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FACULDADE DE MEDICINA DENTÁRIA
VISEU

AESTHETIC PERFORMANCE OF GLASS IONOMERS IN RESTORING CERVICAL LESIONS: A SYSTEMATIC REVIEW

Dissertação apresentada à Universidade Católica Portuguesa
para obtenção do grau de Mestre em Medicina Dentária

Rodrigo Fortunato Marques

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Orientador: Professora Doutora Adriana Bona Matos
Co-Orientador: Professora Doutora Ana Moura Teles

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"A vida é dura para quem é mole"
(*Avô Fortunato)*

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ABSTRACT

Background and objectives: Due to bonding and fluoride-release properties, glass ionomers are useful not only for children but also for the adult population. This systematic review aimed to evaluate and compare the clinical performance of polyacid-modified resin composites (PMRCs) and resin-modified glass ionomer cements (RMGICs) in the restoration of cervical lesions for color stability, surface roughness, and marginal integrity using standardized or modified United States Public Health Service (USPHS) criteria.

Materials and methods: A comparative analysis was conducted using data from 11 clinical studies published between 1999 and 2025. These studies evaluated Class V restorations involving PMRCs and RMGICs, with follow-up periods ranging from 12 to 60 months. Clinical outcomes (color stability, surface roughness, and marginal integrity) were analyzed according to material type and longitudinal evaluation. All studies employed USPHS-based assessment scale.

Results: PMRCs demonstrated greater consistency and superiority in long-term esthetic and clinical outcomes, particularly in preserving color stability, smooth surface texture, and marginal adaptation: key factors for visual integration, biofilm resistance, and long-term sealing performance. Regarding marginal adaptation, both materials performed similarly in the short-term when proper isolation and conditioning techniques were applied. However, PMRCs tended to maintain a more stable marginal seal in long-term scenarios, likely due to their superior mechanical resilience and reduced susceptibility to hydrolytic degradation.

Conclusions: Both PMRCs and RMGICs can provide acceptable clinical outcomes in cervical restorations, but PMRCs appear to offer superior esthetic and mechanical performance over extended periods. RMGICs may still represent a viable alternative in cases with high caries risk or moisture-sensitive conditions, although their long-term durability remains comparatively limited.

Keywords: Cervical lesions, non-carious cervical lesions, color stability, surface roughness, marginal integrity.

RESUMO

Introdução: Devido às suas propriedades de adesão e libertação de flúor, os ionómeros de vidro são úteis não só para as crianças, mas também para a população adulta. Esta revisão sistemática teve como objetivo avaliar e comparar o desempenho clínico de compósitos de resina modificada por poliácidos (PMRCs) e cimentos de ionómero de vidro modificados por resina (RMGICs) na restauração de lesões cervicais quanto à estabilidade de cor, rugosidade superficial e integridade marginal, utilizando critérios USPHS ou USPHS modificados.

Materiais e métodos: Foi conduzida uma análise comparativa utilizando dados de 11 estudos clínicos publicados entre 1999 e 2025. Estes estudos avaliaram restaurações de Classe V de PMRCs e RMGICs, com períodos de seguimento que variaram entre 12 e 60 meses. Os resultados clínicos (estabilidade da cor, rugosidade superficial e integridade marginal) foram analisados de acordo com o tipo de material e a avaliação longitudinal. Todos os estudos utilizaram a escala de avaliação baseada na USPHS.

Resultados: Os PMRC demonstraram maior consistência e superioridade nos resultados estéticos e clínicos a longo prazo, particularmente na preservação da estabilidade da cor, textura superficial lisa e adaptação marginal: fatores-chave para a integração visual, resistência ao biofilme e desempenho de selamento a longo prazo. Em relação à adaptação marginal, ambos os materiais apresentaram um desempenho semelhante a curto prazo quando foram aplicadas técnicas de isolamento e condicionamento adequadas. No entanto, os PMRC tenderam a manter um selamento marginal mais estável em cenários de longo prazo, provavelmente devido à sua superior resiliência mecânica e menor suscetibilidade à degradação hidrolítica.

Conclusões: Tanto os PMRC como os RMGIC podem proporcionar resultados clínicos aceitáveis nas restaurações cervicais, mas os PMRC parecem oferecer um desempenho estético e mecânico superior durante períodos prolongados. Os RMGIC podem ainda representar uma alternativa viável em casos com elevado risco de cárie ou condições sensíveis à humidade, embora a sua durabilidade a longo prazo permaneça comparativamente limitada.

Palavras-chave: Lesões cervicais, lesões cervicais não cariosas, estabilidade de cor, rugosidade superficial, integridade marginal.

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List of Abbreviation

CL-Cervical Lesion

GIC-Glass Ionomer Cement

NCCL-Non-Carious Cervical Lesions

PMRC- Polyacid Modified Resin Composites

RC-Resin Composites

RMGIC-Resin-Modified Glass Ionomer Cement

USPHS-United States Public Health Service

1. Introduction

1. Introduction

Cervical lesions (CLs) refer to the loss of tooth structure in the cervical region of the tooth and may arise from both carious and non-carious origins(1). Carious cervical lesions (CCLs) are typically caused by demineralization due to bacterial activity, while non-carious cervical lesions (NCCLs) result from factors such as erosion, abrasion, abfraction, or attrition(1). These lesions are common in clinical practice and present significant restorative challenges, particularly in achieving long-term aesthetic and functional outcomes(1).

NCCLs are a widespread dental condition, with an average global prevalence of 46.7% among adults (2). However, prevalence rates can vary significantly, ranging from 9.1% to 93%, depending on factors like diagnostic criteria, age groups, and geographic location(2). For instance, South America records the highest prevalence at 69%, while North America reports the lowest at 19% (2). Older individuals are more commonly affected, likely due to prolonged exposure to contributing factors such as abrasion, erosion, and occlusal stress (2). As expected, individuals who may not receive regular dental care display a slightly higher prevalence of NCCLs than those who regularly seek dental care, highlighting the impact of diverse environmental and behavioral factos (2). Variations in diagnostic terminology, including terms like "root defects" and "abfraction" further influence the reported rates across different studies (2).

Successfully restoring these areas depends on using materials that combine strong adhesion, long-lasting durability, and compatibility with oral tissues, while enduring the unique challenges of the oral environment, such as occlusal forces and saliva influence (3). Among the range of available options, glass ionomer cement (GIC), RMGIC, and PMRC have gained significant popularity in addressing CLs (3).

GIC is valued for its ability to form a chemical bond with dentin and enamel, sustained fluoride release, and compatibility with biological tissues (4,5). However, limitations such as its susceptibility to moisture during the setting process and lower mechanical strength led to the development of RMGIC (4,5). By incorporating resin components,

RMGIC provides improved strength, enhanced aesthetics, and greater moisture resistance (5,6). Similarly, PMRC, also called "compomer," combines the fluoride-releasing capability of glass ionomers with the mechanical properties and polishability of resin composites (RCs), offering another effective solution for NCCL restorations (5,6).

Although esthetic materials are widely used to restore CLs, their long-term effectiveness and durability remain a topic of discussion (5). Outcomes such as retention, marginal adaptation, fluoride release, aesthetic performance, and resistance to wear often vary across different studies, making it challenging to establish definitive recommendations for material selection (5)

1.1 NCCL

These types of lesions are very common in daily clinical practice (7). What we can see is a tissue loss in the cervical third of the affected teeth that is not related to dental cavities (7). NCCL can have different shapes such as shallow grooves, large wedge-shaped defects with sharp line angles, or even disc-shaped lesions (8). Thus, the reasons that led to restoring them are aesthetics, increased sensitivity, and bacterial plaque accumulation (8).

