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Non-nutritive sucking habits, dental malocclusions, and facial morphology in Brazilian children: a longitudinal study

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SUMMARY The aim of this longitudinal study was to assess the relationship between non-nutritive sucking habits and the presence of anterior open bites (AOBs) and posterior crossbites and their association with facial morphology among 4- to 6-year-old children attending state schools in the city of Recife, Brazil. The sample comprised 287 children, both males and females. The proportion of boys to girls was approximately 50 per cent. The average age was 4 years 5 months at the beginning and 6 years 6 months at the end of the study. Data were collected from interviews with mothers or carers, and the clinical examination was carried out by two calibrated examiners. Statistical analysis was undertaken using bivariate analysis, Pearson's chi-square, McNemar, and Stuart–Maxwell tests.

The results revealed a significant reduction in AOB ($P<0.001$) and a slight increase in the prevalence of posterior crossbites. Both occlusal traits were associated with a previous history of sucking habits. The most prevalent morphological facial type, assessed using the morphological facial index, was high (≥88 mm) and a statistically significant ($P = 0.02$) association was found between facial morphology and an AOB. Children with an average or high facial morphology measurement exhibited a greater prevalence of AOB when compared with those with lower measurements. Self-correction of AOB was associated with cessation of sucking habits but facial morphology remained unaltered.

Introduction

Sucking habits and associated occlusal anomalies have been studied extensively. It has been demonstrated that an anterior open bite (AOB) and posterior crossbite are the most frequent malocclusions associated with prolonged sucking habits (Larsson, 2001; Warren and Bishara, 2002; Burford and Noar, 2003; Katz *et al.*, 2004).

Katz *et al.* (2004) assessed the relationship between non-nutritive sucking habits, facial morphology, and malocclusion in 330 Brazilian 4-year olds. The results demonstrated that a large percentage (67.9 per cent) of children exhibited non-nutritive sucking habits at some point in their lives. AOB and posterior crossbites were found in 36.4 and 12.1 per cent of the children, respectively. An association was also observed between malocclusions and non-nutritive sucking habits. The authors drew attention to the magnitude of the problem and emphasized the need for more longitudinal studies to allow clinical practice guidelines to be developed.

Farsi and Salama (1997) studied 583 Saudi children aged 3–5 years and found posterior crossbites in 5.5 per cent of the group. However, they noted that crossbites were equally prevalent in children with and without sucking habits, suggesting that factors other than the habit may be responsible for this occlusal trait.

It has been shown that self-correction of an AOB may occur following cessation of a sucking habit during the primary dentition (Fields, 1986; Larsson, 2001; Katz and Rosenblatt, 2005) although the same does not apply to a posterior crossbite (Infante, 1976; Kurol and Berglund, 1992). However, it must be noted that a posterior crossbite is more frequent in the primary than in the mixed and permanent dentitions, suggesting that some crossbites in the primary dentition are self-correcting (Thilander *et al.*, 1984; Thilander and Lennartsson, 2002).

A randomized clinical trial carried out in Stockholm followed 76 children with a unilateral posterior crossbite from 4 to 9 years of age and found that 17 per cent of the crossbites showed self-correction (Lindner, 1989).

The aetiology of malocclusion is primarily genetic with environmental influences (Vig and Fields, 2000). It is believed that the facial growth pattern is an important genetic factor which contributes to the development of malocclusions and also influences the treatment of such anomalies (Moyers, 1988; Enlow, 1993). According to Proffit and Fields (1986), children who have a balanced, or horizontal, growth pattern are more likely to experience self-correction of an open bite than those with a long face or vertical growth pattern.

There are few Brazilian studies in the literature which have investigated the most prevalent malocclusions and their associated aetiological factors. Thus, the aim of the present longitudinal study was to assess the relationship between non-nutritive sucking habits and the presence of AOB and posterior crossbites, as well as their association with facial morphology.

