International Journal of Medical Toxicology & Legal Medicine Volume 27, No. 3, 2024
e-ISSN: 0974-4614
p-ISSN: 0972-0448

Impact of Direct Restorative Dental Materials on Surface Root Caries Treatment

Mohammad abdulrahman aldossari[1], Bader Mohammed almotairiy[1], Khalid Ibrahim Alanazi[1], Yazeed sultan Alsabeh[1], Khalid Mohammed Faqihi[1], Musab Jurayyad Aljurayyad[1], Abdullah Saeed Albaqami[1], Bader Saad Aldobaian[1], Abdulhmeed abdulmohsen alodib[1], Sakhar Fahad Almuhaya[2]

[1]Dentist, North Riyadh Dental Center
[2]Dentist, MOH. Rc2

Received: 15.09.2024 Revised: 30.10.2024 Accepted: 09.11.2024

ABSTRACT

Background: Root caries management is essential for tooth preservation. Direct restorative materials like resin-modified GIC, glass ionomer cement (GIC), and composite resins are used for their cariostatic properties and mineralization potential.

Aim: This meta-analysis study aimed to assess the efficacy of direct restorative materials in the therapy of surface root caries.

Methods: A search of PubMed, Embase, Cochrane Library, and Google Scholar identified studies on root caries, restorative materials, remineralization, and mineral density. Additional searches were done on ClinicalTrials.gov and relevant references were reviewed.

Results: The meta-analysis identified 412 studies, with five meeting the inclusion criteria for analysis. These studies focused on evaluating the impact of various restorative materials on mineral profiles, outer lesion depth, and cariostatic efficacy. Key findings include the high remineralization and mineral density retention provided by GIC, especially when modified with SDF or CPP-ACP. SEM and FTIR analyses showed that these materials improved mineral composition and reduced organic matrix exposure at the restoration interface, demonstrating their potential in managing root caries effectively.

Conclusion: GIC and its modified forms, particularly with SDF or CPP-ACP, effectively prevent mineral loss, enhance remineralization, and reduce lesion depth. These materials show promise in root caries management, though more clinical investigations are needed to confirm long-term efficiency.

Keywords: Root Caries, Direct Restorative Materials, Mineral Density, Silver Diamine Fluoride (SDF), Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP), Glass Ionomer Cement (GIC), in Vitro Studies

INTRODUCTION

Periodontal disease and dental caries correlate with alterations in the metabolism and composition of the oral bacteria at specific points. The inability to regulate and manipulate numerous in vivo environmental conditions is due to conditions within the mouth are never stable for a long time. While biofilms in situ investigations were documented to exhibit stability within a single individual, they demonstrated significant variation among different people **(1, 2)**.

In vitro investigations offer advantages as they allow for the control and modification of environmental conditions and microbiota **(3)**. The features of biofilms created by predominant cariogenic bacteria in an artificial mouth were demonstrated to resemble those of caries root surfaces dental plaque **(4)**.

In vitro formation of a biofilm on enamel and dentin results in demineralization identical to that of a natural caries lesion **(5)**. Fontana et al. **(6)** demonstrated that biofilm formation has been related to five cariogenic microorganisms and the extent of enamel demineralization. They discovered that, whereas the duration of sucrose consumption didn't influence lesion size, the incidence of sucrose intake did. No research has yet been conducted on the impact of mixed-species oral biofilms composed of primary cariogenic microorganisms on repaired root surfaces, despite the rising incidence of root-surface caries **(7)**.

This systematic review aimed to assess the efficacy of direct restorative materials in the treatment of surface root caries. By analyzing present evidence, this review seeks to provide insights into the comparative effectiveness of these materials, offering clinicians guidance on material selection to optimize the longevity and success of root caries restorations.

Patients and Methods

Search strategy: A comprehensive literature search has been performed across multiple databases, involving Google Scholar, PubMed, Embase, and the Cochrane Library. The search utilized both text terms and medical subject headings such as Root Caries, Direct Restorative Materials, Remineralization, Mineral Density, In Vitro Studies. Additional research was performed in ClinicalTrials.gov, and the references of selected research and reviews were also examined to identify relevant observational research.

Inclusion criteria: (1): Studies evaluating the effect of direct restorative materials on root caries therapy. (2): In vitro or clinical investigations with quantitative assessments of mineralization, lesion depth, or cariostatic efficacy. (3): Studies using recognized analytical methods (e.g., Micro-CT, SEM, EDX, FTIR) to measure outcomes.

Exclusion criteria: (1): Studies not involving direct restorative materials or not focused on root caries. (2): Studies without quantitative mineralization or cariostatic efficacy data.

