

## A Scoping Review Comparing Oral Microbial Diversity of Fixed Versus Removable Orthodontic Appliances in Mouth-Breathing Children

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### ABSTRACT

Mouth-breathing is a common condition among children undergoing orthodontic treatment, playing a significant role in altering the oral environment. Breathing through the mouth leads to changes in the humidity and temperature of the oral cavity, which can disrupt the balance of the oral microbiome. The study aims to systematically investigate oral microbial diversity in mouth-breathing children undergoing orthodontic treatment and assess the impact of each appliance type. The search process in this review was guided by predetermined clinical questions using the PCC framework: population (P), concept (C), and context (C). Relevant papers published between 2014 and 2024 were identified through PubMed, Scopus, and EBSCOhost databases, following PRISMA-ScR guidelines. Data extraction followed a structured approach, and the JBI Critical Appraisal Checklist was used to assess study quality. Of 204 papers identified, 6 studies met the inclusion criteria. Both appliance types led to shifts in microbial balance, with mouth-breathing children showing overgrowth of facultative anaerobes and reduced aerobic species. This influence appeared more pronounced with fixed appliances. Mouth-breathing in children undergoing orthodontic treatment significantly disrupts the oral microbiome, with fixed appliances showing a more pronounced negative impact on microbial diversity than removable appliances. Further longitudinal studies are required to explore the effects of oral hygiene interventions on the microbial environment and to inform clinical decision-making for better mouth-breathing management.

**Keywords:** *Mouth-Breathing Children; Oral Microbial; Interceptive Orthodontic; Oral Health; Scoping Review*

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### INTRODUCTION

The development of cranial and dentofacial structures is influenced by a variety of genetic and environmental factors. One such environmental factor, respiratory function, has a direct effect on the musculoskeletal system (Topsakal et al., 2024). The respiratory system, along with functions like chewing and swallowing, is vital for the development of head and neck structures (Topsakal et al., 2024). Nasal breathing supports the growth of skeletal and dental structures by maintaining balanced muscle forces (Valcheva et al., 2018). It regulates air intake and, more importantly, exhalation, where oxygen is absorbed into the blood.

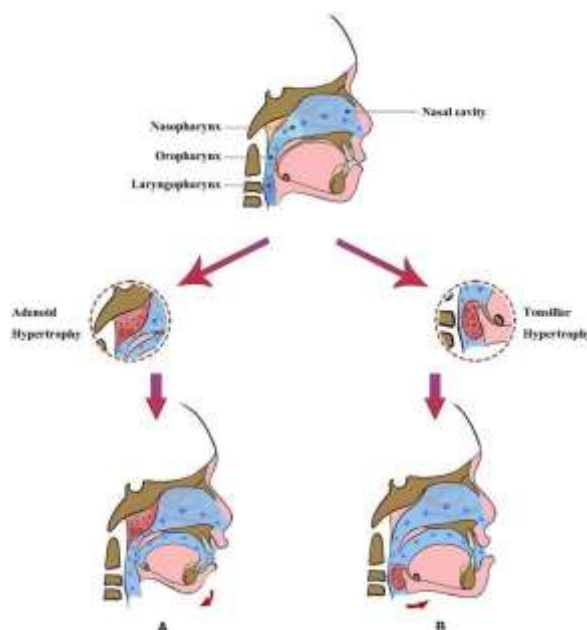
The negative pressure from nasal exhalation allows more time for oxygen to bind to hemoglobin, which requires a 5% carbon dioxide level in the blood (Valcheva et al., 2018). In contrast, individuals who breathe through their mouths experience a reduction in carbon dioxide levels in both the lungs and blood, which consequently results in a diminished oxygen supply to the body's cells (Valcheva et al., 2018).

Mouth breathing (MB) often occurs in individuals with nasal obstruction or those who habitually breathe through their mouths. Breathing through the mouth causes changes in the humidity and temperature inside the mouth, which can disrupts the oral environment, causing dryness and altering the balance of bacteria, and also related to a decrease in intraoral pH which can lead to dental issues like erosion and cavities (Choi et al., 2015; Topsakal et al., 2024). MB

is also linked to oral dysbiosis, halitosis, craniofacial anomalies, and pediatric sleep apnea. It can negatively affect jaw, tongue, and head posture, leading to changes in facial structure and dental development, such as a high palate, underdeveloped jaw, and misaligned teeth as seen in Figure.1 (Choi et al., 2015; Valcheva et al., 2018).

These changes contribute to poor facial skeletal development and malocclusion (Zhao et al., 2021). There was a great correlation between nasopharyngeal airway obstruction causing MB habits and the development of various skeletal and dental abnormalities, eventually leading to higher demand and need for orthodontic care (Elmomani et al., 2015; Zhao et al., 2021). According to one study, reported that among 285 children and adolescents aged 5–18 years old who were undergoing orthodontic treatment reported that 47.7% of them had association with mouth breathing due to nasal obstruction (Alhazmi, 2022).

