

Chlorhexidine in Contemporary Dentistry: A Comprehensive Narrative Review

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ABSTRACT

Objective: This narrative review covers CHX's pharmacology, clinical applications across various dental fields, and associated adverse effects. **Method:** Literature review highlighted systematic reviews and clinical trials showing that CHX mouthrinse effectively reduces dental plaque and inflammation post-surgery. **Results:** Chlorhexidine (CHX) is a bisbiguanide antiseptic known for its broad antimicrobial action and prolonged activity on oral surfaces, primarily used in dentistry when mechanical plaque removal is limited. In endodontics, while CHX exhibits useful antimicrobial properties, it cannot dissolve organic tissue and has limitations such as staining, altered taste, and mucosal irritation. **Novelty:** Hence, CHX should be prescribed judiciously, emphasizing mechanical plaque control as the primary approach, with CHX as a supportive adjunct.

INTRODUCTION

Dental plaque is a structured microbial biofilm that forms on oral surfaces and is the leading cause of dental caries, gingivitis, periodontitis and peri-implant disease. Mechanical removal is still the most reliable method of controlling plaque but its success depends on the dexterity and motivation of the patient, accessibility to affected sites and the condition of the oral tissues. Chemical plaque-control agents may be useful adjuncts when toothbrushing and interdental cleaning are inadequate or temporarily impractical.

Chlorhexidine has been used in health care for over 50 years and remains one of the most studied antiseptics in dentistry. Its clinical utility lies mainly in its wide antimicrobial spectrum, rapid onset of action and ability to adhere to oral tissues. CHX mouthrinse is a well-established antiplaque agent, consistently reducing plaque accumulation and gingival inflammation and frequently described as the reference or 'gold-standard' chemical antiplaque agent [1], [2]. However, this description should not blind clinicians to its disadvantages. Formulation, dose, frequency of use and duration of treatment have an impact on the clinical benefits and adverse effects.

This review critically assesses the role of CHX in current dental practice, differentiates between well-evidenced indications and those with less certain evidence, and offers practical guidance for safe and appropriate prescribing.

RESEARCH METHOD

Narrative review of the literature. A search of PubMed/MEDLINE, Scopus and Google Scholar was performed for English language studies using combinations of the terms 'chlorhexidine', 'dentistry', 'mouthrinse', 'plaque', 'gingivitis', 'periodontitis', 'oral surgery', 'implant', 'peri-implant', 'endodontics', 'caries', 'orthodontics', 'denture' and 'adverse effects'. Systematic reviews, meta-analyses, randomized controlled trials, drug reviews and relevant professional guidelines were prioritized. Older studies that were influential in the field were also included if they provided foundational evidence about CHX substantivity, mechanism of action, or clinical use. Because this was a narrative review rather than a systematic review, we did not calculate pooled effect estimates or conduct a formal risk-of-bias assessment.

CHX is a synthetic, highly basic bisbiguanide, most commonly available for dental use as the water-soluble digluconate salt. Under physiological conditions it is positively charged and attracted to negatively charged sites on bacterial cell walls, salivary glycoproteins, hydroxyapatite, the acquired pellicle and oral mucosa. At low concentrations CHX disrupts the integrity of the membrane and leads to leakage of small intracellular molecules from the cell. At higher concentrations, it precipitates cytoplasmic contents and results in cell death [3], [4]. It is active against a variety of Gram-positive and Gram-negative bacteria and yeasts. The degree of susceptibility depends on the microorganism and the ambient conditions.

The effectiveness of CHX in the mouth is due to its substantivity, i.e. its prolonged retention. On application a fraction of the agent binds to intraoral surfaces and is slowly released, extending the antimicrobial activity beyond the short period of rinsing [5]. This binding might also prevent pellicle formation and bacterial co-aggregation. Unfortunately, these very adsorptive properties also aid in staining because reactions between dietary chromogens and salivary or bacterial products may lead to the formation of brown discoloration on teeth, restorations and tongue.

