# Bacterial Adhesion and the Role of Mouthwashes in Orthodontics: A Literature Review

Valeria Díaz Cabrera[1], Mariano Ortiz Pizarro[1], Katherine Yolanda Lozano Peralta[2], Martin Arturo Vilela Estrada[2], Christian Richard Mejía Álvarez[3], Victor Serna Alarcón[2]*

1. School of Dentistry, Faculty of Medicine, Santo Toribio de Mogrovejo Catholic University, Chiclayo, Peru.
2. School of Medicine, Faculty of Medicine Antenor Orrego Private University, Trujillo, Peru.
3.Continental University, Huancayo, Perú

## Abstract

Bacterial plaque can adhere to materials used in fixed orthodontic treatment. Several studies have reported the chemical control that mouthwashes provide with respect to the reduction of bacterial strains. The objective of the present investigation was to review the bibliographic evidence regarding bacterial adhesion that occurs during orthodontic treatment and the role of mouthwashes with respect to plaque control.

Electronic search expressions were used in the following databases PubMed, Scopus, EBSCO, Science Direct and Virtual Health Library, retrieving a total of 43 articles on which this review was based. There is information available regarding oral mouthwashes, which allow the professional to prescribe or indicate an oral mouthwash with fewer side effects, but with the same antibacterial efficacy of chlorhexidine. In this sense, an interesting option is the rinses of natural origin, which have been successfully tested in experimental studies.

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## Introduction

Oral diseases occur due to the accumulation of bacteria, including bacteria that cause dental caries and periodontal disease[1]. It is also mentioned that the formation of bacterial dental plaque is 2-3 times higher in adult patients with orthodontics compared to patients without treatment[2].

This problem not only affects the accumulation of dental plaque and the formation of cavities, it also promotes an increase in colonized pathogens in biofilms that are directly related to gingival and periodontal problems during orthodontic treatment that will last several months[3]. In this context, oral mouthwashes serve as an effective supplement to help control bacterial contamination, since there is evidence that regular tooth brushing and flossing are not enough. Mouthwashes have played an important role and have been the subject of various investigations in recent years where synthetic and natural principles have been tested to obtain satisfactory results in orthodontic treatment, taking into account its particularities[2,4,5].

The objective of this research is to review the available literature on bacterial adhesion that occurs during orthodontic treatment and the role of mouthwashes with respect to plaque control and other useful indices in monitoring the evolution of treatment.

## Materials and methods

An electronic bibliographic search was carried out in the following databases: PubMed, Scopus, EBSCO, Science Direct and the Virtual Health Library (VHL). Bibliography in English and Spanish was retrieved using the terms MeSH, Non-MeSH, and DeCS used in search expressions presented in Table 1. The inclusion criteria incorporated clinical trials, observational studies and in vitro studies. The following were excluded from the review: systematic reviews, literature reviews, clinical cases, case series, letters to the editor, books, newsletters and announcements. Likewise, the bibliographic recovery period included publications from 2016 to December 14, 2021.

A total of 193 articles were retrieved, of

***Corresponding author:**
Victor Serna Alarcón, MD, MCR, PhD.
Faculty of Medicine,
Antenor Orrego Private University, Trujillo, Peru.
E-mail: victor.serna.alarcon@gmail.com

which the following were obtained: 49 records for PubMed, 38 for Scopus, eight for EBSCO, 87 for Science Direct and 11 for the Virtual Health Library (VHL). Using a reference manager, duplicates were eliminated, keeping a total of 98 publications. The entered records were screened and after reviewing the full-text articles, the proposed exclusion criteria were applied to obtain the 43 articles on which the present review was based, according to the flow chart described in Figure 1.

