Occlusal Development Between Primary and Mixed Dentitions: A 5-year Longitudinal Study

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ABSTRACT

Purpose: The purpose of this study was to evaluate the variations in occlusal relationships and the influence of dental arch type and primate spaces on the development of primary and mixed dentition, including molar-canine relationship and anterior crowding, over a 5-year period.
Methods: One hundred twenty-eight children were examined in schools in Nova Friburgo, Rio de Janeiro, Brazil.
Results: There was a straight terminal plane development (ie, from mesial step to Class I and III, and from distal step to Class II). It was noted that a Class I canine relationship observed in the primary dentition was maintained in 91% of the cases during the mixed dentition presenting type 1 arch and primate spaces, whereas a Class III relationship developed into Class I. There was a modification in the negative overbite followed by mild to severe relationship and then by a moderate one in the mixed dentition, with a discrete increase in overjet compared to the primary dentition. It was verified a greater prevalence of Baume arch type I and primate spaces. As for the molar relation, there were no significant changes in the development from primary to mixed dentition, according to dental arch type and primate spaces. Lower arch crowding, however, was found in 29% of the children, even in the presence of arch type I and primate spaces.
Conclusions: The occlusal relationships in the mixed dentition were influenced and followed a pattern determined by the primary dentition. Arch type I and primate spaces favor both development of Class I malocclusion and the absence of upper arch crowding, although they do not appear to affect the molar relationship and lower arch crowding. **(J Dent Child 2008;75:287-94)**

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KEYWORDS: DENTAL OCCLUSION, DENTITION PRIMARY, DENTITION MIXED, PRIMATE SPACES

The study of dental development and occlusal relationships is fundamentally important in pediatric dentistry and orthodontics because primary occlusion plays a major role in the development of the mixed and permanent dentitions.[1,2]

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The clinical presence of incisors, permanent first molars in occlusal contact, and other primary teeth characterizes the phase of the mixed dentition. According to Angle,[2,6] in this phase the permanent molar relationship is guided by the second primary molars' distal surfaces. Canine relationship, overbite, and overjet in the mixed dentition are classified in the same way as the primary dentition.[7]

Accordingly, the aim of the present study was to evaluate the variations in occlusal relationships between primary and mixed dentitions over a 5-year period, verifying molar and canine relationships as well as overbite and overjet. In addition, the influence of dental arch type and primate spaces on the development of occlusal relationships and anterior crowding was evaluated.

Few longitudinal studies have provided clinical evaluations to explain the modifications observed during dental development,[27] which is further impaired by the quantitatively limited samples. Accordingly, the relevance of this study is justified as it corroborates concepts already established in the literature and supports clinical information for helping specialists achieve correct diagnosis and prognosis of the development of dental occlusion in children.

METHODS

SUBJECTS

This study was based on a longitudinal epidemiological survey in which 254 3- to 6-year-old Brazilian children (meaN=56.7 months±11 SD) who attended public schools in Nova Friburgo, Rio de Janeiro, Brazil, were clinically examined. All of them presented complete primary dentition (moment 1 the first time the children were examined), according to criteria by Assumpção.[8]

Five years later, 170 children were located again for a further examination (moment 2 the second time the children were examined). They were also evaluated according to the following exclusion criteria: presence of carious lesion and/or restoration affecting the occlusal and interproximal relationship of the opposite and adjacent teeth, respectively; alterations in number; size and/or shape of the teeth; excessive wear on occlusal surfaces; absence of permanent first molars; premature loss of primary teeth; children who had been submitted to orthodontic treatment; children having complete permanent dentition; and children without lacking a free and informed consent signed by their caregivers. This research was approved by the Committee on Ethics in Research of the Clementino Fraga Filho Hospital, Federal University of Rio de Janeiro, Rio de Janeiro.