Recent studies suggest orthodontic treatment for growing children can address transverse maxillary deficiency and mandibular retrusion, potentially improving pediatric obstructive sleep apnea (Alhazmi, 2022; Bucci et al., 2023). Interceptive orthodontic treatments, whether functional or orthopedic, using fixed or removable appliances, have shown positive effects on respiratory outcomes in children with MB and craniofacial issues. However, these treatments also pose risks, such as altering oral biofilm and increasing the risk of oral diseases (Bucci et al., 2023).



**Figure 1. Mouth breathing in individuals with respiration obstruction Class II malocclusion or Class III malocclusion and a tendency of anterior teeth crossbite**

Microbial diversity in the oral cavity plays a crucial role in maintaining oral health. A balanced and diverse microbiome is typically associated with a healthy oral environment, whereas a disrupted or imbalanced microbiome (dysbiosis) can lead to various oral health issues. To advance the field of research regarding treatment assessment of the oral microbiome, it is important to examine the diversity of oral microbial in MB children that using orthodontic appliances (Bucci et al., 2023).

This scoping review has two main objectives. The primary aim is to systematically examine the diversity of oral microbial in mouth-breathing children using orthodontics

appliances, focusing on their association with oral disease risk. Secondly, this review aims to evaluate and compare the effects of each type of appliance to inform clinical decision-making for mouth-breathing management in Children. Based on these aims, the following focused research questions were addressed: “Which type of orthodontic appliance—fixed or removable—demonstrates better oral microbial control in mouth-breathing children?”

## **METHOD**

This scoping review adhered to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines to ensure a systematic approach (Tricco et al., 2018). The PCC (Population, Concept, Context) framework defines inclusion and exclusion criteria. The PCC framework was chosen because it effectively maps evidence across studies while focusing on the broad area of research, aligning with the objectives of this review.

A comprehensive search was conducted across multiple electronic databases, including PubMed, Scopus, EBSCOhost, and additional manual searching from relevant study designs and limited to studies published in English from 2014 to 2024. The research question and, consequently, the search strategy were formulated using the PCC acronym as follows:

Population (P) = Children 1-18 years of age with mouth-breathing who were using interceptive orthodontic appliances

Concept (C) = Oral Microbial Diversity

Context (C) = The use of interceptive orthodontic appliances

Keywords and Medical Subject Headings (MeSH) terms were used, and Boolean operators were applied in all electronic databases (i.e. “Oral Microbial” AND “Mouth-breathing Children” OR Adolescent AND “Fixed Orthodontics” AND “Removable Appliances”).

The different steps for the scoping review were completed independently screened all titles and abstracts from the initial search results for relevance based on the inclusion and exclusion criteria by the two reviewers (M.U. and R.S.). Both reviewers independently assessed full-text articles to confirm eligibility, applying the same predefined criteria.

Data were systematically extracted using a structured approach to ensure consistency and accuracy. An Excel® Spreadsheet was used to manage references, exclude duplicates, and summarize extracted data, following which 6 articles were selected to be a part of this scoping review. The data extraction process involved reviewing all included studies and recording key information in a table format. Any disagreements on selected study were resolved by consensus and discussion by all authors.

The data quality was evaluated by applying to the Joanna Briggs Institute (JBI) Critical Appraisal Checklist. The JBI methodology for scoping review guideline is highly regarded for its clear scope definition, rigorous and transparent processes, and ability to incorporate diverse evidence types (Aromataris & Munn, 2020). Structured data extraction and synthesis processes, outlined in the JBI guideline, facilitate the derivation of impactful conclusions relevant to practice and policy (Aromataris & Munn, 2020).

The JBI for cross-sectional, case controls and cohort studies contained between eight and eleven items with four possible response categories: “yes,” “no,” “unclear” and “not applicable.” Two reviewers independently assessed the quality of the studies (M.U. and R.S.).

An overall score for each study was calculated by summing the number of “yes” responses. A score of  $\leq 30\%$  was considered low quality, a score between 31 and 60% was moderate and a score  $\geq 61\%$  was high quality and included to the further analysis. No studies were excluded on the basis of methodological quality. Differing conclusions and any disagreements were resolved by discussion between the two reviewers. All of six studies were classified as high quality and included in this scoping review.

