Overlap of the Primary Dentition in Children

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Objective: *The aim of the present study was to estimate the amount of overlap in children with the primary dentition.* ***Study design:*** *The sample consisted of 20 Japanese boys between 3 and 5 years of age (mean age: 4years 10 months). Landmarks on their maxillary and mandibular dental models were digitized using a three-dimensional mechanical digitizer in a single coordinate system. Multilevel statistical models created best-fit polynomial curves to determine overbite, overjet and buccal height of all primary teeth and describe the dental arch forms.* ***Results:*** *No significant side differences were detected. The primary canine showed the largest overbite (1.87 mm) and buccal height (9.07 mm). The primary second molar exhibited the largest ovejet (2.76 mm). Buccal height was the least variable measurement.* ***Conclusion:*** *Occlusal relationships of the primary dentition were evaluated in 3-dimensions, establishing overlap variables for clinical diagnosis and treatment planning.*

Keywords: *primary dentition, child, occlusion, dental arch*
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INTRODUCTION

Unilateral posterior crossbite is one of the most frequent malocclusions in children, with an incidence between 6% and 9 %.[1-3] It occurs between 19 months and 5 years of age, and is characterized by a narrow maxillae between the right and left molars relative to the mandible.[4] Even when palatal width is over-expanded during treatment, relapse can occur because of the lack of functional adaptation or insufficient overbite and overjet in the affected region.[5]

Cheek and lip biting has been observed in 5.6 % of children from 6 to 11 years old of age in Croatia[6] and 12.7 % of Indian school children.[7] Severe cases of this habit can cause facial emphysema.[8] Cheek biting may be related to overlap relationships (*i.e.*, overbite and overjet) between the maxillary and mandibular molars. However, to our knowledge, standard values for the overlap of primary dentition, including molars, are lacking. Development of such standards would help diagnosis and treatment planning.

Therefore, the purpose of this study was to elucidate maxillary and mandibular overlap relationships in children with primary dentition. To archive this purpose: 1) three-dimensional superimposition of the maxilla and mandibular arch forms were performed; 2) an optimized arch form for both the maxillary and mandibular dentitions were described by means of polynomial equations; and 3) overlap of the maxillary and mandibular primary dentitions (*i.e.*, overbite, overjet, and buccal height) were evaluated.

MATERIAL AND METHODS

Subjects

Subjects consisted of 20 Japanese boys between 3 and 5 years of age (mean age: 4 years 10 months). The criteria for selection included: 1) a complete primary dentition; 2) no loss of tooth structure as a result of caries; 3) no restored

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teeth; 4) no crowding of either the upper or lower dentitions; 5) normal occlusal relationships; 6) no inflammatory finding in their attached gingiva; and 7) sound temporomandibular joints. Informed consent to participate in this study was obtained from the parents of all children. Prior to entering the study, approval was obtained from the clinical ethics committee of Kagoshima University Hospital.

Model measuring system

A mechanical 3-dimensional digitizing system (MicroScribe G2X; Immersion, San Jose, California, USA) recorded the three-dimensional coordinates of the selected points on dental casts (Fig. 1) and translated them into digital three-dimensional models.

The series of custom computer programs, Tigaro,[9] transformed the 3-dimensional coordinates of both dental arches into a single coordinate system at the intercuspal position.[9] The coordinate system used 3 landmarks on the base of the maxillary model. (Fig. 1B) The horizontal standard plane was defined as the plane established by the 6 lingual cervical ridges of the mandibular dentition. Ten points on the palatal suture were used to establish the anterior-posterior axis. Finally, the origin of this system was moved parallel to the intersection point of both the palatal suture and the second palatal ruga because of its stability.[10] Prior to analyses, side differences of the digitized points were examined, and no statistical differences were detected. Accordingly, values of points on the left and right sides were combined for analyses.

The reproducibility of the measurements and analysis system were assessed by statistically analyzing the differences between double measurements. The total methodological error was tested using Dahlberg's method:

$$S(i) = \sqrt{\frac{sd^2}{2n}}$$

Where d is the difference between individual tooth widths and n is the number of subjects. The errors ranged from 0.01 mm to 0.20 mm, indicating that these errors were negligible.

