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ORIGINAL ARTICLE

Variation in Salivary pH and Dental Caries in Children with and without Cleft Lip and Palate Before and After Toothbrushing

Mariela Ruthsana Romero-Velarde[1], Gloria Esperanza Cruz-Gonzales[2], Ana Sixtina Aliaga-Mariñas[1], Lucy del Pilar Chiong-Lam[1], Sharom Tamara Flores-Quinteros[1], Rafael Morales-Vadillo[3]

[1]School of Dentistry, Federico Villarreal National University, Lima, Peru.
[2]Faculty of Medical Technology, Federico Villarreal National University, Lima, Peru.
[3]School of Dentistry, University of San Martin de Porres, Lima, Peru.

Corresponding author: Rafael Morales-Vadillo **E-mail:** rmoralesv@usmp.pe

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ABSTRACT

Objective: To assess the relationship between salivary pH variation — measured before and after toothbrushing — and the presence of dental caries in children aged 0–12 years with and without cleft lip and palate (CL/P) in Lima, Peru. **Material and Methods:** This analytical and longitudinal study included 104 children, of whom 65 had CL/P and 39 did not. Salivary pH was measured using MQuant® pH-indicator strips, before and after oral hygiene with a fluoridated toothbrush and toothpaste Dentito®. Additionally, the Decayed, Missing, and Filled Permanent (DMFT) Teeth/decayed, extracted, and filled primary teeth index (dmft) was determined through an odontogram. **Results:** Significant differences in pre- and post-brushing salivary pH were observed in both groups ($p < 0.001$), with greater variation among children with CL/P. However, no significant relationship was found between salivary pH variation and the presence of dental caries in either the CL/P group ($p=0.718$) or the non-CL/P group ($p=0.726$). **Conclusion:** Children with cleft lip and palate exhibited a significantly greater variation in salivary pH before and after toothbrushing compared with children without cleft lip and palate; this variation was not found to be associated with the presence of dental caries.

Keywords: Jaw Abnormalities; Cleft Palate; Dental Caries; Saliva.

Introduction

Cleft lip and palate (CL/P) is one of the most common craniofacial malformations worldwide. It affects multiple facial structures, including the alveolar ridge, palate, nose, and ears. This condition can lead to several functional and health complications, including inadequate lip seal, mouth breathing, dental caries, enamel hypoplasia, molar-incisor hypomineralization, and periodontal disease. CL/P is characterized by either partial or complete structural fusion failures between the lip and the palate during the embryonic stage [1].

Saliva is a unique fluid with the potential to become the diagnostic sample of choice, driven by advances in detection technologies and the presence of clinically relevant biomolecules [1]. Such biomolecules contribute to several essential functions, including lubrication, antimicrobial properties, sugar and acid dilution, remineralization, and buffering capacity, which plays a crucial role in maintaining acid-base balance — specifically, salivary pH — which is essential for regulating acidic and alkaline byproducts of bacteria in the biofilm [2-6]. The biofilm can alter the pH balance of the oral cavity. Acidic byproducts lower the pH and contribute to the dental demineralization characteristic of dental caries. In this context, salivary pH measurement can serve as an important biomarker for monitoring and potentially altering the progression of dental caries [6].

Rapidly progressing dental caries are common in children and can lead to the destruction of dentition [7]. Early childhood caries is a condition that significantly affects children up to approximately 5 years of age, compromising their quality of life and causing infection, swelling, pain, and other symptoms [8,9].

Children with CL/P have a reduced ability to remineralize dental enamel due to a lower capacity to neutralize acids, which is suggested to result from alterations in their salivary glands [3]. Additionally, studies indicate children with CL/P tend to have lower, more acidic salivary pH levels [10]. Furthermore, research has found that those who used a presurgical device exhibited higher levels of Streptococcus mutans and Lactobacillus, along with acidic salivary pH, increasing their risk of dental caries [11]. Individuals with CL/P exhibit alterations in the normal oral microbiota, dental eruption, and tooth structure, leading to challenges in oral hygiene and contributing to a higher incidence of dental caries [12,13].

