



REVIEW ARTICLE

THE ROLE OF HERBAL AND PHYTOCHEMICAL-BASED MOUTHWASHES IN MAINTAINING PERIODONTAL HEALTH IN ORTHODONTIC PATIENTS: A NARRATIVE REVIEW

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ABSTRACT

Orthodontic treatment poses challenges to maintaining periodontal health due to increased plaque accumulation, gingival inflammation, and enamel demineralization associated with fixed appliances. Conventional chemical mouthwashes like chlorhexidine are effective but often cause undesirable side effects such as staining and mucosal irritation. In contrast, herbal and phytochemical-based mouthwashes offer antimicrobial, anti-inflammatory, and antioxidant benefits with minimal adverse effects. This review explores the role of plant-based mouthwashes—including green tea, neem, aloe vera, triphala, curcumin, and clove—in improving periodontal outcomes among orthodontic patients. These natural formulations inhibit pathogenic biofilms, reduce inflammatory mediators, and support tissue healing while preserving oral microbial balance. Comparative analyses reveal that many herbal mouthwashes perform as effectively as chlorhexidine in reducing plaque and gingival inflammation. Their favorable safety profile and holistic action make them a promising adjunct in long-term orthodontic care. Future research should focus on optimizing delivery systems and validating long-term efficacy through clinical trials.

Keywords: Orthodontic treatment, Herbal mouthwash, Periodontal health, Phytochemicals, Gingivitis, Chlorhexidine alternatives, Green tea, Aloe vera, Curcumin, Biofilm inhibition

INTRODUCTION

Orthodontic treatment is essential for correcting malocclusion, enhancing dental function, and improving facial aesthetics. The use of fixed orthodontic appliances, such as brackets, wires, and bands, provides effective alignment of teeth but simultaneously introduces challenges in maintaining oral hygiene. These appliances create additional retention sites for food debris and plaque, making routine oral hygiene maintenance more complex

compared to individuals without orthodontic appliances.^{1,2}

One of the primary concerns associated with orthodontic treatment is the increased risk of periodontal diseases.³ The presence of orthodontic brackets alters the oral microenvironment, promoting bacterial colonization and biofilm formation. As a result, patients undergoing orthodontic treatment often experience higher levels of

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plaque accumulation, leading to gingival inflammation, periodontal tissue breakdown, and enamel demineralization. If left unmanaged, these conditions can progress to irreversible periodontal damage, affecting the long-term stability of orthodontic outcomes.⁴

Mouthwashes have traditionally been recommended as adjuncts to mechanical plaque control methods, such as toothbrushing and flossing, to mitigate the increased risk of periodontal complications.⁵ Among these, chlorhexidine (CHX)-based mouthwashes have been widely recognized as the gold standard due to their broad-spectrum antimicrobial efficacy.⁶ CHX effectively reduces plaque formation and gingival inflammation; however, its long-term use is associated with adverse effects, including tooth staining, mucosal irritation, and altered taste perception. These drawbacks have prompted the search for alternative formulations with comparable efficacy but fewer side effects.

In recent years, herbal and phytochemical-based mouthwashes have gained attention as promising alternatives to conventional chemical formulations. Many medicinal plants contain bioactive compounds with antimicrobial, anti-inflammatory, and antioxidant properties, making them suitable for oral health applications. These natural formulations not only help in controlling plaque and gingivitis but also contribute to maintaining the balance of the oral microbiome without causing significant side effects.^{7,8}

Several studies have demonstrated the effectiveness of herbal mouthwashes, including those formulated with green tea, neem, aloe vera, triphala, clove, and curcumin. These plant-derived ingredients exhibit potent antibacterial activity against oral pathogens, modulate inflammatory responses, and provide a protective barrier against oxidative stress-induced tissue damage.^{9,10} Their potential in improving periodontal health among orthodontic patients highlights the need for further clinical research and integration into routine orthodontic care.

The aim of this review is to explore the role of herbal and phytochemical-based mouthwashes in maintaining periodontal health during orthodontic treatment. This review will discuss the challenges posed by orthodontic appliances in oral hygiene maintenance, the mechanisms of action of herbal formulations, their comparative efficacy against conventional mouthwashes, and future perspectives on their clinical application in orthodontic patients.

