurements, a statistically significant difference was found only in the cranial base dimension (S-SE). The stepwise discriminant analysis showed that the mesiodistal size of the maxillary primary canine, the maxillary and mandibular dental arch lengths, and the posterior cranial base length (S-Ba) were effective discriminators in separating the two groups.

Conclusions: It is concluded that larger primary tooth size is the chief indicator in the development of dental crowding. However, the maxillary and mandibular dental arch lengths and the cranial base dimensions, especially that of the posterior cranial base length in the primary dentition, should also be considered as indicators when attempting to predict dental crowding in the early mixed dentition. (Pediatr Dent 23:118-122, 2001)

Crowding of the permanent teeth, especially in the anterior part of the mandible, is believed to be the most frequent form of malocclusion in children.[1] In pediatric dental practice, an increase in the number of consultations by parents, concerning the possibility of future dental crowding occurring in their children has been observed. This is probably due to the increased esthetic demands of our day and to the popularity of the orthodontic treatment.

More information is required for the early screening of the patients who will develop dental crowding at the stage of permanent teeth eruption. Such information would allow them to receive proper advice and preventive care at the stage of primary dentition.

Longitudinal studies are particularly useful for providing data to predict the future development of the dentition and for the description of the individual growth changes,[2] because they provide information on changes that occur, stage by stage, during the process of development. Several researchers have been using longitudinal methods, however, many of these studies are focused on the mixed and permanent dentitions.[3-6] It is quite rare to find longitudinal studies that deal with subjects in the primary dentition.

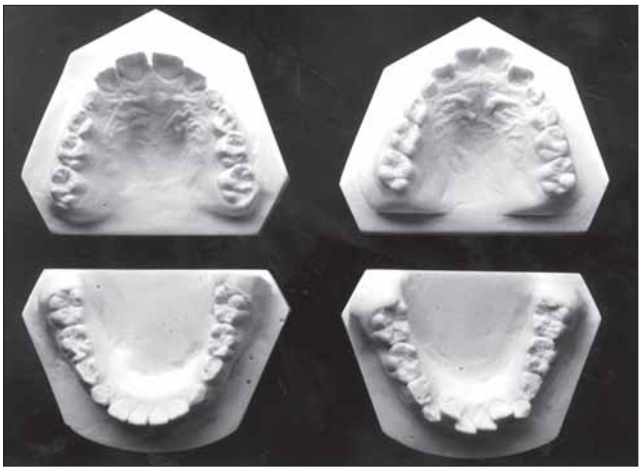

Fig 1. The sample was divided, according to the sum of the labio-lingual displacements of the six anterior teeth, measured from contact point to contact point in millimeters into two groups, crowding group (right) and normal alignment group (left).

Among these few authors, Bishara et al[7] tried to develop a prediction method of tooth size-arch length relationship in the permanent dentition from the available dental measurements in the primary dentition. Their results showed that the accuracy of predicting the discrepancies in the permanent dentition from the available dental measurements in the primary dentition is limited.

Bishara et al, in another study,[8] used longitudinal data sets and followed the changes in arch length from 6 weeks to 45 years of age. They found that the greatest incremental increases in arch length occurred during the first two years of life and that it continued to increase until 13 years in the maxillary arch and until 8 years in the mandible arch.

The purpose of the present study was to find indicators of crowding, which would be found in the primary dentition (mean age of 5 years) and may lead to future occurrence of dental crowding in the mixed dentition (mean age of 9 years), using dental and craniofacial measurements.