Dental arch forms

Separate polynomial regression equations were fitted to each dimension of the dental arch forms using MlWin® software (Center for Multilevel Modeling, Institute of Education, London, UK).[11,12] The estimation procedures uses iterative generalized least squares. The mean maxillary and mandibular dental arch shape equations were given by the formula:

$$Y_t = a + b \cdot t + c \cdot t^2 + d \cdot t^3 + e \cdot t^4 + f \cdot t^5 + g \cdot t^6 + h \cdot t^7 + i \cdot t^8$$

Where a, b, …., i were coefficients given by this analysis and t was the number of each labial (buccal) cuspal ridge from the primary central incisor to the primary second molar. Because the number of digitized cuspal ridges on the primary second molar was different between the two dentitions, the range of t was $-7 <= t <= 7$ for the maxilla and $-8 <= t <= 8$ for the mandible. (Figure 1B) By combining pairs of 2-dimensional polynomials views of projected arch shapes in the horizontal (occlusal), frontal and sagittal planes could be drawn.

Overlap parameters

Overlap parameters between the maxillary and mandibu-

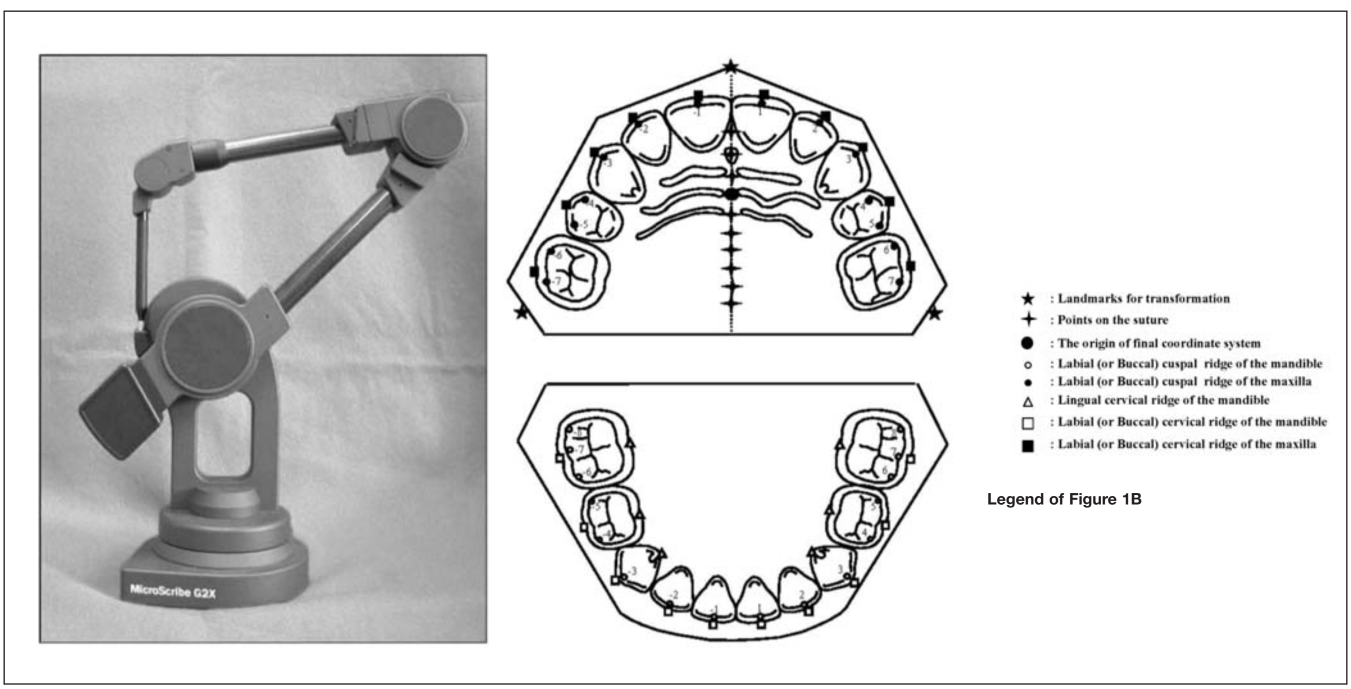

Figure 1. (A): the measuring device (Microscribe G2X) used in this study. (B) Digitized points 1) for the transformation of the coordinate system (★), 2) to make standard plane (Δ), 3) to generate the anterior-posterior axis (✳), 4) for the origin of system (●), 5) to make dental arch form (numbering as "t" in the text) (•), and 6) to measure buccal height (■).