## Review

### Bacterial microflora in orthodontic appliances

Not only dental surfaces, but also foreign surfaces, such as orthodontic appliances, can represent an ideal substrate for biofilm formation[6,7]. The presence of various fungal, pathogenic bacterial and opportunistic strains in the superficial layer of the biofilm, as well as in the periodontal pockets, produce bacterial adhesion on the components of orthodontic appliances[8,9]. For example, a higher prevalence of *Enterococcus faecalis, Enterococcus faecium, Staphylococcus aureus, Escherichia coli, Candida albicans*, has been described in patients with fixed appliances compared to patients with removable or untreated[10]. Microbial plaque retention also depends on the type of ligation, elastic ligatures or stainless steel that are used to hold the wire in the brackets, which contribute to the retention of the supragingival plate[11,12]. *Fusobacterium nucleatum, Porphyromonas gingivalis* and *Treponema denticola* have been described more frequently in lingual appliances, *Fusobacterium periodontium* and *Prevotella* with a higher percentage in labial fixed appliances, while *Campylobacter rectus* and *Tannerella forsythia* showed slightly higher counts in aligners[13]. Although other authors report plaque scores and significantly lower gingivitis rates in patients treated with aligners[14].

### Factors influencing bacterial adhesion

Some of the factors that can facilitate bacterial adhesion in orthodontic appliances are: surface roughness, salivary composition and flow, incubation time, frequency of sucrose ingestion, and oral hygiene[3,6]. The appliances complicate the effective brushing of the teeth, causes a possible retention of food and an imbalance in the homeostasis of the oral cavity[15]. Rough surfaces create sites for plaque retention by increasing the surface area for new bacterial niches, with poor mechanical removal and preventing the displacement of bacterial colonies[11,16].

Both the quantity and quality of saliva are important in microbiological growth[2,4], if the normal quantity of saliva decreases then there is hyposalivation, which causes thick saliva, cavities in atypical places and an increase in the frequency of oral infections, especially due to *Candida spp*.[17,18].

### Bacterial adhesion in orthodontic archwires

There are some studies that have shown that surface roughness and surface free energy are two key aspects to explain bacterial adhesion to coated and uncoated orthodontic archwires[6,8]. There are also reports on the coating of stainless steel or nickel-titanium (NiTi) with polytetrafluoroethylene or epoxy resin in order to improve aesthetics, but that it could increase the adhesion of bacterial biofilm, showing that fully coated arches accumulate significantly more microorganisms. in comparison to arches with less or without coating such as stainless steel or NiTi [8,19].

### Bacterial adhesion to orthodontic bands and cements

Fixed orthodontic appliances create retention areas for plaque accumulation, increasing the risk of enamel demineralization[7,9]. White spot lesions caused by decalcification around the bands are frequently observed, which has promoted alternatives such as coating with silver nanoparticles on the surface of the band, achieving an adequate antibacterial effect in vitro[13,20]. Choosing a band cement with less bacterial adhesion would be beneficial in preventing and reducing white spot, a common lesion when fixed appliances are removed. In this regard, Transbond Plus Band Cement (3M Unitek, St. Paul, MN, USA) is mentioned as a light-curing cement with less adhesion than *Streptococcus sanguinis* and *Streptococcus mutans*[13-15]. The use of conventional glass ionomer cements has been decreasing due to reports that show greater bacterial filtration in orthodontic bands, due to the incorporation of air microbubbles during their preparation[21].

### Bacterial adhesion in brackets

The self-ligating brackets that were accepted in recent decades thanks to the elimination of the need for ligatures, have shown greater adherence of the species of the red and orange bacterial complexes, due to the topographic characteristics of the bracket[3,13]. In several studies on brackets, it has been possible to identify acidogenic bacteria present, especially *Streptococcus mutans* and *Lactobacillus acidophilus*, responsible for reducing the pH and causing dental plaque accumulation approximately one month after union[14,21]. It was reported that metal brackets have a lower susceptibility to bacterial adhesion compared to ceramic brackets, while others mention that there is no such difference[11,22]. An important argument to affirm the above would be that the metallic bracket has a surface free energy of 40.0 dynes/cm$^2$, which is higher compared to the ceramic bracket and therefore, it is affirmed that there is a superior bacterial adhesion in the metallic bracket[23]. However, recent research has reported that positive charges of metal ions repel the negative charges existing in the bacterial membrane, even concluding that the silver coating can decrease the adhesion of *Streptococcus mutans* and *Streptococcus sobrinus* to the brackets[24,25].