NCCL is shown to be greater in upper teeth compared with lower teeth and the most affected teeth are incisors, canines, and premolars, but medical doctors can detect their presence in molars as well (8).

But what is the etiology of this condition? The answer to this question can be divided into 4 categories: erosion, abrasion, abfraction, and attrition (1).

1.1.1 Erosion

Erosion is the chemical dissolution of mineralized dental tissues, such as enamel and dentin, caused by exposure to acidic substances without the involvement of bacteria (7,8). This process leads to the gradual loss of tooth structure as acids dissolve the

mineral content of the teeth (7,8). Erosion often stems from extrinsic acids from dietary (beverages like sodas, fruit juices, or acidic foods) or intrinsic acids related to conditions like gastric reflux, or frequent vomiting (7,8).

Clinically, erosion is characterized by smooth, shiny, and shallow depressions on the tooth surface, with rounded edges that may appear polished (8,9). In more advanced stages, the loss of enamel can expose the underlying dentin, leading to increased tooth sensitivity (8,9). Erosion typically affects surfaces that have direct contact with acidic substances, such as the occlusal surfaces of posterior teeth or the inner surfaces of upper anterior teeth (8,9).

The progression of erosion depends on factors such as the frequency and intensity of acid exposure, saliva's ability to neutralize and buffer acids, and individual dietary habits (1,9). Saliva acts as a natural defense mechanism by diluting acids and supplying minerals like calcium and phosphate to repair early damage (1,9). However, if the frequency of acid exposure surpasses the saliva's protective capacity, the tooth structure begins to erode (1,9).

Managing erosion involves identifying and minimizing the sources of acidic exposure, encouraging dietary modifications, and promoting remineralization with fluoride or calcium-enriched products (7,8). In severe cases, where significant damage has occurred, restorative treatments may be required to rebuild tooth structure and restore function (7,8).

1.1.2 Abrasion

Abrasion refers to the mechanical loss of tooth structure caused by external forces, rather than chemical or biological processes (8,9). This type of wear is often associated with improper oral hygiene practices, such as vigorous toothbrushing with hard-bristled brushes or the use of abrasive toothpaste (8,9). These actions gradually wear the enamel or dentin, particularly in areas like the cervical regions of teeth, which are more prone to mechanical stress (8,9).

Typically, abrasion manifests as V-shaped or notched lesions near the gum line, where excessive brushing pressure is frequently applied (8,9). Over time, this mechanical damage can lead to cosmetic concerns, increased tooth sensitivity, and even pulp exposure if left untreated (8,9). These lesions are characterized by smooth, polished surfaces that are the result of repeated mechanical abrasion (8,9).

Several factors influence the severity and rate of abrasion progression, including the frequency and intensity of brushing, the abrasiveness of the toothpaste used, and individual habits, such as applying excessive force during brushing (9). Additionally, acidic conditions in the oral environment can weaken tooth surfaces, making them more susceptible to abrasion (9).

Addressing abrasion involves both preventive and restorative approaches(8). Dentists often recommend softer toothbrushes, less abrasive toothpaste, and proper brushing techniques to minimize mechanical stress on the teeth (8). For cases where significant tooth loss has occurred, restorative treatments, such as the use of GICs or composite materials, can help repair the lesions and protect the remaining tooth structure (9).

1.1.3 Abfraction

Abfraction is a condition where tooth structure is lost at the cervical region due to mechanical stress, primarily caused by forces exerted during occlusal loading (7,9). These forces create flexural stress, leading to microfractures in the enamel and dentin over time (7,9). Unlike erosion and abrasion, which are caused by chemical and physical factors, abfraction occurs due to stress concentration on specific areas of the tooth (7,9).

Typically, abfraction lesions present as wedge-shaped notches near the gum line (7,9). These lesions are distinguished by their sharp internal angles and smooth surfaces, making them different from the rounded patterns of abrasion or the shallow, dish-shaped characteristics of erosion (7,9). Abfraction may occur alone or in conjunction with other NCCLs, such as abrasion and erosion, complicating its diagnosis and treatment (7,9).

The development of abfraction depends on factors such as the intensity and direction of occlusal forces, the type of bite alignment, and habits like teeth grinding (bruxism) (7). Additionally, the structural integrity of enamel and dentin and the condition of surrounding tissues contribute to the likelihood of formation and progress of abfraction lesions (7).

Treatment for abfraction focuses on reducing the underlying stress on teeth, such as adjusting the bite or providing occlusal guards for patients with bruxism (9). In cases of severe damage, restorative interventions may be required to rebuild lost tooth structure and prevent further deterioration. Materials like GICs or RCs are often used because they offer both durability and aesthetic restoration while withstanding functional demands on the tooth (7,9).

1.1.4 Attrition

Attrition is the gradual wearing down of tooth surfaces caused by direct contact between teeth (9). This form of mechanical wear is a natural process that occurs over time due to chewing and grinding. However, certain factors, such as bruxism (teeth grinding), malocclusion, or the absence of posterior teeth, can accelerate this wear (9). Unlike erosion or abrasion, attrition results solely from mechanical friction between opposing teeth and does not involve chemical processes (9).

The effects of attrition are most observed as flattened cusps and polished surfaces on the affected teeth. In more severe cases, the wear can expose the underlying dentin, leading to heightened sensitivity and an increased risk of further damage. Individuals who grind or clench their teeth frequently are at a higher risk, as these habits amplify the intensity and frequency of tooth contact (4,9).

Several factors influence the rate of attrition, including age, dietary patterns, and the distribution of occlusal forces (3,9). For example, diets requiring vigorous chewing can accelerate the process, and a misaligned bite may focus excessive forces on specific teeth, intensifying wear in those areas (3,9).

Managing attrition involves addressing its underlying causes (3). Treatments may include using occlusal splints to reduce the effects of bruxism or correcting bite alignment with orthodontic procedures. In more advanced cases, restorative options such as crowns or onlays may be necessary to rebuild lost tooth structure and safeguard the remaining enamel (3). Preventive strategies, like raising awareness of grinding habits and encouraging the use of protective devices, play a crucial role in slowing progression and preserving oral health (3).

1.2 Materials to restore NCCLs

1.2.1 GIC

GIC emerged in the 1970s as a breakthrough in restorative dentistry (4,5). This innovative material was designed as a two-part system, combining fluoro aluminosilicate glass powder with polyalkenoic acid liquid (4,5). When mixed, these components undergo an acid-base reaction, creating a substance capable of chemically bonding to mineralized tooth surfaces (4,5). This material also introduced fluoride release, making it an excellent choice for preventing secondary caries (4,5).

During the 1980s, improvements in GIC formulations addressed challenges like moisture sensitivity and low mechanical strength, enabling broader applications and better performance (2,4). By the 1990s, RMGICs were introduced, incorporating resin elements such as 2-hydroxyethyl methacrylate (HEMA) (2,4). These updates enabled dual curing via acid-base reactions and light activation, along with improved durability and aesthetic outcome (2,4).

Further advancements over the years have led to the creation of hybrid systems, nano-filled resins, and PMRCs (called compomers) (4,5). These innovations aimed to enhance GIC's handling characteristics, strength, and visual appeal (4,5). As a result, GIC has become a versatile material suitable for high-caries-risk restorations, as well as liners and bases under composite fillings (4,5).

The continued evolution of GIC demonstrates an ongoing effort to balance mechanical performance, fluoride-releasing benefits, aesthetics, and practical utility, ensuring its importance in modern restorative dentistry (4,5).

