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ORIGINAL ARTICLE

Effect of heat disinfection methods on the surface roughness of silicone nipples

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Abstract

Introduction and Objective: Pacifier and silicone nipples have been widely used, although there is a lack of information on which disinfection procedures are most effective and safe. The aim was to evaluate the effect of heat disinfection methods on the surface of three different types of silicone pacifiers (conventional, orthodontic A and orthodontic B). **Method**: The pacifiers were randomly assigned into two groups of 10 specimens each according to the disinfection protocol, microwave (seven minutes) or boiling water (five minutes), performed once a day. They were subsequently immersed in artificial saliva (12 hours) and stored in a dry environment to mimic routine use for 30 days. The surface was evaluated with a scanning electron microscope and profilometer at baseline, 15 and 30 days. **Results:** The orthodontic B pacifier showed a higher surface roughness at baseline, but an increase in the surface roughness, saliences and pores was observed at 15 and 30 days in all specimens ($p < 0.001$; three-way mixed model), irrespective of the disinfection method. **Discussion:** There were remarkable changes to the surface of the silicone pacifiers after 15 and 30 days of heat disinfection procedures. Awareness of their harmful effect on the surface of a pacifier is important so as to improve the recommendations given to caregivers to ensure effective disinfection with the least possible damage.

Keywords: Pacifiers. Silicone elastomers. Disinfection. Sucking behavior. Microscopy.

Efeito dos métodos de desinfecção por calor na rugosidade da superfície de bicos de silicone

Resumo

Introduçao e Objetivo: Embora ainda amplamente utilizada, faltam informações sobre os procedimentos de desinfecção mais eficazes e seguros para chupetas e bicos de silicone. O objetivo foi avaliar o efeito de métodos de desinfecção térmica na superfície de três tipos de chupetas de silicone (convencional, ortodôntica A e ortodôntica B). **Método**: As chupetas foram distribuídas aleatoriamente em 2 grupos com 10 espécimes de cada chupeta, de acordo com o protocolo de desinfecção: micro-ondas (7 min) ou água fervente (5 min), realizado uma vez ao dia e posteriormente imersos em saliva artificial (12 h) e armazenadas em ambiente seco para mimetizar o uso rotineiro por 30 dias. A superfície foi avaliada por microscopia eletrônica de varredura e perfilômetro no início do estudo, 15 e 30 dias após. **Resultados**: A chupeta ortodôntica B apresentou

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maior rugosidade superficial no início do estudo, embora tenha sido observado aumento da rugosidade superficial, saliências e poros aos 15 e 30 dias em todos os espécimes das três chupetas (p < 0,001; ANOVA modelo Misto de Três Vias), independentemente do método de desinfecção. **Discusão:** Os resultados mostraram mudanças notáveis na superfície das chupetas de silicone após 15 e 30 dias de procedimentos de desinfecção térmica. Este conhecimento é importante para aprimorar as recomendações dadas aos pais/cuidadores para garantir uma desinfecção eficaz com o menor dano possível.

Palavras-chave: Chupetas. Elastômeros de silicone. Desinfecção. Comportamento de Sucção. Microscopia.

Keypoints

What is known
- There is a lack of information on the most effective and safe disinfection procedures for pacifiers.

What is added
- Remarkable changes to the surface of silicone pacifiers after 15 and 30 days of heat disinfection procedures, which can increase bacterial colonization.

Introduction

Although the prevalence of sucking habits varies across countries and cultures, they are very common in children and often introduced shortly after birth. Their widespread use can be attributed to some positive effects reported by parents, such as soothing the child[1] and relieving pain during painful experiences[2], besides being recommended to prevent the risk of sleep-related infant deaths[3]. However, in addition to their impact on the duration of breastfeeding[4,5] and orofacial development[6,7], pacifiers can also be considered a vehicle of contamination and microbial transmission due to their permanent contact with saliva and oral microflora[8]. Some authors have shown that the use of a pacifier can be associated with the occurrence of otitis media[9], dental caries[10] and intestinal parasitic infections. Considering the high prevalence in several countries, disinfection methods to eliminate contamination by oral microorganisms in pacifiers and nipples are an important issue in pediatrics, although there is no consensus on the most effective and safe disinfection procedure.