2. Challenges in Maintaining Periodontal Health During Orthodontic Treatment

Orthodontic treatment poses significant challenges in maintaining periodontal health due to the presence of fixed appliances that hinder effective plaque removal and create a favorable environment for pathogenic bacteria. The increased retention of food particles and biofilm formation predispose patients to various periodontal complications, including gingivitis, periodontitis, and enamel demineralization.¹¹ Addressing these challenges requires a combination of mechanical plaque control and adjunctive therapies, such as mouthwashes, to minimize microbial colonization and maintain periodontal stability throughout treatment.

2.1 Increased Plaque Accumulation and Biofilm Formation

Fixed orthodontic appliances, including brackets, bands, and wires, create multiple retention sites that facilitate bacterial adhesion and biofilm formation. These structures obstruct proper tooth brushing and interdental cleaning, leading to an increase in plaque accumulation compared to individuals without orthodontic appliances.¹² Studies have demonstrated that orthodontic patients exhibit significantly higher plaque index (PI) and gingival index (GI) scores, indicating compromised oral hygiene and a heightened risk of periodontal diseases.¹³

The orthodontic biofilm is a complex, multispecies microbial community dominated by cariogenic and periodonto-pathogenic bacteria. *Streptococcus mutans* and *Lactobacillus* spp. are primary contributors to enamel demineralization due to their ability to ferment dietary carbohydrates and produce organic acids, leading to a decline in pH and subsequent enamel dissolution.¹⁴ Additionally, anaerobic bacteria such as *Porphyromonas gingivalis* and *Tannerella forsythia* are frequently detected in orthodontic patients and are implicated in periodontal tissue destruction and the progression of gingival inflammation.¹⁵

The prolonged presence of bacterial biofilm increases the production of inflammatory cytokines, such as interleukin-1 β (IL-1 β) and tumor necrosis factor-alpha (TNF- α), exacerbating soft tissue inflammation and bone resorption.¹⁶

As a result, effective biofilm management strategies, including the use of adjunctive mouthwashes with antimicrobial properties, are essential to mitigate plaque accumulation and maintain periodontal health in orthodontic patients.

2.2 Gingival Inflammation and Periodontal Diseases

Gingival inflammation is one of the earliest and most prevalent complications observed in orthodontic patients. The accumulation of plaque around orthodontic brackets triggers an inflammatory response in the gingival tissues, leading to clinical manifestations such as redness, swelling, and bleeding upon probing. This inflammatory condition, commonly referred to as orthodontic gingivitis, affects a significant proportion of patients and can progress to more severe periodontal diseases if not adequately managed. A longitudinal study by Ristic et al. reported that orthodontic patients exhibited increased gingival inflammation within the first six months of treatment, with a corresponding rise in periodontal pocket depth and bleeding on probing. The continuous presence of bacterial endotoxins and inflammatory mediators can lead to connective tissue degradation and alveolar bone resorption, increasing the risk of orthodontic relapse post-treatment.¹⁷

Moreover, orthodontic forces exerted on teeth can modulate the host immune response, altering the balance between pro-inflammatory and anti-inflammatory cytokines. Excessive or prolonged inflammation may contribute to periodontal breakdown, necessitating rigorous plaque control measures, including herbal and phytochemical-based mouthwashes that provide anti-inflammatory benefits without the adverse effects associated with chemical formulations.¹⁸

2.3 Enamel Demineralization and White Spot Lesion

Enamel demineralization is a significant concern in orthodontic patients, with white spot lesions (WSLs) being one of the most frequently observed complications. These lesions occur due to the localized dissolution of enamel minerals, primarily as a result of prolonged acid exposure from cariogenic bacteria within the biofilm. WSLs are characterized by opaque, chalky white areas on the enamel surface, which not only compromise aesthetics but also predispose the tooth to further decay and cavitation. The prevalence of WSLs in orthodontic patients has been reported to be as high as 50%, with lesions most commonly observed around the bracket periphery where plaque accumulation is highest. The demineralization process is primarily driven by a decrease in pH due to bacterial metabolism, resulting in calcium and phosphate loss from the enamel surface. Without timely intervention, these lesions can become permanent post-treatment, leading to long-term cosmetic and structural concerns.¹⁹

