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CHLORHEXIDINE IN DENTAL PRACTICE: INTERACTIONS BETWEEN CHLORHEXIDINE AND DENTAL MATERIALS: A NARRATIVE REVIEW AND CLINICAL IMPLICATIONS

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ABSTRACT

Background

Chlorhexidine (CHX) is widely used in dentistry, but its interaction with dental materials may influence their bonding, surface, mechanical, and esthetic properties. These effects appear to depend on material composition, CHX concentration, and exposure duration.

Aim

To synthesize current evidence on the interactions between CHX and commonly used dental materials and to evaluate their clinical relevance in restorative, prosthetic, and implant dentistry.

Materials and Methods

A narrative literature review was conducted using PubMed/MEDLINE, Scopus, and Web of Science. English-language studies published between January 1986 and October 2025 were considered. Laboratory studies, clinical studies, systematic reviews, and meta-analyses evaluating physicochemical, mechanical, bonding, biological, or clinical effects of CHX on dental materials were included. In total, 27 publications were included in the final narrative synthesis. Findings were synthesized narratively because of substantial heterogeneity in materials, exposure protocols, and outcome measures.

Results

Short-term CHX exposure generally produced limited effects on immediate bond strength and mechanical performance. In adhesive dentistry, CHX improved resin-dentin bond preservation after aging, although the effect varied with adhesive strategy and exposure conditions. Prolonged exposure was associated with increased surface roughness, discoloration, or reduced hardness in selected resin-based, glass-ionomer, and acrylic materials. Low CHX concentrations generally preserved fluoride release from glass-ionomer materials. Titanium surfaces showed limited changes after short-term exposure, whereas prolonged exposure to concentrated CHX produced minor physicochemical alterations.

Conclusions

The effects of CHX on dental materials are primarily material, concentration, and exposure dependent. Short term exposure generally causes limited changes, whereas prolonged or repeated exposure may affect selected surface and esthetic properties. CHX may improve long term resin dentin bond preservation, but further clinical studies are needed to determine the clinical relevance of these effects in restorative, prosthetic, and implant dentistry.

Keywords: Chlorhexidine; Dental materials; Resin composites; Dental adhesives; Glass-ionomer cements; Titanium implants.

INTRODUCTION

Chlorhexidine (CHX) is widely used in dentistry as an adjunct in preventive, periodontal, endodontic, prosthetic, and implant procedures [1-8]. Beyond its antimicrobial effects, increasing evidence indicates that CHX may interact with dental materials and influence their surface, mechanical, esthetic, and bonding properties [3,9-17,20].

These interactions are material-, concentration-, and exposure-dependent. In adhesive dentistry, CHX has received particular attention because of its ability to inhibit matrix metalloproteinases and cysteine cathepsins involved in degradation of the hybrid layer, potentially improving long-term resin-dentin bond durability [9-18]. Conversely, prolonged or repeated exposure has been associated with changes in surface roughness, discoloration, hardness, and selected physicochemical properties of resin-based composites [19,37], glass-ionomer cements [21-26], acrylic denture materials [27-30], and titanium surfaces [31-34].

Despite the growing number of studies investigating individual material groups, the available evidence remains fragmented, with substantial variation in material composition, CHX concentration, exposure protocols, and evaluated outcomes. A clinically oriented synthesis comparing these effects across restorative, prosthetic, and implant materials is therefore needed.

AIM AND RESEARCH QUESTIONS

The aim of this narrative review was to synthesize current evidence on the interactions between CHX and commonly used dental materials, with particular emphasis on resin composites and adhesive systems, glass-ionomer and resin-modified glass-ionomer cements, acrylic denture materials, temporary cements, fluoride and bleaching-related interactions, and titanium implant surfaces. The clinical relevance of these interactions and implications for material performance were also evaluated.

The review addressed three questions: (1) how does CHX affect the physical, mechanical, and bonding properties of dental materials; (2) how do concentration and exposure duration influence these effects; and (3) what are the potential clinical implications of these interactions?