Subjects and methods

This longitudinal study was conducted in public schools in the city of Recife, the capital of Pernambuco, a state in the northeast of Brazil. The project was approved by the Ethics Committee of Pernambuco State University. The sample comprised children from 4 to 6 years of age; the average age was 4 years 5 months at the beginning and 6 years 6 months at the end of the study.

Children were excluded from the study if their parents did not agree to their participation; they had cavities and/or extensive restorations; marked occlusal wear or early loss of primary teeth; alterations in the number, size, and shape of teeth and syndromes or systemic problems affecting craniofacial growth.

To determine the sample size and validity of the methodological procedures, a pilot study was conducted that included 100 children from 4 to 6 years of age attending two state schools. The prevalence of malocclusions associated with sucking habits found in the pilot study was then used to calculate the sample required for the main investigation. Using a formula for cohort studies in the Statcalc of Epi Info Version 2000 (Atlanta, Georgia, USA) software package, it was estimated that 252 children would be required, with an additional 30 per cent to compensate for possible dropouts during the study period. Hence, the initial sample comprised 330 children (Katz *et al.*, 2004).

The children were randomly selected from 14 of 153 nursery schools by a stratified randomized sampling technique. The nursery schools were randomly selected from each administrative region in proportion to the number of schools in each region.

The data were collected with a questionnaire, completed during personal interviews with each child's mother or carer, which included questions on gender, date of birth, and the presence or absence of non-nutritive sucking habits such as dummy and/or digit (thumb or finger) sucking. Data regarding the duration of sucking habits, i.e. the number of years between start and cessation, were not considered because most mothers were uncertain about this. Two calibrated examiners carried out the clinical examinations; the first examination was in 2002 and the second in 2004.

Dental examinations were performed under natural light in a classroom environment, using tongue depressors, gloves, and masks in compliance with the infection control protocol of the Brazilian Ministry of Health. The occlusion was assessed in centric occlusion, and the examiner was blinded to the information collected from the parental interviews. An AOB was recorded when there was lack of vertical overlap of more than 3 mm between the primary incisors with the posterior teeth in occlusion. When a physiological AOB, related to eruption of the central permanent incisors, was observed, it was recorded as an absence of malocclusion. A posterior crossbite was recorded when one or more of the maxillary molars occluded palatal to the buccal cusp of the opposing mandibular teeth.

Facial morphology was assessed using the morphological facial index (MFI) defined as the ratio of morphological face height and the bizygomatic width. Morphological face height is defined as the distance between nasion and gnathion and the bizygomatic width as the distance between the zygoma points (Martin and Saller, 1959). The measurements were taken directly on the patient's face with a 6 inch Digimatic calliper accurate to 0.02 mm (Mitutoyo Sul Americana Ltda, São Paulo, Brazil) and recorded in millimetres. Facial morphology was categorized as low (≤83.9 mm), average (84.0–87.9 mm), or high (≥88.0 mm).

To ensure standardization of the diagnostic criteria during the two phases of the study, calibration of the examiners was performed using the Kappa (κ) test (Bulman and Osborn, 1989). The κ coefficients for inter- and intra-examiner calibration were 0.96 and 1.0, respectively.

The data were statistically analysed using the Statistical Package for Social Sciences Version 7.5 (SPSS Inc., Chicago, Illinois, USA) and SAS System, Version 8.2 (Cary, North Carolina, USA). Bivariate analysis, Pearson's chi-square, McNemar, and Stuart–Maxwell tests were used for statistical analysis. Significance was predetermined at $P < 0.05$.

Results

At the end of the 2-year follow-up, the dropout rate was 13 per cent ($n = 43$) with the 287 children remaining. The ratio of boys to girls was approximately 1:1.

A statistically significant reduction in the prevalence of sucking habits ($P < 0.001$) and AOB ($P < 0.001$) was observed with age. The prevalence of a posterior crossbite increased slightly from 9.1 to 10.4 per cent, but this was not statistically significant (Table 1).

