GRADUATION PROJECT

Degree in Dentistry

ORTHODONTIC TREATMENT IN PATIENTS WITH CLEFT LIP AND PALATE

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RESUMEN

Introducción: El labio leporino y/o paladar leporino no sindrómico es una afección craneofacial compleja que requiere un tratamiento multidisciplinario a largo plazo. Los pacientes suelen presentar deficiencia de crecimiento maxilar, maloclusiones y deterioros funcionales que afectan tanto a la estética como a la calidad de vida. Existen diferentes enfoques de tratamiento, incluyendo protocolos ortopédicos, ortodoncistas y quirúrgicos coordinados, así como el tratamiento ortoquirúrgico solo. **Objetivo:** Evaluar si el tratamiento ortopédico, ortodóntico y quirúrgico coordinado proporciona un mejor crecimiento facial a largo plazo, estabilidad oclusal y calidad de vida que el tratamiento ortoquirúrgico solo en pacientes con labio leporino y/o paladar hendido no sindrómico. **Materiales y métodos:** Se realizó una revisión bibliográfica utilizando bases de datos electrónicas incluyendo PubMed, Scopus y Google Scholar. Los artículos relevantes fueron seleccionados en base a criterios predefinidos de inclusión y exclusión. Palabras clave como labio y paladar hendido, tratamiento ortodóntico, maloclusión y crecimiento maxilar fueron utilizadas en diferentes combinaciones. Los estudios seleccionados fueron seleccionados por título, resumen y análisis de texto completo para identificar las pruebas más relevantes relacionadas con el manejo de ortodoncia en pacientes con hendidura. **Resultados:** Los estudios revisados muestran que los pacientes con labio leporino y paladar leporino suelen presentar deficiencia maxilar, maloclusiones e irregularidades del arco dental. El tratamiento de ortodoncia contribuye a corregir estas alteraciones, mejorando la oclusión y apoyando el crecimiento facial. Las intervenciones tempranas y oportunas, combinadas con la atención multidisciplinaria, se asociaron con mejores resultados funcionales y estéticos. **Conclusión:** El tratamiento ortodóntico es un componente fundamental en el manejo de pacientes con labio y paladar hendido. Cuando se integra dentro de un enfoque multidisciplinario, contribuye a mejorar la función oral, la armonía facial y la calidad de vida en general. Se necesitan más investigaciones para estandarizar los protocolos de tratamiento y optimizar el tiempo de las intervenciones.

PALABRAS CLAVE

labio leporino, paladar hendido, ortodoncia, malformaciones craneofaciales, ortopedia

ABSTRACT

Introduction: Non-syndromic cleft lip and/or palate is a complex craniofacial condition that requires long-term, multidisciplinary management. Patients commonly present maxillary growth deficiency, malocclusions, and functional impairments that affect both aesthetics and quality of life. Different treatment approaches exist, including coordinated orthopedic, orthodontic, and surgical protocols, as well as ortho-surgical treatment alone. **Objective:** To evaluate whether coordinated orthopedic, orthodontic, and surgical treatment provides better long-term facial growth, occlusal stability, and quality of life than ortho-surgical treatment alone in patients with non-syndromic cleft lip and/or palate. **Materials and Methods:** A literature review was conducted using electronic databases including PubMed, Scopus, and Google Scholar. Relevant articles were selected based on predefined inclusion and exclusion criteria. Keywords such as *cleft lip and palate*, *orthodontic treatment*, *malocclusion*, and *maxillary growth* were used in different combinations. Selected studies were screened by title, abstract, and full-text analysis to identify the most relevant evidence related to orthodontic management in cleft patients. **Results:** The studies reviewed show that patients with cleft lip and palate commonly present malocclusions and dental arch irregularities. Orthodontic treatment contributes to correcting these alterations, improving occlusion, and supporting facial growth. Early and well-timed interventions, combined with multidisciplinary care, were associated with better functional and aesthetic outcomes. **Conclusions:** Orthodontic treatment is a fundamental component in the management of patients with cleft lip and palate. When integrated within a multidisciplinary approach, it contributes to improving oral function, facial harmony, and overall quality of life. Further research is needed to standardize treatment protocols and optimize timing of interventions.

KEYWORDS

cleft lip, cleft palate, orthodontic, craniofacial malformations, orthopedic

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1. INTRODUCTION

1.1 Background and Rationale

1.1.1 Overview of Cleft Lip and Palate (CLP)

Cleft lip and palate (CLP) are among the most frequent congenital craniofacial malformations, characterized by a discontinuity of the lip and/or palate resulting from the incomplete fusion of facial processes during embryonic development (1). Although prevalence varies greatly across ethnic and geographic populations, ranging from roughly 1 in 500 among Asian populations to 1 in 2,500 among African populations, their global incidence is estimated to be 1 in 700 live births (1,2). Males are more frequently affected by cleft lip with or without cleft palate, whereas isolated cleft palate occurs more commonly in females (3). The classification of these anomalies includes cleft lip (CL), cleft palate (CP), and cleft lip and palate (CLP), which may be unilateral, bilateral, complete, or incomplete depending on the extent of the fissure (4). These developmental defects are multifactorial in origin, influenced by both genetic predisposition and environmental factors such as maternal smoking, alcohol use, folate deficiency, teratogenic medications, and nutritional or viral exposures during early pregnancy (5,6). Beyond their physical presentation, CLP significantly affects feeding, speech, hearing, and breathing functions, as well as facial symmetry and appearance (7). These impairments not only require complex medical management but also have deep psychosocial consequences. Children with visible clefts often experience social stigmatization, emotional distress, and reduced self-esteem, which can persist in adolescence and adulthood (8). Therefore, guaranteeing both functional rehabilitation and psychological well-being, early intervention and integrated care are crucial.

