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Original Article

Comparative Evaluation of Periodontal Health in Patients with Bilateral Versus Unilateral Cleft Lip and Palate: A Systematic Review and Meta-Analysis

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ABSTRACT

The current body of research regarding periodontal health across various cleft types remains inconsistent and inconclusive. Hence, this systematic review and meta-analysis aimed to evaluate and contrast the oral health status of children diagnosed with bilateral cleft lip and palate (BCLP) against those with unilateral cleft lip and palate (UCLP). A comprehensive search was performed across six electronic databases for publications available up to June 2022 that compared periodontal conditions between BCLP and UCLP patients. The meta-analysis utilized a random-effects model with inverse variance weighting. Out of 858 initially identified records, 58 were reviewed in full, and 5 studies meeting the inclusion criteria were ultimately analyzed. These studies collectively examined 86 BCLP and 132 UCLP participants from three continents, focusing on periodontal indicators such as plaque index (PI), gingival index (GI), periodontal probing depth (PPD), and clinical attachment loss (CAL). Findings indicated a statistically significant increase in CAL on the facial surface among BCLP patients (mean difference: −0.44; 95% confidence interval: 0.27–0.61; $Z = 5.07$; $p < 0.0001$), whereas other periodontal parameters showed no notable variation between groups. Given the documented relationship between cleft-related surgical management and periodontal outcomes, these aspects should be carefully considered when designing individualized treatment strategies.

Keywords: Cleft lip, Plaque index, Cleft palate, Gingival index, Periodontal diseases

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Introduction

Cleft lip and palate rank among the most common congenital anomalies affecting the head and neck region [1-4], occurring in roughly 1 out of every 700 live births. Studies indicate that the occurrence of these malformations varies with geographic location, socioeconomic factors, and ethnicity [5]. Among different populations, American Indians have the highest reported prevalence at 2.62 per 1,000 live births, followed by Japanese [1.73 per 1,000], Chinese [1.56 per 1,000], and White individuals [1.55 per 1,000], while Black populations show the lowest prevalence of 0.58 per 1,000 [6]. Data from a five-year span further suggest that the overall congenital anomaly rate has increased in the United States, whereas international trends show a decline [7].

Orofacial clefts encompass a wide spectrum of congenital defects with variable morphology, ranging from isolated cleft lip to complete unilateral cleft lip and palate (UCLP), bilateral cleft lip and palate (BCLP), or clefts of the soft palate alone. These defects originate from incomplete or failed fusion of the medial nasal and maxillary processes during early embryogenesis.

Cleft lip and palate can also be part of syndromic conditions such as Treacher Collins syndrome, Pierre Robin sequence, and DiGeorge syndrome. Risk factors include advanced maternal age, smoking, and alcohol consumption. While the precise mechanisms remain unclear, mutations in genes such as PAX9, TGF-β, IRF, and MSX1 play a key role in craniofacial development. Unilateral clefts represent approximately 75% of cases, with left-sided clefts being more common, while bilateral clefts make up about 25% of cases. Most dental anomalies in cleft patients occur in the anterior maxilla, potentially due to surgical interventions performed during tooth bud development [8].

Individuals with cleft lip and palate often face challenges in oral functions such as speech, swallowing, and oral hygiene. Clinical care begins immediately after birth, with the first interventions typically initiated within the first month. Organizations like the American Cleft Palate Craniofacial Association (ACPA) recommend multidisciplinary care, involving surgeons, pediatricians, orthodontists, speech therapists, prosthodontists, pedodontists, phoniatricians, and laryngologists [9, 10].

The risk of dental caries and periodontitis is elevated in patients with cleft lip and palate [11, 12]. Before cleft closure, soft tissue folds hinder oral hygiene and serve as niches for pathogenic microorganisms, increasing the potential for periodontal infection [13]. Research has shown higher rates of caries and periodontal breakdown in UCLP and BCLP patients [3, 14, 15]. Contributing factors include irregular dental arches, orthodontic appliances, and the presence of Simonart's band, a soft tissue connection bridging the cleft gap near the nostril or alveolar margin after closure [16]. These factors collectively promote the progression of periodontal disease [3, 14, 15, 17].

Although studies show that individuals without clefts generally have better oral health than those with cleft anomalies, few studies have compared oral health across different cleft types. No systematic review has yet specifically examined periodontal outcomes in relation to cleft type. This review aims to evaluate the periodontal status of patients with BCLP compared to those with UCLP.