1.2.1.1 Properties

1.2.1.1.1 Chemical Bonding

GICs are well-regarded in restorative dentistry for their ability to form a direct and stable chemical bond with tooth structures like enamel and dentin (3). This process involves ionic interactions between the carboxyl groups in the polyalkenoic acid component of the GIC and calcium ions present in hydroxyapatite, the primary mineral of teeth (3). Such a bond ensures a durable and secure attachment without relying on intricate adhesive systems (3).

This unique bonding mechanism is particularly advantageous for restorative procedures where mechanical retention is limited, such as in CLs (3). Unlike resin-based materials that depend on micromechanical retention, GICs directly interact with the tooth mineral content to create a stable and long-lasting bond (3). Additionally, this chemical interaction remains effective in moisture-rich environments, where other adhesive systems may struggle to perform reliably (3).

Beyond their bonding capability, GICs provide continuous fluoride release, promoting remineralization and offering additional protection against secondary caries (3). This dual functionality enhances their value, especially in minimally invasive dentistry, where preserving tooth structure and promoting oral health are priorities (3).

The chemical adhesion properties of GICs make them a preferred choice for cases requiring both simplicity and durability (3). Their ability to bond chemically, combined with their preventive benefits, positions GICs as indispensable in a variety of clinical applications, ensuring long-term success in restorative treatments (3).

1.2.1.1.2 Fluoride Release

GICs are highly regarded for their ability to release fluoride, which is a key feature of their effectiveness as a restorative dental material (4,5). This process involves a continuous ion-exchange mechanism, where fluoride ions diffuse from the cement matrix into the surrounding oral environment (4,5). Initially, there is a rapid release of fluoride after the material is placed, followed by a gradual and sustained release over time (4,5).

Fluoride released by GICs plays an essential role in caries prevention (5). It aids in the remineralization of tooth structures, forming fluorapatite, a mineral that is more resistant to acid attacks than hydroxyapatite (5). Additionally, fluoride interferes with the activity of caries-causing bacteria by reducing their acid production, thereby halting or slowing down the progression of tooth decay (5). This makes GICs particularly useful for patients with a high risk of caries or in scenarios where additional fluoride delivery is beneficial (5).

Another advantage of GICs is their ability to "recharge" their fluoride content through exposure to fluoride-containing products like toothpaste, mouth rinses, or professional treatments (5). This recharge capability allows the material to maintain its fluoride-releasing function over extended periods, further enhancing its preventive properties (5).

However, the amount and rate of fluoride release from GICs can be influenced by factors such as their composition, how they are cured, and the conditions in which they are placed (5). RMGICs, which include resin components, tend to release less fluoride than traditional GICs, although they offer improved mechanical properties (5).

Overall, the fluoride-releasing properties of GICs highlight their dual purpose as both a restorative and preventive material (4,5). This turns it an invaluable choice in minimally invasive dentistry and for patients at a high risk of developing dental caries (4,5).

1.2.1.1.3 Compatibility with Oral Tissues

GICs are well known for their high level of biocompatibility, making them an excellent choice for restorative dental treatments (4,5). Their chemical structure and interaction with tooth tissues result in minimal irritation to the oral environment, including enamel, dentin, and surrounding soft tissues (4,5). Unlike resin-based materials, GICs do not release potentially harmful monomers, further enhancing their safety profile and suitability for use in sensitive areas of the oral cavity (4,5).

A major factor contributing to their biocompatibility is the nature of their setting mechanism, which is based on an acid-based reaction between polyalkenoic acid and fluoro aluminosilicate glass (4,5). This reaction produces a chemically stable material that integrates seamlessly with the tooth surface, promoting tissue healing and reducing the risk of adverse reactions (4,5). In addition, the consistent release of fluoride ions not only helps combat bacterial activity but also supports the overall health of the surrounding tissues by creating a favorable environment for oral health (4,5).

When used in deeper cavities, GICs demonstrate a remarkable ability to protect the pulp (5). By creating a tight seal over exposed dentin, they significantly reduce the permeability of dentinal tubules, effectively blocking irritants from reaching the pulp (5). This characteristic helps minimize the risk of postoperative sensitivity, making GICs a preferred material for restorative procedures involving deep cavities (5).

GICs are also well tolerated by gingival and mucosal tissue (5). Their chemical stability and non-toxic properties reduce the likelihood of allergic reactions or tissue inflammation (5). Furthermore, their fluoride-releasing capabilities contribute to a healthier oral environment, which can prevent bacterial growth and inflammation in the tissues surrounding the restoration (5).

In summary, the biocompatibility of GICs with oral tissues is a key reason for their widespread use in restorative dentistry (4,5). Their ability to maintain tissue health, coupled with benefits like fluoride release and effective adhesion, makes them a highly reliable option in cases requiring both restorative and biological compatibility (4,5).

1.2.1.1.4 Thermal Expansion Similar to Teeth

GICs are valued for their thermal expansion properties, which closely resemble those of natural tooth structures (4,5). This similarity allows GICs to adapt seamlessly to temperature changes in the oral cavity, reducing the risk of stress or separation at the interface between the restoration and the tooth (4,5). Such thermal compatibility is essential for ensuring that GICs maintain a strong and stable bond, even when subjected to the temperature variations caused by eating or drinking hot and cold items (4,5).

By having a coefficient of thermal expansion that aligns with teeth, GICs help prevent microleakage, a problem often encountered with materials that expand or contract at rates different from the tooth (4). Discrepancies in thermal behavior can lead to gaps at the margins of the restoration, creating pathways for bacteria and fluids (4). These issues can cause sensitivity, secondary caries, or even restoration failure (4). GICs effectively mitigate these risks by maintaining a consistent seal during thermal fluctuations, enhancing the restoration's longevity and protecting the tooth's health (4).

The thermal stability of GICs also contributes to their reliability in clinical use (5). Unlike certain resin-based materials that may shrink or stress under thermal changes, GICs retain their dimensional integrity over time (5). This durability makes them particularly suitable for restorations in areas prone to stress, where maintaining a strong and lasting seal is critical (5).

The thermal expansion characteristics of GICs, combined with their other benefits such as fluoride release and biocompatibility, make them a reliable choice for restorative dentistry (5). Their ability to match the thermal behavior of natural teeth ensures not only functional restoration but also the preservation of the tooth's structural integrity (5).

1.2.1.1.5 Minimal Shrinkage During Setting

GICs are highly regarded for their minimal shrinkage during the setting process, which plays a crucial role in their effectiveness as a restorative material (4,5). Unlike resin-based composites, which often experience significant polymerization shrinkage, GICs set through an acid-base reaction (4,5). This chemical process limits volumetric changes, ensuring a more stable bond with the tooth structure and reducing the likelihood of microleakage (4,5).

The limited shrinkage of GICs helps to minimize stress at the interface between the restoration and the tooth, a critical factor in preventing restoration failure (5). This property is essential for preserving the integrity of restoration margins, as it prevents the formation of gaps where bacteria and fluids could infiltrate (5). By maintaining a consistent and secure seal, GICs contribute to the long-term success and durability of dental restorations (5).

This characteristic is especially advantageous in cases involving deep cavities or teeth with compromised structures (4). Since GICs exhibit minimal contraction, they can adapt well to cavity walls, even in areas where achieving mechanical retention is difficult (4). This makes them particularly suitable for treating NCCLs and root caries, where a tight seal is vital for clinical success (4).

The dimensional stability offered by GICs' minimal shrinkage also enhances their durability under the challenging conditions of the oral environment, including thermal and mechanical stresses (5). This stability ensures that restorations maintain their position and functionality over time, providing reliable long-term results (5).

In conclusion, the minimal shrinkage exhibited by GICs during their setting process is a key factor in their widespread use in restorative dentistry (5). By reducing stress, maintaining a strong seal, and ensuring durability, they offer an effective solution for a variety of restorative challenges (5).