Received August 31, 2000 Revision Accepted January 13, 2001

Table 1. Definition of the Dental Measurements

1. UE	Mesiodistal width of the maxillary primary second molar
2. UD	Mesiodistal width of the maxillary primary first molar
3. UC	Mesiodistal width of the maxillary primary canine
4. UB	Mesiodistal width of the maxillary primary lateral incisor
5. UA	Mesiodistal width of the maxillary primary central incisor
6. UA E-E	Distance between right and left lingual surfaces of the maxillary primary second molars
7. UA E-A	Distance between the most prominent labial surface of the maxillary primary central incisors and the midpoint of the distal surfaces of right and left maxillary primary molars
8. UA D-D	Distance between right and left lingual surfaces of the maxillary primary first molars
9. UA C-C	Distance between right and left lingual surfaces of the maxillary primary canines
10. LE	Mesiodistal width of the mandibular primary second molar
11. LD	Mesiodistal width of the mandibular primary first molar
12. LC	Mesiodistal width of the mandibular primary canine
13. LB	Mesiodistal width of the mandibular primary lateral incisor
14. LA	Mesiodistal width of the mandibular primary central incisor
15. LA E-E	Distance between right and left lingual surfaces of the mandibular primary second molars
16. LA E-A	Distance between the most prominent labial surface of mandibular primary central incisors and the midpoint of the distal surfaces of right and left mandibular primary molars
17. LA D-D	Distance between right and left lingual surfaces of the mandibular primary first molars
18. LA C-C	Distance between right and left lingual surfaces of the mandibular primary canines

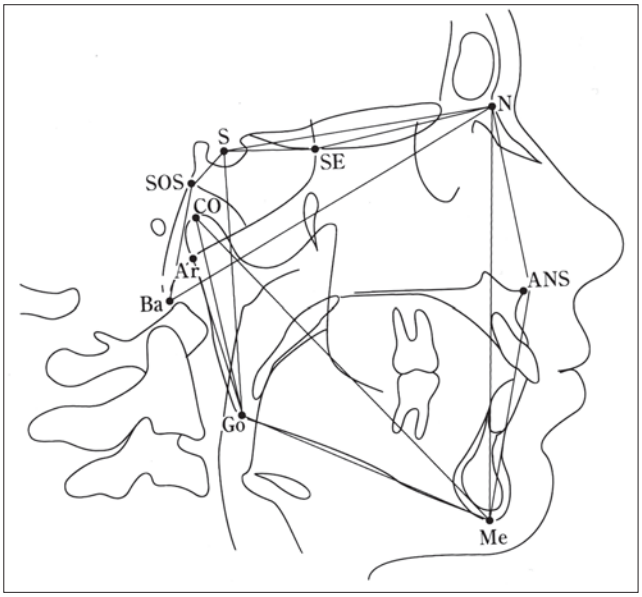

Fig 2. Forty-eight cephalometric landmarks were selected to build up 50 linear and 8 angular measurement sites for the skeletal and dental evaluation of the craniofacial structure.

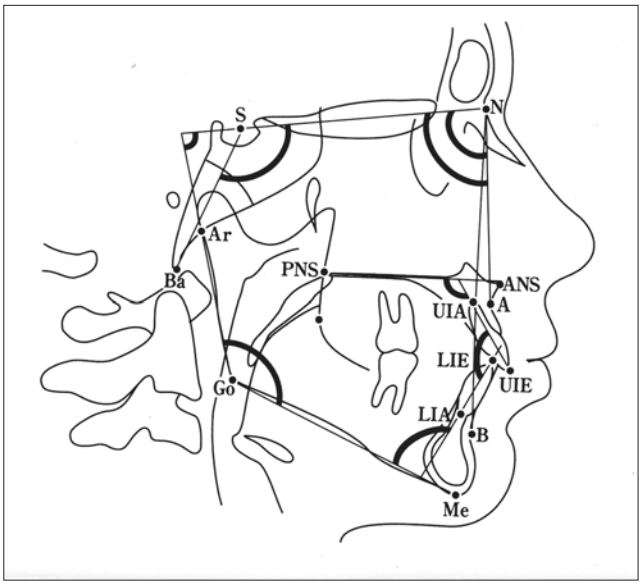

Fig 3. Angular measurement sites.