## RESULTS AND DISCUSSION

PRISMA-ScR flowchart, providing an overview of the result obtained from the literature search. Out of the initially identified 204 articles following inclusion and exclusion criteria, 24 duplicates were removed. In total, 32 articles were included after screening the title and the abstract following the eligibility criteria, and their full texts were read and screened. A further 26 articles were excluded, yielding a total of 6 studies were incorporated into this scoping review as seen in Figure.3. Out of the 6 articles, one study is Cross Sectional study, three studies are Case-Control and the last two are Cohort Study.

The data analysis involves reviewing the characteristics and findings of each study to draw conclusions. Since the studies were diverse, the results were summarized narratively in Table.2 to account for differences in study designs and outcomes.

### **Influence of Mouth-Breathing on Microbial Composition**

Mouth breathing (MB) has been shown to significantly alter the microbial composition of the oral cavity, as demonstrated in Vrankova et al. Children who breathe through their mouths often exhibit distinct microbiota, including a higher prevalence of *Solobacterium* and *Candida* species (Vrankova et al., 2024). The study highlighted that mouth-breathing children were more prone to halitosis and had an increased apnea-hypopnea index, indicating that mouth breathing may exacerbate oral health issues.

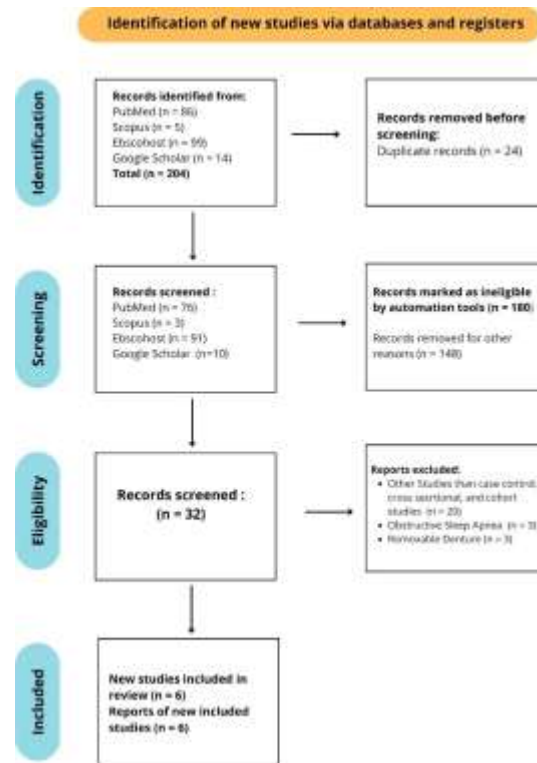


Figure 2. PRISMA-Scr Flowchart

The drying effect caused by mouth breathing may lead to changes in the oral pH and an imbalance in the oral microbiome, fostering the growth of opportunistic bacteria and fungi. These changes contribute to a higher risk of fungal infections and bacterial overgrowth, further complicating the oral health of children undergoing orthodontic treatment. Overall, MB appears to disrupt the normal microbial balance, potentially making children more susceptible to oral diseases like candidiasis and halitosis (Lin et al., 2022), periodontal markers like bleeding on probing, as reported by Ghijssels et al. (Ghijssels et al., 2014; Perkowski et al., 2019).

In contrast, removable appliances, while still affecting microbial composition, may cause less plaque retention and allow for more effective oral hygiene practices, potentially reducing the severity of these microbial shifts. Clear aligners, that one of the removable appliance, as discussed by Song et al., also affect the oral microbiome, but their impact may differ from that of fixed appliances.