Preventive strategies for enamel demineralization include fluoride-based mouthwashes, which aid in enamel remineralization by forming fluorapatite, a more acid-resistant mineral phase. However, emerging evidence suggests that herbal mouthwashes containing phytochemicals such as catechins from green tea, curcumin from turmeric, and tannins from neem may also provide protective effects against enamel demineralization by reducing bacterial adhesion and acid production. These natural agents offer an alternative approach to managing WSLs while minimizing the risks associated with excessive fluoride exposure (Figure 1).²⁰

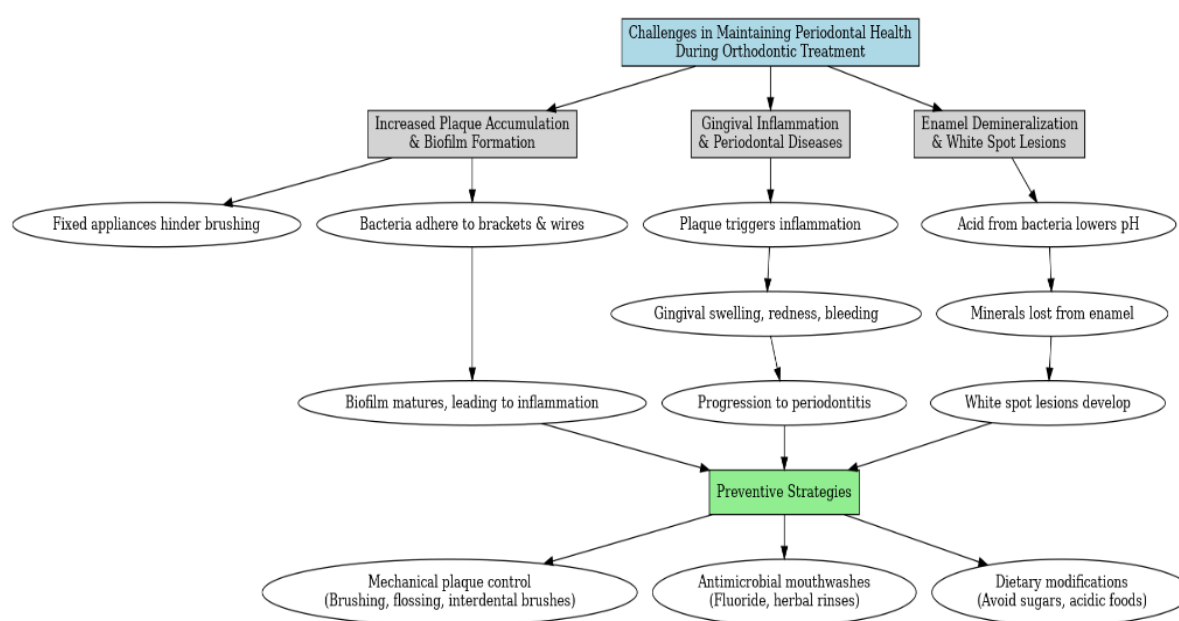


Figure 1. Challenges in maintaining periodontal health during orthodontic treatment

DISCUSSION

3. Mechanisms of Action of Herbal and Phytochemical-Based Mouthwashes:

3.1 Antimicrobial Properties

Herbal mouthwashes exert antimicrobial effects through multiple mechanisms, including inhibition of bacterial adhesion, suppression of quorum sensing, and modulation of biofilm formation (Palombo, 2011).²¹ Phytochemicals such as flavonoids, tannins, and polyphenols interfere with bacterial colonization and metabolism, reducing plaque accumulation and preventing the establishment of pathogenic microbial communities.²²

