Indian Dental Association Ludhiana
IDA LUDHIANA's JOURNAL:
le – Dentistry

Doi:10.21276/ledent.2021.05.01.09

Review Article

GIC and its Advancements: An Overview

Savita Dhingra[1], Kunal Singla[2], Radhika Singhal[3], Fathima Amal[4], Sheenam Kansal[5], Meenal Arora[6]

[1]Consultant Dental Surgeon, Vancouver, British Columbia, [2]Consultant Dental Surgeon, Panipat, Haryana, [3]Senior Lecturer, Department of Periodontics and Implantology, J.N.Kapoor DAV (C) Dental College, YamunaNagar, Haryana, [4]Senior Lecturer, Department of Conservative Dentistry and Endodontics, Pushpagiri College of Dental Sciences, Thiruvalla, Kerala, [5]Reader, Department of Conservative Dentistry and Endodontics, JCD Dental College, Sirsa, [6]Consultant Dental Surgeon, Karnal, Haryana.

Abstract

Due to continuous increase in demand of patients and challenges faced by dental practitioners, there is need for research and advancements in dentistry specifically in restorative materials like GIC, Composite and Ceramics. In this article, we are mainly concerned with basic GIC (Glass Ionomer Cement) and its modifications. Modifications should be done in both component i.e in liquid and powder. Various modifications carried out are poly acid- modified composite resins/compomers, self- hardening glass ionomers, new fluoride releasing glass ionomers, low pH "smart" materials, fluoride charge materials, bioactive glass, fibre – reinforced glass ionomer cements etc. Detailed explanation of basic GIC as material and its modifications are mentioned in article.

Keywords: Glass ionomer, Materials, Nanotechnology

Corresponding Author: Dr. Sheenam Kansal, Reader, Department of Conservative Dentistry and Endodontics, JCD Dental College, Sirsa, Haryana Email: sheenamkansal@gmail.com

How to Cite: Dhingra S, Singla K, Singhal R, Amal F, Kansal S, Arora M. GIC and its advancements. IDA Lud J –*le* Dent 2021;5(1):68-81.

INTRODUCTION

Glass Ionomer Cement was developed in England in the year 1972 by Wilson & Kent.[1] The glass ionomer cement has been evolved as a hybrid from the silicate cement & the polycarboxylate cement.[2] In this cement powder is glass & the setting reaction & adhesive bonding to the tooth involves ionic bond thats why named as glass iononer cement.[3]

History

The term glass ionomer was coined by Wilson & Kent in 1972[1]. Later, Mclean et al stated that more correct name for this cement is glass polyalkenoate cement because chemically they are not true ionomers[4] and because of extensive use of cement as dentin replacement, it has been referred as " Man-made dentin" or " dentin substitute".[5]

Glass ionomer is a reliable material that binds chemically to enamel, dentin & cementum. Its powder is an acid soluble calcium fluoro-alunmino silicate similar to that of silicate cement but, with higher alumina:silica ratio to overcome the deficiencies & limitations of silicate cement i.e. high solubility, mechanical adhesion to tooth & severe pulp irritant which was principle.[6,7]

Definition

Glass ionomer is the generic name of a group of materials that use silicate glass powder and aqueous solution of polyacrylic acid.[8]

Wilson and Niholson: A cement that consists of basic glass & an acidic polymer which sets by an acid base reaction between these components[9]

Classification

A) According to Wilson and McLean in 1988[10]

Type I – Luting Cements

Type II – Restorative Cements

Restorative Aesthetic

Restorative Reinforced

Type III – Lining /Base cements

B) According to Application[11]

1.Type I – Luting Cements

2. Type II – Restorative Cements

Aesthetic Filling Materials

Reinforced Materials

3. Type III – Lining Cement

4. Type IV – Fissure Sealant

5. Type V – Orthodontic Cement

6. Type VI – Core Build up Cement

C) Newer Classification[12]

1. Traditional Glass Ionomer

A. Type I – Luting Cement

B. Type II – Restorative Cements

C. Type III – Liners and Bases

2. Metal modified Glass Ionomer

A. Miracle Mix

B. Cermet Cement

3. Light cure Glass Ionomer

4. Hybrid Glass Ionomer

A) Composite resin in which filler sustained with glass ionomer particles.