The performance of CHX is partly dependent on its formulation. Anionic ingredients such as sodium lauryl sulphate, which are present in some toothpastes, may reduce the amount of active CHX available. Clinicians often recommend a gap between brushing and rinsing with CHX, although the interaction varies between products. Alcohol doesn't need to be antimicrobial. Children and patients with xerostomia, sensitive oral mucosa, religious concerns, and a history of alcohol dependence may prefer alcohol-free formulations.

Table 1. Typical CHX products and illustrative uses. Indications and concentrations approved vary from country to country and between manufacturers. Clinicians should consult the product label

Formulation	Typical strength	Representative dental use	Principal limitation
Mouthrinse	0.12-0.20%	Short-term control of plaque and gingivitis; postoperative support	Staining and taste alteration; dependent on adherence
Gel	0.2-1%	Localized periodontal, caries-prevention, or mucosal application	Retention and supporting evidence vary by indication
Varnish	Usually 1-40%	Targeted or research-based caries and periodontal applications	Products and clinical protocols are heterogeneous
Chip	2.5 mg	Local adjunctive treatment in periodontal pockets	Cost and only modest additional benefit
Spray	Approximately 0.2%	For patients who cannot rinse effectively	Coverage and delivered dose may be inconsistent
Endodontic solution or gel	Approximately 0.2-2%	Antimicrobial root-canal irrigant or intracanal medicament	Does not dissolve organic tissue; incompatible with NaOCl

The most convincing evidence for CHX is in the control of supragingival plaque and plaque-induced gingivitis. Cochrane review found [2] that CHX mouthrinse in addition to mechanical oral hygiene resulted in a marked reduction in plaque and a more modest benefit for gingivitis over four to six weeks. If gingival inflammation is mild at baseline, the additional reduction may have limited clinical relevance. In general, continued unsupervised treatment is not recommended, as the staining will become more pronounced with prolonged use. Similar results were reported in another systematic review [6]. Both 0.12% and 0.20% preparations are effective and the total delivered dose, rinse volume and overall formulation may be as important as the stated concentration [7].

CHX may be useful following either non-surgical or surgical periodontal therapy in patients who have difficulty removing plaque. However, it cannot eliminate calculus, does not consistently eliminate a mature subgingival biofilm, and should never replace professional debridement or individualised oral hygiene instruction. Local placement of CHX chips in selected residual periodontal pockets may provide a small additional benefit in probing measurements, but this benefit should be considered against cost, pocket anatomy and the modest treatment effect.

After tooth extraction, periodontal surgery, implant placement or grafting, patients might not be able to brush safely around the surgical wound. Short course of CHX can be beneficial in limiting the plaque accumulation during this healing phase. A recent systematic review and meta-analysis showed a beneficial effect of CHX on wound

healing after oral surgery, although the included procedures and treatment protocols were quite diverse [8]. CHX has been also studied for prevention of alveolar osteitis following third-molar extraction. Locally applied gels may reduce risk in selected patients, but recommended protocols and licensed indications vary between products. Patients should still avoid aggressive rinsing immediately after an extraction and follow the specific post-op advice given by their surgeon.

In implant dentistry, CHX is often used in the early stages of healing and as an adjunct in the management of peri-implant mucositis or peri-implantitis. It might decrease supragingival plaque when mechanical cleaning is difficult temporarily. However, peri-implant diseases are biofilm-associated diseases that require thorough mechanical debridement, management of local risk factors and ongoing maintenance care. CHX alone should not be considered as a definitive therapy for peri-implantitis. Clinicians should also consider prosthetic staining, patient compliance, and potential effects on healing cells in cases of repeated or long-term exposure. However, in-vitro cytotoxicity cannot be directly equated with clinical harm, but does support avoiding unnecessarily high concentrations or prolonged exposure.

