# The Effects of Infant Feeding Patterns on the Occlusion of the Primary Dentition

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## ABSTRACT

The purpose of this study was to investigate the effects of different methods of infant feeding on the development of the occlusion in the primary dentition. The study included 126 children. Parents completed questionnaires regarding feeding and health history, and the primary dental occlusion was recorded for each child. The authors found that: (1) predominant bottle-feeding between 0 and 6 months of age was associated with the development of a pacifier habit; (2) children who used a pacifier were more likely to develop a nonmesial step occlusion, an overjet >3 mm, and an open bite; (3) children who sucked their thumb were more likely to develop an overjet >3 mm; and (4) in the absence of nonnutritive oral habits, children who were predominantly bottle-fed between 0 and 6 months of age were more likely to develop an overbite >75%, although just shy of nominal statistical significance. (*J Dent Child.* 2003;70:197-203)

KEYWORDS: INFANT FEEDING, OCCLUSION, BREAST-FEEDING

The nutritional, immunological, and developmental benefits of breast-feeding have been clearly established.[1,2,3] The high levels of vitamins and certain minerals found in breast milk contribute considerably to the health of the infant.[1] Additionally, the introduction of immunoglobulins, enzymes, and leukocytes via breast milk supplements the infant's undeveloped immune system and helps defend against bacterial and viral infection.[4] Human milk consumption in infancy has also been shown to enhance neurodevelopment, as well as reduce the risk for allergies, rhinitis, asthma, and dental caries.[5,6,7]

There exists substantial documentation that further credits breast-feeding with enhanced oral development and the formation of proper swallowing technique. Sucking and swallowing are reflex mechanisms that represent the first coordinated muscular activity of the infant.[8] This muscular activity is different for various methods of sucking. Breast-feeding involves placement of the nipple into the infant's mouth angled toward the hard and soft palate.[2] The lips and gums are pinched together at the base of the nipple as the tongue is drawn progressively backward, extracting milk toward the rear of the mouth.[1,2,8] Milk extraction is further aided by the negative pressure created intraorally by muscular sucking motions.[1] Because a breast nipple lactates in noncontinuous fine streams from its pores, the active sucking requires substantial energy expenditure and strenuous muscle activity.[1,9] This allows for proper development of the muscles involved: the orbicularis oris, masseter, buccinator, pharyngeal constrictors, and posterior digastric.[1,8] The contractive forces these muscles supply additionally influence the thrust and physiological growth of the mandible.[10,11,12] At the same time, this process creates a tongue positioning that facilitates the development of proper swallowing technique.[13]

Bottle-feeding, alternatively, involves a different type of nipple and therefore an entirely different method of deglutination. Despite attempts to design physiological rubber nipples that mimic a breast, there is little data that substantiates any benefit of one design over another.[8,14] Turgion-O'Brien[8] explained that rubber nipples, especially those that are not physiologically designed, extend much further back toward the pharyngeal wall. Additionally, milk is more easily released and its flow is often more rapid than from a human nipple.[8] The physiological ramifications of these differences are two-fold. First, less muscle activity is necessary to extract fluid, resulting in decreased development of pertinent facial musculature, including the orbicularis oris, masseter, and digastric muscles.[8,13,15] Second, the tongue is positioned improperly in a forward direction upon swallowing in an effort to regulate the fast and continuous flow of milk.[8,15] Straub[15] explained that swallowing habits learned in infancy may persist indefinitely. If these habits are abnormal, such as the tongue thrust produced in bottle-feeding, it may have profound detrimental effects on occlusion.[15]