1.2.1.1.6 Aesthetic Challenges and Surface Texture

GICs present notable aesthetic challenges, primarily due to their limited ability to replicate the natural appearance of teeth and their tendency to develop surface roughness over time (3,5). These characteristics make them less ideal for restorations in highly visible areas, such as the front teeth (3,5). GICs often struggle with shade matching and translucency, which can lead to restorations that do not blend seamlessly with the surrounding tooth structure (3,5). Over time, color changes may occur due to factors like water absorption, incomplete polymerization, and staining caused by external factors (3,5).

The surface texture of GICs is another significant limitation (3,5). Compared to resin-based materials, GICs tend to have a rougher finish due to their larger filler particle sizes and porosities introduced during the mixing process (3,5). This roughness can increase over time with exposure to wear and abrasive forces, such as tooth brushing (3,5). A rougher surface not only diminishes the visual appeal of the restoration but also facilitates the accumulation of plaque and staining, further impacting the aesthetics of the material (3,5).

Although polishing and applying surface coatings can improve the initial smoothness of GICs, these measures are often temporary (3,5). Over time, the polished surface may deteriorate, and the material's susceptibility to discoloration and texture degradation becomes more evident (3,5). This makes achieving a lasting, smooth, and polished finish more challenging when using GICs compared to RCs (3,5).

While GICs offer significant functional benefits, such as fluoride release and biocompatibility, their aesthetic shortcomings remain a concern (3). Addressing these limitations through improved formulations could enhance their surface texture and color stability, making them a more appealing option for use in visible restorations without compromising their practical advantages (3).

1.2.1.1.7 Sensitivity to Moisture

GICs are particularly sensitive to moisture during their initial setting phase, a characteristic that can greatly influence their clinical performance (3,4). This sensitivity arises because the acid-base reaction that sets the material is dependent on water, making it vulnerable to both moisture contamination and dehydration during this critical period (3,4). Excess moisture during setting can weaken the cement, reducing its strength, while dehydration may lead to surface cracking and compromised adhesion to tooth structures (3,4).

Maintaining a controlled environment during placement is essential to avoid issues caused by saliva or other oral fluids (4,5). Moisture contamination during the setting phase can soften the surface of GICs, making them more prone to wear, discoloration, and premature failure (4,5). Additionally, this exposure can negatively impact their aesthetic properties, such as translucency and color stability, which is particularly problematic for restorations in visible areas of the mouth (4,5).

To counteract these challenges, protective measures have been developed (3,5). One effective strategy is the application of surface coatings or varnishes immediately after placement (3,5). These coatings act as a shield, preventing both moisture intrusion and dehydration, allowing the GIC to set properly and achieve optimal strength (3,5). Another advancement is the introduction of RMGICs, which include resin components to reduce moisture sensitivity and enhance their mechanical and handling properties during the setting phase (3,5).

Even with these improvements, careful handling of GICs is critical to minimize moisture-related issues (3,4). Using isolation techniques, such as rubber dams or cotton rolls, during placement can help maintain a dry field, ensuring the materials are set without interference (3,4). These precautions preserve the cement's integrity, preventing problems such as weakened adhesion or microleakage (3,4).

1.2.1.1.8 Mechanical Strength

GICs exhibit moderate mechanical strength, which makes them well-suited for specific applications in restorative dentistry, though their use is often limited in areas subjected to high mechanical stress (3,4). Their structure, primarily composed of fluoro aluminosilicate glass and polyalkenoic acids, provides reasonable compressive strength but lower tensile and flexural strength compared to resin-based materials (3,4) . This inherent limitation means that GICs are more prone to fracture and wear in high stress conditions (3,4).

A key factor influencing the mechanical performance of GICs is their brittle nature, resulting from their glassy matrix (4,5). However, recent advancements, such as the introduction of RMGICs and glass hybrid systems, have significantly improved their mechanical properties (4,5). RMGICs incorporate resin components to enhance fracture resistance and reduce brittleness, while glass hybrid systems achieve greater strength and wear resistance through innovations in particle size and material composition (4,5).

Clinical research has demonstrated that GICs perform effectively in low-stress environments, such as NCCLs (3,5). However, their durability in load-bearing areas remains inferior to that of RCs (3,5). Despite this, GICs are often preferred in cases where their unique benefits, including fluoride release and biocompatibility, outweigh their mechanical limitations (3,5). This makes them a reliable choice for specific applications where stress resistance is not the primary concern (3,5).

Efforts to improve the mechanical strength of GICs have included the application of protective surface coatings and enhanced curing methods, both of which improve wear resistance and surface hardness (3,4). These advancements have expanded the usability of GICs into more demanding clinical scenarios, though their strength still does not match that of RCs (3,4).

In conclusion, while the mechanical strength of GICs is moderate and best suited for low-stress applications, ongoing innovations such as RMGICs and glass hybrid

systems have improved their performance (3,4). However, their use in high-stress areas remains limited, highlighting the need for further development to enhance their mechanical properties and broaden their clinical applications (3,4).

1.2.1.1.9 Resistance to Wear

GICs offer moderate resistance to wear, though they are generally less durable than RCs, especially in areas exposed to high mechanical forces (3,5). Their composition, which includes fluoro aluminosilicate glass particles, provides a reasonable level of durability for use in low-stress regions (3,5). However, GICs are less effective in withstanding wear in high-stress or abrasive environments, such as occlusal surfaces, due to their lower mechanical strength (3,5).

One of the main factors affecting the wear resistance of GICs is their sensitivity to external conditions, particularly during the early stages of setting (3,5). Exposure to moisture or acidic environments can weaken the material, increasing its vulnerability to mechanical wear (3,5). Over time, this degradation can lead to material loss, particularly in the presence of acidic conditions, which exacerbate surface erosion (3,5).

The surface texture of GICs also plays a role in their wear resistance (3). The relatively rough surface, which arises from the larger particle sizes and porosities in the material, makes GICs more susceptible to abrasion (3). Forces, such as brushing, can accelerate the material's wear over time (3). While protective measures like surface coatings or finishing gloss can improve wear resistance temporarily, these effects tend to diminish with prolonged use, leaving the material exposed to further degradation (3).

Despite these challenges, GICs remain effective for restorations in areas that are not subjected to significant mechanical stress, such as NCCLs or certain pediatric applications (3,5). Their unique properties, such as fluoride release and the ability to chemically bond to tooth structures, compensate for some of their mechanical limitations, making them a valuable option in specific clinical contexts (3,5).

1.2.1.1.10 Ease of Application

GICs are renowned for their simplicity in application, making them a highly practical choice in restorative dentistry (4,5). Their ease of use is largely attributed to their self-adhesive properties, which eliminate the need for complex preparation steps such as the application of separate bonding agents or acid etching (4,5). This streamlined process is particularly beneficial when treating CLs, where maintaining a dry and clean operative field can be challenging (4,5) .

A significant advantage of GICs lies in their ability to chemically bond directly to tooth structures, removing the need for additional adhesive systems (4,5). This property, combined with straightforward mixing and placement techniques, reduces overall chairside time, benefiting both clinicians and patients (4,5). Studies have highlighted that GICs, particularly glass hybrid systems, enable faster procedures compared to RCs, making them a preferred material in cases where time efficiency is critical (4,5).

The material's extended working time and quick initial setting phase allow for precise placement and contouring, which is particularly important in cervical restorations requiring careful adaptation. Unlike resin-based materials, GICs are less affected by moisture contamination, further enhancing their reliability in less-than-ideal clinical environments (5).

GICs are especially suitable for pediatric and elderly patients, where quick and straightforward procedures are often necessary (4,5). Their ease of handling, combined with minimal equipment requirements, makes them an ideal choice for routine dental treatments (4,5). Additionally, the development of pre-encapsulated GIC formulations has further simplified their application by ensuring accurate mixing ratios and reducing the risk of operator error (4,5).