The methods for decontaminating and disinfecting pacifiers reported in the literature include distilled water, a neutral detergent[11], rinsing solutions such as alcohol-free mouthwash, chlorhexidine gluconate mouthwash, 70% hydrogen peroxide, 2.5% sodium hypochlorite, a commercially available antiseptic toothbrush rinse (Brushtox®)[11-16], and spray solutions containing 0.12% chlorhexidine[12], all with varying effectiveness. Boiling in water is another common procedure frequently used at home and is recommended by manufacturers and health professionals for pacifier and bottle nipple disinfection[12]. Microwave use has also become a routine procedure for disinfecting dental devices and materials, such as a prosthesis and pacifiers[17]. However, disinfection procedures can lead to changes to the surfaces of pacifiers, which may facilitate the colonization of microorganisms. The extent of the alteration to the surface may vary depending on the type of pacifier and according to the frequency and duration of the disinfection method.

While there are studies on the contamination of pacifiers in the literature[8,11-15], the current knowledge regarding the morphological changes to pacifier surfaces due to disinfection methods is very limited. To the best of our knowledge, no previous study has examined the effect of disinfection procedures on the roughness of pacifiers' silicone surfaces over time, which may vary depending on the composition of the material and the geometrical format. Such information is helpful to improve the recommendations given to caregivers to ensure the effective and safe disinfection of pacifiers and bottle nipples. Thus, the objective of this study was to assess the effect of heat disinfection methods on the surface roughness of three different types of pacifiers.

Methods

Specimen characteristics and disinfection procedures

This is an in vitro analytical study. Sixty silicone pacifiers in total, with 20 units of three different types of nipples, were used: conventional (n. 41,620 Kuka Baby + 6 m, São Paulo, Brazil), orthodontic A (n. 41,900 Kuka Baby + 6 m, São Paulo, Brazil) and orthodontic B (Super Soothie™ + 3 m 421335424791; SCF190/02 Philips Avent, Stamford, USA). These pacifiers were selected so that we could include the two anatomical models of pacifiers available commercially: conventional and orthodontic. The Super Soothie was also chosen for evaluation because it was introduced to the market with a different nipple shape and visual appearance of the silicone nipple surface compared to the two usual models, and is very popular in Neonatal Intensive Care Units in the USA[18].

The pacifiers were randomly divided into two groups according to the disinfection protocol by a third person using software (Excel). In the first group, the conventional, orthodontic A and orthodontic B pacifiers (10 units each) underwent the disinfection process using a specific device and a microwave steam sterilizer (Philips Avent SCF281/05 Microwave Steam Sterilizer, Brazil and Midea microwave 1,100 watts, São Paulo, Brazil, respectively) adjusted to power level seven (corresponding to 70% of full power) for seven minutes, as described by Nelson-Filho et al.[19]. In the second group, the same number of pacifiers was subject to the boiling water procedure for five minutes, according to the recommendations of Silva RC, et al.[20].

After disinfection, the pacifiers were cooled to room temperature for 30 minutes and then immersed in artificial saliva at 37 °C (MA-033 oven, Marconi, Piracicaba, SP, Brazil) for 12 hours to mimic routine use, with the following composition: 2.2 g/L gastric mucin, 0.381 g/L sodium chloride, 0.231 g/L calcium chloride, 0.738 g/L potassium phosphate, 1.114 g/L potassium chloride, 0.02% sodium azide and a trace of sodium hydroxide to pH 7.0[19]. In the subsequent hours, pacifiers were stored in a dry environment to mimic routine use by a child. This procedure was repeated once a day for 30 days.

In order to perform pre- and post-treatment analysis (baseline, after 15 and 30 days of disinfection procedures), two standardized circular specimens measuring 5 mm in diameter were gathered from each nipple of the pacifiers using a tap (Krause 10; Santo André; Brazil), one for profilometer analysis and the other for scanning electron microscope (SEM) analysis. Each specimen was then washed in distilled water and placed in an ultrasonic bath for 10 minutes.

