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Review Article

Glass Ionomer Cements for Restoration of Primary Molars: A Review

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Abstract

Glass ionomer cements are considered a successful material for restoring primary teeth, their ease of handling, biocompatibility, ability to adhere to tooth structure, and most impotently the release and of fluoride make them very attractive materials for use in the pediatric population. Several modifications of glass ionomer cements have been introduced for clinical use, some were more successful than others, with the most recent addition, the hydroxyapatite enhanced glass ionomer cement.

Aim: To discuss the composition, properties, types and recent developments of glass ionomer restorative materials focusing on their use in restoring primary molars.

Methods: The data were obtained through searching multiple electronic databases including "PubMed", "EBSCO", "Science Direct" and "Google Scholar" for English-language publications between the years 1990-2018 using a combination of keywords such as glass ionomer, GIC, primary molars, fluoride release. Abstracts and full texts were utilized to identify the most relevant studies.

Results: A total of two hundred and twenty-nine articles were reviewed along with multiple references obtained from review articles. From those one hundred and twenty were found to be the most relevant and were used for this review.

Conclusion: Glass ionomer is a very versatile material and has boundless potential in pediatric dentistry, it is bioactive because of the ion exchange that occurs after the material sets and allows for adhesion to tooth structure and for fluoride release. Poor mechanical properties were the main weakness of this material, however modifications including resin modified glass ionomers proved to be successful for restoring primary molars. The glass carbomer cement, another modification of glass ionomer cements still needs to be studied furthermore.

***Keywords:** Glass Ionomer Cement; Resin Modified Glass Ionomer; Primary Molars; Dental Restoration; Fluoride Release; Hydroxyapatite*

Abbreviations

GIC: Glass Ionomer Cement; GCC: Glass Carbomer Cement; RMGIC: Resin Modified Glass Ionomer Cement; HEMA: 2-Hydroxyethyl Methacrylate; HA: Hydroxyapatite; ART: Atraumatic Restorative Treatment; ITR: Interim Therapeutic Restoration; LED: Light Emitting Device

Introduction

With the high demand for esthetics, composites resin restorations became the commonly used materials for restoring carious molars, and their long-term success has been improving over the years [1]. However, the demands of primary teeth with regards to the most appropriate restorative material differ from those of permanent teeth. Primary teeth have a short life span; but they contribute a major role in the development of permanent dentition. Primary teeth play an important role in guiding and aligning erupting permanent dentition, which is crucial for the development of speech in a growing child [2]. Premature loss of primary teeth is related to the development of malocclusion in permanent dentition [3] and may be associated with the development of particular harmful oral habits, speech and chewing problems, and abnormal swallowing [4].

It is commonly known among dentists and dental researches that secondary caries development is a problem that is more frequently associated with composite resin restorations than with other restorative materials [5]. In a systematic review, [6] it was found that secondary caries were associated with the composite restorative material itself, similarly, several studies observed significantly more caries with composite resin than with amalgam [5]. However, it was also concluded that the type and the location of the composite restoration is also a determining factor for the development of recurrent caries. Composite resin restorations appear to favor the growth of cariogenic bacteria on their surfaces, which has been associated with specific surface properties, release of unpolymerized monomers and biodegradation products and the lack of antibacterial properties [6].

Successful restoration of cavities in primary molars can be considered challenging. It is different from restoring cavities in permanent molars because factors such as the level of cooperation of the child and the handling properties and setting time of the restorative material will have some influence on the success rate of the restoration [7]. Composite resin restorations are technique sensitive and their success depends greatly on the skill level of the operator [8]. In addition, for good adhesion to occur, contamination of the cavity by saliva or blood must be completely avoided, which may not always be easy to achieve in the clinical setting [6].

Glass ionomer cement (GIC) has been suggested as a suitable material for the restoration of primary teeth [9]. It was first introduced in the early 1970s [10] and has been available for over 47 years now. The material exhibited many attractive features, including adhesion to tooth structure allowing for minimal removal of sound tooth structure, fluoride release providing cariostatic action and biocompatibility [11].

The aim of this review is to discuss the, properties, types and recent developments of glass ionomer materials, focusing on their use as a restorative material for primary molars.