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The etiology of malocclusion in the primary dentition remains surprisingly underresearched. Over the past few decades, there have been a handful of attempts to demonstrate a direct association between method of feeding and occlusion. Labbok and Hendershot[10] found that increased duration of breast-feeding was associated with a decline in the proportion of children needing later orthodontic treatment. Adamiak[16] found a clear negative association between the duration of breast-feeding and the incidence of occlusal anomalies. Meyers and Hertzberg[17] similarly found an increasing prevalence of need for orthodontic treatment with increasing degree of exposure to the bottle. Additionally, Davis and Bell[18] demonstrated an association between exclusive bottle-feeding and malocclusion in the anteroposterior plane. However, not all studies came to similar conclusions. In a detailed study of dental arch development, Bishara et al[14] found no statistically significant association between feeding method and arch growth. Legovic and Ostric[11] and Simpson and Cheung[19] both reported no difference in the frequency of malocclusion between breast-fed and bottle-fed children. Legovic and Ostric[11] further explained the difficulty of deriving clear associations due to the numerous endogenous and exogenous factors that influence the occurrence of malocclusion.

It is clear that the influence of feeding method on occlusion is controversial. Several criticisms have been made about studies that attempt to make these associations, claiming that the occlusal development is multifactorial, and it is not possible to evaluate the exclusive influences of single variables.[20] Sanger[20] cited genetic contributions, nonnutritive sucking habits, and duration of feeding times as variables that were too often overlooked. Bishara et al[14] suggested that a lack of longitudinal studies may in part add to the difficulty in determining the role of single etiologic factors in the development of malocclusions. Westover et al[1] added that lack of standardization in defining swallowing techniques and failure to consider sociopsychological influences created difficulty in interpreting results.

Of particular interest was the association between method of infant feeding and the development of nonnutritive sucking habits. Although it was generally agreed upon that digit sucking and pacifier use was detrimental to occlusal development, whether the method of feeding had a causal relationship with the habits was highly debated in current literature.[14,21] Klackenberg,[22] Traisman,[23] and Hannah[24] all found no relationship between sucking habits and type of feeding. Conversely, Straub[15] and Farsi[25] found a lower prevalence of nonnutritive sucking habits among breast-fed children.

Previous studies have frequently been based on questionnaires without direct clinical measurements of the dentition. Additionally, some have used measurements on the permanent dentition to indicate primary malocclusions retrospectively. Others have used isolated cultures or races that may not have been representative of the general population. Since occlusal development is multifactorial, any study investigating the association between the dental occlusion and the method of infant feeding must directly measure the dentition and control for potentially confounding variables.

The goal of this study was to investigate the effects of different methods of infant feeding on the development of occlusion of the primary dentition.

# METHODS

## PATIENT SELECTION

Children between the ages of 2 and 6 were recruited from an outpatient clinic at the Children's Hospital Boston from February to December 1999. The subjects of this investigation were recruited from subjects taking part in a study[26] researching occlusion and otitis media in children. Because the same criteria were used to select subjects for both studies, a single questionnaire was used to gather data for both. The 2 studies were approved by the Clinical Investigation Committee of the Children's Hospital Boston.

Patients were recruited daily during regular outpatient clinic hours. The parents of all children with dates of birth that matched the study's criteria were invited to participate. They were then asked to give consent to the study and fill out the questionnaire. Separately, the children were screened for inclusion criteria by medical record review and, if eligible for the study, examined. Only those children with complete primary dentition and without any erupted permanent teeth were retained in the study. Exclusion criteria included a history of cleft lip and/or palate or other oral maxillofacial surgery, craniofacial syndromes, trisomy 21, family inability to speak English, and inability of the child to cooperate. Personnel who recruited families and administered the questionnaire were unaware of the findings from the examination of the child, and the person who examined the children was unaware of the information collected on the questionnaires.

## QUESTIONNAIRE

The parent questionnaire asked about previous or persisting nutritive and nonnutritive sucking habits, as well as the child's history of ear disease, tonsil and adenoid removal, allergies, and smoke exposure. Specifically, parents were asked for the age of onset and duration of finger or thumb-sucking habits and/or pacifier use, and to quantify the frequency of each of 3 feeding methods—breast, bottle, or cup—during each of the 6-month periods that made up the child's first 2 years of infancy. Frequency of feeding was graded according to the following categories: method not used, infrequently used, used moderately, and frequently used. Since a child might have received nutrition via all 3 methods, the child was considered to be predominantly bottle-fed when the bottle score was higher than the breast score and the cup score. The same criterion was used to determine periods of being predominantly breast-fed and predominantly cup-fed.