Methods

The subjects were chosen from the files of the Growth Study of Twins of the Department of Pediatric Dentistry, Tokyo Medical and Dental University, in which the semiannual records of 130 pairs of Japanese twins were accumulated from the age of 3 to 15. Dental casts of the maxillary and mandibular arches, and the lateral cephalograms of 23 untreated subjects at the primary dentition (mean age of 5 years) and in the early mixed dentition (mean age of 9 years), were selected for the analysis. These subjects had no missing teeth and few caries limited on occlusal surfaces. One set of the records was selected from each pair of twins in order to exclude any environmental or genetic similarities.[9] Male and female subjects were pooled together, since there were no differences in means between the genders.[10]

The two sub-samples were defined and grouped at the time of early mixed dentition on the basis of the Irregularity Index by Little,[11] in which the degree of crowding is evaluated by the sum of the labio-lingual displacements of the six anterior teeth, measured from contact point to contact point in millimeters (Fig 1). Those cases exceeding 4.0 mm of total displacement were included in the crowded group (N=11) and the cases displaying less than 2.0 mm were classified as the normal group (N=12). There were no cases with total displacement between 2 to 4mm. The crowded group turned out to be crowded and the normal group stayed as normal even after the complete eruption of permanent teeth except the third molar.

The dental cast measurements were performed on 18 measurement sites (Table 1) to evaluate tooth size and dental arch dimensions, using a sliding digital caliper (CD-15CP/ Mitutoyo Corp., Kanagawa, Japan). The casts were measured under the same criteria, with which the probe of the digital caliper was held parallel to the long axis of the dental crowns.

The 46 lateral cephalograms (23 of each developmental stage) were traced by one author to avoid interobserver variability.[12] The 48 cephalometric landmarks were selected in addition to the generally accepted points in the traditional cephalometric analysis. These points were used to build up 50 linear and 8 angular measurement sites for the skeletal and dental evaluation of the craniofacial structure (Figs 2, 3). In order to reduce the measurement error, each measurement on the casts and the cephalograms was performed on three different occasions, by the same examiner and the averages of these three measurements were used for the analysis. Moreover, preliminary evaluation of measurement error showed that no significant difference was found between the measurements at a significance level of $P<0.05$.

Descriptive statistics, such as means and standard deviations were calculated. The Student's t-test was used to calculate the differences between the means. Stepwise discriminant analysis was further applied to find dental or craniofacial parameters that best discriminated between these two groups. All the statistical analyses were performed by using computer software (SPSS Version 7.5J, SPSS Inc.).

Table 2. Results of the Dental Measurements

		Normal Mean	±SD	Crowding Mean	±SD
1.	UE	9. 2	0.3	9.5	0.5
2.	UD	7.0	0.3	7.3	0.3*
3.	UC	6.2	0.3	6.7	0.3*
4.	UB	5.2	0.3	5.5	0.4*
5.	UA	6.3	0.4	6.6	0.3
6.	UA E-E	32.4	2.1	32.1	1.7
7.	UA E-A	28.9	1.7	29.5	2.2
8.	UA D-D	27.4	1.8	27.1	1.6
9.	UA C-C	25.1	1.3	24.0	1.3
10.	LE	10.1	0.4	10.5	0.3*
11.	LD	7.8	0.3	8.1	0.4
12.	LC	5.6	0.4	5.9	0.3*
13.	LB	4.5	0.3	4.7	0.3
14.	LA	3.9	0.2	4.1	0.3*
15.	LA E-E	28.7	2.3	28.9	2.0
16.	LA E-A	26.4	1.0	26.4	1.5
17.	LA D-D	23.8	1.8	23.7	1.2
18.	LA C-C	19.5	1.4	18.8	1.4

*P< 0.05

Results

According to the results from the Student's t-test, significant differences were found in the mean values of the mesiodistal width of the maxillary primary first molar, canine and lateral incisor and mandibular primary second molar, canine, and central incisor (Table 2). For all the other teeth measured, the crowded group had some tendency to show greater mean values, although they were not statistically significant.