Materials and Methods

A literature search was performed using electronic databases "PubMed", "EBSCO", "Science Direct" and "Google Scholar" for relevant studies written in English and published between the years 1990-2018. Full text articles and abstracts were utilized to isolate studies that provide information on the composition, properties and modifications of glass ionomer materials, and on the setting reaction, application technique, and clinical success of conventional GIC, resin modified glass ionomer cement (RMGIC), hydroxyapatite enhanced glass ionomer cement and finally the resin-based materials with glass ionomer particles. Both clinical trials and *in-vitro* studies were used.

Results and Discussion

A total of two hundred and twenty-nine articles were reviewed along with multiple references obtained from review articles. From those one hundred and twenty were found to be the most relevant and were used for this review.

Composition of Glass Ionomers

Glass ionomer materials are basically composed of aqueous polymeric acids and fluoride containing silicate glass particles. The two are mixed together either manually, or if supplied in a capsule then they are mixed using an automated mixer to produce a viscous paste [12].

The Polymeric acid used in GIC is polyalkenoic acid, either the homopolymer (polyacrylic acid), or the copolymer of acrylic acid and maleic acid. The type of polymer used influences the properties of the produced cements by affecting the molecular weight. High molecular weight polymers increase the cement's strength, but on the other hand, they increase its viscosity making the cement hard to mix [12].

The glass particles in the GIC are mainly calcium or strontium alumino-fluoro-slicate powder [13]. This powder must be basic in nature, so it can react with the polymeric acid to form a salt. This is established by using both alumina and silica in the preparation [12]. Calcium and strontium can substitute each other in the preparation of the glass particles, replacing calcium with strontium has the effect of increasing the radiopacity of GIC without negatively altering the cement appearance [12,13].

General Characteristics of Glass Ionomers

Glass ionomers are known to have a number of potential advantages over other restorative materials including fluoride release, chemical bonding to tooth structure and biocompatibility [14]. In addition, GIC have low setting exotherm which makes them safe for placement near the pulp tissue without worrying about thermal damage [15].

Adhesion to Tooth Structure

The ability of glass ionomer to adhere to tooth structure is a great clinical advantage as it allows for better retention, and minimizes microleakage [12].

The principle behind the adhesion of GIC to dentin is explained by two inter-related mechanisms. The first one relies on forming a hybrid layer (micromechanical interlocking) where the polyalkenoic acid component of the GIC acts on exposing the collagen fibers present in dentin allowing the ionomeric components of the cement to diffuse into the collagen matrix and create micromechanical bonds [16].

In clinical practice, the application of a conditioning solution (37% aqueous polyacrylic acid for 10 - 20 seconds) followed by rinsing on freshly cut tooth surface allows for removal of the smear layer, helps in opening the dentinal tubules, and partially demineralizes the tooth surface leading to an increase in the surface area available for micromechanical interlocking [16].

The other principle, the true chemical bonding is based on the ionic bonds that form between the carboxyl groups of the polyalkenoic acid and the calcium ions of the hydroxyapatite (HA) crystals that are bonded to the collage fibers [17]. Overtime, an ion-exchange layer is formed between the GIC and the tooth structure as ions continue to diffuse in the interface zone, this allows the material to adhere strongly to the tooth structure [18].

Fluoride Release and Recharge

The release of fluoride is considered one of the most important assets of these materials [19]. Fluoride released from glass ionomer materials increases in acidic conditions and helps buffering the acidity by raising the pH level of the oral environment [20]. This property allows glass ionomer restorations to promote remineralization of dental surfaces adjacent to them by inhibiting acid induced demineralization of those dental tissue surfaces [21].

It has been proposed in the literature that fluoride release in glass ionomers happens through two main mechanisms, the first is a quick, short-term reaction that occurs during the first 24 hours after restoration placement and comprises dissolution of fluoride ions from the glass particles at the surface of the restorative material when the setting reaction takes place [22]. In one study, it was shown that the greatest amount of fluoride release occurred especially during the first 4 hours after restoration placement [23].

The second mechanism involves a more gradual, sustained, long-term release of fluoride ions from the bulk of the restoration that occurs when the glass particles dissolve in the acid water of the hydrogel matrix [24]. Long-term fluoride release from GICs has been shown to extend from several months to over 3 years in *in-vitro* studies [25,26].

The cariostatic action of GICs is dependent mainly on its ability to release fluoride ions during and after the setting reaction. However, the amount of fluoride ions released will decrease overtime. That is when "recharging" the restorative material with fluoride becomes beneficial. The ability of the restorative material to act as a fluoride reservoir depends on its permeability, a permeable material allows for deep absorption of the ions into the bulk of the material, while a relatively impermeable material will only allow absorption of fluoride ions into the proximate subsurface [27].

