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Original Article

The Effect of Acidic Beverages on Resin-Modified Glass Ionomers

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ABSTRACT

Background: Resin-modified glass ionomer cements are widely used in restorative dentistry because they chemically bond to tooth structure, release fluoride, and offer improved handling and mechanical properties compared with conventional glass ionomer cements. However, frequent exposure to acidic beverages may compromise their surface integrity and adhesive performance. Objective: This narrative review aimed to synthesize current evidence on the effects of acidic beverages on the physicochemical, adhesive, and micromorphological properties of resin-modified glass ionomer cements. Methods: Relevant literature was reviewed from PubMed, ScienceDirect, Google Scholar, and Scopus using terms related to resin-modified glass ionomer cement, acidic beverages, dental erosion, microhardness, surface roughness, bond strength, wear resistance, fluoride release, and restorative dental materials. Evidence was synthesized qualitatively by outcome domain. Results: Acidic beverages, particularly cola drinks and fruit juices, were associated with reduced surface hardness, increased surface roughness, weakened dentin bond strength, and micromorphological deterioration at the RMGIC–dentin interface. RMGICs showed greater resistance than conventional glass ionomer cements but remained vulnerable to repeated or prolonged acidic exposure. Conclusion: Frequent acidic beverage exposure may reduce the long-term clinical durability of RMGIC restorations. Dietary counselling, careful material selection, and standardized future in vitro and in vivo studies are required. Keywords: Resin-modified glass ionomer cement; acidic beverages; dental erosion; microhardness; surface roughness; bond strength.

INTRODUCTION

Dental caries and erosive tooth wear remain major contributors to irreversible loss of dental hard tissue, impaired oral function, restorative treatment burden, and reduced oral health-related quality of life. Among modifiable dietary factors, frequent consumption of acidic beverages, including carbonated soft drinks, fruit juices, sports drinks, and fermented dairy-based drinks, has been consistently associated with enamel and dentin demineralization because these beverages can lower the oral pH below the critical threshold required for mineral stability. Their erosive potential is influenced not only by pH but also by titratable acidity, buffering capacity, calcium, phosphate and fluoride content, viscosity, exposure frequency, and salivary clearance, all of which determine the duration and severity of acid challenge to dental tissues and restorative interfaces (1,2).

Glass ionomer cements have remained clinically valuable in restorative dentistry because they chemically bond to enamel and dentin, release fluoride, demonstrate anticariogenic potential, and are useful in patients at increased caries risk. However, conventional glass ionomer cements have limitations, including early moisture sensitivity, relatively low fracture toughness, reduced wear resistance, and inferior mechanical strength compared with resin-based restorative materials. Resin-

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modified glass ionomer cements were developed to overcome some of these limitations by incorporating hydrophilic resin monomers into the conventional glass ionomer system, thereby combining an acid–base setting reaction with resin polymerization. This modification improves handling, early strength, esthetics, working time, and clinical versatility while preserving important glass ionomer characteristics such as fluoride release and chemical adhesion to tooth structure (3,4).

Resin-modified glass ionomer cements are widely used in pediatric dentistry, cervical restorations, orthodontic bonding, atraumatic restorative treatment, liners, bases, and sandwich restoration techniques. Their clinical appeal is particularly strong in situations where fluoride release, moisture tolerance, and adhesion to tooth structure are desirable. Despite these advantages, their long-term performance depends on the stability of both the glass ionomer matrix and the resin-modified phase under repeated oral challenges. In patients with frequent acidic beverage intake, the restorative material is exposed to repeated cycles of low pH, ion exchange, surface dissolution, water sorption, and potential degradation at the tooth–restoration interface. These processes may reduce surface microhardness, increase surface roughness, alter fluoride release, weaken dentin bond strength, and promote micromorphological defects that compromise restoration longevity (5,6).