In general, bacterial colonization could be better explained in terms of its dependence on time, which tends to become significant with long-term observation times[14,26], in addition to other intervening factors such as sex, salivary flow and oral hygiene[11,14, 27].

**Bacterial adhesion to luting materials**

It has been described that the adhesives used to join fixed orthodontic appliances have a greater tendency to retain cariogenic streptococci, causing the formation of biofilms,[9,28] which, added to excess resin as a frequent error in their use, generate adequate conditions for bacterial colonization[29,30]. In this sense, the use of glass ionomer due to its fluorine concentration provides an advantage with respect to its anticariogenic properties[31,32], there are even studies showing that the addition of substances with a composition similar to glass ionomer can inhibit bacterial adherence in saliva samples[21,24].

Cariogenic streptococci seem to adhere more to adhesives than to the bracket material itself, with the highest adhesion in resin-modified glass ionomers which, added to inferior mechanical properties[16,17,32], have led to their increasingly being replaced by light-curing adhesive cements such as Orthocem (FGM, Joinville, SC, Brazil) and Transbond XT (3M Unitek, St. Paul, MN, USA)[32,33], but with a certain advantage over the latter in reducing the growth of Streptococcus mutans[32].

Recent research demonstrated in vitro, the significant growth decrease of Streptococcus mutans when an amino acid such as arginine was incorporated into Orthocem resinous cement (FGM, Joinville, SC, Brazil), while it was also verified that the use of copper oxide nanoparticles (NPOCu) were effective against Streptococcus mutans and Lactobacillus acidophilus[24,32,33].

**Mouthwashes for plaque control**

Chemical plaque removal appears as a complement to mechanical removal, with the addition of an antimicrobial chemical agent with antiplaque activity in toothpastes, mouthwashes or both[34-44]. Table 2 summarizes some active principles reported in research in recent years, used in mouthwashes to control plaque in orthodontic treatment.

## Discussion

In the reviewed publications, it is stated that the degree of bacterial colonization related to orthodontic appliances is affected by the energy and surface roughness of the material from which the appliance or device is made, which added to the design and dimensions of the appliance, generating difficulty to perform hygiene efficiently[3,25]. Another significant variable for the alteration of the microbiota, but not much studied, is the amount of time the device is used in the oral cavity[7,8,45]. Along with the quantitative change, there is also a qualitative variation as we can observe in the bacteria of the red complex (*Porphyromonas gingivalis*, *Treponema denticola* and *Tannerella forsythia*), which are more difficult to eliminate, are more pathogenic and with a remarkable adherence, where the recommendation of chemical agents such as oral mouthwashes becomes important[3,27]. In this sense, chlorhexidine gluconate, the “gold standard” for many years due to its broad bactericidal spectrum but with known adverse effects, has been compared to other alternatives with fewer adverse effects, but with the same efficacy[1,2,11]. Lately, research has been directed to testing oral mouthwashes based on natural products, with more biocompatible, less toxic components and even with a different socioeconomic impact[30,31,35].

However, it would also be reasonable to affirm that the susceptibility of each subject, as well as other factors capable of altering the balance of the biofilm, could play a key role in determining dental and periodontal sequelae[45].