MATERIALS AND METHODS

Search Strategy

A narrative literature review was conducted to identify and synthesize published evidence concerning the interactions between chlorhexidine (CHX) and dental materials. The literature search was performed in PubMed/MEDLINE, Scopus, and Web of Science and covered publications from January 1986 to October 2025. The search strategy combined controlled vocabulary (MeSH terms where applicable) and free-text terms related to chlorhexidine, dental materials, and material properties.

The search terms included combinations of the following concepts: (“chlorhexidine” OR “chlorhexidine digluconate” OR “chlorhexidine gluconate” OR “chlorhexidine diacetate”) AND (“dental materials” OR “dental material” OR “resin composite” OR “adhesive” OR “dentin bonding” OR “glass ionomer” OR “resin-modified glass ionomer” OR “acrylic resin” OR “PMMA” OR “denture base” OR “temporary cement” OR “titanium” OR “dental implant”) AND (“bond strength” OR “surface roughness” OR “hardness” OR “color stability” OR “mechanical properties” OR “fluoride release” OR “surface properties” OR “physicochemical properties”).

Reference lists of key reviews and eligible articles were also screened manually to identify potentially relevant studies not retrieved by the electronic search.

Eligibility Criteria

Studies were considered eligible when they investigated the interaction of CHX with dental materials or material-related interfaces and reported at least one relevant outcome, including bond strength, bond durability, surface roughness, hardness, color stability, mechanical properties, fluoride release, antibacterial activity, surface characteristics, or other physicochemical properties.

The review included in vitro and laboratory studies, randomized clinical trials, clinical studies, systematic reviews, meta-analyses, and relevant narrative reviews when they provided information directly relevant to the objectives of the review. Publications addressing CHX use in dentistry without evaluating its interaction with dental materials were used only when necessary to provide mechanistic or clinical context.

Studies were excluded when they were unrelated to dental materials, focused exclusively on non-dental applications of CHX, or did not provide information relevant to the

material-related outcomes addressed in this review. Duplicate records were removed before screening.

Study Selection and Data Extraction

Titles and abstracts identified through the database searches were screened for relevance to the review objectives. Potentially relevant publications were subsequently assessed on the basis of their full text. Reference lists of selected publications were also screened manually to identify potentially relevant studies.

A total of 286 records were identified through the electronic database searches. After removal of 64 duplicate records, 222 records were screened by title and abstract. Of these, 158 records were excluded because they did not meet the eligibility criteria. 64 full text reports were assessed for eligibility, of which 37 were excluded after full text assessment. In total, 27 publications were included in the final narrative synthesis, contributing to a total of 42 references cited throughout the work.

For each included publication, the following information was extracted: author and year of publication, study design, dental material or material interface investigated, CHX formulation and concentration, exposure protocol and duration, experimental or clinical conditions, principal outcome measures, and main findings. Particular attention was given to differences in CHX concentration, exposure duration, frequency of exposure, material composition, surface characteristics, and aging protocols, as these factors were considered important sources of heterogeneity between studies.

Data Synthesis

Because of substantial heterogeneity in study designs, dental materials, CHX concentrations, exposure protocols, aging procedures, and outcome measures, a narrative synthesis was performed rather than a quantitative meta-analysis.

The evidence was organized according to the principal material categories: (1) resin-based composites and adhesive systems, (2) glass-ionomer and resin-modified glass-ionomer cements, (3) temporary cements and luting materials, (4) fluoride-related interactions and remineralization, (5) bleaching-related effects, (6) acrylic and PMMA denture materials, and (7) titanium implant surfaces.

Findings were compared according to the direction and consistency of reported effects, with particular consideration of whether observed changes were associated with short-term versus prolonged or repeated CHX exposure. Where findings were in-

consistent, the differences were considered in relation to material composition, CHX concentration, exposure conditions, and experimental methodology.

The synthesis was used to evaluate the three predefined review questions: (1) how CHX affects the physical, mechanical, esthetic, and bonding properties of dental materials; (2) how CHX concentration and exposure duration influence these effects; and (3) what potential clinical implications can be derived from the available evidence.

Methodological Considerations

This review was designed as a narrative review rather than a systematic review. Therefore, no formal risk-of-bias assessment or quantitative pooling of effect estimates was performed. The interpretation of the evidence considered the methodological characteristics of individual studies and the distinction between laboratory findings and clinical evidence.

