Review Article

Modifications in Glass Ionomer Cement-development and Improvements

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Abstract

Dentin substitute belongs to the group of cements called acid–base cements. Glass ionomer cement (GIC) was found around mid-1970 by Wilson and Kent. Conventional GIC is available as powder and liquid. Setting reaction of GIC is acid–base reaction. GIC has wide range of applications in dentistry when compared with other tooth-colored restorative cements due to its biocompatibility, cost-effectiveness and ability to adhere to the tooth structure without any bonding agent, anti-cariogenic property due to its fluoride releasing capacity, thermal compatibility with enamel and dentin, and ability to seal even in the moist environmental conditions of the mouth. In spite of all the advantages of conventional GIC', certain disadvantages are lack of adequate strength and toughness, which has limited its use in high stressing bearing areas in posterior tooth. To overcome the problems, conventional GIC's properties are constantly modified by reinforcing with resins, metals, bio-active glass, proline, chlorhexidine, zirconia, hydroxyapatite, casein phosphopeptide-amorphous calcium phosphate, and nano bioceramic sized glass particle, calcium aluminate, composite, condensable/self-hardening GIC, low-viscosity/flowable GIC, and fiber-reinforced GIC. An overview of properties, limitations, advantages, disadvantages, and various applications of these recent advances in GIC's are discussed in this review article.

Keywords: Fluoride release, Glass ionomer cement, Restoration.

Introduction

Glass ionomer cement (GIC) also called as polyalkenoates/man-made dentin/dentin substitute is an acid–base biocompatible material cement which includes an fluoro-aluminosilicate glass powder, a polyacrylic acid, and tartaric acid in liquid, which forms ionic bonds with tooth structure.[1] It was first reported by Wilson and Kent in 1972. ADA specification number for GIC is 96. It has wide applications in dentistry, when compared with other tooth-colored restorative materials, GIC can be placed without any prior application of bonding agents in prepared cavities.[2] It has the ability to bond to the tooth structure which is prepared, including the moist environmental conditions and also seals the marginal gaps on the interfaces among restoration and the tooth substrate.

Composition

Conventional GICs are available as powder and liquid.

Powder

Silica, alumina, calcium, and fluoride form the basic constituents of GIC powder.

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Liquid

Tartaric acid, iconic, maleic, and tricarboxylic acids.

Mode of Supply

1. Powder-liquid form
2. Capsulated form
3. Twin syringe form.

Setting Reaction

GIC's setting reaction takes place by acid base reaction. Four processes involved are dissolution, initial setting, final setting, and maturation. When the powder and the liquid are mixed together, the surface of the powder is dissolved by the hydroxyl ions from

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the liquid leaving an ion depleted silica gel layer. The fluoride ions gets released with calcium, aluminum, and sodium ions into the aqueous medium. There is an immediate rapid reaction of the calcium ions in the powder with the polyacrylic acid within the liquid for the initial setting, then another reaction occurs with the aluminum ions, which causes the more gradual slow release of the latter ion from its anionic complex. Reaction of these metal ions with the carboxylic acid groups tends to displace the water from its some of the hydration sites, and which leads to some ionic cross-linking of the polyacid chains. All these reactions lead to insolubilization and stiffening of the GIC restorative material.[3]

Classification Depending on Clinical Applications

- Type I GIC – used for luting, it has low film thickness and rapid set
- Type II GIC – used for restorative purposes
- Type III GIC – used as liners/bases, it has low viscosity.

Properties of GIC

- It is bioactive and biocompatible and its thermal diffusivity is close dentin thereby protects pulp
- GIC has anticariogenic property because it inhibits caries formation by releasing fluoride more therapeutically
- When compared with other tooth-colored cements,[4] GIC reported with very few allergic reactions and reduced dental post-operative sensitive.

Limitations

- GIC lacks color stability, poor esthetics
- Low flexural strength and fracture toughness leads to brittleness.[5]

Recent Modifications in GIC

To overcome these limitations, various modifications in the GIC were done.