In low- and middle-income countries such as Peru, genetic, environmental, and nutritional factors shape health outcomes in specific ways, making locally generated evidence essential. In oral health, despite abundant international literature on children with CL/P and the high prevalence of childhood caries in Peru, there are no up-to-date data linking variation in salivary pH with the presence of this disease. This gap limits understanding of underlying mechanisms and underscores the need for research to guide preventive and therapeutic strategies tailored to the local context [14-18].

Therefore, the aim of the current study is to determine the relationship between salivary pH variation measured before and after toothbrushing and the presence of dental caries in children with and without CL/P in Lima, Peru. The null hypothesis was: "There is no statistically significant relationship between salivary pH variation, measured before and after toothbrushing, and the presence of dental caries in children in Lima, Peru, either among those with CL/P or those without it."

Material and Methods

Study Design and Ethical Clearance

The present analytical, relational, longitudinal study was approved by the Ethics Committee of the Faculty of Dentistry, Universidad Nacional Federico Villarreal (UNFV), Lima, Peru (Act No. 3288-2024, May 2024). The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki

for research involving human subjects. Written informed consent was obtained from the parents or legal guardians of all participating children before enrollment in the study.

Participants

Sampling followed a nonprobability convenience design, with participants selected from clinical visits at the Department of Pediatric Dentistry. The sample comprised 104 children aged 0-12 years — 65 with CL/P and 39 without — who underwent general evaluation at the Pediatric Dentistry service of a Peruvian nongovernmental organization. Owing to wide age variability and limited representation in certain age groups, stratification by age group was not considered methodologically appropriate, as it would not have adequately represented the study population.

Data Collection

Participants were instructed not to eat, drink, or brush their teeth for at least 1 hour before the dental examination. For children older than 3 years, unstimulated whole saliva was collected by asking them to spit into a 15 mL disposable cup, both before and after toothbrushing for 2 minutes with fluoridated toothpaste (1100 ppm F; Dentito®, Intradevco Industrial S.A., Lima, Peru). For children younger than 3 years, saliva was collected using disposable 1 mL syringes.

Unstimulated whole saliva was collected from each participant, and salivary pH was measured 60 seconds after collection, both before and after toothbrushing. Salivary pH was assessed using MQuant® pH-indicator strips (pH 0–14, four-color scale; Merck KGaA, Darmstadt, Germany). Test strips were immersed in the saliva sample for 15 seconds, following the manufacturer's instructions. The color change was compared with the manufacturer's reference chart. Salivary pH values were recorded on the data collection form and independently verified by two research authors to ensure accuracy [19].

All teeth of each child were clinically examined for dental caries, and the findings were recorded using the DMFT/dmft index. An odontogram was completed in accordance with the Peruvian Ministry of Health guidelines. Data was tabulated, and scores were assigned to each child. The clinical examinations and scoring were performed by the principal research author, who is duly qualified to apply the DMFT/dmft index for caries detection.

The data collection form included the study variables: salivary pH variation, measured before and after toothbrushing with fluoridated toothpaste, and dental caries, assessed using the DMFT/dmft index.

Data Analysis

As data followed a non-normal distribution, non-parametric statistics were used. The Mann-Whitney U test compared salivary pH variation and DMFT/dmft scores between children with and without CL/P. Spearman's rank correlation assessed the relationship between pH variation and dental caries. All analyses were performed using SPSS v.28 (IBM Corp., Armonk, NY, USA) with a significance level of $p < 0.05$.

Results

Table 1 and Figure 1 present the descriptive statistics of salivary pH variation in children aged 0 to 12 years, comparing those with and without CL/P before and after toothbrushing. The mean pH variation in children with CL/P (0.82) was significantly higher than that in children without CL/P (0.38) (Mann-Whitney U test, $p = 0.001$).

Table 1. Mean, median, and standard deviation of salivary pH variation (pre- and post-toothbrushing) in children with and without CL/P.

Group	Mean	95% CI		Median	SD	Min.	Max.
		Lower	Upper				
Children with CL/P	0.82	0.65	0.98	1.00	0.659	-1	2
Children without CL/P	0.38	0.18	0.59	0.00	0.633	-1	2

95% CI: 95% Confidence Interval; SD: Standard Deviation; Min. Minimum; Max. Maximum.