(3): Reviews, case studies, or studies lacking specific data on the restorative material's impact on root caries.

Data extraction: Two researchers conducted separate assessments of the titles and abstracts of all the papers generated to determine their relevance. We thoroughly examined each trial that was discovered and decided about whether to include it or not. Researchers also independently extracted the data into a standardized data extraction form. The two reviewers established a consensus on decisions about the inclusion of research and data extraction. The 3rd researcher would have the final authority to determine trial eligibility and extract data where discrepancies have been discovered.

RESULTS

Literature search results

The primary search across databases yielded 412 potentially relevant studies, 200 duplicate studies were removed, 35 full texts were assessed for eligibility. Finally, five investigations have been involved in the systematic review. The PRISMA flow diagram is illustrated in **Figure 1**.

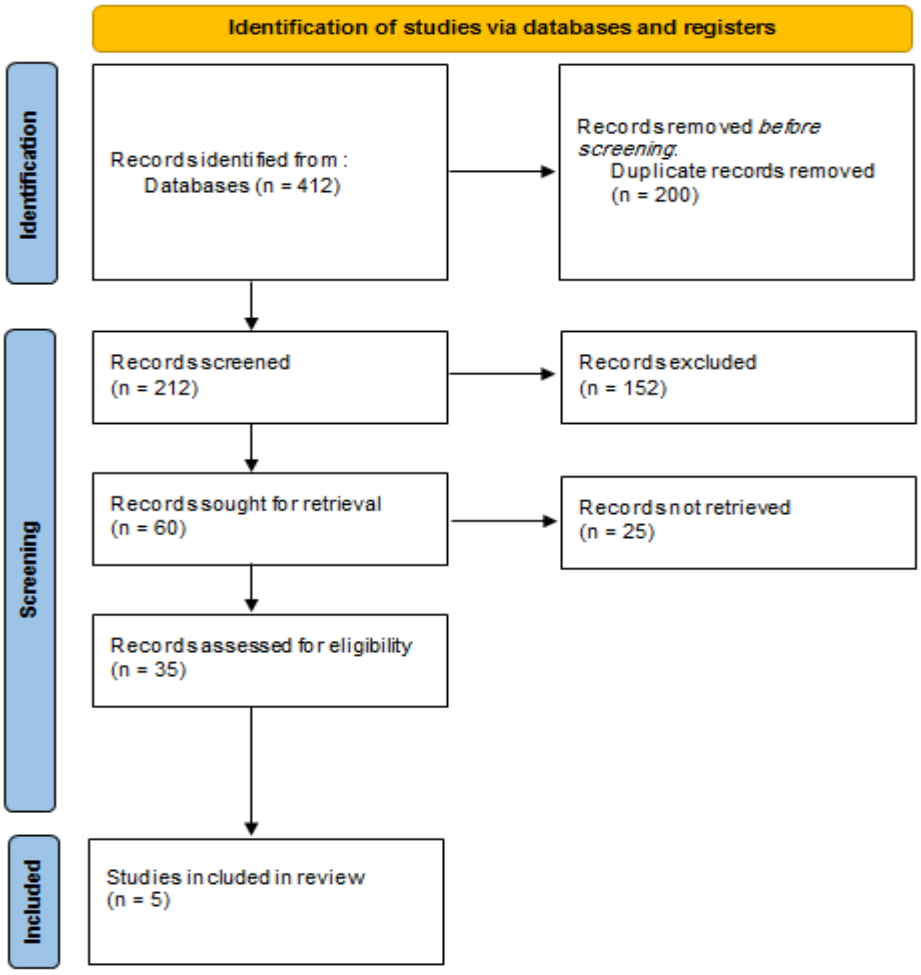

Figure 1: Prisma flow diagram for involved study.

Characteristics of the studies involved

Our comprehensive systematic review encompassed 5 studies, the baseline summary and features for the involved studies are illustrated in Tables 1.

Table 1: characteristics of our included study.