RESULTS

The included literature comprised in vitro studies, clinical studies, randomized clinical trials, systematic reviews, meta-analyses, and narrative reviews. The identified evidence addressed resin-dentin bonding, resin-based composites, glass-ionomer and resin-modified glass-ionomer cements, temporary cements, fluoride-related interactions, bleaching-related effects, acrylic denture materials, and titanium implant surfaces. Study characteristics and principal findings are summarized in Table 1.

Across the included studies, resin-dentin bonding was the most extensively investigated material-related outcome, followed by antibacterial and mechanical properties of glass-ionomer materials and surface characteristics of acrylic and titanium materials. Reported outcomes varied according to material type, CHX concentration, exposure duration, exposure protocol, and study design.

Resin-Based Composites and Adhesive Systems

The effects of CHX on resin-based materials are best documented at the resin-dentin interface. CHX inhibits matrix metalloproteinases and cysteine cathepsins involved in degradation of the hybrid layer. Application of CHX, particularly at a concentration of 2%, generally has little effect on immediate bond strength but may improve bond-

strength preservation after aging, although the magnitude of this effect varies according to the adhesive system, dentin substrate, CHX concentration, and aging protocol [9-17].

Clinical and laboratory studies have investigated whether CHX pretreatment influences the long-term performance of adhesive restorations. While some studies have reported improved retention or reduced degradation of resin-dentin bonds, others have found no significant long-term clinical advantage. Overall, the evidence suggests that the potential benefit of CHX is more apparent under experimental aging conditions than in short-term clinical outcomes [11-15].

Repeated exposure of resin composites to CHX-containing mouthrinses may also affect surface characteristics and color stability. Reported changes include increased surface roughness, reduced surface quality, and extrinsic discoloration, although the magnitude of these effects varies substantially according to composite composition, surface characteristics, and exposure conditions [19,37].

Overall, the available evidence supports a potential role of CHX in preserving resin-dentin bond stability, particularly under aging conditions, whereas its effects on the surface and esthetic properties of resin composites appear to be material- and exposure-dependent [9-19,37].

Glass-Ionomer Cements and Resin-Modified Glass-Ionomer Cements

In glass-ionomer cements (GICs) and resin-modified glass-ionomer cements (RMGICs), the effects of CHX depend primarily on its concentration, chemical form, mode of incorporation, and cement formulation. CHX has been incorporated into GICs and RMGICs to enhance antibacterial activity, with studies reporting increased inhibition of cariogenic bacteria and reduced biofilm activity [21-25].

However, incorporation of CHX may also affect the physical and mechanical properties of the cement. The available evidence indicates that these effects are concentration-dependent, with higher CHX loadings more likely to increase setting time and adversely affect selected mechanical properties. Lower concentrations generally produce smaller changes, although the response varies according to the cement formulation [21-26].

Effects on fluoride release are likewise formulation-dependent. CHX incorporation may alter fluoride-release kinetics, and higher concentrations or specific CHX formulations may reduce fluoride release. Therefore, antibacterial enhancement should be consid-

ered together with the potential effects on fluoride release and mechanical performance [21,25,26].

Experimental studies of CHX-containing RMGICs have demonstrated enhanced antibacterial and antibiofilm activity, with some formulations maintaining acceptable mechanical properties at selected concentrations. For example, incorporation of 1.25% CHX into an RMGIC increased antibacterial and antibiofilm activity with relatively limited effects on mechanical properties, whereas higher CHX concentrations produced greater reductions in compressive or diametral tensile strength [22,26]. These findings support a concentration- and formulation-dependent effect rather than a uniform response across GIC and RMGIC materials.

Overall, CHX incorporation may provide an antimicrobial benefit in GICs and RMGICs, but increasing CHX concentration can compromise selected material properties. The available evidence therefore supports evaluation of CHX concentration and cement formulation when considering CHX-modified glass-ionomer materials [21-26].

