ORIGINAL ARTICLE

Association between allergic rhinitis, bottle feeding, non-nutritive sucking habits, and malocclusion in the primary dentition

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Arch Dis Child 2006;**91**:836–840. doi: 10.1136/adc.2005.088484

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Accepted 5 June 2006
Published Online First 9 June 2006

Aim: To determine the association between allergic rhinitis, bottle feeding, non-nutritive sucking habits, and malocclusion in the primary dentition.

Methods: Data were collected on 1160 children aged 4–5 years, who had been longitudinally followed since the age of 4 months, when they were admitted to nurseries in a suburban area of Tampico–Madero, Mexico. Periodically, physical examinations were conducted and a questionnaire was given to their parents or tutors.

Results: Malocclusion was detected in 640 of the children (51.03% had anterior open bite and 7.5% had posterior cross-bite). Allergic rhinitis alone (adjusted odds ratio = 2.87; 95% CI 1.57 to 5.25) or together with non-nutritive sucking habits (adjusted odds ratio = 3.31; 95% CI 1.55 to 7.09) had an effect on anterior open bite. Bottle feeding alone (adjusted odds ratio = 1.95; 95% CI 1.07 to 3.54) or together with allergic rhinitis (adjusted odds ratio = 3.96; 95% CI 1.80 to 8.74) had an effect on posterior cross-bite. Posterior cross-bite was more frequent in children with allergic rhinitis and non-nutritive sucking habits (10.4%).

Conclusions: Allergic rhinitis alone or together with non-nutritive sucking habits is related to anterior open bite. Non-nutritive sucking habits together with allergic rhinitis seem to be the most important factor for development of posterior open bite in children under the age of 5 years.

Growth and development of the craniofacial complex (mandibles, dental arches) and external modifying effects (non-nutritive sucking habits, bottle feeding, and nasal obstruction) have been studied by many researchers in paediatrics and dentistry.[1–7] Dental malocclusion (defined as: the loss of the harmonious fitting of two dental arcades with the distal surface of the second inferior deciduous molar slightly mesialised or in the same plane of the distal surface of the superior second molar, and without a correct transversal relationship, with the superior canine cusp inserting just distally to the inferior canine and with the superior incisors partial overhanging the inferior incisors) is one of the manifestations of altered growth of the craniofacial complex.[2 8 9] The documented prevalence of malocclusion in childhood is as high as 49.7%.[3 10] Non-nutritive sucking habits (NNSH) and bottle feeding (BF) are external factors widely known to favour the development of malocclusion.[2 8 11 12] A prevalence of 67.5% of malocclusion in children with NNSH[4] and 41% in children fed with bottles has been reported.[8] Recent studies have shown that prolonged early NNSH and BF affect occlusion and the dental arches,[13–15] while breast feeding for long periods serves as a protective factor against the development of occlusion disorders.[8 13 14 15]

On the other hand, the relationship between nasal obstruction, particularly allergic rhinitis (AR), and development of the craniofacial complex have been studied by several researchers.[16–18] The conclusions of some studies are debatable; several authors have not found a relationship between nasal obstruction and malocclusion, while others have detected a clear connection.[19–21] Studies to establish the incidence level of allergic rhinitis compared to other risk factors for the development of malocclusion are therefore required.

Allergic rhinitis is a chronic respiratory disease that mostly affects children.[22] The prevalence of AR in children ranges from 1.3% to 52%.[23] In children with malocclusion, the prevalence of AR is 12.2%.[20] Clinical manifestations of AR are: volley of sneezes, balanced nasal obstruction, hyaline rhinorrhoea, and nasal pruritus. During physical examination, there is turbinal bone hypertrophy and a transversal line at the posterior nasal wall.[22 23] Allergic rhinitis is a chronic hereditary disease which can become serious. During its clinical progression, it can have complications such as persistent oral breathing, changes in the normal development of the upper maxilla, and the presence of asthma or frequent infections of the near tissues or structures (paranasal sinus, middle ear).[17–22 24]

The aim of this study was to determine the association between allergic rhinitis, bottle feeding during the first year of life, non-nutritive sucking habits, and malocclusion in a cohort of children aged 4–5 years old during primary dentition.

METHODS

The study took place in the Tampico–Madero–Altamira, Mexico area. The region, comprised of these three cities, lies in the southern part of the state of Tamaulipas, on the coastline of the Gulf of Mexico, located 542 km northwest of Mexico City. It has an area of 1492 km^2 and a population of over 900 000 inhabitants.