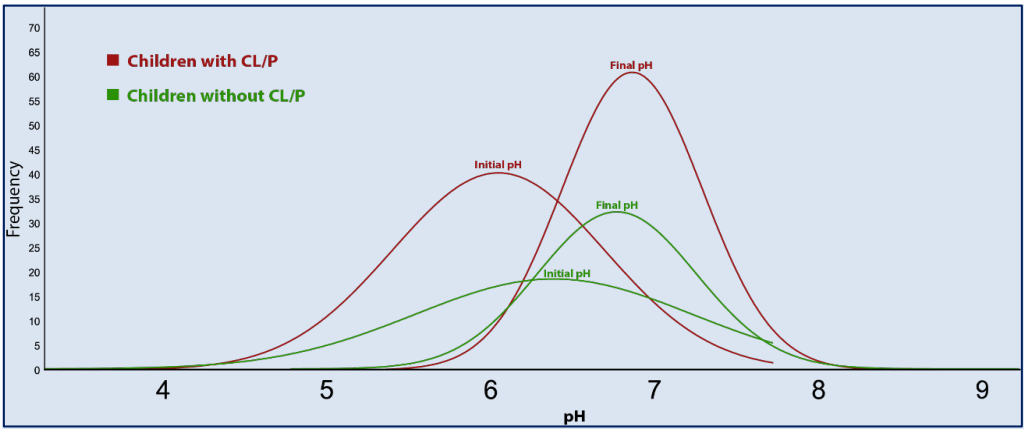


Figure 1. Comparison of salivary pH variation between children with and without CL/P.

Table 2 and Figure 2 show the mean DMFT/dmft scores for children with and without CL/P. The mean score for the CL/P group was 8.00, compared to 2.49 in the non-CL/P group, with a statistically significant difference between the groups ($p < 0.001$).

Table 2. Descriptive statistics comparison of the DMFT/dmft index between children with and without CL/P.

Group	Mean	95% CI		Median	SD	Min.	Max.	p-value*
		Lower	Upper					
Children with CL/P	8.00	6.56	9.44	8.00	5.796	0	21	<0.001
Children without CL/P	2.49	1.42	3.55	1.00	3.284	0	12	

95% CI: 95% Confidence Interval; SD: Standard Deviation; Min. Minimum; Max. Maximum; *Group comparison performed using the Mann-Whitney U test.

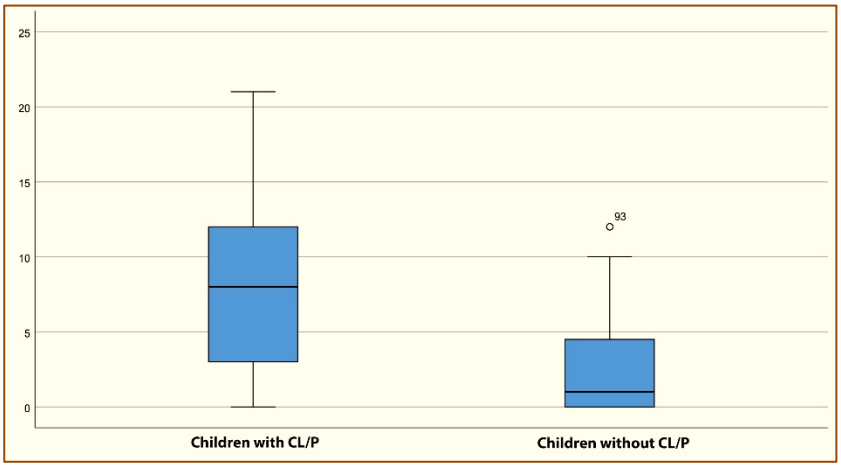


Figure 2. Comparison of the DMFT/dmft index between children with and without CL/P.

Figure 3 shows the scatter plot of salivary pH variation versus the DMFT/dmft index in children with CL/P. Spearman's rank correlation indicated no statistically significant association between these variables in either the CL/P group (p = 0.718) or the non-CL/P group (p = 0.726).