Profilometer analysis

All specimens were initially attached in a glass plate to a flat, parallel surface to facilitate the reading of the surface roughness. The specimens were then analyzed by the profilometer (Dektak d-150; Veeco, Plainview, New York, NY, USA) to randomly measure the surface roughness (Ra) at three sites (vertical, horizontal and oblique) on the surface of each sample using a blinded procedure. Three readings were performed on the profilometer measuring point. Initially, the specimen was positioned on the center of the surface, then to the right and left of the first reading, amounting to a 10 mm reading within 10 seconds. The parameter evaluated was the arithmetic mean of the surface roughness (Ra) determined from the three readings[20].

Scanning electron microscope (SEM) analysis

The specimens were dried and mounted on a holder using double-sided adhesive carbon tape. They were then sputter-coated with gold (Balzers-SCD 050 Sputter Coater, Liechtenstein) and examined using a scanning electron microscope (JEOL JSM 5600 LV, Tokyo, Japan) operating at 500 × magnification. The morphological analysis was performed using a blinded procedure and then described according to the images obtained by SEM.

Statistical analysis

Data were statistically analyzed using SPSS 24.0 software (IBM Corp., NY, USA), considering an α level of 5%, by one of the authors (PMC, Applied Statistics Spec). The exploratory statistics consisted of means and standard deviation, and normality was tested by using the Shapiro-Wilk test and quantile-quantile-plot (Q-Q plot) analysis. The variable "surface roughness" did not show normal distribution and was transformed by the log (Log).

A general linear model –three-way ANOVA mixed mode– was used to test the within-subjects factor (time: surface roughness at baseline and after treatment) and two between-subjects factors (type of pacifier and disinfection protocol) and the interaction between these factors in the observed roughness variance. The results of the Mauchly sphericity test and Levene's test for equality of variances were evaluated as ANOVA premises; when necessary, the Huynh-Feldt correction was applied. The main effects were then tested for group and time comparisons. Bonferroni's adjustment was applied for multiple comparisons.

Results

Table 1 shows the experimental trial employed to examine the change in the surface roughness of each type of pacifier (conventional, orthodontic A and orthodontic B), submitted to 15 and 30 days of heat disinfection procedures (boiled and microwave steamed).

The three-way ANOVA mixed model showed a significant time*pacifier interaction effect ($p < 0.001$) (Table 1). The main effects were then tested for group and time comparisons (one-way ANOVA repeated measures),

Table 1. Evaluation of the time pacifier disinfection effect on pacifier surface roughness (μm): a three-way mixed model

Pacifier	Disinfection	n	Surface roughness at baseline	Surface roughness after disinfection 15 days	Surface roughness after disinfection 30 days
			Mean (SD)	Mean (SD)	Mean (SD)
Conventional	Boiled	10	225.00[a] (44.16)	487.00[a] (130.09)	583.00[a] (101.00)
	Microwave	10	365.27[a] (116.23)	615.00[a] (193.11)	720.00[a] (174.40)
Orthodontic A	Boiled	10	245.37[a] (66.00)	456.00[a] (67.00)	586.25[a] (76.10)
	Microwave	10	413.02[a] (144.09)	563.02[a] (173.16)	625.42[a] (172.05)
Orthodontic B	Boiled	10	18246.00[b] (3044.00)	23717.14[b] (5225.26)	25079.00[b] (5523.00)
	Microwave	10	13256.2[b] (5372.00)	18684.03[b] (6244.33)	21675.08[b] (5750.00)

Three-way mixed model	F	p	Partial eta squared	Power
Time effect	47.486	< 0.001	0.468	1.000
Time pacifier effect	37.263	< 0.001	0.580	1.000
Time disinfection effect	0.502	0.501	0.009	0.110
Time pacifier disinfection effect	0.602	0.569	0.022	0.151

SD: standard deviation.
a ≠ b in the same column (p < 0.001; one-way ANOVA; Bonferroni's post-test).

which showed that the effect of time (disinfection treatment) was significant for all groups ($p < 0.001$). A difference in surface roughness between pacifiers was also found, with the roughness of the orthodontic B pacifier significantly greater than the conventional ($p < 0.001$) and orthodontic A models ($p < 0.001$). For all specimens, the change in the surface roughness was greater in the first 15 days compared to the subsequent 15 days (Fig. 1 and table 1).