In summary, the simplicity of application, combined with chemical bonding capabilities, moisture tolerance, and reduced procedure times, makes GICs a reliable and efficient material for a wide range of restorative needs (4,5). Their user-friendly properties and versatility reinforce their role as a valuable tool in modern dental practice (4,5).

1.2.2 RMGIC

As mentioned before, RMGIC is an innovative dental material that integrates the benefits of traditional GIC) with advanced resin technologies (5,6). Developed in the late 1980s, RMGIC was designed to overcome the challenges associated with GIC, including limited strength, poor resistance to moisture during setting, and less favorable aesthetic qualities (5,6).

1.2.2.1 Composition

The formulation of RMGIC includes three main components:

1. **Glass powder**: a fluoro aluminosilicate material responsible for fluoride release and the acid-base reaction.

2. **Polyalkenoic acid** reacts with the glass particles during the setting process to form the base structure.

3. **Resin monomers (e.g., HEMA)**: provide light-activated curing, enhancing strength and reducing water sensitivity during setting.

This material undergoes a dual-setting mechanism: the acid-base reaction provides initial strength and chemical bonding, while the resin polymerization triggered by light curing further reinforces the material (5,6).

1.2.2.2 Properties

1.2.2.2.1 Sustained Fluoride Release

RMGIC continues the legacy of traditional GIC by releasing fluoride over time (5,6). This slow release helps protect against caries and promotes the remineralization of surrounding tooth structures (5,6). Additionally, the material can recharge fluoride from external sources, extending its protective effects (5,6).

1.2.2.2.2 Improved Strength

By incorporating resin into its formulation, RMGIC offers greater compressive and tensile strength than conventional GIC (5,6). While it does not match the robustness of composite resins, it is suitable for areas of the mouth with moderate stress (5,6).

1.2.2.2.3 Resistant to Moisture During Setting

Unlike traditional GIC, RMGIC can better withstand exposure to moisture during its initial setting period (5,6). This makes it more suitable for applications in areas where complete isolation is difficult, such as near the gum line (5,6).

1.2.2.2.4 Strong Chemical Bonding

RMGIC chemically bonds to both dentin and enamel, creating a durable interface without the need for adhesives (5,6). This ensures long-lasting restorations and minimizes the risk of marginal gaps or microleakage (5,6).

1.2.2.2.5 Enhanced Aesthetics

Although RMGIC may not achieve the same level of translucency as composite resins, it offers significant aesthetic improvements compared to traditional GIC (5,10). Its improved appearance makes it a more acceptable option for visible restorations (5,10).

1.2.2.2.6 Strengths and limitations

RMGIC offers several strengths, including extended fluoride release with recharging capabilities, better resistance to moisture compared to conventional GIC, and simplified clinical procedures due to its chemical adhesion to tooth surfaces (5). It also provides reasonable strength and aesthetics for various dental applications (5). However, it has limitations, including limited durability in areas subjected to high occlusal stress, susceptibility to surface wear and discoloration over time, and aesthetic properties that remain inferior to composite resins (5,6).

RMGIC is a highly valuable dental material that bridges the gap between conventional GIC and composite resins (5,6,10). Its fluoride release, chemical adhesion, and improved resistance to moisture make it a reliable choice for a wide range of applications (5,6,10). While not as strong or aesthetically pleasing as composite resins, its versatility and unique benefits ensure its continued relevance in restorative dentistry (5,6,10).

1.2.3 PMRC

PMRCs, often referred to as "compomers," are hybrid restorative materials that merge some of the benefits of GICs and RCs (5,11). While PMRCs lack the traditional acid-base reaction seen in GICs, they retain the ability to release fluoride, making them a valuable material for treating NCCLs and other restorations (5,11).

1.2.3.1 Composition

PMRCs are made up of a resin-based matrix combined with glass-ionomer fillers (5,11). The resin matrix typically contains compounds such as Bisphenol A-glycidyl methacrylate (Bis-GMA) urethane resins, and TEGDMA, while the fillers include fluoride-containing glass particles like strontium fluoride (5,11). PMRCs are light-cured, similar to RCs, and this polymerization mechanism provides strength while enabling gradual fluoride release (5,11).

1.2.3.2 Properties

1.2.3.2.1 Fluoride Release and Recharge

One of the standout features of PMRCs is their ability to release fluoride slowly over time, helping prevent secondary caries (5,11). Additionally, they can absorb and release fluoride from external sources, such as fluoride toothpaste, boosting their caries-preventive potential (5,11).

1.2.3.2.2 Enhanced Mechanical Properties

PMRCs are stronger and more durable than conventional GICs, with physical properties such as compressive strength and hardness resembling those of RCs (11). This makes them a suitable choice for restorations in areas exposed to moderate stress (11).

1.2.3.2.3 Aesthetic Appeal and Handling

PMRCs are available in natural, tooth-colored shades, which deliver excellent aesthetics for visible restorations (5,11). They are also easy to handle, offering smooth application and effective polishing compared to traditional GICs (5,11).

1.2.3.2.4 Strong Adhesion

When paired with dentin bonding agents, PMRCs provide strong adhesion to both enamel and dentin (5,11). This ensures secure and durable restorations, especially in cervical areas that are challenging to treat (5,11).

1.2.3.2.5 Reduced Moisture Sensitivity

Unlike GICs, PMRCs are less affected by moisture during their setting phase (5,11). This allows for more consistent results in clinical situations where isolation is difficult, such as subgingival areas or near gingival margins (5,11).

PMRCs offer a unique blend of characteristics that combine the benefits of GICs and RC, making them an excellent choice for addressing NCCLs. These materials adhere effectively to both enamel and dentin when used with bonding agents, which is particularly advantageous in areas like cervical lesions that demand a strong dual adhesion (5,11). Additionally, the fluoride-releasing properties of PMRCs enhance their preventive capabilities by reducing the risk of secondary lesion formation (11). Unlike traditional GICs, PMRCs possess superior physical attributes, including enhanced compressive strength and wear resistance, making them more durable in areas

experiencing moderate stress (11). Clinical evaluations, such as those conducted on Dyract eXtra, indicate strong long-term performance in terms of marginal adaptation and retention, key factors for preserving the stability of NCCL restorations (11). However, challenges remain with issues like color changes and marginal staining, often caused by environmental influences such as water absorption and resin breakdown over time (5,11). Despite these limitations, PMRCs represent a reliable option for minimally invasive and preventive dental practices, effectively addressing the needs of NCCLs while providing durable and aesthetic restorations (5,11).

2. Objectives

2. Objectives

This systematic review seeks to comprehensively assess and compare the clinical performance of two widely used restorative materials RMGIC and PMRC in the treatment of cervical lesions. These lesions, which may arise from both carious and non-carious etiologies, pose unique restorative challenges due to their anatomical location, proximity to the gingival margin, and often complex etiology involving biomechanical, chemical, and microbiological factors.

The review places particular emphasis on evaluating critical clinical parameters that influence restorative success, namely marginal integrity, color stability, and surface roughness. These variables are essential in determining the long-term functional and aesthetic viability of restorations placed in cervical regions, which are especially susceptible to wear, marginal leakage, and visual prominence.

By systematically analyzing the current body of literature, this review aims not only to identify trends and comparative outcomes among these restorative materials but also to contextualize their performance in diverse clinical scenarios. In doing so, it intends to provide clinicians with clear, evidence-based guidance on material selection tailored to the specific needs of cervical lesion management. Ultimately, this synthesis of clinical evidence aspires to contribute to improved patient care through more informed, durable, and personalized restorative choices.