Resin modified GIC

It contains polymers such as hydroxyethyl methacrylate hydrophilic monomers and associated initiator system. When compared to conventional GIC, it has higher flexural strength and fracture toughness.[6] Other properties are preventing post-operative sensitivity when placed under direct restorations, internal fluoride ion release to provide an sustained antimicrobial action.[7]

Condensable/self-hardening GIC

It is a chemically activated RMGIC; hence, there is no light activation and intended for luting. It contains monomers, benzoyl peroxide as chemical initiators and tertiary amines for its self-polymerization. It is commonly used in pediatric dentistry for cementation of luting crowns and bands. Even though it is packable and can be easily condensed, followed by easy placement, and rapid finishing can be carried out when compared with conventional GIC's.

Compomer

It is a material which has both the essential components of GIC from powder and liquid. The difference is that it contains powder and liquid but at levels lesser than to initiate the conventional acid–base reaction due to absence of polyacrylic acid liquid. It is combination of "comp" for composite "omer" for ionomer. Here, adhesion requires acid-etching as acid–base reaction for ion exchange which requires water, needs some time after placement. Bond strength is 18–24 Mega Pascal. Fluoride release is significantly less when compared with Type II or RMGIC. Fracture toughness, flexural strength, and wear resistance of compomer are higher when compared with conventional GIC but less than composite.[8]

Giomers

Hybrid restorative material consists of GIC and composite. It is based on the concept of pre-reacted glass ionomer technology (PRG), in which pre-reacted stable phase of GIC is used as fillers, it can be either surface pre-reacted/fully/entire pre-reacted type of glass ionomer.[8] The fluoroaluminate glass reacts with polyalkenoic acid in the liquid to yield a stable phase of GIC, followed by mixing the pre-reacted stable phased glass with the resin. Giomers are highly biocompatible restorative material, with higher fluoride release and it also resists plaque accumulation. Studies stated that giomers has mechanical and esthetic qualities similar to composite resins and ease of handling.[9]

Commericial name: Beautiful II, Reactmer.

Bioactive glass

At the University of Florida, Hench[10] found the first bioglass in the year 1973. When acid dissolutes glass, there is a formation of a layer which is enriched with the calcium and phosphate around the glass, and it can form intimate bioactive bonds with bone cells and gets fully integrated with the bone.[11] It has superior surface area with higher dissolution rate and thus faster apatite formation. It rises the pH of aqueous solutions, thereby inhibits bacteria's. GIC reduces marginal gap formation which is the main disadvantages of many cements.[11] Due to its hemostatic effect, it can be used in bone regeneration in interproximal bone defects.

Commericial name: Prevest DENTPRO MICRON bioactive Radio-opaque glass ionomer dental cement.

Zirconomer

Also called as white amalgam due to its increased strength and its durability. It is considered as a substitute for miracle mix. The addition of zirconia fillers increases the mechanical properties and mostly used in stress-bearing areas and also reduces the unnecessary mercury hazards.[12] It is indicated for people with high caries index due to its sustained fluoride release property and for superior esthetics.[13]

Chlorhexidine impregnated GIC

Chlorrhexidine hexametaphosphate (CHX) was incorporated into the GIC to enhance its anticariogenic property. It has a dose-dependent CHX release over a period of 14 months. Studies have reported that incorporation of chlorrhexidine diacetate and cetrimide at 2% tends to decrease the compressive strength and prolong the setting time.