However, the roughness did not differ when analyzing the type of disinfection, microwave steamed or boiled, as observed by the absence of a significant time disinfection effect.

The morphology analysis of the SEM images of the conventional and orthodontic A pacifiers show similar characteristics of the silicone surface at baseline, when no disinfection procedure had been performed: striaes, pores and saliences on the surface of the material are very discrete (Figs. 2A and 3A, respectively). The roughness, salience and pores on the surface after 15 and 30 days of disinfection procedures are of note (Figs. 2B and 2C, 3B and 3C, respectively).

The images of the orthodontic B pacifier showed the highest baseline surface roughness compared to the orthodontic A and conventional ones (Fig. 4A). The roughness, saliences and pores on the surface are even more pronounced after 15 and 30 days of disinfection procedures, with a remarkable irregular distribution of striaes (Fig. 4B) and saliences and pores (Fig. 4C).

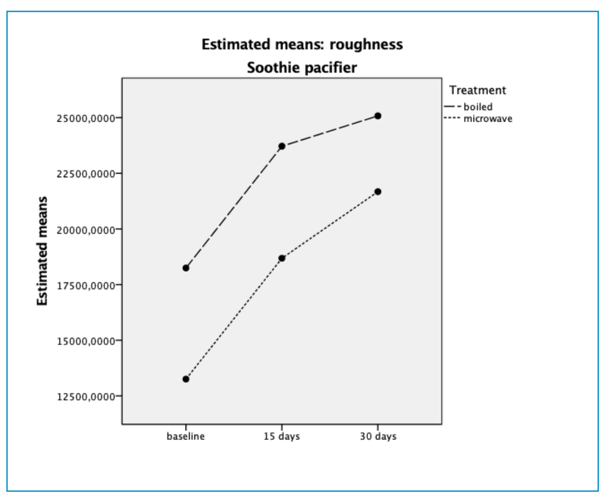

Figure 1. Effect of 15 and 30 days of heat disinfection on the surface roughness of the orthodontic B pacifier.

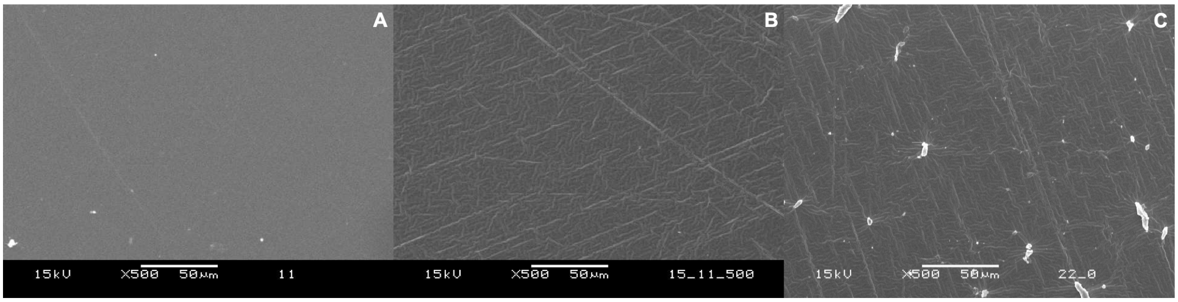

Figure 2. Representative scanning electron microscopy (SEM) images of the conventional pacifier atbaseline **(2A)** and after 15 days **(2B)** and 30 days **(2C)** of the disinfection procedures (original magnification: 500×).