B) Pre-cured glasses blended into composite

Composition

Powder[9]

Silica (SiO_2) – 35.2 - 41.9%, Alumina ($Al2O_3$) – 20.1 - 28.6%, Aluminium Flouride (AlF_3) 1.6 – 2.4 %, Calcium Fluoride (CaF_2) – 15-20 %, Sodium Fluoride (NaF) – 3.6-9.3 %, Aluminium Phosphate ($AlPO_4$) – 3.8 – 12 %, Lanthanum, Strontium, Barium in traces for radiopacity (Fluorides act as ceramic flux)

Powder of traditional GIC is a calcium fluoroaluminosilicate glass. This powder is referred to as an 'ION-LEACHABLE GLASS'.[13] Heating at 1100-1500^{0}C results in fusion of components to form a uniform glass. The molten mass is then cooled & the mass is then finally powdered to the required size. Particle size depends on its use i.e.For restoration- 50mm, For luting- 20mm. Finer the particle, rapid the setting & stronger the cement.[9]

Function of each component[14]

- Silica, alumina, calcium fluoride (fluorite) take part in reaction with acid to form soluble gel.
- Fluoride: Lowers the fusion temp, working characteristics of paste is improved, strength of set cement is increased and in moderate amount enhances translucency. Fluoride is released over prolonged period which contributes to anticariogenic property of cement.
- Alumina: increased content, increases compressive strength and decreases translucency.
- Crylite: lowers the fusion temp (acts as a flux),increases the translucency of set cement.
- Aluminium phosphate: 1. Improves translucency of set cement. 2. gives strength to the cement.

Modifications in powder[15]

Anhydrous GIC - dried polyacrylic acid, Miracle mix – Silver tin alloy, Silver-palladium / Titanium alloy – Cermet cement and Light, Dual, Tricure GIC – BisGMA, TEGDMA and HEMA.

Liquid[9]

Polyacrylic acid – 45%, Itaconic acid – 5%, Maleic acid – 5%, Tricarboxylylic acid – 5% , Tartaric acid – traces and Water – 50% (hydrates reaction product).

Originally, liquids were aq. solution of polyacrylic acid. The liquid was too viscous, tend to gel with tim & in current cements, liquid is usually 45% solution of copolymer of polyacrylic acid & rest are modifiers & water. These itaconic acid, maleic acid & tricarboxylic acid tend to increase the reactivity of liquid, decreases the viscosity & also reduces tendency for gelation. Tannic acid is found in some composition in order to enhance bonding to dentine because tannic acid adheres to collagen. Tartaric acid improves handling characteristics, increases working time, aids in snap set.[9,14]

The role of water

The GIC are water-based cements in which water act as reaction medium and it results in increase in strength as it forms siliceous hydrogen & the metal salts . Also, if water is lost from cement by desiccation while it is setting, the cement forming reactions will stop. Water content in set cement → 11-24%. Cement is stable only in an atmosphere of 80% relative humidity (Hornsby 1980).[3,10]

Effect of water on cement

Early contamination: results in loss of calcium polyacrylate chain, absorption of water, loss of translucency, loss of physical properties, leaves cement susceptible to erosion.

Dehydration: leads to cracking & fissuring of cement, softening of surface, loss of matrix forming ions.[16]

Modifications in liquid[9]

Anhydrous cement – only water and tartaric acid, Light cure composite – HEMA and Amino acid modification

Dispensing[5]

Powder and liquid (with different shades), Pre-proportioned capsule (for mixing with mechanical mixers), Powder (anhydrous GIC which can be mixed with water), Two pastes (mixed and light cured) and Single Paste (Compomers) as tubes or compules (Cavifils)

Setting reaction

GIC is formed by reaction of 3 materials:

Fluoro alumino silicate glass powder, an ionic polymer of polyacrylic acid and Water. It can be set by acid base reaction or light cure polymerisation.[17]

Cement structure

Shows matrix phase and structure of filler. The nature of cohesive forces binds the matrix together and is presumed to be a mixture of ionic cross links, hydrogen bridges and chain entanglements.[3]

Setting reaction by light cure polymerization

Two stage process. It can be divided into:

