Biologic Variation In Selected Relationships Of Opposing Posterior Teeth*

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In broad anatomic perspective, this paper pertains to nonpathologic variability of the human maxillary and mandibular dental arches considered jointly. It centers on individual differences in spatial and temporal relations among opposing dental units. The segment of ontogeny that is studied begins with the deciduous dentition prior to any oral eruption of permanent teeth and extends to complete replacement of the deciduous dentition with permanent teeth.

OBJECTIVES

The several purposes of the investigation may be grouped under the captions: (1) describing trait distributions, (2) correlating pairs of traits, and (3) studying trait changes ontogenetically. Grouping in this manner, a statement of specific aims is as follows:

1. To describe frequency distributions for:

a. The anteroposterior relation of opposing deciduous second molar teeth at a stage shortly before beginning eruption of permanent first molar teeth.

b. The difference between eruption ages for opposing permanent first molar teeth.

c. The anteroposterior relation of opposing permanent first molar teeth at the time they initially occlude.

2. To present correlation statistics indicating:

a. The association between the anteroposterior relation of opposing deciduous second molar teeth and the anteroposterior relation of opposing permanent first molar teeth.

b. The association between the difference in age of eruption of opposing permanent first molar teeth and the anteroposterior relation of opposing permanent first molar teeth.

3. To investigate longitudinally:

a. The changes for different individuals in the anteroposterior relation of opposing permanent first molar teeth during the first year after they reach occlusal contact and over the period from initial occlusion to the youngest age at which all of the deciduous teeth are replaced by occluding permanent teeth.

b. The changes, during age intervals of three and five years, in the anteroposterior relation of opposing permanent first molar teeth among individuals with the mesiobuccal cusps of these teeth in the same vertical plane at the time of initial occlusion.

SUBJECTS

The subjects were 109 white children, 53 boys and 56 girls, participating in the Facial Growth Study* at the State University of Iowa. Children were enrolled in this program at ages between three and one half and five

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*A longitudinal research program in operation since 1946.

years; the requisites for enlistment were parental willingness to cooperate in a long-term study and likelihood of continuing residence in or near Iowa City.

Each subject accepted for inclusion in the present investigation had on file maxillary and mandibular dental casts satisfying specified criteria at stipulated dental stages. The criteria were as follows:

1. All deciduous molar and canine teeth present on both sides of each dental arch.
2. No casting defects or distortions in the areas of the deciduous second and permanent first molar teeth.
3. No indication of caries affecting the mesial or distal surfaces of teeth in the buccal segments of either dental arch.
4. A dental history showing that the child had not received orthodontic treatment.

The dental stages were:

1. Time at which each of the permanent first molar teeth erupted into the oral cavity.
2. Time at which the opposing permanent first molar teeth on the right and left sides of the dental arches reached occlusion.
3. Two years prior to the time of initial occlusion of the opposing permanent first molar teeth on each side of the arches.

Portions of the total sample were available for study at one or more of four later dental stages. Three of these stages were defined with reference to the time of initial occlusion of opposing permanent first molar teeth; they succeed this event by one year, three years, and five years. The fourth stage was defined as the earliest age when all of the permanent dental units except the third molar teeth had erupted to the occlusal level. For acceptance at any of these stages it was required that a child's dental casts were processed satisfactorily, and that his dental history was negative for orthodontic treatment.

In the aggregate, the sample may be characterized as a group of American-born white children predominantly of orthwest European descent and above average in socioeconomic status. Eighty per cent of the subjects were descendants of immigrants from the British Isles, Germany, Scandinavia, or the Netherlands; all except three per cent had at least two grandparents of northwest European ancestry. Information on occupation of the fathers showed that two-thirds of them held professional or managerial positions and the remaining one-third commercial, skilled, or semiskilled positions.

Materials and Methods

The source materials for data collection were hydrocal dental casts made from alginate impressions. Impressions were obtained at semiannual intervals below age twelve years and at annual intervals above this age.

Different methods were used for three tasks: (1) classifying the anteroposterior relation of opposing deciduous second molar teeth, (2) obtaining the difference between eruption ages of opposing permanent first molar teeth, and (3) classifying the anteroposterior relation of opposing permanent first molar teeth.