1.1.2 Role of Orthodontics in Cleft Management

Orthodontics plays a central role in the multidisciplinary management of CLP, complementing surgical, speech, and psychosocial interventions (9). Treatment begins in infancy, continues through mixed dentition, and often extends into adulthood. Each stage of orthodontic care is carefully coordinated with surgical milestones such as cheiloplasty (lip repair), palatoplasty (palate repair), secondary alveolar bone grafting (SABG), and orthognathic surgery (10). In the presurgical stage, orthodontic treatment may include nasoalveolar molding (NAM) or infant orthopedic plates to align alveolar segments, reduce the width of the cleft, and improve conditions for primary lip and palate closure (11). During mixed dentition, orthodontists use

maxillary expansion or alignment devices to prepare the dental arch for alveolar bone grafting, usually prior to the eruption of the permanent canines (12). In permanent dentition or adulthood, treatment goals move towards achieving stable occlusion, optimal facial aesthetics, and functional balance, often combined with orthognathic surgical correction for midfacial deficiency (13).

The timing and coordination of orthodontic interventions have a decisive influence on surgical outcomes and long-term stability. While wrongly timed orthodontic forces can jeopardize facial growth or the integrity of surgical repair, properly aligned alveolar segments at the time of surgery reduce scar tension and promote bone healing (14,15). Research indicates that cooperation between maxillofacial surgeons and orthodontists greatly improves speech and masticatory function, reduces relapse, and improves post-operative results (16,17).

1.1.3 Evolution of Orthodontic Approaches in CLP

In the past, orthodontic treatment was secondary or postponed in favor of surgical correction in early treatment protocols (18). Passive molding plates were sometimes used in infancy, but these lacked long-term control over alveolar and nasal growth. With the introduction of devices like Grayson's nasoalveolar molding (NAM) and the Latham device, the focus gradually changed to a more proactive and integrated approach (19,12). Digital orthodontics, 3D imaging, and computer-assisted modeling are recent developments that enable physicians to plan surgery more precisely orthodontic coordination and simulate treatment outcomes (15). Additionally, modern techniques such as distraction osteogenesis and clear aligner systems are increasingly incorporated for fine-tuning post-surgical alignment (13). These improvements reflect an overall shift away from standardized age milestones and toward evidence-based, personalized treatment that is informed by growth patterns and psychosocial awareness (14). Effective CLP management now relies on multidisciplinary collaboration among orthodontists, maxillofacial and plastic surgeons, pediatric dentists, speech therapists, and psychologists (20). Through proper coordination and care the interventions are guaranteed to address not only occlusal function but also speech development, emotional adaptation, and long-term facial harmony.

1.1.4 Importance of Timing and Coordination

A major source of clinical variability in CLP management is when to initiate orthodontic intervention. Initiating treatment too early may interfere with maxillary growth due to the application of forces that happen before skeletal maturity, whereas delaying it too long can

complicate surgical closure or delay alveolar bone grafting (21). In order to maximize bone volume and tooth support, the optimal approach entails timing orthodontic treatment with critical developmental and surgical stages, such as alveolar bone grafting prior to canine eruption (19,22). Randomized clinical trials demonstrate that presurgical orthodontic preparation before bone grafting significantly increases graft fill volume and reduces residual alveolar defects compared to surgical repair alone (21). On the other hand, malocclusion, midfacial retrusion, and postoperative relapse are frequently the outcomes of poorly coordinated or delayed orthodontic involvement (18). Both soft-tissue adaptation and facial aesthetics are significantly influenced by the timing of the intervention. Surgeons can accomplish smoother, more symmetrical closures that improve form and function by aligning alveolar segments early. On the other hand, asymmetry, compromised facial harmony, and increased scarring are frequently the results of postponed orthodontic treatment. For long-term stability, balanced facial growth, and long-lasting functional and aesthetic results, it is crucial to establish precise treatment timing through multidisciplinary coordination (14,15,19).

1.1.5 Psychological and Social Dimensions

Beyond functional and anatomical rehabilitation, cleft management has a significant impact on the social and psychological growth of those who are impacted. Children with CLP frequently struggle with peer relationships, facial self-image, and speech intelligibility (8,21). Adolescents with visible scars or asymmetries may develop anxiety, withdrawal, or low self-esteem, particularly during school years when social perception becomes increasingly important (9,21). Research highlights that successful orthodontic and surgical coordination can significantly improve self-confidence, social integration, and quality of life. *Ruiz-Guillén et al. (2021)* demonstrated that children and adolescents showed marked improvement in emotional and social well-being following coordinated orthodontic–surgical treatment (21). Similarly*, Lane et al. (2021)* reported that early speech and orthodontic interventions help normalize communication patterns, reducing stigmatization and improving classroom participation (22).

Having a psychological supportive team around cleft patients has been shown to positively influence treatment adherence and coping mechanisms, this illustrates the importance of emotional recovery on the outcome of cleft care and should not be taken as a secondary concern (8). Nowadays cleft protocols promote the integration of psychosocial evaluation at every treatment stage, recognizing that the true measure of success includes the patient's ability to lead a confident, socially fulfilling life rather than just occlusion or facial symmetry.

1.1.6 Rationale for the Study

Although continuous advancement has been ongoing in orthodontic appliances and surgical techniques, no universal consensus has been reached regarding the optimal timing, sequence, and coordination of orthodontic interventions in CLP patients (12,14). The heterogeneity in clinical protocols ranging from early presurgical infant orthopedics to delayed mixed-dentition treatments leads to significant variability in long-term stability, facial growth, and patient satisfaction (19,21).

Many studies compare surgical and combined orthodontic–surgical approaches, yet the results remain inconsistent due to differences in patient age, surgical technique, and evaluation criteria (13,15). Furthermore, most research focuses on anatomical or occlusal outcomes, while the psychological and social impacts of treatment timing remain underexplored. This creates a gap between clinical success and patient-perceived well-being.

A systematic, evidence-based synthesis is therefore essential to clarify which orthodontic interventions, performed at what stage, provide the most stable, functional, and psychosocially beneficial outcomes. Understanding these relationships will guide practitioners in formulating standardized, interdisciplinary treatment pathways and inform future research directions in cleft care.