Studies have shown that herbal extracts like neem (*Azadirachta indica*), green tea (*Camellia sinensis*), and pomegranate (*Punica granatum*) possess significant antibacterial activity against cariogenic bacteria such as *Streptococcus mutans* and *Lactobacillus spp.*²³ Additionally, essential oils from clove (*Syzygium aromaticum*) and tea tree (*Melaleuca alternifolia*) disrupt bacterial cell walls, leading to bacterial lysis and biofilm inhibition.²⁴ Herbal mouthwashes have also been found to inhibit volatile sulfur compound (VSC)-producing bacteria, thereby contributing to the reduction of halitosis, which is often associated with periodontal disease.²⁵

3.2 Anti-Inflammatory Effects

The anti-inflammatory potential of herbal mouthwashes is attributed to their ability to regulate host immune responses by inhibiting pro-inflammatory mediators. Bioactive compounds such as flavonoids, alkaloids, and terpenoids suppress the production of interleukin-1 beta (IL-1 β), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF- α), which play a crucial role in periodontal inflammation.²⁶

For instance, chamomile (*Matricaria chamomilla*) and aloe vera (*Aloe barbadensis*) have been demonstrated to reduce gingival inflammation by downregulating cyclooxygenase-2 (COX-2) and nitric oxide synthase (iNOS) pathways (Fani & Kohanteb, 2017).²⁷ Similarly, curcumin, the active component of turmeric (*Curcuma longa*), has been shown to inhibit nuclear factor-kappa B (NF- κ B) signaling, thereby preventing periodontal tissue destruction and modulating the host response to microbial challenge.²⁸

Clinical studies suggest that herbal mouthwashes containing Miswak (*Salvadora persica*) and liquorice

(*Glycyrrhiza glabra*) can significantly reduce gingival bleeding and probing depth in patients with chronic gingivitis and periodontitis.²⁹

3.3 Antioxidant Potential

Oxidative stress is a key factor in the progression of periodontal disease, leading to tissue damage through excessive production of reactive oxygen species (ROS) and activation of inflammatory cascades. Herbal mouthwashes, rich in polyphenols, flavonoids, and tannins, act as potent antioxidants that scavenge free radicals and mitigate oxidative damage.²⁹

For example, green tea catechins (epigallocatechin gallate, EGCG) have been shown to inhibit lipid peroxidation and enhance antioxidant enzyme activity, thereby protecting periodontal tissues from oxidative stress-induced destruction.³⁰ Resveratrol, a polyphenol found in grapes and berries, has been reported to enhance osteoblast differentiation and suppress osteoclastogenesis, which is crucial in maintaining alveolar bone integrity.³⁰

4. Common Herbal and Phytochemical-Based Mouthwashes for Orthodontic Patients

Green tea (*Camellia sinensis*) mouthwash is a widely studied alternative to conventional chemical mouthwashes. Its rich catechin content, particularly epigallocatechin gallate (EGCG), provides strong antibacterial and antioxidant properties. EGCG inhibits *Streptococcus mutans* biofilm formation, reducing the risk of white spot lesions in orthodontic patients. It also modulates inflammatory pathways by suppressing IL-1 β and TNF- α , effectively reducing gingival irritation caused by orthodontic brackets. The high antioxidant content of green tea helps mitigate oxidative stress-induced periodontal damage, which is particularly beneficial during prolonged orthodontic treatment.³¹

Aloe vera-based mouthwash has demonstrated significant antimicrobial and wound-healing properties due to its active constituents, including anthraquinones, flavonoids, and vitamins A, C, and E. Clinical studies have shown that aloe vera mouthwash is as effective as chlorhexidine (CHX) in reducing plaque accumulation and gingival inflammation, without the side effects of staining or taste disturbances. Aloe vera's ability to promote fibroblast proliferation enhances tissue repair, making it a valuable adjunct in orthodontic care.³²

Triphala-based mouthwash, derived from the traditional Ayurvedic formulation of *Terminalia chebula*, *Terminalia bellirica*, and *Embllica officinalis*, has shown efficacy in

plaque control and gingival health maintenance. Its key bioactive compounds, including gallic acid and chebulagic acid, exhibit strong antibacterial activity against *S. mutans* and *Lactobacillus spp.*, making it effective in reducing the risk of caries in orthodontic patients. Triphala also possesses anti-inflammatory properties by inhibiting COX-2 and modulating macrophage activity, reducing gingival swelling and irritation. Additionally, its potent antioxidant effects contribute to periodontal healing by neutralizing reactive oxygen species.³³