Method in determining the anteroposterior relation of opposing deciduous second molar teeth: — A procedure was sought whereby the relationship of opposing posterior termini of the deciduous dental arches could be rated by viewing pairs of occluded casts from their buccal aspects.

On dental casts of the mandibular arch it was satisfactory to mark the most posterior point of each deciduous second molar. Always this point fell in

the region of the distobuccal cusp and was visible in a buccal view.

In the maxillary arch, the posterior termini of deciduous second molars lie lingual to the alveolar ridges and are not visible in buccal perspective. Projections buccally were made by placing one edge of a steel rule against both terminal points and drawing a fine line from each point laterally across the alveolar ridge to its buccal side.

It follows that marks were placed on the buccal aspects of the dental casts representing, for the right and left sides separately, (A) the posterior terminus of the maxillary deciduous dental arch and (B) the posterior terminus of the mandibular deciduous dental arch. The casts for a given subject were oriented for rating with the maxillary and mandibular arches in occlusion. Each observed relationship of opposing marks was classified using the following criteria:

I. A anterior to B, or A and B in the same vertical plane.

II. A posterior to B by amounts not exceeding 1.0 mm.

III. A posterior to B by amounts greater than 1.0 mm and not exceeding 2.0 mm.

IV. A posterior to B by more than 2.0 mm.

Two orthodontists served as raters (D.B.C. and E.H.H.*). Each made two independent ratings for each side of every pair of casts. Whenever less than three of the four ratings on a given side were in agreement, an additional rating was made. Sides rated five times and still yielding less than three agreements, were rated twice more. In the original series of four ratings, there were three or more agreements for 80 per cent of the 218 sides examined. For only five per cent of the sides was it necessary to obtain seven ratings.

A specific numerical rating was considered a valid measure of the relation between the posterior termini of opposing second deciduous teeth when it was obtained at least three times in a series of four or five independent ratings or, four times in a series of seven ratings. The data for each side of every pair of accepted casts met one of these criteria.

By the above procedures 218 highly reliable ratings of the anteroposterior relation of opposing second deciduous teeth ($N = 109$ for the right and left sides of the dental arches) were accumulated at a stage shortly before oral eruption of any permanent first molar teeth.

Method in obtaining the difference between eruption ages of opposing permanent first molar teeth: — A tooth was considered erupted when the gingiva was perforated sufficiently to expose an area of tooth enamel approximately one mm in diameter. The time of reaching this stage was approximated from inspection of the series of semiannual casts for each subject.

Two odontologists (H.V.M. and V.B.K.*) estimated the age of eruption of each permanent first molar tooth. Initially, both made independent estimates to the nearest month of age. Whenever their paired records for a given tooth disagreed by two months or more, an additional pair of records was obtained.

For 84 per cent of the 436 teeth, the two initial estimates were either alike or differed by not more than one month. The midpoint of each pair of these estimates was accepted as the age of eruption. On those teeth (16 per

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cent) for which four records were secured, the mean of the tetrad was taken as the age of eruption.

The final procedural step was that of subtracting the eruption age of each maxillary tooth from the eruption age of its antagonist, thereby obtaining values for the difference in age of eruption of opposing permanent first molar teeth.

Method in determining the anteroposterior relation of opposing permanent first molar teeth:— Ratings were made relating a mark on the maxillary dental cast to one of three marks on the mandibular cast. With the aid of a sharp pencil and magnifying glass, short vertical lines visible in a buccal view were drawn to indicate the anteroposterior locations of (C) the tip of the mesiobuccal cusp on the maxillary permanent first molar teeth; and, on the mandibular permanent first molar tooth, (D) the crest of the mesial marginal ridge, (E) the tip of the mesiobuccal cusp, and (F) the buccal groove.

After these sites had been marked, pairs of casts were placed in occlusion and, for the right and left sides separately, classified in one of the following categories:

1. C anterior to D (Angle Class II).
2. C between D and 0.5 mm. anterior to E.
3. C within ±0.5 mm. of E (end-to-end).
4. C between 0.5 mm. posterior to E and 0.5 mm. anterior to F.
5. C within ±0.5 mm. of F (Angle Class I).
6. C more than 0.5 mm. posterior to F.