## Conclusions

According to the literature reviewed, orthodontic appliances alter the subgingival and supragingival ecosystem, favoring the predominance of periodontopathogenic and cariogenic microorganisms. Orthodontic materials have a different capacity for the adhesion and growth of bacterial biofilms, with the surface roughness and surface free energy of each material playing a key role. Mouthwashes can prevent bacterial adhesion and complement oral hygiene in orthodontic patients. According to the microbiological and clinical evaluation in the included studies, the described mouthwashes introduced significant improvements in the evaluated parameters. Some undesirable side effects reported by the use of mouthwashes of synthetic origin, the tendency to evaluate mouthwashes based on herbs or natural principles has increased, with promising results in most cases.

## Ethical Statement

This literature review does not need any ethical permission. The manuscript has not been fully or partially published elsewhere. The authors declare that they have actively participated in the preparation of the manuscript, as well as are responsible for its content.

## Declaration of Competing Interest

The authors declare that they have no competence in economic or personal interests that may have influenced the preparation of this review and all authors have made substantive contribution to this manuscript, and all have reviewed the final paper prior to its submission.

## Declaration of Interest

The authors report no conflict of interest.

| Database | Search expression |
|---|---|
| PubMed | ("orthodontic brackets"[MeSH Terms]) AND (mouthwashes OR "bacterial adhesion"[MeSH Terms]) |
| Scopus | orthodontic AND ( mouthwashes AND "bacterial adhesion" ) |
| EBSCO | (chlorhexidine AND brackets) OR (iodopovidone AND “orthodontic braces”) |
| Science Direct | (brackets AND mouthwash) AND (bacterial) |
| VHL | (chlorhexidine AND brackets) OR (iodopovidone AND “orthodontic braces”) |