1. Powder component of light cure GIC consists of initiators for light curing and liquid component is consists of HEMA – responsible for polymerization by light.
2. Initial polymerization of methacrylate groups followed by acid base reaction of powder and liquid.[2]

<u>Indications</u>[5,16,18]

1) Restoration of permanent teeth: Class V and Class III cavities, Abrasion / Erosion lesion and Root caries
2) Restoration of deciduous teeth: Class I cavities and Rampant caries, nursing bottle caries
3) Luting or cementing: Metal restorations - inlays, onlays, crowns, Non-metal restorations - composite inlays and onlays, Veneers, Pins and posts and Orthodontic bands and brackets.
4) Preventive restorations: Tunnel preparation and Pit and fissure sealants.
5) Protective liner under composite and amalgam.
6) Dentine substitute

7) Core build up

8) Splinting of periodontally weak teeth

9) Glazing (Fuji Coat LC): Glazing of traditional GIC filling, Improving aesthetics of old GIC filling and Protection of new GIC filling

10) Other restorative technique: Layered restorations/ Laminated restorations / Bilayered restorations, Atraumatic restorative treatment (Fuji VIII and Fuji IX) and Bonded restorations

11) Endodontics: Repair of external root resorption, Repair of perforation, Retrograde filling, Temporizing a broken tooth

Contraindications[19]

Class IV carious lesions or fracture incisors, Lesions involved large area of labial enamel where esthetics is of major importance, Class II carious lesions where conventional cavities are prepared, replacement of existing amalgam and lost cusp area.

Advantages[20]

Adhesive property, No retention features are required, Aesthetic restorative material, Liberates fluoride that is anticariogenic, Biocompatible, Low oral solubility, Easy to manipulate, Easily available and permanent restorative material.

Disadvantages[21]

Debond readily, Highly technique sensitive, Poor edge strength, Initial set allergic to moisture, Clinically poor aesthetic, White & crazed surface and Lack of fracture toughness.

Clinical placement of GIC[3,5,9,10,16]

1) Isolation.

2) Tooth preparation: Both Mechanical and Chemical.

3) Cement placement

4) Surface protection

5) Finishing & polishing

- ***Isolation:*** Saliva, sulcular fluid and haemorrhage has to be controlled during the restoration procedure. Rubber dam, cotton rolls, saliva ejectors, retraction cord are generally used.

- ***Tooth preparation:***

- **Mechanical:**

- Tooth preparation is not dictated by all the rules specified by G.V. Black for amalgam due to the adhesive nature, poor abrasive resistance & anticariogenic property of GIC.

- In class III access is gained through lingual marginal ridge with a small sized inverted cone bur, extending incisally & gingivally depending on the extent of caries. The labial enamel should be preserved as far as possible.

- In class 5 lesions, it can be only in enamel or cementum, the cavity preparation begins from the lesion extending inciso-gingivally & mesiodistally.

- If the extent of lesion is too wide, a groove can be placed on occlusal & gingival wall or on all 4 walls (mesial,distal) *a) Outline form*

It is dictated by the caries discoloration & aesthetics. In proximal lesions, no attempt should be made to break the contact to place the restoration in self-cleansing area. What ever unaffected tooth material is remaining should be left behind even if it is not supported by dentin, unless it does not come under direct occlusal contact. The facial wall should be left intact. Gingival extent as dictated by the lesion. Care should be exercised to manage sulcular fluid and tissue haemorrhage.

b) Retention & Resistance form

Retention for GIC is by true adhesion via ionic exchange, so any step to create undercuts or dovetail would be destruction of tooth structure unnecessarily.

Resistance is provided by maintaining 1mm minimum depth for the bulk of the restoration.

c) Convenience form

In class III, lingual wall is broken for convenience. Teeth may be mechanically separated. To avoid removal of sound tooth structure smallest drills should be used to remove the caries. In class 5 lesions, lip & cheek retractors & tongue guards are useful.

d) *Prophylaxis & debriding*

Bonding of GIC can be enhanced if the surface is clean & conditioned. Prophylaxis by pumice slurry is carried in rubber cups or bristle brush to remove plaque & pellicle.

e) Chemical preparation

After through prophylaxis, the cavity is conditioned using chemical agents. Citric acid- 50%, tannic acid- 25%. Of all these 10-20% polyacrylic acid is most commonly used. It is applied for 10-20 seconds & washed away. It removes the smear layer without demineralizing & opening the dentinal tubules. RMGICs have an additional step of priming the tooth surface by priming agent supplied by manufactures. It is applied liberally & spread to a thin layer by gentle blast of air followed by light activation for 20secs.