Temporary Cements and Luting Materials

Evidence regarding the interaction between CHX and temporary cements is limited. An experimental study of CHX-containing provisional cement demonstrated antibacterial activity against *Streptococcus mutans*, while the effect on tensile strength depended on the formulation and CHX incorporation [36]. Therefore, the available evidence is insufficient to establish a consistent clinically relevant effect of CHX on the mechanical or adhesive performance of temporary cements.

Overall, CHX may provide an antimicrobial benefit when incorporated into selected provisional cement formulations, but further studies are required to determine its effects on mechanical performance and subsequent adhesive procedures [36].

Fluoride Preparations and Remineralization

Available evidence does not indicate a clinically relevant chemical incompatibility between CHX and fluoride. However, the timing and sequence of application may influence fluoride availability and the preventive effects of the two agents. In experimental models, CHX exposure has been investigated in combination with fluoride-containing preparations, with effects depending on application timing and formulation [35].

In relation to glass-ionomer materials, the addition of CHX may alter fluoride-release kinetics depending on the cement formulation and CHX concentration [21,25,26].

Therefore, the available evidence supports a generally compatible relationship between CHX and fluoride-based preventive strategies, while the effects of their combined or sequential use on dental materials remain formulation-dependent [21,25,26,35].

Bleaching Agents

Available evidence concerning the interaction between CHX and bleaching procedures is limited. The available literature does not indicate that CHX directly interferes with peroxide-based bleaching. The main material-related concern is potential extrinsic discoloration of susceptible restorative materials following repeated CHX exposure [19,37].

The magnitude of color change depends on the composition of the restorative material, resin matrix characteristics, surface properties, and exposure conditions [19,37]. Therefore, the available evidence does not support a direct chemical incompatibility between CHX and peroxide-based bleaching agents, although repeated CHX exposure may have esthetic implications for susceptible restorative materials.

Acrylic Denture Materials

Short-term exposure to CHX-containing disinfectant solutions generally produces limited changes in the mechanical properties of acrylic denture-base materials. However, repeated or prolonged disinfection may affect surface characteristics, including surface roughness and color stability, depending on the acrylic formulation, polishing condition, disinfectant concentration, and exposure protocol [27-30].

Studies evaluating denture-base and reline materials have demonstrated that the effect of CHX on surface roughness is material-dependent, with some materials showing measurable surface alterations after repeated immersion [27]. Changes in color have also been reported following chemical disinfection, although the magnitude of discoloration varies according to the denture-base material and disinfection procedure [28,29].

More recent evidence indicates that the response of conventional and CAD/CAM-processed denture-base resins to cleansing and disinfection procedures may differ. CAD/CAM materials may demonstrate greater resistance to changes in surface topography and microbial adherence under selected experimental conditions [30]. However, evidence concerning 3D-printed denture-base materials remains limited.

Overall, CHX can be used for short-term disinfection of acrylic denture materials with relatively limited material changes, but repeated or prolonged exposure should be considered in relation to surface roughness, color stability, and the specific characteristics of the denture material [27-30].

Titanium Implant Surfaces

CHX has been investigated as a chemical decontamination agent for titanium implant surfaces, particularly in the context of peri-implant disease. Available laboratory evidence indicates that the effects of CHX depend on the surface characteristics of the titanium, the concentration and duration of exposure, and the decontamination protocol [31-34].

Studies evaluating smooth and rough titanium surfaces have reported differences in CHX adsorption and interaction with the titanium oxide layer [32,33]. More intensive antimicrobial treatment protocols may also affect selected physicochemical and cytocompatibility characteristics of titanium surfaces, although the magnitude and clinical relevance of these changes remain uncertain [31].

Systematic evidence concerning chemical decontamination of implant surfaces indicates substantial heterogeneity between protocols and limited evidence for the superiority of individual chemical agents. Mechanical debridement therefore remains an important component of peri-implant surface decontamination, while CHX should be considered an adjunct rather than a substitute for mechanical treatment [34].

Overall, the available evidence does not demonstrate a consistent clinically relevant adverse effect of short-term CHX exposure on titanium implant surfaces. However, the effects of repeated or prolonged exposure, particularly on modified and nanostructured implant surfaces, remain insufficiently characterized [31-34]. The main characteristics and findings of the included studies are summarized in Table 1.