The clinical relevance of this issue is strengthened by the increasing availability and consumption of acidic drinks across age groups, particularly among children, adolescents, athletes, and individuals with dietary patterns involving frequent intake of carbonated or fruit-based beverages. Although resin-modified glass ionomer cements are generally considered more acid resistant than conventional glass ionomer cements, laboratory studies suggest that they are not fully protected against prolonged or repeated acidic exposure. The magnitude of degradation may vary according to beverage composition, exposure protocol, material formulation, maturation time, storage medium, and the outcome measure used. Therefore, isolated findings from individual in vitro studies are difficult to translate directly into clinical recommendations without careful synthesis of the available evidence (7,8).

Existing literature has addressed the erosive effects of acidic beverages on enamel and dentin, and several studies have evaluated the surface characteristics of glass ionomer-based restorative materials after acidic challenge. However, the evidence specific to resin-modified glass ionomer cements remains fragmented across different beverages, experimental protocols, commercial formulations, and measured outcomes. There is also limited integration of evidence concerning the adhesive interface, even though bond degradation may be clinically more important than surface changes alone. This creates a practical knowledge gap for clinicians who must select restorative materials and provide dietary counselling for patients with frequent acidic beverage exposure.

Using a PICO-oriented framework, this review focuses on resin-modified glass ionomer cement restorations as the material of interest, acidic beverages and acidic dietary exposures as the exposure, neutral storage media or other restorative materials where available as comparators, and physicochemical, mechanical, adhesive, and micromorphological changes as outcomes. The objective of this narrative review was to synthesize current evidence on the effect of acidic beverages on resin-modified glass ionomer cements, with emphasis on microhardness, surface roughness, bond strength, interfacial integrity, wear-related changes, fluoride-related behavior, and clinical implications for restorative material selection and patient counselling.

MATERIALS AND METHODS

This narrative literature review was conducted to synthesize available evidence on the effects of acidic beverages and acidic dietary exposures on the physicochemical, mechanical, adhesive, and micromorphological properties of resin-modified glass ionomer cements used in restorative dentistry. The review was designed to provide a clinically oriented synthesis rather than a pooled quantitative estimate, because the available studies varied substantially in experimental design, beverage type, exposure duration, material formulation, outcome measurement, and comparator groups.

A structured literature search was performed using PubMed, ScienceDirect, Google Scholar, and Scopus to identify peer-reviewed studies and relevant review articles addressing resin-modified glass ionomer cements, glass ionomer-based restorative materials, acidic beverages, dental erosion, surface degradation, adhesive performance, and restorative material longevity.

Search terms included "resin-modified glass ionomer cement," "RMGIC," "glass ionomer cement," "acidic beverages," "soft drinks," "carbonated beverages," "cola," "orange juice," "fruit juice," "sports drinks," "yogurt drinks," "dental erosion," "microhardness," "surface roughness," "bond strength," "wear resistance," "fluoride release," and "restorative dental materials." Boolean operators were used to combine material-related terms with exposure-related and outcome-related terms, and additional records were identified through manual screening of reference lists from relevant articles.

Studies were considered eligible when they evaluated resin-modified glass ionomer cements or directly relevant glass ionomer-based restorative materials exposed to acidic beverages or acidic dietary media, and when they reported outcomes related to microhardness, surface roughness, surface morphology, wear resistance, solubility, fluoride release, dentin bond strength, adhesive-interface integrity, or material degradation. In vitro, ex vivo, and clinically relevant experimental studies were considered, while review articles were used to support background, biological plausibility, and interpretation of mechanisms. Studies were excluded when they did not evaluate resin-modified glass ionomer cements or a clearly relevant comparator, when the exposure was unrelated to acidic beverages or dietary acids, when outcome data were insufficient for interpretation, when the article was limited to abstracts, editorials, letters, or conference material, or when the full text was not available in English.