CHX is supplied as a solution or gel for use as an endodontic irrigant, final rinse or intracanal medicament. The advantage of this situation is its wide antimicrobial activity and its ability to persist on dentine. It may be effective against microorganisms associated with persistent endodontic infection such as *Enterococcus faecalis* and *Candida* species. However, CHX does not dissolve necrotic organic tissue and therefore cannot replace sodium hypochlorite as the main irrigant when tissue dissolution is required [9], [10].

A significant clinical incompatibility exists between CHX and sodium hypochlorite. This interaction creates an orange-brown precipitate that can reduce dentinal permeability and compromise the seal. These two solutions must never be mixed straight away. When used in the same treatment, both should be flushed thoroughly with an appropriate intermediate solution and dried according to an established protocol before the irrigant is changed. CHX can also precipitate with ethylenediaminetetraacetic acid, and therefore the sequence of irrigation should be planned carefully.

CHX decreases mutans streptococci and has been investigated in mouth rinses, gels and varnishes for the prevention of dental caries. However, reduction in bacterial counts has not reliably resulted in a clinically significant reduction in caries, and the evidence in favor is less strong than for fluoride. CHX should therefore not replace fluoride toothpaste, professionally applied fluoride where indicated, dietary counselling or fissure sealants. Occasionally, a targeted short course may be considered for selected high-risk patients but routine prescribing solely to prevent caries is not strongly supported [4]. In children, clinicians also need to consider whether the child can rinse without swallowing, whether the product is licensed for the age group concerned and whether it contains alcohol.

Fixed orthodontic appliances provide more plaque-retentive areas and can make effective cleaning more difficult. Systematic review evidence indicates that CHX

mouthrinse can reduce plaque and gingival inflammation during orthodontic treatment, however, the studies available are limited by short follow-up periods and the problem of staining [11]. Hence it is best used only for short periods where gingival control is poor or there is an acute clinical need, together with brushing and interdental-cleaning advice specific to the appliance.

CHX is effective against *Candida* species and may help to reduce the denture biofilm. But it can adsorb to acrylic resin causing denture discolouration and taste changes. One should not expect denture stomatitis to resolve with CHX alone unless contributing factors such as continuous denture wearing, inadequate prosthesis hygiene, trauma, xerostomia and systemic risk factors are also addressed. Antiseptic products can affect denture-base resins, soft liners, metals and surface properties, so compatibility with the prosthetic material needs to be considered. If the person is frail or dependent and cannot safely rinse, a CHX gel or spray can be used to assist in mechanical cleaning by the carer, provided that the ability to swallow and the risk of aspiration have been assessed.

The most well-known side effect of CHX is the brown extrinsic staining of the teeth, tongue and restorations, which is one of the main reasons for limiting its duration of use. Other reported effects are altered taste, oral burning, mucosal tenderness or desquamation, increased supragingival calculus, and transient parotid gland swelling [12], [13]. Many of these changes improve after CHX is stopped and teeth are professionally cleaned, but they can still decrease patient acceptance and adherence.

Rare but potentially fatal immediate allergic reactions to CHX including anaphylaxis. Patients with a history of an unexplained reaction to an antiseptic, a coated medical device, or other CHX-containing product should not be re-exposed without appropriate assessment. CHX should also be avoided in the eyes or middle ear as it is toxic to these tissues. Avoid accidental swallowing, especially by children and individuals with impaired swallowing.

CHX has been shown to be toxic to fibroblasts, osteoblast-like cells and other mammalian cells in-vitro in a concentration- and exposure-time-dependent manner. These observations warrant cautious dosing and avoidance of direct application into tissues. However, they are not themselves evidence that a mouthrinse used properly will interfere with healing in patients. For meaningful safety assessment, concentration, formulation, duration of contact, extent of exposure and available clinical evidence should be taken into account.