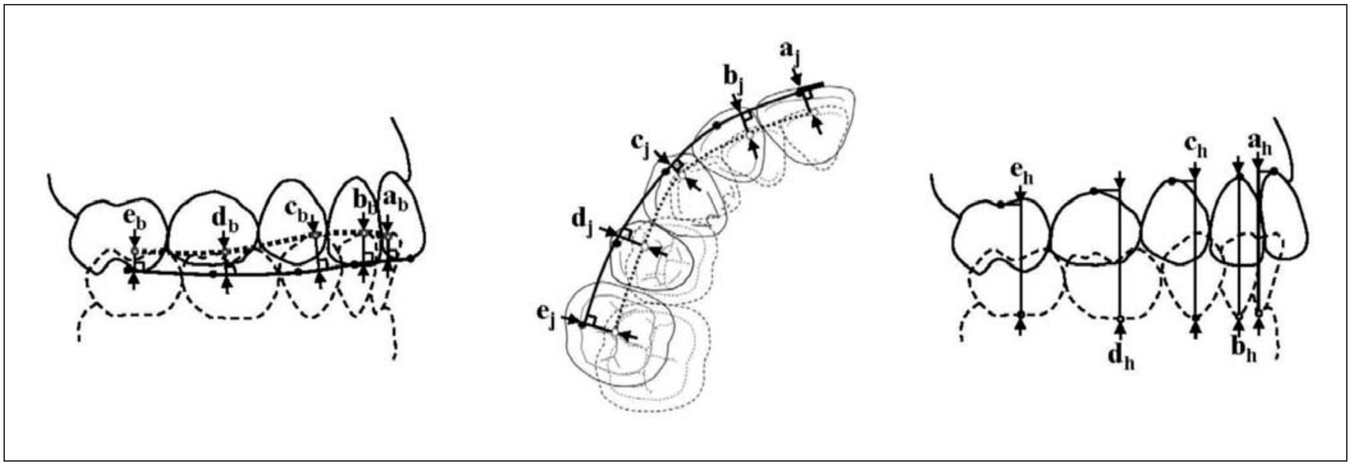

Figure 2. Overlap parameters measured in this study. (A) overbite (from a_b to e_b), (B) overjet (from a_j to e_j), and (C) buccal height (from a_h to e_h).

lar dentitions in this study were: 1) overbite: distance between the maxillary buccal cervical points (at molars: average of 2 or 3 buccal ridges) to the closest point on the mandibular polynomial curve in the sagittal view (Fig. 2A); 2) overjet: the same distance as in the overbite but in the horizontal view of the curve (Fig. 2B); and 3) buccal height: the vertical distance of cervical points between facing teeth on the maxilla and mandible (Fig. 2C). Means, standard deviations and coefficients of variation of each overlap parameter at each tooth position were calculated using statistical functions in Microsoft® Office Excel 2003 Sp3.

RESULTS

The coefficients of the three polynomial curves for each dentition are listed in Table 1. For example, the best estimate for the vertical position of the maxillary canine cuspal ridge ($t = 3$) was calculated as follows:

$$\mathrm{Vert}_3 = -7.94 + (4.10 * 10^{-2}) * 3^1 + (2.65 * 10^{-2}) * 3^2 + (-6.83 * 10^{-2}) * 3^3 + (-7.31 * 10^{-2}) * 3^4 + (4.47 * 10^{-4}) * 3^5 + (4.94 * 10^{-3}) * 3^6 + (-8.73 * 10^{-6}) * 3^7 + (4.10 * 10^{-4}) * 3^8 = -7.302$$

Table 1. Coefficients of polynomial terms vertical, anterior-posterior, and lateral axes for the maxillary and mandibular dental arch shapes. Characters in parenthesis correspond to those in the formula in the text.

Coefficient	Maxilla			Mandible		
	Vertical	Anterior-posterior	Lateral	Vertical	Anterior-posterior	Lateral
Constant	-7.94	1.18	-2.09 * 10^{-1}	8.05	1.16 * 101	-2.26 * 10^{-1}
1st order (a)	4.10 * 10^{-2}	7.01 * 10^{-2}	3.32 * 10^{0}	3.49 * 10^{-2}	1.36 * 10^{-2}	3.28 * 10^{0}
2nd order (b)	2.65 * 10^{-2}	-5.78 * 10^{1}	4.02 * 10^{-2}	-1.98 * 10^{-2}	-5.46 * 10^{-1}	5.44 * 10^{-2}
3rd order (c)	-6.83 * 10^{-3}	7.01 * 10^{-2}	3.93 * 10^{-1}	1.22 * 10^{-3}	-6.34 * 10^{-4}	3.79 * 10^{-1}
4th order (d)	-7.31* 10^{-2}	-3.65 * 10^{-2}	-1.65 * 10^{-3}	-6.21 * 10^{-3}	-4.04 * 10^{-2}	-1.70 * 10^{-3}
5th order (e)	4.47 * 10^{-4}	-4.09 * 10^{-5}	-2.57 * 10^{-2}	-1.93 * 10^{-4}	-9.83 * 10^{-6}	-2.48 * 10^{-2}
6th order (f)	4.94 * 10^{-3}	9.90 * 10^{-4}	2.68 * 10^{-5}	2.10 * 10^{-4}	1.10 * 10^{-3}	2.73 * 10^{-5}
7th order (g)	-8.73 * 10^{-6}	-	4.81 * 10^{-4}	5.54 * 10^{-6}	-	4.60 * 10^{-4}
8th order (h)	-1.00* 10^{-4}	-	-	-	-	-