The selection process involved screening article titles and abstracts for relevance to the review question, followed by full-text assessment of studies that appeared to meet the eligibility criteria. Studies were prioritized when they directly examined resin-modified glass ionomer cement behavior after exposure to acidic beverages such as cola drinks, fruit juices, sports drinks, fermented dairy drinks, or acidic food preparations. Studies involving conventional glass ionomer cements, compomers, composites, sealants, enamel, or dentin were considered only when they provided comparative context, mechanistic explanation, or clinically relevant interpretation for acid-mediated degradation of glass ionomer-based restorative materials.

Data were extracted narratively and organized according to publication details, study design, restorative material evaluated, acidic medium or beverage tested, exposure protocol, comparator condition, outcome measures, and principal findings. Particular attention was given to changes in surface microhardness, surface roughness, bond strength to dentin, micromorphological changes observed through imaging methods, wear-related changes, solubility, fluoride-related behavior, and reported mechanisms of degradation. Where available, information on beverage pH, duration of immersion, cycling protocol, storage medium, specimen preparation, maturation time, and testing method was considered because these factors may substantially influence the interpretation and comparability of findings.

The methodological strength of the included experimental evidence was judged narratively by considering clarity of study design, appropriateness of comparator groups, description of specimen preparation, reproducibility of acidic exposure conditions, relevance of outcome measurement, adequacy of statistical reporting, and consistency between methods and conclusions. Studies with clearly described materials, exposure protocols, and outcome assessment procedures were given greater interpretive weight than studies with limited methodological detail. Because of heterogeneity in materials, acidic media, exposure durations, and measurement methods, formal meta-analysis was not performed.

The evidence was synthesized qualitatively by grouping findings into clinically meaningful outcome domains: surface hardness, surface roughness, adhesive bond strength, interfacial morphology, material degradation mechanisms, comparative resistance of conventional and resin-modified glass ionomer cements, and implications for restorative dentistry. Patterns across studies were interpreted cautiously, with emphasis on consistency of direction rather than numerical pooling. The synthesis also considered potential sources of variability, including beverage acidity, titratable acidity, exposure frequency, material maturation, resin content, glass ionomer formulation, and differences between laboratory immersion models and real oral conditions. Ethical approval was not required because this review used previously published literature and did not involve human participants, biological samples, patient records, or identifiable personal data.

RESULTS

The included evidence showed consistent adverse effects of acidic beverages and acidic dietary media on dental hard tissues and restorative materials. Studies directly involving resin-modified glass ionomer cements were limited, but the available RMGIC-specific evidence indicated that acidic challenge can reduce adhesive performance and alter surface characteristics. Broader evidence from conventional glass ionomers, compomers, nanocomposites, enamel, and dentin supported the biological and material plausibility of acid-mediated degradation, but these studies were interpreted as contextual rather than direct evidence for RMGIC clinical performance.

Table 1. Characteristics and Main Findings of Included Evidence on Acidic Beverages, Dental Hard Tissues, and Resin-Modified Glass Ionomer Cement-Related Outcomes