The differences in the capabilities of restorative materials to absorb and release fluoride were demonstrated in Preston., *et al*.s' study [28] . Glass ionomer restorative materials, resin modified glass ionomer materials, compomers and composites were charged with a sodium fluoride solution containing 500 ppm fluoride ions 13 times over a period of 2 years. At the end of that period, glass ionomer-based materials showed a significantly better potential to release fluoride, followed by compomers indicating their ability to recharge themselves with fluoride while composites' ability to recharge was almost negligible. Furthermore, studies have shown that daily brushing with a fluoridated toothpaste showed significant recharge-ability in glass ionomers [29].

On the other hand, it has been shown that aged glass ionomer restorations tend to lose their ability to recharge [30]. In one study [31] they found that 1 month old glass ionomer restorations showed minimum to no recharge of fluoride suggesting that these materials may be less effective at undergoing fluoride recharge than has been previously assumed.

Antibacterial Effect

GICs are also known to have antibacterial effects. Studies have reported that the populations of mutans streptococci found on the surfaces of glass ionomer restorations were lower than the one found on composite resin restorations [32,33]. Studies have also shown that the drop in pH after sucrose fermentation by mutans streptococci layered on a surface of a GIC disk was less than that on a surface of a composite resin disc [34] suggesting that glass ionomers have the ability to inhibit acid production by mutans streptococci leading to a decrease in their population [35].

In a more recent *in-vitro* study, new insight was provided that supports the antibacterial effect of GIC and its effect on the bacterial acid production, extracellular polysaccharides formation and the accumulation of cariogenic bacteria. It was also concluded that this anticariogenic action is strongly correlated with the fluoride release that occurs during the second slow phase [36].

Several glass ionomer-based products were developed for clinical use, each with their own special properties and advantages. Modifications were done to either enhance good qualities or to strengthen physical weaknesses. In addition, resin-based materials were modified by the incorporation of the glass ionomer part.

Conventional GIC

Starting with the initial product, the first generation of GIC produced in 1972 was called Alumino – Silicate Polyacrylic acid (ASPA-I). This product displayed very poor setting and was followed by the ASPA-II where tartaric acid was added to the mix to enhance the setting reaction. ASPA-III came next but was discontinued because it stained the mouth, and ASPA-IV was the first product that could be commercially marketed [37]. These products were supplied as glass powder and polyacrylic acid liquid, as a result, any increase in the molecular weight or concentration of the acid leads to increase in the viscosity of the liquid, making the cement more difficult to manipulate [37].

The second generation GIC, also called "water-hardening GIC" has water as the liquid component of the cement, and the polyacrylic acid is used in its solid form and mixed with the glass powder [38]. The main advantage of this modification is the ability to increase the molecular weight of the acid without altering the viscosity of the cement [37].

Setting Reaction

Conventional GIC sets by an acid-base reaction during which a number of ionic elements are released from the glass particles including fluoride ions [22]. Tartaric acid is added to the mix to delay the setting reaction, increase the working time, and improve manipulation of the cement [37].

Restoration Technique

Conventional GIC is supplied either in 2 bottles that contain the polyalkenoic acid in one and the glass powder in the other, where the acid and power are mixed manually on a mixing pad. Or it can be supplied in capsules where it can be mixed using an automated mixer and then activated and applied using a specially designed applicator gun.

Prior to restoration placement, the tooth surface should be treated with a conditioning solution (37% aqueous polyacrylic acid) for 10 - 20 seconds followed by rinsing to remove the smear layer. Then the material is applied and molded and left to set. A light-cured varnish is available for coating the restoration and limiting the water movement across its surface. It also helps with the color stability of the restoration [39].

Clinical Success

For the restoration or primary molars, based on strong evidence, conventional GIC was not recommended for restoring class II cavities [40,41]. It was found to have poor anatomical form and marginal integrity [42,43].

In a clinical study [44] comparing the performance of GIC with amalgam, a total of 1058 restorations were placed in different types of cavity preparations. The 36-month follow up results for the class II cavities demonstrated a significantly higher failure rate ($p < 0.001$) in the GIC group (22%), and tooth or restoration fracture was the most common cause for failure (26%). The 96-month follow up results [45] showed an increase in the failure rate of GIC restorations from 22% to 46%.

