

Presence of *Candida spp.* in infants oral cavity and its association with early childhood caries

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Abstract

Candida spp., mainly *C. albicans*, colonizes oral cavity of infants. Transmission by mother to childbirth, pacifier use, feeding habits and caries are factors related to *Candida* oral colonization. Some researches related that early childhood caries favor the oral colonization of *C. albicans*. The present literature review described the presence of *Candida spp.* in oral cavity of infants and its association with early childhood caries (ECC). The literature was searched for original papers relating *Candida*, pacifier and baby bottle usage and ECC. The articles were selected using Bireme and Medline databases. Manual tracing of references cited in key papers was also elicited. It can be concluded that *Candida spp.* colonization in the infants' oral cavity, especially *C. albicans*, can be related to the pacifier usage, feeding habits and caries lesions. The early childhood caries favor the *C. albicans* colonization, although it's role in the carious process need further studies to be elucidate scientifically.

Key Words:

candida, early childhood caries, pacifier, baby bottle

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Introduction

The mainly *Candida* specie that colonize the human oral cavity is *Candida albicans* (*C. albicans*)¹, its presence as well as occurrence period may be related to many factors such as birth infections, nurse's fingers, hospital maternity, baby bottle and infected pacifier, maternal skin, air and water²⁻⁵. Furthermore, an important factor related to the colonization of *C. albicans* is carious teeth that may constitute an ecologic niche for the progression and dissemination from this yeast in the human organism⁶.

At first, the oral cavity of neonates is germ-free or contains the same microorganisms of the mother's vagina, which will decrease in number some days after birth and will be readily changed by child caretaker microorganisms⁷. Thus, the cariogenic microorganisms can be transmitted to the infant and the caries development may be favored⁸.

Early childhood caries (ECC) is the actual term designed for the first caries lesions manifestation in infants younger than 6 years old⁹. The etiology is related to the frequent and prolonged habits like sleep or put to bed with a bottle until the child fall asleep and sweetened pacifier¹⁰. When the excessive use of baby bottle predicts this caries pattern, the primary maxilar incisor is the first teeth to be affected in the clinical examination. So, demineralized areas and further cavities at the gingival margin are developed. The next susceptible teeth are the primary first molars; however, the primary mandibular incisor teeth are usually not affected by the cariogenic challenge. The rapid progression of ECC could take the whole crown¹¹.

Studies on microflora of ECC were initiated in the 1980's and the predominant microorganisms identified were mutans Streptococci, although others have been isolated, e.g. *Candida* spp., *Lactobacillus* spp., *Veilonella* spp.¹². Between them, *C. albicans* have shown a high acidogenic potential¹³ and biofilm formation affected by dietary sugars¹⁴, highlighting the researchers' interests in the role of *C. albicans* in caries process, mainly in infants.

Thus, the aim of the present literature review is describe the relationship between pacifier and baby bottle usage with *Candida* spp. colonization in infants as well as show *C. albicans* association with early childhood caries, considering the studies present in the literature.

Reviewing Methodology

The authors searched for papers using Bireme and Medline databases from 1960 to 2006. The search was supplemented by manual searching of reference lists from each relevant paper identified. The main search terms were "Candida", "pacifier", "baby bottle", "early childhood caries", "nursing caries" and "baby bottle caries". A total of 25 records were originally identified through the filters. These were printed as abstracts or full-text articles if the abstract was missing. Only original papers were considered. Interim reports,

abstracts, letters, reviews, and chapters in textbooks were discarded. Articles in German were not accepted. This way, 11 articles were obtained. The main reason for exclusion of 14 articles was papers that evaluated the colonization of *Candida* in children with health disturbs, like candidiasis, seborrheic dermatitis, bacteremia, septicemia, acute otitis media, acute diarrhea, persistent palatal ulcer and bloodstream infections. Additionally, 13 studies were included from references of the 11 selected papers in order to explain some findings. One thesis was found relating *Candida* and ECC. Thus, 17 studies were critically assessed (Table 1).

Literature Review

Pacifier and baby bottle usage associated with Candida spp. colonization in infants

During the early childhood, the infants are more susceptible to opportunistic microorganisms colonization in the oral cavity, especially *C. albicans*, due to immature immune system and microflora not already established⁷. Furthermore, pacifier and baby bottle habits can favor the yeast colonization because they are usually in close contact with the environment. Therefore, researches have been developed in order to investigate these two factors associated to *Candida* colonization.