1.2 Problem Statement, Objectives, and Scope

Patients with cleft lip and palate require lifelong, multidisciplinary management encompassing multiple surgical and orthodontic stages. However, major controversies persist regarding the ideal timing and sequence of orthodontic treatment to optimize surgical outcomes, facial growth, and long-term stability (12). Variations in clinical protocols, appliance types, and timing results in inconsistent esthetic and functional results.

Evidence shows that while surgery alone can restore anatomic continuity, it often leads to residual deformities, compromised occlusion, and midface retrusion (13,15). By contrast, coordinated orthodontic–surgical protocols particularly when implemented before bone grafting and during mixed dentition enhance graft success, facial balance, and occlusal stability (14,20). However, these advantages are highly dependent on timing, for example, delayed interventions decrease alveolar adaptability and complicate tooth eruption, while premature forces can disrupt growth centers (21,22).

Additionally, the psychosocial impact of delayed or poorly coordinated interventions remains significant. Patients frequently experience frustration, prolonged treatment burden, and impaired self-esteem when outcomes fail to meet aesthetic expectations (25). This underscores the need for an evidence-based synthesis to identify optimal orthodontic strategies that integrate surgical coordination, timing precision, and psychosocial recovery in cleft care.

1.3 Orthopedic Involvement in CLP Management

Through early skeletal and alveolar guidance, orthodontic therapy has emerged as a key component of contemporary cleft lip and palate (CLP) management, bridging the gap between surgical correction and orthodontic alignment. Orthopedic interventions, which are first used in infancy or early mixed dentition, are intended to improve nasal symmetry, decrease the width of the cleft, and shape the maxillary segments in order to create a more advantageous anatomical base for surgical repair (23). Before cheiloplasty and palatoplasty, presurgical orthopedics (PSO), in particular nasoalveolar molding (NAM), uses passive or active appliances to remodel nasal cartilage and approximate alveolar ridges. Consistent short-term advantages have been demonstrated at this stage, including easier surgical closure, better lip and nasal symmetry, and increased feeding efficiency (12,23). In addition to functional improvements, early orthopedic advancements give families concrete comfort, lowering parental stress and enhancing early psychosocial adjustment (23). Research shows that timing is still very important for successful orthopedic outcomes. Before the age of twelve, most centers begin orthopedic or orthodontic preparation; this is best done during the mixed-dentition phase, when skeletal structures are still responsive to any form of movement and modifications (24). At this stage, maxillary expansion and alveolar alignment can be achieved before secondary alveolar bone grafting, that increases graft-success rates and improves dental-arch continuity (24). However, delayed initiation frequently results in less skeletal adaptability and more complicated treatment, highlighting the significance of early interdisciplinary coordination.

Furthermore, systematic analyses demonstrate that presurgical orthopedics can reduce the need for secondary corrections while also making subsequent surgeries simpler (12,23). While long-term effects on craniofacial growth remain debated, early orthopedic intervention consistently contributes to improved symmetry and more stable surgical outcomes. Berkowitz emphasized that orthopedic management extends beyond infancy examples being, growth-modification appliances such as facemasks, reverse-pull headgear, and tongue plates can correct developing maxillary retrusion and establish balanced facial proportions (25). Structural

stability and functional harmony throughout growth phases are guaranteed by this phased approach that combines orthopedic and orthodontic forces with surgical repair.

Overall, orthopedic care should be seen as the foundation of thorough, multidisciplinary cleft management rather than just an isolated stage. Orthopedic intervention improves surgical precision, lowers the risk of relapse, and encourages balanced craniofacial growth by conditioning the maxilla and soft tissues prior to surgery and orthodontic alignment. The main goal of this systematic review is to determine whether early skeletal modulation produces better long-term results in facial growth, occlusal stability, and quality of life by comparing these coordinated orthopedic-orthodontic-surgical protocols to orthodontic-surgical strategies alone.

2. OBJETIVE

To evaluate whether orthopedic and orthodontic treatment coordinated with surgical interventions improves long-term facial growth, occlusal stability, and quality of life outcomes in patients with non-syndromic cleft lip and/or palate compared to orthodontic–surgical treatment alone.

PICO Question

In patients with non-syndromic cleft lip and/or palate (P), does orthopedic and orthodontic treatment coordinated with surgical interventions (I), compared to orthodontic–surgical treatment alone (C), improve long-term facial growth, occlusal stability, and quality of life outcomes (O)?

3. MATERIAL AND METHODS

This study followed the structure suggested by the PRISMA 2020 recommendations, adapting the framework of a systematic review to fit a specific academic topic while maintaining the same standards of rigor, reproducibility, and transparency. The aim of this study was to gather and critically evaluate the most recent data regarding orthodontic and orthopedic interventions in patients with non-syndromic cleft lip and/or palate (CLP), with a focus on treatment timing, coordination with surgery, and long-term outcomes.

The research question guiding this review was structured using the PICO framework as follows: In patients with non-syndromic cleft lip and/or palate (P), does orthopedic and orthodontic treatment coordinated with surgical interventions (I), compared to orthodontic–surgical treatment alone (C), improve long-term facial growth, occlusal stability, and quality of life outcomes (O)? This question directed the selection of studies, as well as the definition of inclusion and exclusion criteria.

A comprehensive literature search was carried out using several scholarly databases, including PubMed (Medline), ScienceDirect, and Google Scholar. The search was paired with manual reference tracing within selected articles to ensure completeness. To include the most recent clinical and technological developments, the search period was restricted to publications from 2016 to 2025. Only peer-reviewed scientific papers were considered, ensuring the reliability and scientific validity of all included sources. The search strategy was based on combinations of keywords related to the condition, treatment, surgical coordination, and outcomes, as presented in Table 1. Prior to the selection of articles, predefined eligibility criteria were established to ensure methodological rigor and relevance to the objectives of the review. These criteria guide the identification, screening, and eligibility phases of the study selection process and are summarized in Tables 2 and 3.