Cement placement

a) *Mixing of the cement:* The best method is to use the capsulated cement with syringe. Hand mix has to be done with great care mixing can be done on mixing pad or glass slab. Glass slab having the advantage to be cooled to increase WT. Agate or plastic spatula is recommended. Before dispensing the powder, shake the bottle lightly to fluff up the powder, use the lip of the bottle to ensure the powder is full of the spoon at the level of the scope. The powder is dispensed on the pad and first divided into 2 halves. Then the liquid is taken¸1st tilt the liquid bottle horizontally, gently squeeze to allow the liquid to displace the air through the nozzle and occupy the nozzle. Now bottle is oriented vertically and gently squeezed to dispense the required ratio of liquid at only one drop at a time, without air bubble. If liquid has become more viscous over time, place the bottle in 70^{0}c water bath for 15mins. and allow it to cool before using the liquid. The 1st increment of powder is rooled over the liquid to wet the surface of the powder particles. Do not vigorously spatula the 1st half of powder should be wet in 10-15 sec. Roll the second half mixing is then completed in about 30 sec. Do not spread the mix around the pad.

i) Loss of gloss or slump test

This helps to recognize the cement is properly mixed. The mix cement is placed on the glass slab. Lift the top of the pile of the cement with a spatula. The cement breaks and slump back. This is a proper mix. There will be a point where the cement breaks but does not slump. WT- 60-90 sec. for conventional GIC. 2-3 mins. For RMGICs.

ii) Restoration

The conventional and RMGIC are placed in the same way. The one bulk placement, removal of excess & contouring the filling are carried out similarly. Use of matrix helps in positive placement of the cement on to the tooth surface & reduces voids & porosities. With a syringe dispenses the tip is placed on the cavity floor & cement ejected into the cavity as the nozzle is withdrawn out till it gets the initial hardness the matrix is left in place. The light cure GIC should be sufficiently cure to avoid deficient light activation 60sec.cure is mandatory. After initial set the conventional cement should be protected by resin bonding agent since the 1st 24hrs are very critical for the cement to water sensitivity. Though for the light cure GIC after the light polymerization it does not imbibe water but it can dehydrate so even it should be protected. Light activated resin enamel bond are better than varnish the later being more impermeable.

Finishing & polishing

Best finish is necessarily the matrix finish. Initial contouring is done by BP blade, gold foil knife or diamond points in high speed. Final finish is done for conventional GIC after 24 hrs, many prefer doing the initial contouring after 24hrs. Final finishing after 24 hrs for conventional GIC is done by soflex discs, super fine diamond points, silicon abrasives embedded in rubber. Finishing using abrasive should be carried out using water spray to avoid dehydrated surface. Protection of surface with a light cured bonding agent should be done after finishing & polishing the surfaces. Other than conventional GIC, the remaining such as RMGIC,fuji IX GP, miracle mix can be final finished & polished after the initial set & surface protected immediately.

Surface protection:

With light cured bonding resin:

1. Fill irregularities on the surface
2. Gives smooth finish
3. More impermeable to water than varnish

One study which compared & evaluated rise in pulpal temperature during finishing & polishing of composite resin, RMGIC and Compomer at different speeds with and without coolant.concluded that,

1. Dry polishing is avoided.
2. If needed it should be done with intermittent pressure & at low speed less than 5000rpm.
3. Polishing done with high speed above 5000 can be done using coolant & with intermittent pressure.

Instructions

1. Powder- liquid supplied by different manufactures should never be interchanged results in altering the physical properties.

2. Both powder liquid bottles should finally closed at all times & stoopers should be replaced immediately after dispensing.
3. Liquid should never be stored in refrigerator
4. Make sure mixing slab is not below dew point before dispensing powder.
5. Clean up procedure.

