Review Article

# Resin-modified Glass Ionomer Cement and its Use in Orthodontics - Concept Old is Gold: View Point

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**ABSTRACT**

Developed in 1992 and ADA specification number-92, glass ionomer cement (GIC) (silicate glass powder and an aqueous solution of polyacrylic acid) is widely used as restorative material in conservative dentistry for luting, for restoration (esthetic and reinforced), orthodontic treatment, cavity base, and buildups. While the modified resin GIC, the simplest form of GI cement which contains a small quantity of a water-soluble and polymerized resin component is widely used restorative material and in orthodontic practice also known as traditional GIC. Due to lack of moisture sensitivity, low mechanical strength, and impaired translucency in 1988, resin-modified GI (RMGI) cement were introduced by adding polymerizable hydrophilic resin to CGI (Conventional GI) formulations. Its adhesive nature of getting adhere to both enamel and dentin makes it more attractive to use in orthodontic and in various other branches of dentistry. Orthodontic usage of GIC increased dramatically with the development of resin-modified GIC. These are adhesive cement with improved physical properties and more stable hydrogels compared with GIC. This article critiques the literature to evaluate the cement for its credibility as orthodontic cement, both regarding varied applications as well as physical properties attributed when compared to other commonly used cement available for applications in orthodontic.

**Key words:** Glass ionomer cement, hydroxyethylmethacrylate, resin-modified glass ionomer cement

## INTRODUCTION

Orthodontics devices should interfere minimally with the patient's comfort appearance, oral function and hygiene. Although various dental cements and resin adhesives are used to attach orthodontic devices to the teeth, the higher strength dental cements and improved resin adhesives permit the use of smaller, more patient-friendly orthodontic devices. It is also desired to develop orthodontic appliances and materials, which are more hygienic and less harmful for the oral environment and teeth. This desire has led to the development of resin-modified glass ionomer cements (RMGIC) for orthodontic bonding.

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GIC

- RMGICs (traditional GICs- hybrid) in traditional GICs small amount of light curing resin were added thus exhibit properties of both. And due some more additional features, it exhibits more superior than conventional GICs.
- RMGICs (conventional GICs)
- Nanoionomer (fluoroaluminosilicate- as filler <3 micron)- developed in the field of RMGI is a hybrid of traditional GIC and nanofiller technology. Furthermore, known as nanofilled RMGICs.

The new and modified resin cements in orthodontic treatments such as adhesive resins and hybrid cement resin combinations offer improved physical properties and clinical benefits.[1]

The integrity of an orthodontic appliance is essential in orthodontic treatment to the continuity of treatment mechanics. Although direct bonding of fixed orthodontic appliance attachment is in routine practice for anterior teeth, while molars are often bonded because of the failure

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rates tend to be lower in molars than that of anterior bonded attachments.[2] Improved retention is mainly due to increase in surface area of the bands.

In early time of orthodontics zinc phosphate cements were used for molar band cementation until 1980s but due to the incidence of increased solubility and enamel demineralization in zinc phosphate under loose bands, GIC has become a more attractive alternative in orthodontics especially due to its property of fluoride release.[3]

Other names are:
- Hybrid ionomers
- Resin-reinforced ionomers
- Resin-modified ionomers
- Resinomers
- Ionomer-modified resins
- Polyalkenoate cement.

Widely used nick name of GIC:
- Dentin substitute
- Manmade dentin
- Artificial dentin.

Introduced in the US as alumno silicate polyacrylate.

## HYBRID CEMENTS

To increase fluoride release and obtain adequate bond strength compared to composites, the combination of GIC and composite resin were developed to create "hybrid cement" which allowed snap set, decreases moisture contamination and increase the rate of strength development. These materials are intended to overcome the disadvantages of conventional GICs while preserving their clinical advantages.