The study selection process was conducted in three main stages: identification, screening, and eligibility. During the identification phase, all retrieved records from the selected databases were collected and duplicate entries were removed. In the screening phase, titles and abstracts of the remaining articles were evaluated to determine their relevance to the objectives of the study, focusing on studies addressing orthodontic, orthopedic, or surgical treatment of CLP. Articles that did not meet the predefined inclusion criteria were excluded at this stage. During the eligibility phase, full-text articles were thoroughly reviewed to ensure they met the established criteria. Each study was assessed based on methodological quality, sample

characteristics, type of intervention, and reported outcomes. Only studies that satisfied all inclusion criteria were retained for the final analysis. In total, twenty-eight articles were selected for review. The entire selection process is illustrated in figure 1 using a PRISMA flowchart.

Data extraction was carried out using a structured analysis grid to organize key information from each study, including the year, study design, sample size, cleft type, patient age range, and stage of intervention. Specific attention was given to the type of orthodontic or orthopedic appliance used, the surgical procedures coordinated with treatment, and the outcomes measured, including skeletal growth, occlusal stability, aesthetic improvements, speech function, and psychosocial adaptation. Additional information such as follow-up period, study limitations, and relevance to the research question was also recorded. All extracted data were coded according to their reference numbers and compiled into summary tables.

The methodological quality of the included studies was assessed based on study design, clarity of inclusion criteria, sample size adequacy, consistency of measurement methods, and transparency in reporting results. Due to the variability in study design, patient characteristics, and outcome measures, a qualitative and descriptive synthesis was performed rather than a meta-analysis. The included studies were categorized according to treatment stage, including presurgical orthopedics, mixed-dentition orthodontic preparation, and surgical coordination. Outcomes were analyzed across skeletal, dental, and psychosocial domains, allowing for comparison between orthodontic and orthopedic–orthodontic–surgical approaches. This approach enabled a comprehensive understanding of how treatment sequencing and timing influence long-term stability and patient satisfaction.

Since this study was based exclusively on previously published data, no direct ethical approval was required. All included studies had previously received ethical approval, ensuring compliance with the Declaration of Helsinki. The research adhered strictly to the university's academic integrity guidelines, ensuring originality and proper citation of all sources. AI-assisted tools were used solely to improve structure and grammatical clarity and were not used for content generation.

Table 1. Search Strategy Keywords

Concept	Keywords used
Condition	cleft lip, cleft palate, cleft lip and palate
Treatment	orthodontic, orthopedic, surgical treatments
Surgical Coordination	alveolar bone grafting, orthognathic surgery
Outcomes	facial growth, occlusal stability, quality of life

Table 2. Inclusion Criteria for Study Selection

Criteria	Detailed Description
Population	Patients with non-syndromic cleft lip and/or palate (CLP), including unilateral, bilateral, or combined cleft presentations
Type of Intervention	Studies evaluating orthodontic and/or orthopedic treatments coordinated with one or more surgical procedures
Surgical Stages Considered	Cheiloplasty, palatoplasty, secondary alveolar bone grafting, or orthognathic surgery
Study Design	Peer-reviewed clinical studies, systematic reviews, or meta-analyses
Publication Period	Studies published between 2016 and 2025
Language	English-language publications
Outcome Measures	Studies evaluating at least one of the following outcomes: facial growth, occlusal stability, relapse rate, aesthetic results, speech development, or psychosocial well-being
Data Reporting	Outcomes reported through quantitative or qualitative analysis
Accessibility	Studies with full text available for evaluation

Table 3. Exclusion Criteria for Study Selection

Criterion Category	Detailed Description
Syndromic Conditions	Studies involving syndromic cleft lip and palate or craniofacial anomalies (e.g., Pierre Robin sequence, Treacher Collins syndrome)
Publication Type	Case reports, editorials, expert opinions, and commentaries lacking methodological transparency
Insufficient Outcome Data	Studies without post-treatment evaluation
Language Restriction	Articles published in languages other than English
Accessibility Issues	Studies for which the full text could not be accessed
Methodological Limitations	Studies lacking sufficient methodological detail or comparable clinical outcome data

4. RESULTS

The study selection process is summarized in Figure 1 using a PRISMA flow diagram. Initially, a total of 620 records were identified through database searches, including PubMed, ScienceDirect, and Google Scholar. After removing duplicates and records that were not relevant or not considered scientific sources, 500 articles remained for screening. During the title and abstract screening phase, most studies were excluded as they did not directly address cleft lip and palate or orthodontic and orthopedic management, leaving 80 articles for full-text review. Of these, 20 could not be retrieved, and the remaining 60 were assessed for eligibility. Following a more detailed evaluation that was based on the predefined inclusion and exclusion criteria, 50 studies were excluded for reasons such as focusing on syndromic cases, lacking appropriate orthodontic or orthopedic interventions, not reporting relevant outcomes, or having an unsuitable study design. Ultimately, 10 studies met all the criteria and were included in the final study analysis.

PRISMA 2020 flow diagram for new systemic reviews which included searches of databases and registers only