The children who participated in this study were part of a population included in another major multidisciplinary

Abbreviations: AR, allergic rhinitis; BF, bottle feeding; NNSH, non-nutritive sucking habits

Table 1 Demographic data of the total population

	n	%
Total	1160	
Age (years)	4–5	
Gender		
Male	582	50.2
Breast feeding	686	59.1
Bottle feeding	349	30.1
Non-nutritive feeding habits	256	22.1
Allergic rhinitis	334	28.8
Allergic rhinitis + bottle feeding	273	23.5
Allergic rhinitis + NNSH	77	6.6
Malocclusion	640	55.2

research project, in which a series of specialists took part: an allergy specialist, paediatric dentists, a paediatrician, specialists in family medicine, psychologists, nurses, social workers, and dental assistants. The study took place in 2004. A cohort of children 4–5 years old, born in 1999, 2000, or 2001 were included in the study. The children attended nurseries as required by the Scheme of Ordinary Participation and Unique Communitarian Neighborhood Program, organised by the Mexican Institute of Social Security (IMSS) and preschool education schools (kindergarten) of the area. Physical examinations were performed as part of the nurseries' healthcare activities; weight, height, vaccinations, and detection of contagious and non-contagious diseases were recorded. The nurseries had sufficient information to identify and locate previously registered children, even after their departure at 4 years of age.

Information on each child's lifestyle was recorded, with special emphasis on the number of hours the children watched television and played sports, type of feeding, and the person in charge of their feeding. The children's family allergy history was recorded (family atopy was defined when the father or the mother suffered from asthma or allergic rhinitis). Information on socioeconomic status, parents' education and qualifications, type of family, and family dynamics was also obtained.

Information was collected by questionnaire. It was validated by two pilot studies. In each of these studies, 20 individuals were interviewed during a 15 day period; agreement was 75%. Information on gender, age, weight, and height of the children was obtained. The following information was also recorded: type of feeding during the first year of life, frequency of breast feeding (defined when the children were exclusively breast fed until 4 months old), when they were bottle fed with different types of milk (defined when bottle feeding started before 4 months old), mixed feeding (neither of above two categories), or whether the children had shown any non-nutritive sucking habit—thumb or pacifier sucking for at least four months in the first year of life.

Diagnosis of the different types of malocclusion was made by direct examination of the mouth by a paediatric odontologist using disposable gloves, a tongue stick, and a millimetric scale ruler. Horizontal open bite was measured from the lip-incisive edge of the central superior incisors to the lip surface of the central inferior incisors parallel to the occlusal plane. Measures were categorised as abnormal when open bite exceeded 3 mm, while a horizontal open bite with the same measure or less was considered normal. Vertical open bite was registered in those cases where there was loss of vertical contact among the superior and inferior teeth.

Posterior cross-bite was registered in cases of an inverse relation of one or more teeth or both sides of the jaw.

Children were diagnosed with allergic rhinitis when the parents gave an affirmative answer to the question: has your child experienced snoring, itching, or a stuffy nose without having a cold or the flu? Physical examination of the nostrils was performed using a Welch Allen rhinoscope to determine the size of the tubular bones and the characteristics of the nasal mucosa. To diagnose atopy in children who showed allergic rhinitis symptoms, prick sensitivity tests were carried out and considered positive when the child was reactive to at least one of the allergens used. Skin prick tests were done on the back using 1 mm flanged lancets and extracts of mixed grass pollen, house dust mites (dermatophagoides pharinae and pteronyssinus), cat and dog fur, cockroaches, alternaria, aspergillus, and histamine and diluents as controls. The test solutions used were prepared as single batches by Freeman Laboratories SA de CV, Mexico. Skin prick test reactions to each extract were recorded after 15 minutes, and considered positive if the papule diameter was equal or greater than the diameter of the histamine control wheel. The wheel diameter was estimated using the formula proposed by Thomas.[25]

Written, oral, and informed consent of the parents was requested. The study was approved by the Ethics Committee of the No. 6 Regional General Hospital of the IMSS and the Faculty of Medicine of the Autonomous University of Tamaulipas. The researchers and the parents of the patients were kept blind to the specific research objectives.

Statistical analysis

We used dichotomous variables (yes or no) for indicating the presence or absence of a certain characteristic. For the analysis, single frequencies and central tendency measures (medians and standard deviations) were used. A 2×2 contingency table (χ^2, odds ratios (OR), and 95% CI) was used to determine malocclusion risks caused by BF, NNSH, and AR by comparing one group with malocclusion and another group without it. We estimated adjusted ORs in a logistic regression model in order to determine the effect of one variable having adjusted for the other. Any p value <0.05 was considered significant. Data were analysed using the statistical package SPSS 11.0.