Classifications were obtained for 550 sides of dental arches representing selected stages between the time opposing permanent first molar teeth reached occlusion and the time twenty-eight permanent teeth were in occlusion. Every side was classified twice by each of two orthodontists (D.B.C. and E.H.H.) working independently. Whenever less than three of the four ratings were in agreement, an additional rating was made. Eighty-nine per cent of the four-record series gave at least three agreements; on extending the series to five, three agreements were obtained in all instances. It follows that each numerical rating utilized for the anteroposterior relation of opposing permanent first molar teeth symbolizes no less than three corresponding records among series of four or five independent appraisals.

Anteroposterior Relation of Opposing Deciduous Second Molar Teeth

Frequency distributions for the anteroposterior relation of the posterior termini of opposing deciduous second molar teeth are presented in Table I. On the total sample of 109 children, frequencies of the different ratings are displayed for the right side of the dental arches and for the left side. Also shown are frequencies on those children (55 of the 109) having the same rating for both sides of the arches. Among the 54 children (50 per cent) having dissimilar ratings on the right and left sides, there were differences of one category for 45 (42 per cent), two categories for 7 (6 per cent), and three categories for 2 (2 per cent).

Further discussion of variation in the relation of occluded deciduous dental arches will center on the following generalization: At the odontic stage shortly before beginning eruption of permanent first molar teeth, the posterior termini of the maxillary dental arch, in relation to corresponding termini of the mandibular arch, are with no greater frequency (1) anterior, or directly above, than (2) posterior by 1.0 mm. or more. For supporting sta-

TABLE I

Anteroposterior relation of the most posterior points of the deciduous dental arches determined two years before the permanent first molar teeth reach occlusion.

Anteroposterior Category	Right Side N	%	Left Side N	%	Both Sides N	%
I	9	8	19	17	8	7
II	38	35	31	28	16	15
III	47	43	42	39	25	23
IV	15	14	17	16	6	5

The age distribution for the 109 subjects at this stage extends from 4 years to 6.5 years.

tistics from Table I, note that the relative frequencies from combining categories I and II approximate 44 per cent on each side of the arches and, conversely, those from combining categories III and IV approximate 56 per cent on each side.

The generalization harmonizes with findings from Clinch[3], but is discordant with findings from Baume[1] and Murray[8]. Clinch measured the anteroposterior distance between the terminal points of opposing deciduous second molar teeth on dental casts for 59 children between ages 4.2 and 6.2 years. When these measurements are tabulated in terms of the categories of the present study, 52 per cent fall in categories I or II, and 48 per cent in categories III or IV. The differences between these percentages and those obtained in the present study are not significant statistically (standard error of difference $= 7.4$; $t = 1.1$.).

On dental casts for thirty children between ages four years and six years, Baume studied the anteroposterior relation of the termini of opposing deciduous arches. He reported, without defining the classification categories, that the terminus of the maxillary arch was posterior to that of the mandibular arch in 14 per cent of his subjects. Murray, using *norma lateralis* roentgenograms taken with the dental arches in occlusion on twenty children between ages 5.5 years and 6.5 years, measured along an occlusal line from a perpendicular passing through the lowest point of the left pterygomaxillary fissure to the most posterior points on the maxillary and mandibular deciduous second left molar teeth. The maxillary dimension was found to be surpassed by the mandibular dimension in one subject (5 per cent) only.

The reports of Baume and Murray, based on a total of fifty subjects, lend support to the view that in children around age five years the termini of the deciduous dental arches lie "in the same vertical plane in the majority of cases."[4] Findings from Clinch and the present study, utilizing 168 subjects, draw attention to (1) the wide variation in anteroposterior relation of opposing termini of deciduous arches and (2) the substantial (*ca.* 50 per cent) frequency with which a given terminus of the mandibular arch is anterior by at least 1.0 mm. to that of its maxillary counterpart.

Difference in Eruption Ages of Opposing Permanent First Molar Teeth

As stated previously, difference values were derived by subtracting the age of eruption of each permanent maxillary first molar tooth from the age of eruption of its antagonist. Separate ordered series were compiled for the

TABLE II

Age of oral eruption of the permanent mandibular first molar tooth minus age of oral eruption of the permanent maxillary first molar tooth. Differences expressed in years.

Side of Dental Arches	N	P_5*	P_{25}	Mean	P_{75}	P_{95}
Right	109	—.50	—.16	+.11	+.33	+.66
Left	109	—.42	—.08	+.10	+.34	+.59

* P_5 = fifth percentile, P_{25} = twenty-fifth percentile, etc.

values representing the right and left sides of the dental arches. Table II describes both series statistically. It will be seen:

1. More than 25 per cent of the values for each side of the arches denote earlier eruption in the maxillary arch than in the mandibular arch.