Material and Methods

This systematic review followed PRISMA guidelines **(Figure 1)** and the PICOS framework. The population included children, adolescents, and adults with cleft lip and palate; the exposure/intervention was BCLP; the control group consisted of UCLP patients; the outcome of interest was periodontal status; and the study designs included observational and cross-sectional studies **(Table 1)**. Two authors [JW and AG] independently extracted the relevant data, with any disagreements resolved by a third reviewer [PB]. Extracted information was organized in tables including study design, sample size, participant demographics, dentition type, cleft type, group matching, study outcomes, and periodontal indices used **(Table 2)**. The review is registered in the Open Science Framework [doi:10.17605/OSF.IO/KNJZE].

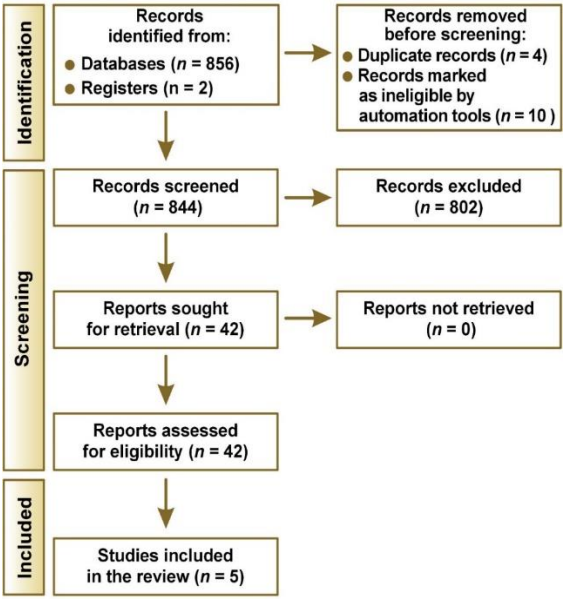

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of the study

Table 1. PICOS Framework and Research Question

PICOS	Description
Patients	Children, adolescents, and adults with cleft lip and palate, regardless of whether they have received surgical treatment, and without any syndromic diagnosis
Intervention/Exposure	Presence of bilateral cleft lip and palate (BCLP)
Control	Individuals with unilateral cleft lip and palate (UCLP)
Outcome	Evaluation of periodontal health using standardized indices and clinical protocols
Study Design	Observational and cross-sectional studies
Research Question	Do individuals with BCLP exhibit differences in periodontal health compared to those with UCLP?

BCLP – bilateral cleft lip and palate; UCLP – unilateral cleft lip and palate.

Table 2. Summary of Studies Included in the Review

Study	Country	Study Design	Sample Size	Control Group	Cleft Surgery	Mean Age [years]	Dentition Examined	Method of Outcome Assessment	Parameters Evaluated	Key Findings
Sudhakar *et al.* [18]	India	Case–control	20 BCLP patients	20 UCLP patients	Not reported	15	Not reported	Clinical examination	PI, SBI, PPD, CAL	All parameters were significantly higher in BCLP patients except SBI.
Eldeeb *et al.* [19]	USA	Cross-sectional	26 cleft patients (17 M, 9 F; 8 BCLP, 18 UCLP)	29 non-cleft patients (11 M, 18 F)	Patients underwent alveolar bone grafting from the iliac crest, covered with mucogingival or mucobuccal flaps per Broude and Waite	BCLP: 16.8 UCLP: 16.2	Permanent (maxillary canine and 6 Ramfjord teeth)	Clinical examination	PI, GI, PPD, CAL, width of attached gingiva in canine region	Cleft patients had higher PI values; no significant differences in GI, PPD, or CAL.
Gaggl *et al.* [20]	Austria	Cross-sectional	50 cleft patients (30 UCLP, 20 BCLP)	30 UCLP patients	Not reported	BCLP: 21.4 UCLP: 18.9	Permanent	Clinical examination	CAL, API, SBI, pathologic mobility	Elevated SBI scores in cleft patients; BCLP group showed more periodontal damage, especially near cleft-adjacent teeth.