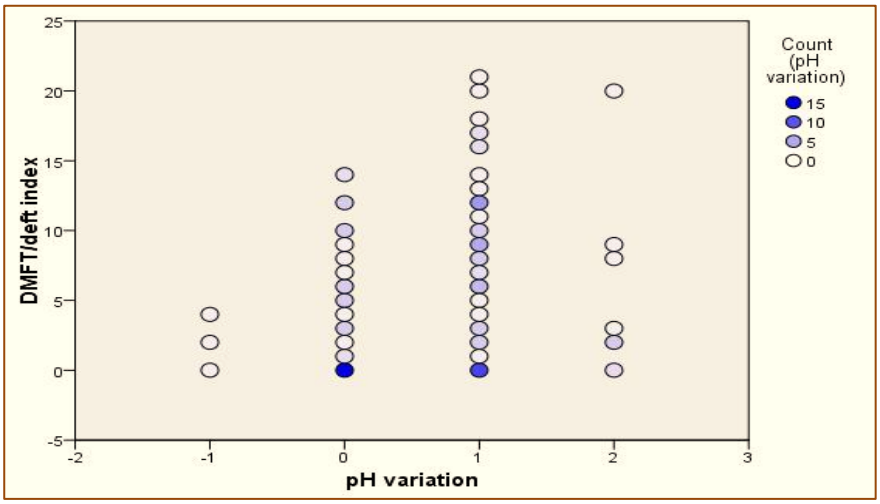


Figure 3. Relationship between salivary pH variation and the DMFT/dmft index in children with CL/P.

Discussion

Research indicates that children with CL/P experience more severe oral health problems than their healthy peers, including higher rates of dental caries, poorer oral hygiene, and ear infections, as well as differences in the oral microbiota between those with and without CL/P [20].

Saliva contains multiple components and physicochemical properties essential for maintaining oral health. In this study, toothbrushing was performed with fluoridated toothpaste because fluoride's primary mechanism is to enhance enamel remineralization and slow demineralization by attracting calcium and phosphate ions from saliva. Fluoride also interferes with S. mutans metabolism by restricting carbohydrate transport and storage and by reducing extracellular polysaccharide production through its interaction with the enolase enzyme [21].

We evaluated salivary pH variation in children aged 0–12 years with CL/P before and after oral hygiene with a toothbrush and fluoridated toothpaste. The final mean pH was significantly higher than the initial mean pH ($p < 0.001$). A similar significant difference was observed among children without CL/P ($p < 0.001$). This finding is consistent with Rodríguez et al. [22], who reported that parent-supervised toothbrushing in children with CL/P promotes better overall oral hygiene and influences the composition of the oral microbiome. The mechanical action of toothbrushing — regardless of duration — contributes to differences in the microbiota between children with and without CL/P. Preventive interventions, such as proper toothbrushing, therefore, remain essential for maintaining good oral hygiene in children with CL/P. Although the increased risk of dental caries in this population is not fully understood, many potential risk factors are related to the difficulty of cleaning hard-to-reach areas.

The importance of saliva is underscored by the fact that individuals with salivary deficiencies — such as those with CL/P — are more prone to oral disease. Saliva contains a wide range of antimicrobial components, including lysozyme, lactoferrin, histatins, defensins, and secretory IgA, that help buffer pH and are continually renewed. Swallowing also helps clear food debris, desquamated cells, and microbial byproducts [23].

In dental caries, the biofilm shifts toward acidogenic and acid-tolerant bacteria (e.g., S. mutans and Lactobacillus spp.) that drive enamel demineralization. These organisms metabolize dietary sugars to acids, creating localized low pH (~5.5). If such acidic conditions persist without sufficient time for remineralization, carious lesions develop [22,23]. This mechanism may help explain our findings on the prevalence of dental caries in children with CL/P, as measured by the DMFT/dmft index [24]. On average, children with CL/P had eight carious teeth, whereas those without CL/P had two, a statistically significant difference ($p < 0.001$). Jiang et al. [25] suggest that the interplay between nasal and oral functions in individuals with CL/P may influence the oral microbiota, potentially disrupting its balance and increasing disease susceptibility. Recent studies similarly indicate that children with CL/P experience compositional shifts in the oral microbiota, which may contribute to their heightened risk of oral health complications.