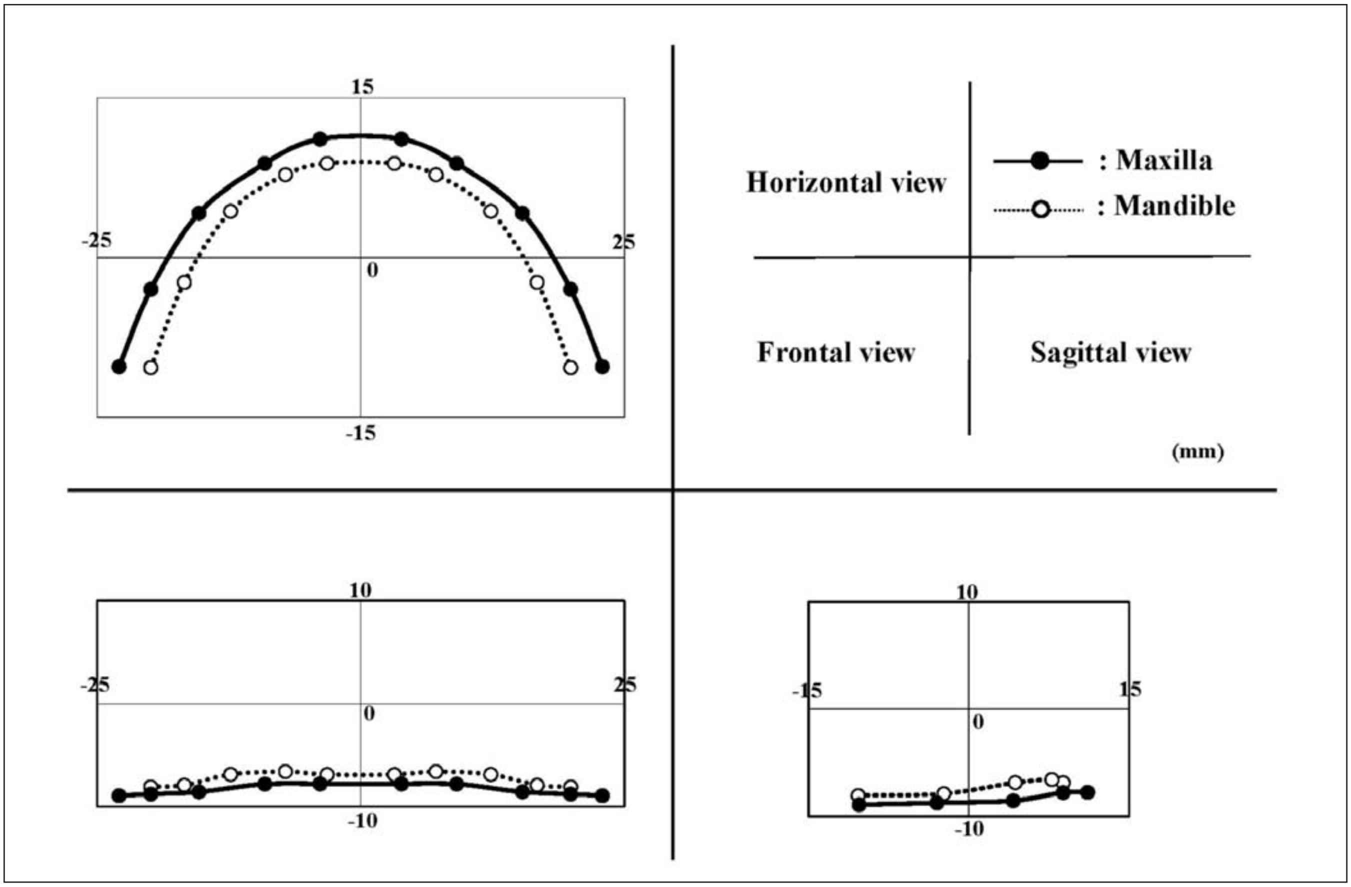

Figure 3. Projected lines of the labial and buccal cuspal ridges onto three orthogonal planes described by means of the polynomial equations generated by the multilevel linear model analysis.