RESULTS

A total of 1160 children were studied; 50.2% were males (table 1); 55.2% (n = 640) of the children included in the project had some form of malocclusion. The most frequent type of malocclusion was anterior open bite (92.5%).

In general terms, we did not find any differences in the percentage of children with malocclusion (table 2) and those without malocclusion suffering from allergic rhinitis (55.4% *v* 55.1%). Allergic rhinitis (OR = 1.01; 95% CI 0.76 to 1.33; p = 0.99), NNSH (55.9% *v* 55.0%; OR = 1.03; 95% CI 0.78 to 1.37; p = 0.85), and bottle feed alone (59.0% *v* 53.5%; OR = 1.10; 95% CI 0.99 to 1.22; p = 0.09) had no effect on malocclusion. The combination of AR with BF for more than a year (50.2% *v* 56.7%; OR = 0.76; 95% CI 0.58 to 1.00; p = 0.06) or with NNSH (54.5% *v* 55.2%; OR = 0.97; 95% CI 0.61 to 1.54; p = 0.99) does not favour the development of malocclusion.

Bottle feeding, AR, and AR + NNSH (table 2) were associated with malocclusion, determined by logistic regression model comprising all children included in this study with adjustment for another variable. The combination of AR + BF showed statistical significance.

Of children with anterior open bites, 52.3% had allergic rhinitis (table 3), in comparison to 50.7% of the children with anterior open bite without AR. Based on the analysis, AR alone (OR = 1.06; 95% CI 0.81 to 1.40; p = 0.69), or together with BF (44.2% *v* 53.1%; OR = 0.70; 95% CI 0.53 to 0.93; p = 0.01) or NNSH (44.2% *v* 51.5%; OR = 0.74; 95% CI 0.46 to

Table 2 Effect of bottle feeding, non-nutritive sucking habits, and allergic rhinitis on malocclusion

Group	Malocclusion Yes	%	No	%	Crude OR (95% CI)	p value	Logistic regression OR (95% CI)	p value
Bottle feeding (+)	206	59.0	143	41.0	1.10 (0.99 to 1.22)	0.09	1.37 (1.06 to 1.78)	0.01
Bottle feeding (−)	434	53.5	377	46.5				
NNSH (+)	143	55.9	113	44.1	1.03 (0.78 to 1.37)	0.85	1.08 (0.77 to 1.51)	0.62
NNSH (−)	497	55.0	407	45.0				
AR (+)	144	55.4	116	44.6	1.01 (0.76 to 1.33)	0.99	2.87 (1.57 to 5.25)	<0.01
AR (−)	496	55.1	404	44.9				
AR + bottle feeding (+)	137	50.2	136	49.8	0.76 (0.58 to 1.00)	0.06	0.27 (0.14 to 0.51)	0.01
AR + bottle feeding (−)	503	56.7	384	43.3				
AR + NNSH (+)	42	54.5	35	45.5	0.97 (0.61 to 1.54)	0.99	3.31 (1.55 to 7.09)	<0.01
AR + NNSH (−)	598	55.2	485	44.8				

(+) Children with the characteristic for over a year; (−) children without the characteristic for over a year.
AR, allergic rhinitis; NNSH, non-nutritive sucking habits.

1.18; p = 0.25) was not a risk factor for development of anterior open bite. Our results show that NNSH (48.4% *v* 51.8%; OR = 0.87; 95% CI 0.66 to 1.15; p = 0.38) or BF during the first year of life (53.6% *v* 49.9%; OR = 1.57; 95% CI 0.90 to 1.48; p = 0.28) have no effect on anterior open bite. The effect of AR + BF on anterior open bite was small.

AR alone or together NNSH (table 3) was associated with anterior open bite, determined by logistic regression model with adjustment for another variable. The combination of AR + BF showed statistical significance.

Data show that the effect of non-nutritive sucking habits and bottle feeding on posterior cross-bite (table 4) is more important than that caused by allergic rhinitis; 7.4% *v.* 3.2% of the children with a history of NNSH had a twofold risk of posterior cross-bite (OR = 2.41; 95% CI 1.33 to 4.39; p < 0.01). BF has an effect on posterior cross-bite (6.0% *v* 3.3%; OR = 1.85; 95% CI 1.03 to 3.33; p = 0.02). The risk of posterior cross-bite triples if the children simultaneously have NNSH and AR (10.4% *v* 3.7%; OR = 3.02; 95% CI 1.36 to 6.71; p < 0.01). AR had no effect on posterior cross-bite (3.1% *v* 4.4%; OR = 0.68; 95% CI 0.31 to 1.47; p = 0.42).