There was a statistically significant change in facial morphology throughout the study and an increased MFI was the most prevalent, although the percentage of those with average and low measurements increased over the 2-year period (Table 1).

The prevalence of an AOB was higher among children with sucking habits. A statistically significant association between these two variables was established in the two phases of the study ($P < 0.001$; Table 2). Table 3 shows the assessment of AOB according to facial morphology. At the second examination, there was a significant association between the MFI and the occurrence of an AOB ($P = 0.0227$). There was also a statistically significant association between a posterior crossbite and sucking habits at 4 years of age ($P = 0.0027$; Table 4). However, the MFI was not associated with the occurrence of a posterior crossbite ($P = 0.4968$ and $P = 0.1786$ for the initial and final examinations, respectively; Table 5).

AOBs showed an 18.8 per cent level of self-correction ($n = 54$) with two new cases (0.7 per cent). Only 0.4 per cent

of posterior crossbites self-corrected ($n = 1$) and there were five new cases (1.7 per cent).

Table 6 shows the analysis of self-correcting AOBs according to cessation of sucking habits and the facial morphology type in those children who, at the first examination, exhibited both sucking habits and an AOB. A statistically significant association was found between the cessation of sucking habits and self-correction of an AOB ($P < 0.001$). The greatest prevalence of self-correction was recorded in children with a low MFI (77.8 per cent); however, this was not statistically significant (Table 6).

Table 1 Prevalence of sucking habits, anterior open bite, posterior crossbite, and facial morphology in the two phases of the study.

Variable	Assessment				Significance (P)
	Initial examination		Final examination		
	n	%	*n*	%	
Sucking habit					
Yes	100	34.8	48	16.7	
No	187	65.2	239	83.3	P* < 0.001†
Total group	287	100.0	287	100.0	
Anterior open bite					
Yes	92	32.1	40	13.9	
No	195	67.9	247	86.1	P* < 0.001†
Total group	287	100.0	287	100.0	
Posterior crossbite					
Yes	26	9.1	30	10.4	
No	261	90.9	257	89.6	P* = 0.1015
Total group	287	100.0	287	100.0	
Morphological facial index					
Low facial skeleton	23	8.0	76	26.5	
Average facial skeleton	34	11.9	89	31.0	P‡ < 0.001†
High facial skeleton	230	80.1	122	42.5	
Total	287	100.0	287	100.0	

*McNemar test. †Statistical significance at 5.0%. ‡Stuart–Maxwell test.

Discussion

The prevalence of sucking habits in the current study was higher than that found in previous research (Øgaard *et al.*, 1994; Adair *et al.*, 1995; Farsi and Salama, 1997; Keski-Nisula *et al.*, 2003). According to Jenkins *et al.* (1984) and Massler (1963), sucking habits appear to be related to socio-economic status as well as to cultural features. The difference may also be explained by the level of heterogeneity in the target population. The population in the northeast of Brazil is a mixture of Negroes, Indians, and those of Portuguese ancestry. The population heterogeneity in Pernambuco contrasts with that of other studies involving relatively homogeneous populations (Øgaard *et al.*, 1994; Farsi and Salama, 1997; Keski-Nisula *et al.*, 2003). In one study (Adair *et al.*, 1995) involving Afro- and Euro-Americans, the time of cessation of sucking habits was said to be related to such heterogeneity.

Although there was no professional intervention during the period between the first and second examinations, a significant reduction in the prevalence of sucking habits was observed, reflecting a natural tendency among school-age children towards habit cessation (Katz and Rosenblatt, 2005; Bishara *et al.*, 2006). The cessation of sucking habits was also associated with a significant reduction in AOB. These findings are in agreement with Fields (1986), Moyers (1988), and Larsson (1985), who found that the cessation of sucking habits between 4 and 6 years of age can result in an improved occlusion. Levine (1998) suggested that if the habit persists beyond this stage, and especially if a forward tongue thrust develops, there is less possibility of improvement.