Regarding the relationship between salivary pH variation before and after toothbrushing with fluoridated toothpaste and the presence of dental caries in children with and without CL/P, no statistically significant association was observed ($p = 0.718$). This finding is consistent with Reis de Souza et al. [10], who analyzed 45 patients with and without CL/P using test strips to measure salivary pH. They likewise found no significant difference in salivary pH between groups. However, they noted a tendency toward more acidic values in the CL/P group and recommended further research to clarify this issue

Further studies on the characteristics and properties of saliva in patients with CL/P are recommended to better understand its role in the prevention and control of dental caries, which is a common condition in this population. Based on the findings regarding saliva, preventive programs should be developed that incorporate these data to effectively prevent dental caries in children with CL/P.

Conclusion

Although children with cleft lip and palate exhibited a significantly greater change in salivary pH before and after toothbrushing than children without cleft lip and palate, this variation was not associated with dental caries.

Authors' Contributions

MRRV	https://orcid.org/0000-0002-7081-6780	Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft and Writing - Review and Editing.
GECG	https://orcid.org/0000-0003-1937-5446	Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft and Writing - Review and Editing.
ASAM	https://orcid.org/0000-0002-5635-5498	Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft and Writing - Review and Editing.
LPCL	https://orcid.org/0000-0002-5847-0692	Conceptualization, Methodology, Investigation, and Writing - Review and Editing.
STFQ	https://orcid.org/0000-0002-3066-2633	Methodology and Investigation.
RMV	https://orcid.org/0000-0002-7835-6408	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Gonzales J, Campos J. Labio paladar fisurado: Una perspectiva global. Diagnóstico 2018; 57(1):21-24. https://doi.org/10.33734/diagnostico.v57i1.78 [In Spanish].

[2] Deshpande RR, Sabhlok S, Waknis P, Sarve P, Mutha M, Shep S, et al. Comparative evaluation of salivary total protein in cleft lip palate children to their mother and between healthy children to their mother. RJPBCS 2015; 6(5):386-390.

[3] Gallego-Molina BH, González-Vélez YC, Peña M, Bedoya-Correa CM, Parada-Sanchez MT. Composición y función salival en niños con labio con/sin paladar hendido no sindrómico. CES Odontología 2022; 34(2):61-75. https://doi.org/10.21615/cesodon.5923 [In Spanish].

[4] Chaudhari PK, Kharbanda OP, Chaudhry R, Pandey RM, Chauhan S, Bansal K, et al. Factors affecting high caries risk in children with and without cleft lip and/or palate: A cross-sectional study. Cleft Palate Craniofac J 2021; 58(9):1150-1159. https://doi.org/10.1177/1055665620980206

[5] Almaeeni MM, Hassan AM. Selected salivary physicochemical properties among cleft lip and palate children in Iraq. Int J Med Res Heal Sci 2018; 7(9):132-136.

[6] Braine NR, Centanini IA, Pontes LS, Michels B, Vianna MS, Rezende CE, et al. Evaluation of the salivary pH and its correlation with dental caries in a population of Brazilian adolescents. Concilium 2023; 23(6):430-439. https://doi.org/10.53660/clm-1152-23d29

[7] Talukdar L, Saha S, Dhinsa K, Rai A, Tiwari V, Trivedi H. Comparison of craniofacial morphology characteristics along with dental caries status and salivary properties of operated cleft lip and palate patients with noncleft patients. J Indian Soc Pedod Prev Dent 2022; 40(3):265-273. https://doi.org/10.4103/jisppd.jisppd_278_22

[8] Alazmah A. Early childhood caries: A review. J Contemp Dent Pract 2017; 18(8):732-737. https://doi.org/10.5005/jp-journals-10024-2116

[9] Machiulskiene V, Campus G, Carvalho JC, Dige I, Ekstrand KR, Jablonski-Momeni A, et al. Terminology of Dental Caries and Dental Caries Management: Consensus Report of a Workshop Organized by ORCA and Cariology Research Group of IADR. Caries Res 2020; 54(1):7-14. https://doi.org/10.1159/000503309

[10] de Souza Schacher HR, Rinaldi ML, Azeredo F, Rizzatto SM, Stuani MB, de Menezes LM. The pH salivary biomarker – Is there a difference between cleft and non-cleft orthodontic patients?. JIDMR 2021; 14(3), 1014–1020.