Modifications

In the process of enhancing the mechanical and physical properties of GIC, several modifications have been introduced in the clinical field.

The addition of metal powder or fibers to the GIC mix can improve its strength [37]. It was suggested that these materials can be used instead of amalgam restorations in primary molars [46]. However, it was found that this cement did not possess adequate compressive and flexural strength [47,48]. In one study, silver reinforced GIC, performed significantly worse than conventional GIC and it was not recommended for restoring primary molars [49]. In addition, the unpleasant metallic color of the material did not make it desirable when other esthetic alternatives were available.

Highly viscous glass ionomer cement can be considered an upgrade to the conventional GIC. The high viscosity GIC is especially useful when atraumatic restorative treatment (ART) or Interim therapeutic restoration (ITR) are considered. Several studies have shown a survival rate that is comparable to conventional restorative treatment when high viscosity GIC is used for ART/ITR in single surface cavities [50,51]. The setting reaction of high viscosity GIC is rapid and depends only on the acid-base reaction, it is more moisture tolerant and its solubility in the oral fluids is low [37]. In one study, the clinical performance and survival of a high viscosity GIC was found to be satisfactory after 2 years of placement in small-medium sized cavities in primary teeth [52].

ART and ITR are both treatment options that share the same technique, however, the goal of the treatment differs. The concept is based on minimizing the intervention and maximizing the prevention and preservation of tooth structure [53]. Initially, it was performed using conventional GIC and a hand instrument to remove the carious tooth structure. Nowadays, highly refined, sharp hand instruments are used to allow simultaneous caries removal and cavity preparation [54,55] accompanied by high viscosity GIC with better physical properties [56].

Interim therapeutic restorations (ITR)are used in very young uncooperative patients [57], or patients with special health care needs where the more technique sensitive options cannot be performed [58]. Moreover, they are very useful for caries control in children with multiple open carious lesions before definitive restoration placement [59].

There is strong evidence supporting the use of the atraumatic restorative treatment (ART) technique in restoring single surface lesions in primary and permanent dentitions [50]. There is evidence as well that ART provides similar survival rates as conventional restorative treatments and is a viable option for restoring inter-proximal lesions in the primary dentition [60].

In one study [51], cavitated primary molars were restored using one of the following treatment protocols: conventional restoration with amalgam; ART using high viscosity GIC; and an ultra-conservative method consisting of ART for small dentine lesions, and enlarging the cavity to facilitate plaque removal with a toothbrush and fluoridated toothpaste for larger lesions. The results indicated that after 3.5 years, no significant difference in the survival rate of restorations was observed between the 3 different treatment protocols, it was also found that the survival rate for molars with single-surface cavities was higher than molars with multiple-surface cavities.

Resin Modified Glass Ionomer Cement

To overcome the disadvantages and problems related to conventional GIC, resin-modified glass ionomer cement (RMGIC) was developed. These restorative materials have shown better wear resistance and higher fracture toughness than conventional GIC [61].

Composition and Setting Reaction

RMGIC is essentially composed of the same components found in conventional GIC, but it also includes a monomer component 2-Hydroxyethyl methacrylate (HEMA) and an initiator (camphorquinone) [12].

RMGIC sets by two different mechanisms. Initially it sets through polymerization of resin thus improving the setting time without compromising the handling properties, followed by additional hardening through the acid–base reaction [11]. Furthermore, most of these materials have the "auto cure or dark cure" property which allows it to achieve complete setting even in areas where the light has not reached [62].

Properties

Fluoride release, and simple clinical handling characteristics of the RMGIC are the main reasons for making it a successful restorative material for use in children [56].

The ability of the material to adhere to tooth structure, and to release fluoride were not altered by the addition of the resin component and are similar to those of conventional GIC [12]. One of the most clinically useful properties of RMGICs is that they are not hydrophobic and sensitive to moisture as composite resin. Visible moisture may cause failure of the restorations, however, the smaller amounts of moisture that are not visible during the procedure that are tolerated by the material [56].

Of all the modifications and alterations done to improve the properties of GIC, RMGIC was the most promising. However, despite the fact that RMGIC clinically performs better than GIC, it remains important to remember that RMGIC contains HEMA and other cytotoxic components rendering it a less biocompatible than regular GIC [35].

Restoration Technique

Similar to that of conventional GIC, however, the material is cured using a light curing device to allow for the setting reaction to take place. A study has shown that conditioning the cavity prior to the application of the RMGIC restoration improved the success rate of the restoration [40].