Several studies found that the use of pacifier increases the occurrence of *Candida* in infants^{2-4,15}. Microorganisms from the outer environment are able to stick to pacifiers as children often drop the pacifiers on the floor and do not take good care of them. The contact with a wide range of microbial species might boost biofilm formation on the surface of pacifier nipples¹⁶. Moreover, the nipples material (silicone versus latex) carries out an influence in yeast colonization. Sio et al.² have found that oral *Candida* in children who sucked pacifier was almost double than the ones that did not, and the frequency of this yeast was lower in silicon than in the latex pacifier (22% e 75%, respectively). Likewise, Comina et al.¹⁶ assessed the microbial contamination on the surface of 25 used pacifier nipples. Nine were made of silicone and 16 were made of latex. The presence of a biofilm was confirmed on 80% of the sample and the two main genera isolated were *Staphylococcus* and *Candida*. Latex pacifier nipples was more contaminated than silicone ones. The material surface may explain this difference, the smoother surface of silicone results in lower microbial adhesion. Moreover, the biofilm thickness in nipples can be influenced by diet because young babies have milkbased diet that brings fewer nutrients for the growth of microorganisms.

The *Candida* frequency and its relationship with feeding and sucking habits were evaluated by Mattos-Graner et al.¹⁷ in brazilian infants (1 to 18 months). They found that 58.3% of the sample was positive to this yeast and the most prevalent species was *C. albicans*. Despite the fact that the

Table1 - Association among the presence of *Candida* spp. in the oral cavity of infants and pacifier, bottle-feeding, breast-feeding and ECC.

Authors	Year	Topics analyzed				Association with <i>Candida</i>			
		Pacifier	Bottle*	Breast**	ECC	Pacifier	Bottle	Breast	ECC
Hodson and Craig ²³	1972	yes	yes		yes	no	no		yes
Sio et al. ²	1987	yes				yes			
Darwazeh and Al-Bashir ³	1995	yes	yes	yes		yes	no	no	
Ollila et al. ⁴	1997	yes	yes			yes	no		
Ollila et al. ¹⁵	1998	yes	yes		yes	yes	yes		yes
Hannula et al. ¹⁹	1999	yes				yes			
Radford et al. ²⁴	2000				yes				yes
Marchant et al. ¹²	2001				yes				yes
Mattos- Graner et al. ¹⁷	2001	yes	yes			yes	no		
Akdeniz et al. ²⁰	2002		yes		yes		yes		yes
Hossain et al. ⁶	2003				yes				yes
Mondin ⁵	2003				yes				yes
Zollner et al. ²¹	2003		yes	yes			yes	no	
Kadir et al. ²²	2005		yes	yes			yes	no	
Carvalho et al. ²⁵	2006		yes		yes		yes		yes
Comina et al. ¹⁶	2006	yes				yes			
Ersin et al. ¹⁸	2006	yes	yes			yes	yes		

* *Bottle=bottle-feeding****Breast=breast-feeding*

pacifier habit was associated to the presence of *Candida* spp., the baby bottle usage was not. It was concluded that the pacifier is an important factor to the colonization and proliferation of this yeast in infants. Likewise, Ersin et al.¹⁸ showed association between *C. albicans* and prolonged pacifier usage. Although they also verified that feeding bottle with sweetened milk and maternal sharing were strongly associated with the colonization of *C. albicans*. Hannula et al.¹⁹ also verified that the mother habits' of cooling the child's food by blowing and cleaning the child's pacifier in her own mouth presented significant relationship with *Candida* colonization in children. Unlike the Mattos-Graner et al.¹⁷ study, others investigations showed that the baby bottle feeding also increases the *Candida* spp. occurrence in infants^{15,20-22}.

Other topic analyzed in the studies was the occurrence of *Candida* spp. in the oral cavity of breast and bottle feeding infants. *Candida* species were much less frequent in infants who were breastfed than in those who were bottlefed²¹⁻²². Kadir et al.²² found that the prevalence of carriage in children who were fed with both breast milk and bottle milk or other

fluids was 18.5%, while in children fed only with breast milk was 0%. This finding showed that there may be intrinsic differences in oral carriage of *Candida* species between different ages and populations and the type of dietary intake may affect the frequency of carriage.

It is clear that exist differences among the studies and it may occur due to several factors, such as type of experimental study design, sample size, material collected (saliva or biofilm), collection of sample (swab, curette), sample analysis technique for identification of yeast (morphological, biochemical and molecular tests), media culture used, etc. However, is recognized that biofilm, which are usually formed on rubber and plastic materials, represents a substratum for *Candida* colonization^{16,20}, and the high incidence of sweetened substances in children's diet, poor oral hygiene, presence of caries lesions and prolonged use of feeding bottles and pacifiers are the major factors related to the high prevalence of *C. albicans* in children^{2,6,15,20,22}.