Study No.	Study ID	Design of Study	Parameter	Evaluation	Finding
1	Zan et al., 2018	Restored root bovine dentin with various restorative materials. Experimentally evaluated the remineralization & demineralization cycles. Assessed the density of minerals and mineral depletion via micro-CT.	Volume of minerals, Average mineral profile, Average mineral loss	Micro-CT,SEM	The mineral profiles of restoration utilizing a two-step self-etch adhesive with composite resin (Beautifil Flow F10) were superior to those of fluoride-free self-etch adhesive (Clearfil SE Bond) & composite resin (Clearfil Majesty ES Flow High), but inferior to those of glass ionomer cement restoration (Fuji-VII).
2	Zhao et al., 2017	Evaluated the impact of Casein Phosphopeptide-Amorphous Calcium Phosphate & SDF in Glass Ionomer Cement on the prevention of root caries. Prepared & repaired specimens using thermocycling & cariogenic bacteria.	Depth of outer lesion, mineral composition, inorganic profile in dentin	Micro-CT,SEM/EDS, Fourier-transform infrared spectroscopy	The combination of SDF treatment with CPP-ACP comprising GIC repair exhibited a synergistic impact in the prevention of root caries. Depth of the external lesion and exposure of collagen. The calcium and phosphate concentration elevated in GIC restorations incorporating CPP-ACP.
3	Yip et al., 2007	Resin-modified glass ionomer (Photac-Fil) & CR (Filtek Supreme) restorations in relation to multispecies biofilm of the mouth	Mineral composition in the organic structure of dentin	SEM/EDS,FTIR	log Ca: P) & diminished exposure of organic matrix & collagen (reduced log[amide I: HPO4 2-]) in comparison to the other material
4	Hara et al., 2006	Restorations of bovine root specimens into intraoral appliances in sixteen human participants. Quantified levels of fluoride from repair, levels of fluoride inside the biofilm, & mineral degradation.	biofilm Mineral loss concentration	computer software & X-ray imaging	Secondary root caries exhibited a greater concentration of released fluoride ions compared to the RC repair.
5	Hara et al., 2002	Evaluated the cariostatic properties of 5 fluoride-comprising restorative materials (DyractAP,Ketac-Fil Plus, Fuji II LC, SureFil/Prime & Bond NT, & Filtek Z250/Single Bond) by simulated caries induction & assessed surface micro-hardness.	Microhardness	Microhardness testing (Knoop diamond indenter)	GIC (Ketac-Fil) and Resin-modified glass ionomer (Fuji II LC) demonstrated cariostatic effects extending to three hundred meters and 150 meters on the subsurface, respectively; however, no effects were noted for the other materials.

Abbreviations: Micro-CT: FTIR: Fourier-transform infrared spectroscopy; Micro-computed tomography; SEM/EDS: Scanning electron microscopy with energy dispersive spectroscopy; SEM: Scanning electron microscopy,

Risk of bias evaluation

Of the five clinical investigations, three have been deemed to have a "low risk" of bias, whilst two have been assessed as having a "moderate risk". All clinical trials have been deemed to have a "low risk" of bias.

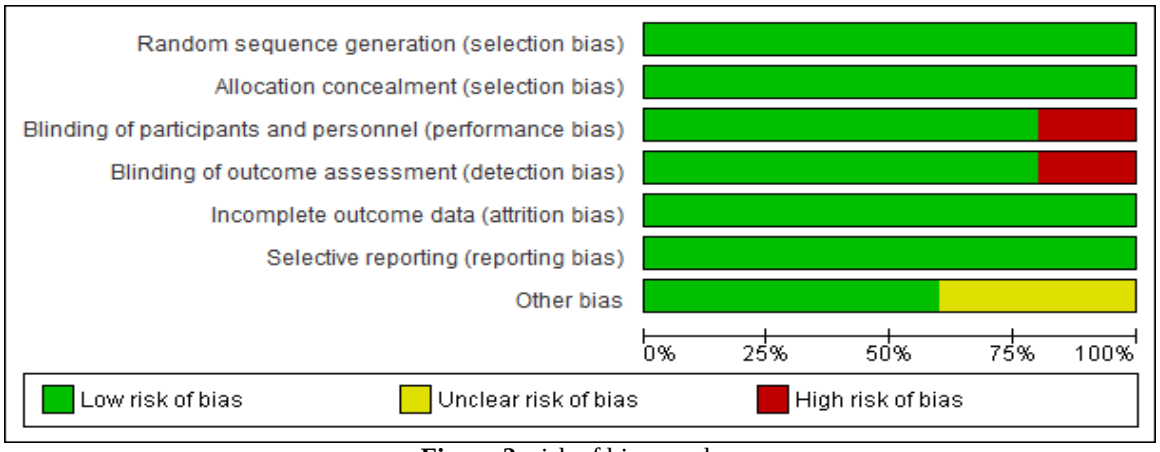

Figure 2: risk of bias graph.