Clinical Success

In the literature, there is evidence that RMGIC is successful in restoring small to moderate class II cavities in primary teeth [40]. Among the studies that were considered in a systematic review [40], only two studies were ranked as high-level evidence in relation to the rest [11,63]. The first one was a randomized clinical trial that included 115 primary molars with class II lesions. They were randomly assigned to either GIC or RMGIC. The results showed that RMGIC performed significantly better at the 36-months follow up ($p < 0.05$) than GIC and that the risk of failure of GIC restorations was 5 times higher. It was also noted that the main reasons for failure for both types of restorative materials were loss of retention and secondary caries [11]. The second study was conducted in a private practice in Greece and included 41 pairs of primary molars with class II lesions. They found that after 24 months, the reported failure rate of RMGIC restorations was 2.4%, but the dropout percentage was considerably high (56%) which might have influenced the results [63].

In a clinical trial comparing the success of GIC with RMGIC [64], the 96-month follow up results showed that 46% of GIC and 36% of RMGIC class II restorations failed, and fracture and loss of retention were the main causes of this failure. When calculating the 50% survival time of the two types of restorations placed, it was 55 months for RMGIC and 48 months for GIC and this was found to be statistically significant ($p < 0.01$). It was concluded from this trial that RMGIC can be recommended for use in primary teeth with class II cavities, however GIC showed better longevity as class III and class V restorations [64].

Hydroxyapatite Enhanced GIC

The ideal restorative material would be one that can be replaced naturally after placement by healthy tooth structure [65]. Attempts have been made to achieve that goal, and the addition of HA particles to the biocompatible GIC is one of them [66]. This started as early as the 1980s with Yamamoto [67] and since then several studies targeted the assessment of the effect of adding HA to conventional GIC restorative materials. [68-71].

Composition and Setting Reaction

Hydroxyapatite crystals $Ca_{10}(PO_4)6OH_2$ are similar in structure to the apatite crystals that are found in the human bones and are greatly biocompatible with the human tissues. They are composed of a form of calcium phosphate that constitutes the main mineral component of tooth enamel and comprises more than 60% of dentin by weight [72]. When HA is added to GIC, the crystals interact with carboxylate groups of the polyacid. This leads to an improvement in the biocompatibility of GIC and potentially the enhancement of the mechanical properties of this material. Furthermore, this interaction renders the material with a structure that is similar to enamel and dentin, which can potentially result in an increase in the restoration's bond strength to the tooth structure [72].

Studies have shown that the addition of the HA particles to the glass ionomer powder has the ability to increase the fracture toughness of the cement [70,71] and improve its flexural strength and microstructural properties [73].

Moreover, other studies mentioned that the incorporation of HA did not affect the sustained release of fluoride from the restorative material and that it helped in maintaining the long-term bond strength to dentin, and that GICs containing 4% by weight of HA particles exhibited enhanced mechanical properties in comparison with commercial GIC [69,74].

The release and re-chargeability of fluoride from GIC is not affected by the incorporation of HA particles [70,75]. In one study, it was shown that HA enhanced GIC acted similarly to conventional GIC in the manner of fluoride release showing initial burst of fluoride concentration following recharge and continued to increase until the third day. After which decline was seen up till the seventh day and finally reaching a plateau extending up to the 21st day [75].

Glass carbomer cement (GCC) is a commercially available HA enhanced GIC. It is a monomer-free, carbomised nano-glass restorative material developed from traditional GIC. In addition to the fluor-aluminium silicate glass particles the GCC contains nano-sized particles of HA and fluorapatite as secondary fillers [76]. The reactive glass is activated with dialkyl siloxane as described in the European Patent, number 20040748628 and the liquid part of the cement is polyacrylic acid [77].

Fluorapatite is added to the GCC to accelerate the remineralization process. It is a more stable form of HA, which is normally found in mineralized tissues. The use of nano-technology greatly increases the reactive surface of the filling material and reduces the amount of matrix between the glass particles providing better physical properties [66]. In A previous research, The chemical transformation of the GCC material into fluorapatite-like material in primary teeth was established after dwelling for 2 - 3 years *in vivo* [78].