On the other hand, significant difference between the mean values of the normal and crowding groups in the cephalometric measurements was found only in the cranial base dimension (Table 3), which was the distance between the points S-SE ($P<0.05$). The other craniofacial measurements did not show any significant statistical differences in means.

According to the results from the discriminant analysis, the first discriminator was the mesiodistal diameter of the maxillary primary canine, followed by the mandibular arch length, the posterior cranial base length (S-Ba), and the maxillary arch length (Table 4). With these results of the discriminant analysis, 92% of all the subjects were correctly classified, which is considered satisfactory.

Discussion

In recent years, there have been a number of reports proposing several methods for the assessment of crowding. These include the use of a brass wire,[13] calipers,[14] digitizer and stylus,[15] catenometer,[15-16] and three-dimensional recording devices.[17] All these methods have advantages and limitations and their results will be dependent upon various factors such as operator's experience, the accuracy of the appliance, and the case itself. In the present investigation, the Irregularity Index[11] has been used for the assessment of dental crowding. Some authors[15-16] have noted that this index has a tendency to assign higher scores to cases involving severe labio-lingual displacement of one or more anterior teeth. However, the index is a reliable method for the assessment of crowding to separate between the normal and the crowding group in the present investigation, in which the cases with less than 2mm of linear displacement were considered normal and those with more than 4mm were considered as crowding.

Larger tooth size has been recognized to be one of the factors of crowding in the permanent dentition.[3,13] There have not been many studies reporting the role of the size of primary teeth in the future manifestation of crowding. In the present study, the mean crown diameters of six primary teeth are significantly larger in crowded group than those in normal group. The results of the discriminant analysis also showed that tooth size, represented by the maxillary primary canine, was an effective factor in distinguishing the groups. Hence, the size of the primary teeth is one of the factors for crowding in the early mixed dentition.

There have been few studies referring to the role of the primary dental arch length for crowding. However, in the present analysis, the primary dental arch lengths of the subjects in the normal group tended to be larger than those found among the subjects in the crowded group, although not statistically significant. In the discriminant analysis, the primary arch lengths of the maxilla and the mandible proved to be meaningful variables for distinguishing the two groups. The absence of statistical significant difference in the dental arch measurements could be due to the size of the present sample. Therefore, a future study might be needed to clarify the role of the dental arch length in a larger sample.

Among the cephalometric measurements, the linear distance S-SE was the only variable to exhibit a statistically significant difference between the groups. However, the linear measurements of the cranial base tended to differ between them. The normal group showed a tendency for larger values in the measurements of the anterior cranial base when compared with the crowded group. This tendency would appear inversely in the measurements of the posterior cranial base, in which the larger values were found in the crowded group. We could assume that the subjects in the normal group have longer anterior cranial base lengths and those subjects in the crowded group have longer posterior cranial base lengths. Furthermore, the discriminant analysis showed that the posterior cranial base (S-Ba) was proved to be an effective variable in discriminating between these groups. The results lead to the belief that the cranial base structures may play an important role in characterizing the groups as crowded or normal.

The S-Ba has been found to be one of the independent factors of the craniofacial complex.[18] It is also known that S-Ba is associated with the horizontal lengths of the mandibular ramus.[19] Therefore, the wider ramus might have some role in the development of crowding by leaving less space for the permanent teeth to erupt in the mandible.[9,20]

Conclusions

According to the results of this investigation, the indicators for the crowding in the early mixed dentition are:

1. The mesiodistal size of primary maxillary canine;
2. Maxillary and mandibular dental arch lengths; and
3. Posterior cranial base length.

These indicators classified 92 percent of the sample correctly.

References

1. Proffit WR. *Contemporary Orthodontics*, Mosby-Year Book, 3rd ed., St. Louis; 1999:134.
2. Sanin C, Savara S. Factors that affect the alignment of the mandibular incisors: a longitudinal study. *Am J Orthod* 64:248-257, 1973.