Hazza'a *et al.* [21]	Jordan	Cross-sectional	98 cleft patients (52 UCLP, 46 BCLP)	98 non-cleft patients	Not reported	12 ± 6.3	Primary and permanent	Clinical examination	PI, GI, DMFT, DMFS	Plaque and gingivitis were more prevalent in cleft patients; BCLP group had higher gingivitis rates.
Pisek *et al.* [22]	Thailand	Cross-sectional	68 cleft patients (34 M, 34 F; 20 BCLP, 36 UCLP)	118 non-cleft patients (48 M, 70 F)	Not reported	BCLP: 11.9 UCLP: 11.9	Primary and permanent	Interview and oral examination	PI, GI, DMFT, DMFS, quality of life	High PI, GI, and DMFT scores affected speech and smiling; no significant differences in primary dentition caries.

M – male; F – female; PI – plaque index; GI – gingival index; DMFT – number of decayed, missing and filled permanent teeth; DMFS – number of decayed, missing and filled surfaces; PPD – periodontal probing depth; CAL – clinical attachment loss; API – approximal plaque index; SBI – sulcus bleeding index.

Search strategy

A comprehensive literature search was performed using PubMed®, Scopus, Cochrane, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and OpenGrey. Unpublished studies were additionally sourced from the Clinical Trials Registry – India. The search was confined to studies published up to February 2023. Reference lists of included articles were also examined to capture additional relevant studies. The search employed the following MeSH terms: "cleft lip"; "cleft palate"; "periodontal status"; "attachment loss"; and "oral hygiene". Boolean operators (AND, OR) were used to combine terms, creating a search strategy aligned with the review objectives. MeSH terms were selected from the top of the hierarchy to ensure that related subheadings were included.

Screening and selection

All retrieved records were imported into Rayyan (https://www.rayyan.ai) to facilitate screening of titles and abstracts. Eligible studies were observational or cross-sectional designs that compared two groups and provided quantitative data. Only original research comparing periodontal status between BCLP and UCLP, with UCLP as the control, was included. Studies focusing on bone grafts, dental anomalies, syndromic clefts, as well as case reports, case series, or letters to the editor, were excluded. Reference lists of relevant studies and gray literature were checked to identify additional studies that might have been missed. Studies with indirect or qualitative data, or those lacking a control group, were excluded, although their references were screened for potential relevant research.

Objectives

The review aims to offer a thorough understanding of periodontal health in individuals with BCLP worldwide. As their treatment needs and required healthcare infrastructure differ markedly from those with UCLP, these insights can guide healthcare providers and policymakers in developing appropriate care strategies across various age groups.

Results of the search

The initial search yielded 858 articles **(Figure 1)**. The records were imported into Rayyan for sorting and selection based on titles and abstracts. After removing duplicates and ineligible studies (n = 14), 802 studies

were excluded. Full-text assessment resulted in 42 included studies, with 5 meeting criteria for meta-analysis. Detailed characteristics of these studies are summarized in **Table 2**.

Most studies were cross-sectional, with one employing a case–control design. The studies reported periodontal parameters comparing BCLP and UCLP patients. Altogether, 86 BCLP individuals were evaluated, with a mean age of 15 years. Studies were conducted in Jordan, Austria, the United States, Thailand, and India. Syndromic patients were excluded in all studies to minimize confounding. Samples were categorized according to cleft type. Male-to-female ratios in the experimental group ranged from 30:70 to 62:38, and in the UCLP control group were 40:60. Only one study provided details regarding the presence of cleft surgery and the time elapsed since the procedure.

Characteristics of selected studies

The studies assessed periodontal status using various parameters. Ali and Mazin selected teeth representative of overall periodontal health according to Ramfjord: maxillary right first molar, maxillary right canine, maxillary left central incisor, maxillary left canine, maxillary left first premolar, mandibular right central incisor, and mandibular right first premolar [23]. Of the five studies, four assessed oral hygiene using the plaque index (PI) [18-22], one used the approximal plaque index (API) [20], three measured gingival health with the gingival index (GI) [19, 21, 22], two reported periodontal condition via the sulcus bleeding index (SBI) [18, 20] and periodontal probing depth (PPD) [18, 19]. Clinical attachment loss (CAL) was assessed in three studies [18–20], pathologic mobility in one [20], and one study examined patients' quality of life [22]. Gaggl *et al.* evaluated periodontal outcomes post-orthodontic treatment [20]; however, these results may not fully represent true periodontal status due to potential impacts of orthodontic appliances and dentoalveolar expansion in surgically treated cleft areas.

Quality assessment

Study quality was evaluated using a modified Newcastle–Ottawa Scale (NOS) adapted for cross-sectional studies [24]. Four criteria were applied: clarity of participant selection, control and ascertainment of exposure, comparability of study design or analysis, and management of confounding factors. The outcome assessment method, whether structured or self-reported, was also considered. All studies had matched study and control groups.