[11] Hassani H, Chen JW, Zhang W, Hamra W. Comparison of microbial activity among infants with or without using presurgical nasoalveolar molding appliance. Cleft Palate Craniofac J 2020; 57(6):762-769. https://doi.org/10.1177/1055665620908150

[12] Grewcock RE, Innes NPT, Mossey PA, Robertson MD. Caries in children with and without orofacial clefting: A systematic review and meta-analysis. Oral Dis 2022; 28(5):1400-1411. https://doi.org/10.1111/odi.14183

[13] Tamasas B, Cox TC. Massively increased caries susceptibility in an Irf6 cleft lip/palate model. J Dent Res 2017; 96(3):315-322. https://doi.org/10.1177/0022034516679376

[14] Rodrigues R, Fernandes MH, Bessa Monteiro A, Furfuro R, Carvalho Silva C, Vardasca R, et al. Are there any solutions for improving the cleft area hygiene in patients with cleft lip and palate? A systematic review. Int J Dent Hyg 2019; 17(2):130-141. https://doi.org/10.1111/idh.12385

[15] World Health Organization [WHO]. Oral health. [Internet]. Geneva: World Health Organization; 2020. Available from: https://www.who.int/news-room/fact-sheets/detail/oral-health [Accessed on April 4, 2025].

[16] Castillo JL, Palma C, Cabrera-Matta A. Early childhood caries in Peru. Front Public Health 2019; 7:337. https://doi.org/10.3389/fpubh.2019.00337

[17] Romero-Velarde M, Cruz-Gonzales G, Morales-Vadillo R. Factores de riesgo asociados a la presencia de caries dental en niños con labio y paladar fisurado de cinco regiones del Perú. GICOS 2023; 8(3):70-83. https://doi.org/10.53766/GICOS/2023.08.03.05 [In Spanish].

[18] Allam GG, Sobeh IA. Caries experience varies in Egyptian children with different combinations of cleft lip and palate and is related to carbohydrate intake between meals. Cleft Palate Craniofac J 2021; 58(4):414-418. https://doi.org/10.1177/1055665620952297

[19] Madariaga VI, Pereira-Cenci T, van Gennip LLA, van Leeuwen SJM, Walboomers XF, Loomans BAC. Exploring the relationship of salivary pH and flow rate with tooth wear severity: A cross-sectional study. J Dent 2025; 152:105499. https://doi.org/10.1016/j.jdent.2024.105499

[20] Gershater E, Liu Y, Xue B, Shin MK, Koo H, Zheng Z, et al. Characterizing the microbiota of cleft lip and palate patients: A comprehensive review. Front Cell Infect Microbiol 2023; 13:1159455. https://doi.org/10.3389/fcimb.2023.1159455

[21] Ghaly M, Eldosoky A. Effectiveness of chlorhexidine varnish in preventing dental caries in patients with cleft lip and palate. Egyptian Dent J 2023; 69(1):21-32. https://doi.org/10.21608/edj.2022.161953.2255

[22] Rodrigues R, Chung AP, Mortensen MS, Fernandes MH, Monteiro AB, Furfuro R, et al. Temporal oral microbiome changes with brushing in children with cleft lip and palate. Heliyon 2021; 7(3):e06513. https://doi.org/10.1016/j.heliyon.2021.e06513

[23] Rosier BT, Marsh PD, Mira A. Resilience of the oral microbiota in health: Mechanisms that prevent dysbiosis. J Dent Res 2018; 97(4):371-380. https://doi.org/10.1177/0022034517742139

[24] Domínguez M, Mehta R, Ahuja D, Batra P, Gupta A. Putting 'STOP' to excess caries of cleft lip and palate patients. Int Dent J 2025; 75(3):2323-2332. https://doi.org/10.1016/j.identj.2024.11.012

[25] Jiang W, Yan Z, Chen Z, Gu L, Bao H, Cao Y, et al. Investigating oral microbiome profiles in patients with cleft lip and palate compared with the healthy control. BMC Oral Health 2024; 24(1):623. https://doi.org/10.1186/s12903-024-04387-3