RMGIC is such combination. They consist of two components; they self-cure by acid-base reaction of GIC have a diffusion-based adhesion between the cement and tooth surface. Polyacid modified composite resins consist of a similar combination. They are essentially resin matrix composites in which filler is replaced by ion-leachable aluminosilicate glass that will not self-cure by acid-base reactions of GIC and behave primarily like resins,[4] which sets by polymerization of methacrylate group.

RMGICs have been introduced to restorative dentistry during the mid-1990s, and then, into orthodontics. Several studies have been carried out on this material, and the results have been very encouraging.[5]

Orthodontic use of GICs increased dramatically with the development of RMGIC. These are adhesive cement with improved physical properties, and more stable hydrogels compound with GICs.[1,6]

## SETTING REACTION OF RMGIC

RMGIC has a setting mechanism by three reactions when the powder and liqfuid are mixed; an acid-base reaction similar to that of conventional GIC is initiated. In addition, this material can be cured quickly by light activation from the visible light-curing device. The light activates free radical polymerization of hydroxyethylmethacrylate (HEMA) and other two monomers to form a poly-HEMA matrix that hardens the material. The third reaction is a self-cure of resin monomers. It is the light initiated reaction that allows for the early placement of the arch wires, while the acid-base reaction occurs simultaneously and continues for a period after the mass has been cured by light activation. It is believed that poly-HEMA and polyacrylic metal salt ultimately forms a homogenous matrix that surrounds the glass particles. As results, light activated polymerization reaction is well-harmonized with acids base reaction in this formation.

Literature reveals the widespread use of these hybrid cements not only as luting agents but also as bracket adhesives. Currently, the most commonly used adhesives for orthodontics bracket bonding is based on composite resin. However, GI systems have certain advantages. They bond directly to tooth tissue through the interaction of polyacrylate ions and hydroxyapatite crystals, thereby avoiding acid etching. In addition, they have a cariostatic action due to their fluoride leaching ability.[6] Nevertheless, their use in orthodontic bonding has been limited due to inferior mechanical properties, in particular bond strength.[8]

The advantages of the hybrid ionomer and the resin cement over the traditional GIC include the following, improved setting time, longer working time due to snap set by photo curing and a rapid development of the early strength, which makes the set matrix more tolerant to the effects of moisture, thus these superior properties accounting for increase in bond strength.[9,10] However, studies suggest that the new generation of RMGICs, which include varying amounts of a photocurable monomer, have improved properties including bond strength.[11-13]

The latest introduction has been the paste-paste type of RMGIC, which makes clinical hardening safe and easy and had performed well without clinical failure over a 21-month period.[14]

## PROPERTIES

### RMGIC, Band Cementation Material

Millett *et al.*[15] compared mean shear-peel bond strength and predominant site of bond failure of micro-etched orthodontic bands cemented with RMGIC, a modified composite or a conventional GIC. The survival time of bands was also assessed following simulated mechanical stress in a ball mill. There was no significant difference in mean shear-peel bond strength between the cement groups. The proportion of specimens failing at each interface differed significantly between cement groups. The predominant site of bond failure for bands cemented with the RMGIC was at the enamel/cement interface which implies faster clean up time following debanding clinically with these luting agents than with other cements. The mean survival time of bands cemented with either of the RMGICs or with the modified composite was significantly longer than for those cemented with the conventional GIC. The findings indicate that although there appears to be equivalence in the mean shear-peel bond strength of the band cements assessed, the fatigue properties of the conventional GIC when subjected to simulated mechanical stress seem inferior to those of the other cements for band cementation.

The study was performed (1) to compare the mean shear-peel bond strength of orthodontic bands luted to porcelain molar denture teeth with GIC, RMGIC, or compomer cement; (2) to assess the amount of cement remaining on the teeth after debanding; (3) to compare the survival times of the cemented bands subject to mechanical fatigue. No differences were found in mean shear-peel bond strength among the three groups. The amount of cement remaining on the teeth varied between the compomer and GIC groups, with more compomer cement remaining relative to GIC. The mean survival times of bands cemented with compomer or RMGIC were longer than for bands cemented with GIC.[16]

Uysal *et al*.[17] compared microleakage patterns of conventional GIC, RMGIC, and polyacid-modified composite for band cementation. Conventional GIC is associated with more microleakage than RMGIC and modified composite at both cement-band and cement-enamel interfaces.