2. Typically, the maxillary permanent first molar tooth erupts slightly (0.1 years) later than the opposing mandibular permanent first molar tooth.

3. More than 25 per cent of the values for each side of the arches show eruption in the mandibular arch to antedate eruption in the maxillary arch by not less than 0.3 years.

The range of individual variation extends from the permanent maxillary first molar tooth erupting 1.3 years before its antagonist to the reverse relation at a magnitude of 2.3 years.

The difference values for the right and left sides of the dental arches were correlated. A Pearson product-moment coefficient of $r = +.69$ was obtained. It is tenable to conclude: (1) there is a statistically significant association between eruption relations of opposing permanent first molar teeth on the two sides of the arches, and (2) the association is positive in direction and of moderate strength.

Anteroposterior Relation of Opposing Permanent First Molar Teeth

Table III presents frequencies for the ratings pertaining to the anteroposterior relation of opposing permanent first molar teeth at the time these teeth reach occlusion. It will be recalled that (1) ratings at this ontogenetic stage were obtained on the total sample of 109 children, and (2) for each subject the buccal segments of both dental arches were intact.

The sections of Table III dealing with the right and left sides of the

TABLE III

Anteroposterior relation of opposing permanent first molar teeth at the time they reach occlusion.

Anteroposterior Category	Right Side N	Right Side %	Left Side N	Left Side %	Both Sides N	Both Sides %
1	7	6	5	4	2	2
2	12	11	11	10	4	4
3	30	28	22	20	13	12
4	41	38	40	37	23	21
5	18	16	30	28	14	13
6	1	1	1	1	1	1

dental arches separately yield the following findings:

1. The typical relation of opposing permanent first molar teeth at the time of initial occlusion is with the tip of the mesiobuccal cusp of the maxillary tooth somewhat anterior to the buccal groove of the mandibular tooth. More than 35 per cent of the ratings show this relationship (see figures for category 4).

2. Almost 25 per cent of the ratings show the tip of the mesiobuccal cusp of the permanent maxillary first molar tooth falling in or near the same vertical plane as the mesiobuccal cusp tip of the mandibular tooth (see figures for category 3). The mesiobuccal cusp tip of the maxillary tooth, from an additional 20 per cent of the ratings, is indicated to lie in or near the same vertical plane as the buccal groove of the permanent mandibular first molar (see figures for category 5).

3. At the time opposing permanent first molar teeth reach occlusion, the anteroposterior variation of the tip of the mesiobuccal cusp of the maxillary tooth is scattered between a position anterior to the crest of the mesial marginal ridge of the mandibular tooth (5 per cent) and a position posterior to the buccal groove of the mandibular tooth (1 per cent).

The righthand portion of Table III indicates that identical ratings for both sides of the dental arches were obtained on slightly more than one-half of the 109 subjects. Ratings of the two sides differed by one category for forty-one subjects (38 per cent), by two categories for eight subjects (7 per cent), and by three categories for three subjects (3 per cent). The three-category discrepancies included two children with ratings of one and four, and one child with ratings of two and five.

Association Between Anteroposterior Relations of Opposing Deciduous Second Molar and Permanent First Molar Teeth

The coefficient of contingency, C, is an appropriate statistic[5] for determining the strength of association between the anteroposterior relation of opposing deciduous second molar teeth at a stage shortly before eruption of permanent first molar teeth (variable X) and the anteroposterior relation of opposing permanent first molar teeth at the time they reach occlusion (variable Y). In applying this correlation procedure, it was necessary to combine some of the rating categories so that every theoretical cell frequency would be 5 or higher.

For the left side of the dental arches, C was computed using the four categories of opposing deciduous second molar teeth and collapsing the six categories of opposing permanent first molar teeth as follows: 1-3, 4, 5-6. The coefficient of contingency derived from this 4 x 3 table is $C = +.47$. A moderate positive relationship is indicated. On the one hand, the hypothesis of zero correlation in the population may be rejected, since the value secured for Chi square (31.2) is statistically significant ($P = 0.01$ when, with 6 *df*, Chi square is not less than 16.8). On the other hand, the maximum value attainable from a 4 x 3 table is $C = .93$. It is a reasonable interpretation that the obtained $C = +.47$ symbolizes a positive association of moderate strength.