Table 3. Modified Newcastle–Ottawa Scale (NOS) for Evaluating the Quality of Cross-Sectional Studies

Study	Selection	Comparability	Outcome	Quality Score
Sudhakar *et al.* [18]	**	**	*	5
Eldeeb *et al.* [19]	****	0	**	6
Gaggl *et al.* [20]	****	*	***	8
Hazza'a *et al.* [21]	****	**	**	8
Pisek *et al.* [22]	****	**	**	8

Results

Participants' oral hygiene was evaluated using the plaque index (PI), approximal plaque index (API) [25], and gingival index (GI). Gingival health was specifically assessed with the GI, following the criteria established by Silness and Loe [26]. The analysis focused on the mean differences in PI and GI scores between the cleft groups, with a mean difference of 0.14 (0.01–0.27). Comparisons across studies did not reveal statistically significant differences (Z = 2.09, p = 0.04). As shown in **Figures 2 and 3**, the BCLP group demonstrates a more favorable trend within the forest plots [19, 22]. Heterogeneity among studies assessing gingival indices was low (I^2 = 40%) **(Figure 2)**, whereas studies evaluating plaque indices exhibited substantial heterogeneity (I^2 = 83%) **(Figure 3)**.

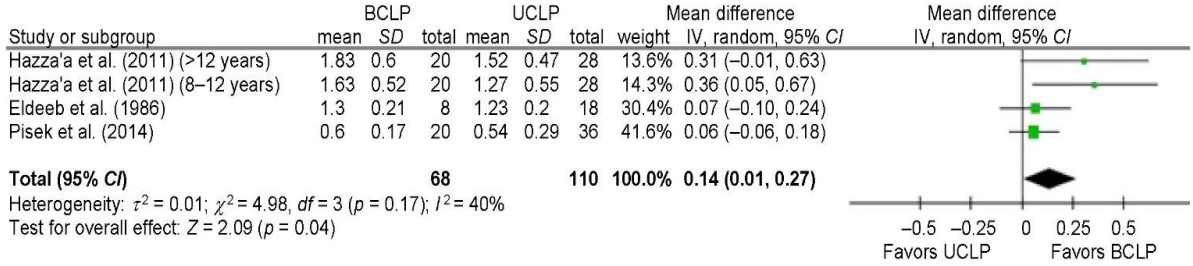

Figure 2. Forest plot illustrating the comparison of gingival index (GI) scores between patients with bilateral cleft lip and palate (BCLP) and those with unilateral cleft lip and palate (UCLP)
SD – standard deviation; CI – confidence interval; df – degrees of freedom

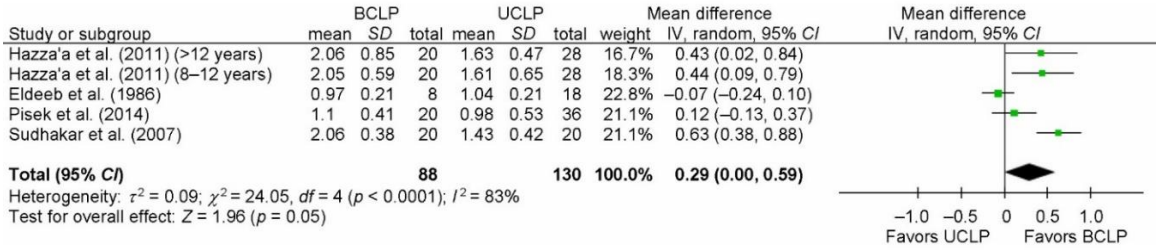

Figure 3. Forest plot showing the comparison of plaque index (PI) scores between patients with bilateral cleft lip and palate (BCLP) and those with unilateral cleft lip and palate (UCLP)

Periodontal evaluation – CAL, SBI, PPD

The periodontium was assessed using the periodontal index proposed by Silness and Loe [26] along with clinical attachment loss (CAL) measurements [27]. The included studies examined periodontal status in the maxillary arch, specifically in the anterior and posterior regions and in teeth adjacent to the cleft. However, these site-specific data were not suitable for meta-analysis due to comparability issues. Consequently, the current analysis focused on CAL across all surfaces of the maxillary canine on the cleft side, including the mesial, facial, palatal, and distal surfaces. A statistically significant increase in CAL was observed on the facial surface in BCLP patients (mean difference: −0.44; 95% CI: −0.61 to −0.27; Z = 5.07; p < 0.00001), with low heterogeneity across studies (I^2 = 0%) **(Figure 4)**. Assessment of publication bias was not possible due to the small number of studies. On the remaining three surfaces, periodontal measurements in the BCLP group were comparable to those in the UCLP group, as illustrated in **Figures 5, 6, and 7**.