The results (Table 2) show a statistically significant association between an AOB and the presence of sucking habits, which is in agreement with Øgaard *et al.* (1994), Adair *et al.* (1995), Svedmyr (1979), Karjalainen *et al.* (1999), and Larsson (1975). The presence of a continuing sucking habit was not associated with a posterior crossbite, but it is of note that sucking habits were risk factors for the presence of the two occlusal traits studied. This finding is in agreement with Infante (1976), Svedmyr (1979), Modéer

Table 2 Prevalence of an anterior open bite according to sucking habit.

	Sucking habit	Anterior open bite						*P* value	PR (IC)*
		Yes		No		Total			
		n	%	*n*	%	*n*	%		
Initial examination	Yes	79	79.0	21	21.0	100	100.0	P† < 0.001‡	11.36 (6.66–19.38)
	No	13	6.9	174	93.1	187	100.0		1.00
Total group		92	32.1	195	67.9	287	100.0		
Final examination	Yes	30	62.5	18	37.5	48	100.0	P† < 0.001‡	14.94 (7.84–28.47)
	No	10	4.2	229	95.8	239	100.0		1.00
Total group		40	13.9	247	86.1	287	100.0		

*PR and CI represent prevalence ratio and confidence interval of 95%. †Chi-square test. ‡Statistical significance at 5.0%.

Table 3 Prevalence of an anterior open bite according to the morphological facial index.

	Morphological facial index	Anterior open bite						*P* value	PR (IC)*
		Yes		No		Total			
		n	%	*n*	%	*n*	%		
Initial examination	Low	7	30.4	16	69.6	23	100.0	*P*† = 0.7105	1.0
	Average	13	38.2	21	61.8	34	100.0		1.26 (0.59–2.66)
	High	72	31.3	158	68.7	230	100.0		1.03 (0.54–1.96)
Total group		92	32.1	195	67.9	287	100.0		
Final examination	Low	5	6.6	71	93.4	76	100.0	*P*† = 0.0227‡	1.00
	Average	19	21.4	70	78.6	89	100.0		3.24 (1.27–8.28)
	High	16	13.1	106	86.9	122	100.0		1.99 (0.76–5.22)
Total group		40	1.9	247	86.1	287	100.0		

*PR and CI represent prevalence ratio and confidence interval of 95%. †Chi-square test. ‡Statistical significance at 5.0%.

Table 4 Prevalence of a posterior crossbite according to sucking habit.

	Sucking habit	Posterior crossbite						*P* value	PR (CI)*
		Yes		No		Total			
		n	%	*n*	%	*n*	%		
Initial examination	Yes	16	16.0	84	84.0	100	100.0	*P*† = 0.0027‡	2.99 (1.41–6.35)
	No	10	5.4	177	94.6	187	100.0		1.00
Total group		26	9.1	261	90.9	287	100.0		
Final examination	Yes	8	16.7	40	83.3	48	100.0	*P*† = 0.1231	1.81 (0.86–3.82)
	No	22	9.2	217	90.8	239	100.0		1.00
Total group		30	10.5	257	89.5	287	100.0		

*PR and CI represent prevalence ratio and confidence interval of 95%. †Pearson's chi-square test. ‡Significant association at 5.0%.

Table 5 Prevalence of a posterior crossbite according to the morphological facial index.

		Posterior crossbite						*P* value	PR (CI)*
		Yes		No		Total			
		n	%	*n*	%	*n*	%		
Initial examination	Low	2	8.7	21	91.3	23	100.0	*P*† = 0.4968	1.0
	Average	1	2.9	33	97.1	34	100.0		0.34 (0.03–3.52)
	High	23	10.0	207	90.0	230	100.0		1.15 (0.29–4.57)
Total group		26	9.1	261	90.9	287	100.0		
Final examination	Low	10	13.2	66	86.8	76	100.0	*P*† = 0.1786	2.01 (0.83–4.86)
	Average	12	13.5	77	86.5	89	100.0		2.06 (0.88–4.82)
	High	8	6.6	114	93.4	122	100.0		1.00
Total group		30	10.5	257	89.5	287	100.0		

*PR and CI represent prevalence ratio and confidence interval of 95%. †Fisher's exact test.

et al. (1982), Øgaard *et al.* (1994), and Warren *et al.* (2005).