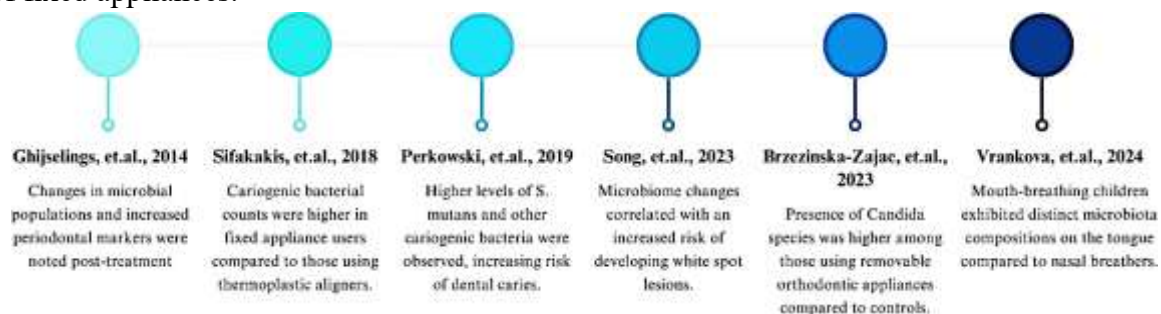


Figure 3. Key Finding Six Included Studies

### **Influence of Orthodontic Appliances on Microbial Composition**

Orthodontic treatment, regardless of appliance type, has a profound impact on the oral microbiome. Fixed appliances, in particular, are associated with significant changes in microbial populations. Perkowski et al., and Ghijselings et al. observed an increase in pathogenic strains of bacteria, such as *Enterococcus faecalis*, *Staphylococcus aureus*, and *Candida albicans* in patients with fixed appliances (Ghijselings et al., 2014; Perkowski et al., 2019). These appliances provide more surface area for plaque accumulation, contributing to the growth of cariogenic bacteria like *S. mutans* and *Lactobacillus acidophilus*, which can increase the risk of dental caries. Fixed appliances may also disrupt the oral environment by reducing the ability of the natural oral microbiome to self-regulate.

While they are less likely to harbor plaque due to the ability to remove them for cleaning, Song et al., found that clear aligners can still disrupt the oral microecosystem, leading to dysbiosis and an increased risk of white spot lesions (WSLs). This suggests that even removable appliances can create an environment conducive to microbial imbalance, especially when the aligners are not cleaned properly or worn for extended periods without removal (Song et al., 2023).

### **Microbial Diversity Effects on Oral Health**

A balanced, diverse microbiome is crucial for maintaining healthy oral conditions. Diverse microbial populations help to keep pathogenic organisms in check, reducing the risk of diseases like dental caries, periodontal disease, gingivitis, and oral infections. Dysbiosis, or a reduction in microbial diversity, can contribute to the overgrowth of pathogenic species, which can lead to tooth decay, gum inflammation, and oral fungal infections (like *Candida albicans*). Perkowski et al., and Ghijselings et al., found that fixed appliances were linked to an increase in harmful bacteria, highlighting how appliance use can lead to an imbalance in the microbiome, which in turn can affect oral health (Perkowski et al., 2019).

The presence of opportunistic bacteria such as *Enterococcus faecalis* and *Staphylococcus aureus* (as found in Perkowski et al. and Ghijselings et al.) is a sign of microbial imbalance, and these bacteria can lead to periodontal diseases and infections. Imbalance microbial diversity is also linked to fungal overgrowth, particularly *Candida albicans*. Brzezinska-Zajac et al., and Vrankova et al., observed that children using orthodontic appliances exhibited higher rates of *Candida* colonization, which can cause oral candidiasis, halitosis, and other infections. Lastly, the disruption of microbial balance, such as the changes seen with clear aligners in Song et al., increases the risk of developing white spot lesions, an early sign of enamel demineralization, which can lead to tooth decay if not addressed promptly.

### **Comparison of Fixed versus Removable Appliances for Microbial Control in Mouth Breathing Children When comparing the microbial effects of**

Fixed and removable appliances, several studies highlight the greater microbial disruption associated with fixed appliances. For example, Sifakakis et al., found that patients with fixed appliances had higher counts of cariogenic bacteria such as *S. mutans* compared to those using thermoplastic aligners (Sifakakis et al., 2018). This is likely due to the fixed appliances' ability to trap food particles and plaque around the brackets, which can lead to

bacterial growth and increased risk of caries. Conversely, removable appliances, like aligners, offer better opportunities for maintaining oral hygiene as they can be taken out for cleaning.

This may explain why Sifakakis et al., observed lower plaque and gingivitis scores in aligner users (Sifakakis et al., 2018). However, removable appliances are not without their own drawbacks. Brzezinska-Zajac et al., found that removable appliances were linked to higher colonization rates of *Candida albicans* in children, especially in older children (over 9 years old). While removable appliances may allow for easier oral hygiene, they can still encourage fungal growth due to the warm, moist environment created by the appliances in the mouth. Additionally, Song et al., noted that clear aligners, while offering a more aesthetic and hygienic option, can still contribute to oral dysbiosis and increase the risk of WSLs if not properly managed (Brzezinska-Zajac et al., 2023; Lin et al., 2022; Song et al., 2023; Vrankova et al., 2024).

## CONCLUSION

Mouth-breathing, common in children undergoing orthodontic treatment, alters oral temperature and humidity, disrupting the microbiome balance; fixed appliances exacerbate this by retaining pathogenic bacteria and elevating risks of caries and periodontal disease, while removable ones, though easier to clean, can still promote fungal overgrowth and dysbiosis. Appliance selection for these children should thus prioritize hygiene habits, type-specific microbial risks, ongoing microbiome monitoring, and robust oral hygiene practices. However, current studies are limited by short-term focus and inadequate control of confounders like diet, hygiene, and systemic health, hindering isolation of orthodontic impacts. For future research, longitudinal studies are recommended to track long-term microbial shifts, evaluate hygiene interventions' efficacy, and enable personalized, preventive strategies in pediatric dentistry.

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