Fiber reinforced GIC

It is also called as polymeric rigid inorganic matrix material, a light-cured GIC. Incorporation of continuous network fibers or scaffold of alumina and SiO_2 ceramic fibers into the GIC powder increases mechanical properties of GIC. This type of GIC increases the depth of cure, increases the flexural strength of the set cement, reduces the polymerization shrinkage, and improves wear resistance.[14]

Calcium aluminate GIC/CERAMIR

It consists of calcium aluminate and glass ionomer type I, designed mainly for luting the fixed prosthesis. Calcium aluminate maintains a basic pH during the process of curing. This polyacrylic acid has dual function, that is, cross-linked by calcium ions which are leached from both sides of GIC and calcium aluminate. Reduction in microleakage, excellent biocompatibility, as well as long-term stability and strength are the properties of ceramir.

Commercial name: Ceramir.

Proline containing GIC

It is an amino acid-containing GIC. Due to its excellent biocompatibility, it can be used as a dental restorative material as well as a bone cement. Proline modified GIC shows higher surface hardness values while comparing with Fuji IX GIC after 1 week of maturation.[8] Even though it showed water sorption that does not affect its fluoride release.

Hainomer

"HAINOMER" was developed by incorporating hydroxyapatite within the glass powder and studies also have shown a promising role as retrograde filling material during the initial clinical trial. It is used as bone cements in oral and maxillofacial surgical purposes since it directly bonds to bone and affects its growth and development.[15]

Commercial name: Micron super.

Amalgomers

Conventional GIC is a reinforced with ceramic to suit the strength and durability of amalgam and studies shown that its properties are even superior to dental amalgam. It bonds to tooth structure and has exceptional characteristics like GIC. Amalgomer shows the conventional acid–base reaction of GIC. It has properties of fluoride release, adhesion, and it prevent shrinkage, and creep corrosion which are commonly associated with other restorative materials. It is the world's first GIC to pass the ISO strength test.[16]

Commercial name: Amalgomer CR.

NANO bioceramic impregnated GIC

De Caluwe *et al*.[17] reported incorporating nano-sized glass particles into conventional GIC's. It enhance the compression strength and elastic-modulus and also affects the setting time. Incorporation of nano-sized particles led to wider particle size distribution, thereby improves its mechanical properties by increasing its mechanical values. Main property is that these nano-bioceramic impregnated GIC occupies the empty space between the glass ionomer particles and by occupying, it acts as a reinforcing material in the composition of GIC, which increases the serviceability and also increases the shelf life of GIC.

Commercial name: Ketac N100 light curing nano ionomer restorative.

CPP-ACP containing GIC

ACP was introduced by Aaron S Posener around mid-1960's. This GIC is reinforced by incorporating CPP, it has superior effects as restorative material. CPP helps in remineralization and has anti-cariogenic property. Studies shown that CPP-ACP incorporation with fluoride has synergistic potential for remineralization.[18] Incorporation of 1.56% CPP-ACP into the conventional GIC significantly increases its micro-tensile bond strength (33%) and compressive strength (23%) and also enhances the release of calcium, phosphate, and fluoride ions at both neutral and acidic Ph.[19] Superior luting cement for orthodontic band cement with an improved anti-cariogenic potential. It promotes remineralization of enamel subsurface lesions.

Commercial name: MI Paste plus: Recaldent.

Low viscosity/flowable GIC

It is a material developed to increase the amount of fluoride release in GIC without interfering in its strength. It is used as liners, pit and fissure sealers, endodontic sealers, and also in cervical areas which are generally hypersensitive.

Commercial name: Fuji lining LC.

This fluoride charged material has 2 Part, comprises restorative part and a charge part.

First part is used in the usual way, when the first burst of fluoride occurs, then the material is given a fluoride charge using the second charge part of material which is a gel material, it replenishes the first part by ion exchange and increases the therapeutic application of fluoride.

Low pH "smart" material

Even when the oral pH is low, the fluoride is released in the low pH material. It is also called "Smart" materials, due to its therapeutic use. The fluoride release is episodic to increase its therapeutic use.

Conclusion

GIC has vast therapeutic advantages particularly in caries prevention, remineralizing activity, but it has limited fracture resistance. These are the various recent developments and improvements in GIC done to overcome conventional limitations of GIC.

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