The prevalence of a posterior crossbite increased slightly, despite the reduction in sucking habits, suggesting that a posterior crossbite may be associated with exposure to sucking habits before 4 years of age and that its maintenance does not, as suggested by Svedmyr (1979), depend on a continued habit after this age.

Table 6 Assessment of the incidence of self-correction of an anterior open bite (AOB) according to cessation of sucking habit and facial morphology.

Variables	Self-correction of AOB						*P* value	PR (CI)*
	Yes		No		Total			
	n	%	*n*	%	*n*	%		
Abandoned habits								
Yes	38	84.4	7	15.6	45	100.0	*P*† < 0.0001‡	3.19 (1.80–5.66)
No	9	26.5	25	73.5	34	100.0		1.00
Total group	47	59.5	32	40.5	79	100.0		
Facial morphology								
Low	14	77.8	4	22.2	18	100.0	*P*† = 0.1469	1.34 (0.93–1.94)
Average	18	50.0	18	50.0	36	100.0		0.86 (0.56–1.32)
High	22	57.9	16	42.1	38	100.0		1.00
Total group	54	58.7	38	41.3	92	100.0		

*PR and CI represent prevalence ratio and confidence interval of 95%. †Pearson's chi-square test. ‡Significant association at 5.0%.

The Brazilian population has cultural habits similar to those of other developing countries. This is evidenced in this investigation since the prevalence of posterior crossbites is in agreement with studies conducted both in developed and developing countries (Modéer *et al.*, 1982; Øgaard *et al.*, 1994; Warren and Bishara, 2002; Warren *et al.*, 2005). On the other hand, primitive societies show a lower prevalence of malocclusions, especially posterior crossbites, which are usually correlated with higher masticatory frequency and different nutrition (Larsson, 1983; Corruccini *et al.*, 1985; Thilander *et al.*, 1991).

Only one subject showed self-correction of a posterior crossbite during the 2-year follow-up. These results are in agreement with Infante (1976), Proffit and Fields (1986), and Karjalainen *et al.* (1999), who stated that spontaneous correction of a posterior crossbite rarely occurs. In contrast, Lindner (1989), Kurol and Berglund (1992), and Thilander and Lennartsson (2002) reported that a percentage of self-correction does occur. These studies were carried out over a longer period (5–10 years), which may explain the difference in the results.

Further research, including cephalometric evaluation of patients with and without sucking habits, is needed to clarify why a large number of children who have sucking habits do not develop a malocclusion (Farsi and Salama, 1997) and also why children without such a habit have this disorder (Paredes Galardo and Paredes Cencillo, 2005).

In this cohort study, the majority of the children (84.0 per cent), in spite of having sucking habits at the first examination, did not develop a posterior crossbite and only 10.4 per cent presented with this occlusal trait at the 2-year follow-up. The low prevalence of a posterior crossbite does not characterize the problem as a public health issue and only a longer follow-up of the sample would be able to justify the need for early treatment. There is no evidence at present to support the routine correction of a posterior crossbite in the primary dentition (Malandris and Mahoney, 2004).

In a large number of children with a posterior crossbite associated with an AOB at the start of the study, the AOB self-corrected after cessation of the sucking habit, which suggests that correction of an AOB is associated with a reduction in face height and may account for the changes in the MFI values.

The facial morphological analysis was based on anthropometric measurements. While cephalometric analysis would have allowed definition, localization, and quantification of skeletal disharmonies, due to ethical, operational, and financial difficulties, these analyses were not possible.