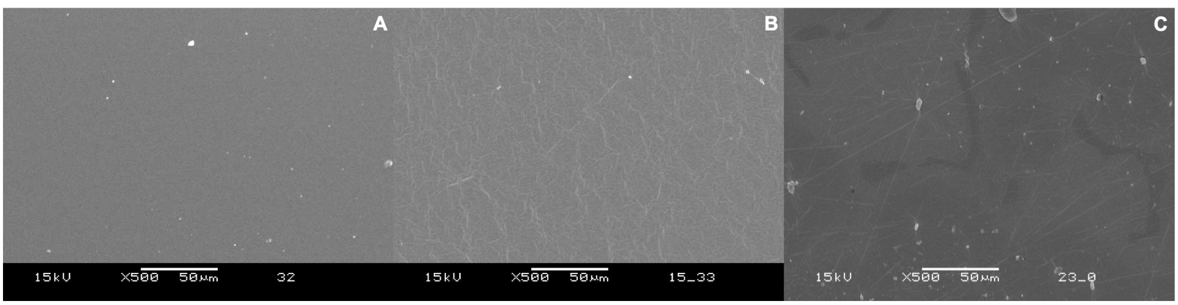

Figure 3. Representative scanning electron microscopy (SEM) images of the orthodontic A pacifier at baseline **(3A)** and after 15 days **(3B)** and 30 days **(3C)** of the disinfection procedures (original magnification: 500×).

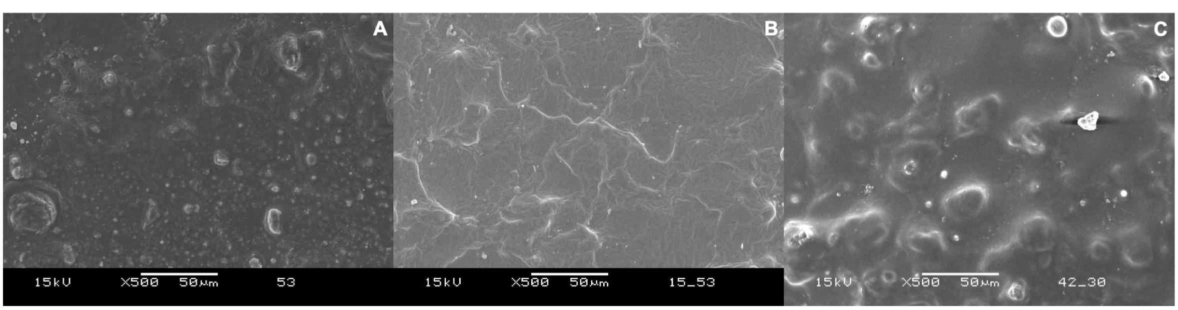

Figure 4. Representative scanning electron microscopy (SEM) images of the orthodontic B pacifier at baseline **(4A)** and after 15 days **(4B)** and 30 days **(4C)** of the disinfection procedures (original magnification: 500×).

Discussion

This study demonstrated the detrimental effects of heat disinfection procedures on the silicone surface of pacifiers after 15 and 30 days, evidenced by the formation of pores, striae, and increased surface roughness on all specimens. Even though silicone rubber, a blend of organic and inorganic compounds produced through the polycondensation of silanol groups, typically exhibits higher heat resistance compared to other materials[21,22], our findings demonstrated that the disinfection methods evaluated led to thermal degradation, altering the morphology of the material. When exposed to high temperatures during microwave disinfection or boiling, the silicone can soften, which can cause deformation or an uneven surface texture as the material cools and solidifies, thereby increasing the susceptibility of the material to microbial colonization.

An important aspect to consider is the relationship between surface roughness and bacterial colonization as rougher surfaces tend to retain more microorganisms, which can increase the risk of oral and systemic infections in children. Previous studies indicate that bacterial adhesion is facilitated on irregular surfaces through the creation of microenvironments protected from shear forces and cleaning agents[23]. Moreover, a rougher surface increases the overall surface area, providing more sites for microbial adhesion. Therefore, the observed changes in pacifier surface roughness after the tested disinfection methods are clinically relevant and suggest the need for developing new disinfection recommendations or new materials that minimize this deterioration.

The microscope analysis showed porosity, roughness and bubbles in the surface of all specimens after 15 days of heat disinfection procedures, which also increased after 30 days. Similarly, Silva et al.[20] evaluated surface changes on pacifiers after a single heat disinfection process, observing pores and roughness on latex pacifiers and little blisters on silicone pacifiers. The change in surface roughness did not change in accordance with the heat disinfection method used, microwave or boiling water, but it is important to consider that the microwave procedure has some advantages in terms of user safety.