Early childhood caries and *Candida* spp.

Although there are an extensive number of studies about

early childhood caries and *Candida* spp. separately, there are few reports about the association between them. The carious lesion is the highest colonization site of *C. albicans*^{5,12} because it provides an ecologic niche for this microorganism that may be released to the human organism⁶.

A hierarchy of adherence exists among *Candida* species that leads to a clear correlation between adhesion and virulence. *C. albicans* and *C. tropicalis* adhere to oral epithelial cells and acrylic prosthesis surfaces in a greater extent than the nonpathogenic species, such as *C. krusei* e *C. guilliermondii*¹.

Hodson and Craig²³ were the first researches that evaluated the prevalence of *C. albicans* in the dental biofilm. Children with poor hygiene habits, high caries prevalence and pacifier or baby bottle feeding were evaluated. The authors concluded that the influence of caries cavities on the yeast prevalence appeared to be greater than the sweet-eating habit itself and the use of pacifier and baby bottle with sweeteners. Some studies found that the *Candida* spp. prevalence, especially *C. albicans*, is greater in ECC infants than caries-free ones. Hodson and Craig²³ also found that *C. albicans* in the biofilm of ECC (56%) are twice more prevalent than caries-free children (33%). Radford et al.²⁴ compared the frequency of isolation of yeasts in the saliva of one-year-old infants and these microorganisms were isolated more frequently from infants with caries compared to those who were caries-free (23.7% e 10.4%, respectively). Likewise, Marchant et al.¹² found that the frequency of *C. albicans* isolation were 89% in carious dentin of ECC versus 7% in biofilm of children without carious lesions. Hossain et al.⁶ observed that infants caries-free presented only 2% of *C. albicans* in saliva samples. In contrast, the ECC group harboured the highest concentration of yeast, 67% in the saliva and 82% in carious lesions. Carvalho et al.²⁵ also verified that the frequency of *C. albicans* in carious dentin and biofilm from ECC (60.4%) children was higher when compared to caries (14.3%) and caries-free (12.5%) groups.

The decrease in *Candida* spp. colonization after the dental treatment was investigated by Mondin⁵ in 64 infants aging 2 to 3 years, whom 32 were caries-free while 32 had caries. The operative intervention decreased the number of yeasts in ECC children, however they were not completely eliminated. The predominant species were *C. albicans* in the ECC group. Unfortunately, there is little information regarding a possible relationship between *C. albicans* and caries, although scientific evidence about the yeast cariogenic potential exists¹³⁻¹⁴. *C. albicans* shows poor attachment to the clean tooth surface itself and requires a pellicle of proteins such as amylase, albumine, immunoglobulins, prolin-rich proteins to promote binding²⁶. Additionally, this yeast may show interaction with other microbes and microbial products. Also, the co-aggregation reactions with bacteria may play a large role in the colonization of oral mucosal and hard tissues.

Once yeast cells become attached to bacteria and /or oral surfaces, their growth may be enhanced by the metabolic products of oral bacteria²⁶. Furthermore, *C. albicans* has a high collagenolytic activity and can adhere to the intact and denaturated collagen exposed from dentin. This process may contribute to the persistence of *C. albicans* on the surface of dissolved hydroxyapatite because of high adherence capacity of this yeast to collagen¹³.

The effect of dietary sugars on *Candida* biofilm formation has also been studied from an oral point of view, since dietary carbohydrates modulate microbial colonization of the latter niche. Two monosaccharides, glucose and galactose, have been extensively investigated for their effect on candidal adhesion¹⁴. Several studies have demonstrated that culture media that are rich in carbohydrates such as glucose, sucrose and particularly galactose, increase the adherence of *C. albicans* to epithelial cells and to dental acrylic surfaces due to the additional production of the fibrillar-floccular surface layer that became the yeast more resistant, favoring the adhesion and biofilm formation^{14,27-28}. Clinically, this is extremely important because a carbohydrate rich diet may lead to the development and colonization of *C. albicans*.

The ECC children have a frequent habit of night bottle feeding²⁹. Milk contains lactose, which will be degraded to galactose and glucose, following the addition of sucrose in baby bottle. Based on this finding, Carvalho et al.²⁵ suggested that in ECC infants there is a higher adhesion of *C. albicans* due to the presence of these sugars. However, additional researches are required in order to prove this association. Although there are few studies about *C. albicans* and early childhood caries in the literature, the association between this yeast and caries-active infants is present. Thus, the role of *C. albicans* in the development and etiology of dental caries disease need to be more investigate.