CLINICAL EXAMINATION

The clinical examinations were completed at the public schools, Rio de Janeiro, by a single trained and calibrated examiner.[8] The following conditions were evaluated:

1. Occlusion of the permanent first molars, classified according to angle: Class I, Class II, Class III, and subdivision (right and left);
2. intercuspidation of the primary canines, classified using the criteria by Foster and Hamilton[5]-Class I (when the maxillary canine cusp tip occludes with the mandibular canine's distal surface); Class II (when the maxillary canine's cusp tip occludes mesially with the mandibular canine's distal surface); and Class III (when the maxillary canine's cusp tip occludes distally with the mandibular canine's distal surface; right and left);
3. overbite, verified from the permanent mandibular central incisors' incisal edges to overlapping points of the permanent maxillary central incisors' incisal edges;
4. overjet, verified from the permanent mandibular central incisors' buccal surfaces to the permanent maxillary central incisors' incisal edges as follows: top-to-top (0), mild (1.0-2.0 mm), moderate (2.1-4.0 mm), severe (4.1 mm or >), and negative (<0). Plastic millimeter rulers were used for these measurements;
5. dental arch type: type I (with interdental spaces); and type II (without interdental spaces); and
6. crowding, considered when the interproximal trespass of the permanent maxillary and mandibular incisors was greater than 2 mm.

STATISTICAL ANALYSIS

The Kappa test was used for evaluating the interexaminer and intraexaminer concordance, molar and canine relationships, and crowding (categorical variables) whose values were, respectively, 0.84, 0.85, and 1.00 for the former (interexaminer: molar, canine and crowding) and 0.95, 0.95, and 1.00 for the latter (intraexaminer: molar, canine and crowding) with weighted Kappa test results (ordinal variables) showing 1.0 for overbite and 0.85 for overjet.

Epi Info 6.04 (CDC, Atlanta, GA, USA) and SPSS 11.0 (SPSS, Inc, Chicago, Ill) software were used for analyzing the results and correlating the data, followed by a descriptive analysis of the results. For categorical and ordinal variables, the McNemar and Wilcoxon chi-square tests were used, respectively, considering that they are paired data.

RESULTS

Of the 170 children, 5 had left the city and 37 were excluded (exclusion criteria), totaling a sample of 128 8- to 11-year-olds (meaN=115 months±11), of which 71 (56%) were male. When the occlusal relationship of the permanent first molars was observed, it was found that 91 (71%) were Class I, 19 (15%) Class II, and only 1 (1%) was Class III. The data correlation found from the primary to mixed dentition showed development of the straight terminal plane to Class I, from the mesial step to Class I and/or III and from the distal step to Class II; it was also shown that most of the unilateral variations occurring in the primary dentition developed into a bilateral Class I relationship. On the other hand, the bilateral straight terminal plane developed not only into Class I, but also had unilateral characteristics of Class II (Table 1).

The mixed dentition showed a Class I canine relationship in 93 (74%) children. It should be noted that the Class I relationship in the primary dentition was also observed in the mixed dentition of 52 (90%) children. In addition, a Class III relationship was observed in 18 (14%) children with primary dentition and in only 2 (2%) children with mixed dentition, although 15 (83%) developed a Class I relationship. The unilateral variations in the primary dentition (N=32) also developed into a Class I relationship (N=22) in the mixed dentition (Table 2).

*Table 1. Association Between Primary and Mixed Molar Relationship **

Primary molar relationship	Mixed molar relationship: Class I		Class II		Class III		Class II subdivision		Class III subdivision		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Straight terminal plane	72	79	9	10	0	0	10	11	0	0	91	100
Mesial step	6	60	2	20	1	10	0	0	1	10	10	100
Distal step	3	21	8	57	0	0	3	21	0	0	14	100
Unilateral mesial step	3	60	0	0	0	0	2	40	0	0	5	100
Unilateral distal step	7	88	0	0	0	0	0	0	1	13	8	100
Total	**91**	**71**	**19**	**15**	**1**	**1**	**15**	**12**	**2**	**2**	**128**	**100**

** The unilateral relations were grouped in terms of function of straight terminal plane in the deciduous dentition and Class I in the mixed dentition: McNemar chi-square test: P=.780 (nonsignificant).*