No.	Publication	Authors	Year	Evidence Type	Material or Tissue Focus	Acidic Exposure or Context	Main Outcome Domain	Principal Finding
1	Soft Drinks and Dental Health: A Review of the Current Literature	Tahmassebi JF, Duggal MS, Malik-Kotru G, Curzon MEJ	2006	Review	Dental hard tissues	Soft drinks	Dental erosion	Soft drink consumption was associated with adverse dental effects
2	Effect of Acidic Food and Drinks on Surface Hardness of Enamel, Dentine, and Tooth-Coloured Filling Materials	Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D	2005	In vitro study	Enamel, dentin, tooth-coloured restorative materials	Acidic foods and drinks	Surface hardness	Acidic foods and drinks reduced surface hardness
3	The Biocompatibility of Resin-Modified Glass-Ionomer Cements for Dentistry	Nicholson JW, Czarnecka B	2008	Review	Resin-modified glass ionomer cements	Resin monomer content	Biocompatibility	HEMA contributed to lower biocompatibility compared with conventional glass ionomers
4	Effect of Dentin Conditioning and Erosive Coca-Cola Challenge on the Micro-Shear Bond Strength and SEM Evaluation of Resin-Modified Glass-Ionomer Cement: An In Vitro Study	Zaghloul NM	2019	In vitro study	Resin-modified glass ionomer cement and dentin interface	Coca-Cola	Bond strength; SEM morphology	Dentin conditioning improved bonding, while Coca-Cola exposure reduced bonding performance
5	Conventional and Resin-Modified Glass Ionomer Cement Surface Characteristics After Acidic Challenges	Nica I, Stoleriu S, Iovan A, Tărăboanță I, Pancu G, Tofan N, Brânzan R, Andrian S	2022	In vitro study	Conventional glass ionomer cement and resin-modified glass ionomer cement	Acidic liquids	Surface roughness	Acidic immersion increased surface roughness, with conventional glass ionomer cement more affected than resin-modified glass ionomer cement
6	Acidic Beverages and Foods Associated with Dental Erosion and Erosive Tooth Wear	Carvalho TS, Lussi A	2019	Review	Dental hard tissues	Acidic beverages and foods	Erosive tooth wear	Erosive potential was related to pH, buffering capacity, titratable acidity, viscosity, and mineral content
7	The Effect of Coca-Cola and Fruit Juices on the Surface Hardness of Glass-Ionomers and Compomers	Aliping-McKenzie M, Linden RWA, Nicholson JW	2003	In vitro study	Glass ionomers and compomers	Coca-Cola and fruit juices	Surface hardness	Acidic beverages reduced surface hardness of glass-ionomer-based materials
8	A Comparative Evaluation of the Effect of Different Beverages on Colour	Singh T, Mahalakshmi V, Sahu S, Chatterjee	2023	In vitro study	Nanocomposite restorative material	Beverages including	Surface micromorphology; colour stability	Prolonged beverage exposure affected surface integrity

No.	Publication	Authors	Year	Evidence Type	Material or Tissue Focus	Acidic Exposure or Context	Main Outcome Domain	Principal Finding
	Stability and Surface Micromorphology of Nanocomposite Restorative Material	S, Khan AM, Haqh MF, Singh V				carbonated drinks		

Table 2. Synthesis of Findings by Outcome Domain

Outcome Domain	Evidence Source	Material or Tissue Focus	Direction of Finding	Interpretation Level
Dental erosion	Tahmassebi et al.; Carvalho and Lussi	Enamel and dentin	Increased erosive risk	Contextual evidence
Surface hardness	Wongkhantee et al.; Aliping-McKenzie et al.	Dental hard tissues; glass-ionomer-based materials	Reduced surface hardness	Direct and contextual evidence
Surface roughness	Nica et al.	Conventional GIC and RMGIC	Increased surface roughness	Direct comparative evidence
Bond strength	Zaghloul	RMGIC–dentin interface	Reduced micro-shear bond strength after Coca-Cola exposure	Direct RMGIC evidence
Interfacial morphology	Zaghloul	RMGIC–dentin interface	Micromorphological deterioration after erosive challenge	Direct RMGIC evidence
Biocompatibility	Nicholson and Czarnecka	RMGIC	Lower biocompatibility related to HEMA content	Contextual RMGIC evidence
Colour stability and surface morphology	Singh et al.	Nanocomposite restorative material	Altered surface micromorphology after beverage exposure	Contextual restorative-material evidence

Acidic beverage exposure was associated with deterioration across several clinically relevant domains. Surface hardness reduction and surface roughening were the most consistently reported material-level effects, while the RMGIC-specific bonding study showed that Coca-Cola exposure reduced dentin bonding performance despite the beneficial effect of dentin conditioning. The comparative evidence suggested that resin-modified glass ionomer cement may be more resistant to acidic degradation than conventional glass ionomer cement, although it remains vulnerable to prolonged or repeated low-pH exposure.