Based in this literature review, it can be concluded that:

Candida spp. colonization in the infants' oral cavity, especially *C. albicans*, may be related to the pacifier usage, feeding habits and caries lesions.

The early childhood caries favor *C. albicans* colonization, although it's role in the carious process need further studies to be elucidate scientifically.

References

1. McCullough MJ, Ross BC, Reade PC. *Candida albicans*: a review of its history, taxonomy, epidemiology, virulence attributes, and methods of strain differentiation. Int J Oral Maxillofac Surg. 1996; 25: 136-44.
2. Sio JO, Minwalla FK, George RH, Booth IW. Oral candida: is dummy carriage the culprit? Arch Dis Child. 1987; 62: 406-20.
3. Darwazeh AMG, Al-Bashir A. Oral candidal flora in healthy infants. J Oral Pathol Med. 1995; 24: 361-4.
4. Ollila P, Niemela M, Uhari M, Larmas M. Risk factors for colonization of salivary lactobacilli and candida in children. Acta Odontol Scand. 1997; 55: 9-13.
5. Mondin MEBG. Incidência de *Candida* spp. em crianças com cárie de mamadeira, antes e após o tratamento dental

- [dissertação]. Piracicaba: Faculdade de Odontologia da Universidade de Campinas; 2003.
6. Hossain H, Ansari F, Schulz-Weidner N, Wetzel WE, Chakraborty T, Domann E. Clonal identity of *Candida albicans* in the oral cavity and the gastrointestinal tract of pre-school children. *Oral Microbiol Immunol.* 2003; 18: 302-8.
 7. Scherma AP, Santos DVO, Jorge AOC, Rocha RF. Presença de *Candida* spp. na cavidade bucal de lactentes durante os primeiros quatro meses de vida. *Cienc Odontol Bras.* 2004; 7: 79- 86.
 8. Li Y, Caufield PW. The fidelity of initial acquisition of mutans streptococci by infants from their mothers. *J Dent Res.* 1995; 74: 681-5.
 9. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes. *J Publ Health Dent.* 1999; 59: 192-7.
 10. Berkowitz RJ. Causes, treatment and prevention of early childhood caries: a microbiologic perspective. *J Can Dent Assoc.* 2003; 69: 304-7.
 11. Milnes AR. Description and epidemiology of nursing caries. *J Public Health Dent.* 1996; 56: 38-50.
 12. Marchant S, Brasilsford, SR, Twomey AC, Roberts GJ, Beighton D. The predominant microflora of nursing caries lesions. *Caries Res.* 2001; 35: 397-402.
 13. Nikawa H, Yamashiro H, Makihira S, Nishimura M, Egusa H, Furukawa M, Setijanto D, Hamada T. In vitro cariogenic potencial of *Candida albicans*. *Mycoses.* 2003; 46: 471-8.
 14. Jin Y, Samaranayake LP, Samaranayake Y, Yip HK. Biofilm formation of *Candida albicans* is variably affected by saliva and dietary sugars. *Arch Oral Biol.* 2004; 49: 789-98.
 15. Ollila P, Niemela M, Uhari M, Larmas M. Prolonged pacifier-sucking and use of a nursing bottle at night: possible risk. *J Dent Child.* 2001; 68: 33-6, 10.
 16. Comina E, Marion K, Renaud FN, Dore J, Bergeron E, Freney J. Pacifiers: a microbial reservoir. *Nurs Health Sci.* 2006; 8: 216-23.
 17. Mattos-Graner RO, de Moraes AB, Rontani RM, Birman EG. Relation of oral yeast infection in Brazilian infants and use of a pacifier. *J Dent Child.* 2001; 68: 33-6.
 18. Ersin NK, Eronat N, Cogulu D, Uzel A, Aksit S. Association of Maternal-Child Characteristics as a Factor in Early Childhood Caries and Salivary Bacterial Counts. *J Dent Child.* 2006; 73: 105-11.
 19. Hannula J, Saarela M, Jousimies-Somer H, Takala A, Syrjanen R, Kononen E, Asikainen S. Age-related acquisition of oral and nasopharyngeal yeast species and stability of colonization in young children. *Oral Microbiol Immunol.* 1999; 14: 176-82.
 20. Akdeniz BG, Koparal E, Sen BH, Ates M, Denizci AA. Prevalence of *Candida albicans* in oral cavities and root canals of children. *J Dent Child.* 2002; 69: 189-292.
 21. Zollner MS, Jorge AO. *Candida* spp. occurrence in oral cavities of breastfeeding infants and in their mothers' mouths and breasts. *Pesqui Odontol Bras.* 2003; 17: 151-5.