For molars, the average of 2 or 3 points (3 points were used only for the mandibular primary second molar as shown in Figure 1B) on the buccal ridge was estimated. The dental arch forms in three projected planes could then be superimposed using these coefficients. (Fig. 3)

Overlap parameters of the primary dentition are described in Table 2. The largest overbite (1.87 mm) and buccal height (9.07 mm) were observed at the primary canine. The smallest overlap was measured at the primary first molar (1.11 mm in overbite) and the primary central incisor (7.34 mm in buccal height). The smallest and the largest overjet were observed at the primary canine (1.87 mm) and at the primary second molar (2.76 mm), respectively. At every tooth position the buccal height had the largest standard deviation (SD) and the overbite the least. However, the coefficient of variation (CV) of buccal height was less than 20 % at every tooth position and was the smallest among the three variables. The primary second molar had the largest CV, and the primary canine had the smallest.

DISCUSSION

Study models provide a 3-dimensional view of a patient's occlusion enabling the clinician to evaluate abnormal occlusion in more detail than by clinical examination. For example, they are more amenable to routine measurements than are intraoral measurements. Although, many methods have

Table 2.Overlap parameters in children with primary dentition. Characters in parenthesis correspond to those in Figure 2.

Tooth	Overbite			Overjet			Buccal Height		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Primary central incisor (a)	1.43	0.73	51.0	2.42	1.06	43.8	7.34	1.11	15.1
Primary lateral incisor (b)	1.54	0.9	58.4	1.93	1.13	58.5	8.94	1.33	14.9
Primary canine (c)	1.87	1.05	56.1	1.86	1.17	62.9	9.07	1.33	14.7
Primary first molar (d)	1.11	0.77	69.4	2.55	1.05	41.2	8.29	1.35	16.3
Primary second molar (e)	1.77	1.24	70.1	2.76	1.47	53.3	8.17	1.54	18.8

SD: Standard Deviation, CV: Coefficient of Variation (%)

been used to measure and analyze plaster casts, the overlap relation, especially of the molars in the primary dentition, has been neglected.

Some investigators have argued that the polynomial equation is more appropriate for analysis of various occlusions than other mathematical formulae (e.g., ellipse, parabola, catenary and beta).[13-15] Multilevel statistical modeling can generate the average maxillary and mandibular arch forms as polynomial equations. This approach provides several important advantages over existing methods, including objectivity, a more complete description of the dental arch form, a hierarchical description of the arch form variation, and an ability to test hypotheses statistically.[11, 12]

The results of this investigation cannot be compared directly with past literature because no previous report has analyzed 3-dimensional overlap of the entire primary dentition. The Japanese Society of Pediatric Dentistry[16] reported the buccal height at the primary central incisor of 83 Japanese normal boys to be 7.84 ± 1.00 mm (7.34 ± 1.11 mm in our study) with a CV of 12.8 % (15.1 % in our study). The small differences between the studies may be because they measured this distance by sliding caliper as a 3-dimensional straight distance. All values in our study seem to be within the ranges of clinical findings.

One interesting finding was the relatively larger variability for all three measurements of the primary second molar. This tooth showed the widest overjet and the second shortest buccal height among deciduous teeth. In contrast, the primary central incisor exhibited less variation and a smaller CV compared with the other teeth, suggesting it is more stable than the primary molars. This finding is noteworthy because pediatric dentists feel that the overlap of the primary central incisor, including labial and palatal (or lingual) inclination, is very easily affected by the intraoral and extraoral pressures.

Because mean overbite in all primary teeth was less than 2.0 mm and their CV was larger than 50 %, overbite might not be regarded as the stable parameter for clinical use. In contrast, buccal height could be considered a stable parameter because its CV was less than 20 % in all primary teeth.

CONCLUSION

The present morphometric study evaluated the 3-dimensional overlap of the primary dentition in a sample of Japanese boys by generating average dental arch forms of both the maxilla and mandible with multilevel linear models. The results of this investigation indicated that:

1. Polynomial curves can accurately describe maxillary and mandibular dental arch forms.
2. The ovelap relationships of all primary teeth, including overbite, overjet and buccal height at the intercuspal position, can be analyzed from the polynomial curves.
3. Buccal height is the most stable of the three variables.

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