*Table 2. Association Between Primary and Mixed Canine Relationship **

Primary canine relationship	Mixed canine relationship: Class I		Class II		Class III		Unilateral Class II		Unilateral Class III		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Class I	52	90	4	7	0	0	1	2	1	2	58	100
Class II	4	24	7	41	0	0	5	29	1	6	17	100
Class III	15	83	0	0	2	11	0	0	1	6	18	100
Unilateral Class II	7	50	2	14	0	0	5	36	0	0	14	100
Unilateral Class III	15	83	1	6	0	0	2	11	0	0	18	100
Total	**93**	**74**	**14**	**11**	**2**	**2**	**13**	**10**	**3**	**3**	**125**	**100**

** Three children were excluded due to the presence of a permanent canine; McNemar chi-square test: P<.001*

Table 3 shows the development of overbite between primary and mixed dentitions, where 56 (44%) children presented negative overbite and 47 had mild overbite (37%). Severe overbite was more predominantly seen in 52 children (47%) with mixed dentition, whereas moderate cases were seen in 34 (27%). Of the 56 (44%) children presenting negative overbite in their primary dentition, only 10 (8%) had the same characteristic in their mixed dentition. Nonetheless, a greater number of children had mild overjet (N=74; 58%) followed by 31 children with moderate cases (24%) for primary dentition; the same occurred when the mixed dentition was evaluated, 65 (51%) and 41 (32%) children, respectively. When the dentitions were compared, however, a discrete decrease was noted in the number of children with mild overjet, but an increase was observed in the moderate cases. As for the primary negative overjet, 3 (2%) children presented this condition and only one had it in the mixed dentition. Indeed, this child was the same one presenting a primary molar relationship in mesial step and Class III molar relationship in the mixed dentition (Table 4).

Of the 128 children, 70% (N=89) presented arch type I and primate spaces in both jaws and 5% (N=6) presented arch type II and absence of primate spaces in both jaws (Table 5).

PRIMARY CANINE RELATIONSHIP

The presence of arch type I and primate spaces in both jaws associated with the development of a canine relationship

*Table 3. Association Between Primary and Mixed Overbite**

Primary overbite	Mixed overbite: Top-to-top N	%	Light N	%	Moderate N	%	Severe N	%	Negative N	%	**Total** N	%
Top-to-top (0)	1	17	1	17	2	33	2	33	0	0	**6**	**100**
Light (1.0-2.0 mm)	0	0	14	30	16	34	17	36	0	0	**47**	**100**
Moderate (2.1-4.0 mm)	0	0	1	11	1	11	7	78	0	0	**9**	**100**
Severe (4.1 mm or >)	0	0	1	10	1	10	8	80	0	0	**10**	**100**
Negative (<0)	5	9	9	16	14	25	18	32	10	18	**56**	**100**
Total	**6**	**5**	**26**	**20**	**34**	**27**	**52**	**41**	**10**	**8**	**128**	**100**

** Wilcoxon test: P=.171 (nonsignificant)*

*Table 4. Association Between Primary and Mixed Overjet**

Primary	Mixed overbite: Top-to-top N	%	Light N	%	Moderate N	%	Severe N	%	Negative N	%	**Total** N	%
Top-to-top (0)	0	0	1	50	1	50	0	0	0	0	**2**	**100**
Light (1.0-2.0 mm)	2	3	44	60	22	30	4	5	2	3	**74**	**100**
Moderate (2.1-4.0 mm)	1	3	13	42	12	39	5	16	0	0	**31**	**100**
Severe (4.1 mm or >)	0	0	6	33	6	33	5	26	1	6	**18**	**100**
Negative (<0)	0	0	1	33	0	0	1	33	1	33	**3**	**100**
Total	**3**	**2**	**65**	**51**	**41**	**32**	**15**	**12**	**4**	**3**	**128**	**100**

** Wilcoxon test: P=.654 (nonsignificant)*

showed that Class I was maintained in 91% (N=41) of the cases involving mixed dentition, where 33 (37%) cases of unilateral Class II, Class III, and unilateral Class III relationships developed into Class I relationships. Also, 24 (73%) children with mixed dentition represented a total of 67 (75%) Class I cases (Table 6). Among the children with arch type II and absence of primate spaces in both jaws, there was development of Class I, Class III, and unilateral Class III into Class I in the mixed dentition. Among the children presenting with arch type I in both jaws and primate spaces only in the maxilla, 7% (N=9) and 56% (N=5), respectively, developed Class I in the mixed dentition.