**Table 1.** Database search strategies.

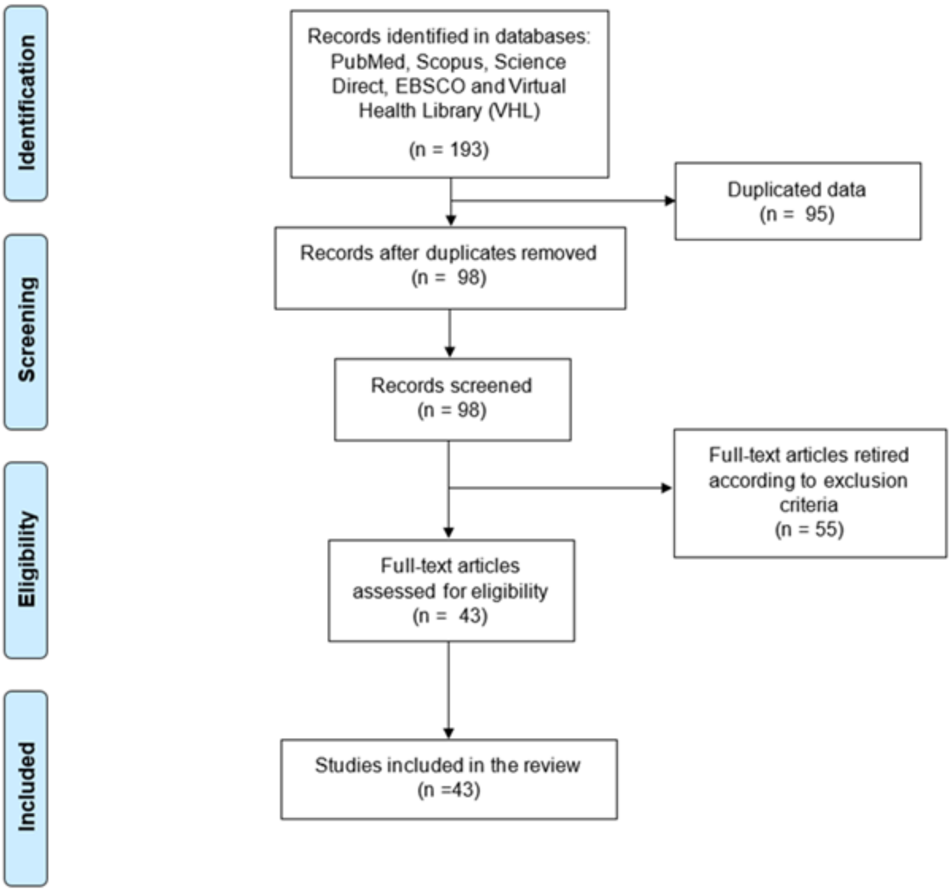


**Figure. 1** PRISMA flowchart showing systematic sequence for included studies.

| Active principle | **Researches** | Study design | Outcomes |
|---|---|---|---|
| Chlorhexidine | Nishad et al.,2017<br>Jurišić et al., 2018<br>Sobouti et al.,2018<br>Niazi et al.,2018<br>Yaghini et al., 2019<br>Hasriati et al.,2020<br>Bauer et al., 2021 | Randomized clinical trial | Chlorhexidine demonstrated greater antimicrobial efficacy against *Streptococcus mutans*, but also comparable antimicrobial efficacy with herbal mouthwashes. |
| Essential oils | Akbulut, 2020 | Clinical trial prospective | Significant decrease in *Streptococcus oralis*, *Streptococcus mitis* and *Candida*. An improvement in plaque and gingival index, compared to placebo. |
| Cetylpyridinium chloride (CPC) | Herrera et al., 2018 | Randomized clinical trial | Long-term improvement in plaque and gingival index, similar to those obtained with conventional essential oils. |

| | | | |
|---|---|---|---|
| Chlorine dioxide | Yeturu et al.,2016 | Randomized clinical trial | A significant reduction of plaque and gingival index was obtained by using chlorine dioxide, similar to chlorhexidine. |
| Probiotic | Shah et al.,2019<br>Goyal et al., 2019 | Randomized clinical trial | Significant reduction in *Streptococcus* and *Porphyromonas gingivalis* counts. Better effect on gingival index and similar effect on plaque index compared to chlorhexidine. |
| Salvadora persica | Halawany et al., 2016<br>Niazi et al.,2018<br>Sobouti et al.,2018 | In vitro<br>Randomized clinical trial<br>Randomized clinical trial | The Salvadora persica 10% has inhibitory capacity against *Streptococcus Mutans.* It has obtained good results in gingival and plaque indices, including against Chlorhexidine 0.2% and CPC 0.05%. |
| Chitosan | Hasriati et al.,2020 | Randomized clinical trial | The Chitosan extract 1% rinse showed antibacterial activity equivalent to Chlorhexidine, specifically against *Tannerella denticola*. |
| Chamomile | Goes et al.,2016 | Randomized controlled clinical (pilot) | The oral rinse with Chamomile 1% reduced the plaque index and gingival bleeding index similarly to Chlorhexidine 0.12%, but without the adverse effects. |
| Azadirachta indica (Neem) | Nishad et al., 2017 | Randomized clinical trial | Neem oral rinse reduced the growth of *Streptococcus Mutans*, as well as plaque and gingival index, similar to Chlorhexidine. |
| Propolis | Dehghani et al.,2019 | Randomized clinical trial | The use of the Propolis extract 1% rinse was effective in reducing plaque, gingival and periodontal index, similar to Chlorhexidine 0.2%. |

| | | | |
|---|---|---|---|
| Zingiber officinale | Bauer et al., 2021 | Prospective clinical study | The Zingiber officinale 0.5% rinse was effective against *Streptococcus mutans*, similar to Chlorhexidine 0.12%. The gingival inflammation index decreased but did not show the same substantivity. |
| Green tea<br>Aloe vera-green tea | Gök et al., 2020<br>Yaghini et al., 2019<br><br>Raju et al., 2017 | In vitro<br>Randomized clinical trial<br>Prospective clinical study | Green tea extract was shown to have a bacteriostatic effect. The use of green tea decreased plaque and bleeding rate, similar to Chlorhexidine 0.12% but without staining effects. |

**Table 2.** Chlorhexidine and potential mouthwashes in orthodontic patients.

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