CHX is a broad-spectrum antiseptic and with repeated exposure may change the composition of the oral microbiome. Recent studies have demonstrated microbial changes after prolonged use, but the duration of these changes and whether they have significant clinical implications are unknown. Laboratory studies have demonstrated increased resistance to CHX and adaptive microbial responses, and some of the mechanisms involved may also contribute to tolerance to antibiotics or other biocides. There is no clear evidence at present that a short course of dental treatment, indicated clinically, leads to significant antibiotic resistance. However, responsible antimicrobial

use necessitates refraining from indefinite or preventive prescribing without clear benefit [14], [4]. In future clinical studies, in addition to plaque indices, microbiome recovery, susceptibility changes, and patient-relevant outcomes should be evaluated.

Chlorhexidine (CHX) should only be recommended when there is a clear clinical indication for its use. It is an adjunct to, not a replacement for, daily toothbrushing and interdental cleaning. In most cases CHX should be prescribed for a short, well-defined period of time and the patient should be reviewed prior to continuing treatment. The choice of the right concentration and the method of administration should be based on the treatment area, the patient's ability to use the product correctly and the manufacturer's instructions. Patients should also be warned about common side effects, especially staining of teeth and restorations, and temporary changes in taste. They should be advised to leave a suitable interval between toothbrushing and CHX rinsing if their toothpaste contains ingredients that may reduce the effectiveness of CHX.

In endodontic treatment, CHX should not be directly mixed with sodium hypochlorite, as this may lead to an undesirable chemical reaction. When both irrigants are needed during the same procedure, they should be separated by an appropriate intermediate-rinsing protocol. Clinicians should also enquire whether patients have previously had an allergy or an unexplained reaction to CHX. Patients should be told to stop using the product and seek immediate medical help if they develop swelling, hives, difficulty breathing or any other signs of an allergic reaction. The importance of effective mechanical plaque removal, professional cleaning, adequate fluoride exposure and control of disease-related risk factors should continue to be emphasized throughout the course of treatment. CHX should therefore be considered an adjunctive measure in an overall preventive and therapeutic approach.

While CHX has been subject to extensive study, the interpretation of the evidence at hand is not always straightforward. There is considerable variability between studies regarding CHX concentration, total dose, frequency and duration of use, alcohol content, adjunctive treatments, baseline plaque control in the study population, and methods used to assess outcomes. Short-term experimental gingivitis studies have shown that CHX can reduce plaque and gingival inflammation under controlled conditions. But these results may not fully represent the benefits that patients experience in routine or extended use in everyday clinical practice.

Another concern is that many studies focus primarily on indirect measures such as plaque scores and bacterial counts. Although the results are useful, they do not always demonstrate whether CHX results in clinically meaningful improvements in outcomes that are more directly relevant to patients and clinicians, such as pain reduction, improved wound healing, reduced postoperative complications, clinical attachment gain, caries prevention, or long-term implant survival. Furthermore, the concentration, composition, and delivery method of the CHX products are different. Therefore, findings for one formulation should not be extrapolated to every CHX-containing product.

Further studies should determine the lowest effective dose and the shortest useful duration of therapy for each clinical indication. Different delivery methods of CHX

should be assessed using consistent criteria, and researchers should identify patients most likely to experience meaningful benefits. Further studies are necessary to investigate the effects on oral tissues and wound-healing cells, possible interactions with restorative and prosthetic materials, and the time required for the oral microbiome to return to normal after treatment. The clinical significance of decreased susceptibility of microorganisms to CHX needs to be further clarified. Finally, well-designed clinical trials should compare CHX not only with placebo but also with high-quality mechanical plaque control and alternative antiseptics that may afford similar benefits with fewer unwanted effects, especially tooth staining.

RESULTS AND DISCUSSION

Result

The reviewed literature indicates that chlorhexidine (CHX) is an effective adjunct for short-term control of dental plaque and gingival inflammation. Systematic reviews have shown that CHX used in combination with mechanical oral hygiene significantly reduces plaque accumulation and gingival inflammation [2], [6]. Both 0.12% and 0.20% formulations are effective although clinical difference between concentrations appears limited [7].