Table 3. Acidic Exposure Factors and Mechanisms Relevant to RMGIC Degradation

Exposure or Material Factor	Reported Mechanistic Relevance	Associated Outcome
Low pH	Acid-mediated dissolution of mineral and glass-ionomer matrix components	Surface softening; material degradation
High titratable acidity	Prolonged acid-neutralizing demand	Increased erosive potential
Low calcium, phosphate, and fluoride content	Reduced protective mineral saturation	Enamel and dentin demineralization
Repeated or prolonged exposure	Cumulative acid challenge	Surface roughness; reduced hardness
Cola drinks	Low-pH acidic exposure	Reduced RMGIC bond strength; surface degradation
Fruit juices	Acidic and titratable-acid exposure	Reduced hardness of glass-ionomer-based materials
Resin modification with HEMA	Resin-related biological concern	Lower biocompatibility compared with conventional GIC
Dentin conditioning	Improved surface preparation before RMGIC placement	Improved baseline bonding

The degradation of RMGICs under acidic conditions appears to be driven by combined chemical, mechanical, and interfacial mechanisms. Low pH and high titratable acidity promote dissolution and ion leaching from the glass-ionomer matrix, while repeated exposure increases cumulative surface damage. At the adhesive interface, acidic challenge may contribute to dentin demineralization, weakening of calcium-polyacid interactions, hydrolytic degradation of resin-containing components, and loss of adaptation between the restorative material and dentin. Dentin conditioning may improve initial bonding, but available evidence suggests that it does not fully prevent erosive degradation during repeated Coca-Cola exposure.

The excluded studies were not used as core evidence because they either lacked adequate methodological detail, did not focus directly on RMGIC-specific outcomes, or evaluated broader restorative materials without sufficient relevance to the review objective. These exclusions strengthened the internal coherence of the synthesis by prioritizing studies that directly addressed acidic beverage exposure, glass-ionomer-based degradation, or RMGIC-specific adhesive and surface outcomes.

The reviewed evidence indicates that acidic beverages adversely affect both dental hard tissues and restorative materials, with the strongest direct relevance to resin-modified glass ionomer cements seen in studies evaluating surface roughness and dentin bond strength. Acidic drinks such as Coca-Cola and fruit juices were repeatedly associated with reduced surface hardness or increased degradation of glass-ionomer-based restorative materials. Although some contextual studies examined enamel, dentin, compomers, nanocomposites, or conventional glass ionomer cements rather than RMGICs alone, these findings support the broader mechanism that low-pH dietary exposures can compromise mineralized tissues and restorative surfaces through demineralization, matrix dissolution, and surface corrosion.

Table 4. Studies Excluded from Core Synthesis and Reasons for Exclusion

No.	Publication	Primary Reason for Exclusion
1	A Comparative Evaluation of the Effect of Sports and Fruit Drinks on the Surface Roughness of Nanofilled Composite and Light Cure GIC: An In Vitro Study	Limited relevance to RMGIC-focused synthesis
2	Evaluation of Microleakage and Surface Texture of Resin Modified GIC and Flowable Composite Immersed in Soft Drink and Fresh Fruit Juice: An In Vitro Study	Insufficient methodological and outcome detail in available manuscript summary
3	Assessment of Glass Ionomer Cements Restorations After Acidic Erosive Challenges: An In Vitro Study	Insufficient methodological and outcome detail in available manuscript summary
4	Effect of Coloring Beverages on Different Esthetic Restorative Materials in Primary Teeth	Primary focus outside acidic degradation of RMGIC
5	Erosion Effect of Acidic Drinks on Two Types of Glass Ionomer Cement	Insufficient methodological and outcome detail in available manuscript summary

For surface characteristics, acidic challenges were associated with increased roughness and reduced hardness of glass-ionomer-based materials. The comparative evidence suggested that conventional glass ionomer cement was more affected by acidic immersion than resin-modified glass ionomer cement, indicating that resin modification may provide partial protection against acid-mediated degradation. However, this relative resistance should not be interpreted as complete stability, because RMGICs still demonstrated surface and adhesive vulnerability under erosive conditions.