3. Materials and Methods

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3.1 Exploratory Search Processing

Pubmed and Scopus were searched to find papers that matched our topic on December 19th, 2024. The search method was developed by combining phrases that suited the goal of our review, which deals with the comparison of various restorative techniques of NCCLs. Hence, the following terms were used:

- “Glass ionomer cement” OR "resin-modified glass ionomer cement” OR “polyacrilic acid modified composite” OR “compomer” OR “glass ionomer” = 10706 papers
- “cervical lesions” = 539 papers

When we combined both searches, 81 papers were retrieved from PubMed, while 43 came from Scopus. Selected papers were exported to Ryyan Platform, where duplicates were excluded.

3.2 Inclusion Criteria

The articles were selected using the following inclusion criteria: (1) studies only on adult human subjects; (2) clinical trials and randomized controlled trials; (3) English and Portuguese language and (4) studies concerning the treatment through various glass ionomer cements to restore CLs.

3.3 Data Processing

Three reviewers (R.M., A.M.T. and A.B.M.) performed the screening phase, excluding articles that did not fit the topic by reading the manuscript's title and the abstract. Any discrepancies between the two authors were resolved by discussion between reviewers. For now, we have 61 papers to be read in full to decide if they will be selected or not for this study. PRISMA diagram (Fig. 1) shows the numbers of papers during the screening process.

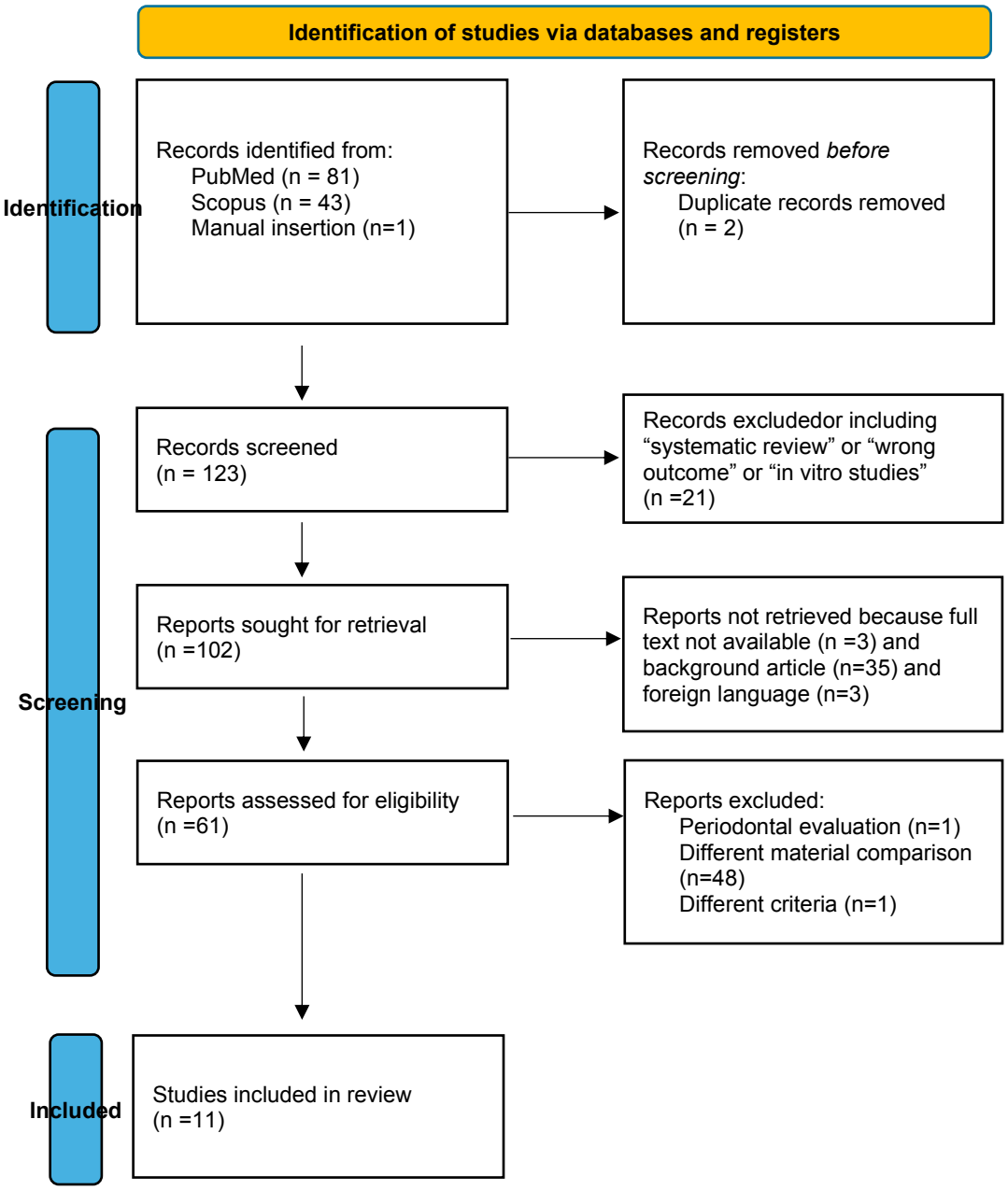
3.4 PICOS Criteria

Population - Adults with NCCLs

Intervention - Restorative treatments of CL´s with Glass Ionomers

Comparisons - Comparing before and post intervention

Outcomes - Color change, roughness and microleakage.



4. Results

4. Results

4.1 General description of the included studies

Following a comprehensive screening process aligned with PRISMA guidelines, 11 clinical studies were selected for this review. These publications, spanning from 1999 to 2018, assessed the clinical performance of tooth-colored restorative materials in treating NCCLs, classified as Class V restorations. The included studies were conducted across diverse geographic regions, including Germany, Brazil, the United States, Turkey, India, and Australia, and featured a variety of research designs, such as randomized controlled trials, prospective comparative clinical studies, and observational cohort studies in private practice settings.

Across all studies, restorative materials evaluated included PMRCs and RMGICs. Sample sizes ranged from 12 to 61 patients, with total numbers of restorations often exceeding the number of participants due to multiple lesions per individual.

All studies used the USPHS or modified USPHS evaluation criteria, ensuring consistent assessment of key clinical outcomes such as color match, surface texture, marginal integrity, and retention. A smaller subset of studies also incorporated additional indices or scoring systems for esthetic and functional durability.

Follow-up durations varied from 12 months to 60 months, enabling both short- and long-term comparisons of material performance. The heterogeneity in adhesive protocols, cavity preparation methods, and finishing techniques across studies further contributed to the depth of comparative clinical evidence included in this review.

Table 1 Summary of the clinical studies included in the review, detailing country of origin, study type, sample size, follow-up duration, and restorative materials assessed.

Study	Country (inferred)	Study Type	Participants (n)	Follow-up Duration	Materials Assessed
Folwaczny et al. (2000)	Germany	Randomized Clinical Trial	37	24 months	PMRC, 2 RMGIC, RC
Brackett et al. (2001)	USA	Randomized Clinical Trial	31	24 months	PMRC, RMGIC
Folwaczny et al. (2001)	Germany	Randomized Clinical Trial	37	36 months	PMRC, 2 RMGIC, RC
Folwaczny et al. (2001)	Germany	Randomized Clinical Trial	16	60 months	PMRC, 2 RMGIC, RC
Ermis et al. (2002)	Turkey	Clinical Trial	30	24 months	4 PMRC, RMGIC
Loguercio et al. (2003)	Brazil	Clinical Trial	12	60 months	PMRC, RMGIC
Smales et (2004)	Australia	Clinical Trial	61	60 months	PMRC, RMGIC
Burgess et al. (2004)	USA	Randomized Clinical Trial	-	36 months	PMRC, RMGIC, 2 RC
Chinelatti et al. (2004)	Brazil	Randomized Clinical Trial	19	12 months	2PMRC, RMGIC
Onal et al. (2005)	Turkey	Randomized Clinical Trial	30	24 months	2PMRC, RMGIC, RC
Hussainy et al. (2018)	India	Randomized Clinical Trial	-	12 months	PMRC, RMGIC, Flow

4.2 Table of results for Color Stability

Table 2 Percentage of restorations with Alpha scores according to USPHS or modified USPHS criteria for color stability.