MOLAR RELATIONSHIP

Regarding molar relationships, 89 children showed no significant changes in the development from primary into mixed dentition. The relations in mesial step (N=8; 9%) and unilateral mesial step (N=4; 5%) tended to develop into Class I (N=7; 11%), whereas those with a straight terminal plane (N=65; 73%), in spite of developing Class I (N=51; 79%), also developed Class II (N=6; 9%) and unilateral Class II (N=8; 13%) cases. A discrete increase in Class II and unilateral Class II relationships was found in the mixed dentition (Table 7). Among the 6 children presenting with arch type II and absence of primate spaces in both jaws, straight terminal plane, distal step, mesial step, and unilateral mesial step ended up developing into Class I in 83% (N=5) of the cases involving mixed dentition. Among 9 children presenting with arch type I in both jaws and primate spaces only in the maxilla, 78% (N=7) developed Class I in the mixed dentition, of which 67% (N=6) were in straight terminal plane.

Table 5. Association Between Dental Arch Type and Primate Spaces										
Baume dental arch type	Primate Spaces									
	Absence (both jaws)		Presence (both jaws)		Presence (upper)/ absence (lower		Absence (upper)/ presence (lower)		**Total**	
	N	%	N	%	N	%	N	%	**N**	**%**
Type I (both jaws)	2	2	89	86	9	9	3	3	**103**	**100**
Type II (both jaws)	6	86	0	0	1	14	0	0	**7**	**100**
Type I (upper)/type II (lower)	0	0	4	36	6	55	1	9	**11**	**100**
Type II (upper)/type I (lower)	1	14	3	43	1	14	2	29	**7**	**100**
Total	**9**	**7**	**96**	**75**	**17**	**13**	**6**	**5**	**128**	**100**

Table 6. Influence of Both Dental Arch Type I and Presence of Primate Spaces on Canine Relationship in Both Jaws												
Canine relationship	**Canine relationship in the mixed dentition**											
	Class I		Class II		Class III		Unilateral Class II		Unilateral Class III		**Total**	
Primary dentition	N	%	N	%	N	%	N	%	N	%	**N**	**%**
Class I	41	91	2	4	0	0	1	2	1	2	**45**	**100**
Class II	2	18	5	46	0	0	4	36	0	0	**11**	**100**
Class III	12	80	0	0	2	13	0	0	1	7	**15**	**100**
Unilateral Class II	4	50	0	0	0	0	4	50	0	0	**8**	**100**
Unilateral Class III	8	80	1	10	0	0	1	10	0	0	**10**	**100**
Total	**67**	**75**	**8**	**9**	**2**	**2**	**10**	**11**	**2**	**2**	**89**	**100**

CROWDING

Of the 89 children with arch type I and primate spaces in both jaws, 70% (N=62) did not present with anterior crowding in the mixed dentition involving the jaws, although 29% (N=26) showed crowding in the lower arch (Table 8) under the same circumstances. Among the 6 children presenting with arch type II and absence of primate spaces, 83% (N=5) developed mandibular crowding in the mixed dentition. Among the 9 children with arch type I in both jaws and primate spaces in the maxilla, 56% (N=5) showed mandibular crowding in the mixed dentition.

DISCUSSION

In dentistry, normal occlusion is characterized by the adequate anatomical relationship of the teeth in association with correct physiology of the masticatory system.[3]

This study shows a 50% sample loss (N=126) compared to the initial sample, although this percentage was not enough to produce a bias in the study because the quality of the sample was maintained proportionally as well as its characteristics.

Due to the difficulty in pairing the data of molar and canine relationships because of their localization (right and left), the data were grouped as Class II and III subdivisions regarding the former and grouped as unilateral Class II and unilateral Class III regarding the latter, resulting in 2 other groups.