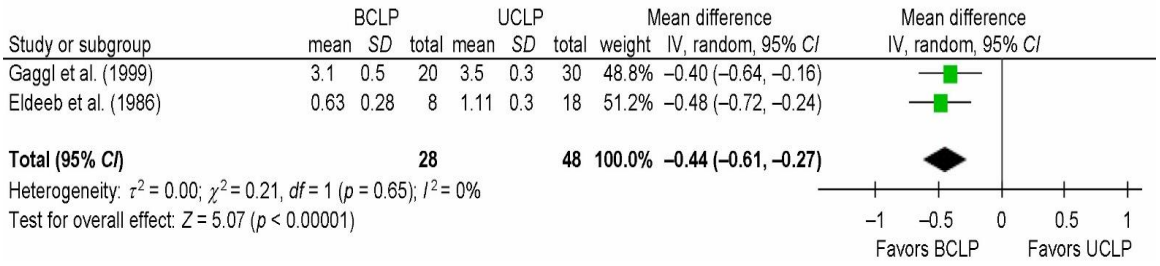

Figure 4. Forest plot illustrating the comparison of clinical attachment loss (CAL) on the facial surface of maxillary canines between patients with bilateral cleft lip and palate (BCLP) and those with unilateral cleft lip and palate (UCLP)

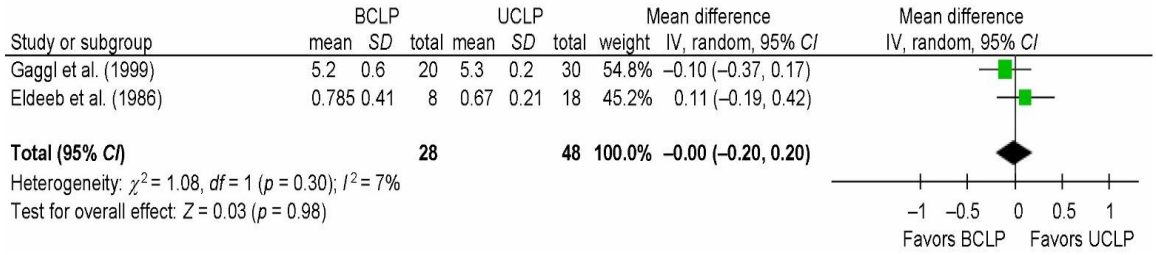

Figure 5. Forest plot showing clinical attachment loss (CAL) on the distal surface of maxillary canines in patients with bilateral cleft lip and palate (BCLP) compared to those with unilateral cleft lip and palate (UCLP)

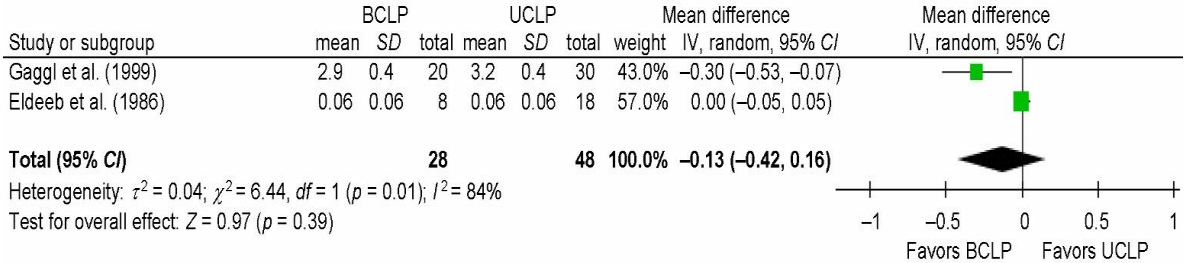

Figure 6. Forest plot depicting clinical attachment loss (CAL) on the palatal surface of maxillary canines in

patients with bilateral cleft lip and palate (BCLP) versus those with unilateral cleft lip and palate (UCLP)