The most clinically important RMGIC-specific evidence concerned the adhesive interface. Coca-Cola exposure was associated with reduced micro-shear bond strength between RMGIC and dentin, while dentin conditioning improved baseline bonding performance. This suggests that appropriate surface preparation may enhance initial adhesion but may not fully protect the interface against repeated acidic exposure. Micromorphological observations further supported this interpretation, showing deterioration at the RMGIC–dentin interface after erosive challenge. These findings are clinically relevant because interfacial breakdown may contribute to marginal failure, microleakage, secondary caries risk, and reduced restoration longevity.

The evidence also indicates that beverage erosive potential cannot be explained by pH alone. Titratable acidity, buffering capacity, mineral content, viscosity, exposure duration, and frequency of intake are important determinants of erosive behavior. Therefore, clinical recommendations should not focus only on avoidance of low-pH beverages but should also address frequency of consumption, sipping habits, oral clearance time, and preventive dietary counselling. In patients with frequent acidic beverage exposure, clinicians should consider both material selection and risk modification strategies when planning RMGIC restorations.

Overall, the synthesis supports the conclusion that resin-modified glass ionomer cements are more resistant to acidic challenges than conventional glass ionomer cements but remain susceptible to surface degradation, roughening, hardness reduction, and adhesive-interface weakening under repeated or prolonged acidic exposure. The available evidence is mainly laboratory-based, and differences in materials, exposure protocols, beverages, and outcome measures limit direct comparison across studies. Future research should use standardized acidic exposure cycles, clinically relevant beverage immersion models, commercial RMGIC formulations, and long-term assessment of microhardness, surface roughness, fluoride release, wear resistance, bond durability, and interfacial morphology.

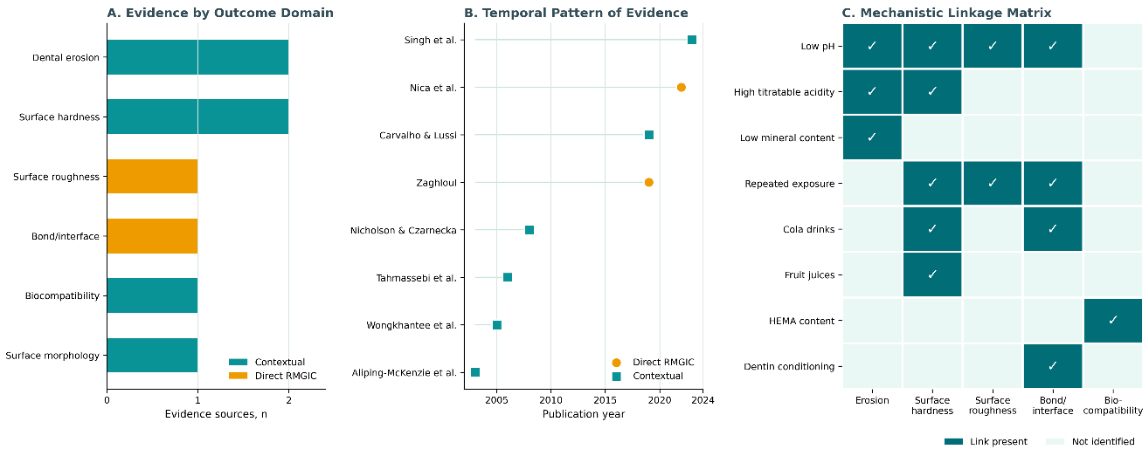

Figure 1 Evidence Mapping of Acidic Beverage Effects on Resin-Modified Glass Ionomer Cement Outcomes