On the right side of the dental arches, the required minimum for each theoretical cell frequency was met by a 2 x 4 table. This table was formed by the following: deciduous second molar categories I-II and III-IV; permanent first molar categories 1-2, 3, 4, 5-6. The obtained statistics are $C = +.47$ and Chi square $= 31.6$. With 3 *df*,

P = 0.01 when Chi square is not less than 11.3; the maximum value attainable from a 2 x 4 table is C = .91. As before, the finding of a direct moderate relationship is tenable.

An analysis was done for the left side of the dental arches using the same 2 x 4 contingency-table construction as was employed for the right side. The statistics from this comparable treatment are C = +.42 and Chi square = 23.3.

It follows that the initial occlusal relation of opposing permanent first molar teeth is not determined *solely* by the anteroposterior relation of the posterior termini of opposing deciduous second molar teeth.

Of the several facets of the above finding that could be specified, one has particular relevance in orthodontic diagnosis. At the stage prior to eruption of permanent first molar teeth, there are twenty-eight sides of occluded deciduous dental arches for which the posterior terminus of the maxillary arch is either anterior to the posterior terminus of the mandibular arch or in the same vertical plane as the posterior terminus of the mandibular arch (see Table I, category I). After the opposing permanent first molar teeth have erupted to occlusal contact, 20 (71 per cent) of the 28 sides fall in categories 1 or 2, *i.e.*, the tip of the mesiobuccal cusp of the maxillary permanent first molar tooth lies anterior to the mesiobuccal cusp of the mandibular permanent first molar tooth by 0.5 mm. or more. From reference to Table III, note that this subgroup includes less than 60 per cent of the total number of sides placed in categories 1 and 2.* Clearly, in the orthodontic examination of five-year-old children, it would be unsound to assume that whenever posterior termini of opposing deciduous arches lie in the same vertical plane this forbodes an Angle Class II relation of opposing permanent first molar teeth.

*The specific placements are nine in category 1 (75 per cent of the Table III total for category 1) and eleven in category 2 (48 per cent of the Table III total for category 2).

Association Between Order of Eruption and Anteroposterior Relation of Opposing Permanent First Molar Teeth

To what extent is there concomitant variation of the differences in eruption age of opposing permanent first molar teeth and the anteroposterior relations of these teeth at the time of initial occlusion? This question was studied by means of the same correlation method as was used in the previous section.

For each side of the dental arches, a 3 x 3 contingency table was found satisfactory. Differences between the eruption ages of opposing permanent first molar teeth were tabulated in the following categories: maxillary tooth erupting earlier than mandibular tooth by 0.15 years or more; maxillary tooth erupting less than 0.15 years before, at the same time, or less than 0.20 years after the mandibular tooth; and maxillary tooth erupting later than the mandibular tooth by 0.20 years or more. Ratings for anteroposterior relation of opposing permanent first molar teeth at the stage of initial occlusion were grouped as follows: 1-2, 3, 4-6.

The statistics obtained are C = +.36 and Chi square = 16.3 for the right side of the dental arches and, for the left side, C = +.41 and Chi square = 21.5. With 4 *df*, P = 0.01 when Chi square is not less than 13.3. It follows that both coefficients of contingency represent a positive relationship of low-moderate strength.

In a study utilizing dental casts secured on sixty children "before and

after the eruption of the permanent first molars," Baume[2] reported that in those children showing "Angle Class II malocclusion after eruption . . . the upper permanent first molar always erupted before the lower one." Comparable data from the present investigation are as follows: Of the 35 sides of the dental arches placed in categories 1 and 2 with respect to the anteroposterior relation of opposing permanent first molar teeth (Angle Class II malocclusion), 80 per cent show eruption of the maxillary tooth earlier than the mandibular tooth by periods varying from 2 weeks to 15 months, and 20 per cent show eruption of the two opposing teeth at the same time or eruption of the maxillary tooth later than its antagonist by intervals varying from 2 weeks to 3 months.