Table 3. Results of the Cephalometric Measurements

Variable	Measurement sites	Normal Mean	±SD	Crowding Mean	±SD
19	S-N	62.5	2.4	61.4	2.4
20	S-SE	27.8	1.9	25.7	2.3*
21	SE-N	35.0	2.2	35.8	2.1
22	S-BA	37.1	2.0	37.4	2.3
23	S-SOS	14.1	1.4	14.2	1.4
24	SOS-BA	24.8	2.3	25.3	2.4
25	N-BA	90.5	2.5	90.1	3.1
26	N-ANS	42.7	2.2	43.0	2.5
27	S-GO	62.7	3.8	62.0	4.2
28	CO-GO	46.4	3.2	45.9	3.0
29	AR-GO	38.1	2.9	37.4	2.6
30	A'-PTM'	42.6	2.3	43.0	1.9
31	A'-UMC'	21.4	2.2	22.0	1.4
32	UMC'-PTM	44.2	2.3	44.8	3.1
33	A'-UIE'	-2.0	2.4	-2.3	1.9
34	UIE-UIE'	23.5	4.4	25.6	1.3
35	UMC-UMC	18.1	1.6	18.1	1.3
36	ME-CO	88.7	4.4	89.0	3.8
37	ME-GO	53.0	5.2	54.0	3.2
38	B'-LIE'	3.6	1.8	3.3	1.8
39	B'-LMC'	20.1	2.2	19.2	1.3
40	B'-AB'	38.6	3.0	37.3	2.7
41	B'-PB'	68.6	3.3	69.1	4.6
42	B'-CO'	81.7	3.4	80.8	3.8
43	LIE'-LMC'	16.5	1.6	15.9	1.6
44	LMC'-AB'	18.5	1.9	18.2	2.2
45	AB'-PB'	30.0	1.5	31.8	2.8
46	PB'-CO'	13.1	3.1	11.7	2.3
47	LIE-LIE'	35.1	2.0	34.8	1.6
48	LMC-LMC'	29.0	1.7	29.3	1.5
49	AB-AB'	24.5	1.7	25.4	2.0
50	PB-PB'	16.7	2.9	18.2	3.3
51	CO-CO'	38.9	3.7	39.1	4.2
52	UIE"-UMC"	20.1	2.8	20.0	4.4
53	UIE"-UDC"	29.8	2.8	29.5	4.3
54	UIE"-AB	37.6	4.0	37.3	6.4
55	UDC"-AB	7.8	2.6	7.9	2.7
56	PB-AB	31.1	1.5	32.6	2.5
57	A"-UMC"	16.2	2.0	13.9	7.0
58	A"-UDC"	26.0	2.1	23.4	7.0
59	A"-AB	33.8	3.2	31.3	8.9

*$P < 0.05$

Cephalometric points marked with ' refer to the projection of the original point on the mandibular or maxillary plane, respectively.

Cephalometric points marked with " refer to the projection of the original point on the occlusal plane.

Cont. Table 3. Results of the Cephalometric Measurements

Variable	Measurement sites	Normal Mean	±SD	Crowding Mean	±SD
60	LIE"-LMC"	17.5	1.5	16.7	1.6
61	LIE"-LDC"	27.3	1.4	26.5	1.7
62	LIE"-AB	36.6	1.9	35.3	2.5
63	LDC"-AB	9.2	1.8	8.8	2.0
64	B"-LMC"	17.4	1.8	16.6	1.6
65	B"-LDC"	27.2	1.6	26.5	1.5
66	B"-AB"	36.5	2.7	35.2	2.9
67	ANS-ANS"	28.5	2.8	28.1	2.9
68	ME-ME"	32.8	2.0	32.7	1.2
69	<N-S/S-BA	129.0	2.4	130.0	4.8
70	<S-N/N-A	80.9	1.9	81.9	4.5
71	<ME-GOI/GOI-AR	130.1	4.3	129.2	4.7
72	<GOI-ME/S-N	39.4	5.0	39.0	4.2
73	<PNS-ANS/UIA-UIE	6.3	1.9	6.9	2.6
74	<ANS-PNS/LIA-LIE	96.9	5.1	94.0	7.2
75	<ME-GOI/LIA-LIE	87.9	6.9	91.1	6.2
76	<LIE-LIA/UIE-UIA	142.8	10.2	142.9	10.8