Other techniques[22]

Tunnel preparation, Sandwich technique and Atraumatic Restorative Treatment (ART)

Recent advances in glass ionomer[23,24]

Improved traditional glass ionomers

- highly viscous GIC/packable GIC/ condensable GIC
- low viscosity GIC

Metal – modified glass ionomers

- Miracle Mix
- Cermet

Resin modified glass ionomers

Poly acid- modified composite resins / compomers

Self- hardening glass ionomers

New fluoride releasing glass ionomers:

- Low pH "smart" materials
- Fluoride charge materials

Others include Bioactive glass, Fibre – reinforced glass ionomer cements, Giomers, Command set, Amalgomer, Nano GIC, Amino acid based GIC, CPP-ACP containing GIC, GIC with antibacterial agent, Ketac endo aplicap, Pango GIC, Fuji ortho LC.

Improved traditional glass ionomers

Highly viscous GIC / Packable GIC/ Condensable GIC[25]

In the early 1990s, a highly viscous/packable GIC was launched. This material was developed largely as a need for filling materials in the atraumatic restorative treatment.

Composition: components of conv.gic+ aluminosilicate glass 90-95% +POLYACRYLIC ACID 3-5%. Liquid- polyacrylic acid 45% + distilled water 50%. Examples: fuji IX, ketac molar

Low viscosity GIC[26]

This glass ionomer has been developed as liners, fissure protecting materials for hypersensitive cervical areas and endodontic materials. These materials are highly flowable and have been designed with low powder-liquid ratios. During tooth eruption period, these are used as fissure protection material.

Metal – modified Glass Ionomers[27,28]

Due to lack of toughness, GIC cannot withstand high-stress concentrations. So, with the inclusion of metal filler particles, GIC have been modified to improve the toughness. For the modification, two methods have been employed.

1. Silver alloy admix or miracle mix or silver cermet

2. Glass cermet

Miracle Mix

In 1980, Sced and Wilson incorporated amalgam alloys into glass ionomer cements to increase the flexure strength. In the ratio of 7:1, Spherical silver amalgam alloy powder is mixed with Type II glass ionomer powder. Simmons in 1983 clinically used this system. However, their esthetics is poor as they tend to impart a gray to blackish color to the cement and they do not take burnish.

Glass Cermet

McLean and Gasser in 1985 developed the "cermet"-ionomer to improve the strength and abrasion resistance of GIC. These cements contain glass-metal powders sintered to high density which have been made to react with polyacids to form a cement. Eg: Ketac silver

***Resin modified Glass Ionomers*[27]**

They were introduced in 1988 by Antonucci et al to overcome the problems of conventional GIC. Due to slow acid-base reaction, traditional GIC show moisture sensitivity and low early strength. To overcome these drawbacks and to impart additional curing process and allow the bulk of the material to mature through the acid-base reaction, some polymerizable resin functional groups have been added to GIC**.**

Classification

1. DUAL CURE: eg. Geristore
2. TRICURE: eg.Vitremer
3. Photocure: eg. Dyract
4. Autocure: eg. Prosthodont

***Polyacid modified resin composite: (Compomer)*[29]**

Acc to McClean & Nicholson: A material that contains either or both of essential components of a glass ionomer cement but at levels insufficient to promote the acid base curing in the dark"they are essentially resin composites with glass fillers & dehydrated paa.

Compomers are the combination of composites (COMP) & glass ionomers (OMER)

They contain dimethacrylate monomer & two carboxylic groups along with ion leachable glass.. The glass particles which are fillers are partially silanated to ensure bonding with the matrix. Compared to RMGIC they have limited dual set mechanism. The dominant setting reaction is the resin photo polymerization & no acid base can occur until later when the material absorbs water. They are: Single paste light curing materials and Glass particles as fillers

Two different resins for matrix including a light curable monomer- UDMA OR BIS-GMA. Variable quantity of dehydrated PAA incorporated along with the filler. Adhesion purely by resin to dentin method or ion exchange cannot arise at any stage. Photo activation is necessary for this material.

***New fluoride releasing Glass Ionomers*[30]**

The development of *fluoride* releasing material was made in order to overcome the shortcomings faced by fluoride releasing materials.

I) With increase in the fluoride release, structure of the material becomes more open. This is associated with low strength.

II) In order to improve the strength of these fluoride containing materials, if they are made more dense & strong, the efficiency of ion release is reduced only after placement of restoration there is sudden burst of fluoride release followed by a rapid decline in ion release rate.