Lo and Moyers[6] have reported: "In cases of Class II molar relationship there is a strong tendency for the maxillary molars to erupt prior to their mandibular counterparts." The data of the present study confirm this generalization at two odontic stages: when opposing permanent first molar teeth attain occlusal contact, and one year later. At each stage, the maxillary tooth is found to erupt before the mandibular tooth in 80 per cent of the Class II group, *i.e.*, the group for categories 1 and 2 combined.

The probability that Class II malocclusion is *preceded* by eruption of the maxillary permanent first molar tooth ahead of its antagonist should not be regarded as equivalent to the probability that earlier eruption of the maxillary tooth is *followed by* Class II malocclusion (distoclusion). Among the seventy-five sides of the dental arches for which the permanent maxillary first molar tooth erupted before its opposing mandibular tooth, the ratings for anteroposterior relation on reaching occlusion are distributed as follows: 37 per cent in categories 1 and 2, 31 per cent in category 3, and 32 per cent in categories 4 and 5. These findings give scant support to the view that "arrival of the maxillary first molar ahead of the mandibular first molar . . . is symptomatic of developing distoclusion."[7]

How efficiently is it possible to predict Class II malocclusion of opposing permanent first molar teeth from joint utilization of the anteroposterior relation of posterior termini of opposing deciduous second molar teeth, and the difference between eruption ages of opposing permanent first molar teeth? Information on this question was secured by employing the following twofold scheme: (1) classification in category I with respect to the anteroposterior relation of the most posterior points of the deciduous dental arches prior to eruption of permanent first molar teeth, and (2) eruption of the permanent maxillary first molar tooth 0.5 years or more before eruption of its antagonist.

Ten sides of the dental arches (five for each sex) are found to meet both of these prescriptions. All ten register a Class II relation of opposing permanent first molar teeth on initial occlusion.* Nevertheless, there are twenty-five sides of the dental arches which remain unselected by the predictive scheme and have a Class II relation of the permanent first molar teeth when these teeth erupt to occlusion (see figures for categories 1 and 2, right and left sides, in Table III). It follows that, although the scheme has some forecasting value, it predicts no more than one-third of the Class II relations

*Class II predictions below 100 per cent correct are obtained from the use of any larger portion of the distribution for (1) anteroposterior relation of opposing deciduous dental arches or (2) difference in eruption ages of opposing permanent first molar teeth.

with which the clinician will be confronted.

Change with Age in Anteroposterior Relation of Opposing Permanent First Molar Teeth

Beginning with the stage of initial occlusion of opposing permanent first molar teeth, it was possible to study 89 subjects (44 girls and 45 boys) over a one-year period, and 48 subjects (23 girls and 25 boys) over the interval ending when all of the permanent teeth except the third molars had erupted to the occlusal level. For these subjects, dental casts were available with all of the posterior deciduous teeth present at two stages, and their permanent successors all present at the third stage.

Findings for the first year after initial occlusion of opposing right and left permanent first molar teeth are as follows:

1. Of the 178 sides of the occluded dental arches, each rated independently at the two stages, 62 per cent show no change.

2. There are one-category changes for 35 per cent of the paired ratings representing the beginning and end of the year. These changes occur about equally in both directions: the specific relative frequencies are 49 per cent in one direction and 51 per cent in the other.

3. Three per cent of the 178 sides of occluded dental arches, each rated at the two stages one year apart, change more than one category. Included here are three shifts in one direction and two in the other. More explicitly, there are two unilateral shifts from category 2 to category 4, a unilateral shift from category 1 to category 3 and a bilateral shift from category 5 to category 3.

Longitudinal study of changes in the anteroposterior relation of opposing permanent first molar teeth over the period from initial occlusion to the stage when all of the deciduous teeth have been replaced by occluding permanent teeth gives the following findings:

1. Of the ninety-six sides of occluded dental arches, each rated independently at the two stages, 19 per cent show no change.

2. Eight per cent of the sides shift to a lower numbered category. None of these shifts exceeds one category.

3. Seventy-three per cent of the sides change to a higher numbered category. Comprising this 73 per cent, there are 47 one-category changes, 20 two-category changes, and 3 changes of more than two categories. The two-category shifts are largely from category 3 ("end-to-end") to category 5 (Angle Class I), or from category 4 to category 6 (tip of mesiobuccal cusp of maxillary tooth more than 0.5 mm. posterior to buccal groove of opposing mandibular tooth). Two of the larger shifts are from category 3 to category 6. The maximum shift is from category 2 (mesiobuccal cusp tip of maxillary tooth between mesiobuccal cusp tip and anterior marginal ridge of mandibular tooth) to category 6.