At the second examination, an association was found between facial morphology and AOB ($P = 0.02$). Children with an average or high MFI exhibited a higher prevalence of AOB compared with those with a low MFI. These findings are in agreement with Almeida and Ursi (1990) and Ngan and Fields (1997). Self-correction of an AOB was not associated with facial morphology but with cessation of the sucking habit.

A longitudinal study of this type was appropriate for investigating the effect of non-nutritive sucking habits and facial morphology in the presence of malocclusions, especially since there was no professional intervention which could have distorted the results. This cohort was representative of the population and the relatively low dropout of 13 per cent should not affect the findings of the present investigation.

Conclusions

1. Non-nutritive sucking habits are risk factors for the occurrence of an AOB and a posterior crossbite.
2. AOBs were associated with the presence of continuing sucking habits, whereas the same was not true for posterior crossbites.
3. There was a significant reduction in the prevalence of AOBs with age, suggesting the self-corrective nature of this malocclusion.

4. A statistically significant association was found between facial morphology and AOB among 6-year-old children.
5. Self-correction of an AOB was associated with the cessation of sucking habits but not with facial morphology.
6. There was no association between sucking habits and facial morphology in the assessment of the two occlusal traits studied.

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References

Adair S M, Milano M, Lorenzo I, Russel C 1995 Effects of current and former pacifier use on the dentition of 24- to 59-month-old children. Pediatric Dentistry 17: 437–444

Almeida R R, Ursi W J S 1990 Anterior open bite: etiology and treatment. Oral Health 80: 27–31

Bishara S E, Warren J J, Broffitt B, Levy S M 2006 Changes in the prevalence of nonnutritive sucking patterns in the first 8 years of life. American Journal of Orthodontics and Dentofacial Orthopedics 130: 31–36

Bulman J S, Osborn J F 1989 Statistics in dentistry. Brazil Dental Journal 166: 78–90

Burford D, Noar J H 2003 The causes, diagnosis and treatment of anterior open bite. Dental Update 30: 235–241

Corruccini R S, Flander L B, Kaul S S 1985 Mouth breathing, occlusion, and modernization in a north Indian population. An epidemiologic study. Angle Orthodontist 55: 190–196

Enlow D H 1993 Facial growth, 3rd edn. Saunders Company, Philadelphia, pp. 1–23.

Farsi N M, Salama F S 1997 Sucking habits in Saudi children: prevalence, contributing factors and effects on the primary dentition. Pediatric Dentistry 19: 28–33

Fields H W 1986 Treatment of nonskeletal problems in preadolescent children. In: Profft W R (ed). Contemporary orthodontics Profft W R (ed). Mosby, Philadelphia, pp. 342–384.

Infante P F 1976 An epidemiologic study of finger habits in preschool children, as related to malocclusion, socioeconomic status, race, sex and size of community. Journal of Dentistry for Children 1: 33–38

Jenkins P M, Feldman B S, Stirrups D R 1984 The effect of social class and dental features on referral for orthodontic advice and treatment. British Journal of Orthodontics 11: 185–188

Karjalainen S, Rönning O, Lapinleimu H, Simell O 1999 Association between early weaning, non-nutritive sucking habits and occlusal anomalies in 3-year-old Finnish children. International Journal of Paediatric Dentistry 9: 169–173

Katz C R T, Rosenblatt A 2005 Nonnutritive sucking habits and anterior open bite in Brazilian children: a longitudinal study. Pediatric Dentistry 27: 1–5

Katz C R T, Rosenblatt A, Gondim P P C 2004 Nonnutritive sucking habits in Brazilian children: effects on deciduous dentition and relationship with morphology. American Journal of Orthodontics and Dentofacial Orthopedics 126: 53–57

Keski-Nisula K, Lehto R, Lusa V, Keski-Nisula L, Varrela J 2003 Occurrence of malocclusion and need of orthodontic treatment in early mixed dentition. American Journal of Orthodontics and Dentofacial Orthopedics 124: 631–638