CHX was also found to have beneficial effects in some postoperative conditions, notably in reducing plaque accumulation and the risk of alveolar osteitis after oral surgery [8]. CHX has a wide antimicrobial spectrum and substantivity in endodontics but cannot dissolve organic tissue and cannot replace sodium hypochlorite [9], [10].

Short-term use of CHX during orthodontic treatment has also been supported by evidence to reduce plaque and gingival inflammation [11]. However, its use is associated with side effects especially tooth staining, taste alteration, mucosal irritation and increased calculus formation [12], [13]. Emerging evidence of changes in the oral microbiome and reduced susceptibility of microbes also points to limiting CHX to clearly indicated and time-limited clinical situations [14].

Overall, the evidence supports CHX as an effective short-term adjunctive antimicrobial agent, particularly for plaque control and gingival health, but emphasizes it should not be used as a substitute for mechanical plaque removal or definitive periodontal and endodontic treatment.

Discussion

The findings of this narrative review support that chlorhexidine (CHX) is still an effective adjunct for short-term control of dental plaque and gingival inflammation. The strongest evidence is for gingivitis from plaque where the additional benefits of CHX are seen in combination with mechanical oral hygiene [2], [6]. But its clinical utility has to be balanced against side effects, particularly staining of the teeth and changes in taste.

The effectivity of CHX is mainly related to its broad antimicrobial activity and substantivity that makes it able to be retained for a longer time on the oral surfaces [3]–[5]. Evidence comparing 0.12% and 0.20% preparations indicates that both concentrations are effective, with only a small advantage for 0.20% in plaque reduction and no clear

difference in gingival inflammation [7]. Therefore, higher concentrations should not automatically be considered clinically superior.

CHX also has a useful role in selected clinical situations where mechanical plaque control is temporarily difficult. In oral surgery, a recent systematic review and meta-analysis involving 33 studies and 4,766 cases found that CHX significantly improved postoperative wound healing and reduced the risk of alveolar osteitis [15]. These findings support short-term postoperative use, although differences among surgical procedures and treatment protocols should be considered.

CHX is an effective antimicrobial agent with substantivity in endodontics but it does not dissolve tissue and hence cannot substitute sodium hypochlorite when there is a need for removal of organic tissue [9], [10]. Similarly, in orthodontic patients CHX may enhance plaque control and gingival health in compromised oral hygiene situations but its prolonged use is limited by staining and other adverse effects [11].

It is important to consider the effect of CHX on the oral microbial ecosystem. Recent evidence indicates that CHX can modify the composition of oral microbiota and decrease its diversity, especially by affecting nitrate-reducing bacteria [16]. Although the long-term clinical implications of these changes are unknown, these findings support minimizing unnecessary or prolonged exposure to CHX.

To summarize, the current evidence supports the use of CHX as a short-term adjunct, indication-specific rather than as a routine long-term mouthrinse. Its greatest benefit appears to occur when mechanical plaque control is temporarily inadequate. Appropriate selection of concentration, formulation, duration, and patient is therefore essential to maximize clinical benefits while minimizing adverse effects [4], [13], [17].

CONCLUSION

Fundamental Finding: Chlorhexidine is still a useful dental antiseptic, especially as a short-term adjunct in the control of plaque and gingivitis and at times when normal mechanical cleaning is restricted. It also has some useful applications, although indication-specific, in oral surgery, implant care, endodontics, orthodontics and special-care dentistry. **Implication:** Rational prescribing should involve careful selection of patient, formulation, concentration and duration. Mechanical removal of biofilm remains the mainstay of prevention and treatment. **Limitation:** These benefits must be balanced against staining, taste change, effects on mucosa, rare hypersensitivity reactions and the unknown ecological consequences of prolonged exposure. **Future Research:** the unknown ecological consequences of prolonged exposure.

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