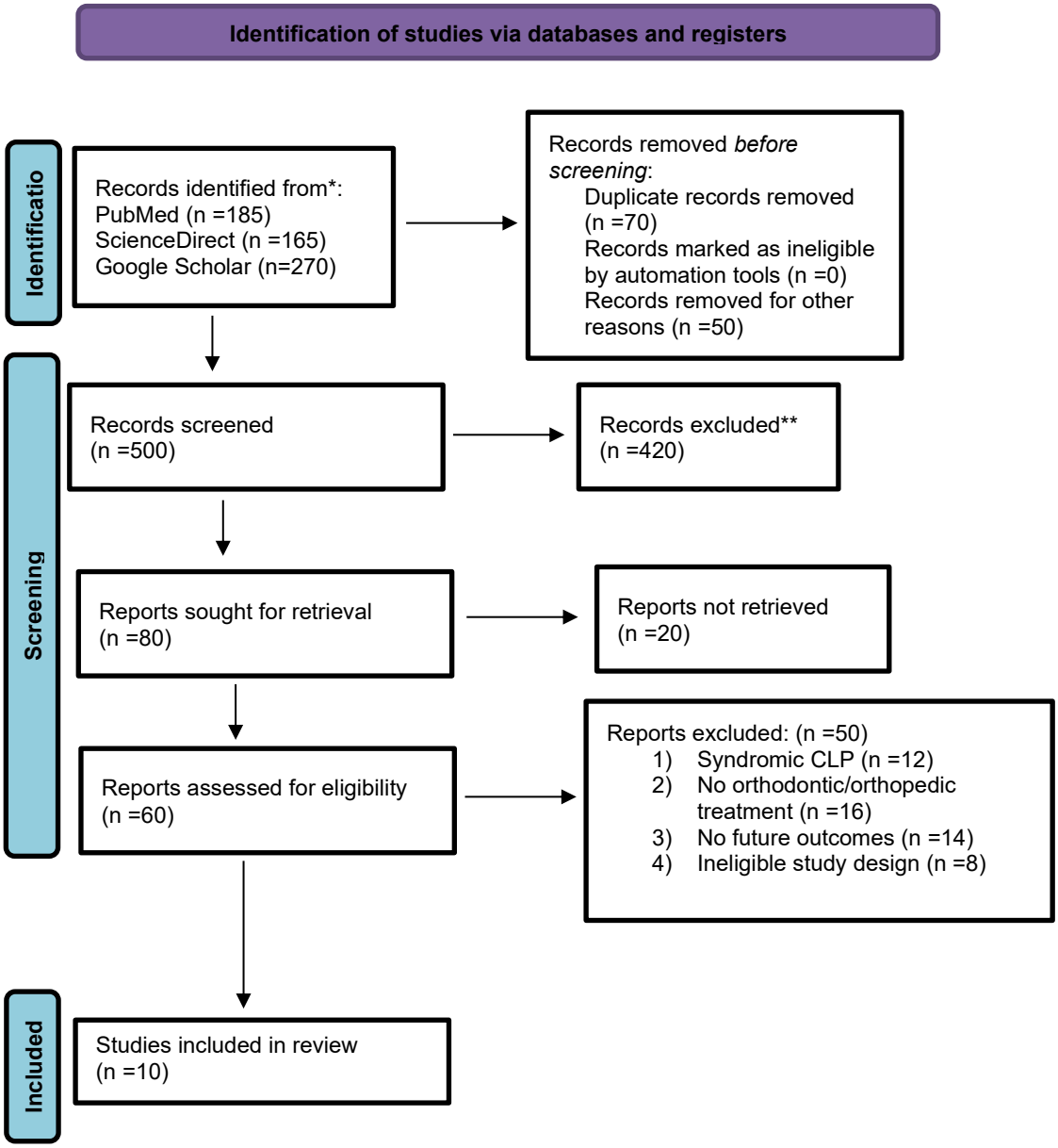


Figure 1. Flowchart of literature search and selection criteria

Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

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Table 4. Orthodontic and Orthopedic Appliances Used Across Included Studies (n=10)

Illustrates the range of orthopedic and orthodontic appliances used across the included studies.

Author (Year)	Appliance Type	Treatment Phase	Purpose of Appliance	Key Observations
Hosseini et al. (2017) (12)	NAM, passive molding plates	Presurgical infancy	Alveolar approximation, nasal shaping	Short-term improvement in cleft width and nasal symmetry
Alzain et al. (2017) (23)	NAM, orthopedic plates	Presurgical	Facilitate lip and palate repair	Improved surgical conditions
Tanaka & Saito (2019) (9)	Expansion appliances	Early mixed dentition	Dentoalveolar development	Improved transverse arch development
Chang et al. (2016) (13)	Fixed orthodontic appliances	Pre-bone graft	Alignment prior to grafting	Improved graft integration
Ma et al. (2021) (14)	Orthodontic preparation devices	Pre-SABG	Optimize alveolar bone grafting	Higher graft success rates
Berkowitz (2016) (25)	Facemask, reverse-pull headgear	Growth modification	Maxillary advancement	Improved facial balance

Presurgical devices such as nasoalveolar molding and passive plates were first implemented during infancy to improve alveolar alignment and nasal symmetry before surgical repair. In later stages, expansion appliances, fixed orthodontic systems, and growth-modification devices were used to optimize arch form and maxillary development prior to bone grafting or orthognathic surgery. Overall, appliance selection was closely linked to treatment timing and surgical coordination.

Table 5. Timing of Orthodontic / Orthopedic Intervention in CLP Patients

Highlights the importance of developmental timing in cleft management.

Study Group	Age / Dentition Stage	Intervention Type	Clinical Rationale	Reported Impact
Infant stage	Birth–6 months	Presurgical orthopedics (12,23)	Reduce cleft severity before surgery	Easier cheiloplasty and palatoplasty
Early childhood	Primary dentition	Limited orthopedic guidance (13,14)	Maintain arch form	Mixed evidence on long-term growth
Mixed dentition	6–12 years	Orthodontic expansion and alignment (13,14)	Prepare for SABG	Improved graft success and canine eruption
Adolescence	Permanent dentition	Comprehensive orthodontics (15)	Occlusal correction	Increased stability when coordinated
Post-growth	Adulthood	Orthodontic finishing (15,25)	Functional optimization	Improved masticatory efficiency

Early presurgical orthopedic intervention was associated with improved surgical conditions (12,23), while mixed-dentition orthodontic preparation was consistently linked to enhanced alveolar bone graft success and improved eruption patterns (13,14). Delayed intervention has been shown to increase skeletal rigidity and treatment complexity (15,25). These findings reinforce the necessity of stage-specific orthodontic planning.

Table 6. Surgical Procedures Coordinated with Orthodontic Treatment

Summarizes how orthodontic and orthopedic treatments were coordinated with major surgical milestones.