Table 1. Summary of the included studies evaluating the interactions between chlorhexidine and dental materials

AUTHOR, YEAR	DENTAL MATERIAL / INTERFACE	STUDY DESIGN	CHX EXPOSURE / PROTOCOL	MAIN OUTCOME(S)	KEY FINDINGS
Carrilho et al., 2007 [9]	Resin-dentin interface	In vitro	CHX pretreatment	Bond strength after aging	CHX preserved resin-dentin bond strength after aging.
Carrilho et al., 2010 [10]	Human dentin	In vitro	CHX exposure	CHX substantivity	CHX demonstrated substantivity to human dentin.
Hamdan-Nassar et al., 2019 [11]	Resin restorations / adhesive interface	Meta-analysis	2% CHX after acid etching	Microtensile bond strength	The effect of CHX on bond strength varied among experimental conditions.
Montagner et al., 2015 [12]	Adhesive restorations	Randomized controlled trial	CHX pretreatment	Restoration retention	CHX pretreatment did not demonstrate a consistent clinically relevant improvement in retention.
Sartori et al., 2013 [13]	Adhesive restorations	Clinical follow-up study	CHX digluconate	Clinical restoration performance	CHX treatment did not produce a consistent improvement in clinical adhesive restoration performance.
Dutra-Correa et al., 2013 [14]	Adhesive systems	Clinical study	CHX pretreatment	Clinical adhesive performance	Effects differed according to adhesive system.
Hajizadeh et al., 2013 [15]	Posterior composite restorations	Randomized clinical study	CHX application	Postoperative sensitivity	CHX application was evaluated for its effect on postoperative sensitivity.
Kiuru et al., 2021 [16]	Dentin bonding	Systematic review and meta-analysis	MMP inhibitors	Bond durability	MMP inhibition was associated with preservation of dentin bonding in several experimental studies.
Yaghmoor et al., 2022 [17]	Dental adhesive systems	Systematic review and meta-analysis	MMP inhibitors	Bond strength	MMP inhibitors showed variable effects on coronal composite bond strength.
Hamdy et al., 2023 [19]	Nanohybrid resin composite	In vitro	Different mouthrinses	Microhardness and color stability	Mouthrinse exposure produced material-dependent changes in microhardness and color stability.
Tüzüner et al., 2019 [21]	GIC/RMGIC	Review	Antimicrobial additives including CHX	Mechanical and antimicrobial properties	CHX may enhance antimicrobial activity, while higher concentrations may adversely affect selected material properties.

Sanders et al., 2002 [22]	Resin-modified GIC	In vitro	CHX incorporation	Antibacterial and physical properties	CHX-containing RMGIC demonstrated antibacterial activity with concentration-dependent material effects.
Türkün et al., 2008 [23]	CHX-containing GIC	In vitro / long-term evaluation	CHX incorporation	Antibacterial and physical properties	Long-term antibacterial activity was demonstrated, with effects on selected physical properties.
Becci et al., 2014 [24]	High-viscosity GIC	In vitro	CHX diacetate incorporation	Bond strength	CHX addition affected bond strength according to the experimental formulation.
Marti et al., 2014 [25]	GIC	In vitro	CHX gluconate incorporation	Mechanical, physical and antibacterial properties	CHX increased antibacterial activity; mechanical and physical effects were formulation-dependent.
Hussein et al., 2025 [26]	Conventional GIC	In vitro	CHX incorporation	Antibacterial activity, fluoride release, solubility, compressive strength	CHX-containing GIC showed altered antibacterial and selected material properties compared with conventional GIC.
Machado et al., 2012 [27]	Denture-base and relined materials	In vitro	CHX immersion	Surface roughness	Surface roughness changes varied according to material and disinfection protocol.
Carvalho et al., 2012 [28]	Acrylic denture-base resin	In vitro	Disinfectant solutions	Material properties	Disinfection produced material-dependent changes.
Polyzois et al., 1997 [29]	Denture-base materials	In vitro	Disinfection/sterilization immersion	Color stability	Color changes varied according to material and treatment.
Alfouzan et al., 2023 [30]	Conventional and CAD/CAM denture resins	In vitro	Denture cleansers	Microbial adherence and surface topography	Material type influenced microbial adherence and surface characteristics following cleansing.
Kotsakis et al., 2016 [31]	Titanium implant surfaces	In vitro	Antimicrobial agents	Physicochemical and cytocompatibility properties	Antimicrobial treatment altered selected titanium surface properties under experimental conditions.
Kozlovsky et al., 2006 [32]	Smooth and rough titanium	In vitro	CHX exposure	CHX-titanium interaction	CHX interaction differed between smooth and rough titanium surfaces.
Barbour et al., 2009 [33]	Titanium dioxide surfaces	In vitro	CHX functionalization	Bacterial adhesion	CHX functionalization altered <i>Streptococcus gordonii</i> adhesion.