Hence, to overcome these two approaches were developed: Fluoride charge materials and Low pH "Smart" materials.

Fluoride charge materials[31]

This is the modified GIC & has two part material system- restorative part, charge part. The restorative part of the material is used in the usual way. When the 1st burst of fluoride is expanded and the therapeutic potential of the restoration is spent. The material is given a second fluoride charge using gel material that replenishes the fluoride sites in the restoration by ion exchange & recovers the fluoride release and therapeutic potential of the restoration. This is achieved without replacing material. This approach is still in the experimental stage.

Low pH "Smart" Materials[32]

Second approach is to optimize the efficiency of fluoride materials. When caries attack may be most threatening then only flouride release should be there, specifically at low ph which is the mechanism of these materials hence termed as smart materials. In these fluoride is not released all the time, the episodic release prolongs the usefulness of the material.

Bioactive Glass[33]

Hench and co. developed the idea of bioactive glasses in 1973. On stimulation there is formation of layer rich in ca & phosphate around the glass that can bond with intimate bioactive bonds with the bone cells & hence, material gets fully integrated into the bone. These bioactive glasses grow ca phosphate rich layer in presence of Calcium and phosphate saturated saliva thats why it is an excellent material for use in maxillofacial and craniofacial surgeries as its performance is better than hydroxyapatite.

In some studies, in order to improve biocompatibility & biomechanically match GIC to bone, hydroxyapatite+ ionomer were developed & named as HAIONOMERS.

It is a promising material which possess good mechanical properties. Potential to use as bone cement & performed implants for hard tissue replacement in the field of otologic, oral maxillofacial & orthopedic surgery.

Its used for Alveolar ridges augmentation in edentulous arches, cementation of custom made implants into place, intra-bony pockets correction in periodontology and may also help in the formulation of bioglass ceramics- with superior strength for fabricating crowns.

Fibre – reinforced Glass Ionomer Cements[27]

Polymeric Rigid Inorganic Matrix Materials or PRIMM is the newer development in resin-modified glass ionomer cements has lead to the incorporation of alumina fibres into the glass powder to improve upon its flexure strength.

Giomers[34]

Developed by Shofu, utilizes the hybridization of glass ionomer and composite resin to develop a new family of fluoride releasing direct aesthetic restoratives and adhesion called Giomer characterised by pre-Reacted Glass ionomer (PRG)

The fluoroaluminosilicate glass is reacted with PAA prior to being incorporated into resin. This prereacted GIC acts as filler bestowing the abilities of fluoride release & recharge.

Depending upon the amount of glass which is reacted, PRG Technology can be of 2 types,

1) **F- PRG- reaction of full or entire glass**
2) **S- PRG- surface of glass**

Amalgomer (Ceramically reinforced GIC)-AHL[5]

Designed to match the strength & durability of amalgam & aesthetic are like ceramic. It has natural adhesion to tooth structure and has sustained high level of F release Good biocompatibility & dimensional stability. No corrosion, shrinkage & thermal conductivity. It has less creep value and snap set.

Nano GIC (Ketac Nano)[35]

Composition

- Paste A: FAS, silane treated silica and zirconia nanofillers, methacrylate and dimethacrylate resins, and photoinitiators
- Paste B: is water based and contains polyalkenoic acid copolymer (Vitrebond copolymer), silane treated zirconia, silica nanoclusters, and HEMA
- Primer: Contains water, HEMA, polyalkenoic acid copolymer, and photoinitiators.

Amino acid based GIC[36]

One of the factors affecting the structure of glass ionomers is the chemical composition of the polymer matrix which contains homopolymers or copolymers of unsaturated mono-di or tricarboxyllic acids. The major problem lies with these formulations is in –COOH groups which are directly attached to the backbone and are closely oriented to each other, resulting in rigid polymeric structures. It is presumed that the strength or fracture resistance of the ionomer material is weakened due to this stearic hindrance, which brings about a significantly reduced –COOH-Al^{3+} in the set cement.

So acrylic acid polymers were modified with N – acryloyl or N – methacrylaminoacids. Such as N – methacrylolyl – glutamic acid, providing possible path to improved conventional galss ionomer. These newly formulated polyacids have flexible side chains tethering the carboxylic acids allowing more freedom & less steric hindrance when the carboxylic acid groups are undergoing chemical reaction. This type of modifications has improved the fracture toughness of glass ionomer cement.