Neem (*Azadirachta indica*) mouthwash has gained recognition for its antibacterial and anti-inflammatory properties, attributed to compounds such as nimbidin and azadirachtin. Research has demonstrated that neem mouthwash significantly reduces plaque formation and gingival bleeding, making it suitable for long-term use in orthodontic patients. It disrupts bacterial cell walls and inhibits glucosyltransferase activity, thereby preventing biofilm development. Neem also modulates the immune response, preventing exaggerated inflammatory reactions that can lead to periodontal tissue damage. Unlike chlorhexidine, neem mouthwash does not cause staining or alter taste perception, making it a preferable alternative for prolonged orthodontic treatment.³⁴

Curcumin-based mouthwash, derived from *Curcuma longa*, has been extensively studied for its therapeutic effects on oral health. Curcumin acts by inhibiting the nuclear factor kappa B (NF-κB) signaling pathway, thereby reducing inflammation in gingival tissues. It also blocks matrix metalloproteinases (MMPs), which contribute to periodontal breakdown. As an antioxidant, curcumin scavenges free radicals and enhances cellular defense mechanisms against oxidative stress.

Clinical studies have shown that curcumin-based mouthwashes are as effective as 0.2% chlorhexidine in reducing gingival inflammation, making them a promising alternative for orthodontic patients experiencing gingival irritation.³⁵

Clove (*Syzygium aromaticum*) mouthwash, rich in eugenol, offers analgesic, antibacterial, and anti-inflammatory benefits. Eugenol disrupts bacterial lipid membranes, leading to microbial cell death, while also exerting an analgesic effect by modulating the transient receptor potential vanilloid 1 (TRPV1) receptor.

This makes clove mouthwash particularly useful for orthodontic patients experiencing pain from wire tightening or gingival irritation. In addition to its pain-relieving properties, clove oil inhibits prostaglandin synthesis, reducing inflammation and swelling in periodontal tissues.³⁶

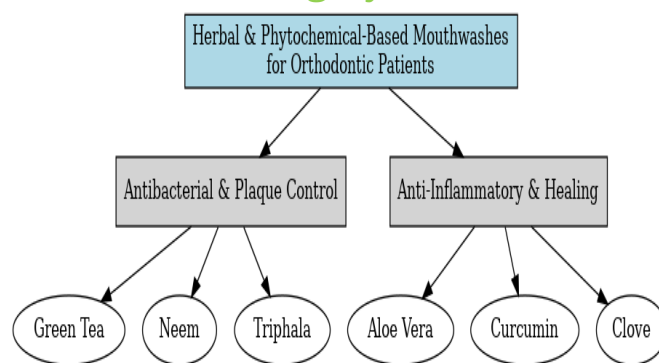


Figure 2. Herbal and phytochemical based mouthwashes

5. Comparative Analysis: Herbal vs. Conventional Mouthwashes

Clinical studies have consistently shown that herbal mouthwashes can be as effective as conventional chlorhexidine (CHX) mouthwashes in reducing plaque accumulation and gingival inflammation. A study by Hernández-Neuta et al. (2014) reported that herbal formulations containing active compounds such as catechins, curcumin, and polyphenols demonstrated antimicrobial efficacy comparable to CHX. These natural compounds inhibit bacterial adhesion, biofilm formation, and inflammatory pathways, contributing to improved periodontal health.³⁷

One of the major advantages of herbal mouthwashes over CHX is the absence of significant side effects. While CHX is widely recognized for its potent antimicrobial activity, long-term use is associated with adverse effects such as tooth staining, mucosal irritation, altered taste perception, and, in some cases, desquamation of the oral mucosa. These drawbacks often lead to poor compliance among patients undergoing prolonged orthodontic treatment. Herbal mouthwashes, on the other hand, do not cause discoloration of teeth or restorations, making them more suitable for long-term use without aesthetic concerns.