## RMGIC, BONDING MATERIAL

Three orthodontic adhesives were compared in the areas of shear-peel bond strength, location of adhesive failure, and extent of enamel cracking before bonding and after debonding of orthodontic brackets.[18] The adhesive included a composite resin control, a RMGIC, and a polyacid-modified composite resin under dry and saliva-contaminated conditions. Although the bond strength of the composite resin control (20.19 MPa) was significantly greater ($P < 0.05$) than that of the adhesives in the other groups, clinically acceptable shear-peel bond strengths were found for all adhesives.

Jost-Brinkmann and Böhme[19] compared bond strength of light-cured RMGIs with composite adhesives strength for bonding ceramic brackets to metal and porcelain. In addition, the effect of mechanically retentive versus silanized bracket bases on shear bond strength was investigated.

The investigated light-cured GICs provide sufficient strength for bonding ceramic brackets, but in terms of bond failure site and bracket fracture, they provide no advantage over composite adhesives.

## EFFECT OF DIFFERENT CURING METHODS ON BOND STRENGTH

Conventional GICs may be a viable option for bracket bonding when the major disadvantages of these materials, such as the slow setting reaction and the weak initial bond strength, are solved. Normally, RMGICs and conventional GICs require several days to reach full strength. During this period, the cement is still weak and the conventional GICs, in particular, are susceptible to dissolution. Algera *et al*.[20] investigated the influence of ultrasound (UC) and heat application on the setting reaction of GICs, and to determine the tensile force to debond the brackets from the enamel. A conventional fast setting GIC and two RMGICs were investigated. Three modes of curing were performed (1) according to the manufacture's prescription (SC); (2) with 60 s application of heat (HC); or (3) with 60 s application of UC. The tensile force required to debond the brackets was determined as the tension 15 min after the start of the bonding procedure. Curing with heat and UC shortened the setting reaction and significantly ($P < 0.05$) increased the bond strength to enamel. The evaluation of the mode of failure after debonding showed an increase of cement remnants on the enamel surface in all groups after HC or UC compared with SC. However, at this stage with current materials such as fast setting conventional GIC, the bond strength obtained with HC and UC is still low compared with RMGIC.

Wendl *et al*.[21] compared shear bond strength after 1 and 24 h of a light-cured resin and a light-cured GIC using various polymerization lamps (halogen, high-performance halogen, xenon, and diode) for the direct bonding of brackets. The self-curing resin was used as the control. All polymerization lamps achieved the minimum bond strength of 5-8 MPa. With light cure resin bond strength was dependent on curing time. Halogen lamp achieved the highest bond strength with a curing time of 40 s. Bond strength for RMGIC, on the other hand, was independent of the duration of light curing and the type of lamp used. The bond strength of the RMGIC were similar to or somewhat higher than those achieved with light-cured composite resin ($P = 0.039$) when lamps with short polymerization times were used but were significantly lower ($P < 0.001$) when compared with the self-curing composite adhesive. After 24 h, the bond strengths of all adhesives showed a significant increase. Bond failure for light cure resin occurred at the bracket-composite resin adhesive interface in 90% and with self-cure resin in 57%. However, RMGIC showed far more cohesive and mixed failures, indicating an improved bond between bracket and cement.

## FLUORIDE RELEASE

The oral environment of orthodontic patients undergoes changes, such as pH reduction, larger number of sites available for *Streptococcus mutans* collection, and increased accumulation of food particles, which may lead to an increased number of *S. mutans* colony-forming units (CFU) in saliva. Such changes may contribute to the development of the decalcification lesions frequently found at the end of orthodontic treatments.

Clinically, white spot lesions can be seen around brackets. These lesions are incipient carious lesions that can be remineralized by application of fluoride. Fluoride-releasing bonding materials and cements have been used because they reduce the need for patient compliance and potentially inhibit demineralization.