The panelled evidence map shows that the current literature is concentrated around surface hardness, dental erosion, surface roughness, and RMGIC–dentin interface outcomes, with only two included studies providing direct RMGIC-specific or direct comparative evidence. Panel A demonstrates that surface roughness and bond/interface outcomes contain the most clinically relevant direct RMGIC evidence, whereas dental erosion, surface hardness, biocompatibility, and surface morphology are supported mainly by contextual studies involving dental hard tissues or other restorative materials. Panel B shows that the evidence base spans from 2003 to 2023, with direct RMGIC-focused evidence appearing mainly in more recent experimental studies. Panel C summarizes the mechanistic synthesis, showing that low pH, repeated acidic exposure, cola drinks, fruit juices, high titratable acidity, mineral content, HEMA-related resin chemistry, and dentin conditioning are linked to different degradation pathways, including erosion, surface hardness reduction, increased roughness, adhesive-interface compromise, and biocompatibility concerns. This figure supports the interpretation that RMGICs are relatively more resistant than conventional glass ionomer cements but remain vulnerable to clinically relevant acidic beverage exposure, particularly at the surface and adhesive interface.

DISCUSSION

This narrative review synthesized evidence on the effect of acidic beverages on resin-modified glass ionomer cements, with emphasis on surface characteristics, adhesive performance, micromorphological changes, and clinically relevant degradation mechanisms. The available evidence indicates that repeated or prolonged exposure to acidic beverages can compromise the physicochemical and adhesive stability of RMGICs, although these materials appear to demonstrate greater acid resistance than conventional glass ionomer cements. The most consistent findings across the reviewed literature were reduction in surface hardness, increase in surface roughness, weakening of the RMGIC–dentin bond, and evidence of surface or interfacial deterioration after exposure to acidic media. These findings are clinically important because surface softening and roughening may increase plaque retention, staining, wear susceptibility, and marginal deterioration, while adhesive-interface degradation may contribute to microleakage, secondary caries, postoperative sensitivity, and reduced restoration longevity (9,10).

The degradation of RMGICs under acidic conditions can be explained by the chemical structure and setting behavior of glass ionomer-based materials. RMGICs combine the acid–base reaction of conventional glass ionomers with resin polymerization, which improves early mechanical behavior and handling but does not fully eliminate susceptibility to low-pH environments. Acidic beverages may promote dissolution of the glass-ionomer matrix, leaching of ions, disruption of calcium-polyacid salt bridges, and surface erosion. The resin-modified component may improve resistance compared with conventional GICs, but repeated acid challenge can still produce surface irregularities and loss of material integrity. This explains why RMGICs may perform better than conventional GICs under acidic immersion while still showing measurable degradation after prolonged exposure (6,9).

The role of beverage composition is central to interpretation of the findings. Although pH is an important determinant of erosive potential, it is not the only factor responsible for material degradation. Titratable acidity, buffering capacity, calcium and phosphate content, fluoride concentration, viscosity, exposure frequency, and oral clearance time all influence the duration and severity of the acidic challenge. Cola drinks and fruit juices were repeatedly identified as aggressive acidic media in the reviewed evidence, likely because of their low pH and acid-retentive properties. Sports drinks and fermented dairy-based drinks may also contribute to erosive challenge depending on their formulation and frequency of intake. Therefore, clinical risk assessment should not rely only on whether a beverage is acidic, but should also consider patient-specific consumption patterns, including sipping behavior, intake frequency, timing relative to meals, and oral hygiene practices (2,8).

The adhesive interface appears to be one of the most clinically relevant sites of degradation. The reviewed RMGIC-specific evidence showed that dentin conditioning can improve baseline bonding, but acidic challenge, particularly Coca-Cola exposure, may reduce micro-shear bond strength and produce micromorphological changes at the RMGIC–dentin interface. This suggests that appropriate clinical technique can strengthen initial adhesion but cannot fully compensate for repeated erosive exposure. The possible mechanisms include dentin demineralization, loss of ionic bonding potential, increased permeability, hydrolytic degradation of resin-containing components, and disruption of adaptation between the restorative material and tooth structure. These interfacial effects are especially important in cervical restorations and pediatric restorations, where margins may be exposed to frequent dietary acids and plaque-related acidic conditions (10,11).