## CLINICAL MEASUREMENTS

All of the clinical measurements were obtained by one of the authors using a digimatic caliper (model no. 500-320, Mitutoya Corp, Commercial Scale Co, Agwam, Mass) and a plastic millimeter ruler. Each measurement was performed 3 times and the average of the 3 was recorded. All occlusal relationships were evaluated with the child in centric occlusion. Measurements were

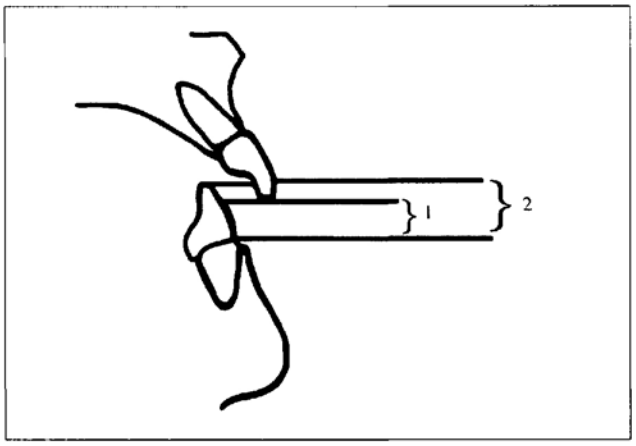


***Figure 1. Description of clinical measurements.***
***1=Occluded Mandibular Incisor Height (OMIH)***
***2= Total Mandibular Incisor Height (TMIH)***

taken with respect to the vertical (overbite), anteroposterior (overjet and canine/molar occlusion), and transverse (cross bite) planes:

1. Overbite was determined by measuring in millimeters the full height of the labial surface of the primary lower central incisor (from gingival margin to incisal edge), referred to as total mandibular incisor height (TMIH) (Figure 1). The exposed surface of the same tooth when in full occlusion, referred to as occluded mandibular incisor height (OMIH), was then measured. From this difference in length, a percentage of overlap by the corresponding primary upper central incisor was calculated using the formula: [(TMIH-OMIH)/TMIH]. For the purpose of this study, an overlap of greater than 75% was defined as a deep bite. Subjects who did not have any overlap were considered to have open bites, and the distance between incisal edges was measured in millimeters.

2. Overjet was determined by measuring in millimeters the horizontal distance between the lingual surface of a primary upper central incisor and the labial surface of its corresponding lower central incisor while in full occlusion. For the purpose of this study, an overjet of greater than 3 mm was considered abnormal.

3. Terminal plane relationships of the primary second molar and canine were recorded bilaterally as either end-to-end, distal step, or mesial step. End-to-end and distal step relationships were combined as nonmesial step relationships and were considered malocclusions for this study.

(4) If present, any anterior or posterior cross bites were noted.

All data were collected on structured data collection forms.

## *STATISTICAL ANALYSES*

Univariable relationships between nutritive feeding type (at 0- 6, 6-12, and 12-18 months) and nonnutritive oral habits and other potential confounders and between occlusal characteristics and nonnutritive oral habits and other potential confounders were examined in tables and evaluated with Fisher's exact test. Multivariable logistic regression was used to evaluate the relationship between feeding method and malocclusion while controlling for confounders. Because only 5 children had cross bite and virtually all children were using only a cup during the 18 to 24-month interval, these characteristics could not be evaluated.