By observing the microscope images of the orthodontic B pacifier, and considering the results of the profilometer analysis, we can conclude that the orthodontic B pacifier has a rougher silicone surface than the orthodontic A and conventional models. This type of pacifier has been widely used[18], probably because it is made with softer silicone, which may affect sucking behavior and the child's preference. Suction is an innate function of the human being and sucking on a pacifier or feeding nipple is one of the first oromotor tasks an infant will do soon after birth[18]. The act of sucking on a pacifier produces a rich stream of sensory cues from cutaneous and deep afferents, especially the lip vermilion and the tip of the tongue, which are areas with high densities of mechanoreceptive afferents[24], and the physical characteristics of the nipple, such as size, shape, roughness and stiffness are an important source of afferent sensory information[18,25].

It is also important to note that previous studies suggest that pacifier use may disrupt the normal flow of saliva, increasing the incidence of dental caries[26,27]. The surface of the pacifier may affect oral sugar clearance, which would prolong conditions of low pH in plaque and thereby favor the selection of aciduric microorganisms that are responsible for the development of caries. According to Nelson-Filho et al.[19], pacifiers become contaminated by *Streptococcus mutans* immediately after their use and, thus, they should be routinely disinfected[12]; besides, it was observed that *Candida albicans* is able to grow and adhere to the silicone surface of pacifiers even in the absence of a nutrient culture medium[11]. A review of the literature[26] on the surface roughness of oral hard materials established that a surface roughness greater than 0.2 μm resulted in an increase in plaque accumulation and in the risk of bacterial contamination, thus increasing the risk for caries and periodontal inflammation. The effect of surface roughness on microorganism colonization might be explained by the fact that bacterial adhesion is more likely on surface irregularities, which may predispose the child to increased levels of salivary *lactobacilli spp* and *candida spp*[27] and, thus, to oral and systemic diseases.

Moreover, Comina et al.[8] assessed microbial contamination on the surface of 25 pacifiers provided by daycare centers and observed the presence of a biofilm on 80% of the samples. A previous study showed that using a 0.12% chlorhexidine solution spray and seven minutes of microwave irradiation were almost equally effective for disinfecting pacifiers, reducing the number of *Streptococcus mutans* colonies[23]. Lopes et al.[9] tested three disinfection protocols: 3.5% neutral detergent, 2.5% sodium hypochlorite and 15 minutes of boiling water. They found they all showed the same effectiveness in controlling *Candida albicans* in the surface of pacifiers. They also observed that vigorous cleaning with water was not sufficient to eliminate the contamination.

The above results, together with our findings, may help health professionals and caregivers to choose the most convenient and effective disinfection procedure. To date, there is no established consensus on the best pacifier disinfection protocol; according to the Canadian Paediatric Society[28], the pacifier should be subject to boiling water for five minutes before the first use and then kept clean by washing with hot, soapy water after each use. Another study[9] suggested that pacifiers should be disinfected in boiling water for 15 minutes weekly and Bachelli et al.[23] pointed out that sodium hypochlorite forms trihalomethanes, which may constitute a disadvantage of its use.

Another important aspect to be considered is that parents or caregivers should always check that the pacifiers and nipples are in good condition and be discarded if there are visible cracks, tears, swelling or if they have a grainy or sticky texture[29], and preferably every two months, before damage occurs[28]. These recommendations are consistent with the changes observed in the structural properties after 30 days of heat disinfection performed daily in this study. Future studies are needed to examine the association between microbial contamination and the surface roughness of nipples in pacifiers and bottles after repeated disinfection procedures.

Although there is a need to discourage the use of nonnutritive sucking habits and formulae to prevent the early cessation of breastfeeding and orofacial impairments[5,6,30], the use of pacifiers and bottles is still prevalent. Thus, the results of this study are helpful in allowing health professionals to improve the recommendations given to parents to ensure an effective disinfection procedure with the least damage possible to the silicone. Besides, the development of pacifiers that remain smooth with a uniform surface even after multiple disinfection procedures is desirable in order to reduce potential bacterial colonization. By way of a limitation of the study, the limited number of material types may be relevant as we tested only silicone rubbers. However, the use of latex pacifiers (natural rubber) has been discouraged.