Study	Follow-up	PMRC (%)	RMGIC (%)
Folwaczny et al. (2000)	24 months	94.6	79.6
Brackett et al. (2001)	24 months	87.0	100.0
Folwaczny et al. (2001)	36 months	77.0	51.0
Folwaczny et al. (2001)	60 months	81.3	28.6
Ermis et al. (2002)	24 months	92.6	89.0
Loguercio et al. (2003)	60 months	81.8	14.0
Smales et al. (2004)	60 months	90.8	83.6
Chinelatti et al. (2004)	12 months	78.8	95.0
Onal et al. (2005)	24 months	29.4	36.0

4.3 Table of results for Surface roughness

Table 3 Percentage of restorations with Alpha scores according to USPHS or modified USPHS criteria for surface roughness.

Study	Follow-up	PMRC (%)	RMGIC (%)
Folwaczny et al. (2000)	24 months	94.6	18.4
Folwaczny et al. (2001)	36 months	83.0	13.0
Folwaczny et al. (2001)	60 months	93.8	78.6
Loguercio et al. (2003)	60 months	100.0	14.0
Burgess et al. (2004)	36 months	94.0	63.0
Chinelatti et al. (2004)	12 months	44.9	55.0
Onal et al. (2005)	24 months	56.6	46.0
Hussainy et al. (2018)	12 months	97.1	97.0

4.4 Table of results for Marginal Integrity

Table 4 Percentage of restorations with Alpha scores according to USPHS or modified USPHS criteria for marginal integrity.

Study	Follow-up	PMRC (%)	RMGIC (%)
Folwaczny et al. (2000)	24 months	73.2	67.5
Brackett et al. (2001)	24 months	30.0	62.0
Folwaczny et al. (2001)	36 months	70.0	57.0
Folwaczny et al. (2001)	60 months	62.5	42.9
Ermis et al. (2002)	24 months	85.7	95.0
Loguercio et al. (2003)	60 months	38.5	84.6
Burgess et al. (2004)	36 months	42.0	47.0
Chinelatti et al. (2004)	12 months	97.8	95.0
Onal et al. (2005)	24 months	44.5	36.0
Hussainy et al. (2018)	12 months	67.6	90.9

5. Discussion

5. Discussion

Color stability is a key factor in the long-term esthetic success of restorations, especially in anterior or premolar teeth, where even slight shade deviations are easily visible and often unacceptable to patients. Nine in eleven clinical studies included in this review evaluated the color stability or discoloration of Class V restorations over varying follow-up periods, using modified USPHS criteria. In general, PMRCs outperformed RMGICs, particularly in mid- to long-term evaluations, as demonstrated by the majority of the selected studies. In a 24-month study, Folwaczny et al. (2000), including 158 restorations, reported 94.6% color stability for PMRCs compared to 79.6% for RMGICs, demonstrating clear superiority (10) This was further supported by a 36-month follow-up from Folwaczny et al. (2001), which found that 77% of PMRC restorations maintained their original shade (Alfa score), whereas only 51% of RMGICs achieved the same outcome (12). Extending the evaluation to 60 months, Folwaczny et al. (2001) again observed a marked advantage for PMRCs, which retained 81.3% Alfa scores, while RMGICs fell to just 28.6%(1). The authors attributed this decline to the susceptibility of RMGICs to hydrolytic degradation, ion leaching, and particularly, the accumulation of pigments within the glass matrix, which visibly compromised esthetics over time. Similarly, Loguercio et al. (2003), in another 60-month clinical trial with 32 restorations, reported 81.8% color stability for PMRCs and only 14% for RMGICs, confirming a trend of progressive chromatic deterioration in glass ionomer-based materials under prolonged functional and moisture exposure (3). Ermis et al. (2002) also found more favorable results for PMRCs, with 92.6% Alfa scores after 24 months versus 89% for RMGICs, a narrower difference, but one still favoring the resin-based alternative (13). In a large real-world clinical study, Smales et al. (2004) assessed 160 restorations in general dental practice and reported color stability in 90.8% of PMRCs and 83.6% of RMGICs after 60 months, suggesting that even under variable operator conditions, PMRCs remain the more color-stable material (14).

However, three studies presented findings in favor of RMGICs, particularly in short-term settings. Brackett et al. (2001), in a two-year clinical trial involving 68 restorations placed by a single experienced clinician, found 100% of RMGIC restorations retained

Alfa scores, surpassing PMRCs, which achieved 87% (15). The authors emphasized that this unexpected outcome was likely due to consistent operator technique, excellent moisture control, and optimal handling, all of which may have mitigated the limitations typically associated with RMGICs (15). Chinelatti et al. (2004), in a 12-month study including 87 restorations, reported 95% Alfa scores for RMGICs and 78.8% for PMRCs (5). In this case, the authors attributed the favorable RMGIC performance to the use of improved material formulations and more efficient light-curing and polishing protocols, which may have enhanced surface resistance and appearance(5). Onal et al. (2005) also showed better short-term results for RMGICs, with 36% of restorations maintaining Alfa scores after 24 months, compared to only 29.4% for PMRCs (16). In summary, although some short-term studies have shown positive outcomes for RMGICs under ideal conditions, the collective clinical evidence clearly supports the superior long-term color stability of PMRCs. As observed by Folwaczny et al. (2001), the marked discoloration in RMGICs is likely related to hydrolytic degradation and pigment accumulation within the ionomer matrix, suggesting that resin-based materials with more stable matrices offer greater long-term esthetic reliability (1).

Surface texture plays an essential role in both the esthetic longevity and biological compatibility of restorations. Rougher surfaces are more prone to plaque accumulation, staining, and gingival inflammation, which can compromise both appearance and periodontal health. Eight in eleven clinical studies included in this review examined the surface roughness of Class V restorations using modified USPHS criteria, with particular emphasis on Alfa ratings that indicate smooth, clinically acceptable surfaces. When comparing RMGICs and PMRCs, most studies demonstrated more favorable surface outcomes for PMRCs, especially in long-term evaluations.

Folwaczny et al. (2000), in a 24-month follow-up, reported that 94.6% of PMRCs maintained smooth surfaces, while just 18.4% of RMGICs did, reinforcing the idea that PMRCs exhibit higher surface smoothness retention under clinical conditions (10). Their later study, Folwaczny et al. (2001), with 161 restorations over 36 months, showed that only 13% of RMGICs achieved Alfa scores, compared to 83% of PMRCs (12). The authors attributed this disparity to the smoother polishability and more resin-

rich matrix of PMRCs, which allow for better initial surface adaptation and reduced surface degradation (12). In a later 60-month study, Folwaczny et al. (2001) observed that 93.8% of PMRCs and 78.6% of RMGICs achieved Alfa scores, once again supporting the superior long-term surface quality of PMRCs (1). Loguercio et al. (2003), in a 5-year evaluation of 32 restorations, also found strong results for PMRCs: 100% of restorations retained Alfa ratings for surface roughness, while only 14% of RMGICs remained smooth (3). The authors emphasized the greater susceptibility of RMGICs to wear and chemical degradation, especially under occlusal forces and oral pH fluctuations, as key contributors to surface deterioration (3). Finally, Burgess et al. (2004), in a multicenter study with multiple operators and 60 restorations evaluated over 36 months, found that 94% of PMRCs maintained smooth surfaces compared to only 63% of RMGICs (17). Despite the increased variability inherent in a real-world, multi-practitioner context, PMRCs continued to exhibit a marked advantage (17).