Hart et al., 2024 [34]	Dental implant surfaces	Systematic review and meta-analysis	Mechanical/chemical decontamination	Surface decontamination	Evidence for chemical decontamination methods was heterogeneous.
Almohefer et al., 2018 [35]	Enamel/caries lesions	In vitro	Fluoride toothpaste + CHX	Remineralization	Effects depended on application timing and formulation.
Lewinstein et al., 2012 [36]	Provisional cement	In vitro	CHX diacetate incorporation	Antibacterial activity and tensile strength	CHX-containing provisional cement showed antibacterial activity; tensile strength was formulation-dependent.
Khosravi et al., 2016 [37]	Nanofilled and microhybrid composites	In vitro	CHX mouthrinse exposure	Color stability	CHX exposure affected color stability, with differences between composite types.

DISCUSSION

The present review indicates that the effects of chlorhexidine (CHX) on dental materials are predominantly material-, concentration-, and exposure-dependent. The evidence was most consistent for the resin-dentin interface, whereas findings for restorative, prosthetic, temporary, and implant materials were more heterogeneous. Importantly, the magnitude and direction of the reported effects differed between experimental protocols, limiting direct comparison across material categories.

Resin-dentin bonding and adhesive systems

The most consistent finding concerned the potential preservation of resin-dentin bond strength following CHX pretreatment and subsequent aging. CHX has been investigated primarily because of its inhibitory effects on matrix metalloproteinases and other enzymes involved in degradation of the collagenous component of the hybrid layer [9-17]. The available evidence indicates that this mechanism may contribute to improved bond-strength retention over time, although an improvement in immediate bond strength has not been demonstrated consistently.

The distinction between immediate and aged bond strength is clinically relevant. Findings from laboratory studies and meta-analyses suggest that the principal potential advantage of CHX is related to preservation of the adhesive interface rather than an immediate increase in bond strength [9-17]. However, the evidence remains heterogeneous because adhesive systems differ in composition, application strategy, sol-

vent characteristics, and interaction with dentin. In addition, most investigations assessing long-term bond preservation were performed under laboratory aging conditions. Therefore, the extent to which these findings translate into improved long-term clinical restoration survival remains uncertain.

Resin-based restorative materials

Compared with the resin-dentin interface, evidence concerning the direct effects of CHX on resin-based restorative materials was less consistent. Changes in surface roughness, microhardness, and color stability varied according to composite composition and exposure protocol [19,37]. Repeated or prolonged exposure was more frequently associated with measurable changes than short-term exposure.

These findings suggest that the response of resin composites cannot be attributed to CHX exposure alone. Resin matrix composition, filler characteristics, degree of polymerization, surface finishing, and water sorption may influence the susceptibility of a restoration to chemical and physical changes. Consequently, observations obtained with one composite formulation should not automatically be extrapolated to other resin-based materials.

The available evidence therefore does not support a uniform adverse effect of CHX on resin composites. Rather, it indicates that prolonged exposure may influence selected surface and esthetic properties in susceptible materials, particularly under experimental conditions that may exceed routine clinical exposure [19,37].

Glass-ionomer and resin-modified glass-ionomer cements

The evidence concerning GICs and RMGICs demonstrates a balance between potential antibacterial effects and concentration-dependent changes in material properties. CHX incorporation has been associated with increased antibacterial activity in several experimental studies [21-26]. At the same time, changes in mechanical properties, fluoride release, solubility, and other physical characteristics have varied between formulations.