BF and the combination of AR + BF were associated with posterior cross-bite, determined by logistic regression model with adjustment (table 4) for AR, NNSH, and AR + NNSH.

DISCUSSION

For many years, aetiology of malocclusion has been studied. Risk factors include non-nutritive sucking habits, bottle feeding, and allergic rhinitis. Katz *et al* found a 67.9% prevalence of NNSH;[4] Viggiano *et al* reported 42%.[8] In our study, 22.3% of the children included had a history of NNSH.

With respect to bottle feeding, Viggiano *et al* reported that 41% of the children in their study were bottle fed;[8] the prevalence of children bottle fed in our group was 30.1%. Based on current information, the prevalence of rhinitis in children with malocclusion is 12.7%, similar to that reported for the general population.[23] We found a prevalence of 22.2% of children with malocclusion having AR.

The results of studies on the association between AR, NNSH, BF, and malocclusion have been controversial. Some authors have found an association between AR,[17] NNSH, or[4] BF during the first year of life[8] and malocclusion;[19] others report that the effect is only related to certain types of malocclusion.[9 20]

Our data on 1160 children show that allergic rhinitis, bottle feeding, and non-nutritive sucking habits during the first 12 months of life seem to only favour a form of malocclusion.

In the current study, 51.03% of the children had anterior open bite. Based on the results, AR alone or together with NNSH, during the first year of life, seem to have an effect on anterior open bite. Previous reports have been controversial; they have found an effect[8 20] or no effect of NNSH, AR, or BF on anterior open bite.[9 19]

One of the most frequent types of malocclusion is posterior cross-bite (prevalence 13%).[26] Some researchers have found that non-nutritive sucking habits and breast feeding constitute the main risk factors for development of posterior cross-bite.[8 9 13 14 26] Our data support an aetiological role of NNSH and BF on posterior cross-bite. Children with NNSH have a twofold risk of posterior cross-bite. This risk is threefold when the children have NNSH and AR.

It is generally believed that one of the complications that arise during the chronic development of AR is malocclusion. This is due to the children breathing through their mouths, as a result of the nasal obstruction inherent in AR.[17] Bresolin *et al* state that an anterior open bite is a sign of AR.[27] Our study

Table 3 Effect of bottle feeding, non-nutritive sucking habits, and allergic rhinitis on open bite

Group	Anterior open bite Yes	%	No	%	Crude OR (95% CI)	p value	Logistic regression OR (95% CI)	p value
Bottle feeding (+)	187	53.6	162	46.4	1.57 (0.90 to 1.48)	0.28	1.27 (0.98 to 1.64)	0.06
Bottle feeding (−)	405	49.9	406	50.1				
NNSH (+)	124	48.4	132	51.6	0.87 (0.66 to 1.15)	0.38	0.96 (0.69 to 1.34)	0.82
NNSH (−)	468	51.8	436	48.2				
Allergic rhinitis (+)	136	52.3	124	47.7	1.06 (0.81 to 1.40)	0.69	2.87 (1.57 to 5.25)	<0.01
Allergic rhinitis (−)	456	50.7	444	49.3				
AR + bottle feeding (+)	121	44.2	152	55.7	0.70 (0.53 to 0.93)	0.01	0.27 (0.14 to 0.51)	0.01
AR + bottle feeding (−)	471	53.1	416	46.9				
AR + NNSH (+)	34	44.2	43	55.8	0.74 (0.46 to 1.18)	0.25	3.31 (1.55 to 7.09)	<0.01
AR + NNSH (−)	558	51.5	525	48.5				

(+) Children with the characteristic for over a year; (−) children without the characteristic for over a year.

Table 4 Effect of bottle feeding, non-nutritive sucking habits, and allergic rhinitis on posterior cross-bite

Group	Cross-bite Yes	%	No	%	Crude OR (95% CI)	p value	Logistic regression OR (95% CI)	p value
Bottle feeding (+)	21	6.0	328	94.0	1.85 (1.03 to 3.33)	0.02	1.95 (1.07 to 3.54)	0.02
Bottle feeding (−)	27	3.3	784	96.7				
NNSH (+)	19	7.4	237	92.6	2.41 (1.33 to 4.39)	<0.01	1.82 (0.85 to 3.87)	0.1
NNSH (−)	29	3.2	875	96.8				
Allergic rhinitis (+)	8	3.1	252	96.9	0.68 (0.31 to 1.47)	0.42	0.39 (0.12 to 1.29)	0.1
Allergic rhinitis (−)	40	4.4	860	95.6				
AR + bottle feeding (+)	16	5.9	257	94.1	1.66 (0.89 to 3.08)	0.14	3.96 (1.80 to 8.74)	<0.01
AR + bottle feeding (−)	32	3.6	855	96.4				
AR + NNSH (+)	8	10.4	69	89.6	3.02 (1.36 to 6.71)	<0.01	0.67 (0.00 to 138.1	0.67
AR + NNSH (−)	40	3.7	1043	96.3				

(+) Children with the characteristic for over a year; (−) children without the characteristic for over a year.

showed an association between AR and anterior open bite, particularly in children with NNSH, which challenges the interested researcher to develop prospective clinical trials to determine the effect of AR on dental arches of children over 5 years old.