The literature says that the straight terminal plane in the primary dentition could develop into Class I, II, III, or top-to-top in permanent dentition; the distal step would only develop into Class II and the mesial step could develop into Class I or III.[3,4] Based on this description, a study carried out by Di Nicoló et al[9], has reported that straight terminal plane had developed into Class I in 69% of the cases involving mixed dentition, followed by 32% of Class II cases. The mesial step cases characterized 87% of Class I relationships, followed by 14% of Class II relationships. Also, distal step cases (11%) represented 73% of Class II and 27% of Class I relationships, with no case of Class III being reported. This study shows that a Class I relationship was achieved in 71% (N=91) of the cases) for mixed dentition, followed by 15% (N=19) of Class II cases and only 1 Class III case (1%). In addition, one can see a development of Class II molar subdivision in children presenting a bilateral straight terminal plane, thus corroborating the findings by Bishara et al[26] and Legovic.[10] This latter author studied 128 children with a straight terminal plane and found that 31 developed Class II subdivision (24%).

According to Freitas,[11] who evaluated the mixed dentition of 122 Brazilian children, the percentage of children presenting with Class I was 58%, followed by 33% with Class II, and 9% with Class III. In another study carried out in 2001, Di Nicoló et al referred to a longitudinal evaluation of the canine relationship between primary and mixed dentitions.[9] It was shown that a canine relationship developed into Class I in the mixed dentition, followed by Class II, and no case of Class III. A higher relationship was observed, however, in the mixed dentition regarding Class I, followed by Class III and Class II.

It is speculated that the difficulty in evaluating the canine relationship in longitudinal studies is due to the period of its exfoliation, which was indicated by the number of children being excluded from the present study—the only occlusal relationship in a sample consisting of 125 children. Based on the literature and the results obtained in the present work, it is believed that the alterations in a canine relationship between primary and mixed dentitions are related to a notable increase in intercanine distance, which is necessary for accommodating the permanent incisors.[12] Further studies are recommended to evaluate the influence of primate spaces in canine relationship, because their absence in the mixed dentition is due to the canine distalization in order to accommodate the permanent incisors.[13]

Bishara et al[14] noted an increase in overjet and a reduction in overbite between primary and mixed dentitions in a sample of 65 children. Additionally, Bishara and Jakobsen[15] found a significant increase in overjet among 5- to 10-year-olds, although Di Nicoló et al[9] found an increase in both overjet and overbite between primary and mixed dentitions. In spite of the divergent results found in the literature, this study corroborates other authors' findings by showing an increase in overbite and a discrete increase in overjet.

The results showed a more favorable condition for the development of a Class I canine relationship in the mixed

Table 7. Influence of Both Dental Arch Type I adn Presence of Primate Spaces on Molar Relantioship in Both Jaws

Molar relationship	**Molar relationship in the mixed dentition**											
	Class I		Class II		Class III		Class II subdivision		Class III subdivision		Total	
Primary dentition	N	%	N	%	N	%	N	%	N	%	N	%
Straight terminal plane	51	79	6	9	0	0	8	12	0	0	65	100
Mesial step	2	22	5	56	0	0	2	22	0	0	9	100
Distal step	5	63	1	13	1	13	0	0	1	13	8	100
Unilateral mesial step	3	100	0	0	0	0	0	0	0	0	3	100
Unilateral distal step	2	50	0	0	0	0	2	50	0	0	4	100
Total	**63**	**71**	**12**	**14**	**1**	**1**	**12**	**14**	**1**	**1**	**89**	**100**

Table 8. Association Between Dental Arch Type and Crowding in the Presence of Primate Spaces (Both Jaws)

Baume dental arch type	**Crowding**									
	Absence (both jaws)		Presence (both jaws)		Absence (upper)/ presence (lower		Presence (upper)/ absence (lower)		**Total**	
	N	%	N	%	N	%	N	%	**N**	**%**
Type I (both jaws)	62	70	6	7	20	23	1	1	**89**	**100**
Type II (both jaws)	0	0	0	0	0	0	0	0	**0**	**100**
Type I (upper)/Type II (lower)	0	0	3	75	1	25	0	0	**4**	**100**
Type II (upper)/Type I (lower)	1	33	1	33	0	0	1	33	**1**	**100**
Total	**63**	**66**	**10**	**10**	**21**	**22**	**2**	**2**	**96**	**100**