This variability is important because the addition of an antimicrobial agent may alter the setting reaction or microstructure of a cement. The available studies do not establish a single concentration that produces the same balance between antimicrobial activity and material performance across all GIC/RMGIC formulations [21-26].

Accordingly, CHX-containing GICs should be considered formulation-specific materials rather than interchangeable with conventional GICs. The evidence supports further development of antimicrobial GIC formulations, but it does not justify assuming that incorporation of CHX will improve the overall clinical performance of every GIC or RMGIC.

Temporary cements and fluoride-related interactions

Evidence concerning temporary cements was limited compared with that for adhesive systems and restorative materials. Experimental incorporation of CHX into provisional cement demonstrated antibacterial activity, while mechanical effects were dependent on formulation [36]. The limited number of studies prevents a reliable assessment of the long-term clinical consequences of CHX incorporation into temporary luting materials.

Similarly, evidence concerning interactions between CHX and fluoride-related procedures was limited. Available experimental findings suggest that the effects depend on application timing and formulation rather than demonstrating a uniform adverse interaction [35]. These findings do not provide sufficient evidence to establish a clinically important incompatibility between CHX and fluoride-based preventive approaches.

Bleaching-related considerations

The evidence related specifically to bleaching procedures was comparatively limited. Available studies primarily address color changes in resin-based restorative materials following CHX exposure rather than demonstrating a direct chemical incompatibility between CHX and peroxide-based bleaching systems [19,37].

This distinction is important clinically. The principal concern supported by the available evidence is potential extrinsic discoloration of susceptible restorative materials rather than evidence that CHX directly interferes with the bleaching reaction. The extent of discoloration depends on the composition and surface characteristics of the restorative material and on the exposure conditions.

Acrylic denture materials

Acrylic and PMMA denture materials generally demonstrated greater tolerance to short-term exposure than to repeated or prolonged disinfection. However, changes in

surface roughness and color stability have been reported in selected materials and protocols [27-30].

The variability between studies indicates that the effect of CHX-containing disinfection cannot be generalized to all denture-base materials. Material formulation, polishing quality, surface characteristics, disinfectant concentration, and exposure duration may all influence the observed response. Evidence involving CAD/CAM-processed denture materials also indicates that manufacturing technology may modify the susceptibility of denture-base polymers to chemical exposure [30].

From a clinical perspective, these findings support the use of CHX-containing disinfection according to an appropriate protocol rather than assuming that repeated immersion is material-neutral.

Titanium implant surfaces

The evidence concerning titanium implant surfaces is heterogeneous. CHX interacts with titanium and titanium oxide surfaces, and experimental studies indicate that the nature of the surface, including its roughness and physicochemical characteristics, can influence this interaction [31-33]. Studies of chemical and mechanical decontamination methods further demonstrate substantial variation between treatment protocols [34].

Although selected laboratory studies have identified changes in physicochemical or cytocompatibility-related properties following antimicrobial treatment, these findings should not be interpreted as evidence that routine CHX exposure necessarily causes clinically significant implant surface damage [31-34]. The available evidence does not establish a consistent adverse effect under routine short-term conditions.

At the same time, the evidence is insufficient to support prolonged or repeated CHX exposure as a means of implant-surface decontamination without consideration of the specific implant surface and treatment protocol. Mechanical and chemical decontamination methods should therefore be considered in the context of the characteristics of the affected implant surface and the clinical objective.

Clinical implications and overall interpretation

Taken together, the evidence supports a protocol-specific rather than universal approach to CHX use with dental materials. The strongest potential material-related benefit is preservation of resin-dentin bond stability after aging. In contrast, effects on

resin composites, GIC/RMGIC, acrylic materials, temporary cements, and titanium surfaces are more dependent on material composition and exposure conditions [9-37].

The distinction between short-term clinical exposure and prolonged or repeated laboratory exposure is particularly important. Laboratory studies frequently use exposure durations or concentrations that do not directly reproduce routine clinical conditions. Consequently, experimentally observed changes in surface or mechanical properties should not automatically be interpreted as clinically significant deterioration.