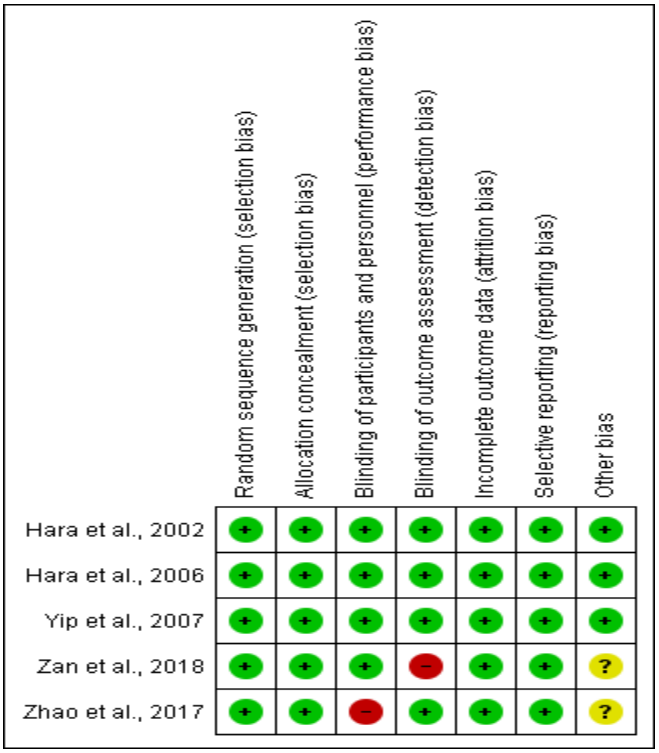

Figure 3: risk of bias summary.

DISCUSSION

Root caries, a type of tooth decay that affects the roots of teeth, is a growing concern, especially among older adults and those with gingival recession. These lesions develop when the tooth's root surface becomes exposed to bacteria, leading to demineralization and cavity formation. Treating root caries presents unique difficulties because the complexity of the root surface structure & the proximity to gingival tissues, making it crucial to select restorative materials that can withstand the oral environment, bond effectively to the root surface, and resist further bacterial invasion **(8)**.

Direct restorative dental materials—like glass ionomer cements, composite resins, & resin-modified glass ionomers—are widely used in treating surface root caries. Each of these materials varies in properties like adhesion, wear resistance, fluoride release, and ease of application, all of which can influence their effectiveness in the long-term success of root caries treatment **(9)**. While composite resins offer excellent esthetics and strength, glass ionomer cements provide additional benefits, including fluoride release that can help reduce secondary caries risk. Resin-modified glass ionomers combine the advantages of both, providing enhanced adhesion & durability (10, 11).

In the present meta-analysis research, we assessed the effect of various direct restorative dental substances on the therapy outcomes of surface root caries. Consequently,Zhao IS et al. (12) reported that both silver diamine fluoride therapy & alteration with casein phosphopeptide-amorphous calcium phosphate had a significant

impact on depth of outer lesion (p-less than 0.001). Scanning electron microscopy /EDX revealed an elevation of phosphorus & calcium in the root dentine close to the restoration in groups three and four (casein phosphopeptide-amorphous calcium phosphate modified glass ionomer cement).
Additionally, our findings indicated that Fourier-transform infrared spectroscopy (FTIR) revealed a significant impact of casein phosphopeptide-amorphous calcium phosphate modified glass ionomer cement & silver diamine fluoride treatment on the amide I-to-hydrogen phosphate ratio at the material-root interface (p-value equal 0.001).
Zan KW et al. (13) discovered through Micro-CT analysis that the 28-day REM sample exhibited reduced mineral loss on the surface of the dentin compared to the 4-day DEM specimen, indicating remineralization of the surface of dentin surrounding the restoration.
Similarly, Tonprasong et al. conducted a systematic review to evaluate the efficiency of direct restorative substances in root caries treating in both clinical & in-vitro studies. Their review also provided updates on current developments and future perspectives in restorative dental materials for root caries. The findings showed that glass ionomer cement (GIC) exhibited an excellent cariostatic effect in most in vitro studies. Resin-modified glass ionomer (RMGIC) restorations demonstrated lowered activity of recurrent caries but were less effective than GIC. For composite resin restorations, development efforts primarily focus on enhancing tooth structure strength and incorporating antimicrobial properties (16).
Additionally, Yip et al. performed an elemental analysis to evaluate the mineral composition of repaired root surfaces subjected to a simulated oral biofilm in culture system of an artificial mouth. Their research revealed that GIC was the only restorative material between the tree evaluated that provided both therapeutic & preventive impacts on the root surface against an initial cariogenic challenge posed by mixed-species biofilm, under conditions simulating a high-caries-risk environment without supplementary oral therapeutic interventions. Applying scanning electron microscopy, Yip et al. noted that following 3 weeks of biofilm culture, only GIC exhibited a significant elevation in the calcium-to-phosphorus (Ca) ratio on the root surface adjacent to the restoration (P-value less than 0.01), whereas this effect wasn't detected on the enamel side (P-value equal 0.72) **(17)**.