Biocompatibility-related concerns also require careful interpretation. The inclusion of resin monomers, particularly HEMA, improves handling and mechanical characteristics of RMGICs but may reduce biocompatibility compared with conventional glass ionomers. The clinical relevance of this issue depends on curing adequacy, remaining dentin thickness, depth of restoration, pulpal proximity, and the extent of monomer release. Although the present review primarily focused on acidic beverage exposure rather than cytotoxicity, resin-matrix degradation under unfavorable oral conditions may have implications for long-term biological behavior. These concerns should not be overstated, but they support the need for adequate curing, careful material selection, and avoidance of unnecessary pulpal exposure in deep restorations (12).

From a clinical perspective, the findings support the use of dietary counselling as part of restorative treatment planning. Patients with frequent intake of acidic beverages should be informed that these drinks can affect not only enamel and dentin but also restorative material performance. For patients receiving RMGIC restorations, clinicians should advise reduced frequency of acidic beverage consumption, avoidance of prolonged sipping, use of water rinsing after acidic intake, and delayed toothbrushing immediately after erosive exposure when dental hard tissues are softened. Material selection should also consider the patient's caries risk, erosion risk, salivary function, oral hygiene status, and restoration site. Although RMGICs offer clinical advantages through fluoride release and adhesion, they should not be assumed to be fully resistant to dietary acid challenge.

This review has several limitations. Most available evidence is laboratory-based, and in vitro immersion models do not fully reproduce saliva buffering, pellicle formation, oral clearance, temperature fluctuations, masticatory forces, biofilm activity, or patient-level variability. Exposure protocols varied across studies, including differences in beverage type, pH, immersion duration, cycling frequency, storage medium, specimen maturation time, and tested RMGIC formulation. These differences limit direct comparison and prevent quantitative pooling. Some included evidence was contextual rather than RMGIC-specific, including studies on dental hard tissues, conventional glass ionomers, compomers, or other restorative materials. Such evidence supports biological plausibility but cannot be interpreted as direct proof of RMGIC clinical failure. The review was also limited by incomplete numerical extraction from the available manuscript data, which restricted the ability to report pooled effect sizes, confidence intervals, or dose-response estimates.

Future research should use standardized and clinically relevant acidic exposure models that reflect real patterns of beverage consumption rather than continuous immersion alone. Studies should report beverage pH, titratable acidity, mineral content, immersion cycles, storage conditions, material maturation time, commercial formulation, and testing method in sufficient detail to support reproducibility. Long-term studies should evaluate microhardness, surface roughness, fluoride release, solubility, wear resistance, bond durability, marginal adaptation, and interfacial morphology using both laboratory and clinical designs. Comparative studies across commercial RMGIC formulations are also needed to determine whether differences in resin content, glass composition, filler distribution, and polymerization behavior influence acid resistance. Such evidence would help clinicians select restorative materials more precisely for patients at high risk of erosive dietary exposure.

CONCLUSION

Acidic beverages negatively affect the physicochemical and adhesive performance of resin-modified glass ionomer cements by reducing surface hardness, increasing surface roughness, weakening dentin bond strength, and producing micromorphological deterioration at the tooth–restoration interface. RMGICs appear to be more resistant to acidic exposure than conventional glass ionomer cements, but they are not fully protected against repeated or prolonged low-pH challenge, particularly from cola drinks, fruit juices, sports drinks, and other acidic dietary exposures. These findings support the importance of dietary counselling, careful restorative material selection, appropriate dentin conditioning, and preventive risk management in patients with frequent acidic beverage intake. Future research should use standardized in vitro and in vivo acidic challenge models to compare commercial RMGIC formulations and evaluate long-term outcomes such as microhardness, fluoride release, wear resistance, bond durability, and interfacial integrity.

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