CPP-ACP Containing GIC[37]

GIC containing CPP-ACP nanoparticles may have been physically encapsulated into the set GIC & has been formed with unreacted glass particles (Matsuya et al 1984) & therefore, released as acid eroded cement in acidic buffer. Acid catalysed release of CPP-ACP nanoparticles from GIC is consistent with protection of adjacent dentin observed during acid challenge. When it is added in GIC may have directly increased microtensile bond strength.

GIC with Antibacterials[38]

When used as a varnish on tooth surface showed to reduce no. of interproximal Mutans Streptococci.

When RMGIC combined with CHX resulted in greater reduction in S.mutans compared to conventional GIC & did not degrade physical properties.

CONCLUSION

Since the development of GIC nearly three decades ago, these material have found increasing applications in clinical dentistry. Clinical experience has defined the practical advantages & disadvantages of GIC system. This resulted in improved formulations & more controlled technique of course it is difficult to produce an ideal material, but with the current level of intensive research on GIC. Deficiencies can be eliminated or at least reduced resulting in an ever improving range of materials of this type.

REFERENCES

1. *McCabe, John F.; Walls, Angus W.G. (2008). Applied Dental Materials (9 ed.). Oxford, United Kingdom: Wiley-Blackwell (an imprint of John Wiley & Sons Ltd). pp. 284–287.*
2. *Lohbauer U. Dental glass ionomer cements as permanent filling materials?- properties, limitations and future trends. Materials (Basel) 2010;3(1):76-96.*
3. *Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. J Funct Biomater 2016;7(3): 16-30.*
4. *Dental Water Based Cements; International Organization for Standardization: Geneva, Switzerland, 2003.*
5. *Garg N, Garg A. Textbook of operative dentistry. 2nd ed 2013, Jaypee Brothers Publication, New Delhi.*
6. *Francisconi LF, Scaffa PMC, Barros RV, Coutinho M, Francisconi SAP. Glass ionomer cements and their role in the restoration of non-carious cervical lesions. J Appl Oral Sci 2009;17(5): 364-69.*
7. *Mount, G.J. Color Atlas of Glass Ionomer Cement, 2nd ed.; Martin Dunitz: London, UK, 2002.*
8. *Millett, Declan T.; Glenny, Anne-Marie; Mattick, Rye Cr; Hickman, Joy; Mandall, Nicky A. (2016-10-25). "Adhesives for fixed orthodontic bands". The Cochrane Database of Systematic Reviews.*
9. *Anusavice KJ. Phillips science of dental materials. 11th ed 2003 Elsevier St. Louis, Missouri.*
10. *Tyas MJ. Milestones in adhesion: Glass-ionomer cements. J Adhes Dent 2003;5: 259-66.*
11. *Peutzfeldt A. Compomers and glass ionomers: Bond strength to dentin and mechanical properties. Am J Dent 1996;9: 259-63.*
12. *Saito S, Tosaki S, Hirota K. Characteristics of glass ionomer cements. In: CL Davidson, IA Mjor (eds). Advances in glass-ionomer cements. Chicago: Quintessence Publishing, 1999;15-50.*
13. *McLean, J.W.; Nicholson, J.W.; Wilson, A.D. Guest Editorial: Proposed nomenclature for glass-ionomer dental cements and related materials. Quintessence Int. 1994, 25, 587–589.*
14. *Smith DC. Composition and characteristics of glass ionomer cements. J Am Dent Assoc 1990;120(1): 20-22.*
15. *Moheet IA, Luddin N, Ab Rahman I, Kannan TP, Ghani NR, Masudi SM. Modifications of glass ionomer cement powder by addition of recently fabricated nano-fillers and their effect on the properties: A review. Eur J Dent 2019;13(3): 470-77.*