CONCLUSION

This meta-analysis study indicated that glass ionomer cement and its modified forms, particularly when combined with silver diamine fluoride or CPP-ACP, provided superior outcomes in preventing mineral loss, enhancing remineralization, and reducing lesion depth. Elemental analysis confirmed that GIC-based restorations led to increased calcium and phosphate deposition, contributing to their preventive and therapeutic advantages. Overall, these materials hold significant promise in root caries management, although further clinical studies are needed to confirm their long-term efficacy across diverse populations.

REFERENCES

1. Arweiler NB, Hellwig E, Sculean A, Hein N, Auschill TM. Individual vitality pattern of in situ dental biofilms at different locations in the oral cavity. Caries research. 2004 Aug 20;38(5):442-7.
2. Nyvad B, Takahashi N. Integrated hypothesis of dental caries and periodontal diseases. Journal of oral microbiology. 2020 Jan 1;12(1):1710953.
3. Bradshaw DJ, Lynch RJ. Diet and the microbial aetiology of dental caries: new paradigms. International dental journal. 2013 Dec 1;63:64-72.
4. Chen X, Daliri EB, Kim N, Kim JR, Yoo D, Oh DH. Microbial etiology and prevention of dental caries: exploiting natural products to inhibit cariogenic biofilms. Pathogens. 2020 Jul 14;9(7):569.
5. Kidd EA, Fejerskov O. What constitutes dental caries? Histopathology of carious enamel and dentin related to the action of cariogenic biofilms. Journal of dental research. 2004 Jul;83(1_suppl):35-8.
6. Fontana M, Haider A, Gonzalez-Cabezas C. Caries lesion development and biofilm composition responses to varying demineralization times and sucrose exposures. Biofilms. 2004 Oct;1(4):229-37.
7. Griffin SO, Griffin PM, Swann JL, Zlobin N. Estimating rates of new root caries in older adults. Journal of dental research. 2004 Aug;83(8):634-8.
8. Gati D, Vieira AR. Elderly at greater risk for root caries: a look at the multifactorial risks with emphasis on genetics susceptibility. International journal of dentistry. 2011;2011(1):647168.
9. Mickenautsch S, Grossman E. Atraumatic Restorative Treatment (ART): factors affecting success. Journal of Applied Oral Science. 2006;14:34-6.
10. 1Almuhaiza M. Glass-ionomer cements in restorative dentistry: a critical appraisal. J Contemp Dent Pract. 2016 Apr 1;17(4):331-6.
11. 1Berg JH, Croll TP. Glass ionomer restorative cement systems: an update. Pediatric dentistry. 2015 Apr 15;37(2):116-24.
12. Zhao IS, Mei ML, Burrow MF, Lo EC, Chu CH. Prevention of secondary caries using silver diamine fluoride treatment and casein phosphopeptide-amorphous calcium phosphate modified glass-ionomer

cement. Journal of dentistry. 2017 Feb 1;57:38-44.
13. Zan KW, Nakamura K, Hamba H, Sadr A, Nikaido T, Tagami J. Micro-computed tomography assessment of root dentin around fluoride-releasing restorations after demineralization/remineralization. European journal of oral sciences. 2018 Oct;126(5):390-9.
14. Hara AT, Turssi CP, Ando M, González-Cabezas C, Zero DT, Rodrigues Jr AL, Serra MD, Cury JA. Influence of fluoride-releasing restorative material on root dentine secondary caries in situ. Caries research. 2006 Aug 29;40(5):435-9.
15. Hara AT, Turssi CP, Serra MC, Nogueira MC. Extent of the cariostatic effect on root dentin provided by fluoride-containing restorative materials. Operative Dentistry. 2002 Sep 1;27(5):480-7.
16. Tonprasong W, Inokoshi M, Shimizubata M, Yamamoto M, Hatano K, Minakuchi S. Impact of direct restorative dental materials on surface root caries treatment. Evidence based and current materials development: A systematic review. Japanese Dental Science Review. 2022 Nov 1;58:13-30.
17. Yip HK, Guo J, Wong WH. Protection offered by root-surface restorative materials against biofilm challenge. Journal of dental research. 2007 May;86(5):431-5.