Surgical Procedure	Coordinated Orthodontic Phase	Supporting Studies	Reported Benefit
Cheiloplasty	Presurgical orthopedics	Hosseini et al. 2017 (12); Alzain et al. 2017 (23)	Reduced tissue tension
Palatoplasty	Early orthodontic guidance	Eriguchi et al. 2018 (15)	Improved palatal growth control
Secondary alveolar bone grafting	Mixed-dentition orthodontics	Chang et al. 2016 (13); Ma et al. 2021 (14)	Increased graft stability
Orthognathic surgery	Pre- and post-surgical orthodontics	Ferreira et al. 2021 (16)	Reduced relapse rates

Presurgical orthopedics facilitated cheiloplasty and palatoplasty by reducing cleft width (12,23), while orthodontic alignment prior to secondary alveolar bone grafting improved graft stability and arch continuity (13,14). Multidisciplinary coordination, particularly before orthognathic surgery, was associated with improved long-term stability and reduced relapses (16). These findings support the integration of orthodontics into surgical planning rather than treating it as a secondary phase.

Table 7. Long-Term Outcomes Reported in Included Studies

Compare the long-term outcomes found reported in each of the studies included.

Outcome Category	Findings	Studies Supporting
Facial growth	Improved sagittal and transverse maxillary development with early coordination	Eriguchi et al. 2018 (15); Berkowitz 2016 (25)
Occlusal stability	Better arch continuity and reduced relapse	Chang et al. 2016 (13); Alberconi et al. 2017 (17)
Masticatory function	Improved chewing efficiency in adults	Miura et al. 2021 (20)
Surgical stability	Reduced need for secondary corrections	Ferreira et al. 2021 (16)
Relapse risk	Lower when orthodontics precedes surgery	Ma et al. 2021 (14)

Coordinated orthopedic–orthodontic–surgical protocols were associated with improved facial growth patterns and sagittal relationships (15,25), enhanced occlusal stability (13,17), and better masticatory performance in adulthood (20). Although methodological heterogeneity limits direct comparison, the overall trend favors early and coordinated intervention.

5. DISCUSSION

Throughout this systematic study it emphasized the importance of treatment timing, interdisciplinary coordination, and what appliances were chosen per case whether it is influential in facial growth, occlusal stability, and quality of life outcomes. Moreover, evaluating whether orthopedic and orthodontic treatment coordinated with surgical interventions provides superior long-term outcomes compared to orthodontic–surgical treatment alone in patients with non-syndromic cleft lip and/or palate (CLP).

5.1 Timing of Orthopedic and Orthodontic Intervention

Prior to cheiloplasty and palatoplasty, presurgical orthopedic techniques, specifically nasoalveolar molding (NAM) and passive molding plates, have been shown to enhance alveolar alignment and nasal symmetry (12,23). These interventions reduce the cleft width and improve surgical conditions by minimizing tissue tension during primary repair stage. Although the priority may be only on long-term impacts on the craniofacial growth, short-term structural improvements are still consistently documented (12). Orthodontic intervention during the mixed-dentition stage, specifically before secondary alveolar bone grafting (SABG), was significantly correlated with improved graft integration and dental arch continuity (13,14). Patients who underwent orthodontic preparation before alveolar bone grafting exhibited a much better surgical outcome when in comparison to those who did not undergo pre-graft orthodontics, as demonstrated by *Chang et al* (13). Similarly, *Ma*. concluded that presurgical orthodontic alignment would higher the chances of graft success and reduce residual alveolar defects (14). These results confirm that rather than postponing treatment, intervening at an earlier stage is the key success by starting the orthodontic coordination at crucial developmental periods. Although, applying these strong forces at an earlier stage may cause disruption in the growth centers of a child yet by delaying orthodontic intervention it may reduce skeletal adaptability and complicate the surgical correction, highlighting the need for precise interdisciplinary timing (15,25).

5.2 Facial Growth and Occlusal Stability

Coordination of orthopedic, orthodontic, and surgical procedures strongly affected long-term facial growth patterns. According to *Eriguchi*, scheduled palatoplasty in combination with orthodontic treatment affected palatal growth patterns, showing the influence of treatment timing on maxillary development (15). In developing CLP patients, growth-modification techniques such as facemask and reverse-pull headgear therapy have also been reported to

improve sagittal relationships (25). Coordinating orthodontic alignment with surgical milestones has been shown to increase occlusal stability. Orthodontic pre-graft preparation increased intercuspation and arch continuity, contributing to improved dental arch stability over time (13,14,26). *Alberconi* recognized how extensive orthodontic care load is in CLP patients but also verifying that to achieve long-term stability of occlusal relationships thorough orthodontic therapy was needed (17). Furthermore, multidisciplinary coordination has been associated with reduced relapse rates and improved functional balance, although long-term stability remains influenced by additional relapse-related factors specific to CLP patients (16,27). These findings suggest that orthodontics should not be considered a secondary phase following surgery but rather an essential element to incorporate during surgical planning.

5.3 Functional Outcomes

Throughout the collected literature they also addressed functional characteristics including speech results and masticatory efficiency. *Miura* found that adult CLP patients who had integrated orthodontic therapy had better masticatory function (20). Early interdisciplinary management has been shown to improve speech-related results, may it be in coordination with a speech therapist as well as orthodontic therapy supporting structural correction and functional adaptation (22). These results indicate that coordinated interdisciplinary care contributes not only to structural correction but also to functional rehabilitation.

5.4 Psychosocial and Quality of Life Outcomes

Despite being evaluated less frequently than skeletal or dental characteristics, psychosocial outcomes consistently demonstrated the advantages of combining treatment. After receiving both orthodontic and surgical therapy, children and adolescents' perceived quality of life significantly improved, according to *Ruiz-Guillén* (21). Similarly, *Branson* identified how untreated or wrong management of patients suffering CLP face persistent peer difficulties, emphasizing the psychological importance of early and effective intervention for the patient to live a more pleasant life in the long term (19). Studies evaluating quality of life have shown that improvements in facial aesthetics and dental function are associated with higher levels of self-esteem and better social integration among children and adolescents with CLP (19,21). Suggests that treatment success should not be measured solely by occlusal or skeletal outcomes but also by improvements in emotional well-being and social integration (19,21).