The theory behind how bottle feeding and non-nutritive sucking habits favour the development of malocclusion concerns the different participation of the cranial-facial muscle complexes to those used when the children are breast feeding. Their tongues move like pistons, exerting a force against the palate. This causes a change, altering the harmonious development of the dental arcades.[28] It is generally accepted that breast feeding during the first year of life contributes to the harmonious development of the cranial-facial complex. The mechanism proposed relies on the child placing the mother's areola and nipple in its mouth, using its lips to squeeze, rather than suck breast milk.[8 29]

NNSH and BF compared to AR constitute the most important risk factors for development of certain types of malocclusion in children under 5 years old in our region. This concurs with previous reports which have shown that NNSH and BF only seem to affect posterior cross-bite.[8 14 26]

We conclude that AR has an effect on malocclusion (anterior open bite) in children under 5 years old. There is a clear need for establishing community health programmes limiting NNSH and BF among those children.

What is already known on this topic

- Results from previous studies on the effect of allergic rhinitis on malocclusion development have been inconclusive
- Previous reports have suggested that non-nutritive sucking and bottle feeding may be responsible for certain forms of malocclusion

What this study adds

- Data show that allergic rhinitis, alone or combined with non-nutritive sucking habits, is a significant risk factor for the development of anterior open bite in children under 5 years old
- Non-nutritive sucking habits and bottle feeding seem to be the most important risk factors, rather than allergic rhinitis, for posterior cross-bite

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Competing interests: none declared

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ARCHIVIST

Teratogenicity of first trimester ACE inhibitors

Fetal urine production begins towards the end of the first trimester. Angiotensin converting enzyme (ACE) inhibitors are thought to produce a fetopathy by inhibiting fetal urine production and therefore only do so when taken in the second and third trimesters: the drugs have been considered safe in the first trimester. Features of the fetopathy include renal dysplasia and renal failure, oligohydramnios, hypoplastic calvaria, and intrauterine growth retardation. [Perhaps strangely, if the condition is secondary to fetal anuria or oliguria, they do not seem to include all the features of Potter's syndrome, although pulmonary hypoplasia may, apparently, be a feature]. Now a study in Tennessee (William O Cooper and colleagues. *New England Journal of Medicine* 2006;**354**:2443–51, see also editorial, ibid: 2498–500) has suggested that maternal use of ACE inhibitors in the first trimester increases the risk of major congenital malformations, especially of congenital heart disease and central nervous system (CNS) malformations.

A cohort of 29 507 infants born between 1985 and 2000 included 209 who had been exposed to an ACE inhibitor in the first trimester only, 202 who had been exposed to other antihypertensive drugs in the first trimester only, and 29 096 with no antihypertensive drug exposure at any time in pregnancy. The risk of major congenital malformation was increased significantly, by a factor of 2.7, in the ACE inhibitor group, compared with the no exposure group, but was not increased in the group exposed to other antihypertensives. The risk of cardiovascular malformations was increased 3.7-fold and of CNS malformations 4.4-fold. The numbers of congenital malformations were, however, small and the findings need to be confirmed. The nine children in the ACE inhibitor group with cardiovascular malformations had atrial septal defects, ventricular septal defects, pulmonary stenosis, and patent ductus arteriosus, as either single or combined defects. Three children exposed to ACE inhibitors had CNS malformations, one each with spina bifida, microcephaly plus an eye defect, and coloboma. Two had renal dysplasia.

Maternal medication with an ACE inhibitor in the first trimester is associated with increased risk of a major congenital malformation. ACE inhibitors block the conversion of angiotensin I to angiotensin II. Angiotensin II receptors are widely expressed in fetal tissues and it is suggested that angiotensin II may play a part in the early development of the heart, kidneys, and brain. An editorialist deplores the paucity of available information about the teratogenic risks associated with most drugs and suggests that women who become pregnant while taking an ACE inhibitor should change their medication. Women who have taken an ACE inhibitor in early pregnancy should be offered detailed ultrasonography and echocardiography at 18 weeks gestation.