

GLASS IONOMER CEMENTS (GIC) IN DENTISTRY: A REVIEW

TR. Mahesh Singh*, P .Suresh**, J .Sandhyarani***, J .Sravanthi****

- *Government Medical College, Jagdalpur.
- ** Resident, Conservative and Endodontics.
- *** Dentist, Sandhya Dental Clinic, Jagdalpur.
- **** Dentist, Air Force Hakimpeth, Hyderabad.

Abstract: GIC (GLASS IONOMER CEMENTS) is the versatile material used in dentistry since 1871, but it's use resurged recently as an ideal cementing material. In view of it's wide use in dental practice, the discussion of GIC is important to the dental practitioners.

Key words: GIC (Glass Ionomer Cements), Dental Cement Material.

INTRODUCTION

“Necessity is the mother of invention”. It was the late 1960's. History had already witnessed a host of restorative materials including amalgam, composite, cast alloys etc. but all had fallen short of that certain perfection that the dental researches and clinician yearned for.....that of a material that would be esthetic, adhesive, biocompatible, anticariogenic and relatively economical. It was during this time that cement came into the picture and created quite a sensation by not only possessing a majority of the desirable properties but also providing much scope for modification and improvement. This was the Glass Ionomer Cement.

Glass ionomer is a combination of 'Glass' powder and 'ionomer'-ic acid GIC can be defined as a water- based material that hardens following an acid-base reaction between the basic fluoro aluminosilicate glass powder and an acidic solution of polyacrylic acid.

Composition

Powder = Is basically an acid soluble calcium aluminosilicate glass containing fluoride. It is formed by fusing silica + alumina + calcium fluorite, metal oxides and metal phosphates at 1100^o-1500^o C and then pouring the melt onto a metal plate / into water. The glass formed is crushed, milled and ground to a form powder of 20 – 50 μ size depending on what it's going to be used for. They get decomposed by acids due to the presence Al⁺³ ions which can easily enter the silica network. It is this property that enables cement formation.

Functions of components:

Alumina (Al₂ O₃)

- Increase opacity

Silica (SiO₂)

- Increase Translucency

Fluoride: Its has 5 functions

- Decrease fusion t^o
- Anticariogenecity
- Increase translucency
- Increase working time
- Increase strength

Calcium fluoride (Ca F₂)

- Increase opacity
- Acts as flux

Aluminium phosphates

- Decrease melting t^o
- Increase translucency

Cryolite (Na₃ Al F₆)

- Increase translucency
- Acts as flux

Na⁺, K⁺, Ca²⁺, Sr²⁺

- Include high reactivity of glass with polyacid.

Al₂O₃: SiO₂ ratio is crucial and should be $\geq 1:2$ for cement formation to occur. Cement formation will occur only when there will be sufficient replacement of Si by Al to render the network susceptible to acid attack.

The glass can be modified by several ways to enhance the physical properties of the cement.

1. Ca can be replaced by Sr, Ba or La to give a R/O glass
2. Washing glasses with organic acids to remove surface concentration of Ca which will help prolong WT
3. Corundum, Rutile, Baddelyte disperse phases can be added to increase flexural strength
4. Metals, resins, fibers are added to increase the strength.

Liquid: Originally, the liquid for GIC was an aqueous solution of PAA in a concentration of about 50%. This was quite viscous and tended to gel over time. Thus, PAA was co-polymerized with other acids such as itaconic, maleic and tricarboxylic acids. This polyelectrolytic liquid of GIC is, thus, also called as polyalkenoic acids. Recently polyvinyl phosphoric acid has also been introduced to this system.

A typical liquid of GIC contains 40-55% of 2:1 polyacrylic : itaconic acid co- polymer and water.

The basic functions of these co-polymers include:

- the co- polymeric acids are more irregularly arranged than the homo polymer. This reduces H- bonding between acid molecules and reduces degree of gelling
- decrease the viscosity
- reduce tendency for gelation, hence, improves storage.
- Increase the reactivity of liquid

The rest of the liquid comprises of water, which is an important constituent of GIC. It is the reaction medium and helps in hydrating the matrix.

Additives:

1. Tartaric acid

- Increases WT
- Increases translucency
- Improves manipulability
- Increases strength

5-15% of optically active isomer of TA is added.

2. Polyphosphates: extends Working Time.

3. Metal oxides: accelerates Setting Time.

The reactivity of the polyacid depends on:

- ingredients= maleic acid is a more reactive acid than PAA
- Mol .wt and concentration= increase reactivity

Properties of GIC

GIC show a variety of properties and are clearly very diverse materials

ADHESION:

Adhesion of GIC helps in:

- Providing a conservative approach to restorations
- Providing a perfect seal

Different Conditioners used are :

1. POLY ACRYLIC ACID : Is the conditioner of choice as it is a part of the cement forming acid. It alters the surface energy, exposing highly mineralized tooth surface to diffusion of acid and ion exchange. This enhances adaptation of cement (10%, 10sec)
2. 50% citric acid, 5 sec.
3. 25% tannic acid, 30 s
4. 2% Ferric chloride
5. NaF
6. EDTA
7. Mineralising solution –Levine solution

BIOCOMPATIBILITY:

Adverse affect of GIC on living tissues are minimal. Any inflammatory response of pulp towards GIC due to its high initial pH of 0.9 to 1.6 resolves within 20-30 days. No ill effects are caused by PAA because:

- PAA is a weak acid, which becomes weaker when partly neutralized
- Its diffusion into the tubular dentin is unlikely due to its high molecular weight and heavy chain entanglement
- It gets readily precipitated by the calcium ions in the tubules.
- Dissociated H⁺ ions remain near the chain due to electrostatic attraction

The occasional post insertions sensitivity encountered on luting full crowns is due to

- The high initial pH {2.33 (PAA) liquid and 1.76 (water settable)} which persists for about 5 mins.
- Lower P: L ratio
- Pre-existing pulpitis
- Minimal D thickness to prevent this, certain precautions should be taken.
- Don't remove smear layer
- Protect deep areas of cavities with Ca (OH)₂

ANTICARIOGENECITY:

GIC has the unique property of being cariostatic due to the sustained release of fluoride, which confers resistance to caries not only on the restored tooth but also on the adjacent tooth. The influence of fluoride is found in a zone of resistance to demineralization, which is at least 3mm thick around a GIC restoration.

Fluoride contributes to carious inhibition in the oral environment by means of both

- Physicochemical mechanism
- Biologic mechanism

AESTHETICS:

A degree of translucency exists for GIC due to the glass fillers. Its translucency depends on its formation. It is important to note that because of slow hydration reactions, Glass ionomer takes at least 24hrs to fully mature and develop translucency. Translucency increases as the cement ages. Resistance to stain is largely dependent on obtaining a good surface finish. The colour seems to be unaffected by oral fluids as compared to composites which tend to stain.

DIMENSIONAL STABILITY:

A correctly manipulated and protected GIC shows a volumetric setting contraction of ~ 3%. At higher humidities, the cement tends to absorb water and expand so much so that a net expansion occurs while at lower humidities, a low shrinkage occur.

DISSOLUTION AND DISINTEGRATION:

The loss of soluble matrix forming species from the cement can lead to disintegration of the cement. This can be caused by:

- Early water contamination
- Chemical attack such as plaque acids / APF gel application
- Mechanical wear

It is mandatory to protect the GIC in its first ½ hour of life. A solubility of only 0.4% (wt) is seen as compared to other cements

DURABILITY AND LONGEVITY:

According to one study, the GIC restoration evaluated in erosion-abrasion lesions, 83% showed retention even after 10yrs. Failure rate ranges from 0-70%, which is more of a measure of the clinicians skill than of the inherent quality of the material

STRENGTH:

One of the major limitations of GIC is their susceptibility to brittle fracture. As compared to composite and amalgam, GIC's are weak and lack rigidity. The weakness appears to be in the matrix, which is prone to crack propagation. A certain degree of porosity also develops as it is a 2 part material, which needs to be mixed prior to placement

RADIOPACITY:

GIC are fairly R/O due to inclusion of radio opacifiers like BaSO₄. Most GIC's are slightly more radiopaque than dentin and can be differentiated in radiograph.

Clinical Uses: According to Philip's classification**Luting cements (TYPE I):**

The ideal properties of a luting cement according to Mc Lean and Wilson are :

- Low viscosity and film thickness
- Long working time and rapid set at mouth temperature
- Good resistance to aqueous acid attack
- High compression and tensile strength
- Resistance to plastic
- Adhesion to tooth structure
- Cariostatic properties
- Biological compatibility with the pulp
- Translucency
- Radiopacity

Restorative Cement (Type II) :

Indications:

- The erosion/abrasion lesion
- Class V lesion
- Restoration of primary teeth
- Class III lesion
- Laminate restoration
- Microcavity preparation = box,slot,tunnel
- Atraumatic Restorative Treatment (ART)
- Patients prone to rampant caries
- Small medium sized class I lesion
- Repair of open margins around crowns and inlays.

The Powder:Liquid (P:L) = 3:1 As mentioned before, correct surface treatment, manipulation and protection are essential for a long lasting restoration.

Liner and base (TYPE III):

A lining cement is basically used to protect the pulp from temperature change, by sealing dentinal tubules. It needs to be only 0.5mm thick. They have low physical properties and are used to fill voids in cavity preparation. The P:L = 1.5 : 1

A base is used as a dentin substitute. According to Mount, the entire cavity should be filled with GIC and then cut back to make room for amalgam /composite.

Other Uses:

Orthodontic luting cements:

Luting cements are needed to effect a stable attachment of bands and brackets during tooth movement. A common clinical problem is

- demineralization and caries under brackets and bands
- detachment causing schedule disruption and Rx delay.

Both these problems can be solved by using GIC as F release reduces demineralization under brackets and bands. Conventional GIC has shown proven benefit over Zn PO₄ for band cementation with regard to retention and decreased demineralization.

Core build up:

The construction of a core is often necessary prior to crown preparation in order to give the final crown appropriate resistance and retention. Traditional GIC lack the necessary tensile and flexural strengths for anything other than small core build ups or blocking out under cuts in preparations.

GIC in endodontics:

They are used for:

- Sealing root canals orthogradely and retrogradely
- Restoring pulps chamber
- Perforation repair
- Sometimes for repairing vertical fracture.

GIC was used because of:

- Its capacity to bond which enhances seal and reinforces the tooth
- Its good biocompatibility, which would minimize irritation to periradicular tissues
- Its F release, which imparts an anti- microbial effect to combat root canal infection

CONCLUSION

In spite of substantial improvement GIC's have short comings with regard to moisture sensitivity, wear resistance, flexural strength and final finish. Even though chemical adhesion and fluoride release are major benefits, conventional GIC's are restricted to special indications like class III or class V cavities. Advancements have occurred to overcome these problems but most are still awaiting clinical trials.

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