In contrast, some studies reported more favorable or comparable results for RMGICs. Chinelatti et al. (2004), at 12 months, found that 55% of RMGICs achieved Alfa ratings compared to just 44.9% of PMRCs, a reversal of earlier findings (5). This unexpected result was likely influenced by different polishing protocols, including the use of rotary finishing systems, as well as material handling variability during placement and curing (5). Onal et al. (2005) offered more balanced results: after 24 months, 56.6% of PMRCs and 46% of RMGICs were rated Alfa for surface texture (16). Their study highlighted the influence of immediate polishing and operator skill in optimizing outcomes for both materials, especially when using updated formulations (16). Similarly, Hussainy et al. (2018) reported favorable short-term results in a 12-month prospective trial involving 67 restorations. In this case, 97.1% of PMRCs and 97% of RMGICs achieved Alfa scores, attributed to careful placement, moisture isolation, and advanced finishing systems (18). These results suggest that modern material chemistry and clinical protocols have improved the performance of both classes of materials (18).

In conclusion, the data overwhelmingly support the superior long-term surface quality of PMRCs, owing to their lower solubility, better filler-resin bonding, and higher polishability. However, in well-controlled settings and over shorter durations, RMGICs,

particularly newer formulations, can achieve comparable results when appropriate clinical techniques and finishing protocols are applied.

Marginal integrity is a critical determinant of restoration success in NCCLs, where the interface is exposed to thermal stress, moisture, and flexural forces that can degrade adhesive bonds over time. Ten out of eleven clinical studies included in this review evaluated the marginal integrity of Class V restorations using the modified USPHS criteria, focusing on Alfa scores that indicate restorations with intact margins and no visible microleakage. Several studies have demonstrated superior performance of RMGICs compared to PMRCs, particularly in more recent trials. This trend has been partly attributed to improvements in the formulation of RMGICs, which enhance their mechanical properties and reduce solubility over time, as noted by Hussainy et al. (2018) (18). Additionally, studies such as that by Loguercio et al. (2003) emphasized that the ability of RMGICs to chemically bond to dentin and release fluoride likely contributes to their sustained marginal integrity, especially in areas subject to flexural stress (3). Ermis et al. (2002) also noted that the RMGICs tested exhibited better performance in areas with limited enamel margins, possibly due to their reduced technique sensitivity and higher tolerance to humidity compared to PMRCs (13). Brackett et al. (2001) observed a significant advantage for RMGICs after 24 months, with 62% of restorations rated Alfa versus only 30% for PMRCs, attributing this to enhanced handling properties and greater moisture tolerance of the RMGIC material (15). Similarly, Ermis et al. (2002) reported better performance for RMGICs, with 95% Alfa scores compared to 85.7% for PMRCs, highlighting the benefits of fluoride release and adhesion capacity in cervical áreas (13). In a long-term evaluation by Loguercio et al. (2003), RMGICs demonstrated 84.6% marginal integrity over 60 months, whereas PMRCs maintained only 38.5%, suggesting better sealing ability of RMGICs in high-stress zones (3). Burgess et al. (2004) also favored RMGICs, reporting 47% marginal adaptation versus 42% for PMRCs at 36 months (17). More recently, Hussainy et al. (2018) showed that modern RMGIC formulations yielded 90.9% Alfa scores, clearly outperforming PMRCs, which achieved 67.6% after 12 months (18).

On the other hand, some studies found superior marginal integrity in restorations using PMRCs. According to Folwaczny et al. (2000, 2001), the superior wear resistance and

polishability of PMRCs contributed to their better long-term esthetic outcomes and surface stability, particularly under occlusal forces (1,10,12). These authors also highlighted that the technique-sensitive nature of PMRCs could be mitigated under controlled clinical conditions, allowing for optimal marginal adaptation (1,10,12). Onal et al. (2005) further observed that while RMGICs had favorable retention, the better esthetic performance and surface smoothness of PMRCs made them preferable in cases where visual outcomes were prioritized (16). Folwaczny et al. (2000) reported better performance of PMRCs (73.2%) versus RMGICs (67.5%) at 24 months, possibly due to superior esthetics and wear resistance under occlusal stress (10). In a separate trial, Folwaczny et al. (2001) evaluated restorations at two different intervals (1,12). At 36 months, PMRCs maintained 70% Alfa scores, compared to 57% for RMGICs (12). At 60 months, the difference narrowed, with PMRCs at 62.5% and RMGICs at 42.9%, and the authors noted issues such as esthetic degradation and reduced enamel bonding as challenges for RMGICs (1). Onal et al. (2005) also reported a slight advantage for PMRCs at 24 months (44.5% vs. 36%), attributing it to the esthetic superiority of resin-based restoratives (16). Similarly, Chinelatti et al. (2004) observed excellent results for both materials at 12 months, but PMRCs slightly outperformed RMGICs (97.8% vs. 95%) (5).

Taken together, these studies illustrate that while both RMGICs and PMRCs can perform well in the short term, RMGICs have shown superior or at least equivalent marginal adaptation over time in many clinical settings. These results challenge earlier assumptions about the inferiority of RMGICs and highlight the importance of protocol adherence, such as proper isolation, conditioning, and finishing techniques.

A major limitation of this review is that the most recent included clinical study dates back to 2018. Given the ongoing development of restorative materials, it is possible that more recent formulations of RMGIC may exhibit improved clinical outcomes that could bring the results more closer to those of PMRCs. Additionally, the number of eligible studies was limited, and many did not stratify outcomes according to the etiology of cervical lesions, making it difficult to distinguish results between carious and non-carious lesions. Finally, methodological heterogeneity, including variations in

operator skill, cavity preparation, finishing techniques, and follow-up periods, may have introduced bias and limited the comparability of clinical outcomes across studies.

In summary, while PMRCs demonstrate superior long-term color stability and surface smoothness, clinical evidence increasingly shows that RMGICs offer better or comparable marginal integrity, particularly in cervical areas subject to stress and moisture. Their chemical bond to dentin, fluoride release, and improved formulations enhance sealing ability and reduce microleakage over time. Although most esthetic outcomes may favor PMRCs, RMGICs often outperform in maintaining margin adaptation, especially when proper clinical protocols are followed. Material choice should therefore be tailored to each case, balancing esthetic demands with structural durability and long-term sealing performance.

6. Conclusion

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This systematic review highlights that PMRCs generally offer superior long-term outcomes in color stability and surface texture when restoring cervical lesions. Their enhanced resistance to hydrolytic degradation, pigment accumulation, and surface wear ensures better esthetic durability over time. However, when it comes to marginal integrity, a critical factor in preventing microleakage and ensuring restoration longevity, as well as preserving the esthetic continuity of the restoration, RMGICs frequently demonstrate equal or superior performance, especially in areas with limited enamel margins and high moisture exposure. These advantages are largely attributed to RMGICs' chemical adhesion to dentin, fluoride release, and reduced technique sensitivity. While PMRCs remain the preferred option for esthetically demanding, long-term cases, RMGICs may offer a more predictable marginal seal in clinical situations where moisture control is limited or structural retention is a priority. Ultimately, clinicians should weigh both esthetic and functional demands alongside case-specific variables when selecting restorative materials for cervical lesions.

7. Bibliography

7. Bibliography

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