Kurol J, Berglund L 1992 Longitudinal study and cost-benefit analysis of the effect of early treatment of posterior cross-bites in the primary dentition. European Journal of Orthodontics 14: 173–179

Larsson E 1975 Dummy- and finger-sucking habits in 4-year-olds. Swedish Dental Journal 68: 219–224

Larsson E 1983 Malocclusion in juvenile medieval skull material. Swedish Dental Journal 7: 185–190

Larsson E 1985 The prevalence and aetiology of prolonged dummy and finger-sucking habits. European Journal of Orthodontics 7: 172–176

Larsson E 2001 Sucking, chewing, and feeding habits and the development of crossbite: a longitudinal study of girls from birth to 3 years of age. Angle Orthodontist 71: 116–119

Levine R S 1998 Oral aspects of dummy and digit sucking. British Dental Journal 186: 108

Lindner A 1989 Longitudinal study on the effect of early interceptive treatment in 4-year-old children with unilateral crossbite. Scandinavian Journal of Dental Research 97: 432–438

Malandris M, Mahoney E K 2004 Aetiology, diagnosis and treatment of posterior cross-bites in the primary dentition. International Journal of Paediatric Dentistry 14: 155–166

Martin R, Saller K 1959 Lehrbuch der antropologie. In: Rakosi T, Jonas I, Graber T M (eds) Orthodontic-diagnosis. Color atlas of dental medicine. Thieme, New York, p. 109

Massler M 1963 Oral habits, origin, evolution and current concepts of management. Alpha Omega 56: 127–134

Modéer T, Odenrick L, Lindner A 1982 Sucking habits and their relation to posterior crossbite in 4-year-old children. Scandinavian Journal of Dental Research 90: 323–328

Moyers R E 1988 Handbook of orthodontics. Year Book Medical Publishers, Philadelphia, pp. 127–140.

Ngan P, Fields H W 1997 Open bite: a review of etiology and management. Pediatric Dentistry 19: 91–98

Øgaard B, Larsson E, Lindsten R 1994 The effect of sucking habits, cohort, sex, intercanine arch widths, and breast or bottle feeding on posterior crossbite in Norwegian and Swedish 3-year-old children. American Journal of Orthodontics and Dentofacial Orthopedics 106: 161–166

Paredes Gallardo V, Paredes Cencillo C 2005 Prevalencia de los hábitos bucales y alteraciones dentarias en escolares Valencianos. Anales de Pediatria (Barcelona) 62: 261–265

Proffit W R, Fields H W 1986 The development of orthodontic problems. In: Profft W R (ed). Contemporary orthodontics. Mosby, Philadelphia, pp. 95–119.

Svedmyr B 1979 Dummy sucking. A study of its prevalence, duration and malocclusion consequences. Swedish Dental Journal 3: 205–210

Thilander B, Lennartsson B 2002 A study of children with unilateral posterior crossbite, treated and untreated, in the deciduous dentition—occlusal and skeletal characteristics of significance in predicting the long-term outcome. Journal of Orofacial Orthopedics 63: 371–383

Thilander B, Wahlund S, Lennartsson B 1984 The effect of early interceptive treatment in children with posterior cross-bite. European Journal of Orthodontics 6: 25–34

Thilander B, Mohlin B, Engermark I 1991 Orthodontic aspects on a skull collection from the Carmelite monastery in New Varberg. Proceedings of the Finnish Dental Society 87: 115–125

Vig K W L, Fields H W 2000 Facial growth and management of orthodontic problems. Pediatric Clinics of North America 47: 1085–1123

Warren J J, Bishara S E 2002 Duration of nutritive and nonnutritive sucking behaviors and their effects on the dental arches in the primary dentition. American Journal of Orthodontics and Dentofacial Orthopedics 121: 347–356

Warren J J, Slayton R L, Bishara S E, Levy S M, Yonezu T, Kanellis M J 2005 Effects of nonnutritive sucking habits on occlusal characteristics in the mixed dentition. Pediatric Dentistry 27: 445–450