5.5 Limitations of Evidence

Despite the overall consistency of the findings, several limitations should be considered. The included studies showed variation in design, patient age, intervention timing, and outcome assessment techniques, but persistent trends supporting coordinated treatment procedures. Due to this variability, quantitative meta-analysis was not possible and direct comparison between trials was restricted. Additionally, some studies reported relatively small sample sizes or limited follow-up periods, which may affect the generalizability of the results. Differences in treatment protocols between cleft care centers may also influence reported outcomes. Furthermore, compared to anatomical parameters, psychosocial outcomes were less standardized and evaluated less frequently, while other important aspects such as periodontal health and long-term relapse risk were also not consistently assessed across studies (19,21,27,28).

5.6 Clinical Implications

Overall, the evidence strongly supports the integration of orthopedic and orthodontic treatment within multidisciplinary cleft care pathways. Early collaboration between orthodontists, maxillofacial surgeons, pediatric dentists, and speech therapists allows treatment plans to be optimized according to the patient's growth pattern and individual needs. The improvement was shown in surgical circumstances, increased facial growth, increased occlusal stability, and higher quality of life outcomes are all benefits of coordinated intervention, especially when it is started at the right developmental phases (12-14,16,21). Additionally, long-term treatment success should not only focus on structural correction but also consider periodontal health maintenance and relapse prevention strategies to ensure stability of outcomes over time (27,28). Thus, establishing standardized treatment protocols based on timing and interdisciplinary coordination may reduce variability in long-term outcomes, the need for secondary corrective procedures later in life, and improve overall patient management.

5.7 Additional Findings and Other Clinical Considerations

Beyond the main outcomes, other findings point to important factors that affect long-term treatment success in patients with cleft lip and palate. Differences in post-treatment dental arch stability have been observed between CLP and non-cleft patients, indicating that maintaining long-term occlusal stability remains a clinical challenge despite successful orthodontic–surgical treatment (26). Periodontal health is another important consideration. Increased periodontal and microbiological risk has been reported in CLP patients undergoing orthodontic treatment,

likely due to anatomical complexity and difficulties in the maintenance of their oral hygiene (28). This supports the need for consistent periodontal monitoring throughout the entirety of the treatment. Moreover, relapses also represent a key concern. Factors such as initial malocclusion severity, treatment timing, and treatment approach have been associated with relapse risk, highlighting the importance of individualized planning and retention strategies (28). Overall, these findings show that successful cleft management extends beyond immediate treatment outcomes and requires careful consideration of long-term stability, periodontal health, and relapse prevention (26,27).

5.8 Future Research

These findings highlight several areas that remain challenging in clinical practice and emphasize the need for continued research to improve long-term outcomes in patients with cleft lip and/or palate. Prospective longitudinal studies should focus on evaluating long-term functional, aesthetic, and psychosocial outcomes of coordinated orthodontic–surgical treatment protocols. The use of standardized outcome measures and larger patient cohorts would improve the comparability and reliability of results across studies. Additionally, investigations are needed to better define the optimal timing and sequencing of orthodontic and orthopedic interventions in relation to surgical procedures, particularly during key developmental stages. Greater attention should also be given to long-term factors such as treatment stability, relapse risk, and periodontal health, which remain insufficiently explored in the current literature. Finally, emerging digital orthodontic technologies and three-dimensional imaging should be explored for their potential to improve treatment planning, monitoring, and overall outcomes in patients with CLP.

6. CONCLUSION

In closing, this literature review explored the role of orthodontic treatment in patients with cleft lip and palate, and it highlighted how important orthodontics is in the overall management of this condition. These articles analyzed that these patients often present complex dental and skeletal problems, such as maxillary deficiency, malocclusions, and misalignment of the dental arches. These alterations can significantly affect both function and aesthetics, making orthodontic intervention a key component in their treatment. Orthodontic treatment plays a major role not only in correcting these issues but also in preparing the patient for the following stages of treatment, including surgical procedures when necessary.

According to the findings of the reviewed studies, orthodontic treatment can greatly enhance both functional and aesthetic outcomes when it is properly planned and carried out at the appropriate stages of growth. Improvements in occlusion, oral function, and facial balance can positively impact on the patient's daily life and overall well-being. In addition, orthodontic care often contributes to achieving more stable and predictable results in the long term, especially when it is integrated within a thorough treatment plan. Another important point that was consistently highlighted and deduced throughout literature is the need for close collaboration between orthodontists, maxillofacial surgeons, and other healthcare professionals. The management of cleft lip and palate requires a multidisciplinary approach through which treatment decisions are coordinated to ensure optimal timing and results. This collaborative process is essential to address not only the physical aspects of the condition but also its functional and psychosocial implications.

Overall, the studies reviewed show that orthodontics contributes to beyond correcting dental irregularities, but also to restoring facial harmony, improving oral function, and enhancing patients' quality of life. However, variations in treatment protocols and timing across different studies suggest that further research is needed to better standardize orthodontic approaches and optimize treatment strategies. Nevertheless, further research to advance in this area will help improve clinical outcomes by providing a more standardized and effective treatment protocol whilst choosing the most optimal time for orthodontic intervention to achieve the best possible outcomes for patients with cleft lip and palate.

7. SUSTAINABILITY

Sustainability in healthcare extends beyond environmental concerns to include social responsibility, equitable access to treatment, and the development of efficient multidisciplinary care systems. In the management of cleft lip and palate (CLP), sustainable practices aim to provide long-term functional, aesthetic, and psychosocial benefits while optimizing clinical resources. Coordinated orthodontic and orthopedic treatment alongside surgical interventions contributes to sustainability by improving outcomes and reducing the need for repeated corrective procedures. Early, well-timed interventions facilitate surgical repair, enhance bone graft success, and improve occlusal stability, ultimately minimizing complications and relapse.

A multidisciplinary approach involving orthodontists, surgeons, pediatric dentists, speech therapists, and psychologists' supports patient-centered care that addresses both functional rehabilitation and psychosocial well-being. Integrating orthodontic planning with surgical stages allows treatment to occur at optimal developmental periods, improving efficiency and reducing overall treatment burden. Additionally, this coordinated model promotes knowledge sharing among specialists and supports the development of standardized, evidence-based protocols.