## *RESULTS*

Of the 126 children who consented to participate and met all inclusion criteria, 5 were excluded from some of the analysis because data on their questionnaires was incomplete or ambiguous. The median age of the 126 participating children was 4.1 years (range 1.8-6.3 years) and 69% were male. Seventy-nine percent of the children were white, 10% African-American, 6% Hispanic, and 5% various other minorities. The white group was analyzed separately and did not show any notable difference from the combined subject population. For this reason, all races were combined for analysis in this study. Twenty-six percent of the children had a deep bite (>75%), while 17% had an open bite, 25% had an overjet of >3 mm, 78% had a mesial step occlusion, 17% had an end-to-end occlusion, 5% a distal step occlusion, and 4% had a cross bite.

Overall, bottle-feeding was the predominant method during the first year of life while cup-feeding was during the second year (Figure 2). The prevalence of breast-feeding was highest (45%) during the first 6 months of life and declined in the later periods. The prevalence of bottle-feeding on the other hand was 69% during the first 6 months, rose to 88% during the next 6-month period, and declined during the next 2 intervals. Cup-feeding rose in succeeding 6-month time intervals to 83% at 12 to 18 months and 96% at 18 to 24 months.

When the entire sample was included in the analyses, there were no significant associations between being predominantly

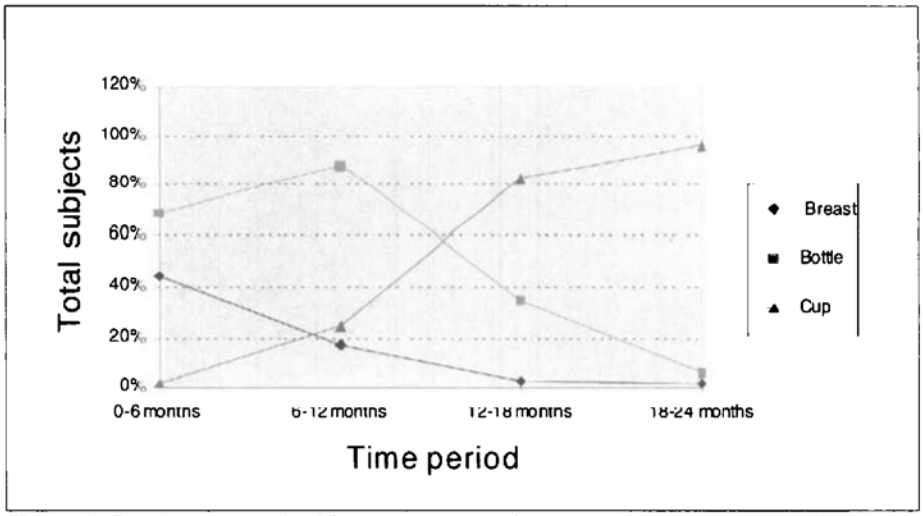


***Figure 2. Total number of subjects demonstrating breast-, bottle- or cup-feeding at different times throughout the first 2 years of infancy.***

**Table 1. Percent of Children With Various Malocclusions in the Primary Dentition Who Have the Feeding Type Listed on the Left (Column Percents)**

| | Overbite >75% | | | Overjet >3 mm | | | Nonmesial step | | | Open bite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes (N=33) | No (N=72) | *P* | Yes (N=32) | No (N=94) | *P* | Yes (N=28) | No (N=98) | *P* | Yes (N=21) | No (N=72) | *P* |
| Predominantly bottle-fed 0-6 mo | 61 | 53 | .32 | 55 | 59 | .43 | 67 | 55 | .20 | 71 | 54 | .16 |
| Predominantly bottle-fed 6-12 mo | 67 | 73 | .32 | 65 | 71 | .32 | 74 | 68 | .37 | 59 | 73 | .19 |
| Predominantly bottle-fed 12-18 mo | 18 | 20 | .54 | 26 | 21 | .38 | 19 | 23 | .40 | 41 | 20 | .05 |

bottle-fed at 0 to 6 months, 6 to 12 months, or 12 to 18 months of age with dental malocclusion in any plane with 1 exception: children who had been predominantly bottle-fed at 12 to 18 months of age were 3.1 times more likely to have an open bite (*P*=.05) (Table 1). For example, Table 1 shows for this finding that 41% of the 21 children in the study with an open bite were predominantly bottle-fed at 12 to 18 months, whereas only 20% of the 72 children in the study without open bites were predominantly bottle-fed at 12 to 18 months.