*$P < 0.05$
Cephalometric points marked with ' refer to the projection of the original point on the mandibular or maxillary plane, respectively.
Cephalometric points marked with " refer to the projection of the original point on the occlusal plane.

Table 4. Results of the Discriminant Analysis

Variable	Coefficient
Maxillary primary canine	1.734
Mandibular arch length	-1.461
Posterior cranial base	0.864
Maxillary arch length	-0.693

3. Doris JM, Bernard BW, Kuftinec MM. A biometric study of tooth size and dental crowding. *Am J Orthod* 79:326-336, 1981.
4. Sampson WJ, Richards LC. Prediction of mandibular incisor and canine crowding changes in the mixed dentition. *Am J Orthod* 88:47-63, 1985.
5. Howe RP, McNamara JA, O'Connor KA. An examination of dental crowding and its relationship to tooth size and arch dimension. *Am J Orthod* 83:363-373, 1983.
6. Berg R. Crowding of the dental arches: a longitudinal study of the age period between 6 and 12 years. *Eur J Orthod* 8:43-49, 1986.
7. Bishara SE, Khadivi P, Jakobsen JR. Changes in tooth size-arch length relationship from the deciduous to the permanent dentition: A longitudinal study. *Am J Orthod Dentofacial Orthop* 108:607-613, 1995.
8. Bishara SE, Jakobsen JR, Nowak A. Arch length changes from 6 weeks to 45 years. *Angle Orthod* 68:69-74, 1998.
9. Ono Y. Relationship between the eruption of mandibular first permanent molar and growth changes of adjacent structures. *Bull Tokyo Med Dent Univ* 27:55-62, 1980.
10. Sakamoto T. A study on the developmental changes of dentofacial complex of Japanese with special reference to the sella turcica. *Nihon Kyousei Shika Gakkai Zashi* 18:1-17, 1959.
11. Little RM. The irregularity index: A quantitative score of mandibular anterior alignment. *Am J Orthod* 68 554-563. 1975.
12. Utermohle CJ, Zegura SL. Intra and interobserver error in craniometry: a cautionary tale. *Am J Phys Anthrop* 57:303-310, 1982.
13. Carey CW. Treatment planning and the technical program in the four fundamental treatment forms. *Am J Orthod* 44:887-898, 1958.
14. Norderval K, Wisth PJ, Boe OE. Mandibular anterior crowding in relation to tooth size and craniofacial morphology. *Scand J Dent Res* 83:267-273, 1975.
15. Rudge SJ, Jones PT, Hepenstal S, Bowden DEJ. The reliability of study model measurement in the evaluation of crowding. *Eur J Orthod* 5:225-231, 1983.
16. Musich DR, Ackermam JA. The catenometer: a reliable device for estimating dental arch perimeter. *Am J Orthod* 63:366-375, 1973.
17. Richmond S. Recording the dental cast in three dimensions. *Am J Orthod Dentofacial Orthop* 92:199-206, 1987.
18. Liebgott B. Factors of human skeletal craniofacial morphology. *Angle Orthod* 47:222-230, 1977.
19. Kasai K, Moro T, Kanazawa E, Iwasawa T. Relationship between cranial base and maxillofacial morphology. *Eur J Orthod* 17:403-410, 1995.
20. Foster TD. *A Textbook of Orthodontics*. Birmingham: Blackwell Scientific Publications;1990:29-146.