Another limitation of CHX is its impact on oral microbiota balance. Prolonged use may disrupt the natural microbial flora, leading to dysbiosis and an increased risk of opportunistic infections such as oral candidiasis. Herbal formulations, however, selectively target pathogenic bacteria while preserving beneficial oral microbiota, maintaining a balanced ecosystem within the oral cavity. For instance, neem and green tea extracts have demonstrated selective antibacterial properties against cariogenic and periodontopathogenic species while sparing commensal bacteria.³⁸

Furthermore, the anti-inflammatory and antioxidant properties of herbal mouthwashes provide additional benefits that extend beyond plaque control. Ingredients such as aloe vera, Triphala, and curcumin not only reduce gingival inflammation but also promote wound healing and tissue regeneration. In contrast, CHX primarily functions as an antimicrobial agent with limited effects on tissue repair.

The long-term safety profile of herbal mouthwashes is another key factor supporting their use in orthodontic patients. Unlike CHX, which may cause cytotoxic effects on fibroblasts and keratinocytes at higher concentrations, herbal formulations are generally biocompatible and well-tolerated by oral tissues. Studies have demonstrated that mouthwashes containing plant-derived polyphenols and flavonoids promote fibroblast proliferation and collagen synthesis, aiding in periodontal health maintenance during orthodontic treatment.

Overall, while CHX remains the gold standard for short-term plaque and gingivitis control, herbal mouthwashes present a promising alternative for long-term use. Their comparable antimicrobial efficacy, coupled with superior biocompatibility, anti-inflammatory properties, and a favorable side effect profile, makes them an attractive choice for orthodontic patients seeking a natural and effective oral hygiene regimen.

CONCLUSION AND FUTURE PERSPECTIVES

Orthodontic treatment significantly increases the risk of plaque accumulation, gingival inflammation, and enamel demineralization due to the presence of fixed appliances that create retentive sites for microbial colonization. Maintaining periodontal health in orthodontic patients is essential to prevent complications such as gingivitis, periodontitis, and white spot lesions. While conventional chlorhexidine (CHX) mouthwashes have been widely used for plaque control, their long-term use is limited by side effects such as staining, mucosal irritation, and taste alteration. As a result, herbal and phytochemical-based mouthwashes have emerged as effective and safer alternatives, offering antimicrobial, anti-inflammatory, and antioxidant benefits.

Several herbal formulations, including those containing green tea, aloe vera, Triphala, neem, curcumin, and clove, have demonstrated promising results in maintaining oral health in orthodontic patients. These natural compounds exhibit strong antibacterial properties against cariogenic and periodonto-pathogenic bacteria, reduce

inflammatory mediators, and promote tissue healing. Comparative studies have shown that herbal mouthwashes perform as effectively as CHX in reducing plaque and gingival

inflammation while avoiding adverse effects. Additionally, their ability to preserve oral microbiota balance makes them an ideal choice for long-term use.

Looking ahead, future research should focus on optimizing the formulation and delivery of herbal mouthwashes to enhance their efficacy and patient compliance. The development of nanotechnology-based herbal formulations, such as nanoparticle-loaded phytochemicals, may improve bioavailability and prolong the therapeutic effects of these natural agents. Further clinical trials with larger sample sizes and long-term follow-ups are necessary to establish standardized protocols for the use of herbal mouthwashes in orthodontic care. Additionally, personalized approaches that consider the individual oral microbiome and genetic susceptibility to periodontal diseases could pave the way for targeted herbal therapies.

Incorporating herbal and phytochemical-based mouthwashes into routine orthodontic care represents a shift towards a more natural and holistic approach to oral health maintenance. With continued advancements in phytotherapy and evidence-based validation of herbal formulations, these natural alternatives have the potential to become mainstream adjuncts in orthodontic periodontal management, ensuring safer and more sustainable oral healthcare solutions for patients worldwide.

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Conflicts of interest/Competing interests

There is no conflict of interest between the authors

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Ethical approval obtained from Institutional Ethical Committee board

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