Predominant bottle-feeding between 0 and 6 months of age was associated with pacifier use (*P*=.008; Table 2). There was no statistically significant association between pacifier use and bottle-feeding between 6 and 12 months of age (*P*=.43) or 12 and 18 months (*P*=.35). No association was found between bottle-feeding and thumb-sucking in any time interval.

Older children were less likely to have an overbite >75% (*P*=.10), overjet >3 mm (*P*=.09), and a nonmesial step occlusion (*P*=.10; Table 3). There was a tendency for white children to have an overbite >75% (*P*=.06), overjet >3 mm (*P*=.12), and a nonmesial step occlusion (*P*=.09) compared to children of other races. Children who used a pacifier were 2.5 times more likely to have a nonmesial step occlusion in the primary dentition (*P*=.05), 2.7 times more likely to have an abnormal overjet (*P*=.05), and 2.9 times more likely to have an open bite (*P*=.07). Children who sucked their thumb were 3.6 times more likely to have an abnormal overjet than children who did not (*P*=.05). However, no statistically significant associations were noted between thumb-sucking and nonmesial step occlusion, overbite, or open bite.

Since it is known that oral habits can affect the developing primary dentition, analysis was done to investigate if these habits had an impact as confounding variables. Since bottle-feeding was associated with pacifier use, which was found to significantly affect occlusion in this study, children with nonnutritive oral habits (digit-sucking or pacifier use) were eliminated prior to evaluating the association between method of infant feeding and the occlusion. Children without nonnutritive sucking habits who were predominantly bottle-fed at 0 to 6 months of age were 3.2 times more likely to have an overbite of >75%, although this association failed to reach nominal statistical significance (*P*=.07). No significant associations were noted between children with an overjet >3 mm, nonmesial step occlusion or open bite and bottle-feeding in this group.

## DISCUSSION

It has long been suggested that the method of feeding in infancy influences the development of occlusion. Several studies and reviews have been written to describe in detail how different types of nutritive feeding and nonnutritive oral habits can affect craniofacial growth as well as swallowing technique, both of which play essential roles in the formation of dental occlusion.[8,10,11,13-15,20,23,33,40] Despite these studies, an understanding of how individual factors are involved in the development of both normal and abnormal occlusion remains imprecise. The purpose of this study was to isolate various methods of infant feeding patterns (breast, bottle, or cup) and other oral habits as developmental factors and investigate their association with occlusion of the primary dentition.

The majority of subjects used in this study were male, white, and were a median age of 4.1 years. The predominance of this gender, race, and age group probably represented a combination of an increased willingness of males, white, and older subjects to participate cooperatively in the study and the distribution of patients seen at Children's Hospital Boston.

**Table 2. Percent of Children Predominantly Bottle-fed at 0 to 6 Months, 6 to 12 Months, or 12 to 18 Months Who Have the Demographic, Nonnutritive Oral Habits, and Occlusal Characteristics Listed on the Left (Column Percents)**

| | Bottle-fed 0-6 months | | | Bottle-fed 6-12 months | | | Bottle-fed 12-18 months | | |
|---|---|---|---|---|---|---|---|---|---|
| | Yes (N=70) | No (N=51) | *P* | Yes (N=84) | No (N=27) | *P* | Yes (N=27) | No (N=94) | *P* |
| Male | 76 | 61 | .06 | 73 | 62 | .17 | 67 | 70 | .45 |
| White | 81 | 76 | .33 | 80 | 78 | .52 | 68 | 83 | .06 |
| Daycare | 51 | 57 | .32 | 55 | 50 | .39 | 52 | 54 | .52 |
| Pacifier | 56 | 32 | .008 | 47 | 43 | .43 | 41 | 47 | .35 |
| Thumb | 13 | 16 | .41 | 14 | 14 | .57 | 15 | 14 | .56 |