Overall, the available evidence supports the use of CHX when its antimicrobial or adhesive-interface effects are clinically indicated, while prolonged exposure should not be assumed to be material-neutral. Decisions concerning CHX use should therefore consider the type of dental material, concentration, exposure duration, and intended clinical application.

Evidence gaps

Several areas remain insufficiently investigated. Contemporary universal adhesive systems, newer bioactive restorative materials, CAD/CAM polymers, and 3D-printed prosthetic materials require further evaluation under standardized exposure and aging protocols. Similarly, additional research is needed to characterize the effects of repeated CHX exposure on modified and nanostructured titanium surfaces.

Future studies should combine standardized laboratory protocols with adequately designed long-term clinical investigations. Such studies are necessary to determine whether changes observed experimentally in bond durability, surface characteristics, mechanical properties, or color stability translate into clinically meaningful differences in restoration longevity, prosthetic performance, or implant outcomes.

Future research should focus on standardized evaluation of CHX interactions with contemporary dental materials, particularly universal adhesive systems, bioactive resin composites, CAD/CAM polymers, and 3D-printed prosthetic materials [38-41]. Studies should report CHX concentration, exposure duration, frequency of exposure, material composition, aging conditions, and clinically relevant outcome measures in a standardized manner.

For adhesive dentistry, long-term clinical studies are needed to determine whether the bond-preserving effects observed after laboratory aging translate into improved restoration longevity. Further investigation should also clarify whether the effects of

CHX differ between contemporary adhesive strategies and material formulations [18,42].

For prosthetic and implant materials, future studies should evaluate repeated exposure under clinically realistic conditions. Particular attention should be given to CAD/CAM and 3D-printed polymers and to modified or nanostructured titanium surfaces. Combining laboratory testing with long-term clinical follow-up would help determine whether experimentally detected changes in surface, mechanical, esthetic, or physicochemical properties have meaningful clinical consequences.

Limitations

The interpretation of the available evidence is limited by substantial heterogeneity among the included studies. Differences in CHX concentration, formulation, exposure duration, application protocol, aging conditions, dental material composition, and outcome assessment limited direct comparison between studies.

A further limitation is the predominance of laboratory investigations, particularly for resin-dentin bonding and material-property outcomes. Laboratory aging protocols may not fully reproduce the chemical, mechanical, and biological conditions encountered clinically. Therefore, experimentally observed changes in bond strength, surface characteristics, hardness, color, or physicochemical properties cannot necessarily be interpreted as clinically relevant deterioration.

The evidence was also unevenly distributed across material categories. Resin-dentin bonding and several restorative materials were relatively well investigated, whereas evidence concerning temporary cements, bleaching-related interactions, contemporary CAD/CAM and 3D-printed materials, and modified implant surfaces was more limited. In addition, differences in study design and outcome measures restricted quantitative comparison across material groups.

Finally, as a narrative review, the synthesis involved qualitative integration of heterogeneous evidence rather than a formal quantitative meta-analysis of all material-related outcomes. Consequently, the conclusions should be interpreted in the context of the available evidence and not as estimates of a uniform treatment effect.

CONCLUSIONS

The available evidence indicates that the effects of chlorhexidine on dental materials are primarily material-, concentration-, and exposure-dependent. Short-term exposure generally produces limited changes, whereas repeated or prolonged exposure may affect selected surface, mechanical, and esthetic properties.

The most consistent evidence concerns the resin-dentin interface, where CHX pre-treatment may improve preservation of bond strength after aging. However, the clinical significance of this effect remains uncertain. For resin composites, GIC/RMGIC, acrylic denture materials, temporary cements, fluoride-related interactions, and titanium implant surfaces, the evidence is more heterogeneous and strongly dependent on material formulation and exposure protocol.

Accordingly, the current evidence supports a material and protocol specific approach to CHX use in restorative, prosthetic, and implant dentistry rather than assuming that prolonged exposure is universally neutral or beneficial for dental materials. Further standardized long term clinical studies are required to determine whether the observed laboratory effects translate into clinically relevant differences in restoration longevity, prosthetic performance, esthetics, and implant surface behavior.

DISCLOSURE

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