16. *Garg N, Garg A. Textbook of operative dentistry. 3rd ed 2015, Jaypee Brothers Publication, New Delhi.*
17. *Mount GJ. An atlas of glass-ionomer cements. A clinician's guide. 3rd ed. London: Martin Dunitz, 2002.*
18. *Rizzante FAP, Cunali RS, Bombonatti JFS, Correr GM, Gonzaga CC, Furuse AY. Indications and restorative techniques for glass ionomer cement. RSBO 2015;12(1): 79-87.*
19. *American Academy of Pediatric Dentistry. Pediatric restorative dentistry. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry; 2020:371-83.*
20. *Nicholson JW. Glass-ionomers in medicine and dentistry. Proc Inst Mech Eng H. 1998;212(2):121-126.*
21. *Forsten L. Fluoride release and uptake by glass-ionomers and related materials and its clinical effect. Biomater. 1998;19(6):503-508.*
22. *Ngo H, Vital SO. Minimal intervention dentistry II: part 7. Minimal intervention in cariology: the role of glass-ionomercements in the preservationof tooth structures against caries. Br Dent J 2014;216: 561-65.*
23. *Al Otaibi G. Recent advancements in glass ionomer materials with introduction of nanotechnology: A review. Int J Oral Care Res 2019;7(1): 21-23.*
24. *Srikumar GPV, Naiza E, Mookambika R, Aanchal A. Newer advances in glass ionomer cement: A review. Annals Essenc Dent 2016;8(4): 19-23.*
25. *Olegario IC, Malagrana APV, Kim SS, Tedesco TK, Calvo AFB, Camargo LB. Mechanical properties of high viscosity glass ionomer cement and nanoparticle glass carbomer. J Nanomater 2015: 1-4.*
26. *Frankenberger R, Sindel J, Kramer N. Viscous glass-ionomer cements: A new alternative to amalgam in primary dentition? Quintessence Int 1997;28(10): 667-76.*
27. *Al Shaibani D, Bamusa B, Bajafar S, Al Eidan S, Almuhaidib D, Alhakeem F, Bakhadher W. Modificatio of glass ionomer restorative material: A review of literature. EC Dent Sci2019;18(5): 1001-1006.*
28. *Upadhya NP. "Glass Ionomer Cement - The Different Generations". Trends in Biomaterials and Artificial Organs 2005; 18(2).*
29. *NicholsonJW. Polyacid-modified composite resins (compomers) and their use in clinical dentistry. Dent Mater 2007;23: 615-22.*
30. *Mousavinasab SM, Meyers I. Fluoride release by Glass ionomer cements, Compomer and Giomer. Dent Res J 2009;6(2): 75-81.*
31. *Rao BSR, Moosani GKR, Shanmugaraj M, Kannapan B, Shankar BS, Ismail PMS. Fluoride release and uptake of five dental restoratives from mouthwashes and dentifrices. J Int Oral Health 2015;7(1): 1-5.*
32. *Singla K, Singh G, Arora M, Sareen K, Anukriti, Jhunthra D. Smart materials: Review article. IDA Lud J - le Dent 2021;5(1): 1-11.*
33. *Hench LL, Jones JR. Bioactive glasses: frontiers and challenges. Front Bioeng Biotechnol 2015;3: 1-12.*
34. *Kalotra J, Gaurav K, Kaur J, Sethi D, Arora G, Khurana D. Recent advancements in restorative dentistry. J Current Med Res Opinion 2020;3(7): 522-30.*

35. *Priyadarshini BI, Jayaprakash T, Nagesh B, Sunil CR, Sujana V, Deepa VL. One year comparative evaluation of Ketac Nano with resin modified glass ionomer cement and Giomer in noncarious cervical lesions: A randomized clinical trial. J Conserv Dent 2017;20(3): 204-09.*
36. *Xie D, Chung D, Wu W, Lemons J, Puckett A, Mays J. An amino-acid modified and non-HEMA containing glass-ionomer cement. Biomater 2004;25: 1825-30.*
37. *Heravi F, Bagheri H, Rangrazi A, Zebarjad SM. Incorporation of CPP-ACP into luting and lining GIC: Influence on wear rate (in the presence of saliva) and compressive strength. ACS Biomater Sci Eng 2016;2(11): 1867-1871.*
38. *Yesilyurt C, Kursat ER, Tasdemir T, Buruk K, Celik D. Antibacterial activity and physical properties of glass-ionomer cements containing antibiotics. Oper Dent 2009;34(1): 18-23.*

Conflict of Interest: None **Source of Support: NiL**