**Table 3. Percent of Children With Various Malocclusions in the Primary Dentition Who Have the Demographic and Nonnutritive Oral Habits Listed on the Left (Column Percents)**

| | Overbite >75% | | | Overjet >3 mm | | | Nonmesial step | | | Open bite | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes (N=33) | No (N=72) | *P* | Yes (N=32) | No (N=94) | *P* | Yes (N=28) | No (N=98) | *P* | Yes (N=21) | No (N=72) | *P* |
| Age >5 | 18 | 32 | .10 | 19 | 33 | .09 | 18 | 33 | .10 | 38 | 32 | .39 |
| Male | 64 | 71 | .30 | 66 | 70 | .39 | 68 | 69 | .52 | 71 | 71 | .60 |
| White | 91 | 76 | .06 | 88 | 76 | .12 | 89 | 76 | .09 | 67 | 76 | .27 |
| Daycare | 55 | 55 | .57 | 44 | 57 | .14 | 43 | 57 | .14 | 48 | 55 | .37 |
| Pacifier | 33 | 45 | .18 | 59 | 41 | .05 | 61 | 41 | .05 | 67 | 45 | .07 |
| Thumb | 18 | 11 | .25 | 25 | 11 | .05 | 21 | 12 | .18 | 19 | 11 | .28 |

The demographics of this study demonstrated not only the type and duration of various feeding methods, but also the prevalence of nonnutritive oral habits among the children studied. The most substantial evidence of association found in this study was between method of feeding and the development of nonnutritive sucking habits. Specifically, children who were predominantly bottle-fed for the first 6 months of their life were found to be much more likely to use a pacifier. These findings were consistent with those of Larsson,[27] Farsi et al,[25] Victoria et al,[28] and Vadiakas et al,[21] all of whom found higher percentages of pacifier habits among children who were bottle-fed. This finding reflects the physiological models described by Straub,[15] Graber,[13] and Turgion-O'Brien,[8] which explained the effects of bottle-feeding on the development and persistence of improper swallowing techniques. The development of sucking methods to accommodate a bottle's nipple may predispose children to prefer the stimulus of a pacifier as they grow older.

The fact that no similar association was found in this study between method of feeding and finger-sucking was substantiated by many other studies.[10,21,24,29,22,23] Klackenburg,[22] Yarrow,[29] and Traisman and Traisman[23] pioneered investigations of this association, all of whom found that method of feeding was not a significant factor in the prevalence of thumb- or finger-sucking habits among children and infants. Hannah,[24] Labbok and Hendershot,[10] and Vadiakas et al[21] later found the same lack of an association. Additionally, there may be cognitive factors involved. Psychoanalytic theory suggests that children possess an inherent oral fixation in which the mouth is the focus of sensation and interest.[28] This motivation to suck is different for each individual, and the extent to which it is done may be purely developmental and independent of previous feeding experiences. An interesting relationship possibly exists between pacifier use and finger-sucking in which pacifier use acts preventively against establishing finger-sucking habits.[21,31,32] Larsson reported in 2 different studies that children forced to break a pacifier habit were at a greater risk of developing a finger-sucking habit instead.[33,34] Similarly, Larsson[34] noted among Swedish children that the prevalence of finger-sucking habits declined as the use of pacifiers increased. Vadiakas et al[21] also found that parental reactions to these habits varied considerably. Although parents generally showed concern about prolonged finger-sucking habits, the degree to which they attempted to intervene was unpredictable. The prevalence of thumb-sucking habits may thus be largely dependent on parental supervision.