Conclusion

The results showed the heat-damaging effect of disinfection procedures on the silicone surface of pacifiers after 15 and 30 days, as observed by the higher number of pores, striaes and roughness of the surface. This implies the need to guide parents and guardians in changing pacifiers regularly and frequently to reduce the risk of infections, considering that the surface roughness of the pacifier increases microbial colonization. Future research should focus on developing resistant silicone materials and evaluating other disinfection methods that ensure the least possible damage.

Author contributions

C. Nobre de Freitas: Conception and design of the study, report, review or other type of work or paper; Acquisition of data either from patients, research studies, or literature; Analysis or interpretation of data either from patients, research studies, or literature; Drafting the article; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. E. Tavares de Sousa: Conception and design of the study, report, review or other type of work or paper; Acquisition of data either from patients, research studies, or literature; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. K. Guedes de Oliveira Scudine: Conception and design of the study, report, review or other type of work or paper; Acquisition of data either from patients, research studies, or literature; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. R.M. Puppin Rontani: Conception and design of the study, report, review or other type of work or paper; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. B. Tomé Martins de Moraes: Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. P. Midori Castelo: Conception and design of the study, report, review or other type of work or paper; Analysis or interpretation of data either from patients, research studies, or literature; Drafting the article; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work.

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Conflicts of interest

None.

Ethical considerations

Protection of humans and animals. The authors declare that no experiments involving humans or animals were conducted for this research.

Confidentiality, informed consent, and ethical approval. The study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

References

1. Janwadkar A, Duran G, Irving TD, Shah D, Arevalo R, Sanchez M, et al. Perception of pacifier use among caregivers of infants 0-1 years of age. J Investig Med. 2023 Dec;71(8):941-5.
2. Li DK, Willinger M, Petitti DB, Odouli R, Liu L, Hoffman HJ. Use of a dummy (pacifier) during sleep and risk of sudden infant death syndrome (SIDS): population based case-control study. BMJ. 2006 Jan 7;332(7532):18-22.
3. Moon RY, Carlin RF, Hand I. Task force on sudden infant death syndrome and the committee on fetus and newborn. Sleep-related infant deaths: updated 2022 recommendations for reducing infant deaths in the sleep environment. Pediatrics. 2022 Jul 1;150:e2022057990.
4. López de Aberasturi Ibáñez de Garayo A, Santos Ibáñez N, Ramos Castro Y, García Franco M, Artola Gutiérrez C, Arara Vidal I. Prevalencia y determinantes de la lactancia materna: estudio Zorrotzaurre [Prevalence and determinants of breastfeeding: The Zorrotzaurre study]. Nutr Hosp. 2021; DOI: 10.20960/nh.03329.
5. Mosquera PS, Lourenço BH, Matijasevich A, Castro MC, Cardoso MA. Prevalence and predictors of breastfeeding in the MINA-brazil cohort. Rev Saude Publica. 2024;57 (Suppl 2):2s.
6. Scudine KG de O, de Freitas CN, Nascimento de Moraes KSG, Bommarito S, Possobon R de F, Boni RC, et al. Multidisciplinary evaluation