dentition when arch type I in both jaws and primate spaces were present. This finding corroborates a study by Di Nicoló, who also evaluated the development of a canine relationship between primary and mixed dentitions.[9] As for the fact that Class III relationships in the primary dentition are more likely to develop into Class I it has been speculated that such development seems to depend on the localization of primate spaces. According to Clinch and Moyers,[3,16] for instance, canine distalization occurs in the mandible and canine mesialization in the maxilla. Even in arch type II and in the absence of primate spaces, there was development into Class I in the mixed dentition, although it was not possible to suggest whether these factors influenced the canine relationship. The differential growth of the jaws[17,18] is believed to be responsible for explaining this development. It could be said that arch type, primate spaces, or jaw growth do not have a definitive influence on the canine relation, but rather an association with it.[3]

As for the molar relationship, it was not possible to suggest a definitive influence due to the similar results found, either regarding arch type or presence of primate spaces. It was found that, even in the presence of arch type I and primate spaces, the straight terminal plane showed development into Class II in 22% (N=14) of the cases; this result was also found in other studies on molar relationship development.[10,19] This condition does not corroborate the hypothesis that either primate space or arch type can influence the molar relation, however, as described by Baume. Considering that the spaces were closed by mesialization of the first molar, it would be acceptable that this closure had occurred more easily in the mandible, giving rise to a Class I condition.[2] Furthermore, studies using plaster models and cephalometric radiographs confirmed the closure of primate spaces and anterior diastemas with the eruption of permanent incisors distalizing the canines.[3,16]

It is believed that the molar relationship undergoes a greater influence from the positioning of second primary molars, because according to the literature, these teeth are responsible for guiding the permanent first molars' eruption.[6,20] Consequently, if there is no mesialization of these primary teeth, the first molars erupt without space for mesialization, resulting in a temporary occlusal relationship when the primary relationship is in a straight terminal plane.[21,22] Three other factors are capable of influencing those 2 conditions: (1) eruption trajectory; (2) mesiodistal diameter of the permanent first molars; and (3) jaw growth.[14,23,24] The latter is very clearly observed in the mixed dentition.[25]

As in the canine relationship, the molar relationship involved most cases with mesial step developing into Class I malocclusion. This agrees with the literature, since the mesial step is more favorable for a Class I development. Whenever the primary mandibular second molar's distal surface is mesially positioned in relation to the maxillary molar, a mesial eruption of the permanent mandibular first molar is more likely to occur.[9,26] This indicates the influence of the primary molar relationship on the permanent molar eruption instead of either primate spaces or arch type.

The results regarding anterior crowding showed that the presence of primate spaces and arch type I were important for better accommodating the maxillary incisors. They were not sufficient, however, for accommodating the mandibular incisors, since mandibular crowding was present in 29% (N=26) of the cases involving mixed dentition. Di Nicoló et al have demonstrated the greater incidence of crowding in the mixed dentition, particularly involving other conditions of primate spaces and arch type influencing mandibular crowding.[27] The fact that mandibular crowding was found even when there were spaces in the mandible leads us to believe that other factors are important for correcting tooth alignment, such as mandibular growth, size of permanent teeth in relation to primary teeth, and the "Nance-free spaces."[28-30]

In view of the description of the occlusal relationships, it is important to further know the development of the dentitions, taking into account the primary occlusal profile in relation to the occlusal profile of the mixed dentition.[7] Furthermore, it is necessary to evaluate the influence of intrinsic and extrinsic factors, such as sex, race, climate, nutritional characteristics (breast-feeding and eating habits), oral habits (thumb-sucking, pacifier use, and oral breathing), and nocturnal habits on occlusal development.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. A molar relationship in a straight terminal plane, Class I canine relationship, mild overjet, and overbite all contributed favorably to the development of an adequate mixed occlusion.
2. Occlusal relationships of the mixed dentition can be influenced by determined factors and follow a pattern determined by primary dentition.
3. Arch type I and primate spaces favor the deve--opment of a Class I relationship, whereas the absence of crowding favors it in the upper arch in the mixed dentition.
4. Dental arch type and primate spaces do not seem to influence occlusal relationships in the mixed dentition.

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