The results of this study clearly confirmed the detrimental effects nonnutritive sucking habits could have on occlusion. Children who used a pacifier were 2.5 times more likely to develop a nonmesial step occlusion, 2.7 times more likely to develop an overjet >3 mm, and 2.9 times more likely to develop an open bite. Children who sucked their thumb were 3.6 times more likely to develop an overjet >3 mm. There is general agreement in the literature that these habits can cause malocclusion, particularly in the anterior region.[8,25,35,36,37,38] Melsen et al[37] attributed the increase in prevalence of open bite and large overjet they found among children with oral habits to the resulting tongue thrust that existed in their swallowing technique. This theory was described in detail in papers by Straub[15] and Graber.[13] Tongue thrusting or having the continuous presence of a thumb or pacifier in the mouth can exert sufficient forward pressure to cause undesirable effects on both the dentition and bone in the anterior portion of the mandible and palate.[39] Larsson[40] explained that the eruption of the primary incisors, as well as growth of the alveolar processes, may be hindered by pacifier use, resulting in an open bite. Cause-and-effect relationships have additionally been reported in the literature between oral habits and Class II malocclusion and posterior cross bites,[36,41,44,45,46,48] although these findings were less definitive and were not supported by the results of this investigation. The extent to which the occlusion was adversely affected in each case depended largely on the duration of the causative force. In the anteroposterior direction, the effects of oral habits may not be as noticeable in the primary dentition as those that progress into the permanent dentition.[45] Effects resulting from oral habits that are terminated early, before age 6, may be transient, whereas those that persist may adversely effect the permanent dentition as well.[29,46,47]

Although various nutritive feeding methods showed trends of increasing or decreasing steadily with age, the extent and duration of nonnutritive oral habits was less predictable, and in this study were found to often outlast the age at which the child was weaned from the breast or bottle. Warren et al[48] found that over 90% of children engaged in some sort of nonnutritive sucking behavior during their first 2 years of life; in 20% of those children that habit persisted beyond 3 years. Because nonnutritive oral habits, such as thumb-sucking and pacifier use, were so common and had such a profound influence on the developing primary occlusion, any possible effect bottle- or breast-feeding may have had could be overpowered. This may explain the findings of this study. When children in this study

with nonnutritive habits were included in the analysis, those who were predominately bottlefed during 12 and 18 months of age were significantly more likely to have an open bite. However, when children with nonnutritive habits were excluded, those who were predominately bottle-fed during the first 6 months of their lives were more likely to have a deep bite, although the association was just shy of nominal statistical significance. Bottle-feeding increased the likelihood that a child would use a pacifier, thus increasing the chance of developing an open bite. In the absence of these nonnutritive habits, bottle-feeding seemed to influence the development of a deep bite.

This unexpected finding may be due to a series of distorted forces as a result of the mechanics of bottle-feeding, including altered muscle development and tooth eruption. The nonnutritive habits that have been shown in this study and in others[15,21,25,27,28] to succeed bottle-feeding may serve to counter the effect of the bottle by reversing those forces of the bottle, eventually causing an open bite.

The difficulty in interpreting these results reflects the multifactorial essence of occlusal development that has posed problems to studies in the past. Genetics is a factor that is difficult to control in any study and is a central limitation in this one as well. It would also be optimal to examine children of the same age, given that substantial growth occurs during the 2- to 6-year old range. However, this is difficult to achieve in a random patient selection process and would likely further jeopardize sample size. A final limitation was the authors' use of a retrospective questionnaire in which data reflected the accuracy of the parents' memory of infant feeding habits; however, the authors had no reason to believe that this would affect one subject group more than another. A future study with a larger sample size and more varied sample is warranted. The task of isolating single variables is paramount and would benefit from long-term studies that could reliably control for simultaneously contributing developmental factors.

## CONCLUSIONS

1. Predominant bottle-feeding between 0 and 6 months was associated with the development of a pacifier habit.

2. Children who used a pacifier were 2.5 times more likely to develop a nonmesial step occlusion, 2.7 times more likely to develop an overjet >3 mm, and 2.9 times more likely to develop an open bite.

3. Children who sucked their thumb were 3.6 times more likely to develop an overjet >3 mm.

4. In the absence of nonnutritive oral habits, children who were predominantly bottle-fed between 0 and 6 months of age were 3.2 times more likely to develop an overbite >75%, although just shy of nominal statistical significance.

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