of pacifier removal on oro-dentofacial structures: a controlled clinical trial. Front Pediatr. 2021;9:703695.
7. Kanellopoulos AK, Costello SE. The effects of prolonged pacifier use on language development in infants and toddlers. Front Psychol. 2024;15:1349323. DOI: 10.3389/fpsyg.2024.1349323.
8. Comina E, Marion K, Renaud FNR, Dore J, Bergeron E, Freney J. Pacifiers: a microbial reservoir. Nurs Health Sci. 2006;8(4):216-23.
9. Salah M, Abdel-Aziz M, Al-Farok A, Jebrini A. Recurrent acute otitis media in infants: analysis of risk factors. Int J Pediatr Otorhinolaryngol. 2013 Oct;77(10):1665-9.
10. Vázquez-Nava F, Vázquez REM, Saldivar GAH, Beltrán GFJ, Almeida AVM, Vázquez RCF. Allergic rhinitis, feeding and oral habits, toothbrushing and socioeconomic status: effects on development of dental caries in primary dentition. Caries Res. 2008;42(2):141-7.
11. Lopes DF, Fernandes RT, Medeiros Y de L, Apolonio ACM. Disinfection of pacifier focusing on Candida albicans. Clin Pediatr (Phila). 2019 Dec;58(14):1540-3.
12. Nelson-Filho P, Louvain MC, Macari S, Lucisano MP, Silva RAB da, Queiroz AM de, et al. Microbial contamination and disinfection methods of pacifiers. J Appl Oral Sci. 2015 Oct;23(5):523-8.
13. Molaudzi M, Molepo J. In vitro efficacy of different solutions in the disinfection of silicone pacifiers. S Afr Dent J. 2017;72(4):158-61.
14. Molepo J, Molaudzi M. Contamination and disinfection of silicone pacifiers: an in vitro study. S Afr Dent J. 2015;70(8):351-3.
15. Pedroso J de F, Sangalli J, Brighenti FL, Tanaka MH, Koga-Ito CY. Control of bacterial biofilms formed on pacifiers by antimicrobial solutions in spray. Int J Paediatr Dent. 2018 Nov;28(6):578-86.
16. Pedroso RS, Siqueira RV. A study on protozoan cysts, helminth eggs and larvae in pacifiers. J Pediatr (Rio J). 1997;73(1):21-5.
17. Sanitá PV, Vergani CE, Giampaolo ET, Pavarina AC, Machado AL. Growth of candida species on complete dentures: effect of microwave disinfection. Mycoses. 2009 Mar;52(2):154-60.
18. Zimmerman E, Barlow SM. Pacifier stiffness alters the dynamics of the suck central pattern generator. J Neonatal Nurs. 2008 Jun;14(3):79-86.
19. Nelson-Filho P, Silva LA, Ds Silva RA, et al. Efficacy of microwaves and chlorhexidine on the disinfection of pacifiers and toothbrushes: an in vitro study. Pediatr Dent; 2011;33(1):10-3.
20. Silva RC, Spolidorio DMP, Zuanon ACC, et al. Pacifier disinfection procedure: superficial morphological aspects and microorganisms colonization. RSBO. 2008;5(1):30-3.
21. Castilho SD, Rocha MAM. Pacifier habit: history and multidisciplinary view. J Pediatr (Rio J). 2009;85(6):480-9.
22. Rochow EG. Silicon and silicones. Berlin: Springer Verlag; 1987. p. 99.
23. Chamele J, Bhat C, Saraf T, Jadhav A, Beg A, Jagtap C, et al. Efficacy of microwaves and chlorhexidine for disinfection of pacifiers and toothbrushes: an in vitro study. J Contemp Dent Pract. 2012 Sep 1;13(5):690-4.
24. Trulsson M, Essick GK. Mechanosensation. In: Miles T, Nauntofte B, Svensson P, editors. Clinical oral physiology Copenhagen: Quintessence; 2004. p. 165-97.
25. Oder AL, Stalling DL, Barlow SM. Short-term effects of pacifier texture on NNS in neurotypical infants. Int J Pediatr. 2013;2013:168459.
26. Bollenl CML, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater. 1997;13(4):258-69.
27. Ollila P, Niemelä M, Uhari M, Larmas M. Risk factors for colonization of salivary lactobacilli and candida in children. Acta Odontol Scand. 1997 Jan;55(1):9-13.
28. Canadian Paediatric Society. Pacifiers (soothers): a user's guide for parents. Paediatr Child Health. 2003 Oct;8(8):520-30.
29. Nelson AM. A comprehensive review of evidence and current recommendations related to pacifier usage. J Pediatr Nurs. 2012 Dec;27(6):690-9.
30. Freitas C de, Castelo PM, Noritomi PY, Scudine K de O, Rontani RMP, Miziara T, et al. Mechanical stress distribution over the palate by different pacifiers assessed by finite element analysis and clinical data. Clin Anat. 2024 Sep;37(6):620-627.