Fischman and Tinanoff[22] found no association between the amount of fluoride released and antimicrobial activity of RMGIC *in vitro*. On the contrary, the bacterial growth inhibiting effect seemed to be associated with GIC acid release. The reduction in RMGIC pH and the size of bacterial growth inhibition areas are consistently associated. The largest amount of acid release from RMGIC and its greatest antimicrobial activity are found immediately after the materials used. As time passes, less acid is released and bacterial growth inhibition decreases. A reduced inhibition effect for *S. mutans* seems to be associated with the fact that these microorganisms are acid-tolerant.

Mota *et al*.[23] investigated the number of *S. mutans* CFU in the saliva and plaque adjacent to orthodontic brackets bonded with a GIC or a resin-based composite. After placement of fixed orthodontic appliances, a significant modification in the number of *S. mutans* CFU in saliva was not observed. The number of *S. mutans* CFU in plaque adjacent to brackets bonded with RMGIC was smaller than in plaque adjacent to brackets bonded with resin-based composite only on the 15th day after placement of the appliance. Topical application of 0.4% stannous fluoride gel on the 30th day did not affect the number of *S. mutans* in plaque; the number of microorganisms in saliva, however, was reduced. This study suggests that the antimicrobial activity of RMGIC occurs only on the initial phase and is not responsible for a long-term cariostatic potential.

## EFFECT OF DIFFERENT BRACKET BASE SURFACES ON BOND STRENGTH

Fracture of the bracket-cement system usually takes place between the bracket and the cement. Especially for GI-based materials, it is helpful if this part of the system can be improved. Algera *et al*.[24] investigated the influence of different bracket base pretreatments in relation to three different cements, a resin composite, a RMGIC, a conventional GIC, on shear as well as on the tensile bond strength. Upper incisor brackets with three types of base treatment, sandblasted, silicoated, and tin-plated, were bonded to bovine enamel. Untreated brackets were used as the controls. The investigated base pretreatments did not have such a beneficial influence on the bond strength that improved clinical results can be expected. Improvement of the bond between bracket and cement might be found in other variables of the bracket-cement enamel system such as the elasticity of the materials.[25-27]

Advantages of RMGIC:

- Excellent compressive and tensile strength compared to water based material
- Very less sensitive to moisture during initial setting time
- Excellent bonding with composites
- Quality of fluoride release causes the formation of fluorohydroxyapatite which makes it more resistant to dimeralization
- Long working time with rapid set and early strength
- Have lower modulus of elasticity
- Twice flexible compared to water based GIs.

Disadvantages:

- Hydrophilic behavior
- Water expansion and hygroscopic expansion
- Leakage is less than water based material but more than resin-based material
- Contains free monomers
- Dehydration
- Rough surface texture and opaqueness.

## CONCLUSION

The RMGIC luting cement gives every indication of becoming the material of choice for cementation of crowns, space maintainers and in orthodontic bonds. Although more long-term data are needed concerning RMGIC, they show remarkable promise for materials at this stage of development.

With all this development on RMGIC, it might be tempting to conclude that original self-hardening GIC is obsolete. RMGICs were developed to overcome the high solubility of GIs. These cements bond to the inorganic dentin via a link to the calcium ion in the dentin. As with GIs, this is an acid-base reaction that occurs in an aqueous environment. By combining the advantages of GI and resin, these materials also release fluoride, have an increased resistance to microleakage, adhere to tooth structure, and are less soluble than a conventional GI.

Overall GICs are necessary materials for modern clinical dentistry. Development of RMGIC has opened a new dimension in restorative dentistry as well as orthodontics.

No material is perfect, but with current levels of intensive research on GI, deficiencies that exist seems to eliminate or at least reduced, resulting in an ever-improving range of material of this type.

Concept-old is gold: RMGIC still is focus because:
- Now with improved mechanical strength
- Need of esthetic in patients
- Higher bond strength.

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