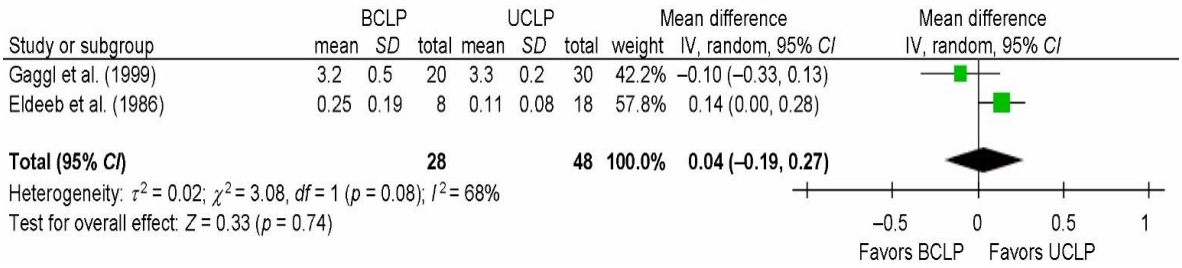

Figure 7. Forest plot illustrating clinical attachment loss (CAL) on the mesial surface of maxillary canines in patients with bilateral cleft lip and palate (BCLP) compared to those with unilateral cleft lip and palate (UCLP)

Discussion

This review centers on periodontal evaluation across different cleft types. Earlier studies have explored the prevalence of caries, skeletal morphology [28], periodontal health, and quality of life [12, 29–35] in individuals with clefts. However, none of these investigations analyzed results according to cleft type. Comparisons of caries prevalence or periodontal status between cleft and non-cleft populations are challenging, as the groups have undergone distinct surgical interventions with variable morbidity at different developmental stages. Furthermore, treatment strategies vary between cleft types, highlighting the importance of identifying existing periodontal issues in BCLP patients to support tailored treatment planning [36].

Marzouk *et al.* performed a systematic review to examine whether individuals with non-syndromic orofacial clefts (OCs) demonstrate higher rates of dental anomalies (DAs) compared to those without OCs [37]. Their findings indicated that individuals with OCs are more likely to exhibit various DAs, including supernumerary teeth, enamel developmental defects, tooth malposition or transposition, rotation, and impaction [37].

In the present systematic review, five studies were included, and data were pooled to compare CAL, gingival indices, and other periodontal parameters across different surfaces of canine teeth. The analysis comprised 86 BCLP patients and 132 UCLP controls. Overall, gingival and periodontal indices were similar between the two groups; however, BCLP patients demonstrated significantly higher CAL values. Meta-analysis revealed that the facial surfaces of canines in BCLP individuals exhibited a notably higher mean CAL.

Although the observed differences in CAL were statistically significant, their clinical relevance may be limited, potentially due to scar tissue formation. Lucas *et al.* reported no significant differences in PI between cleft and non-cleft participants, contrasting with findings from other studies [12], which may be explained by small sample sizes. Participants with different cleft types generally received multidisciplinary care from an early age [12].

Paul and Brandt reported superior dental health in individuals whose cleft did not involve the palate [38]. Additionally, the surgical technique used for uncovering canines may have contributed to attachment loss; however, the lack of detailed documentation regarding the methods employed made verification difficult.

Limitations

Interpretation of these findings should be cautious due to the limited number of available studies. Non-English publications were excluded, and manual searches were not conducted, which may have introduced selection bias. The data could not be stratified by sex due to small sample sizes and limited study numbers, preventing subgroup analyses. Consequently, funnel plots for publication bias could not be generated.

The included studies followed established methodological criteria for GI, PI, and CAL assessments but did not account for intraoperative errors, which could have influenced outcomes. Despite these limitations, the evidence suggests that BCLP patients may experience slightly poorer PPD and CAL compared to UCLP patients, although the clinical significance of these differences remains uncertain.

Conclusions

Key factors contributing to attachment loss in cleft patients include the anatomical features of the cleft site, misaligned teeth, and skeletal discrepancies. Surgical interventions, including cleft repair and bone grafting, hypoplastic defects, scarring, and stages of orthodontic treatment, may limit effective oral hygiene and increase susceptibility to plaque accumulation. This systematic review synthesized evidence from five

studies comparing periodontal parameters among individuals with cleft palates. The findings indicate a higher prevalence of attachment loss on the mesial, facial, and palatal surfaces of canines, particularly in cases involving grafted gingiva from surgical uncovering rather than orthodontic intervention.

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Conflict of Interest: None

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Ethics Statement: None

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