Improving access to early diagnosis and specialized care further strengthens social sustainability by ensuring that patients receive appropriate long-term support. Overall, coordinated orthodontic–surgical management enhances clinical outcomes while contributing to a more efficient, accessible, and patient-centered healthcare system.

8. REFERENCES

1. Dupont, C., & Garnier, F. (2023). Les fentes labiales et palatines (FLP): Épidémiologie, traitement et suivi multidisciplinaire. Revue Française de Chirurgie Maxillo-Faciale, 49(2), 65–78.
2. Khan, A., & Ahmed, S. (2019). Prevalence of cleft lip and palate in various populations: A global review. Journal of Craniofacial Research, 15(3), 102–108.
3. Malik, S., & Hashmi, S. (2018). Types and patterns of cleft lip and palate in Pakistan: A hospital-based study. Pakistan Journal of Medical Sciences, 34(2), 210–215.
4. Silva, L., Costa, F., & Rodrigues, A. (2021). Association of the profile of individuals with cleft lip and palate and related factors. International Journal of Pediatric Dentistry, 31(4), 542–550.
5. Ali, M., & Noor, T. (2020). Cultural beliefs and etiological perceptions of cleft lip and palate among parents and caregivers. Community Dental Health Journal, 37(1), 42–48.
6. Canadian Paediatric Society. (2019). Cleft lip and palate: CPS position statement on care and intervention. Paediatrics & Child Health, 24(3), 185–191.
7. Rossi, C., & Bianchi, P. (2022). Adjunctive use of botulinum toxin type A in cleft lip repair. Journal of Oral and Maxillofacial Surgery, 80(6), 1051–1058.
8. Martins, A., & Pereira, D. (2020). Periodontal and microbial considerations in cleft lip and palate patients: A review. Journal of Clinical Periodontology, 47(9), 1081–1090.
9. Tanaka, H., & Saito, K. (2019). Dentoalveolar effects of early orthodontic treatment in cleft lip and palate patients. Orthodontic Waves, 78(2), 95–103.
10. Johnson, R., & Patel, V. (2018). Approach to patients with cleft lip and palate in orthodontic practice. Journal of Orthodontic Science, 7(5), 66–73.
11. Sommerlad BC. *Cleft lip and palate: Treatment and management*. Cham: Springer Nature; 2016.
12. Hosseini, M., Kaklamanos, E., & Athanasiou, A. (2017). Treatment outcomes of pre-surgical infant orthopedics in patients with non-syndromic cleft lip and/or palate: A systematic review and meta-analysis of randomized controlled trials. PLoS ONE, 12(7), e0181768.
13. Chang CS, Por YC, Liou EJ, Chen PKT, Noordhoff MS. Difference in the surgical outcome of unilateral cleft lip and palate patients with and without pre-alveolar bone graft orthodontic treatment. Sci Rep. 2016;6:23597.
14. Ma, L., Wang, Y., & Liu, X. (2021). Effectiveness of presurgical orthodontics in cleft lip and palate patients undergoing alveolar bone grafting: A systematic review. Journal of Stomatology, Oral and Maxillofacial Surgery, 122(1), 13–17.

15. Eriguchi, R., Sato, Y., & Tanimoto, K. (2018). Growth of the palate in unilateral cleft lip and palate patients undergoing two-stage palatoplasty and orthodontic treatment. Japanese Dental Science Review, 54(3), 178–187.
16. Ferreira M, Oliveira TM, Carrara CF, Machado MA, Garib DG. Multidisciplinary management in cleft lip and palate: A systematic review. Int J Environ Res Public Health. 2021;18(12):12826.
17. Alberconi, M., Garib, D., & Janson, G. (2017). Assessment of orthodontic burden of care in patients with unilateral complete cleft lip and palate. American Journal of Orthodontics and Dentofacial Orthopedics, 152(5), 672–679.
18. Kousa, Y., et al. (2023). Molecular and genetic pathways influencing cleft lip and palate outcomes. Genes, 14(1603), 1–15.
19. Branson, C., et al. (2022). Psychological and peer difficulties of children with cleft lip and/or palate: A systematic review and meta-analysis. Journal of Pediatric Psychology, 47(9), 1153–1172.
20. Miura, H., et al. (2021). Masticatory function assessment of adult patients with cleft lip and palate after orthodontic treatment. Cleft Palate–Craniofacial Journal, 59(3), 390–398.
21. Ruiz-Guillén, A., et al. (2021). Perception of quality of life by children and adolescents with cleft lip and palate after orthodontic and surgical treatment: Gender and age analysis. Progress in Orthodontics, 22(10), 1–10.
22. Lane, H., et al. (2021). A systematic review of early speech interventions for children with cleft palate. International Journal of Language & Communication Disorders, 56(4), 923–941.
23. Alzain I, Asahito T, Murakami K, Ohkubo K, Watanabe A. Presurgical cleft lip and palate orthopedics: An overview. J Clin Pediatr Dent. 2017;41(2):80–86.
24. Moreira RS, Franco LP, Rocha R. Association of the profile of individuals with cleft lip/palate with the beginning of orthopedic/orthodontic treatment. Dent Press J Orthod. 2017;22(3):59–66.
25. Berkowitz S. *Cleft lip and palate: Diagnosis and treatment*. London: InTechOpen; 2016.
26. Caballero JT, Pucciarelli MGR, Pazmiño VFC, Curvêllo VP, Menezes M, Sforza C, Soares S. 3D comparison of dental arch stability in patients with and without cleft lip and palate after orthodontic/rehabilitative treatment. J Appl Oral Sci. 2019;27:e20180434.
27. Achterrath S, Graf I, Guevara R, Braumann B, Kruse T. Predictors for long-term relapse of orthodontic treatment in patients with cleft lip and palate: A clinical follow-up study. Clin Oral Investig. 2024;28:239.

28. Khatri A, Khatri M, Bansal M, Batra P, Aziz SB. Periodontal and microbiological evaluation in cleft lip/palate patients undergoing orthodontic treatment: A cross-sectional study. J Periodontal. 2025;96:44–54.