4. There are four instances of change exceeding one category on *both sides* of the dental arches. One child changes from category 3 to category 5 on both sides, another child from category 4 to category 6 on both sides, another from categories 1 to 3 on one side and 2 to 4 on the other, and another from categories 3 to 5 on one side and 3 to 6 on the other. All of these shifts depict the mandibular permanent first molar tooth moving anteriorly with age in its relation to the maxillary permanent first molar tooth.

Serial Study of Children with Cusp-to-Cusp Relation of Opposing Permanent First Molar Teeth at Initial Occlusion

Thirteen subjects were rated 3 (end-

to-end) bilaterally when the opposing permanent first molar teeth reached occlusion (see Table III). It was possible to study most of these subjects longitudinally, dental casts being available for twelve of them (six of each sex) at initial occlusion and three years later, and for eight of them at initial occlusion and five years later. For both postocclusal stages, dental casts were accepted regardless of the number or assortment of teeth present anterior to the permanent first molar teeth.

Three years after initial occlusion (N = 12):

1. Five children (42 per cent) show no anteroposterior shift on either side of the dental arches, *i.e.*, at both stages the tips of the mesiobuccal cusp of the right and left maxillary teeth are approximately in the same vertical plane as the tips of the corresponding cusps of the mandibular teeth.

2. Seven children (58 per cent) change from category 3 to category 4 on at least one side of the dental arches. This shift toward Class I permanent first molar relationship is found on both sides of the arches for three children. For the remaining members of this subgroup, one side of the arches shows no change in one child, change from category 3 to category 6 in one child, and change from category 3 to category 2 in two children.

Five years after initial occlusion (N = 8):

1. Six children (75 per cent) register a change on each side of the dental arches from category 3 to categories 4 or 5. For three children, the change is to category 4 bilaterally; for two children, it is to category 4 on one side and category 5 (Class I) on the other, and for one child, it is to category 5 bilaterally.

2. Two children (25 per cent) show change on one or both sides of the dental arches from category 3 to category 2 (Class II). For one child, there is no change on one side and a shift to category 2 on the other; for the other child, both sides shift from category 3 to category 2.

The findings of this section indicate that among children whose maxillary and mandibular permanent first molar teeth initially occlude with the tips of the mesiobuccal cusps in the same vertical plane, there is usually a definite, although slight, change in anteroposterior relation with age. Over the first triennium following attainment of the cusp-to-cusp (end-to-end) relation none of the twelve subjects manifests a change of more than one category bilaterally. Extending the postocclusal period to a quinquennium, one only of the eight children accessible for study shows a two-category change bilaterally. The predominant finding is a one-category shift on one or both sides of the dental arches from the opposing mesiobuccal cusp-to-cusp relation toward the Class I relation.

Summary

This study pertains to the variation and correlation of three odontic traits in orthodontically untreated white children. Each trait represents a temporal or spatial relation between two posterior teeth. Opposing deciduous second molar teeth are studied at a stage before the eruption of permanent first molar teeth, and opposing permanent first molar teeth at several stages from their oral eruption to the time all of the deciduous teeth are replaced by permanent teeth.

The data were obtained from hydrocal dental casts accumulated in a long-term research program. Every child accepted as a subject for the study was required to have all deciduous molar and canine teeth present when the permanent first molar teeth reached the occlusal level. The sample com-

prises 109 American-born white children predominantly of northwest European descent and above average socioeconomic status.

Findings are presented on the following topics: (1) variation in the anteroposterior relation of opposing deciduous second molar teeth prior to eruption of the permanent first molar teeth, (2) variation in the sequence of eruption of opposing permanent first molar teeth, (3) variation in the anteroposterior relation of opposing permanent first molar teeth at the time they initially occlude, (4) correlation of the anteroposterior relations of opposing deciduous second molar teeth and permanent first molar teeth, (5) association between the sequence of eruption of opposing permanent first molar teeth and the anteroposterior relation of opposing permanent first molar teeth, and (6) change with age in the anteroposterior relation of opposing permanent first molar teeth, including (7) special study of children showing mesiobuccal cusp-to-cusp relation of these teeth at initial occlusion.

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