Restoration Technique

No conditioning of the cavity is required prior to placement of the restoration. The GCC restorative material is supplied in premeasured capsules that are mixed using a high frequency automated mixer. It is cured through exactly targeted heat. A lamp has been specially developed for this purpose by the producing company and is an integral part of the glass carbomer technology. The thermo-cure lamp is a high-energy lamp that produces heat up to 60°C and operates on wavelengths higher than those produced by regular light cure devices (>1200 mW/cm^2).

The material is also supplied with an organic, biocompatible surface varnish that is carbon-silicone based and is said to help in producing a superior restorative material. It adds to the transparency of the material which is essential for optimum heat-based setting allowing the deeper penetration of the radiating heat [66]. It acts as protector from moisture and saliva contamination during the initial setting phase and from dehydration later on [79]. It also renders the material more insoluble and less susceptible to dissolution by acids [66].

Clinical Success

The GCC is available as a restorative material and a pit and fissure sealant material. There were very few clinical trials conducted using this material, and the ones found were limited to the use of the fissure sealant product rather than the restorative material [76,80-82]. In two studies [80,81], the caries preventive effect and retention of different types of sealants: GIC, GCC, and composite resin was evaluated. The results showed that after two years, significantly more carious pits and fissures were observed with GCC sealants, and the retention of the GCC sealant in occlusal and smooth surface fissures was found to be significantly lower than the other groups.

On the other hand, in another clinical study [76] the retention of the GCC sealant was compared with a commonly used, fluoride releasing resin-based sealant (Helioseal F, Ivoclar Vivadent). The 12-month results showed complete retention in 75% of the GCC and composite sealants and no statistically significant difference ($p < 0.05$) between the two materials regarding the retention rate was found. Additionally, no significant difference in secondary caries development was found between the two materials as well. Similarly, in a more recent study [82] the retention and caries inhibitory effect of GCC sealants were not significantly different from Embrace Wet Bond (a resin based, fluoride releasing sealant) after two years of follow up.

Due to the contradicting findings of the previous studies, it can be concluded that further clinical investigations are required before the long-term success of the GCC material can be determined.

Resin Based Materials with Glass Ionomer Particles (Compomers and Giomers)

These materials were developed to help overcome the moisture sensitivity and poor mechanical performance of conventional GIC, while retaining the fluoride release ability that characterizes the GIC. They provide esthetics and mechanical properties that are comparable to composite resin restorations [22].

Composition and Setting Reaction

Compomers, also known as “polyacid-modified composites”, are composed of ion leaching glass (calcium fluoro-alumino silicate glass), embedded in a polymer matrix. They set by polymerization of the monomers which is a light activated reaction. A limited acid-base reaction takes place later when the material is able to absorb water [83].

Giomers include pre-reacted glass-ionomers to form a stable phase of glass-ionomer fillers in the restoration. They differ from compomers in the fact that the fluoro-alumino-silicate glass particles reacted with polyacrylic acid in the presence of water before they were embedded into the resin matrix [22]. Because of this, pre-reacted fillers allow for increased fluoride release [84].

Restoration Technique

These materials are like composites do not require mixing prior to application and can be dispensed immediately into the cavity. The application of a compomer restoration requires less steps than a composite resin restoration since no etching is required [83,85]. However, both materials are light activated and do not adhere to the tooth structure, thus, as with composites, they both require the use of an adhesive system [86] which would necessitate some compliance from the patient [87]. Due to the nature of the setting reaction, these materials are subjected to polymerization shrinkage, so incremental application is recommended [83].

Clinical Success

Several studies demonstrated a clinical success of compomers that is similar to composite resin when used for restoring primary teeth [88,89]. When compared to GIC and RMGIC in restoring primary teeth, compomers showed better physical properties and similar cariostatic effect [45,90].

Regarding giomers, when comparing their clinical success in permanent dentition, they were found to maintain good quality for a period of eight years [91]. When used for restoring class II cavities in primary molars, giomers had the longest survival rate when compared with RMGIC, compomer and composite resin [92]. Another study also found that up to two years, giomers were useful for esthetically restoring primary and permanent molars [93].

Conclusion

Glass ionomer is a very versatile material and has boundless potential in pediatric dentistry, it is bioactive because of the ion exchange that occurs after the material sets and allows for adhesion to tooth structure and for fluoride release. Poor mechanical properties were the main weakness of this material, however modifications including resin modified glass ionomers proved to be successful for restoring primary molars. The glass carbomer cement, another modification of glass ionomer cements still needs to be studied furthermore.

Conflict of Interest

There is no conflict of interest among the authors of the review in relation to this article.

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